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September 23, 2019

VIA ELECTRONIC FILING

Ms. Kimberley A. Campbell, Chief Clerk
North Carolina Utilities Commission
Dobbs Building
430 North Salisbury Street
Raleigh, North Carolina 27603

Re: Docket No. E-22 Sub 562
Docket No. E-22 Sub 566

Dear Ms. Campbell:

Enclosed for filing in the above-referenced docket on behalf of Virginia Electric and Power Company, d/b/a Dominion Energy North Carolina, is *Late-Filed Exhibit No. 4*.

The Late-Filed Exhibit No. 4 responds to Waste Coal Ash Question No. 2 pursuant to the Commission's September 16, 2019 Order Providing Notice of Commission Questions in the above-captioned matter.

Thank you for your assistance with this matter. Feel free to contact me should you have any questions.

Very truly yours,

/s/Mary Lynne Grigg

MLG:mth

Enclosure

Dominion Energy North Carolina
2019 NC Base Case – Docket No. E-22, Sub 562
Public Staff
Data Request No. 113

The following response to Question No. 1 of Public Staff Data Request No. 113, dated July 2, 2019 has been prepared under my supervision.

Jason E. Williams
Director, Learning Development & Communications
Dominion Energy Services, Inc.

Question No. 1:

Please provide all capital, multiyear, and/or lifecycle cost-benefit analyses performed to evaluate alternatives at the time and immediately leading up to the decisions to excavate and consolidate CCR materials at Bremo and Possum Point. Please include any closure plans and schedules supporting the analyses. The analyses should include, but not be limited to, the following options:

a. Possum Point - *Ash ponds meeting the definition of "inactive" were recommended to close within three years or otherwise be subject to long-term monitoring and other costly provisions of the CCR Rule. DENC's ash ponds at Possum Point qualified as "inactive" under the CCR Rule. Accordingly, DENC proceeded expeditiously to close the inactive ponds at Possum Point by consolidating Ponds A, B, C, and E into Pond D - the largest pond at this site, which is also the furthest from waterways and the only pond at Possum Point with a liner. (Williams p 13)*
b. Bremo - *The EAP and WAP at Bremo qualify as "inactive" ash ponds under the CCR Rule. As such, DENC proceeded expeditiously to close the inactive ponds at Bremo by consolidating the EAP and WAP into the NAP - the largest pond and the pond located furthest from waterways. Since April 20, 2015, ash from the East and West Ponds was excavated and consolidated in the North Pond. (Williams p 14)*
c. Groundwater monitoring per CFR 257.91
d. Water treatment
e. Closure in place
f. Temporary cap-in-place

Response:

a. & b. On June 21, 2010, EPA published its proposed regulations regarding the storage, management, and disposal of CCR ("Draft CCR Rule"). In response, Golder Associates, at the direction of the Company, prepared reports in 2011 analyzing the potential impact of the Draft CCR Rule on the Company's operations at Bremo and Possum Point. The Bremo Report and Possum Point Report are being produced herewith in Attachment Public Staff 113-1. In those reports, Golder presented preliminary closure options and rough cost estimates for compliance with the RCRA Subtitle D alternative in the Draft CCR Rule. It was assumed that the Company could elect to excavate (clean close), cap (close in place), or hybrid close (consolidate) its basins.

After the EPA signed the final CCR rule in December 2014, the Company used the Bremo Report and Possum Point Report to develop its closure plans for the sites.

The Bremo Report evaluated closure options for the West and North Ponds, which in 2011 were the only active ash basins at the site. The Bremo Report recommended that the Company prepare for cap-in-place closure for the North Pond and noted that clean closure of the West Pond was favorable due to its location relative to groundwater, its small size, and the lower estimated cost as compared to cap-in-place. The Bremo Report did not evaluate closure options for the East Pond as it was unclear whether the East Pond would be subject to the rule given its long inactive status and partial soil cover.

Under the final CCR Rule, all ponds at Bremo qualified for "inactive" status, and were eligible for exemption from all long-term groundwater monitoring and post-closure requirements if closed within three (3) years of the CCR Rule's effective date of October 19, 2015. The Company sought to take advantage of this exemption. To achieve this goal, the Company chose to close the West Pond by removal and consolidate the ash into the North Pond, which would be capped along with the East Pond. When the EPA removed the exemption from the CCR Rule in 2016, the Company reevaluated its closure plan for Bremo's East Pond. Due to its location in the flood plain and susceptibility to inundation, long-term maintenance and remediation requirements, and costs, the Company elected to close the East Pond by removal and consolidation to the North Pond. A cost analysis prepared by Golder Associates for closure of the East Pond is included in Attachment Public Staff 113-1. Additional factors supporting the Company's closure plan included: the North Pond had capacity to hold CCR from both the West and East Ponds, the efficiencies gained from coordinating site mobilization for removal of CCR, the overall reduction of the CCR footprint at the site freeing up more land for potential future station projects and uses, the minimization of long-term environmental and regulatory risks associated with maintaining multiple CCR storage units, and moving CCR further away from the James River and to a higher elevation above the flood plain.

The Possum Point Report evaluated closure options for Pond D and Pond E. The Possum Point Report recommended that the Company close both Pond D and Pond E in place with a cap system. However, the cost estimate provide in the report for clean closure of Pond E (excavation and consolidation in Pond D) was less than the estimate for cap-in-place closure. The Possum Point Report did not evaluate closure options for Ponds A, B, or C, because it did not appear at that time that those long inactive ponds would be subject to the rule. Under the final CCR Rule, Ponds A, B, and C were required to be closed as well. Further, under the final CCR Rule, all Possum Point ponds qualified for "inactive" status, meaning the Company could take advantage of the early closure exemption. The Company decided to clean close Ponds A, B, C, and E and to consolidate that ash into Pond D. Factors supporting this decision included: Pond D had capacity to hold CCR from Ponds A, B, C, and E, the relatively small quantities of CCR contained in Ponds A, B, C, and E, the efficiencies gained from coordinating site mobilization for removal of CCR, the near 50% reduction of the CCR footprint at the site freeing up more land for future station projects and uses, the minimization of long-term environmental and regulatory risks associated with maintaining multiple CCR storage units, the minimization of long-term environmental and regulatory risks by consolidating ash in an already lined impoundment, and the movement of CCR further away from Quantico Creek and to a higher elevation above the flood plain.

c. At the time of and immediately leading up to the decision to excavate and consolidate at Bremo and Possum Point, the provisions regarding "inactive" ponds were still effective. As such, closure within 3 years of the effective date of the CCR Rule would have exempted these units from the CCR Rule's requirements for groundwater monitoring (including 40 CFR 257.91), corrective action, and post-closure care.

d. At the time of and immediately leading up to the decision to excavate and consolidate at Bremo and Possum Point, water treatment cost did not factor into the Company's decision, because the VPDES permit conditions at that time only required physical treatment through settlement and retention. Further, any water treatment costs would be consistent under either closure option since dewatering of the ash is a mandatory stage of closure regardless of the closure method.

e. Please see the Company's response to subrequests a. and b. above.

f. At the time and immediately leading up to the decision to consolidate and close in place the ponds at Bremo and Possum Point, a "temporary cap-in-place" option was not considered or evaluated. Such temporary closure would not meet the final cap system or closure timeline requirements established in the final CCR Rule and, therefore, would have eliminated the ponds' qualification for the inactive status exemptions.

Dominion Energy North Carolina
2019 NC Base Case – Docket No. E-22, Sub 562
Public Staff
Data Request No. 113

The following response to Question No. 2 of Public Staff Data Request No. 113, dated July 2, 2019 has been prepared under my supervision.

Jason E. Williams
Director, Learning Development & Communications
Dominion Energy Services, Inc.

Question No. 2:

Please provide all capital, multiyear, and/or lifecycle cost-benefit analyses performed to evaluate alternatives at the time and immediately leading up to the decision to close in place the LAP and UAP at Chesterfield. Please include any closure plans and schedules supporting the analyses. The analyses should include, but not be limited to, the following options:

a. Chesterfield - *The Company has begun the process of closing the LAP and UAP pursuant to federal and state requirements. (Williams p 14)*
b. Water treatment
c. Temporary cap-in-place
d. On-site permitted landfill with sufficient size to store new ash and CCR materials from the LAP and UAP
e. 2017 permitted landfill
f. Elimination of bottom ash sales revenue

Response:

a. On June 21, 2010, EPA published its proposed regulations regarding the storage, management, and disposal of CCR ("Draft CCR Rule"). In response, Golder Associates, at the direction of the Company, prepared a report in 2011 analyzing the potential impact of the Draft CCR Rule on the Company's operations at Chesterfield. The Chesterfield Report is being produced herewith at Attachment Public Staff 113-2. In the report, Golder evaluated and developed rough cost estimates for closure of the Lower Ash Pond ("LAP") under the RCRA Subtitle D alternative in the Draft CCR Rule. For purposes of the report, it was assumed that the Company would be required to close the UAP under the CCR Rule and that it would be able to proceed under the closure plan/schedule developed in 2003 and approved by VA DEQ.

After the EPA signed the final CCR Rule in December 2014, the Company used the Chesterfield Report to develop its closure plans for the sites. Under the final CCR Rule and the VPDES permit for Chesterfield, Dominion was required to close the LAP and UAP. Due to the volume of ash in the UAP and LAP and the lack of alternative onsite locations with sufficient storage capacity, cap-in-place was selected as the closure method for the LAP and UAP. The previous closure plan for the UAP did not meet the new minimum federal requirements under the CCR Rule and was amended accordingly.

b. At the time of and immediately leading up to the decision to close the LAP and UAP in place, water treatment cost did not factor into the Company's decision, because the VPDES permit at that time only required physical treatment through settlement and retention. Further, any water treatment costs would be consistent under either closure option since dewatering of the ash is a mandatory stage of closure regardless of the closure method.

c. At the time of and immediately leading up to the decision to close in place the LAP and UAP at Chesterfield, temporary cap-in-place was not considered or evaluated. Such temporary closure would not meet the final cap system or closure requirements established in the CCR Rule.

d. Closure-in-place was an allowable closure method under the CCR Rule. Closure by removal would have required construction of a new landfill with adequate size to contain all ash from both the LAP and UAP, which would have been significantly more costly than closure-in-place.

e. The decision to construct the landfill permitted in 2017 began in 2009, long before the effective date of the CCR Rule and was designed/permitted to accommodate newly generated ash based on the remaining capacity of the existing ash ponds as well as to facilitate a wet to dry conversion to meet ELG Rule requirements.

f. The project to convert to a bottom ash scraper system from the prior existing sluice method was driven by the ELG rule's prohibition on bottom ash water discharges. As such, elimination of bottom ash sales revenue was not a consideration as the Company was required to comply with the ELG Rule.

FINAL REPORT

FINAL

WET ASH IMPOUNDMENT EVALUATION

BREMO POWER STATION

Submitted to:

Dominion
5000 Dominion Blvd
Glen Allen, VA 23060

Submitted by: **Golder Associates Inc.**
2108 W. Laburnum Avenue, Suite 200
Richmond, Virginia 23227

Distribution:
1 Copy Dominion
1 Copy Golder Associates Inc.

January, 2011 1039-6867

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List of Appendices

1.0 EXECUTIVE SUMMARY

Golder Associates Inc. (Golder) is assisting Dominion with the evaluation of the impacts to station operations from the EPA's proposed regulations regarding disposal of coal combustion residuals (CCR) from electric utilities as published in the Federal Register on June 21, 2010. Consideration was given only to the Co-Proposal under authority of Subtitle D of the Resource Conservation and Recovery Act (RCRA) as it represents a baseline cost and schedule basis for either of the co-proposals presented by the EPA.

This evaluation identifies two major systems at the Bremo station that will be directly or indirectly impacted by the regulations, and all are tied to the regulation effectively eliminating wet ash impoundments as a means of CCR disposal. Closure of the west ash pond at Bremo will force a system change by requiring the construction of an approximate 1.3 million gallon per day (MGD) wastewater treatment plant (WWTP). Both the west and north ponds are slated for closure due to a fuel conversion project for the station which will eliminate the need for the ponds. The fuel conversion project is planned to be complete by the end of 2013.

The current-year (2010), non-escalated conceptual project costs and schedules presented in this report are based on the following scenario:

- Closure of the West pond by clean closure;
- Closure of the North pond in-place;
- Construction of an on-site wastewater treatment plant of approximately 1.3 MGD capacity;
- Other regulatory-driven tasks (GW monitoring, posting of plans, etc.); and,
- Operations and Maintenance (O&M) costs associated with operating the WWTP.

BREMO POWER STATION
CONCEPTUAL COST-LOADED SCHEDULE

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
WWTP Construction *****	$3,581,250	$10,059,056	$7,425,248	$898,446	$ -	**$21,964,000**
West Ash Pond Closure	$ -	$ -	$58,756	$4,031,799	$61,462	**$4,152,017**
North Ash Pond Closure	$ -	$ -	$10,126,049	$20,962,141	$3,040,310	**$34,128,500**
Other Regulatory Tasks	$128,225	$ -	$ -	$ -	$ -	**$128,225**
Additional O&M costs	$ -	$14,000	$14,000	$793,250	$1,053,000	**$1,053,000 (annually)**
Total	**$3,709,475**	**$10,073,056**	**$17,624,053**	**$26,685,636**	**$4,154,772**	**$61,425,742**

* Capital costs for selenium treatment not included
All values are anticipation of the proposed Subtitle D rulings

A conceptual overall project schedule has been developed for the Bremo station, and the estimated time required to complete all three major projects is approximately **4.25 years**, or approximately 8 months ahead of the anticipated regulatory required deadline.

PROJECT No.	103-96868
FILE No.	10396868A05
REV. 0	SCALE AS SHOWN
DESIGN DPM	09/22/10
CADD OSY	09/22/10
CHECK	
REVIEW	

TITLE

AERIAL OF ASH PONDS AND POWER STATION

PROJECT

DOMINION
BREMO POWER STATION
BREMO BLUFF, VA

Golder Associates
Richmond, Virginia

FIGURE 1

2.0 DESCRIPTION OF THE STATION

The Bremo Power Station is located approximately 55 miles west of Richmond, Virginia, in Fluvanna County. There are two coal-fired with a combined capacity of approximately 250 megawatts. The station was constructed in the early-1930's and is now one of the oldest fossil stations in the fleet. The Bremo Station does not have a Flue Gas Desulfurization system. The Bremo Station is anticipated to undergo a fuel conversion program which is anticipated to be complete by 2013. At that time, the ash ponds will no longer be needed.

2.1 Ash Ponds

The Bremo Station operates two ash ponds at the station, the west pond and the north pond. The west pond was constructed c. 1980 and has been in active use since then. The north pond was constructed in 1983 and is used to receive dredged ash from the west pond during dredge events of the west pond. Table 1 shows the capacities of each pond.

TABLE 1

BREMO ASH POND CAPACITIES

Pond	Area (acres)	Capacity (CY) Total / Remaining	Percent full (as of date)
West	17	467,867 / 188,533	60% (7/1/10)
North	96	6,937,000* / 3,226,014	53% (7/1/10)

* capacity to the top of the dam

2.2 Waste Streams

2.2.1 Bottom and Fly Ash

Both the bottom ash and fly ash from the station are wet sluiced to the west ash pond for disposal. Up to 2.6 million gallons per day (MGD) of ash sluice water is pumped to the west pond. Material is periodically dredged to the north pond to restore capacity in the west pond.

2.2.2 Other Plant Waters

The west ash pond receives a significant portion of wastewater and stormwater from the station in addition to the ash slurry water. These "other" waters consist primarily of stormwater flows, bearing cooling water, and the mixed effluent from stormwater treatment pond, totaling 1.3 MGD and higher, depending on precipitation. During precipitation events, a large volume of stormwater flows into the stormwater treatment pond, which then flows into the west ash pond. Sanitary wastewater (from lavatories and sinks in the station) is collected separately and sent to the station's sewage treatment plant for treatment.

3.0 DECISION TREE

During the early work sessions for this evaluation, the project team developed a method of analysis that would be used to systematically evaluate the options available at each station with regards to ash impoundments (Figure 2). The first level of evaluation is to determine if there are impoundments that could be considered for early closure using an anticipated effective date of the EPA regulations of December 31, 2011. The evaluation considered if an impoundment could be fully closed in advance of the effective date, and thereby not be subject to the proposed regulations. Neither pond at the Bremo station was considered for early closure.

The second level of evaluation is to look at each impoundment with regards to the siting requirements proposed in Section 257.64 of the proposed regulations. Due to the fuel conversion project planned for Bremo, continued use of the ponds was not considered. Both the west and north ash ponds were evaluated for closure only.

The evaluations carried out in this report are based on the EPA's proposed regulations as published in the Federal Register on June 21, 2010. Consideration was given only to the Co-Proposal under authority of Subtitle D of the Resource Conservation and Recovery Act (RCRA), as it represents a baseline cost and schedule requirement for the proposed regulations.

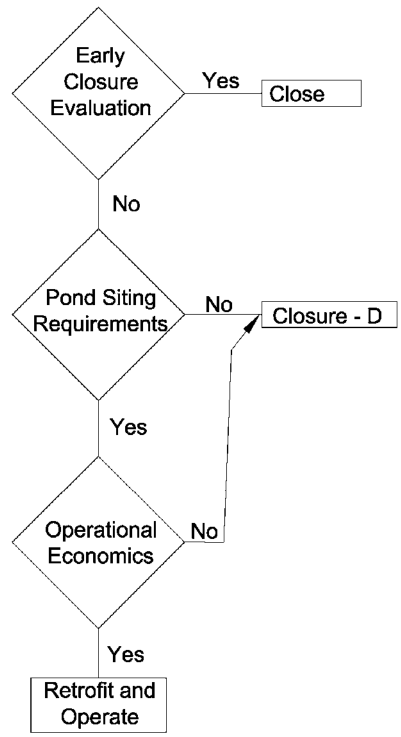


Figure 2 – Decision Tree

4.0 GROUNDWATER MONITORING SYSTEMS

To meet the requirements of the proposed regulations, a groundwater monitoring system must be installed at each surface impoundment within one year of the effective date of the regulations, regardless of future planned use or closure. Since the west and north ponds are a significant distance apart and the Bremo station is in between the ponds, two independent groundwater monitoring systems will be needed.

At a minimum, the north ash pond will require the installation of one to two upgradient groundwater monitoring wells and seven downgradient monitoring wells. Each well must be screened within the uppermost aquifer underlying the pond. Well depths are assumed to be approximately 65 feet. Estimated drilling costs for well installation of the groundwater monitoring network is $38,025. An additional cost of approximately $7,000 will encompass necessary well development and pump installation.

The west ash pond will require one upgradient groundwater monitoring well and four downgradient monitoring wells. Each well must be screened within the uppermost aquifer underlying the pond. Well depths are assumed to be approximately 40 feet. Estimated drilling costs for well installation of the groundwater monitoring network is $15,000. An additional cost of approximately $4,200 will encompass necessary well development and pump installation.

Dominion will need to maintain and upload design, installation, development, and decommission activities for any monitoring wells, piezometers, and other measurement, sampling, and analytical device documentation in the operating record and on a publicly accessible internet site. (§257.91(d)1) It is assumed that Dominion will be able to develop an internet site to incorporate the above mentioned documentation. Well installation certification by registered professional engineer or hydrologist must be posted in operating record and on publicly accessible internet site within 14 days of certification (§257.91(e)2). It is assumed that a certification report will be incorporated by Dominion into the operating record and on to the internet site for the facility

A Well Installation Certification Report is required following completion of the well installations. Estimated cost of completing the certification report is $4,000. Drilling activities and Well Installation Certification reporting can be completed within 60-90 days.

Based on available records, it appears that the Bremo Power Station does not have a Groundwater Monitoring Plan for either ash pond. The approximate cost for developing a Groundwater Monitoring Plan is $4,000 and can be completed within 30-45 days. An initial sampling program to establish the statistical background will need to be completed. At a minimum, four independent background samples collected at minimum 30-days apart, are required from each upgradient well within the first semi-annual groundwater monitoring period. The cost to develop the facility background data, assuming two upgradient wells are constructed, would be approximately ($500/well x 4 events, plus running stats) $20,000. An additional cost of $3,000 would be associated with the completion of a Statistical Background Report. The timeframe for developing background would be approximately 180 days.

The overall cost to install, document, and monitor the groundwater networks for the west and north ponds for the first year is conceptually presented as **$128,225**. To meet the regulatory deadline, the monitoring networks must be established within **one year** of the effective date of the regulations. Annual groundwater monitoring costs for the 14 new wells is estimated at **$14,000** per year.

5.0 ASH POND CLOSURE

Under the closure requirements of the proposed regulations (§257.100), the owner of a surface impoundment must begin closure activities no later than 30 days after the date which the impoundment receives the last known final receipt of CCR, or no later than one year after the last known receipt of CCR if the impoundment has remaining capacity and could reasonably expect to receive additional CCR. Once closure activities begin, the regulations also state that closure activities must be complete within 180 days following the beginning of closure.

Due to the inherent wet nature of CCR in ponds and the large size of these ponds, the 180-day requirement appears to be unreasonable and potentially impossible to meet. Golder's conceptual construction estimates, as discussed further in section 5.1, range from 18 to 29 months for completion. Handling of water before and during construction consumes a significant portion of time for these projects. Once sufficiently dewatered, construction of the closure cap section alone is anticipated to take at least 6 months due to the large acreages and volumes of soil involved. Golder's recent experience with construction of similar closure cap systems on dry landfills has shown to have taken from 6 to 8 months to complete, depending on size.

5.1 West Ash Pond

Under the proposed EPA rules for disposal of CCR, 'Corrective Actions' will be imposed on station owners and operators of surface impoundments in the event that offsite impacts to groundwater and surface water occur. To evaluate the risks to groundwater and surface water that may arise from closure of the impoundments either with the CCR left in place, or through clean closure, it will be important during the design phase to undertake a thorough geologic and hydrogeologic investigation of the pond. This will be necessary to understand the depth to groundwater and its seasonal variation, the hydraulic gradients beneath and beyond the immediate vicinity of the pond, and the different groundwater flow regimes operating. The head differences between the impounded CCR and the groundwater, and the degree of hydraulic connection between the pond and the groundwater will also need to be evaluated. A description of each closure method follows; however the selection of closure method cannot be definitively recommended at this time. Golder recommends an evaluation of closure methods after the initial rounds of groundwater monitoring have been completed in order to better understand the direction and magnitude of possible off-site impacts.

The west ash pond, due its relatively small size, can be considered either for a clean closure or for closure in place. In either case, the closure of the west pond cannot be started until after the completion of the WWTP commissioning and the fuel conversion project. Should clean closure be chosen, there appears to be adequate capacity in the north pond to receive the excavated CCR and excess soils resulting from a clean closure. Clean closure is discussed in section 5.1.1. Closure in place of the west pond would follow the same process described for the north pond, and this is described in section 4.1.2. Separate costs and schedules have been developed for each alternative.

5.2 Clean Closure – West Pond

A clean closure, as presented in §257.100, involves the removal of CCR material from the surface impoundment and removal and/or decontamination of "all areas affected" by releases from the CCR impoundment to meet the state-specific numeric cleanup levels for constituents found in CCR. The final state proposed for the clean closure area of the west pond at Bremo would be a relatively flat area that could be used for future station projects.

The proposed list of constituents found in CCR or that may be affected by a release of CCR to the environment is presented in Appendices III and IV to §257 (proposed regulations). Based on Golder's experience with similarly written regulations for Resource Conservation and Recovery Act (RCRA) corrective action sites, Golder interprets "affected areas" to include both soil and groundwater containing concentrations of constituents found in CCR above the following numerical cleanup levels or documented background (i.e., upgradient and/or naturally occurring) concentrations, whichever is higher:

Groundwater: Virginia Solid Waste Management Regulations Groundwater Protection Standards (based on background concentrations, EPA Maximum Contaminant Levels, or Virginia Department of Environmental Protection Alternate Concentration Limits); Groundwater Protection Standards have not been established by the DEQ for the full list of proposed groundwater monitoring constituents for CCR surface impoundments, but are expected to be established upon implementation of the proposed regulations.

Soils: Environmental Protection Agency Regional Screening Levels (RSLs) for industrial / commercial soils or background concentrations are expected to be appropriate numeric cleanup levels for "affected" soils. The use of industrial / commercial RSLs is a risk-based approach, and would need to be coupled with institutional controls mandating continued industrial / commercial land use. Furthermore, if groundwater is affected by a constituent above the Groundwater Protection Standard, removal of affected soils to the RSL for soil-to-groundwater leaching would be appropriate, as practicable, to further protect groundwater quality.

Concept-level tasks, costs, and durations for clean closure of the west ash pond based on existing information are provided as follows:

1. Removal of CCR materials and soils located above the elevation of the water table: Golder understands that CCR materials are likely present to the base grade of the impoundment and affected soils are likely present to the depth of the pre-impoundment

water table, at a minimum, over the entire footprint of the west ash pond. The average depth of the pre-impoundment water table is estimated to be 10 feet above the elevation of the nearby James River (approximately 200 feet above mean sea level), resulting in an average targeted excavation elevation of 210 feet above mean sea level. Based on Golder's experience with other remedial actions for soil under RCRA, the removal of CCR materials and soils above the water table constitutes clean closure for affected soils.

Golder understands that the north pond has sufficient available volume for the placement of excavated materials from the west ash pond. Sampling of side-walls within the excavation will be required to confirm lateral remediation to the soil clean-up standards.

a. Cost: **$4,080,000**

b. Duration: **11 Months**

2. Groundwater monitoring: Potentially affected groundwater in the region of the west ash pond will be monitored using the planned groundwater monitoring network, required within 1 year of the effective date of the proposed regulations. In addition to this network, it is anticipated that groundwater monitoring at up to five locations within the former footprint of the west ash pond will be required to demonstrate clean closure with respect to groundwater. Using this monitoring network, Golder anticipates that up to three years of semi-annual monitoring for the proposed list of constituents presented in Appendices III and IV of the proposed regulations (§257) will be required to demonstrate that groundwater has not been affected by CCR constituents. Semi-annual evaluations of groundwater monitoring results and reporting will be required. If applicable, a report requesting state approval of the clean closure activities and termination of groundwater monitoring will be required at the end of the anticipated three-year monitoring period.

   a. Cost: **$70,000**

   b. Duration: **36 Months**

The tasks and costs presented represent minimum efforts required for clean closure of the west ash pond. An evaluation of existing groundwater data for analytes presented in Appendices III and IV of the proposed regulation, as compared to current or anticipated Groundwater Protection Standards and site-specific background concentrations, may provide an up-front determination of the feasibility of clean closure of groundwater without corrective actions triggered by potential exceedances of cleanup levels. Potential groundwater remediation for CCR constituents and associated corrective action monitoring, if required, is expected to be a long-term effort, diminishing the potential benefit of a clean closure effort relative to in-place closure of the west pond.

5.3 Closure With Wastes in Place – West and North Ponds

With a material such as CCR, closure in place involves a significant effort to dewater and stabilize the waste mass so that it will be stable and support the final closure cover. *In-situ* solidification of the entire ash body is considered impractical and unfeasible; however, targeted solidification measures may be considered to enhance the overall stability of the ash body. A thorough pre-design evaluation is recommended during initial closure planning to identify potential stabilization needs for the north pond. The general sequence of events for closure with the wastes in place is as follows:

- Removal of free liquids;
- Stabilization of the ash body surface;
- Installation of seepage collection system(s);
- Installation of slurry wall containment (if needed – discussed in Appendix B);
- Grading and shaping of ash surface for drainage;
- Lowering of the embankment height; and,
- Installation of the final cover system.

Pumping of the free liquid from the pond is feasible with normal self priming diesel powered centrifugal pump sets. Given the volumes of free water involved, it is anticipated that trailer or skid mounted pumps would be required for this application, in the 8 to 12-inch size range. The water pumped from the pond may require treatment prior to release to meet VPDES permit conditions and an allowance of $0.02 per gallon for treatment has been made in the conceptual cost estimate. Pumping the initial free liquid from the pond is estimated to take approximately 3 to 5 weeks to complete.

5.3.1 Stabilization of the Waste Surface

Following removal of free liquids, the ash body will require dewatering to the extent needed to provide a firm, safe and trafficable surface on which equipment can be deployed for the construction of the closure cap system. To achieve a stable surface, it is anticipated that the water table within the impounded CCR would need to be lowered by about 5 feet below the surface. If the ash properties are particularly favorable (e.g. high angles of shearing resistance, pozzolanic effects, or better drainage if bottom ash layers are present), then this level may be less.

Working platforms with low ground pressure equipment

If the water table in the impoundment is sufficiently low then it may be possible to progress with cap construction without significant dewatering. This would require pushing out common fill into the impoundment along several working platforms. Each platform might be 12 feet in width initially, and perhaps 3 to 5 feet in thickness. This material would be pushed out using low ground pressure (LGP) equipment, typically D6 dozers. A plan arrangement of these platforms may take the form of a ‘spider web’ pattern, radiating out from equipment turnaround pads at select locations. In this way, access to the entire impoundment surface could be progressed, with final cover system construction commencing from the working platforms.

Typical production rates for a D6 LGP dozer working in this manner are low, perhaps as low as 1,500 cubic yards per day. Even so, at this kind of production rate, the equipment is likely to quickly 'out-push' the available dry and stable areas, so multiple rim ditch and sump arrangements may be needed (see below). Large volumes of imported common fill may be required, at a conceptual cost of $5/CY (placed) to establish the working surface upon which to construct the lined cover system.

Rim ditches and sump pumping

With relatively new ash deposits or those under constant submergence, the need for dewatering is inevitable while working in conjunction with spreading out working platforms with LGP equipment. Dewatering may be achieved by excavating trenches (also known as rim ditches) that would drain seepage waters to strategically located sumps. The sumps would probably be lined with a perforated standpipe, wrapped in geotextile, and with a free draining aggregate collar surround. Centrifugal pumps in the 6-inch to 8 inch size range would be required to continuously pump from the sumps. Depth, width and spacing of the rim ditches and sumps would depend greatly on the properties of the site specific CCR. If the ash surface has significant free liquids and unstable areas that it are not trafficable, then crawler cranes working from the impoundment crest roads using clam shell buckets could be deployed to establish an initial drawdown area around the perimeter of the pond. From here, work would then progress from the outside perimeter towards the center of the pond using LGP equipment.

Surface stabilization with additives

Another expedient that may be used to enhance the bearing capacity of the wet unstable ash surface is to scarify in dry ash or lime. This approach is likely to be more effective than spreading wet material into windrows and waiting for it to dry because that is highly weather dependent and typically proceeds slowly. If it is not possible to scarify in material with a tractor pulled disc or harrow, then an alternate means is to use multiple ripper attachments on an LGP dozer to track in the additive. As stability improves, heavier larger equipment can be deployed (e.g. D7 or larger dozers) to increase productivity.

Dewatering systems

There are a variety of alternate positive dewatering methods available to lower the water table within the impounded CCRs to facilitate cap construction, and these include vacuum well points, deep wells and horizontal drains connected to vacuum pumps. Fly ash has been successfully dewatered using well point systems. Powers *et al*. (2006) summarized the case history documented by the Pennsylvania Electric Company (1985) in a report for EPRI that that was performed by Moretrench Corporation. Jetted-in wellpoints were used to dewater a fly ash lagoon sufficiently such that front end loaders could operate on the ash. This involved a water surface drawdown within the ash in the order of 3 to 5 feet. Powers *et al*. (2006) stated that:

"*Loose saturated material in the lagoon of Fig. 19.41 was too sloppy to be hauled in trucks before treatment. One could walk on the material only by means of plywood. After treatment with the vacuum well point grid, the ash was firm enough to be excavated on a near vertical slope…*"

Well points are typically spaced at about 5 to 10 feet on centers, each connected into a header system which is joined to a vacuum pump system. On the Pennsylvania Electric Company lagoon, rows of well points were deployed spaced in the order of 80 feet apart across the surface, with individual well points spaced approximately 5 to 10 feet on centers along each row. The rows of well points were connected to a perimeter header system with vacuum pumping arrangements and achieved a drawdown of about 3 to 5 feet within one month of operation. For a typical 50 hp well point system, unit costs for installation may be estimated at about $100 per linear foot of header, with running costs at about $6,000 per week. For deep ash deposits requiring excavation ('clean closure") then it can be expected that multiple levels of well points may be required. An alternate to this multiple stage well point system for deep ash deposits would be to install deep wells or ejectors.

Conceptual cost estimates for the surface stabilization can vary widely, based on the geotechnical analysis of the ash body, age, water content, and choice of stabilization method. For the purposes of this evaluation, installation of a well point system at 100-foot line spacing was considered. In the case of the north pond, approximately 40,000 linear feet of header would be installed. The system would need to be operated from the time of installation through construction of the final closure system in order to maintain stability during construction activities. Water recovered from the system would likely require treatment prior to release. A conceptual cost of **$4,000,000** has been established to install the system, and a conceptual operating cost of **$1,096,000** for the duration of construction (approximately **24 months**). Water treatment costs were estimated at $0.02 per gallon. The schedule for installation of the dewatering system is highly dependent on the ash condition and methods employed by the contractor. A base duration of **8 weeks** has been established for conceptual scheduling, knowing that once an area has begun to stabilize, other work can progress while the dewatering installation continues elsewhere.

5.3.2 Installation of Seepage Collection

If, following subsurface exploration and hydrogeologic evaluation of the pond site, it is determined that conditions are favorable for a closure in place, a significant engineering challenge remains in controlling seepage of the leachate from the ash body over the long term post-closure care period. No matter how effective the construction dewatering is during the cap construction period (be it by rim ditching and sump pumping, or wellpoints), it is unlikely to remove significant volumes of water from the body of the ash. Some form of seepage collection system is therefore recommended and likely to be required by the regulatory agency within the overall closure design.

The elements of a seepage collection system for capture of leachate from within the body of the CCR impoundment over the 30 year post-closure care period would be subject to subsurface exploration, design

and analysis. At this stage it is only possible to discuss the type of design components in very general terms, because much will depend on the following factors:

- Permeability characteristics of the CCR which will be different depending on the mix of fly ash, bottom ash, slimes, and boiler slag;
- Effective porosity (specific yield) of the CCR that governs how much interconnected pore space there is for water to drain out under gravity;
- Degree of layering (anisotropy) of the CCR that is governed by the pond specific history of hydraulic filling;
- Impoundment geometry (berm heights, perimeter lengths, slope gradients, plan area, distance to water treatment plant;
- Hydrogeologic conditions in the foundation; and
- Surface water drainage conditions at the toe of the impoundments.

A seepage collection system might include geosynthetic panel drains that comprise sheets of geocomposite drainage net with integral collection pipes at the bottom edge. Panel drains provide a means by which to lower the water table within the impoundment, enhancing slope stability and helping to mitigate the risk of seepage 'break-outs' on the side slopes or toe of the final cover.

Panel drains are placed vertically in trenches excavated into the CCR body from temporary benches by hydraulic excavators or possibly trenching machines. The excavated trenches might be up to 15 feet deep by two feet wide. Slotted flexible pipes can be sewn into the bottom of panel drains, forming a 'sheet drain' to capture liquid from the drainage nets. Flows are then conveyed to collector drains and so called 'down-drains' that would be located at intervals around the impoundment. This kind of arrangement would also require and cleanout risers at various locations for maintenance (e.g. hydro-blasting to clear blockages) and inspection purposes (e.g. video camera surveys). Down-drains typically connect into a perimeter toe drain system around the toe or lowest point of the impoundment. Flows from the perimeter drain are routed to a permanent sump pump station, and then to a wastewater treatment plant prior to discharge.

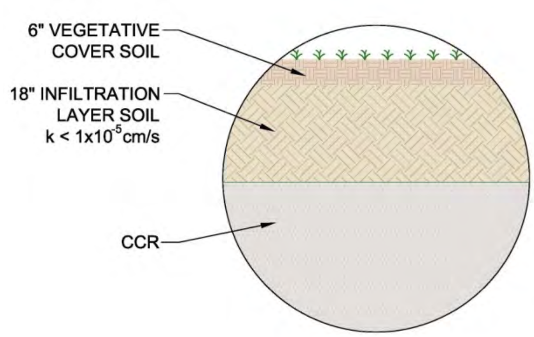
A significant issue arising from installation that needs careful consideration during the design phase is constructability. Loose, wet fly ash typically does not stand unsupported in excavations. The material readily takes in water, but does not release it easily. When disturbed during excavations and under the equipment loads, it turns into a relatively loose, flowable slurry. Unsafe cave-in conditions and equipment stability need to be addressed in a proactive and preemptive manner during design and construction. Dewatering by vacuum assisted well point pumping adjacent to excavations to facilitate drain installation is likely to be required and may be a significant extra cost to be factor into the planning for long term seepage control.

Estimating the schedule duration for installation of a seepage collection system is possible only on a conceptual basis with the limited information currently available. Based on engineering judgment, it is suggested that a period of between 12 and 18 months may be required for construction of a seepage collection systems for closure of ponds in the 100-acre size range. At this strategic planning stage, a conceptual cost estimate for a seepage collection was developed based upon unit rates that have been developed from an impoundment closure project in 2005 in the southeastern USA, escalated to 2010 prices using ENR Construction Cost indices. For conceptual planning, unit costs of $13,500 per acre, or alternatively $85 per linear foot of drainage system installed are suggested. For the north ash pond, a conceptual cost for the installation of a seepage collection system based on 96 acres is **$1,296,000** and would take approximately **one year** to install. This conceptual cost does not include the previously-discussed costs that are likely to be required for well point dewatering in the CCR body to facilitate installation of drains.

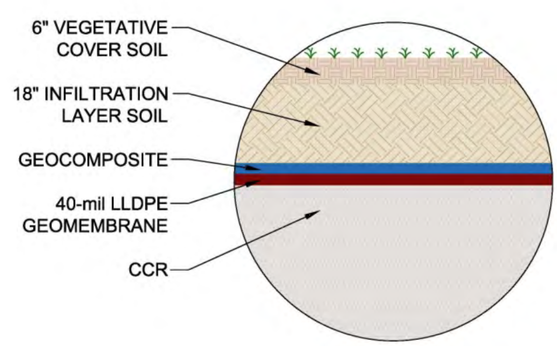
5.3.3 Closure Cap Construction

Once the CCRs are stabilized and prior to placement of the final cap, the surface of the CCR will be shaped to promote positive drainage and prevent infiltration of precipitation. Additional fill material will be needed to adjust the top of the pond from a relatively flat surface to one containing slopes of 2% or more for drainage. The initial as-constructed slope may be steeper than 2% depending on the amount of settling that is anticipated. The goal is have a post-settlement slope of at least 2%. For both ponds, an estimate of 5,000 CY/acre was used for material import.

The final cap system is required to have a permeability (k) of $1x10^{-5}$ cm/s or be less than the bottom liner system, whichever is less permeable. Since both ponds are unlined, a soil-only cover system consisting of 6-inches of vegetative support soil and 18-inches of soil ($k < 1x10^{-5}$ cm/s) would meet the minimum requirements. The final cover could also be constructed with geosynthetic components to decrease the permeability of the system, or if sufficient quantities of suitable soil are not available. However; the cover system would still likely require 24 inches of soil cover to protect the geosynthetic materials. Regulatory approval of an exposed geomembrane cover in Virginia is uncertain. Stormwater run-on and run-off controls will be designed to adequately convey the 25-year, 24-hour storm at a minimum. Two typical closure cap sections are shown below.



Soil Only Cap



Geomembrane Cap

Golder strongly recommends the cap section containing the geosynthetic materials, as they provide permeability up to 5 orders of magnitude less than the soil-only systems. A significant decrease in infiltration and consequently an increase in groundwater protection can be had for a relatively small increase in cost. For the dewatering and closure cap construction sequence for the north pond outlined above, Golder estimates concept-level costs of **$34,130,000** with engineering and construction duration of approximately **27 to 30 months**. For the west pond, closure-in-place costs are conceptually estimated at **7,935,000** with a duration of **12 to 14 months**. These conceptual costs include construction of a slurry wall.

5.4 Summary and Recommendations for Ash Pond Closure

In the preceding sections, two options were presented: clean closure and closure in place. Golder's recommendation is to prepare for an in-place closure of the North Pond and to evaluate the groundwater characteristics of the West Pond for the possibility of clean closure. Clean closure of the West Pond appears to be a more favorable option due to the pond's location relative to groundwater, relatively small size, and lower projected overall cost compared to closure in place. A summary of the conceptual costs are presented, along with the conceptual durations.

TABLE 2A
WEST ASH POND - CLEAN CLOSURE

Task	Duration (months)	Conceptual Cost
Closure Construction	10	$4,080,000
Attenuation monitoring	36	$70,000
Total	**46**	**$4,150,000**

TABLE 2B
WEST ASH POND – CLOSURE IN PLACE

Task	Duration (months)	Conceptual Cost
Engineering	2	$171,000
Closure Construction	10	$7,764,000
Total	**12**	**$7,935,000**

TABLE 3
NORTH ASH POND - CLOSURE IN PLACE

Task	Duration (months)	Conceptual Cost
Engineering	2	$171,000
Closure Construction	27	$33,959,000
Total	**29**	**$34,130,000**

6.0 CONSEQUENCES OF POND CLOSURE

The fuel conversion project would eliminate the need for the ash ponds at Bremo, triggering their closure. Conversion of the ash handling system would not be required; however a wastewater treatment plant to treat “other plant waters” that would no longer go to the ash pond would be required.

The west ash pond serves as the receiving body for the bulk of non-cooling water related discharges from the station. A large quantity of water comes from the station’s storm water pond, which serves as the central collection point for stormwater, low volume wastewaters (floor drains, blowdowns, WWTP effluent, bearing cooling water, etc.). Additional sources of inflow for the lower ash pond include discharges from the coal pile runoff pond and the metals cleaning [neutralization] pond. The anticipated flow into the WWTP is 1.3 MGD, however the influence of stormwater flows may increase this value.

The station’s Virginia Pollution Discharge Elimination System (VPDES) permit includes monitoring of the outfall of the west ash pond (Outfall 002) for the following parameters:

- pH
- Total Suspended Solids (TSS)
- Oil and Grease

Historically, the volume of water and settling time provided by the west ash pond has provided sufficient water quality at the outfall to consistently meet the permit limits. Closure of the pond will have a significant impact on the dilution and biological processes that contributed to a compliant discharge, and will likely prevent the discharge of most or all of these waters without some form of treatment. In addition to the above-listed constituents, future discharges may be subject to monitoring for additional parameters such as the metals manganese and selenium, with discharge limits as low as 50 and 5 parts per billion (ppb) respectively.

For development of the conceptual treatment process for these waters, Golder proposes a two-stage process. The first stage consists of gross solids removal and primary treatment to remove contaminants listed in the current permit. A second stage treatment process would then follow, targeting specific metal constituents in anticipation of the future discharge limits.

The pond also functions as a sedimentation pond for plant wastewater. With the ash sluicing water uses terminated, the pond would need to be replaced with a wastewater treatment system of similar function, but at a new reduced flow rate of 1.3 MGD. Golder understands that the Bremo Power Station is in compliance with the existing limits listed above. The new proposed primary wastewater treatment system is designed to achieve continuous compliance with pH and TSS limits, and will provide incidental treatment for O&G, as well as TOC. Compliance is assumed for O&G, TOC, as well as Ammonia, so unit processes have not been included in the design for these parameters. If there is a history of non-compliance with these additional parameters additional unit processes may be required.

6.1 Flow Reduction and Elimination

Prior to design and construction of a wastewater treatment plant, Golder recommends evaluation of the wastewater flows to identify potential methods to reduce the volume of flow to a new WWTP. Given the high unit costs for treatment that may be required, significant savings in both capital construction costs and long-term Operations and Maintenance (O&M) costs can be realized by such an evaluation. An evaluation of the plant's water use and the processes that produce wastewater should be conducted. Emphasis should be placed on identifying wastewater flows that could be segregated out and undergo only primary treatment and not a more expensive secondary or tertiary treatment. Water reuse opportunities could also be a target of this evaluation to identify sources of water that could be used again within the station.

6.2 Primary Wastewater Treatment

The sequence of unit processes and equipment to provide the primary level of wastewater treatment for discharge in accordance with the existing permit will include the following:

1) Remote control system;
2) Pump stations at Metals Pond and stormwater pond;
3) Equalization Tank with a remote control storage and bleed system to provide less variation in flow to the treatment process;
4) pH adjust tanks, mixers, and controls (with sulfuric acid and sodium hydroxide reagent day tanks and bulk holding tanks);
5) Coagulant addition with rapid mix;
6) Polymer feed with flash mix, and slow mix agglomeration;
7) Lamella style clarifiers with sludge thickener tanks (assuming 500 mg/L TSS after pH adjustment, due to metals precipitation and solids in the source waters);
8) Concrete foundations and metal building.

6.3 Secondary Wastewater Treatment

Secondary wastewater treatment may become necessary following issuance of new effluent limitations guidelines for metals, including manganese and selenium. Removal of manganese and selenium to 50 and 5 ppb, respectively, will require the addition of two distinctly different treatment process trains. Treatment for manganese will require integration with the primary treatment process, as follows:

1) Oxidant feed system and reaction tank with 30 minutes hydraulic retention time;
2) Larger caustic feed system to raise pH to 10.5 for manganese removal;
3) Enlarge pH adjustment tank to provide 30 minutes retention time;
4) Substitute for or replace lamella clarifiers (depending on timing of the installation of primary and secondary treatment facilities) with conventional circular, solids contact clarifiers;
5) Add sludge thickening tankage (increase solids content to 5%) to reduce sludge volume going to sludge handling system;
6) Multi-media filters for polishing of particulate manganese removal; and
7) pH adjustment tank and sulfuric acid feed system to reduce pH into the 6 to 9 range (target will be 7.5 to 8.0).

Removal of selenium will occur downstream of the manganese removal filters because selenium is removed to meet the low limit of 5 ppb using an anaerobic process that would re-solubilize any residual manganese not removed from the clarifier effluent upstream. The selenium treatment process will include the following treatment processes:

1) Storage and feeding system for a carbon source, such as molasses;
2) Modular anaerobic bioreactors for biological reduction of selenium, which deposits in the bioreactors, with modular tanks sized for 0.2 MGD of the wastewater flow;
3) Reaeration tanks, with 2 hours of retention time; and
4) Auto-backwashing screen filters for sloughed solids removal prior to discharge.

6.4 Conceptual Budget and Schedule

The capital cost of the primary wastewater treatment system is dominated by the lamella clarifiers, with the following total conceptual capital costs estimated at:

Primary Wastewater Treatment System: **$11,000,000**

Secondary Wastewater Treatment System: **$11,000,000**

Secondary Treatment System for Selenium: **$28,000,000**

If the primary and secondary treatment systems are designed and constructed in sequence, an equipment savings of approximately $7,000,000 may be realized due to elimination of system redundancies. The implementation schedule for wastewater treatment will be controlled by long-lead times for some of the major equipment, such as the equalization tank, clarifiers and bioreactors, which would range from 7 to 10 months:

- Pre-engineering studies and Design – 7 months, plus 1 month overlap with Procurement
- Procurement of long-lead equipment – 10 months
- Construction (after delivery of long-lead equipment) – 5 months
- Startup and Commissioning – 2 months
- Total implementation time – **24 to 36 months**

This schedule would be shortened by about 3 months if on primary treatment is implemented.

6.4.1 Operations and Maintenance (O&M) Costs

The estimated annual O&M cost for the 1.3 MGD treatment system as described is **$1,040,000** per year. This cost includes:

- 0.75 Full Time Equivalent (FTE) operators/maintenance staff at $100,000 each;
- Electrical usage at $0.02 per kWh;
- Waste disposal for processed sludge;
- Chemical and other consumables; and,
- Maintenance.

6.5 Summary of Pond Closure Consequences

Closure of the E pond cannot commence until the WWTP is in operation. Conceptual costs associated with the construction of the WWTP as described are summarized in Table 4 below:

TABLE 4
WWTP COSTS

Activity	Duration	Conceptual Cost
WWTP Construction - Primary	36 months	$11,000,000
WWTP Construction – Secondary*		$11,000,000
Operations and Maintenance	Annual	$1,040,000
Total		$23,040,000

***** Capital cost for selenium treatment not included

In preparation for closure of the lower pond, Golder recommends starting of planning for a new WWTP at the Bremo Power Station. Potential activities that can be undertaken in advance of the effective date of the regulations include:

- Identify wastewater flows for reduction, reuse or those needing primary treatment only;
- Refine wastewater treatment processes, including bench-scale testing;
- Work with potential vendors and contractors to secure capacity for upcoming projects; and,
- Identify and reserve areas at the station where the facility could be built.

7.0 POST-CLOSURE CARE AND MONITORING

Following closure of a surface impoundment, Dominion will be required to provide post-closure care and monitoring of the impoundments that were closed in place for a period of 30 years. This 30-year period may be adjusted (up or down) depending on the nature of the impoundment and the continued protection of human health and the environment. The goal of the post-closure care program is to maintain the integrity of the surface impoundment closure systems (i.e. cover, leachate, groundwater, etc.) and provide monitoring of groundwater quality around the impoundment. Post-closure care activities are required for the option of closure in place. If a clean closure of the lower ash pond is pursued, this section will only apply to the upper pond.

7.1 Post-Closure Care Requirements

Requirements during the post-closure care period can be grouped into two major categories: systems integrity and monitoring. The final cover system constructed on the impoundment must be maintained to correct the effects of settlement, erosion, animal burrows, human activity, etc. The final cover drainage systems are of key importance, as failure of a stormwater system during a large storm event could damage large portions of the cover and allow contained materials to be exposed to the environment. Routine inspections and mowing of the vegetation will be required.

The seepage collection system will require periodic maintenance to ensure it continues to function and drain accumulated liquids from the ash body. Routine visual inspections of the leachate system and monitoring of the volume of flow will help spot potential problems before they develop into major issues. Treatment of the collected seepage is presumed to be at the station's on-site wastewater treatment facility, at a conceptual cost of $0.02 per gallon. The initial cost for treatment will be higher, but as less seepage is collected these costs are expected to decrease.

The groundwater monitoring network will require periodic inspection to ensure the wells are functional and in good repair. Damaged wells will need to be replaced and developed to continue the statistical background of the overall monitoring network. Monitoring of the groundwater network will be in accordance with the facility's approved groundwater monitoring plan. For this conceptual evaluation, Golder has assumed a semi-annual monitoring frequency and a standard baseline analytical program.

7.2 Conceptual Post-Closure Care Costs

Conceptual costs for the post-closure care period were evaluated using guidance from the Virginia DEQ relating to post-closure care of landfill facilities. Costs are shown in current-year (2010) dollars and are not escalated. If the West Pond is "clean closed", the indicated costs will not apply.

TABLE 4
CONCEPTUAL POST-CLOSURE CARE COST ESTIMATE (30-YEAR)

Pond	Begin Year	End Year	Annual Cost	Total Cost
West	2015	2035	$69,500	$1,185,000
North	2016	2036	$222,750	$6,682,500

8.0 OVERALL PROJECT CONCEPTUAL COST AND SCHEDULE

The conceptual project costs and schedules presented in this section are based on the following assumptions:

- Construction of an on-site wastewater treatment plant of approximately 1.3 MGD capacity;
- Closure of the north ash pond in-place;
- Clean closure of the west ash pond; and,
- Other regulatory-driven tasks (GW monitoring, posting of plans, etc.).

The sequencing of the projects is important, and mainly hinges on the functions provided by the west ash pond. Both the fuel conversion project and the WWTP need to be complete and in service prior to beginning closure of the west pond. Closure of both ponds will need to be completed within five years of the effective date of the regulations unless a waiver is granted for an extension. A conceptual overall project schedule has been developed for the Bremo station, and the estimated time required to complete all major projects described in this evaluation is approximately **4.25 years**, or approximately 8 months ahead of the anticipated regulatory required deadline.

TABLE 5
CONCEPTUAL PROJECT DURATIONS

Activity	Duration	End Date
WWTP Construction	38 months	1Q 2014
West Ash Pond Closure	9 months	3Q 2017 *
North Ash Pond Closure	27 months	2Q 2015
Total	52 months	

* Long expectation of duration of post-construction monitoring period

TABLE 6
COST-LOADED SCHEDULE

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
WWTP Construction *	$3,581,250	$10,059,056	$7,425,248	$898,446	$ -	**$21,964,000**
West Ash Pond Closure	$ -	$ -	$58,756	$4,031,799	$61,462	**$4,152,017**
North Ash Pond Closure	$ -	$ -	$10,126,049	$20,962,141	$3,040,310	**$34,128,500**
Other Regulatory Tasks	$128,225	$ -	$ -	$ -	$ -	**$128,225**
Additional O&M costs	$ -	$14,000	$14,000	$793,250	$1,053,000	**$1,053,000 (annually)**
Total	**$3,709,475**	**$10,073,056**	**$17,624,053**	**$26,685,636**	**$4,154,772**	**$61,425,742**

* Capital costs for selenium treatment not included
All values are anticipation of the proposed Subtitle D ruling

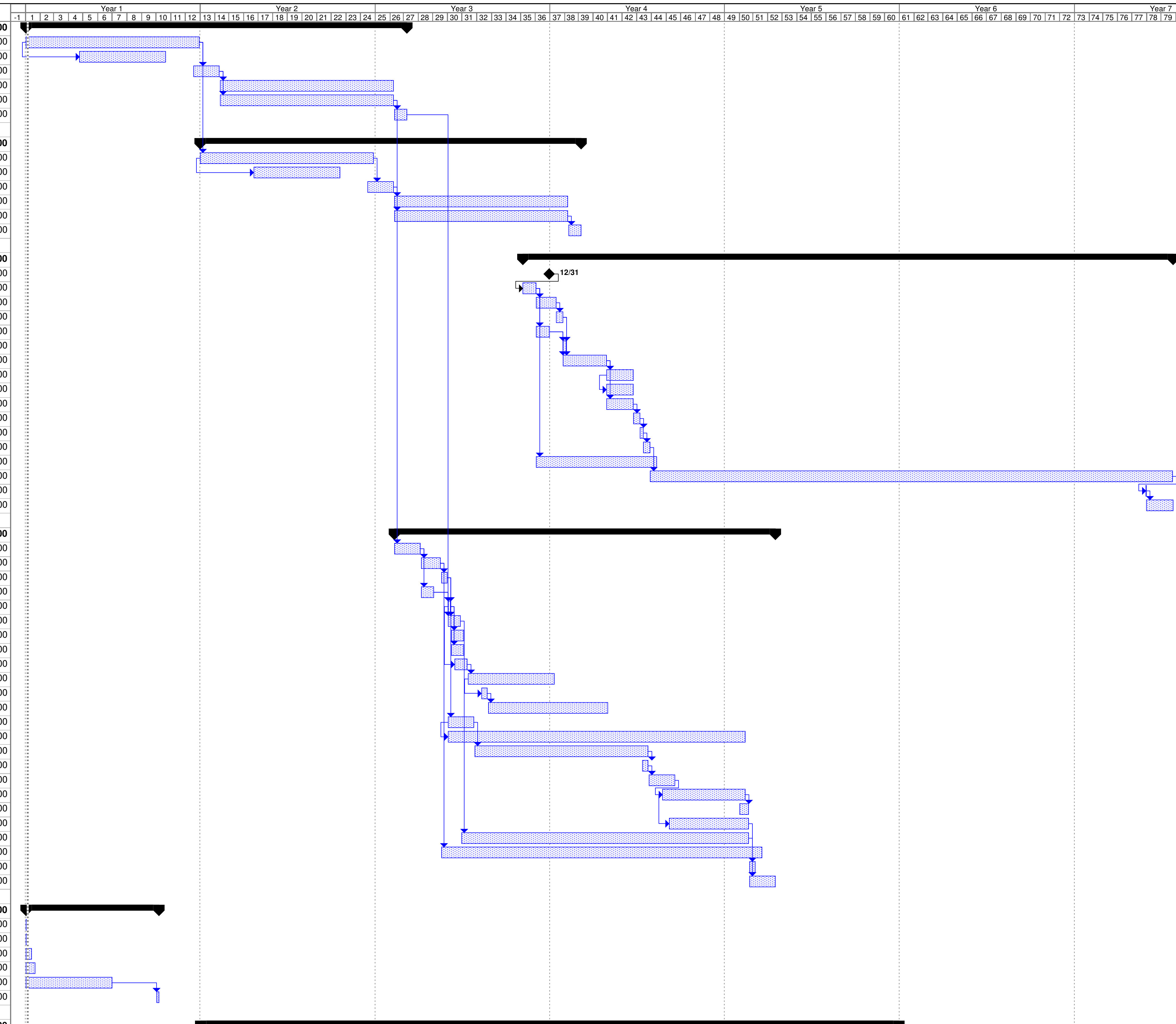
FINAL

APPENDIX A

Cost Loaded Schedules

BREMO POWER STATION
CONCEPTUAL POND CLOSURE SCHEDULE - WEST POND CLEAN CLOSURE

ID	Task Name	Duration	Start	Finish	Predecessors	Cost
1	**BR Waste Water Treatment Plant - primary**	**114 wks**	**1/3/11**	**3/8/13**		**$10,982,000.00**
2	Engineering & pilot testing	52 wks	1/3/11	12/30/11		$750,000.00
3	Procurement, long lead items	26 wks	4/25/11	10/21/11	2SS+16 wks	$2,800,000.00
4	DOM procurement, bid award	8 wks	12/19/11	2/10/12	2FS-2 wks	$125,000.00
5	Construction	52 wks	2/13/12	2/8/13	4	$7,000,000.00
6	Engineering Support during construction	52 wks	2/13/12	2/8/13	4	$182,000.00
7	Startup	4 wks	2/11/13	3/8/13	6	$125,000.00
8						
9	**BR Waste Water Treatment Plant-secondary**	**114 wks**	**1/2/12**	**3/7/14**		**$10,982,000.00**
10	Engineering & pilot testing	52 wks	1/2/12	12/28/12	2	$750,000.00
11	Procurement, long lead items	26 wks	4/23/12	10/19/12	10SS+16 wk	$2,800,000.00
12	DOM procurement, bid award	8 wks	12/17/12	2/8/13	10FS-2 wks	$125,000.00
13	Construction	52 wks	2/11/13	2/7/14	12	$7,000,000.00
14	Engineering Support during construction	52 wks	2/11/13	2/7/14	12	$182,000.00
15	Startup	4 wks	2/10/14	3/7/14	14	$125,000.00
16						
17	**BR West Ash Pond Clean Closure**	**194.2 wks**	**11/6/13**	**7/26/17**		**$4,152,017.00**
18	Fuel conversion project	0.2 wks	12/31/13	12/31/13		$0.00
19	Evaluation of groundwater characteristics	4 wks	11/6/13	12/3/13	18FS-8 wks	$30,000.00
20	DOM procurement, bid award	6 wks	12/4/13	1/14/14	19	$0.00
21	Mobilization, initial survey	2 wks	1/15/14	1/28/14	20	$250,000.00
22	E&S, stormwater permits	4 wks	12/4/13	12/31/13	19	$5,500.00
23	Initial erosion control	1 wk	1/29/14	2/4/14	21,22	$12,000.00
24	Dredge materials to North Pond	13 wks	1/29/14	4/29/14	21,22	$1,508,264.00
25	Excavate & haul pond bottom and sidewalls	8 wks	4/30/14	6/24/14	24	$1,642,453.00
26	Operate dewatering system + treatment	8 wks	4/30/14	6/24/14	25SS	$224,000.00
27	Sidewall sampling, analysis	8 wks	4/30/14	6/24/14	24	$16,500.00
28	Grading of remaining materials	2 wks	6/25/14	7/8/14	27	$100,000.00
29	Seeding	1 wk	7/9/14	7/15/14	28	$34,000.00
30	Install 10 monitoring wells	2 wks	7/16/14	7/29/14	29	$50,000.00
31	Construction Management	36 wks	12/4/13	8/12/14	19	$209,300.00
32	Groundwater monitoring	156 wks	7/30/14	7/25/17	30	$60,000.00
33	Closure Request	0.2 wks	5/31/17	5/31/17	32FS-8 wks	$10,000.00
34	DEQ Certification of closure	8 wks	6/1/17	7/26/17	33	$0.00
35						
36	**BR North Ash Pond Closure**	**114 wks**	**2/11/13**	**4/17/15**		**$34,128,500.00**
37	Engineering	8 wks	2/11/13	4/5/13	6	$171,000.00
38	DOM procurement, bid award	6 wks	4/8/13	5/17/13	37	$0.00
39	Mobilization, initial survey	2 wks	5/20/13	5/31/13	38	$75,000.00
40	E&S, stormwater permits	4 wks	4/8/13	5/3/13	37	$5,500.00
41	Initial erosion control	1 wk	6/3/13	6/7/13	39,40	$25,000.00
42	Initial dewatering	4 wks	6/3/13	6/28/13	7,40,39	$50,000.00
43	Geotechnical Drilling	4 wks	6/10/13	7/5/13	41	$60,000.00
44	Geotechnical monitoring	4 wks	6/10/13	7/5/13	41	$23,600.00
45	Lab testing	4 wks	6/17/13	7/12/13	41SS+2 wks	$24,000.00
46	Reporting, pilot testing	26 wks	7/15/13	1/10/14	45	$125,000.00
47	Slurry wall contractor mobilization	2 wks	8/12/13	8/23/13	46SS+4 wks	$150,000.00
48	Install slurry wall	36 wks	8/26/13	5/2/14	47	$6,035,000.00
49	Install surface dewatering system	8 wks	6/3/13	7/26/13	39	$3,993,600.00
50	Operate dewatering system + treatment	89 wks	6/3/13	2/13/15	49SS	$3,400,000.00
51	Install seepage collection system	52 wks	7/29/13	7/25/14	49	$1,296,000.00
52	Closure contractor mobilization	2 wks	7/14/14	7/25/14	51FS-2 wks	$250,000.00
53	Grading, material import	8 wks	7/28/14	9/19/14	52	$6,450,000.00
54	Cover Construction	25 wks	8/25/14	2/13/15	53FS-4 wks	$9,840,000.00
55	Drainage features	3 wks	2/2/15	2/20/15	54FS-2 wks	$0.00
56	Seeding	24 wks	9/8/14	2/20/15	54SS+2 wks	$192,000.00
57	Construction Quality Assurance (CQA)	86 wks	7/1/13	2/20/15	42	$964,600.00
58	Construction Management	96 wks	5/20/13	3/20/15	38	$980,000.00
59	Project close out	2 wks	2/23/15	3/6/15	56	$18,200.00
60	DEQ Certification of closure	8 wks	2/23/15	4/17/15	57	$0.00
61						
62	**Other Regulatory-Driven Tasks**	**40 wks**	**1/3/11**	**10/7/11**		**$128,225.00**
63	Prepare closure plan	1 wk	1/3/11	1/7/11		$5,500.00
64	Prepare post-closure care plan	1 wk	1/3/11	1/7/11		$5,500.00
65	Install west pond GW network	2 wks	1/3/11	1/14/11		$23,200.00
66	Install north pond GW network	3 wks	1/3/11	1/21/11		$49,025.00
67	Conduct GW sampling & testing 4rds	26 wks	1/3/11	7/1/11		$37,000.00
68	Conduct GW sampling & testing rd2	1 wk	10/3/11	10/7/11	67FS+13 wk	$8,000.00
69						
70	**Regulatory Deadlines**	**208.6 wks**	**1/3/12**	**12/31/15**		**$0.00**

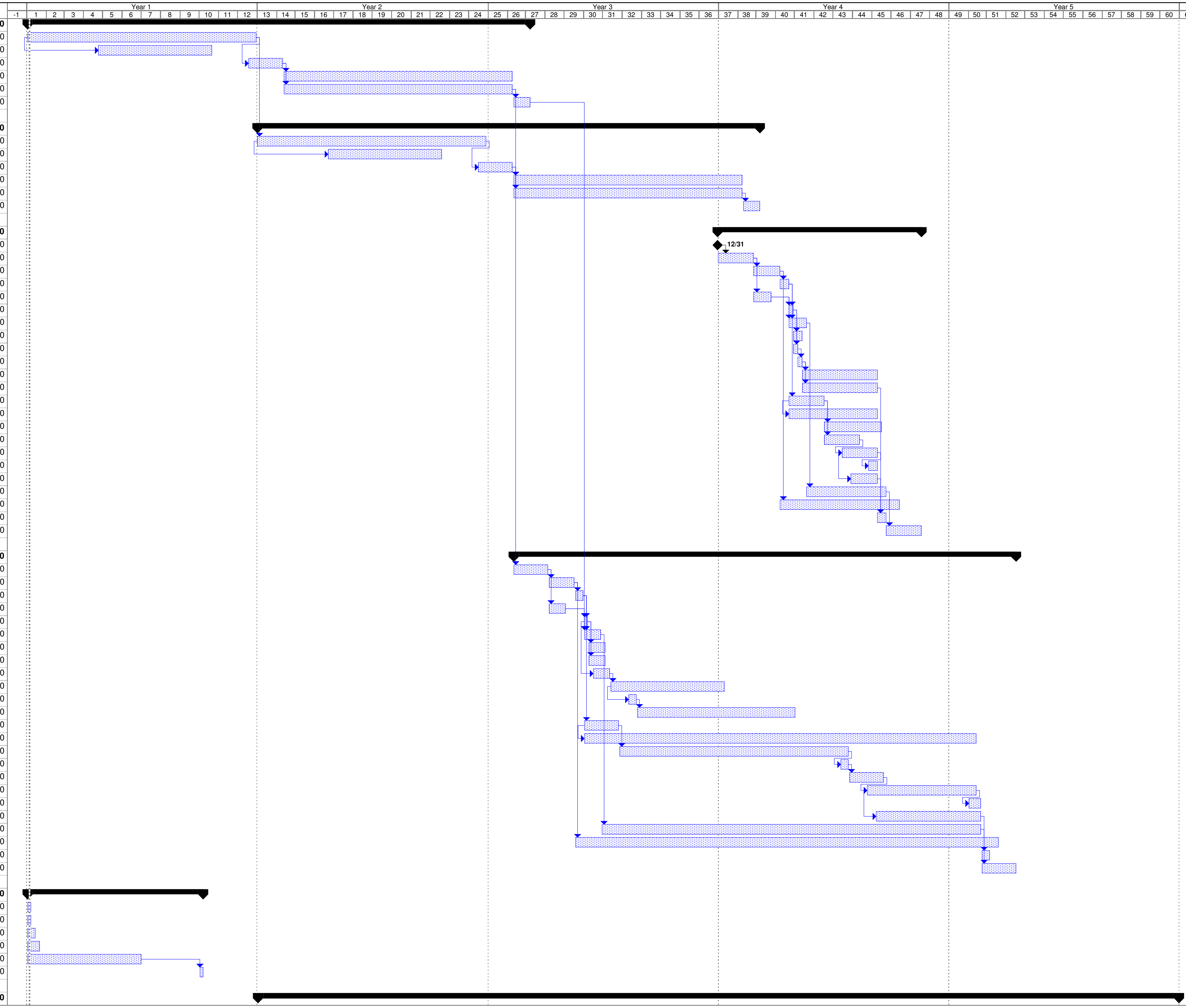


Project: BR Closure Schedule - Baseli
Date: 1/5/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

BREMO POWER STATION
CONCEPTUAL POND CLOSURE SCHEDULE - WEST POND CLOSE IN PLACE

ID	Task Name	Duration	Start	Finish	Predecessors	Cost
1	**BR Waste Water Treatment Plant - primary**	**114 wks**	**1/3/11**	**3/8/13**		**$10,982,000.00**
2	Engineering & pilot testing	52 wks	1/3/11	12/30/11		$750,000.00
3	Procurement, long lead items	26 wks	4/25/11	10/21/11	2SS+16 wks	$2,800,000.00
4	DOM procurement, bid award	8 wks	12/19/11	2/10/12	2FS-2 wks	$125,000.00
5	Construction	52 wks	2/13/12	2/8/13	4	$7,000,000.00
6	Engineering Support during construction	52 wks	2/13/12	2/8/13	4	$182,000.00
7	Startup	4 wks	2/11/13	3/8/13	6	$125,000.00
8						
9	**BR Waste Water Treatment Plant-secondary**	**114 wks**	**1/2/12**	**3/7/14**		**$10,982,000.00**
10	Engineering & pilot testing	52 wks	1/2/12	12/28/12	2	$750,000.00
11	Procurement, long lead items	26 wks	4/23/12	10/19/12	10SS+16 wks	$2,800,000.00
12	DOM procurement, bid award	8 wks	12/17/12	2/8/13	10FS-2 wks	$125,000.00
13	Construction	52 wks	2/11/13	2/7/14	12	$7,000,000.00
14	Engineering Support during construction	52 wks	2/11/13	2/7/14	12	$182,000.00
15	Startup	4 wks	2/10/14	3/7/14	14	$125,000.00
16						
17	**BR West Ash Pond Closure In-Place**	**46.2 wks**	**12/31/13**	**11/18/14**		**$7,935,100.00**
18	Fuel conversion project	0.2 wks	12/31/13	12/31/13		$0.00
19	Engineering	8 wks	1/1/14	2/25/14	18	$171,000.00
20	DOM procurement, bid award	6 wks	2/26/14	4/8/14	19	$0.00
21	Mobilization, initial survey	2 wks	4/9/14	4/22/14	20	$75,000.00
22	E&S, stormwater permits	4 wks	2/26/14	3/25/14	19	$5,500.00
23	Initial erosion control	1 wk	4/23/14	4/29/14	21,22	$12,000.00
24	Initial dewatering	4 wks	4/23/14	5/20/14	21,22	$10,000.00
25	Geotechnical Drilling	2 wks	4/30/14	5/13/14	23	$30,000.00
26	Geotechnical monitoring	1 wk	4/30/14	5/6/14	23	$11,800.00
27	Lab testing	1 wk	5/7/14	5/13/14	26	$11,000.00
28	Reporting, pilot testing	17 wks	5/14/14	9/9/14	27	$125,000.00
29	Install slurry wall	17 wks	5/14/14	9/9/14	27	$2,805,000.00
30	Install surface dewatering system	8 wks	4/23/14	6/17/14	21	$707,200.00
31	Operate dewatering system + treatment	20 wks	4/23/14	9/9/14	30SS	$280,000.00
32	Install seepage collection system	13 wks	6/18/14	9/16/14	30	$229,500.00
33	Grading, material import	8 wks	6/18/14	8/12/14	30	$1,142,500.00
34	Cover Construction	8 wks	7/16/14	9/9/14	33FS-4 wks	$1,742,500.00
35	Drainage features	2 wks	8/27/14	9/9/14	34FS-2 wks	$0.00
36	Seeding	6 wks	7/30/14	9/9/14	34SS+2 wks	$34,000.00
37	Construction Quality Assurance (CQA)	18 wks	5/21/14	9/23/14	24	$170,000.00
38	Construction Management	27 wks	4/9/14	10/14/14	20	$354,900.00
39	Project close out	2 wks	9/10/14	9/23/14	36,29	$18,200.00
40	DEQ Certification of closure	8 wks	9/24/14	11/18/14	37	$0.00
41						
42	**BR North Ash Pond Closure**	**114 wks**	**2/11/13**	**4/17/15**		**$34,128,500.00**
43	Engineering	8 wks	2/11/13	4/5/13	6	$171,000.00
44	DOM procurement, bid award	6 wks	4/8/13	5/17/13	43	$0.00
45	Mobilization, initial survey	2 wks	5/20/13	5/31/13	44	$75,000.00
46	E&S, stormwater permits	4 wks	4/8/13	5/3/13	43	$5,500.00
47	Initial erosion control	1 wk	6/3/13	6/7/13	45,46	$25,000.00
48	Initial dewatering	4 wks	6/3/13	6/28/13	7,46,45	$50,000.00
49	Geotechnical Drilling	4 wks	6/10/13	7/5/13	47	$60,000.00
50	Geotechnical monitoring	4 wks	6/10/13	7/5/13	47	$23,600.00
51	Lab testing	4 wks	6/17/13	7/12/13	47SS+2 wks	$24,000.00
52	Reporting, pilot testing	26 wks	7/15/13	1/10/14	51	$125,000.00
53	Slurry wall contractor mobilization	2 wks	8/12/13	8/23/13	52SS+4 wks	$150,000.00
54	Install slurry wall	36 wks	8/26/13	5/2/14	53	$6,035,000.00
55	Install surface dewatering system	8 wks	6/3/13	7/26/13	45	$3,993,600.00
56	Operate dewatering system + treatment	89 wks	6/3/13	2/13/15	55SS	$3,400,000.00
57	Install seepage collection system	52 wks	7/29/13	7/25/14	55	$1,296,000.00
58	Closure contractor mobilization	2 wks	7/14/14	7/25/14	57FS-2 wks	$250,000.00
59	Grading, material import	8 wks	7/28/14	9/19/14	58	$6,450,000.00
60	Cover Construction	25 wks	8/25/14	2/13/15	59FS-4 wks	$9,840,000.00
61	Drainage features	3 wks	2/2/15	2/20/15	60FS-2 wks	$0.00
62	Seeding	24 wks	9/8/14	2/20/15	60SS+2 wks	$192,000.00
63	Construction Quality Assurance (CQA)	86 wks	7/1/13	2/20/15	48	$964,600.00
64	Construction Management	96 wks	5/20/13	3/20/15	44	$980,000.00
65	Project close out	2 wks	2/23/15	3/6/15	62	$18,200.00
66	DEQ Certification of closure	8 wks	2/23/15	4/17/15	63	$0.00
67						
68	**Other Regulatory-Driven Tasks**	**40 wks**	**1/3/11**	**10/7/11**		**$128,225.00**
69	Prepare closure plan	1 wk	1/3/11	1/7/11		$5,500.00
70	Prepare post-closure care plan	1 wk	1/3/11	1/7/11		$5,500.00
71	Install west pond GW network	2 wks	1/3/11	1/14/11		$23,200.00
72	Install north pond GW network	3 wks	1/3/11	1/21/11		$49,025.00
73	Conduct GW sampling & testing 4rds	26 wks	1/3/11	7/1/11		$37,000.00
74	Conduct GW sampling & testing rd2	1 wk	10/3/11	10/7/11	73FS+13 wks	$8,000.00
75						
76	**Regulatory Deadlines**	**208.6 wks**	**1/3/12**	**12/31/15**		**$0.00**



Project: BR Closure - Alternate
Date: 1/5/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Bremo Power Station
Overall Cost-Loaded Schedule

January 2011

Alternate - Closure in Place of West Pond

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
BR Waste Water Treatment Plant	$ 3,581,250	$ 10,059,056	$ 7,425,248	$ 898,446	$ -	$ 21,964,000
BR West Ash Pond Closure in-place	$ -	$ -	$ -	$ 7,935,100	$ -	$ 7,935,100
BR North Ash Pond Closure	$ -	$ -	$ 10,126,050	$ 20,962,141	$ 3,040,309	$ 34,128,500
Other Regulatory-Driven Tasks	$ 128,225	$ -	$ -	$ -	$ -	$ 128,225
Totals	**$ 3,709,475**	**$ 10,059,056**	**$ 17,551,298**	**$ 29,795,687**	**$ 3,040,309**	**$ 64,155,825**

Baseline Project - Clean Closure of West Ash Pond

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
BR Waste Water Treatment Plant	$ 3,581,250	$ 10,059,056	$ 7,425,248	$ 898,446	$ -	$ 21,964,000
BR West Ash Pond Clean Closure	$ -	$ -	$ 58,756	$ 4,031,799	$ 61,462	$ 4,152,017
BR North Ash Pond Closure	$ -	$ -	$ 10,126,049	$ 20,962,141	$ 3,040,310	$ 34,128,500
Other Regulatory-Driven Tasks	$ 128,225	$ -	$ -	$ -	$ -	$ 128,225
Totals	**$ 3,709,475**	**$ 10,059,056**	**$ 17,610,053**	**$ 25,892,386**	**$ 3,101,772**	**$ 60,372,742**

						Annual Cost
BR O&M Costs	$ -	$ 14,000	$ 14,000	$ 793,250	$ 1,053,000	$ 1,053,000

Bremo Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	Year 1	Year 2	Year 3	Year 4	Year 5
BR Waste Water Treatment Plant						
Engineering & pilot testing	$ 750,000	$ 750,000				
Procurement, long lead items	$ 2,800,000	$ 2,800,000				
DOM procurement, bid award	$ 125,000	$ 31,250	$ 93,750			
Construction	$ 7,000,000		$ 6,219,231	$ 780,769		
Engineering Support during construction	$ 182,000		$ 161,700	$ 20,300		
Startup	$ 125,000			$ 125,000		
BR Waste Water Treatment Plant-secondary						
Engineering & pilot testing	$ 750,000		$ 750,000			
Procurement, long lead items	$ 2,800,000		$ 2,800,000			
DOM procurement, bid award	$ 125,000		$ 34,375	$ 90,625		
Construction	$ 7,000,000			$ 6,246,154	$ 753,846	
Engineering Support during construction	$ 182,000			$ 162,400	$ 19,600	
Startup	$ 125,000				$ 125,000	
WWTP Totals	**$ 21,964,000**	**$ 3,581,250**	**$ 10,059,056**	**$ 7,425,248**	**$ 898,446**	**$ -**

CLEAN CLOSURE OF WEST POND
BASELINE COST SCHEDULE

Bremo Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	Year 1	Year 2	Year 3	Year 4	Year 5
BR West Ash Pond Clean Closure						
Evaluation of groundwater characteristics	$ 30,000			$ 30,000		
DOM procurement, bid award	$ -					
Mobilization, initial survey	$ 250,000				$ 250,000	
E&S, stormwater permits	$ 5,500			$ 5,500		
Initial erosion control	$ 12,000				$ 12,000	
Dredge materials to North Pond	$ 1,508,264				$ 1,508,264	
Excavate & haul pond bottom and sidewalls	$ 1,642,453				$ 1,642,453	
Operate dewatering system + treatment	$ 224,000				$ 224,000	
Sidewall sampling, analysis	$ 16,500				$ 16,500	
Grading of remaining materials	$ 100,000				$ 100,000	
Seeding	$ 34,000				$ 34,000	
Install 10 monitoring wells	$ 50,000				50000	
Construction Management	$ 209,300			$ 23,256	$ 186,044	
Groundwater monitoring	$ 60,000				$ 8,538	$ 51,462
Closure Request	$ 10,000					$ 10,000
DEQ Certification of closure	$ -					
West Pond Clean Closure Totals	**$ 4,152,017**	**$ -**	**$ -**	**$ 58,756**	**$ 4,031,799**	**$ 61,462**

CLEAN CLOSURE OF WEST POND
BASELINE COST SCHEDULE

Bremo Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	Year 1	Year 2	Year 3	Year 4	Year 5
BR North Ash Pond Closure						
Engineering	$ 171,000			$ 171,000		
DOM procurement, bid award	$ -					
Mobilization, initial survey	$ 75,000			$ 75,000		
E&S, stormwater permits	$ 5,500			$ 5,500		
Initial erosion control	$ 25,000			$ 25,000		
Initial dewatering	$ 50,000			$ 50,000		
Geotechnical Drilling	$ 60,000			$ 60,000		
Geotechnical monitoring	$ 23,600			$ 23,600		
Lab testing	$ 24,000			$ 24,000		
Reporting, pilot testing	$ 125,000			$ 117,308	$ 7,692	
Slurry wall contractor mobilization	$ 150,000			$ 150,000		
Install slurry wall	$ 6,035,000			$ 3,084,556	$ 2,950,444	
Install surface dewatering system	$ 3,993,600			$ 3,993,600		
Operate dewatering system + treatment	$ 3,400,000			$ 1,161,348	$ 1,994,157	$ 244,495
Install seepage collection system	$ 1,296,000			$ 558,277	$ 737,723	
Closure contractor mobilization	$ 250,000				$ 250,000	
Grading, material import	$ 6,450,000				$ 6,450,000	
Cover Construction	$ 9,840,000				$ 7,320,960	$ 2,519,040
Drainage features	$ -					
Seeding	$ 192,000				$ 132,800	$ 59,200
Construction Quality Assurance (CQA)	$ 964,600			$ 296,110	$ 585,490	$ 83,000
Construction Management	$ 980,000			$ 330,750	$ 532,875	$ 116,375
Project close out	$ 18,200					$ 18,200
DEQ Certification of closure	$ -					
North Pond CIP Totals	**$ 34,128,500**	**$ -**	**$ -**	**$ 10,126,049**	**$ 20,962,141**	**$ 3,040,310**

Other Regulatory-Driven Tasks						
Prepare closure plan	$ 5,500	$ 5,500				
Prepare post-closure care plan	$ 5,500	$ 5,500				
Install west pond GW network	$ 23,200	$ 23,200				
Install north pond GW network	$ 49,025	$ 49,025				
Conduct GW sampling & testing 4rds	$ 37,000	$ 37,000				
Conduct GW sampling & testing rd2	$ 8,000	$ 8,000				
Regulatory Req Totals	**$ 128,225**	**$ 128,225**	**$ -**	**$ -**	**$ -**	**$ -**

Overall Totals	**$ 60,372,742**	**$ 3,709,475**	**$ 10,059,056**	**$ 17,610,053**	**$ 25,892,386**	**$ 3,101,772**

CLEAN CLOSURE OF WEST POND
BASELINE COST SCHEDULE

Bremo Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	Year 1	Year 2	Year 3	Year 4	Year 5
BR Waste Water Treatment Plant						
Engineering & pilot testing	$ 750,000	$ 750,000				
Procurement, long lead items	$ 2,800,000	$ 2,800,000				
DOM procurement, bid award	$ 125,000	$ 31,250	$ 93,750			
Construction	$ 7,000,000		$ 6,219,231	$ 780,769		
Engineering Support during construction	$ 182,000		$ 161,700	$ 20,300		
Startup	$ 125,000			$ 125,000		
BR Waste Water Treatment Plant-secondary						
Engineering & pilot testing	$ 750,000		$ 750,000			
Procurement, long lead items	$ 2,800,000		$ 2,800,000			
DOM procurement, bid award	$ 125,000		$ 34,375	$ 90,625		
Construction	$ 7,000,000			$ 6,246,154	$ 753,846	
Engineering Support during construction	$ 182,000			$ 162,400	$ 19,600	
Startup	$ 125,000				$ 125,000	
WWTP Totals	**$ 21,964,000**	**$ 3,581,250**	**$ 10,059,056**	**$ 7,425,248**	**$ 898,446**	**$ -**

WEST POND CLOSURE IN PLACE
ALTERNATE COST SCHEDULE

Bremo Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	Year 1	Year 2	Year 3	Year 4	Year 5
BR West Ash Pond Closure in-place						
Engineering	$ 171,000				$ 171,000	
DOM procurement, bid award	$ -					
Mobilization, initial survey	$ 75,000				$ 75,000	
E&S, stormwater permits	$ 5,500				$ 5,500	
Initial erosion control	$ 12,000				$ 12,000	
Initial dewatering	$ 10,000				$ 10,000	
Geotechnical Drilling	$ 30,000				$ 30,000	
Geotechnical monitoring	$ 11,800				$ 11,800	
Lab testing	$ 11,000				$ 11,000	
Reporting, pilot testing	$ 125,000				$ 125,000	
Install slurry wall	$ 2,805,000				$ 2,805,000	
Install surface dewatering system	$ 707,200				$ 707,200	
Operate dewatering system + treatment	$ 280,000				$ 280,000	
Install seepage collection system	$ 229,500				$ 229,500	
Grading, material import	$ 1,142,500				$ 1,142,500	
Cover Construction	$ 1,742,500				$ 1,742,500	
Drainage features	$ -					
Seeding	$ 34,000				$ 34,000	
Construction Quality Assurance (CQA)	$ 170,000				$ 170,000	
Construction Management	$ 354,900				$ 354,900	
Project close out	$ 18,200				$ 18,200	
DEQ Certification of closure	$ -					
West Pond CIP Totals	**$ 7,935,100**	**$ -**	**$ -**	**$ -**	**$ 7,935,100**	

WEST POND CLOSURE IN PLACE
ALTERNATE COST SCHEDULE

Bremo Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	Year 1	Year 2	Year 3	Year 4	Year 5
BR North Ash Pond Closure						
Engineering	$ 171,000			$ 171,000		
DOM procurement, bid award	$ -					
Mobilization, initial survey	$ 75,000			$ 75,000		
E&S, stormwater permits	$ 5,500			$ 5,500		
Initial erosion control	$ 25,000			$ 25,000		
Initial dewatering	$ 50,000			$ 50,000		
Geotechnical Drilling	$ 60,000			$ 60,000		
Geotechnical monitoring	$ 23,600			$ 23,600		
Lab testing	$ 24,000			$ 24,000		
Reporting, pilot testing	$ 125,000			$ 117,308	$ 7,692	
Slurry wall contractor mobilization	$ 150,000			$ 150,000		
Install slurry wall	$ 6,035,000			$ 3,084,556	$ 2,950,444	
Install surface dewatering system	$ 3,993,600			$ 3,993,600		
Operate dewatering system + treatment	$ 3,400,000			$ 1,161,349	$ 1,994,157	$ 244,494
Install seepage collection system	$ 1,296,000			$ 558,277	$ 737,723	
Closure contractor mobilization	$ 250,000				$ 250,000	
Grading, material import	$ 6,450,000				$ 6,450,000	
Cover Construction	$ 9,840,000				$ 7,320,960	$ 2,519,040
Drainage features	$ -					
Seeding	$ 192,000				$ 132,800	$ 59,200
Construction Quality Assurance (CQA)	$ 964,600			$ 296,110	$ 585,490	$ 83,000
Construction Management	$ 980,000			$ 330,750	$ 532,875	$ 116,375
Project close out	$ 18,200					$ 18,200
DEQ Certification of closure	$ -					
North Pond CIP Totals	**$ 34,128,500**	**$ -**	**$ -**	**$ 10,126,050**	**$ 20,962,141**	**$ 3,040,309**

WEST POND CLOSURE IN PLACE
ALTERNATE COST SCHEDULE

Bremo Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	Year 1	Year 2	Year 3	Year 4	Year 5
Other Regulatory-Driven Tasks						
Prepare closure plan	$ 5,500	$ 5,500				
Prepare post-closure care plan	$ 5,500	$ 5,500				
Install west pond GW network	$ 23,200	$ 23,200				
Install north pond GW network	$ 49,025	$ 49,025				
Conduct GW sampling & testing 4rds	$ 37,000	$ 37,000				
Conduct GW sampling & testing rd2	$ 8,000	$ 8,000				
Regulatory Req Totals	**$ 128,225**	**$ 128,225**	**$ -**	**$ -**	**$ -**	**$ -**

Overall Totals	**$ 64,155,825**	**$ 3,709,475**	**$ 10,059,056**	**$ 17,551,298**	**$ 29,795,687**	**$ 3,040,309**

WEST POND CLOSURE IN PLACE
ALTERNATE COST SCHEDULE

FINAL

APPENDIX B

Slurry Wall Barrier

FINAL

SLURRY WALL BARRIER

Assuming that the risks to groundwater are evaluated and that decisions are made to implement a closure with the impounded CCR left in place, then it may be anticipated that a low permeability barrier such as a soil bentonite slurry wall may be required around the entire perimeter of the pond. The consideration for a slurry wall can be made after an evaluation of the initial rounds of groundwater testing to determine the nature and extent of possible contaminant migration. The function of the slurry wall is to minimize the risk of offsite migration of leachate from the impounded CCR materials. Soil bentonite slurry walls have been used by EPA on CERCLA (Superfund) site remediation projects for many years. Technical guidance is provided in the report by EPA entitled "*Slurry Trench Construction for Pollution Migration Control, EPA-540/2-84-001"* (Feb. 1984*)*.

There are various civil engineering construction methods available for installation of slurry walls. The means and methods selected are dependent on the project specific ground conditions, performance requirements for the wall (permeability and strength criteria), depth to a low permeability zone into which the wall is keyed, the wall thickness, and the particular preferences of the specialty geotechnical contractor selected.

Typical installation of a soil bentonite slurry wall in the southeastern USA is by a long reach tracked hydraulic excavator, with maximum wall depths in the 70 to 90 feet range and widths typically in the 2 to 3 feet range. The long reach equipment is deployed to excavate a deep trench into the ground to a design depth that provides for an adequate cutoff into a low permeability stratum in the foundation. Bentonite slurry ('mud') is used to support the trench during the excavation. Bentonite is also mixed with the excavated soils, and sometimes other additives such as Portland cement. These materials are blended together as backfill that is pushed into the trench from one end using a dozer.

Where deeper slurry walls are required, or where conditions are such that a more effective 'milling' of the ground is needed, excavation of the wall can be performed using clam shell buckets suspended from crawler cranes, or various forms of hydraulic grab. Soil cutter mixing (CSM) and auger mixing rigs can also be deployed to mix bentonite and cement with the *in-situ* material.

As part of the design of the wall, a treatability study is required involving indicator tests to 'screen' various commercially available bentonite products for their chemical compatibility with the site specific ground and groundwater conditions, and the site specific CCR leachate. Following this step, a mix design is undertaken that involves various laboratory tests on different batches of soil-cement-bentonite blends to evaluate and optimize the mix to achieve project specific performance criteria. It would not be unreasonable to plan on this slurry wall design and treatability testing phase taking between 6 and 12 months for large, complex and environmentally sensitive projects, and perhaps 3 to 6 months for smaller straightforward projects. Costs for the treatability studies vary widely depending on site specific conditions and performance criteria, and may be in the approximate range of $30,000 to $125,000 per project.

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Whichever form of slurry wall construction is selected, there are significant mobilization, set-up and demobilization costs involved with deployment of the large excavating equipment, dozers, batching plant, material silos, mud hydration tanks, mixers, agitators, and screw pumps. For planning purposes, these associated costs may range between about $100,000 to $250,000 depending on means and methods of construction.

For the conceptual costs for installation, a conventional soil bentonite slurry wall that is assumed to be 50 feet deep by 2 feet wide, surrounding the entire perimeter of the pond is presumed. Subsurface exploration borings along the wall alignment, at perhaps 150 feet intervals, could be required to determine the final design depth. Geotechnical data for this site is not currently available; therefore conceptual cost for a geotechnical investigation specifically for the wall has been included. A unit rate of $17 per vertical square foot of wall has been used in estimating the costs, but it is worth noting that unit rates may range between about $10/SF to $25/SF depending on the specific wall requirements, ground conditions and means and methods of construction. Production rates vary widely depending on these same variables and could be in the range of 25 to 50 linear ft per day per piece of excavating equipment. For a 7,100 foot long, by 50 foot deep slurry wall around the perimeter of the lower ash pond, a conceptual cost estimate of **$7,250,000** and project duration of **16 to 18 months** has been established. Conceptual cost details and cost-loaded schedules are included in Appendix A

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APPENDIX C

Acronyms Used

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AMSL	Above Mean Sea Level
CCR	Coal Combustion Residues
CY	Cubic Yard
E&S	Erosion and Sediment
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
g	gravitational constant
GPM	Gallons Per Minute
HDPE	High Density Polyethylene
MGD	Million Gallons per Day
MHA	Maximum Horizontal Acceleration
mil	one-thousandth of one inch (0.001")
MSW	Municipal Solid Waste
NPDES	National Pollution Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
TOC	Total Organic Carbon
TSS	Total Suspended Solids
VPDES	Virginia Pollution Discharge Elimination System
VSMP	Virginia Stormwater Management Program
VSWMR	Virginia Solid Waste Management Regulations
WET	Whole Effluent Toxicity

FINAL REPORT

FINAL

WET ASH IMPOUNDMENT EVALUATION

POSSUM POINT POWER STATION

Submitted to:

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Golder Associates

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January, 2011

1039-6867

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1.0 EXECUTIVE SUMMARY

Golder Associates Inc. (Golder) is assisting Dominion with the evaluation of the impacts to station operations from the EPA's proposed regulations regarding disposal of coal combustion residuals (CCR) from electric utilities as published in the Federal Register on June 21, 2010. Consideration was given only to the Co-Proposal under authority of Subtitle D of the Resource Conservation and Recovery Act (RCRA) as it represents a baseline cost and schedule basis for either of the co-proposals presented by the EPA.

This evaluation identifies two major systems at the Possum Point station that will be directly or indirectly impacted by the regulations, and all are tied to the regulation effectively eliminating wet ash impoundments as a means of CCR disposal. Closure of the E ash pond at Bremo will force a system change by requiring the construction of an approximate 2 million gallon per day (MGD) wastewater treatment plant (WWTP). Both the D and E ponds are slated for closure due to a previous fuel conversion project which eliminated the need for the ponds other than for stormwater and dilution uses.

The year 2010, non-escalated conceptual project costs and schedules presented in this report are based on the following scenario:

- Closure of the D and E ash ponds in-place;
- Closure of the D pond will take place without schedule impacts from the nearby eagle nest;
- Construction of an on-site wastewater treatment plant of approximately 2 MGD capacity;
- Other regulatory-driven tasks (GW monitoring, posting of plans, etc.); and,
- Operations and Maintenance (O&M) costs associated with operating the WWTP.

POSSUM POINT POWER STATION
CONCEPTUAL COST-LOADED SCHEDULE

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
WWTP Construction *	$6,781,250	$13,925,402	$8,178,133	$979,215	$ -	**$29,864,000**
D Pond Closure	$12,500,852	$28,512,869	$2,710,979	$ -	$ -	**$43,724,700**
E Pond Closure	$ -	$ -	$9,789,566	$5,226,854	$ -	**$15,016,420**
Other Regulatory Tasks	$52,000	$ -	$ -	$ -	$ -	**$52,000**
Additional O&M costs	$ -	$12,000	$12,000	$558,000	$1,104,000	**$1,104,000 (annually)**
Total	**$19,334,102**	**$42,450,271**	**$20,690,678**	**$6,674,069**	**$1,104,000**	**$90,343,120**

* Capital costs for selenium treatment not included
All values are anticipation of the proposed Subtitle D rulings

A conceptual overall project schedule has been developed for the Possum Point station, and the estimated time required to complete all three major projects is approximately **3.5 years**, or approximately 18 months ahead of the anticipated regulatory required deadline.

PROJECT No.	103-96868	
FILE No.	10396868A07	
REV. 0	SCALE AS SHOWN	
DESIGN	DPM	09/22/10
CADD	OSY	09/22/10
CHECK		
REVIEW		

TITLE

AERIAL OF ASH PONDS AND POWER STATION

PROJECT

DOMINION
POSSUM POINT POWER STATION
DUMFRIES, VA

Golder Associates
Richmond, Virginia

FIGURE 1

2.0 DESCRIPTION OF THE STATION

The Possum Point Power Station is located near Dumfries, Virginia, on the confluence of Quantico Creek and the Potomac River. The station converted its coal-fired units to natural gas and oil units in 2003. Due to the conversion from coal, the ash ponds are no longer used for disposal of coal ash. The ponds now are used primarily for stormwater and neutralization of waste water streams from the station. Figure 1 shows the station aerial view and the proposed location of the waste water treatment plant (WWTP).

2.1 Ash Ponds

The station continues to operate two ash ponds near the station, called ponds D and E. The D pond was constructed in approximately 1988 and the E pond was constructed in approximately 1991. Table 1 shows the capacities of each pond.

TABLE 1
POSSUM POINT ASH POND CAPACITIES

Pond	Size (acres)	Capacity (CY) Total / Remaining	Percent full (as of date)
D	120	10,325,333 / 7,725,333	25% (1/1/09)
E	32	968,000 / 242,000	75% (1/1/09)

2.2 Waste Streams

2.2.1 Bottom and Fly Ash

Ash is no longer deposited into either pond; however there are significant quantities of ash from operations prior to 2003 remaining in the ponds.

2.2.2 Other Plant Waters

The E pond receives stormwater and mixed "other" wastewaters from the station. These "other" waters consist primarily of discharge from the oily waste basin, Ash Pond D outfall, and the effluent from metals cleaning pond, for an approximate annual average of 2 million gallons per day (MGD). Both E and D ponds also receive stormwater flows from their respective drainage areas. Sanitary wastewater (from lavatories and sinks in the station) is collected separately and sent to the Prince William County Municipal treatment system for treatment and disposal.

3.0 DECISION TREE

During the early work sessions for this evaluation, the project team developed a method of analysis that would be used to systematically evaluate the options available at each station with regards to ash impoundments (Figure 2). The first level of evaluation is to determine if there are impoundments that could be considered for early closure using an anticipated effective date of the EPA regulations of December 31, 2011. The evaluation considered if an impoundment could be fully closed in advance of the effective date, and thereby not be subject to the proposed regulations. The D pond was considered for early closure, and this evaluation is presented in Section 4.

The second level of evaluation is to look at each impoundment with regards to the siting requirements proposed in Section 257.64 of the proposed regulations. Due to the fuel conversion project, continued use of the ponds was not considered. Both the D and E ash ponds were evaluated for closure only.

The evaluations carried out in this report are based on the EPA's proposed regulations as published in the Federal Register on June 21, 2010. Consideration was given only to the Co-Proposal under authority of Subtitle D of the Resource Conservation and Recovery Act (RCRA), as it represents a baseline cost and schedule requirement for the proposed regulations.

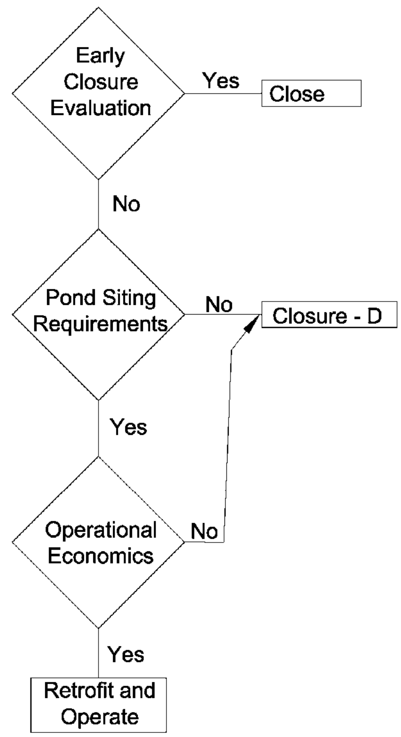


Figure 2 – Decision Tree

4.0 EARLY CLOSURE EVALUATION

4.1 Pond Description

The "D" ash pond at the Possum Point Power Station is no longer actively used for ash disposal; however, the pond continues to receive stormwater for passive treatment prior to release. The D pond is the larger of the two ash ponds, and is approximately 120 acres in area. The D pond was formed by the construction of an earthen embankment approximately 1,600 feet long and 140 feet high, which formed a reservoir across an existing valley. Currently, the pond is estimated to be ¼ full of ash, approximately 2,580,000 CY. Overall capacity of the pond at the top of the berm is 10.3 million CY. Of particular concern at the D pond is the presence of an active bald eagle nest in the vicinity of the pond embankment. Activities at the pond within 660 feet of the nest are restricted to specific time windows throughout the year.

4.2 Possible Pond Closure Scenario

The evaluated scenario for closure of the D pond follows a fairly typical pond closure approach of dewatering, stabilization, and cover construction. Free water in the pond would be drained, and the earthen embankment would likely be reduced in height to prevent future water accumulation. The amount of reduction of the earthen embankment would be dependent on the volume of solid materials in the pond at the time of closure. A visual inspection from recent aerial photos (spring 2010) indicates the embankment could be substantially reduced in height.

Subsequent to removal of the free water in the pond, closure efforts would focus on dewatering and stabilizing the remaining ash and sediments. Dewatering methods could be employed, with the goal of removing the pore water contained within the remaining materials to achieve primary consolidation and provide a stable surface to construct the closure cover. Dewatering ash is typically a slow process, due to the small particle size of the ash materials that prevents rapid movement of water through the material. Most likely a permanent dewatering system would be installed to provide both the primary water removal and to collect residual drainage over longer periods.

Sufficient stabilization of the in-place materials may require an active approach. Active stabilization measures such as addition of lime or cement materials would be chosen based on the material composition, volume of material to be stabilized, and depth and/or degree of stabilization required. The material would need to be stabilized sufficiently to support the weight of the closure cap and the equipment needed for construction. After stabilization of the solids, the area would be graded to promote positive stormwater drainage and accommodate settlement resulting from consolidation.

The closure cap for the D pond would likely be constructed with a combination of geomembrane and soil materials, providing an adequate barrier that minimizes water infiltration and exposure of the ash materials to the environment. Typical cap construction would consist of a layer of geomembrane (40 mil) and a two-foot soil cover. The top six inches of the cap would consist of a vegetative support soil layer that would be permanently seeded to prevent erosion. Construction of the entire 120-acre cap system would take at least 6 to 9 months to complete, and could not begin until the residual solids in the pond were adequately stabilized.

4.3 Closure Scenario Challenges

Due to the presence of the active bald eagle nest near the pond, construction activities are restricted to the time between July 16th and December 14th of each year. In this five-month period, all activities noted above (draining, dewatering, stabilization and cap construction) would have to be completed. It would be impractical to consider that these activities could be completed within the allotted time goal.

4.4 Recommendations

Golder recommends against planning on the early closure of the Possum Point D pond due to the schedule limitations imposed by the bald eagle nest. Complete closure of this pond would likely take a year or more to complete.

5.0 GROUNDWATER MONITORING SYSTEMS

From a review of the 2005 Annual Report, Figure 2 - Monitoring Well Location map, it appears that the facility has approximately 16 existing groundwater monitoring wells located around Ash Ponds D and E. Three of wells are possible upgradient monitoring wells constructed within the same stratum and nine downgradient groundwater monitoring wells constructed within the same stratum that currently monitor Ash Ponds D and E. Additionally, there are six groundwater monitoring wells presented in Figure 2 that appear to monitor different strata then the previously mentioned nine downgradient monitoring wells. Due to the proximity to Potomac River, it is assumed that the estimated depth to groundwater ranges from ten to fifteen feet throughout the groundwater monitoring network. Based on general topography of the area, the groundwater flow direction is assumed to be to the south. A review of the groundwater flow data will be required to determine if the network meets the requirements in the proposed regulations.

Dominion will need to maintain and upload design, installation, development, and decommission activities for any monitoring wells, piezometers, and other measurement, sampling, and analytical device documentation in the operating record and on a publicly accessible internet site. (§257.91(d)1) It is assumed that Dominion will be able to develop an internet site to incorporate the above mentioned documentation. Well installation certification by registered professional engineer or hydrologist must be posted in operating record and on publicly accessible internet site within 14 days of certification (§257.91(e)2). It is assumed that a certification report will be incorporated by Dominion into the operating record and on to the internet site for the facility

It is not known if the Possum Point Station has a Groundwater Monitoring Plan consistent with §257.93 of the proposed regulations. The approximate cost for developing a Groundwater Monitoring Plan "from scratch" is $4,000 and can be completed within 30-45 days, assuming that no additional changes are required to the Groundwater Monitoring Network (additional well installation). Modifications to an existing Groundwater Monitoring Plan, if present, can be achieved within 30-45 days for approximately $2,000.

An initial sampling program to establish the statistical background will need to be completed. At a minimum, four independent background samples collected at minimum 30-days apart, are required from each upgradient well within the first semi-annual groundwater monitoring period. The cost to develop the facility background data, assuming two upgradient wells are constructed, would be approximately ($500/well x 4 events, plus running stats) $26,000. An additional cost of $3,000 would be associated with the completion of a Statistical Background Report. The timeframe for developing background would be approximately 180 days.

The overall cost to document, and monitor the groundwater networks for the D and E ponds for the first year is conceptually presented as **$35,000**. Future monitoring costs are presented as **$12,000** annually.

6.0 ASH POND CLOSURE

Under the closure requirements of the proposed regulations (§257.100), the owner of a surface impoundment must begin closure activities no later than 30 days after the date which the impoundment receives the last known final receipt of CCR, or no later than one year after the last known receipt of CCR if the impoundment has remaining capacity and could reasonably expect to receive additional CCR. Once closure activities begin, the regulations also state that closure activities must be complete within 180 days following the beginning of closure.

Due to the inherent wet nature of CCR in ponds and the large size of these ponds, the 180-day requirement appears to be unreasonable and potentially impossible to meet. Golder's conceptual construction estimates, as discussed further in sections 6.1 and 6.2, range from 18 to 29 months for completion. Handling of water before and during construction consumes a significant portion of time for these projects. Once sufficiently dewatered, construction of the closure cap section is anticipated to take at least 6 months due to the large acreages and volumes of soil involved. Golder's recent experience with construction of similar closure cap systems on dry landfills has shown to have taken from 6 to 8 months to complete, depending on size.

6.1 Ash Pond E

Under the proposed EPA rules for disposal of CCR, 'Corrective Actions' will be imposed on station owners and operators of surface impoundments in the event that offsite impacts to groundwater and surface water occur. To evaluate the risks to groundwater and surface water that may arise from closure of the impoundments either with the CCR left in place, or through clean closure, it will be important during the design phase to undertake a thorough geologic and hydrogeologic investigation of the pond. This will be necessary to understand the depth to groundwater and its seasonal variation, the hydraulic gradients beneath and beyond the immediate vicinity of the pond, and the different groundwater flow regimes operating. The head differences between the impounded CCR and the groundwater, and the degree of hydraulic connection between the pond and the groundwater will also need to be evaluated. A description of each closure method follows; however the selection of closure method cannot be definitively recommended at the current time. Golder recommends an evaluation of closure methods after the initial rounds of groundwater monitoring have been completed in order to better understand the direction and magnitude of possible off-site impacts.

Ash pond E, due its relatively small size, can be considered either for a clean closure or for closure in place. In either case, the closure of the E pond cannot be started until after the completion of the WWTP commissioning. Should clean closure be chosen, there appears to be adequate capacity in the D pond to receive the excavated CCR and excess soils resulting from a clean closure. The final end state of the clean closure of the E pond would be a relatively flat area available for future station projects. Clean closure is discussed in section 6.1.1. Closure in place of the E pond would follow the same process described for the D pond, and this is described in section 6.1.2. Separate costs and schedules have been developed for each alternative.

6.1.1 E Pond Clean Closure Option

A clean closure, as presented in §257.100, involves the removal of CCR material from the surface impoundment and removal and/or decontamination of "all areas affected" by releases from the CCR impoundment to meet the state-specific numeric cleanup levels for constituents found in CCRs. The proposed list of constituents found in CCRs or that may be affected by a release of CCRs to the environment is presented in Appendices III and IV to §257 (proposed regulations).

Based on Golder's experience with similarly written regulations for Resource Conservation and Recovery Act (RCRA) corrective action sites, Golder interprets "affected areas" to include both soil and groundwater containing concentrations of constituents found in CCR above the following numerical cleanup levels or documented background (i.e., upgradient and/or naturally occurring) concentrations, whichever is higher:

Groundwater: Virginia Solid Waste Management Regulations Groundwater Protection Standards (based on background concentrations, EPA Maximum Contaminant Levels, or Virginia Department of Environmental Protection Alternate Concentration Limits); Groundwater Protection Standards have not been established by the DEQ for the full list of proposed groundwater monitoring constituents for CCR surface impoundments, but are expected to be established upon implementation of the proposed regulations.

Soils: Environmental Protection Agency Regional Screening Levels (RSLs) for industrial / commercial soils or background concentrations are expected to be appropriate numeric cleanup levels for "affected" soils. The use of industrial / commercial RSLs is a risk-based approach, and would need to be coupled with institutional controls mandating continued industrial / commercial land use. Furthermore, if groundwater is affected by a constituent above the Groundwater Protection Standard, removal of affected soils to the RSL for soil-to-groundwater leaching would be appropriate, as practicable, to further protect groundwater quality.

Concept-level tasks, costs, and durations for clean closure of the E ash pond based on existing information are provided as follows:

1. <u>Removal of CCR materials and soils located above the elevation of the water table:</u> Golder understands that CCR materials are likely present to the base grade of the impoundment and affected soils are likely present to the depth of the pre-impoundment water table, at a minimum, over the entire footprint of the E ash pond.

The average depth of the pre-impoundment water table is estimated to be approximately sea level. Based on Golder's experience with other remedial actions for soil under RCRA, the removal of CCR materials and soils above the water table constitutes clean closure for affected soils.

Golder understands that the D ash pond has sufficient available volume for the placement of excavated materials from the E ash pond. Sampling of side-walls within the excavation will be required to confirm lateral remediation to the soil clean-up standards.

a. Cost: **$11,230,000**

b. Duration: **18 Months**

2. Groundwater monitoring: Potentially affected groundwater in the region of the E ash pond will be monitored using the existing groundwater monitoring network. In addition to this network, it is anticipated that groundwater monitoring at up to five locations within the former footprint of the E ash pond will be required to demonstrate clean closure with respect to groundwater. Using this monitoring network, Golder anticipates that up to three years of semi-annual monitoring for the proposed list of constituents presented in Appendices III and IV of the proposed regulations (§257) will be required to demonstrate that groundwater has not been affected by CCR constituents. Semi-annual evaluations of groundwater monitoring results and reporting will be required. If applicable, a report requesting state approval of the clean closure activities and termination of groundwater monitoring will be required at the end of the anticipated three-year monitoring period.

a. Cost: **$95,000**

b. Duration: **36 Months**

The tasks and costs presented represent minimum efforts required for clean closure of the E ash pond. An evaluation of existing groundwater data for analytes presented in Appendices III and IV of the proposed regulation, as compared to current or anticipated Groundwater Protection Standards and site-specific background concentrations, may provide an up-front determination of the feasibility of clean closure of groundwater without corrective actions triggered by potential exceedances of cleanup levels. Potential groundwater remediation for CCR constituents and associated corrective action monitoring, if required, is expected to be a long-term effort, diminishing the potential benefit of a clean closure effort relative to in-place closure of CCR.

6.1.2 D and E Ponds - Closure With Wastes in Place

With a material such as CCR, closure in place involves a significant effort to dewater and stabilize the waste mass so that it will be stable and support the final closure cover. *In-situ* solidification of the entire ash body is considered impractical and unfeasible; however, targeted solidification measures may be considered to enhance the overall stability of the ash body. A thorough pre-design evaluation is recommended during initial closure planning to identify potential stabilization needs for the north pond. The general sequence of events for closure with the wastes in place is as follows:

- Removal of free liquids;
- Stabilization of the ash body surface;
- Installation of seepage collection system(s);
- Installation of slurry wall containment (if needed – discussed in Appendix B);
- Grading and shaping of ash surface for drainage;
- Lowering of the embankment height; and,
- Installation of the final cover system.

Pumping of the free liquid from the pond is feasible with normal self priming diesel powered centrifugal pump sets. Given the volumes of free water involved, it is anticipated that trailer or skid mounted pumps would be required for this application, in the 8 to 12-inch size range. The water pumped from the pond may require treatment prior to release to meet VPDES permit conditions and an allowance of $0.02 per gallon for treatment has been made in the conceptual cost estimate. Pumping the initial free liquid from the pond is estimated to take approximately 3 to 5 weeks to complete.

6.1.2.1 Stabilization of the Waste Surface

Following removal of free liquids, the ash body will require dewatering to the extent needed to provide a firm, safe and trafficable surface on which equipment can be deployed for the construction of the closure cap system. To achieve a stable surface, it is anticipated that the water table within the impounded CCR would need to be lowered by about 5 feet below the surface. If the ash properties are particularly favorable (e.g. high angles of shearing resistance, pozzolanic effects, or better drainage if bottom ash layers are present), then this level may be less.

<u>Working platforms with low ground pressure equipment</u>

If the water table in the impoundment is sufficiently low then it may be possible to progress with cap construction without significant dewatering. This would require pushing out common fill into the impoundment along several working platforms. Each platform might be 12 feet in width initially, and perhaps 3 to 5 feet in thickness. This material would be pushed out using low ground pressure (LGP) equipment, typically D6 dozers. A plan arrangement of these platforms may take the form of a ‘spider web’ pattern, radiating out from equipment turnaround pads at select locations. In this way, access to the entire impoundment surface could be progressed, with final cover system construction commencing from the working platforms.

Typical production rates for a D6 LGP dozer working in this manner are low, perhaps as low as 1,500 cubic yards per day. Even so, at this kind of production rate, the equipment is likely to quickly 'out-push' the available dry and stable areas, so multiple rim ditch and sump arrangements may be needed (see below). Large volumes of imported common fill may be required, at a conceptual cost of $5/CY (placed) to establish the working surface upon which to construct the lined cover system.

Rim ditches and sump pumping

With relatively new ash deposits or those under constant submergence, the need for dewatering is inevitable while working in conjunction with spreading out working platforms with LGP equipment. Dewatering may be achieved by excavating trenches (also known as rim ditches) that would drain seepage waters to strategically located sumps. The sumps would probably be lined with a perforated standpipe, wrapped in geotextile, and with a free draining aggregate collar surround. Centrifugal pumps in the 6-inch to 8 inch size range would be required to continuously pump from the sumps. Depth, width and spacing of the rim ditches and sumps would depend greatly on the properties of the site specific CCR. If the ash surface has significant free liquids and unstable areas that it are not trafficable, then crawler cranes working from the impoundment crest roads using clam shell buckets could be deployed to establish an initial drawdown area around the perimeter of the pond. From here, work would then progress from the outside perimeter towards the center of the pond using LGP equipment.

Surface stabilization with additives

Another expedient that may be used to enhance the bearing capacity of the wet unstable ash surface is to scarify in dry ash or lime. This approach is likely to be more effective than spreading wet material into windrows and waiting for it to dry because that is highly weather dependent and typically proceeds slowly. If it is not possible to scarify in material with a tractor pulled disc or harrow, then an alternate means is to use multiple ripper attachments on an LGP dozer to track in the additive. As stability improves, heavier larger equipment can be deployed (e.g. D7 or larger dozers) to increase productivity.

Dewatering systems

There are also a variety of alternate positive dewatering methods available to lower the water table within the impounded CCRs to facilitate cap construction, and these include vacuum well points, deep wells and horizontal drains connected to vacuum pumps. Fly ash has been successfully dewatered using well point systems. Powers *et al*. (2006) summarized the case history documented by the Pennsylvania Electric Company (1985) in a report for EPRI that that was performed by Moretrench Corporation. Jetted-in wellpoints were used to dewater a fly ash lagoon sufficiently such that front end loaders could operate on the ash. This involved a water surface drawdown within the ash in the order of 3 to 5 feet. Powers *et al*. (2006) stated that:

"*Loose saturated material in the lagoon of Fig. 19.41 was too sloppy to be hauled in trucks before treatment. One could walk on the material only by means of plywood. After treatment with the vacuum well point grid, the ash was firm enough to be excavated on a near vertical slope…*"

Well points are typically spaced at about 5 to 10 feet on centers, each connected into a header system which is joined to a vacuum pump system. On the Pennsylvania Electric Company lagoon, rows of well points were deployed spaced in the order of 80 feet apart across the surface, with individual well points spaced approximately 5 to 10 feet on centers along each row. The rows of well points were connected to a perimeter header system with vacuum pumping arrangements and achieved a drawdown of about 3 to 5 feet within one month of operation. For a typical 50 hp well point system, unit costs for installation may be estimated at about $100 per linear foot of header, with running costs at about $6,000 per week. For deep ash deposits requiring excavation ('clean closure") then it can be expected that multiple levels of well points may be required. An alternate to this multiple stage well point system for deep ash deposits would be to install deep wells or ejectors.

Conceptual cost estimates for the surface stabilization can vary widely, based on the geotechnical analysis of the ash body, age, water content, and choice of stabilization method. For the purposes of this evaluation, installation of a well point system at 100-foot line spacing was considered. In the case of the D pond, approximately 50,000 linear feet of header would be installed. The system would need to be operated from the time of installation through construction of the final closure system in order to maintain stability during construction activities. Water recovered from the system would likely require treatment prior to release. A conceptual cost of **$5,000,000** has been established to install the system, and a conceptual operating cost of **$12,160,000** for the duration of construction (approximately **19 months**). Water treatment costs were estimated at $0.02 per gallon. The schedule for installation of the dewatering system is highly dependent on the ash condition and methods employed by the contractor. A base duration of **8 weeks** has been established for conceptual scheduling, knowing that once an area has begun to stabilize, other work can progress while the dewatering installation continues elsewhere.

6.1.2.2 Installation of Seepage Collection

If, following subsurface exploration and hydrogeologic evaluation of the pond site, it is determined that conditions are favorable for a closure in place, a significant engineering challenge remains in controlling seepage of the leachate from the ash body over the long term post-closure care period. No matter how effective the construction dewatering is during the cap construction period (be it by rim ditching and sump pumping, or wellpoints), it is unlikely to remove significant volumes of water from the body of the ash. Some form of seepage collection system is therefore recommended and likely to be required by the regulatory agency within the overall closure design.

The elements of a seepage collection system for capture of leachate from within the body of the CCR impoundment over the 30 year post-closure care period would be subject to subsurface exploration, design

and analysis. At this stage it is only possible to discuss the type of design components in very general terms, because much will depend on the following factors:

- Permeability characteristics of the CCR which will be different depending on the mix of fly ash, bottom ash, slimes, and boiler slag;
- Effective porosity (specific yield) of the CCR that governs how much interconnected pore space there is for water to drain out under gravity;
- Degree of layering (anisotropy) of the CCR that is governed by the pond specific history of hydraulic filling;
- Impoundment geometry (berm heights, perimeter lengths, slope gradients, plan area, distance to water treatment plant;
- Hydrogeologic conditions in the foundation; and
- Surface water drainage conditions at the toe of the impoundments.

A seepage collection system might include geosynthetic panel drains that comprise sheets of geocomposite drainage net with integral collection pipes at the bottom edge. Panel drains provide a means by which to lower the water table within the impoundment, enhancing slope stability and helping to mitigate the risk of seepage 'break-outs' on the side slopes or toe of the final cover.

Panel drains are placed vertically in trenches excavated into the CCR body from temporary benches by hydraulic excavators or possibly trenching machines. The excavated trenches might be up to 15 feet deep by two feet wide. Slotted flexible pipes can be sewn into the bottom of panel drains, forming a 'sheet drain' to capture liquid from the drainage nets. Flows are then conveyed to collector drains and so called 'down-drains' that would be located at intervals around the impoundment. This kind of arrangement would also require cleanout risers at various locations for maintenance (e.g. hydro-blasting to clear blockages) and inspection purposes (e.g. video camera surveys). Down-drains typically connect into a perimeter toe drain system around the toe or lowest point of the impoundment. Flows from the perimeter drain are routed to a permanent sump pump station, and then to a waste water treatment plant prior to discharge.

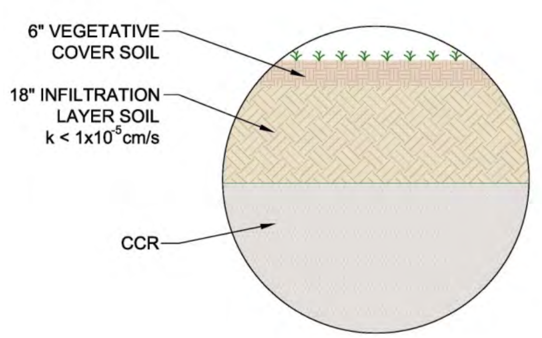
A significant issue arising from installation that needs careful consideration during the design phase is constructability. Loose, wet fly ash typically does not stand unsupported in excavations. The material readily takes in water, but does not release it easily. When disturbed during excavations and under the equipment loads, it turns into a relatively loose, flowable slurry. Unsafe cave-in conditions and equipment stability need to be addressed in a proactive and preemptive manner during design and construction. Dewatering by vacuum assisted well point pumping adjacent to excavations to facilitate drain installation is likely to be required and may be a significant extra cost to be factor into the planning for long term seepage control.

Estimating the schedule duration for installation of a seepage collection is possible only on a conceptual basis with the very limited information currently available. Based on engineering judgment, it is suggested that a period of between 12 and 18 months may be required for construction of a seepage collection systems for closure of ponds in the 100-acre size range. At this strategic planning stage, a conceptual cost estimate for a seepage collection system was developed based upon unit rates from an impoundment closure project in 2005 in the southeastern USA, escalated to 2010 prices using ENR Construction Cost indices. For conceptual planning, unit costs of $13,500 per acre, or alternatively $85 per linear foot of drainage installed are suggested. For the D pond, a conceptual cost for the installation of a seepage collection system based on 120 acres is **$1,620,000** and would take approximately **one year** to install. This conceptual cost does not include the previously-discussed costs that are likely to be required for well point dewatering in the CCR body to facilitate installation of drains.

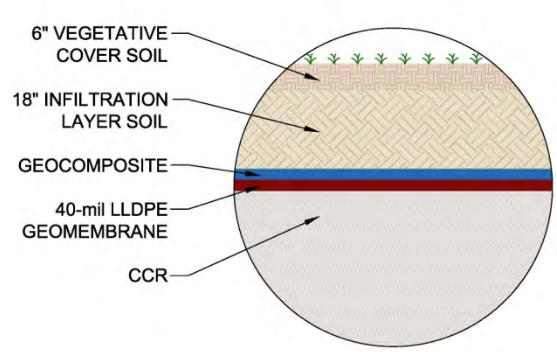
6.1.2.3 Closure Cap Construction

Once the CCRs are stabilized and prior to placement of the final cap, the surface of the CCR will be shaped to promote positive drainage and prevent infiltration of precipitation. Additional fill material will be needed to adjust the top of the pond from a relatively flat surface to one containing slopes of 2% or more for drainage. The initial as-constructed slope may be steeper than 2% depending on the amount of settling that is anticipated. The goal is have a post-settlement slope of at least 2%. For both ponds, an estimate of 5,000 CY/acre was used for material import.

The final cap system is required to have a permeability (k) of $1x10^{-5}$ cm/s or be less than the bottom liner system, whichever is less permeable. Since both ponds are unlined, a soil-only cover system consisting of 6-inches of vegetative support soil and 18-inches of soil (k < $1x10^{-5}$ cm/s) would meet the minimum requirements. The final cover could also be constructed with geosynthetic components to decrease the permeability of the system, or if sufficient quantities of suitable soil are not available. However; the cover system would still likely require 24 inches of soil cover to protect the geosynthetic materials. Regulatory approval of an exposed geomembrane cover in Virginia is uncertain. Stormwater run-on and run-off controls will be designed to adequately convey the 25-year, 24-hour storm at a minimum. Two typical closure cap sections are shown below.



Soil Only Cap



Geomembrane Cap

Golder strongly recommends the cap section containing the geosynthetic materials, as they provide permeability up to 5 orders of magnitude less than the soil-only systems. A significant decrease in infiltration and consequently an increase in groundwater protection can be had for a relatively small increase in cost. For the dewatering and closure cap construction sequence for the D pond outlined above, Golder estimates concept-level costs of **$43,725,000** with engineering and construction duration of approximately **29 months**. For the E pond, closure-in-place costs are conceptually estimated at $**15,016,000** with a duration of **16 months**. These conceptual costs do not include construction of the slurry wall for the D pond, but slurry wall cost is included for the E pond. Construction of the slurry wall is described in Appendix B.

6.1.2.4 Wildlife Concerns

A bald eagle nest exists on the eastern side of the D pond, and has been used yearly by a nesting pair of eagles. Consequently, no disturbances are allowed within 200 meters (660 feet) of the nest area between December 15 and July 15 (7 months each year). A permit may be sought to allow for removal of the nest and measures to keep the eagles away, but approval is not certain. Golder has prepared two schedules and conceptual cost tables to account for having to work around the eagle nesting period.

The impact of having to work around the nesting period is a significant schedule impact and a cost impact as well. Working around the nesting period adds approximately **21 months** to the project schedule and an estimated project baseline increase of at least **$211,000.** The majority of identified costs involve the conceptual contractor demobilization and remobilization costs (estimated at $50,000 per event). Other costs associated with the nesting period are difficult to ascertain, but would include such activities as: repairing existing work in progress due to erosion, extending permits, and preparing the site for a work stoppage. Due to the schedule extension and added costs, Golder strongly recommends seeking relief from the eagle disturbance requirements to facilitate an unimpeded work schedule.

6.2 Summary and Recommendations for Ash Pond Closure

In the preceding sections, two closure options were presented: clean closure of the E pond and closure in place of the D and/or E pond. Golder's recommendation is to close both the D and E ponds **in-place**, as well as seek relief from the eagle disturbance requirements. Although the in-place closure of the E pond is higher, this is due to the inclusion of the slurry wall cost. The slurry wall for Pond E may or may not be needed. A summary of the conceptual costs are presented, along with the conceptual durations.

TABLE 2A
ASH POND E - CLEAN CLOSURE

Task	Duration (months)	Conceptual Cost
Closure Construction	18	$11,230,000
Attenuation monitoring	36	$95,000
Total	**42***	**$11,325,000**

TABLE 2B
ASH POND E – CLOSURE IN PLACE

Task	Duration (months)	Conceptual Cost
Engineering	2	$171,000
Closure Construction	14	$14,845,000
Total	**16**	**$15,016,000**

TABLE 3
ASH POND D - CLOSURE IN PLACE

Task	Baseline – No Eagle		Eagle - impact schedule	
	Duration (months)	Conceptual Cost	Duration (months)	Conceptual Cost
Engineering	2	$171,000	2	$171,000
Closure Construction	27	$43,554,000	48	$43,765,000
Total	**29**	**$43,725,000**	**50**	**$43,936,000**

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7.0 CONSEQUENCES OF POND CLOSURE

The fuel conversion project eliminated the need for the ash ponds at Possum Point; however they are still used for passive treatment of stormwater and other plant waste streams. Closure of the D and E ash ponds would trigger the need for a wastewater treatment plant to treat "other plant waters" that would no longer go to the E ash pond.

The E ash pond serves as the receiving body for the oily waste basin and metals cleaning basin discharges from the station, as well as the outflow from ash pond D. The outfall for the E pond (outfall 005) discharges into Quantico Creek under the station's Virginia Pollution Discharge Elimination System (VPDES) permit. This permit includes monitoring of outfall 005 for the following parameters:

- pH
- Total Suspended Solids (TSS)
- Oil and Grease
- Ammonia
- Total Nitrogen
- Nitrate
- Total Phosphorus
- Temperature
- Whole Effluent Toxicity (WET – TUa and TUc)

Historically, the volume of water and settling time provided by the E pond has provided sufficient water quality at the outfall to consistently meet the permit limits. Closure of the pond will have a significant impact on the dilution and biological processes that contributed to a compliant discharge, and will likely prevent the discharge of most or all of these waters without some form of treatment. In addition to the above-listed constituents, future discharges may be subject to monitoring for additional parameters such as the metals manganese and selenium, with discharge limits as low as 50 and 5 parts per billion (ppb) respectively.

For development of the conceptual treatment process for these waters, Golder proposes a two-stage process. The first stage consists of gross solids removal and primary treatment to remove contaminants listed in the current permit. A second stage treatment process would then follow, targeting specific metal constituents in anticipation of the future discharge limits.

Golder understands that the station is in compliance with the existing limits listed above. The new proposed primary wastewater treatment system is designed to achieve continuous compliance with pH and TSS limits, and will provide incidental treatment for O&G, as well as TOC. Compliance is assumed for O&G, TOC, as well as Ammonia, so unit processes have not been included in the design for these parameters. If there is a history of non-compliance with these additional parameters, then additional unit processes may be required.

7.1 Flow Reduction and Elimination

Prior to design and construction of a wastewater treatment plant, Golder recommends evaluation of the wastewater flows to identify potential methods to reduce the volume of flow to a new WWTP. Given the high unit costs for treatment that may be required, significant savings in both capital construction costs and long-term Operations and Maintenance (O&M) costs can be realized by such an evaluation. An evaluation of the plant's water use and the processes that produce wastewater should be conducted. Emphasis should be placed on identifying wastewater flows that could be segregated out and undergo only primary treatment and not a more expensive secondary or tertiary treatment. Water reuse opportunities could also be a target of this evaluation to identify sources of water that could be used again within the station.

7.2 Primary Wastewater Treatment

The sequence of unit processes and equipment to provide the primary level of wastewater treatment for discharge in accordance with the existing permit will include the following:

1) Remote control system;
2) Pump stations at Metals Pond and stormwater pond;
3) Equalization Tank with a remote control storage and bleed system to provide less variation in flow to the treatment process;
4) pH adjust tanks, mixers, and controls (with sulfuric acid and sodium hydroxide reagent day tanks and bulk holding tanks);
5) Coagulant addition with rapid mix;
6) Polymer feed with flash mix, and slow mix agglomeration;
7) Lamella style clarifiers with sludge thickener tanks (assuming 500 mg/L TSS after pH adjustment, due to metals precipitation and solids in the source waters);
8) Concrete foundations and metal building.

7.3 Secondary Wastewater Treatment

Secondary wastewater treatment may become necessary following issuance of new effluent limitations guidelines for metals, including manganese and selenium. Removal of manganese and selenium to 50 and 5 ppb, respectively, will require the addition of two distinctly different treatment process trains. Treatment for manganese will require integration with the primary treatment process, as follows:

1) Oxidant feed system and reaction tank with 30 minutes hydraulic retention time;
2) Larger caustic feed system to raise pH to 10.5 for manganese removal;
3) Enlarge pH adjustment tank to provide 30 minutes retention time;
4) Substitute for or replace lamella clarifiers (depending on timing of the installation of primary and secondary treatment facilities) with conventional circular, solids contact clarifiers;
5) Add sludge thickening tankage (increase solids content to 5%) to reduce sludge volume going to sludge handling system;
6) Multi-media filters for polishing of particulate manganese removal; and
7) pH adjustment tank and sulfuric acid feed system to reduce pH into the 6 to 9 range (target will be 7.5 to 8.0).

Removal of selenium will occur downstream of the manganese removal filters because selenium is removed to meet the low limit of 5 ppb using an anaerobic process that would re-solubilize any residual manganese not removed from the clarifier effluent upstream. The selenium treatment process will include the following treatment processes:

1) Storage and feeding system for a carbon source, such as molasses;
2) Modular anaerobic bioreactors for biological reduction of selenium, which deposits in the bioreactors, with modular tanks sized for 0.2 MGD of the wastewater flow;
3) Reaeration tanks, with 2 hours of retention time; and
4) Auto-backwashing screen filters for sloughed solids removal prior to discharge.

7.4 Conceptual Budget and Schedule

The capital cost of the primary wastewater treatment system is dominated by the lamella clarifiers, with the following total conceptual capital costs estimated at:

Primary Wastewater Treatment System: **$15,000,000**

Secondary Wastewater Treatment System: **$15,000,000**

Secondary Treatment System for Selenium: **$38,000,000**

If the primary and secondary treatment systems are designed and constructed in sequence, an equipment savings of approximately $10,000,000 may be realized due to elimination of system redundancies. The implementation schedule for wastewater treatment will be controlled by long-lead times for some of the major equipment, such as the equalization tank, clarifiers and bioreactors, which would range from 7 to 10 months:

- Pre-engineering studies and Design – 7 months, plus 1 month overlap with Procurement
- Procurement of long-lead equipment – 10 months
- Construction (after delivery of long-lead equipment) – 5 months
- Startup and Commissioning – 2 months
- Total implementation time – **30 to 40 months**

This schedule would be shortened by about 3 months if on primary treatment is implemented.

7.4.1 Operations and Maintenance (O&M) Costs

The estimated annual O&M cost for the 2 MGD treatment system as described is **$1,092,000** per year. This cost includes:

- 0.75 Full Time Equivalent (FTE) operators/maintenance staff at $100,000 each;
- Electrical usage at $0.02 per kWh;
- Waste disposal for processed sludge;
- Chemical and other supply consumption; and,
- Maintenance.

7.5 Summary of Pond Closure Consequences

Closure of the E pond cannot commence until the WWTP is in operation. Conceptual costs associated with the construction of the WWTP as described are summarized in Table 4 below:

TABLE 4
WWTP COSTS

Activity	Duration	Conceptual Cost
WWTP Construction - Primary	38 months	$15,000,000
WWTP Construction – Secondary*		$15,000,000
Operations and Maintenance	Annual	$1,092,000
Total		$31,092,000

***** Capital cost for selenium treatment not included

In preparation for closure of the lower pond, Golder recommends starting of planning for a new WWTP at the Possum Point Power Station. Potential activities that can be undertaken in advance of the effective date of the regulations include:

- Identify wastewater flows for reduction, reuse or those needing primary treatment only;
- Refine wastewater treatment processes, including bench-scale testing;
- Work with potential vendors and contractors to secure capacity for upcoming projects; and,
- Identify and reserve areas at the station where the facility could be built.

8.0 POST-CLOSURE CARE AND MONITORING

Following closure of a surface impoundment, Dominion will be required to provide post-closure care and monitoring of the impoundments that were closed in place for a period of 30 years. This 30-year period may be adjusted (up or down) depending on the nature of the impoundment and the continued protection of human health and the environment. The goal of the post-closure care program is to maintain the integrity of the surface impoundment closure systems (i.e. cover, leachate, groundwater, etc.) and provide monitoring of groundwater quality around the impoundment. Post-closure care activities are required for the option of closure in place. If a clean closure of the E ash pond is pursued, this section will only apply to the D pond.

8.1 Post-Closure Care Requirements

Requirements during the post-closure care period can be grouped into two major categories: systems integrity and monitoring. The final cover system constructed on the impoundment must be maintained to correct the effects of settlement, erosion, animal burrows, human activity, etc. The final cover drainage systems are of key importance, as failure of a stormwater system during a large storm event could damage large portions of the cover and allow contained materials to be exposed to the environment. Routine inspections and mowing of the vegetation will be required.

The seepage collection system will require periodic maintenance to ensure it continues to function and drain accumulated liquids from the ash body. Routine visual inspections of the leachate system and monitoring of the volume of flow will help spot potential problems before they develop into major issues. Treatment of the collected seepage is presumed to be at the station's on-site wastewater treatment facility, at a conceptual cost of $0.02 per gallon. The initial cost for treatment will be higher, but as less seepage is collected these costs are expected to decrease.

The groundwater monitoring network will require periodic inspection to ensure the wells are functional and in good repair. Damaged wells will need to be replaced and developed to continue the statistical background of the overall monitoring network. Monitoring of the groundwater network will be in accordance with the facility's approved groundwater monitoring plan. For this conceptual evaluation, Golder has assumed a semi-annual monitoring frequency and a standard baseline analytical program.

8.2 Conceptual Post-Closure Care Costs

Conceptual costs for the post-closure care period were evaluated using guidance from the Virginia DEQ relating to post-closure care of landfill facilities. Costs are shown in current-year (2010) dollars and are not escalated.

TABLE 4

CONCEPTUAL POST-CLOSURE CARE COST ESTIMATE (30-YEAR)

Pond	Begin Year	End Year	Annual Cost	Total Cost
D	2015	2035	$265,800	$7,974,000
E	2014	2034	$103,600	$3,108,000

9.0 OVERALL PROJECT CONCEPTUAL COST AND SCHEDULE

The conceptual project costs and schedules presented in this section are based on the following assumptions:

- Construction of an on-site wastewater treatment plant of approximately 2 MGD capacity;
- Closure of the D and E ash ponds in-place;
- Successful relief from eagle disturbance for the D Pond;
- Other regulatory-driven tasks (GW monitoring, posting of plans, etc.); and,
- Operations and Maintenance (O&M) costs associated with operating the WWTP.

The sequencing of the projects is important, and mainly hinges on the functions provided by the E ash pond. The wastewater treatment plant needs to be completed and be in service prior to closure of the E pond can begin. Closure of both ponds will need to be completed within five years of the effective date of the regulations unless a waiver is granted for an extension. A conceptual overall project schedule has been developed for the Bremo station, and the estimated time required to complete all major projects described in this evaluation is approximately **3.5 years**, or approximately 18 months ahead of the anticipated regulatory required deadline.

TABLE 5
CONCEPTUAL PROJECT DURATIONS

Activity	Duration	End Date
WWTP Construction	38 months	1Q 2014
D Ash Pond Closure	31 months	1Q 2013
E Ash Pond Closure	16 months	2Q 2014
Total	42 months	

TABLE 6
COST-LOADED SCHEDULE

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
WWTP Construction *****	$6,781,250	$13,925,402	$8,178,133	$979,215	$ -	**$29,864,000**
D Pond Closure	$12,500,852	$28,512,869	$2,710,979	$ -	$ -	**$43,724,700**
E Pond Closure	$ -	$ -	$9,789,566	$5,226,854	$ -	**$15,016,420**
Other Regulatory Tasks	$52,000	$ -	$ -	$ -	$ -	**$52,000**
Additional O&M costs	$ -	$12,000	$12,000	$558,000	$1,104,000	**$1,104,000 (annually)**
Total	**$19,334,102**	**$42,450,271**	**$20,690,678**	**$6,674,069**	**$1,104,000**	**$90,343,120**

* Capital costs for selenium treatment not included
All values are anticipation of the proposed Subtitle D ruling

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FINAL

APPENDIX A

Cost Loaded Schedules

POSSUM POINT POWER STATION
CONCEPTUAL POND CLOSURE SCHEDULE - NO EAGLE IMPACTS

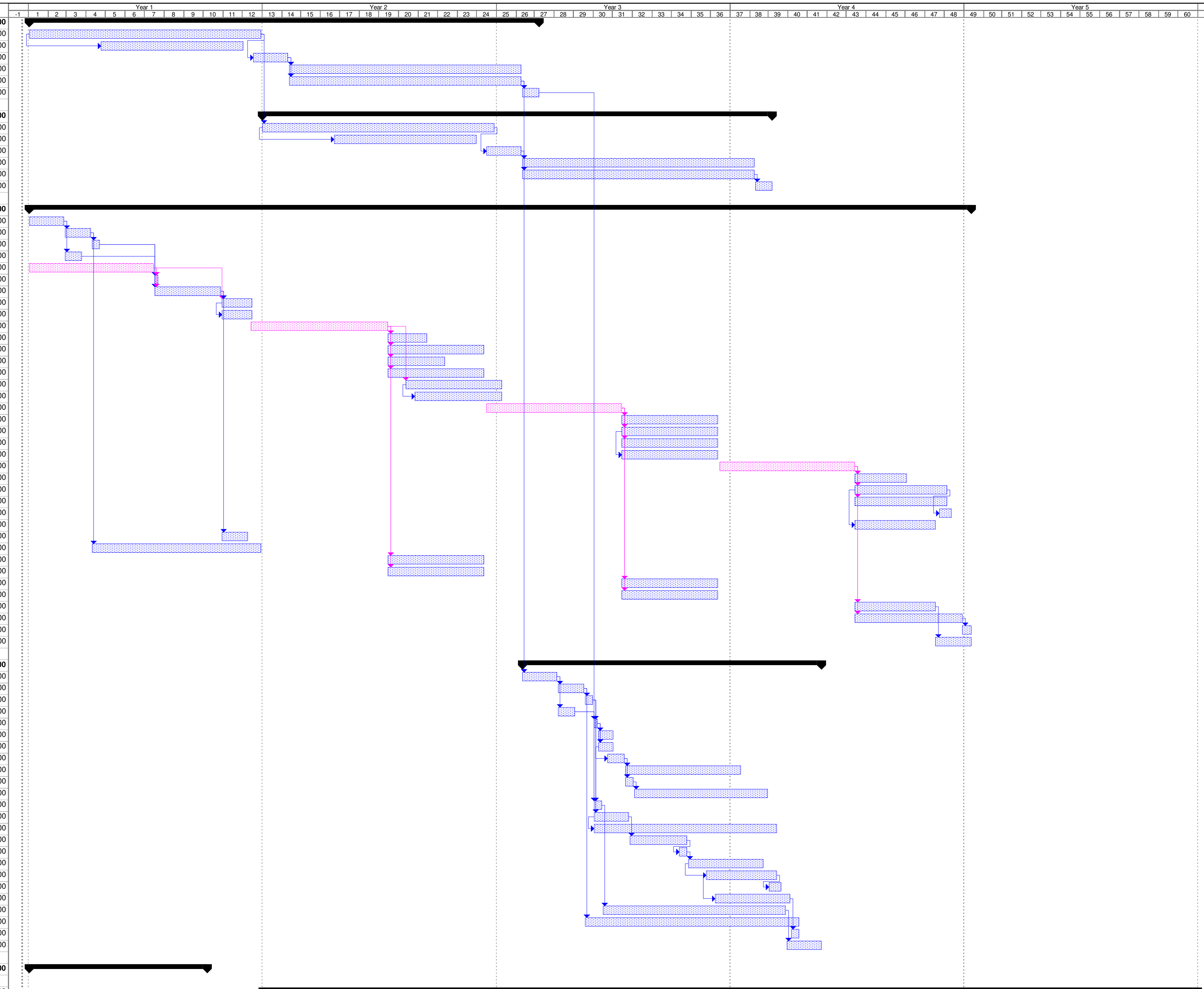
ID	Task Name	Duration	Start	Finish	Predecessors	Cost
1	**PP Waste Water Treatment Plant-primary**	**114 wks**	**1/3/11**	**3/8/13**		**$14,932,000.00**
2	Engineering & pilot testing	52 wks	1/3/11	12/30/11		$1,250,000.00
3	Procurement, long lead items	32 wks	4/25/11	12/2/11	2SS+16 wks	$5,500,000.00
4	DOM procurement, bid award	8 wks	12/19/11	2/10/12	2FS-2 wks	$125,000.00
5	Construction	52 wks	2/13/12	2/8/13	4	$7,750,000.00
6	Engineering Support during construction	52 wks	2/13/12	2/8/13	4	$182,000.00
7	Startup	4 wks	2/11/13	3/8/13	6	$125,000.00
8						
9	**PP Waste Water Treatment Plant-econdary**	**114 wks**	**1/2/12**	**3/7/14**		**$14,932,000.00**
10	Engineering & pilot testing	52 wks	1/2/12	12/28/12	2	$1,250,000.00
11	Procurement, long lead items	32 wks	4/23/12	11/30/12	10SS+16 wk	$5,500,000.00
12	DOM procurement, bid award	8 wks	12/17/12	2/8/13	10FS-2 wks	$125,000.00
13	Construction	52 wks	2/11/13	2/7/14	12	$7,750,000.00
14	Engineering Support during construction	52 wks	2/11/13	2/7/14	12	$182,000.00
15	Startup	4 wks	2/10/14	3/7/14	14	$125,000.00
16						
17	**PP D Ash Pond Closure**	**121 wks**	**1/3/11**	**4/26/13**		**$43,724,700.00**
18	Engineering	8 wks	1/3/11	2/25/11		$171,000.00
19	DOM procurement, bid award	6 wks	2/28/11	4/8/11	18	$0.00
20	Mobilization, initial survey	2 wks	4/11/11	4/22/11	19	$325,000.00
21	E&S, stormwater permits	4 wks	2/28/11	3/25/11	18	$5,500.00
22	Initial erosion control	1 wk	4/25/11	4/29/11	20,21	$25,000.00
23	Initial dewatering	15 wks	4/25/11	8/5/11	20,21	$460,000.00
24	Install surface dewatering system	16 wks	8/8/11	11/25/11	23	$4,992,000.00
25	Operate dewatering system + treatment	80 wks	8/8/11	2/15/13	24SS	$12,160,000.00
26	Install seepage collection system	13 wks	10/3/11	12/30/11	24SS+8 wks	$1,620,000.00
27	Grading, material import	55 wks	11/28/11	12/14/12	24	$9,261,600.00
28	Cover Construction	60 wks	12/26/11	2/15/13	27SS+4 wks	$12,300,000.00
29	Drainage features	3 wks	2/4/13	2/22/13	28FS-2 wks	$0.00
30	Seeding	60 wks	1/9/12	3/1/13	28SS+2 wks	$240,000.00
31	Construction Quality Assurance (CQA)	82 wks	8/8/11	3/1/13	23	$1,200,000.00
32	Construction Management	101 wks	4/11/11	3/15/13	19	$946,400.00
33	Project close out	2 wks	3/4/13	3/15/13	30	$18,200.00
34	DEQ Certification of closure	8 wks	3/4/13	4/26/13	31	$0.00
35						
36	**PP E Ash Pond Closure**	**67 wks**	**2/11/13**	**5/23/14**		**$15,016,420.00**
37	Engineering	8 wks	2/11/13	4/5/13	6	$171,000.00
38	DOM procurement, bid award	6 wks	4/8/13	5/17/13	37	$0.00
39	Mobilization, initial survey	2 wks	5/20/13	5/31/13	38	$75,000.00
40	E&S, stormwater permits	4 wks	4/8/13	5/3/13	37	$5,500.00
41	Initial erosion control	1 wk	6/3/13	6/7/13	39,40	$12,000.00
42	Geotechnical Drilling	3.3 wks	6/10/13	7/2/13	41	$49,500.00
43	Geotechnical monitoring	3.3 wks	6/10/13	7/2/13	41	$19,470.00
44	Lab testing	4 wks	6/24/13	7/19/13	43SS+2 wks	$19,000.00
45	Reporting, pilot testing	26 wks	7/22/13	1/17/14	44	$125,000.00
46	Slurry wall contractor mobilization	2 wks	7/22/13	8/2/13	44	$150,000.00
47	Install slurry wall	30 wks	8/5/13	2/28/14	46	$4,845,000.00
48	Initial dewatering	2 wks	6/3/13	6/14/13	7,40,39	$20,000.00
49	Install surface dewatering system	8 wks	6/3/13	7/26/13	39	$1,331,200.00
50	Operate dewatering system + treatment	41 wks	6/3/13	3/14/14	49SS	$923,000.00
51	Install seepage collection system	13 wks	7/29/13	10/25/13	49	$432,000.00
52	Closure contractor mobilization	2 wks	10/14/13	10/25/13	51FS-2 wks	$250,000.00
53	Grading, material import	17 wks	10/28/13	2/21/14	52	$2,469,750.00
54	Cover Construction	16 wks	11/25/13	3/14/14	53SS+4 wks	$3,280,000.00
55	Drainage features	3 wks	3/3/14	3/21/14	54FS-2 wks	$0.00
56	Seeding	17 wks	12/9/13	4/4/14	54SS+2 wks	$64,000.00
57	Construction Quality Assurance (CQA)	41 wks	6/17/13	3/28/14	48	$320,000.00
58	Construction Management	48 wks	5/20/13	4/18/14	38	$436,800.00
59	Project close out	2 wks	4/7/14	4/18/14	56	$18,200.00
60	DEQ Certification of closure	8 wks	3/31/14	5/23/14	57	$0.00
61						
62	**Other Regulatory-Driven Tasks**	**40 wks**	**1/3/11**	**10/7/11**		**$52,000.00**
67						
68	**Regulatory Deadlines**	**208.6 wks**	**1/3/12**	**12/31/15**		**$0.00**

Project: MSProj11
Date: 12/22/10

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

POSSUM POINT POWER STATION
CONCEPTUAL POND CLOSURE SCHEDULE WITH EAGLE IMPACTS

ID	Task Name	Duration	Start	Finish	Predecessors	Cost
1	**PP Waste Water Treatment Plant-primary**	**114 wks**	**1/3/11**	**3/8/13**		**$14,932,000.00**
2	Engineering & pilot testing	52 wks	1/3/11	12/30/11		$1,250,000.00
3	Procurement, long lead items	32 wks	4/25/11	12/2/11	2SS+16 wks	$5,500,000.00
4	DOM procurement, bid award	8 wks	12/19/11	2/10/12	2FS-2 wks	$125,000.00
5	Construction	52 wks	2/13/12	2/8/13	4	$7,750,000.00
6	Engineering Support during construction	52 wks	2/13/12	2/8/13	4	$182,000.00
7	Startup	4 wks	2/11/13	3/8/13	6	$125,000.00
8						
9	**PP Waste Water Treatment Plant-secondary**	**114 wks**	**1/2/12**	**3/7/14**		**$14,932,000.00**
10	Engineering & pilot testing	52 wks	1/2/12	12/28/12	2	$1,250,000.00
11	Procurement, long lead items	32 wks	4/23/12	11/30/12	10SS+16 wk	$5,500,000.00
12	DOM procurement, bid award	8 wks	12/17/12	2/8/13	10FS-2 wks	$125,000.00
13	Construction	52 wks	2/11/13	2/7/14	12	$7,750,000.00
14	Engineering Support during construction	52 wks	2/11/13	2/7/14	12	$182,000.00
15	Startup	4 wks	2/10/14	3/7/14	14	$125,000.00
16						
17	**PP D Ash Pond Closure**	**210.2 wks**	**1/3/11**	**1/12/15**		**$43,935,622.00**
18	Engineering	8 wks	1/3/11	2/25/11		$171,000.00
19	DOM procurement, bid award	6 wks	2/28/11	4/8/11	18	$0.00
20	Mobilization, initial survey	2 wks	4/11/11	4/22/11	19	$325,000.00
21	E&S, stormwater permits	4 wks	2/28/11	3/25/11	18	$5,500.00
22	Eagle no-work period - demob fee	28 wks	1/3/11	7/15/11		$50,000.00
23	Initial erosion control	1 wk	7/18/11	7/22/11	20,22	$25,000.00
24	Initial dewatering	15 wks	7/18/11	10/28/11	20,21,22	$460,000.00
25	Install surface dewatering system	7 wks	10/31/11	12/16/11	22,24	$2,184,000.00
26	Operate dewatering system + treatment	7 wks	10/31/11	12/16/11	25SS	$1,198,873.00
27	Eagle no-work period - demob fee	30.4 wks	12/15/11	7/15/12		$50,000.00
28	Continue - Install surface dewatering system	9 wks	7/16/12	9/14/12	27	$2,808,000.00
29	Continue - Operate dewatering system + treatment	21.6 wks	7/16/12	12/12/12	27	$3,699,380.00
30	Install seepage collection system	13 wks	7/16/12	10/12/12	27	$1,620,000.00
31	Grading, material import	21.6 wks	7/16/12	12/12/12	27	$3,637,283.00
32	Cover Construction	21.6 wks	8/13/12	1/9/13	27FS+4 wks	$4,428,000.00
33	Seeding	19.6 wks	8/27/12	1/9/13	32SS+2 wks	$80,000.00
34	Eagle no-work period - demob fee	30.2 wks	12/17/12	7/15/13		$50,000.00
35	Continue - Grading, material import	21.6 wks	7/16/13	12/12/13	34	$3,637,283.00
36	Continue - Cover Construction	21.6 wks	7/16/13	12/12/13	34	$4,428,000.00
37	Continue - Operate dewatering system + treatment	21.6 wks	7/16/13	12/12/13	34	$3,699,380.00
38	Seeding	21.6 wks	7/16/13	12/12/13	36SS	$88,000.00
39	Eagle no-work period - demob fee	30.2 wks	12/16/13	7/14/14		$50,000.00
40	Continue - Grading, material import	11.8 wks	7/15/14	10/3/14	39	$1,987,037.00
41	Continue - Cover Construction	20.8 wks	7/15/14	12/5/14	39	$3,444,000.00
42	Continue - Operate dewatering system + treatment	20.8 wks	7/15/14	12/5/14	39	$3,562,366.00
43	Drainage features	3 wks	11/24/14	12/12/14	41FS-2 wks	$0.00
44	Seeding	18 wks	7/15/14	11/17/14	41SS	$72,000.00
45	Construction Quality Assurance (CQA)	6 wks	10/31/11	12/9/11	24	$34,140.00
46	Construction Management	38 wks	4/11/11	12/30/11	19	$345,800.00
47	Construction Quality Assurance (CQA)	21.6 wks	7/16/12	12/12/12	27	$411,480.00
48	Construction Management	21.6 wks	7/16/12	12/12/12	27	$196,560.00
49	Construction Quality Assurance (CQA)	21.6 wks	7/16/13	12/12/13	34	$411,480.00
50	Construction Management	21.6 wks	7/16/13	12/12/13	34	$196,560.00
51	Construction Quality Assurance (CQA)	18 wks	7/15/14	11/17/14	39	$342,900.00
52	Construction Management	24 wks	7/15/14	12/29/14	39	$218,400.00
53	Project close out	2 wks	12/30/14	1/12/15	52	$18,200.00
54	DEQ Certification of closure	8 wks	11/18/14	1/12/15	51	$0.00
55						
56	**PP E Ash Pond Closure**	**67 wks**	**2/11/13**	**5/23/14**		**$15,016,420.00**
57	Engineering	8 wks	2/11/13	4/5/13	6	$171,000.00
58	DOM procurement, bid award	6 wks	4/8/13	5/17/13	57	$0.00
59	Mobilization, initial survey	2 wks	5/20/13	5/31/13	58	$75,000.00
60	E&S, stormwater permits	4 wks	4/8/13	5/3/13	57	$5,500.00
61	Initial erosion control	1 wk	6/3/13	6/7/13	59,60	$12,000.00
62	Geotechnical Drilling	3.3 wks	6/10/13	7/2/13	61	$49,500.00
63	Geotechnical monitoring	3.3 wks	6/10/13	7/2/13	61	$19,470.00
64	Lab testing	4 wks	6/24/13	7/19/13	63SS+2 wks	$19,000.00
65	Reporting, pilot testing	26 wks	7/22/13	1/17/14	64	$125,000.00
66	Slurry wall contractor mobilization	2 wks	7/22/13	8/2/13	64	$150,000.00
67	Install slurry wall	30 wks	8/5/13	2/28/14	66	$4,845,000.00
68	Initial dewatering	2 wks	6/3/13	6/14/13	7,60,59	$20,000.00
69	Install surface dewatering system	8 wks	6/3/13	7/26/13	59	$1,331,200.00
70	Operate dewatering system + treatment	41 wks	6/3/13	3/14/14	69SS	$923,000.00
71	Install seepage collection system	13 wks	7/29/13	10/25/13	69	$432,000.00
72	Closure contractor mobilization	2 wks	10/14/13	10/25/13	71FS-2 wks	$250,000.00
73	Grading, material import	17 wks	10/28/13	2/21/14	72	$2,469,750.00
74	Cover Construction	16 wks	11/25/13	3/14/14	73SS+4 wks	$3,280,000.00
75	Drainage features	3 wks	3/3/14	3/21/14	74FS-2 wks	$0.00
76	Seeding	17 wks	12/9/13	4/4/14	74SS+2 wks	$64,000.00
77	Construction Quality Assurance (CQA)	41 wks	6/17/13	3/28/14	68	$320,000.00
78	Construction Management	48 wks	5/20/13	4/18/14	58	$436,800.00
79	Project close out	2 wks	4/7/14	4/18/14	76	$18,200.00
80	DEQ Certification of closure	8 wks	3/31/14	5/23/14	77	$0.00
81						
82	**Other Regulatory-Driven Tasks**	**40 wks**	**1/3/11**	**10/7/11**		**$52,000.00**
87						
88	**Regulatory Deadlines**	**208.6 wks**	**1/3/12**	**12/31/15**		**$0.00**



Project: MSProj11
Date: 12/22/10

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Possum Point Power Station
Overall Cost-Loaded Schedule

January 2011

Baseline Schedule

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
PP Waste Water Treatment Plant	$ 6,781,250	$ 13,925,402	$ 8,178,133	$ 979,215	$ -	$ 29,864,000
PP D Ash Pond Closure	$ 12,500,852	$ 28,512,869	$ 2,710,979	$ -	$ -	$ 43,724,700
PP E Ash Pond Closure	$ -	$ -	$ 9,789,566	$ 5,226,854	$ -	$ 15,016,420
Other Regulatory-Driven Tasks	$ 52,000	$ -	$ -	$ -	$ -	$ 52,000
Totals	**$ 19,334,102**	**$ 42,438,271**	**$ 20,678,678**	**$ 6,206,069**	**$ -**	**$ 88,657,120**

D Pond Eagle Avoidance Schedule

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
PP Waste Water Treatment Plant	$ 6,781,250	$ 13,925,402	$ 8,178,133	$ 979,215	$ -	$ 29,864,000
PP D Ash Pond Closure - Eagle Avoidar	$ 4,803,260	$ 16,637,684	$ 12,803,749	$ 9,676,369	$ 14,560	$ 43,935,622
PP E Ash Pond Closure	$ -	$ -	$ 9,789,566	$ 5,226,854	$ -	$ 15,016,420
Other Regulatory-Driven Tasks	$ 52,000	$ -	$ -	$ -	$ -	$ 52,000
Totals	**$ 11,636,510**	**$ 30,563,086**	**$ 30,771,448**	**$ 15,882,438**	**$ 14,560**	**$ 88,868,042**

PP O&M Costs	$ -	$ 12,000	$ 12,000	$ 558,000	$ 1,104,000	$ 1,104,000

Possum Point Power Station
Conceptual Cost-Loaded Schedules - Baseline Schedule

January 2011

Activity	Total	2011	2012	2013	2014	2015
PP Waste Water Treatment Plant						
Engineering & pilot testing	$ 1,250,000	$ 1,250,000				
Procurement, long lead items	$ 5,500,000	$ 5,500,000				
DOM procurement, bid award	$ 125,000	$ 31,250	$ 93,750			
Construction	$ 7,750,000		$ 6,885,577	$ 864,423		
Engineering Support during construction	$ 182,000		$ 161,700	$ 20,300		
Startup	$ 125,000			$ 125,000		
PP Waste Water Treatment Plant-secondary						
Engineering & pilot testing	$ 1,250,000		$ 1,250,000			
Procurement, long lead items	$ 5,500,000		$ 5,500,000			
DOM procurement, bid award	$ 125,000		$ 34,375	$ 90,625		
Construction	$ 7,750,000			$ 6,915,385	$ 834,615	
Engineering Support during construction	$ 182,000			$ 162,400	$ 19,600	
Startup	$ 125,000				$ 125,000	
WWTP Totals	**$ 29,864,000**	**$ 6,781,250**	**$ 13,925,402**	**$ 8,178,133**	**$ 979,215**	

PP D Ash Pond Closure						
Engineering	$ 171,000	$ 171,000				
DOM procurement, bid award	$ -					
Mobilization, initial survey	$ 325,000	$ 325,000				
E&S, stormwater permits	$ 5,500	$ 5,500				
Initial erosion control	$ 25,000	$ 25,000				
Initial dewatering	$ 460,000	$ 460,000				
Install surface dewatering system	$ 4,992,000	$ 4,992,000				
Operate dewatering system + treatment	$ 12,160,000	$ 3,192,000	$ 7,934,400	$ 1,033,600		
Install seepage collection system	$ 1,620,000	$ 1,620,000				
Grading, material import	$ 9,261,600	$ 841,964	$ 8,419,637			
Cover Construction	$ 12,300,000	$ 205,000	$ 10,701,000	$ 1,394,000		
Drainage features	$ -					
Seeding	$ 240,000		$ 204,800	$ 35,200		
Construction Quality Assurance (CQA)	$ 1,200,000	$ 307,317	$ 763,902	$ 128,780		
Construction Management	$ 946,400	$ 356,071	$ 489,130	$ 101,199		
Project close out	$ 18,200			$ 18,200		
DEQ Certification of closure	$ -					
D Pond CIP Totals	**$ 43,724,700**	**$ 12,500,852**	**$ 28,512,869**	**$ 2,710,979**	**$ -**	

NO EAGLE IMPACTS
BASELINE SCHEDULE

Possum Point Power Station
Conceptual Cost-Loaded Schedules - Baseline Schedule

January 2011

Activity	Total	2011	2012	2013	2014	2015
PP E Ash Pond Closure						
Engineering	$ 171,000			$ 171,000		
DOM procurement, bid award	$ -					
Mobilization, initial survey	$ 75,000			$ 75,000		
E&S, stormwater permits	$ 5,500			$ 5,500		
Initial erosion control	$ 12,000			$ 12,000		
Geotechnical Drilling	$ 49,500			$ 49,500		
Geotechnical monitoring	$ 19,470			$ 19,470		
Lab testing	$ 19,000			$ 19,000		
Reporting, pilot testing	$ 125,000			$ 112,500	$ 12,500	
Slurry wall contractor mobilization	$ 150,000			$ 150,000		
Install slurry wall	$ 4,845,000			$ 3,456,100	$ 1,388,900	
Initial dewatering	$ 20,000			$ 20,000		
Install surface dewatering system	$ 1,331,200			$ 1,331,200		
Operate dewatering system + treatment	$ 923,000			$ 684,371	$ 238,629	
Install seepage collection system	$ 432,000			$ 432,000		
Closure contractor mobilization	$ 250,000			$ 250,000		
Grading, material import	$ 2,469,750			$ 1,365,626	$ 1,104,124	
Cover Construction	$ 3,280,000			$ 1,107,000	$ 2,173,000	
Drainage features	$ -					
Seeding	$ 64,000			$ 12,800	$ 51,200	
Construction Quality Assurance (CQA)	$ 320,000			$ 221,659	$ 98,341	
Construction Management	$ 436,800			$ 294,840	$ 141,960	
Project close out	$ 18,200				$ 18,200	
DEQ Certification of closure	$ -					
E Pond CIP Totals	**$ 15,016,420**	**$ -**	**$ -**	**$ 9,789,566**	**$ 5,226,854**	**$ -**

Other Regulatory-Driven Tasks						
Prepare closure plan	$ 5,500	$ 5,500				
Prepare post-closure care plan	$ 5,500	$ 5,500				
Conduct GW sampling & testing 4rds	$ 35,000	$ 35,000				
Conduct GW sampling & testing rd2	$ 6,000	$ 6,000				
Regulatory Req Totals	**$ 52,000**	**$ 52,000**	**$ -**	**$ -**	**$ -**	**$ -**

Overall Totals	**$ 88,657,120**	**$ 19,334,102**	**$ 42,438,271**	**$ 20,678,678**	**$ 6,206,069**	**$ -**

NO EAGLE IMPACTS
BASELINE SCHEDULE

Possum Point Power Station
Conceptual Cost-Loaded Schedules
(EAGLE AVOIDANCE ALTERNATE)

January 2011

Activity	Total	2011	2012	2013	2014	2015
PP Waste Water Treatment Plant						
Engineering & pilot testing	$ 1,250,000	$ 1,250,000				
Procurement, long lead items	$ 5,500,000	$ 5,500,000				
DOM procurement, bid award	$ 125,000	$ 31,250	$ 93,750			
Construction	$ 7,750,000		$ 6,885,577	$ 864,423		
Engineering Support during construction	$ 182,000		$ 161,700	$ 20,300		
Startup	$ 125,000			$ 125,000		
PP Waste Water Treatment Plant-secondary						
Engineering & pilot testing	$ 1,250,000		$ 1,250,000			
Procurement, long lead items	$ 5,500,000		$ 5,500,000			
DOM procurement, bid award	$ 125,000		$ 34,375	$ 90,625		
Construction	$ 7,750,000			$ 6,915,385	$ 834,615	
Engineering Support during construction	$ 182,000			$ 162,400	$ 19,600	
Startup	$ 125,000				$ 125,000	
WWTP Totals	**$ 29,864,000**	**$ 6,781,250**	**$ 13,925,402**	**$ 8,178,133**	**$ 979,215**	

Possum Point Power Station
Conceptual Cost-Loaded Schedules
(EAGLE AVOIDANCE ALTERNATE)

January 2011

Activity	Total	2011	2012	2013	2014	2015
PP D Ash Pond Closure - Eagle Avoidance						
Engineering	$ 171,000	$ 171,000				
DOM procurement, bid award	$ -					
Mobilization, initial survey	$ 325,000	$ 325,000				
E&S, stormwater permits	$ 5,500	$ 5,500				
Eagle no-work period - demob fee	$ 50,000	$ 50,000				
Initial erosion control	$ 25,000	$ 25,000				
Initial dewatering	$ 460,000	$ 460,000				
Install surface dewatering system	$ 2,184,000	$ 2,184,000				
Operate dewatering system + treatment	$ 1,198,873	$ 1,198,873				
Eagle no-work period - demob fee	$ 50,000	$ 3,947	$ 46,053			
Continue - Install surface dewatering system	$ 2,808,000		$ 2,808,000			
Continue - Operate dewatering system + treatmer	$ 3,699,380		$ 3,699,380			
Install seepage collection system	$ 1,620,000		$ 1,620,000			
Grading, material import	$ 3,637,283		$ 3,637,283			
Cover Construction	$ 4,428,000		$ 4,141,000	$ 287,000		
Seeding	$ 80,000		$ 74,286	$ 5,714		
Eagle no-work period - demob fee	$ 50,000		$ 3,642	$ 46,358		
Continue - Grading, material import	$ 3,637,283			$ 3,637,283		
Continue - Cover Construction	$ 4,428,000			$ 4,428,000		
Continue - Operate dewatering system + treatmer	$ 3,699,380			$ 3,699,380		
Seeding	$ 88,000			$ 88,000		
Eagle no-work period - demob fee	$ 50,000			$ 3,974	$ 46,026	
Continue - Grading, material import	$ 1,987,037				$ 1,987,037	
Continue - Cover Construction	$ 3,444,000				$ 3,444,000	
Continue - Operate dewatering system + treatmer	$ 3,562,366				$ 3,562,366	
Drainage features	$ -					
Seeding	$ 72,000				$ 72,000	
Construction Quality Assurance (CQA)	$ 34,140	$ 34,140				
Construction Management	$ 345,800	$ 345,800				
Construction Quality Assurance (CQA)	$ 411,480		$ 411,480			
Construction Management	$ 196,560		$ 196,560			
Construction Quality Assurance (CQA)	$ 411,480			$ 411,480		
Construction Management	$ 196,560			$ 196,560		
Construction Quality Assurance (CQA)	$ 342,900				$ 342,900	
Construction Management	$ 218,400				$ 218,400	
Project close out	$ 18,200				$ 3,640	$ 14,560
DEQ Certification of closure	$ -					
D Pond CIP Totals	**$ 43,935,622**	**$ 4,803,260**	**$ 16,637,684**	**$ 12,803,749**	**$ 9,676,369**	**$ 14,560**

Possum Point Power Station
Conceptual Cost-Loaded Schedules
(EAGLE AVOIDANCE ALTERNATE)

January 2011

Activity	Total	2011	2012	2013	2014	2015
PP E Ash Pond Closure						
Engineering	$ 171,000			$ 171,000		
DOM procurement, bid award	$ -					
Mobilization, initial survey	$ 75,000			$ 75,000		
E&S, stormwater permits	$ 5,500			$ 5,500		
Initial erosion control	$ 12,000			$ 12,000		
Geotechnical Drilling	$ 49,500			$ 49,500		
Geotechnical monitoring	$ 19,470			$ 19,470		
Lab testing	$ 19,000			$ 19,000		
Reporting, pilot testing	$ 125,000			$ 112,500	$ 12,500	
Slurry wall contractor mobilization	$ 150,000			$ 150,000		
Install slurry wall	$ 4,845,000			$ 3,456,100	$ 1,388,900	
Initial dewatering	$ 20,000			$ 20,000		
Install surface dewatering system	$ 1,331,200			$ 1,331,200		
Operate dewatering system + treatment	$ 923,000			$ 684,371	$ 238,629	
Install seepage collection system	$ 432,000			$ 432,000		
Closure contractor mobilization	$ 250,000			$ 250,000		
Grading, material import	$ 2,469,750			$ 1,365,626	$ 1,104,124	
Cover Construction	$ 3,280,000			$ 1,107,000	$ 2,173,000	
Drainage features	$ -					
Seeding	$ 64,000			$ 12,800	$ 51,200	
Construction Quality Assurance (CQA)	$ 320,000			$ 221,659	$ 98,341	
Construction Management	$ 436,800			$ 294,840	$ 141,960	
Project close out	$ 18,200				$ 18,200	
DEQ Certification of closure	$ -					
E Pond CIP Totals	**$ 15,016,420**	**$ -**	**$ -**	**$ 9,789,566**	**$ 5,226,854**	**$ -**

Activity	Total	2011	2012	2013	2014	2015
Other Regulatory-Driven Tasks						
Prepare closure plan	$ 5,500	$ 5,500				
Prepare post-closure care plan	$ 5,500	$ 5,500				
Conduct GW sampling & testing 4rds	$ 35,000	$ 35,000				
Conduct GW sampling & testing rd2	$ 6,000	$ 6,000				
Regulatory Req Totals	**$ 52,000**	**$ 52,000**	**$ -**	**$ -**	**$ -**	**$ -**
Overall Totals	**$ 88,868,042**	**$ 11,636,510**	**$ 30,563,086**	**$ 30,771,448**	**$ 15,882,438**	**$ 14,560**

FINAL

APPENDIX B

Slurry Wall Installation

FINAL

A slurry wall barrier was installed in D pond when it was constructed and the E pond may not need one due to site characteristics. Assuming that the risks to groundwater are evaluated and that decisions are made to implement a closure with the impounded CCR left in place, then it may be anticipated that a low permeability barrier such as a soil bentonite slurry wall may be required around the entire perimeter of the E pond. The consideration for a slurry wall can be made after an evaluation of the initial rounds of groundwater testing to determine the nature and extent of possible contaminant migration. The function of the slurry wall is to minimize the risk of offsite migration of leachate from the impounded CCR materials. Soil bentonite slurry walls have been used by EPA on CERCLA (Superfund) site remediation projects for many years. Technical guidance is provided in the report by EPA entitled "*Slurry Trench Construction for Pollution Migration Control, EPA-540/2-84-001"* (Feb. 1984*)*.

There are various civil engineering construction methods available for installation of slurry walls. The means and methods selected are dependent on the project specific ground conditions, performance requirements for the wall (permeability and strength criteria), depth to a low permeability zone into which the wall is keyed, the wall thickness, and the particular preferences of the specialty geotechnical contractor selected.

Typical installation of a soil bentonite slurry wall in the southeastern USA is by a long reach tracked hydraulic excavator, with maximum wall depths in the 70 to 90 feet range and widths typically in the 2 to 3 feet range. The long reach equipment is deployed to excavate a deep trench into the ground to a design depth that provides for an adequate cutoff into a low permeability stratum in the foundation. Bentonite slurry ('mud') is used to support the trench during the excavation. Bentonite is also mixed with the excavated soils, and sometimes other additives such as Portland cement. These materials are blended together as backfill that is pushed into the trench from one end using a dozer.

Where deeper slurry walls are required, or where conditions are such that a more effective 'milling' of the ground is needed, excavation of the wall can be performed using clam shell buckets suspended from crawler cranes, or various forms of hydraulic grab. Soil cutter mixing (CSM) and auger mixing rigs can also be deployed to mix bentonite and cement with the *in-situ* material.

As part of the design of the wall, a treatability study is required involving indicator tests to 'screen' various commercially available bentonite products for their chemical compatibility with the site specific ground and groundwater conditions, and the site specific CCR leachate. Following this step, a mix design is undertaken that involves various laboratory tests on different batches of soil-cement-bentonite blends to evaluate and optimize the mix to achieve project specific performance criteria. It would not be unreasonable to plan on this slurry wall design and treatability testing phase taking between 6 and 12 months for large, complex and environmentally sensitive projects, and perhaps 3 to 6 months for smaller straightforward projects. Costs for the treatability studies vary widely depending on site specific conditions and performance criteria, and may be in the approximate range of $30,000 to $125,000 per project.

Whichever form of slurry wall construction is selected, there are significant mobilization, set-up and demobilization costs involved with deployment of the large excavating equipment, dozers, batching plant, material silos, mud hydration tanks, mixers, agitators, and screw pumps. For planning purposes, these associated costs may range between about $100,000 to $250,000 depending on means and methods of construction.

For the conceptual costs for installation, a conventional soil bentonite slurry wall that is assumed to be 50 feet deep by 2 feet wide, surrounding the entire perimeter of the pond is presumed. Subsurface exploration borings along the wall alignment, at perhaps 150 feet intervals, could be required to determine the design depth of each wall. Geotechnical data for this site is not currently available; therefore conceptual cost for a geotechnical investigation specifically for the wall has been included. A unit rate of $17 per vertical square foot of wall has been used in estimating the costs, but it is worth noting that unit rates may range between about $10/SF to $25/SF depending on the specific wall requirements, ground conditions and means and methods of construction. Production rates vary widely depending on these same variables and could be in the range of 25 to 50 linear ft per day per piece of excavating equipment. For a 5,700 foot long, by 50 foot deep slurry wall around the perimeter of the E ash pond, a conceptual cost estimate of **$5,210,000** and project duration of **12 to 16 months** has been established. Conceptual cost details and cost-loaded schedules are included in Appendix A.

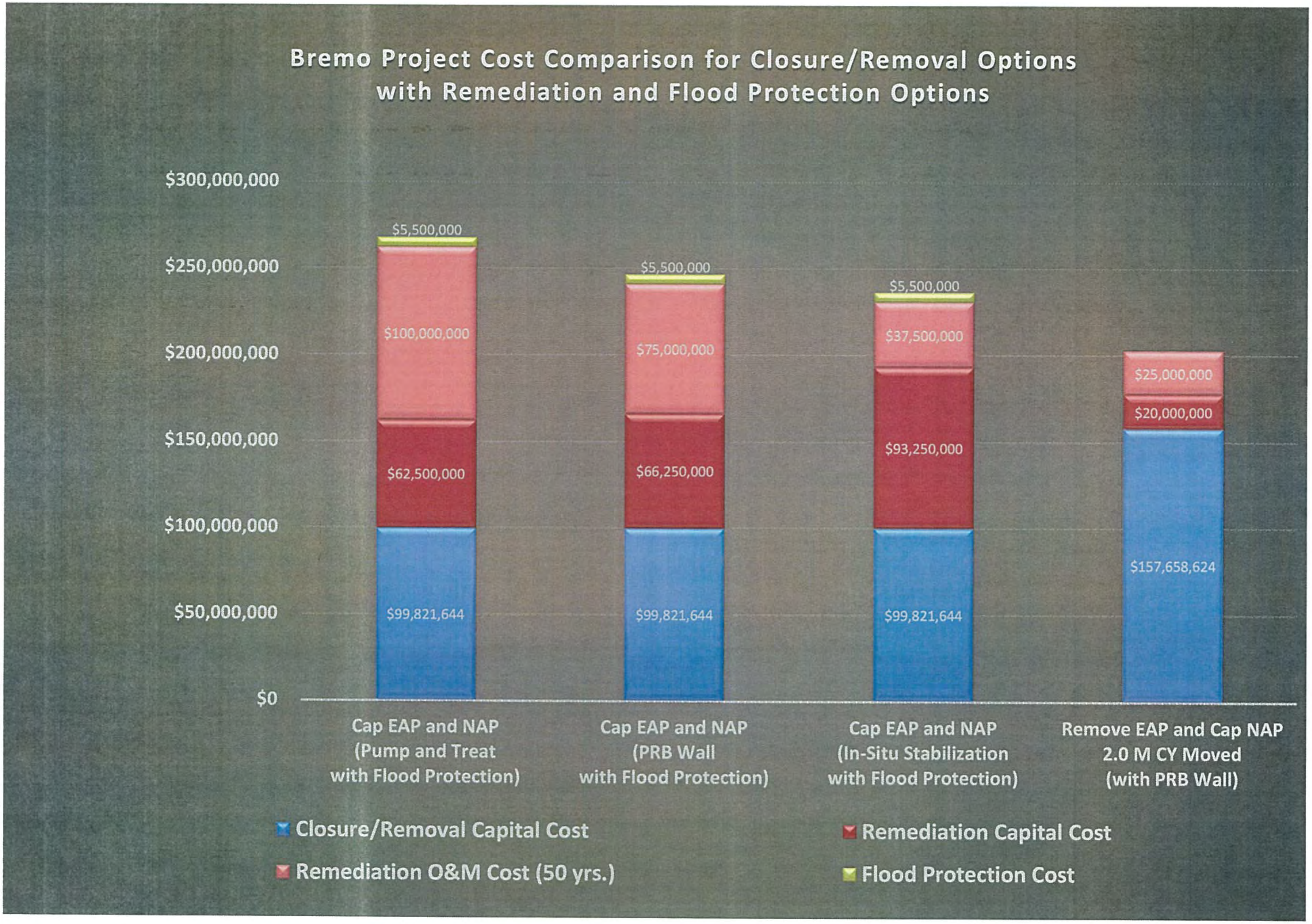
FINAL

APPENDIX C

Acronyms Used

FINAL

AMSL	Above Mean Sea Level
CCR	Coal Combustion Residues
CY	Cubic Yard
E&S	Erosion and Sediment
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
g	gravitational constant
GPM	Gallons Per Minute
HDPE	High Density Polyethylene
MGD	Million Gallons per Day
MHA	Maximum Horizontal Acceleration
mil	one-thousandth of one inch (0.001")
MSW	Municipal Solid Waste
NPDES	National Pollution Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
TOC	Total Organic Carbon
TSS	Total Suspended Solids
VPDES	Virginia Pollution Discharge Elimination System
VSMP	Virginia Stormwater Management Program
VSWMR	Virginia Solid Waste Management Regulations
WET	Whole Effluent Toxicity


Bremo Project Cost Comparison for Closure/Removal Options
with Remediation and Flood Protection Options
$300,000,000
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$0
$5,500,000
$100,000,000
$62,500,000
$99,821,644
$5,500,000
$75,000,000
$66,250,000
$99,821,644
$5,500,000
$37,500,000
$93,250,000
$99,821,644
$25,000,000
$20,000,000
$157,658,624
Cap EAP and NAP (Pump and Treat with Flood Protection)
Cap EAP and NAP (PRB Wall with Flood Protection)
Cap EAP and NAP (In-Situ Stabilization with Flood Protection)
Remove EAP and Cap NAP 2.0 M CY Moved (with PRB Wall)
Closure/Removal Capital Cost
Remediation Capital Cost
Remediation O&M Cost (50 yrs.)
Flood Protection Cost

Cap EAP and NAP (Pump and Treat with Flood Protection)

CLOSURE CAPITAL COST

TASK	COST
NAP Closure Construction	**$18,860,418**
Engineering and Permitting	$1,075,535
Construction Quality Assurance	$1,832,927
Water Treatment	$38,342,673
Sampling and Analysis	$2,330,815
Dominion Project Management	$3,098,750
Subtotal	**$65,541,118**
EAP Closure Construction	**$12,010,624**
Engineering and Permitting	$870,671
Stream Mitigation	$0
Construction Quality Assurance	$714,531
Water Treatment	$18,115,418
Sampling and Analysis	$1,165,407
Dominion Project Management	$1,403,875
Subtotal	**$34,280,526**
Capital Cost Total	**$99,821,644**

REMEDIATION CAPITAL COST

TASK	COST
Pump and Treat	
Mobilization/Demobilization/General Conditions	$5,000,000
Site preparation and Access	$1,500,000
Wastewater Treatment Plant	$35,000,000
Deep Well Extraction System	$3,500,000
Collection and Conveyance System	$1,500,000
Site Electrical	$750,000
On-Site Laboratory	$1,250,000
Engineering Design and Permitting	$2,500,000
Construction Quality Assurance	$1,500,000
Post Closure Care (50 year period)	$5,000,000
Dominion Project Management	$5,000,000
Subtotal	**$62,500,000**
Remediation Total	**$62,500,000**

REMEDIATION O&M COST

TASK	COST
Annual O&M (50 year period)	$100,000,000
Subtotal	**$100,000,000**
O&M Cost Total	**$100,000,000**

FLOOD PROTECTION COST

TASK	COST
Rip Rap Armoring (up to EL. 236 ft amsl, 500-yr event)	$5,500,000
Subtotal	**$5,500,000**
Flood Protection Total	**$5,500,000**

Total	$267,821,644

Cap EAP and NAP (PRB Wall with Flood Protection)

CLOSURE CAPITAL COST

TASK	COST
NAP Closure Construction	**$18,860,418**
Engineering and Permitting	$1,075,535
Construction Quality Assurance	$1,832,927
Water Treatment	$38,342,673
Sampling and Analysis	$2,330,815
Dominion Project Management	$3,098,750
Subtotal	**$65,541,118**
EAP Closure Construction	**$12,010,624**
Engineering and Permitting	$870,671
Stream Mitigation	$0
Construction Quality Assurance	$714,531
Water Treatment	$18,115,418
Sampling and Analysis	$1,165,407
Dominion Project Management	$1,403,875
Subtotal	**$34,280,526**
Capital Cost Total	**$99,821,644**

REMEDIATION CAPITAL COST

TASK	COST
Permeable Reactive Barrier	
Mobilization/Demobilization/General Conditions	$3,500,000
Site Preparation and Access	$2,500,000
Deep Well Extraction System	$3,500,000
Collection and Conveyance System	$1,500,000
Site Electrical	$750,000
Slurry Wall with PRB	$42,000,000
Engineering Design and Permitting	$1,500,000
Construction Quality Assurance	$2,500,000
Post Closure Care (50 year period)	$5,000,000
Dominion Project Management	$3,500,000
Subtotal	**$66,250,000**
Remediation Total	**$66,250,000**

REMEDIATION O&M COST

TASK	COST
Annual O&M (50 year period)	$75,000,000
Subtotal	**$75,000,000**
O&M Cost Total	**$75,000,000**

FLOOD PROTECTION COST

TASK	COST
Rip Rap Armoring (up to EL. 236 ft amsl. 500-yr event)	$5,500,000
Subtotal	**$5,500,000**
Flood Protection Total	**$5,500,000**

Total	**$246,571,644**

Cap EAP and NAP (Partial In-Situ Stabilization with Flood Protection)

CLOSURE CAPITAL COST

TASK	COST
NAP Closure Construction	**$18,860,418**
Engineering and Permitting	$1,075,535
Construction Quality Assurance	$1,832,927
Water Treatment	$38,342,673
Sampling and Analysis	$2,330,815
Dominion Project Management	$3,098,750
Subtotal	**$65,541,118**
EAP Closure Construction	**$12,010,624**
Engineering and Permitting	$870,671
Stream Mitigation	$0
Construction Quality Assurance	$714,531
Water Treatment	$18,115,418
Sampling and Analysis	$1,165,407
Dominion Project Management	$1,403,875
Subtotal	**$34,280,526**
Capital Cost Total	**$99,821,644**

REMEDIATION CAPITAL COST

TASK	COST
Partial In-Situ Solidification (assumes bottom 6 ft)	
Mobilization/Demobilization/General Conditions	$2,500,000
Site Preparation and Access	$1,500,000
Deep Well Extraction System	$3,500,000
Collection and Conveyance System	$1,500,000
Site Electrical	$750,000
Solidification/Stabilization Process ($160/cy)	$56,000,000
Engineering Design and Permitting	$1,000,000
Construction Quality Assurance	$3,000,000
Post Closure Care (50 year period)	$5,000,000
Dominion Project Management	$3,500,000
Subtotal	**$78,250,000**
NAP Corrective Action/Remediation (Permeable Reactive Barrier)	
Mobilization/Demobilization/General Conditions	$3,500,000
Site Preparation and Access	$1,500,000
Slurry Wall with PRB	$7,500,000
Engineering Design and Permitting	$500,000
Construction Quality Assurance	$500,000
Dominion Project Management	$1,500,000
Subtotal	**$15,000,000**
Remediation Total	**$93,250,000**

REMEDIATION O&M COST

TASK	COST
Annual O&M (50 year period)	$37,500,000
Subtotal	**$37,500,000**
O&M Cost Total	**$37,500,000**

FLOOD PROTECTION COST

TASK	COST
Rip Rap Armoring (up to EL. 236 ft amsl. 500-yr event)	$5,500,000
Subtotal	**$5,500,000**
Flood Protection Total	**$5,500,000**

Total	$236,071,644

Remove EAP and Cap NAP (with PRB Wall)

CLOSURE / REMOVAL CAPITAL COST

TASK	COST
NAP Closure Construction	**$16,049,124**
Engineering and Permitting	$1,250,000
Construction Quality Assurance	$2,250,000
Water Treatment	$36,000,000
Sampling and Analysis	$4,050,000
Dominion Project Management	$1,500,000
Subtotal	**$61,099,124**
EAP Removal Construction	**$60,859,500**
Engineering and Permitting	$1,750,000
Stream Mitigation	$1,000,000
Construction Quality Assurance	$1,750,000
Water Treatment	$24,000,000
Sampling and Analysis	$2,700,000
Dominion Project Management	$4,500,000
Subtotal	**$96,559,500**
Capital Cost Total	**$157,658,624**

REMEDIATION CAPITAL COST

TASK	COST
NAP Corrective Action/Remediation (Permeable Reactive Barrier) (assumes post-closure care)	
Mobilization/Demobilization/General Conditions	$3,500,000
Site Preparation and Access	$1,500,000
PRB Wall	$7,500,000
Engineering Design and Permitting	$500,000
Construction Quality Assurance	$500,000
Post Closure Care (50 year period)	$5,000,000
Dominion Project Management	$1,500,000
Subtotal	**$20,000,000**
Remediation Total	**$20,000,000**

REMEDIATION O&M COST

TASK	COST
Annual O&M (50 year period)	$25,000,000
Subtotal	**$25,000,000**
O&M Cost Total	**$25,000,000**

Total	**$202,658,624**

FINAL REPORT

FINAL

WET ASH IMPOUNDMENT EVALUATION

CHESTERFIELD POWER STATION

Submitted to:

Dominion
5000 Dominion Blvd
Glen Allen, VA 23060

Submitted by: **Golder Associates Inc.**
2108 W. Laburnum Avenue, Suite 200
Richmond, Virginia 23227

Distribution:
1 Copy Dominion
1 Copy Golder Associates Inc.

A world of capabilities delivered locally

January, 2011

1039-6867

TABLE OF CONTENTS

List of Appendices

1.0 EXECUTIVE SUMMARY

Golder Associates Inc. (Golder) is assisting Dominion with the evaluation of the impacts to station operations from the EPA's proposed regulations regarding disposal of coal combustion residuals (CCR) from electric utilities as published in the Federal Register on June 21, 2010. Consideration was given only to the Co-Proposal under authority of Subtitle D of the Resource Conservation and Recovery Act (RCRA) as it represents a baseline cost and schedule basis for either of the co-proposals presented by the EPA.

This evaluation identifies three major systems at the Chesterfield station that will be directly or indirectly impacted by the regulations, and all are tied to the regulation effectively eliminating wet ash impoundments as a means of CCR disposal. Closure of the lower ash pond at Chesterfield will force two additional system changes, namely the conversion to dry ash handling and the construction of an approximate 5 million gallon per day (MGD) wastewater treatment plant (WWTP).

The current-year (2010), non-escalated conceptual project costs and schedules presented in this report are based on the following assumptions:

- Closure of the lower ash pond in-place;
- Conversion to dry ash conveyances per the 2009 Golder study;
- Construction of an on-site wastewater treatment plant of approximately 5 MGD capacity; and,
- Other regulatory-driven tasks (GW monitoring, posting of plans, etc.).

CHESTERFIELD POWER STATION
CONCEPTUAL COST-LOADED SCHEDULE

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Totals
WWTP Construction *	$11,431,250	$22,317,010	$17,567,330	$6,714,410	$ -	$ -	**$58,030,000**
Dry Ash Conversion	$2,606,751	$19,462,004	$36,592,263	$6,604,582	$ -	$ -	**$65,265,600**
Lower Ash Pond Closure	$ -	$ -	$ -	$9,435,288	$15,635,616	$4,906,146	**$29,977,050**
Other Regulatory Tasks	$39,900	$ -	$ -	$ -	$ -	$ -	**$39,900**
Additional O&M costs		$14,000	$14,000	$1,496,608	$2,458,144	$2,458,144	**$2,458,144 (annually)**
Total	**$14,077,901**	**$41,793,014**	**$54,173,594**	**$24,250,887**	**$18,093,760**	**$7,364,290**	**$159,753,446**

* Capital costs for selenium treatment not included
All values are anticipation of the proposed Subtitle D rulings

A conceptual overall project schedule has been developed for the Chesterfield station, and the estimated time required to complete all three major projects is approximately **5.5 years**, or approximately 6 months longer than the anticipated regulatory required deadline. Considering that the entire fossil power generation industry will be attempting to make these types of system changes in the same timeframe, Golder recommends seeking an extension as allowed in the regulations rather than attempting to compress the schedule.

PROJECT No.	103-96868	
FILE No.	10396868A08	
REV. 0	SCALE AS SHOWN	
DESIGN	DPM	09/22/10
CADD	OSY	09/22/10
CHECK		
REVIEW		

TITLE

AERIAL OF ASH PONDS AND POWER STATION

PROJECT

DOMINION
CHESTERFIELD POWER STATION
CHESTER, VA

Golder Associates
Richmond, Virginia

FIGURE 1

2.0 DESCRIPTION OF THE STATION

Chesterfield Power Station is located approximately 20 miles south of Richmond, Virginia, in Chesterfield County. There are four coal-fired units and two combined-cycle units with a combined capacity of approximately 1,700 megawatts. The station was constructed in the mid-1940's and is now one of the largest fossil stations in Dominion's fleet. In 2006, the first Flue Gas Desulfurization (FGD) system was installed for unit 6, and a second FGD system is currently being installed for units 3, 4 and 5. The second FGD system is anticipated to be on-line in 2012. Figure 1 on the following page shows the station layout.

2.1 Ash Ponds

The Chesterfield Station operates two ash ponds, the lower pond and the upper pond, both of which are located south of the station on Dominion-owned property. The lower pond was constructed in approximately 1964 and has been in active use since then. The upper pond was constructed in 1983-1984 and was used to receive slurried ash from the station until approximately 2002. In 2002, the pond was converted to a dry monofill stack operation where ash from the lower pond is dredged and hauled to the upper pond by truck as part of an ongoing progressive closure. Table 1 shows the capacities of each pond.

TABLE 1
CHESTERFIELD ASH POND CAPACITIES

Pond	Area (acres)	Capacity (CY) Total / Remaining	Percent full (as of date)
Lower	98	1,200,000 / 470,500	61% (2/12/10)
Upper	112	16,520,500* / 5,224,000	68% (6/1/10)

* Includes capacity of original upper pond plus closure project

In addition to the ash from the Chesterfield Station, the upper pond also serves as the ash disposal facility for the Southampton and Hopewell Stations, and is permitted to receive up to 122,500 tons of ash per year from these stations. On average, the upper pond receives a total of approximately 633,000 wet tons per year; consuming approximately 542,500 CY of airspace per year. The upper pond is projected to provide disposal capacity for the station until approximately 2018, at which time it will reach its design capacity and require final closure. In anticipation of the 2018 closure of the upper pond, a new industrial landfill on a parcel adjacent to the station is currently undergoing the regulatory permitting process, with the goal of being in operation in 2018.

2.2 Ash Pond Waste Streams

2.2.1 Bottom and Fly Ash

Both the bottom ash and fly ash from the station are wet sluiced to the lower ash pond for disposal. The bottom ash is handled separately, and is collected by a recycling contractor for beneficial reuse.

Approximately 30,000 tons of bottom ash are recycled in a typical year. The fly ash, as mentioned previously, is slurried into the lower pond where it is then dredged by the operating contractor for disposal in the upper pond closure.

2.2.2 FGD Gypsum

A byproduct of the Flue Gas Desulfurization process is synthetic gypsum produced in the FGD process. This beige, granular material, is collected for reuse in wallboard manufacturing. Approximately 150,000 tons of gypsum per year are barged to the Tidewater region for reuse. When the second FGD system comes on line in 2012, this total is expected to rise to approximately 300,000 tons per year. Should the gypsum not be needed or not meet the manufacturer's quality specifications, it can also be placed in the upper pond closure or the future industrial landfill.

2.2.3 Other Plant Waters

The lower ash pond receives a significant portion of wastewater from the station in addition to the ash slurry water. A total of approximately 10 million gallons per day (MGD) of water flows into the lower ash pond, of which approximately 5 MGD is ash slurry water and the remaining balance is the combined flow of "other plant waters". These waters consist primarily of storm drain flows, pump seal water, coal pile runoff, and effluent from the FGD wastewater treatment system. During precipitation events, a large volume of stormwater flows into the lower pond. Sanitary wastewater (from lavatories and sinks in the station) is collected separately and sent to Chesterfield County for treatment and disposal.

3.0 DECISION TREE

During the early work sessions for this evaluation, the project team developed a method of analysis that would be used to systematically evaluate the options available at each station with regards to ash impoundments (Figure 2). The first level of evaluation is to determine if there are impoundments that could be considered for early closure using an anticipated effective date of the EPA regulations of December 31, 2011. The evaluation considered if an impoundment could be fully closed in advance of the effective date, and thereby not be subject to the proposed regulations. Not all stations were deemed to have a candidate pond; however at the Chesterfield Station, the upper pond was evaluated for early closure and that evaluation is presented in Section 4 of this report.

The second level of evaluation is to look at each impoundment with regards to the siting requirements proposed in Section 257.64 of the proposed regulations. If the siting evaluation was favorable, the operational economics of each pond were evaluated to consider if it was feasible to continue to operate the pond under the new requirements. At a minimum to continue operation under the proposed rules, an impoundment would have to be dredged of all ash materials, have a composite liner system installed, and be subject to groundwater monitoring.

The evaluations carried out in this report are based on the EPA's proposed regulations as published in the Federal Register on June 21, 2010. Consideration was given only to the Co-Proposal under authority of Subtitle D of the Resource Conservation and Recovery Act (RCRA), as it represents a baseline cost and schedule requirement for the proposed regulations.

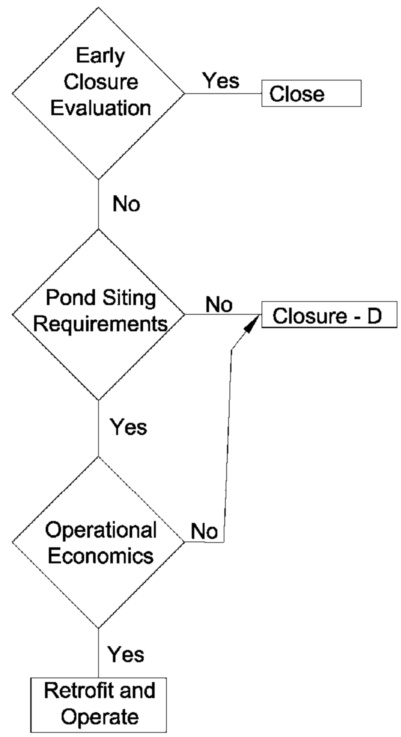


Figure 2 – Decision Tree

4.0 EARLY CLOSURE EVALUATION

4.1 Pond Description

The upper ash pond at the Chesterfield Power Station is permitted as a pond under a Virginia Pollution Discharge Elimination System (VPDES) permit, not under the Virginia Solid Waste Management Regulations (VSWMR). The pond has been operated as a dry monofill stack since 2002 under a long-term progressive pond closure activity. Under the VPDES permit, the upper pond has an approved closure plan consisting of a final grading plan and closure cap consisting of 24 inches of compacted soil. The computed remaining volume in the upper pond as of June, 2010 was 5,224,000 CY.

In a typical year, the operations contractor excavates and hauls between 350,000 to 550,000 tons of ash from the lower pond. Additional sources of ash placed in the upper pond include ash from the Hopewell and Southampton Stations, estimated at 83,000 tons per year; however, the volume from off-site can be as much as 122,500 tons per year. Converting ash tons to cubic yards using 1.2 tons per cubic yard (in place) and allowing for 15,000 CY per year of soil cover material, results in typical yearly volume consumption in the upper pond of 542,500 CY. Using this consumption figure, the upper pond has approximately 8 to 9 years of placement capacity remaining as of June, 2010. An industrial solid waste landfill for the Chesterfield station is currently going through the regulatory permitting process, and is anticipated to be in operation by 2018 to coincide with the closure of the upper pond.

4.2 Conceptual Early Pond Closure Scenario

The evaluated scenario for closure of the upper pond involves the dredging of the lower pond to its maximum extents, and using this material to fill the upper pond to achieve final grades in general compliance with the closure plan. Dredging and hauling operations for the anticipated ash volume would likely take 6 to 9 months to complete. Closure of the upper pond would involve closing approximately 112 acres. Construction of the closure cap would take at least 6 months to complete. With the upper pond closed, the station would then fill the lower pond with slurried ash, ultimately closing the lower pond in place.

4.3 Early Closure Scenario Challenges

With a currently remaining upper pond capacity of over 5 million CY, Dominion would be very challenged to deliver this much material to the upper pond within the timeframe goals. Current estimates put the lower pond's ash volume at approximately 730,000 CY. Complete dredging of the lower pond, plus approximately 1.5 years of station and other off-site ash would result in a total available fill volume of approximately 1,520,000 CY. Filling and closing the upper pond with this reduced volume would sacrifice nearly 4,000,000 CY of available disposal capacity that requires no additional capital cost.

After dredging, the lower pond has a capacity of approximately 1,200,000 CY. Given a fill rate of 527,500 CY/year, the lower pond only provides 2.25 years of disposal capacity. If the lower pond were empty at the end of 2011, the station would run out of disposal capacity by early 2013, nearly five years short of the anticipated operation date of the new landfill. Additionally, ash hauled from offsite stations would have to find alternate disposal methods.

4.4 Early Closure Recommendation

Golder recommends against closing the upper pond early, namely due to the demonstrated lack of long-term disposal capacity in the lower pond. Closing the upper pond would adversely impact the ash disposal options for the Chesterfield station as well as the other stations that depend on the disposal capacity provided by the upper pond. Waiting for the effective regulatory changes to take place would most likely result in a small modification of the closure and post-closure plans for the upper pond. The physical structure of the cap section as planned in the current closure plan would not require modification.

5.0 SITING EVALUATION (§257.64)

For an operator of an existing surface impoundment to continue operating the impoundment under the proposed rules, the operator must make a demonstration that the surface impoundment is not located in an unstable area, or that engineering measures have been incorporated into the design to ensure that the integrity of the structural components of the surface impoundment will not be disrupted. An unstable area is defined as an area that is susceptible to natural or human-induced events capable of impairing the integrity of a surface impoundment. Examples of such unstable areas are:

- Poor foundation conditions such as karst terrain, potential liquefaction areas, highly compressible soils, or man-made structures (mines) underneath the impoundment;
- Areas susceptible to mass movement (landslides, earthquakes); and,
- Flood-prone areas. While not specifically mentioned in the section, Golder chose to include floods due to the 100-year storm event or hurricane storm surge, as these could also be a significant impact to the existing impoundments.

Since the lower pond and the upper pond are adjacent to each other, they were considered together for the siting criteria.

5.1 Evaluation of Foundation Conditions

Both the lower and upper ash ponds at Chesterfield are located adjacent to the former main channel of the James River. While no site investigation study was performed by Golder for this evaluation, certain aspects of the site can be inferred from the location and known history of the site. The lower and upper ponds, although located within 300 feet of each other, are likely to have differing subsurface soil conditions. Figure 3 shows the location of each pond and the relative vicinity of the James River.

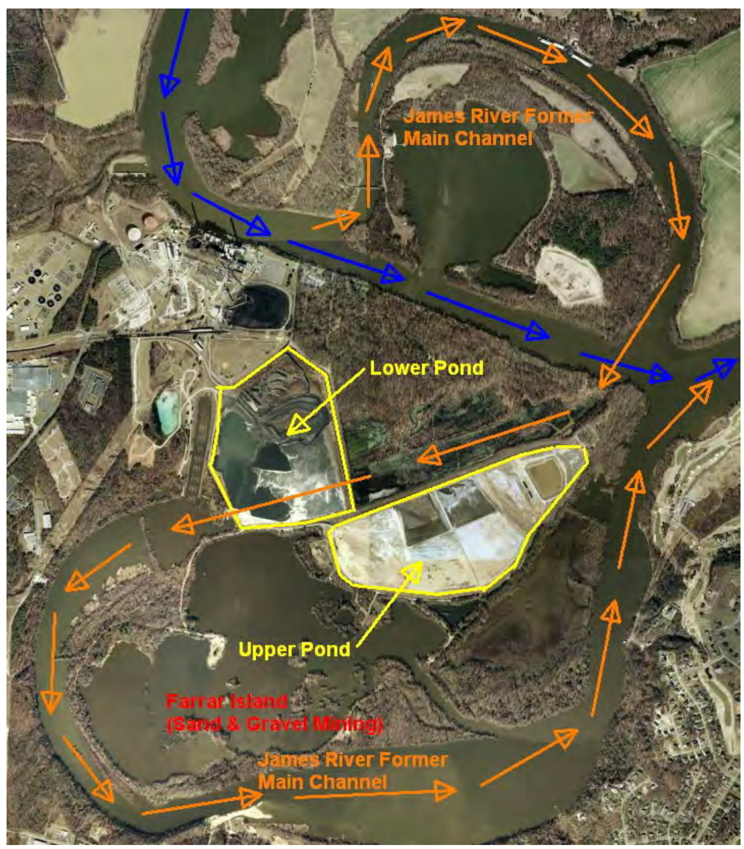


Figure 3 – Chesterfield Station Vicinity Map

5.1.1 Lower Ash Pond

A portion of the lower ash pond is constructed in the former main channel of the James River, and is likely to contain soft, compressible soils that were part of the river channel. The orange arrows in Figure 3 show the James River main channel flow direction until the "Dutch Gap Cutoff" was created in 1930, forming the flow line indicated in blue. The 1964 construction drawings for the lower pond by Stone and Webster do not indicate improvements were to be made to the foundation of the pond during its construction. The dikes forming the lower pond have been in place for approximately 46 years which is a positive historical indicator that they are suitable for their current level service. However; due to the potential compressibility of the subsurface soils, long-term settlement may have resulted in the top elevation of the dike to be lower than the original as-built elevation. If changes in dike elevation or pond size were to be made, a detailed geotechnical investigation will need to be undertaken to evaluate the subsurface conditions.

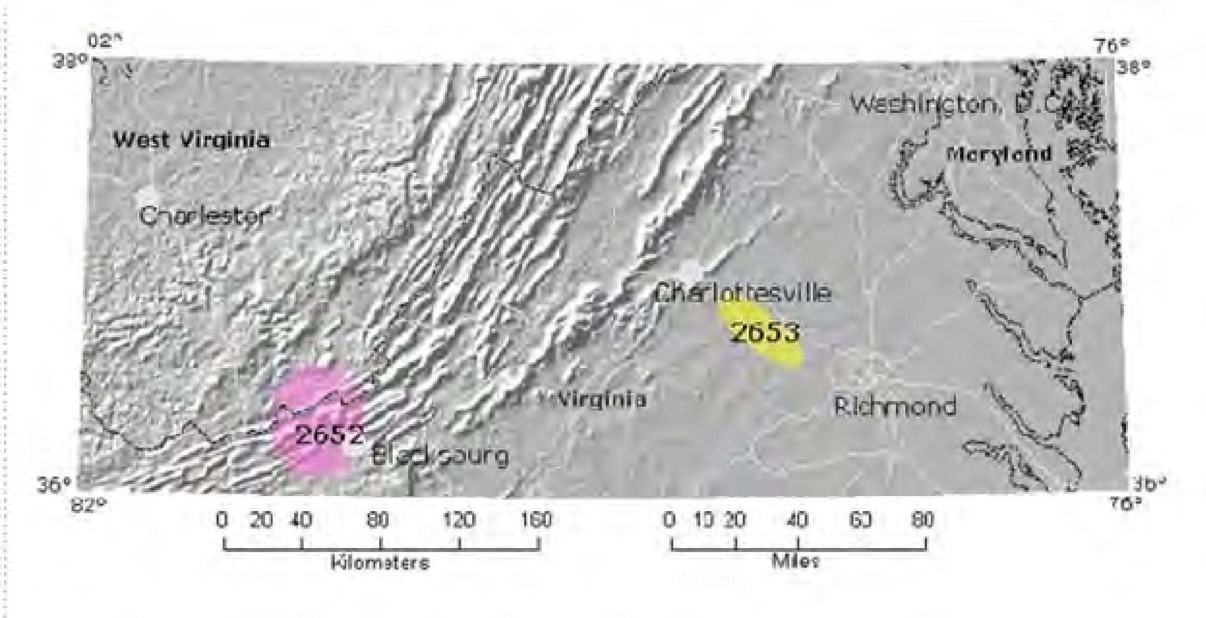
5.1.2 Upper Ash Pond

The upper ash pond was constructed in 1983 – 1984 in an area known as Farrar Island. This island had previously been excavated for sand and gravel deposits, and the resulting area was a mix of wet and dry land areas. A common practice during aggregate mining activities in this area was to wet sluice the material, screen the sluice for sand and gravel recovery, then return the rejected fines to the mine area. The nature and extent of possible mine residues has not been investigated, but prior to the construction of the upper pond, a geotechnical investigation was performed by Schnabel Engineering Associates, P.C. (Schnabel) to evaluate the subsurface conditions of the upper pond. For the 2002 conversion to the monofill progressive closure, the stability of the final configuration was again evaluated by Schnabel and some structural improvements were made to portions of the perimeter dikes as a result. Golder recommends that an evaluation of the foundation conditions of the upper ash pond be prepared by Schnabel to meet the regulatory requirements for unstable areas, due to their historical engineering presence at the facility.

5.2 Evaluation of Unstable Areas

5.2.1 Liquefaction or Active Faulting

The lower and upper ash ponds are not located in an area of recent or active faulting. The closest fault system is the Paleocene age Dutch Gap Fault System north of the station; this system does not indicate any recent (Holocene) movement that would result in failure of containment structures at the facility (Dischinger, 1987). The closest area known to have evidence of recent displacement is in central Virginia, which experienced displacement in Quaternary time (i.e., up to 1.8 million years ago) and is at least 20 miles from the site (see yellow area in figure below).

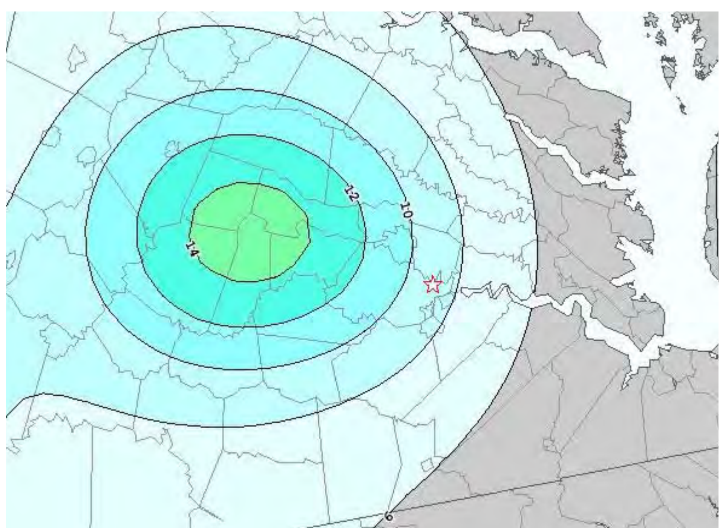


Areas of Quaternary Deformation and Liquifaction, Virginia

Source: http://earthquake.usgs.gov/regional/qfaults/eusa/virginia.php

5.2.2 Seismic Impact

A seismic impact zone is defined in the United States Environmental Protection Agency (USEPA) Technical Manual (Section 6.2) as an area having a 10 percent or greater probability that the maximum horizontal acceleration (MHA) in lithified earth material, expressed as a fraction of the earth's gravitational pull (g), exceeds 0.10g in 250 years (i.e., the probability that one seismic event causing a MHA of 0.10g will occur in any 250-year period is no more than 10 percent) and has a recurrence period (TR) of 2,475 years. Equivalently, MHA is taken as the peak acceleration that has 90 percent probability of not being exceeded in 250 years. In this context, lithified material means all rock, including all naturally occurring and naturally formed aggregated or masses of rock, and excluding man-made materials, such as fill, unconsolidated earth materials and soil, lying at or near the earth surface. Seismic impact zone maps for Virginia present acceleration values for a seismic event having a 2 percent probability that the MHA will be exceeded in 50 years (i.e., Pe = 2 percent in 50 years); however, a seismic risk level of Pe = 2 percent is



USGS Seismic Map – Peak Horizontal Acceleration (%g)
2% Probability of Exceedance in 50 years

almost statistically equivalent to the extreme seismic event as this level has a return period TR = 2,375 years.

The MHA expected to occur in lithified material at the Chesterfield Power Station was estimated using spectral acceleration values developed by the U.S. Geological Survey National Seismic Hazard Mapping Project (Peterson et al., 2008) for the entire United States. The latest version of national seismic maps superseded previous seismic maps [e.g., Algermissen et al. (1982) and Algermissen (1991), which are referenced in the USEPA Technical Manual]. MHA and spectral acceleration values are presented in a latitude-longitude grid that is spaced 0.1 degree in each direction (e.g., see information at http://earthquake.usgs.gov/research/hazmaps/products_data/2008/), which represents an increase in accuracy compared to the earlier seismic impact maps.

The MHA values at the upper and lower ash ponds were calculated using the site coordinates of 37° 22' 17" north and longitude 77° 22' 34" west. For the Pe = 2 percent in 50 years level (i.e., equivalent to the Pe = 10 percent in 250 years level), the peak ground acceleration in rock is obtained as MHA = 0.09457g, or approximately 0.09g. Because the obtained MHA in rock is less than 0.1g, the site is not considered to be within a seismic impact zone.

5.2.3 Man-Made Features

With the exception of the previously-mentioned aggregate mining activities, no manmade features or events that may result in a subsequent failure of the containment structure of either pond are known to exist at the upper or lower ash ponds. The nature and extent of the former mining areas and their possible residues has not been investigated. While the existence of these possible mine residue areas is not a certain fatal flaw for the upper pond, Golder recommends the demonstration for the foundation conditions and improvements made to the upper pond dikes be prepared by Schnabel.

5.2.4 Karst Topography

Karst topography refers to a geologic landscape consisting of soluble bedrock such as limestone or dolomite, which can contain solution caverns or sinkholes formed by water action over long periods of time. Presence of a sinkhole or cave beneath a landfill or pond structure could result in eventual failure of the containment should the void be too close to the surface. Chesterfield County, Virginia, is not located in an area known to contain karst features. Karst topography in Virginia is mainly confined to the western third of the state.

5.3 Flood-Prone Areas

While not a defined criterion in §257.64, the proximity of the James River to the lower pond warrants a brief evaluation. The June 28, 1983 as-built elevation of the lower pond's east dike is shown as 19' above mean sea level (AMSL), with an indicated 100-year flood elevation of 17' AMSL (Drawing CX002 by J.K. Timmons & Assoc.). A more recent flood study for Chesterfield County from the Federal Emergency Management Agency (FEMA, May 1994) shows a 100-year flood elevation of 19' AMSL. As part of a more detailed evaluation for continued use, the existing elevations of the lower ash pond dikes should be determined and compared to the current 100-year flood elevations. If a flood of the 100-year event or larger were to occur in the James River, the potential for the lower pond embankment to be overtopped and the loss of ash materials either due to material washout or embankment failure exists.

5.4 Results of Siting Evaluation

A more rigorous evaluation needs to be conducted for a conclusive statement to be made regarding the potentially unstable areas under the upper and lower ponds in accordance with §257.64 of the proposed regulations. Based on the criteria listed in the proposed regulations, the lower and upper ash ponds at Chesterfield do not appear to be located in a seismic impact area or an area of karst terrain as defined in the proposed regulations. However; due to the presence of the former mine areas in and around the upper pond, Golder recommends a formal evaluation be prepared to determine the risks and describe the actions and improvements taken to mitigate the risks to the upper pond embankments.

6.0 EVALUATION OF CONTINUED USE

The purpose of this section of the evaluation is to consider, under the Subtitle D proposal of the proposed regulations, what the requirements are and what the estimated conceptual costs would be to retrofit and continue use of one or both of the ash ponds at the Chesterfield Station.

6.1 Regulatory Impacts

6.1.1 Proposed CCR Regulations

The proposed CCR regulations, issued in draft form for comment on June 21, 2010, form the basis for the physical and operational changes required to ash surface impoundments for continued use. The retrofit actions required, conceptual costs and schedule are presented in the sections 6.2 and 6.3. Groundwater monitoring will be a new requirement for all CCR facilities, despite being targeted for closure or not. The groundwater monitoring system at Chesterfield appears to meet the minimum requirements as outlined in §257.91; however the documentation of the well construction, commissioning and testing will need to be uploaded to the publicly-accessible internet site. After developing the groundwater statistical background database, routine monitoring on a semi-annual basis will be required.

6.1.2 Potential Effluent Guidelines

On September 15, 2009, the USEPA announced a decision to proceed with rulemaking to review wastewater discharges from power plants and treatment technologies available to reduce pollutant discharges. EPA's decision to revise the current effluent guidelines is largely driven by the high level of toxic-weighted pollutant discharges from coal fired power plants and the expectation that these discharges will increase significantly in the next few years as new air pollution controls are installed. The new discharge standards may include extremely low limits for bioaccumulative metals such as arsenic, magnesium and selenium, as these can be indicative of CCR and/or FGD system runoff. Discharge limits in the 5 to 50 parts per billion (ppb) have been proposed, and in some instances, recently placed into effect. Additional limits may be placed on significant levels of chloride, total suspended solids (TSS), total dissolved solids (TDS), and nutrients.

Removal of these materials to the proposed levels from the wastewater generated by the station, including ash slurry and FGD wastewaters, may require new or a combination of existing treatment technologies and investment of millions of dollars in capital expenditures. Continuing to use the lower ash pond for ash slurry represents a potentially large financial risk should the entire volume of water from the pond require treatment to the proposed levels. Further discussion about potential wastewater treatment infrastructure requirements is included in section 8.2 of this report. Additionally, increased scrutiny is likely on the groundwater quality surrounding the operating ash ponds, representing another potential risk from offsite impacts and potential corrective action requirements.

6.1.3 Wetlands

A visual observation of the northeast and eastern sections of the lower ash pond reveals the possible presence of emergent wetland vegetation. A check of the National Wetlands Inventory (NWI) map does not indicate wetland areas within the boundary of the lower pond; however it is shown as open water. Since the areas are located within the boundary of the active pond and are founded on non-wetland type soils (ash), the potential for these areas to be considered wetland is low. As a precautionary measure prior to disturbance of these areas; however, Golder recommends an evaluation and consultation with the Corps of Engineers to discuss the vegetation and its exclusion from classification as wetlands.

6.2 Continued Use of the Upper Ash Pond

It is important to point out that the upper pond, although officially still permitted as a pond by the Virginia Department of Environmental Quality (DEQ), does not appear to qualify as a surface impoundment as defined in the proposed regulations. For the purposes of the proposed regulations, the upper pond appears to meet the classification for a *CCR landfill*. The only apparent requirements for continued use of a CCR landfill is to make the demonstration for unstable areas (§257.64) and place the demonstration on the publicly-accessible internet site. If this demonstration is unable to be made, the upper pond would be required to close within 5 years of the effective date of the regulations. A two year extension could be granted if no other disposal alternatives are available.

A closure plan has been previously prepared for the upper pond by GAI Consultants Inc. Based on Golder's knowledge of the existing closure plan, it generally meets the requirements in the proposed regulations; however some of the plan text may need to be revised to provide more detailed information to address certain specific requirements. A copy of this closure plan will be required to be posted on the publicly-accessible internet site. The estimated conceptual cost for the continued use of the upper pond is relatively small (**less than $50,000**) and **no schedule impacts** are anticipated.

6.3 Retrofit of the Lower Ash Pond

The lower ash pond meets the definition of a surface impoundment, and is therefore subject to the design criteria for existing surface impoundments (§257.71). In order to continue use of a surface impoundment, the following actions must take place:

Impoundment Retrofit:

- Demonstration for unstable areas (§257.64), certified by a professional engineer and posted on the operator's publicly-accessible internet site;
- Installation of a composite liner system, including dredging of CCR materials prior to liner placement;
- Development of the construction history and posting on the operator's publicly-accessible internet site;
- Development of and posting an emergency action plan (EAP) for the impoundment if it is determined to have a hazard potential rating of *high* or *significant*; and,
- Installation (or upgrade, if necessary) of a groundwater monitoring system.

Operating Criteria (§257.80 – §257.100):

- Fugitive dust and control plan: controls in place so that fugitive dusts do not exceed 35 µg/m^3;
- Stormwater management design to control run-on and run-off from the 25-year, 24-hour storm event;
- Surface water discharge permitting (NPDES);
- Inspections: 1 per 7 days by operating personnel, 1 per year by professional engineer;
- Recordkeeping (listed in §257.84.b.1 – b.7);
- Groundwater monitoring (semi-annual sampling); and,
- Preparation of a closure plan and post-closure care plan.

Several of the items in the above lists have prescriptive deadlines as to when they must be in place in order to continue operation of the impoundment. All durations are given as from the effective date of the regulations (EDR).

On or *before* EDR:

- Prepare and post the Closure and Post-Closure Care plans

1 year from EDR:

- Install groundwater monitoring network
- Begin groundwater monitoring to establish statistical background

5 years from EDR:

- Existing surface impoundments retrofitted in accordance with regulations; or,
- Surface Impoundments not destined for continued operation must be closed; however a two-year extension is possible.

The retrofit construction for the lower ash pond would likely be divided into two construction phases to retrofit approximately one-half of the pond at a time to allow continued operational use during construction. An earthen division berm would be installed at the approximate mid-point of the pond to divide the pond in half to allow continued operations and retrofit construction to take place at the same time. Once divided, the non-operational half of the pond would be drained of free liquids, dredged of ash materials, and a bottom liner constructed.

Pumping of the free liquid from the pond is feasible with normal self priming diesel powered centrifugal pump sets. Given the volumes of free water involved, it is anticipated that trailer or skid mounted pumps would be required for this application, in the 8 to 12-inch size range. The water pumped from the pond may require treatment prior to release to meet VPDES permit conditions, and a conceptual cost of $0.02 per gallon for treatment has been included. Pumping the initial free liquid from the pond is estimated to take approximately 3 weeks to complete. After removal of the free liquid in the pond, continuous dewatering would be required for the duration of the project to collect the water that infiltrates the pond from the outside (groundwater inflow).

After dewatering, the ash material in the pond would be dredged from the pond using either a hydraulic dredge and/or conventional earthmoving equipment. The material would be excavated and placed in the disposal contractor's area for gravity dewatering prior to hauling to the upper pond. The rate at which the ash would be excavated would likely exceed the normal operational rate of ash excavation, so a larger dewatering area would be needed. Given that normal pond operations would be continuing as well, the overall dewatering area would likely need to be at least three times the normal area size. An alternate to gravity dewatering would be the installation of a mechanical dewatering system; however this would add a substantial cost to the project. Ash excavation is estimated to take 10 to 15 weeks per phase to complete. Dewatering and hauling of the material would take an additional 4 to 6 weeks after the completion of dredging.

Following removal of the ash, it is likely the pond floor would require dewatering, excavation, and stabilization to provide an adequate surface on which to work and to support the liner system. The nature and extent of the floor stabilization requirements would need to be explored during the design phase; however a base assumption of the foundation improvements to be made has been included for budget and schedule purposes. The existing pond floor soils would likely need to be removed and replaced with competent material (and possibly reinforcing geosynthetics) capable of providing a suitable construction base for the liner system and support of future loads. For this conceptual estimate, Golder assumed four feet of unsuitable material would need to be removed and then replaced with competent material. Additionally, a dewatering network would likely need to be installed to keep groundwater out of the construction area. Finally, additional stabilization may be required with reinforcing geosynthetic materials such as geogrid or in-situ soil mixing where a cement or other binder material is mixed into the soils to create a stronger material.

The composite liner system specified in the proposed regulations is very similar to that seen in a Municipal Solid Waste (MSW) landfill and the techniques to install it are well known and practiced in the waste industry. At this time, it is unclear whether or not alternative liner systems other than that specifically addressed in the proposed regulations will be allowed. From the top down, the regulatory-prescribed liner system components are:

- Geomembrane (minimum 30 mil thick or 60 mil if HDPE)
- Leachate collection system (likely a geonet composite material)
- 24" compacted clay (hydraulic conductivity (k) < $1x10^{-7}$ cm/s)

Once the first half is constructed, the presumption is that a Certificate to Operate (CTO) would be required from the Virginia DEQ before operations could commence in the newly-constructed, lined pond area. Following successful receipt of the CTO, the division berm would be removed and moved on top of the newly-lined section, allowing enough room to tie the two bottom liner systems together. The ash sluice lines would be diverted into the newly lined section and the construction process would begin again until the entire pond was lined. Golder presumes that an on-site construction manager and Construction Quality Assurance (CQA) consultant would be on site for the duration of the project. For the two-phase construction sequence outlined above, Golder estimates concept-level costs of **$30,500,000** with an engineering and construction duration of approximately **30 to 36 months**.

6.4 Operational Requirements

The operational requirements for a retrofitted surface impoundment are detailed in §257.80 - §257.101 and have been outlined previously in section 6.3. Golder's concept-level opinion of annual cost for operating the surface impoundment, over and above the ash management costs, is approximately **$100,000 per year**. This cost includes weekly inspections by operating personnel, an annual inspection by a professional engineer, semi-annual groundwater monitoring, and maintenance of the required data on the publicly-accessible internet site.

6.5 Summary of Continued Use Evaluation

The upper pond meets the classification for a CCR landfill as defined in the proposed regulations. Following a successful demonstration for unstable areas, Dominion should be able to continue to use the upper pond for the remainder of its design life at minimal additional cost. The lower ash pond would require a retrofit to install a bottom liner system, with a conceptual estimated cost of **$30,500,000** and a project duration of approximately **30 to 36 months**. Operational costs of the retrofitted lower pond are estimated at an additional $100,000 per year to cover required inspections, groundwater monitoring and reporting. Due to potential changes in water discharge standards expected to be promulgated by the EPA in the near future, continuing to use the lower pond for CCR slurry operations represents a potentially large financial risk should the entire discharge volume from the pond require treatment to meet new and more stringent discharge limits.

7.0 ASH POND CLOSURE

If either pond at the Chesterfield station is selected for closure rather than continued use, there are schedule requirements included in the proposed regulations. The pond will be required to be closed no later than 5 years after the effective date of the regulations. The deadline for closure may be extended for up to two years if a demonstration can be made that there is no available alternate disposal capacity and there is not an immediate threat to human health or the environment. An additional and more stringent requirement is for the closure activities to begin no later than 30 days following the last known final receipt of CCR, and closure activities must be completed in accordance with the closure plan within 180 days following the start of closure activities.

Due to the inherent wet nature of CCR in ponds and the large size of these ponds, the 180-day requirement appears to be unreasonable and potentially impossible to meet. Golder's conceptual construction estimates, as discussed further in sections 7.2.1 and 7.2.2, range from 18 to 42 months for completion. Handling of water before and during construction consumes a significant portion of time for these projects. Once sufficiently dewatered, construction of the closure cap section is anticipated to take at least 6 months due to the large acreages and volumes of soil involved. Golder's recent experience with construction of similar closure cap systems on dry landfills has shown to have taken from 6 to 8 months to complete, depending on size.

7.1 Upper Ash Pond

For the purposes of the proposed regulations, the upper pond appears to be classified as a *CCR landfill*. Pending a positive evaluation of the siting requirements, the upper pond most likely can continue to be used to the end of its design life (approximately 2018) with little or no modification. A closure plan has been previously prepared for the upper pond by GAI Consultants Inc. Based on Golder's knowledge of the existing closure plan, it generally meets the requirements in the proposed regulations; however the text of the plan may need to be revised to provide more detailed information to address certain specific requirements. Closure of the upper ash pond would entail the construction of approximately 112 acres of final cap. Closure of the upper ash pond is not included further in the scope of this evaluation due to the 2018 timeframe for closure.

7.2 Lower Ash Pond

If not chosen for retrofit and continued use, Closure of the lower ash pond will be the last step in the overall CCR modifications at the station.

Under the proposed EPA rules for disposal of CCR, 'Corrective Actions' will be imposed on station owners and operators of surface impoundments in the event that offsite impacts to groundwater and surface water occur. Given the proximity of the lower ash pond to groundwater and surface water, and the fact that it does not have a base liner system, the potential risk for off-site impacts is presumed to be high. The potential costs arising from future corrective actions have not been evaluated for this project.

To evaluate the risks to groundwater and surface water that may arise from closure of the impoundments either with the CCR left in place, or through clean closure, it will be important during the design phase to undertake a thorough geologic and hydrogeologic investigation of the pond. This will be necessary to understand the depth to groundwater and its seasonal variation, the hydraulic gradients beneath and beyond the immediate vicinity of the pond, and the different groundwater flow regimes. The head differences between the impounded CCR and the groundwater, and the degree of hydraulic connection between the pond and the groundwater will also need to be evaluated. A description of each closure method follows; however the selection of a closure method cannot be definitively recommended at this time. Before a recommendation can be made, Golder recommends an evaluation of closure methods after the initial rounds of groundwater monitoring have been completed in order to better understand the direction and magnitude of possible off-site impacts.

7.2.1 Clean Closure

A clean closure, as presented in §257.100, involves the removal of CCR material from the surface impoundment and removal and/or decontamination of "all areas affected" by releases from the CCR impoundment to meet the state-specific numeric cleanup levels for constituents found in CCR. Two conceptual end states of a clean closure at the Chesterfield lower pond would be to leave the site as an open area after excavation, or reclaiming the area to a "dry land" condition. Leaving the pond area as an open pond would likely fill with water and become a shallow pond level with the surrounding river. Filling the area with soil would require additional permitting and importing approximately two million cubic yards of clean fill material.

The proposed list of constituents found in CCR or that may be affected by a release of CCR to the environment is presented in Appendices III and IV to §257 (proposed regulations). Based on Golder's experience with similarly written regulations for Resource Conservation and Recovery Act (RCRA) corrective action sites, Golder interprets "affected areas" to include both soil and groundwater containing concentrations of constituents found in CCR above the following numerical cleanup levels or documented background (i.e., upgradient and/or naturally occurring) concentrations, whichever is higher:

Groundwater: Virginia Solid Waste Management Regulations Groundwater Protection Standards (based on background concentrations, EPA Maximum Contaminant Levels, or Virginia Department of Environmental Protection Alternate Concentration Limits); Groundwater Protection Standards have not been established by the DEQ for the full list of proposed groundwater monitoring constituents for CCR surface impoundments, but are expected to be established upon implementation of the proposed regulations.

Soils: Environmental Protection Agency Regional Screening Levels (RSLs) for industrial / commercial soils or background concentrations are expected to be appropriate numeric cleanup levels for "affected" soils. The use of industrial / commercial RSLs is a risk-based approach, and would need to be coupled with institutional controls mandating continued industrial / commercial land use (e.g. deed restriction). Furthermore, if groundwater is affected by a constituent above the Groundwater Protection Standard, removal of affected soils to the RSL for soil-to-groundwater leaching would be appropriate, as practicable, to further protect groundwater quality.

Concept-level tasks, costs, and durations for clean closure of the lower ash pond based on existing information are provided as follows:

1. <u>Removal of CCR materials and soils located above the elevation of the water table:</u> Golder understands that CCR materials are likely present to the base grade of the impoundment and affected soils are likely present to the depth of the pre-impoundment water table, at a minimum, over the entire footprint of the lower ash pond. Due to the former presence of the James River within a portion of the lower ash pond, the depth of the pre-impoundment water table is conservatively estimated to be the average elevation of the James River, approximately 3.5 feet above mean sea level. Based on Golder's experience with other remedial actions for soil under RCRA, the removal of CCR materials and soils above the water table constitutes clean closure for affected soils.

   Golder understands that the upper ash pond has sufficient available volume for the placement of excavated materials from the lower ash pond. Sampling of side-walls within the excavation will be required to confirm lateral remediation to the soil clean-up standards.

   Anticipated best case: clean closure and leave area as open pond:

   Cost: **$15,270,000**

   Duration: **18 Months**

   Alternate case: clean closure and provide fill material to restore to useable land:

   Cost: **$25,070,000**

   Duration: **38 Months**

2. <u>Groundwater monitoring:</u> Potentially affected groundwater in the region of the lower ash pond will be monitored using the existing groundwater monitoring network. In addition to this network, it is anticipated that groundwater monitoring at up to five locations within the former footprint of the lower ash pond will be required to demonstrate clean closure with respect to groundwater. Using this monitoring

network, Golder anticipates that up to three years of semi-annual monitoring for the proposed list of constituents presented in Appendices III and IV of the proposed regulations (§257) will be required to demonstrate that groundwater has not been affected by CCR constituents. Semi-annual evaluations of groundwater monitoring results and reporting will be required. If applicable, a report requesting state approval of the clean closure activities and termination of groundwater monitoring will be required at the end of the anticipated three-year monitoring period.

Cost: **$110,000**

Duration: **3 Years**

The tasks and costs presented represent minimum efforts required for clean closure of the lower ash pond. An evaluation of existing groundwater data for analytes presented in Appendices III and IV of the proposed regulation, as compared to current or anticipated Groundwater Protection Standards and site-specific background concentrations, may provide an up-front determination of the feasibility of clean closure of groundwater without corrective actions triggered by potential exceedances of cleanup levels. Potential groundwater remediation for CCR constituents and associated corrective action monitoring, if required, is expected to be a long-term effort, diminishing the potential benefit of a clean closure effort relative to in-place closure of the lower pond.

Clean closure of the lower pond in approximately 2014 would consume volume in the upper pond such that it would reach design capacity grade approximately mid-2017, at least a full year in advance of the timing currently planned for the opening of the new landfill facility. While not a certain fatal flaw, it would require an advancement of the landfill schedule to accommodate it. Additionally, clean closure of the lower pond without the alternative of filling the pond would eliminate the possibility of use of the 98 Dominion-owned acres for future projects.

7.2.2 Closure With Wastes in Place

With a material such as CCR, closure in place involves a significant effort to dewater and stabilize the waste mass so that it will be stable and support the final closure cover. *In-situ* solidification of the entire ash body is considered impractical and unfeasible; however, targeted solidification measures may be considered to enhance the overall stability of the ash body. Due to the low height of the lower ash pond, *in-situ* solidification was not evaluated for this project. A thorough pre-design evaluation is recommended during initial closure planning to identify potential stabilization needs early. The general sequence of events for closure with the wastes in place is as follows:

- Removal of free liquids;
- Stabilization of the ash body surface;
- Installation of seepage collection system(s);
- Installation of slurry wall containment (if needed);
- Grading and shaping of ash surface for drainage; and,

- Installation of the final cover system.

Pumping of the free liquid from the pond is feasible with normal self priming diesel powered centrifugal pump sets. Given the volumes of free water involved, it is anticipated that trailer or skid mounted pumps would be required for this application, in the 8 to 12-inch size range. The water pumped from the pond may require treatment prior to release to meet VPDES permit conditions and an allowance of $0.02 per gallon for treatment has been made in the conceptual cost estimate. Pumping the initial free liquid from the pond is estimated to take approximately 3 to 5 weeks to complete.

7.2.2.1 Stabilization of the Waste Surface

Following removal of the free liquids from the pond, the ash body will require dewatering to the extent needed to provide a firm, safe and trafficable surface on which equipment can be deployed for the construction of the closure cap system. To achieve a stable surface, it is anticipated that the water table within the impounded CCR would need to be lowered by about 5 feet below the surface. If the ash properties are particularly favorable (e.g. high angles of shearing resistance, pozzolanic effects, or better drainage if bottom ash layers are present), then this level may be less.

Working platforms with low ground pressure equipment

If the water table in the impoundment is sufficiently low then it may be possible to progress with cap construction without significant additional dewatering. This would require pushing out common fill into the impoundment along several working platforms. Each platform might be 12 feet in width initially, and perhaps 3 to 5 feet in thickness. This material would be pushed out using low ground pressure (LGP) equipment, typically D6 dozers. A plan arrangement of these platforms may take the form of a 'spider web' pattern, radiating out from equipment turnaround pads at select locations. In this way, access to the entire impoundment surface could be progressed, with the final cover system construction commencing from the working platforms.

Typical production rates for a D6 LGP dozer working in this manner are low, perhaps as low as 1,500 cubic yards per day. Even so, at this kind of production rate, the equipment is likely to quickly 'out-push' the available dry and stable areas, so multiple rim ditch and sump arrangements may be needed (see below). Large volumes of imported common fill may be required, at a conceptual cost of $5/CY (placed) to establish the working surface upon which to construct the final cover system.

Rim ditches and sump pumping

With relatively new ash deposits or those under constant submergence, the need for dewatering is inevitable while working in conjunction with working platforms with LGP equipment. Dewatering may be achieved by excavating trenches (also known as rim ditches) that would drain seepage waters to strategically located sumps. The sumps would probably be outfitted with a perforated standpipe, wrapped in geotextile, and with a free draining aggregate collar surround. Centrifugal pumps in the 6-inch to 8 inch size range would be required to continuously pump from the sumps. Depth, width and spacing of the rim ditches and sumps would depend greatly on the properties of the site specific CCR. If the ash surface has significant free liquids and unstable areas that are not trafficable, then crawler cranes working from the impoundment crest roads using clam shell buckets could be deployed to establish an initial drawdown area around the perimeter of the pond. From here, work would then progress from the outside perimeter towards the center of the pond using LGP equipment.

Surface stabilization with additives

Another expedient that may be used to enhance the bearing capacity of the wet unstable ash surface is to scarify in dry ash or lime. This approach is likely to be more effective than spreading wet material into windrows and waiting for it to dry because that is highly weather dependent and typically proceeds slowly. If it is not possible to scarify in material with a tractor pulled disc or harrow, then an alternate means is to use multiple ripper attachments on an LGP dozer to track in the additive. As stability improves, heavier larger equipment can be deployed (e.g. D7 or larger dozers) to increase productivity.

Dewatering systems

There are a variety of alternate positive dewatering methods available to lower the water table within the impounded CCRs to facilitate cap construction, and these include vacuum well points, deep wells and horizontal drains connected to vacuum pumps. Fly ash has been successfully dewatered previously using well point systems. Powers *et al*. (2006) summarized the case history documented by the Pennsylvania Electric Company (1985) in a report for EPRI that that was performed by Moretrench Corporation. Jetted-in wellpoints were used to dewater a fly ash lagoon sufficiently such that front end loaders could operate on the ash. This involved a water surface drawdown within the ash in the order of 3 to 5 feet. Powers *et al*. (2006) stated that:

"*Loose saturated material in the lagoon of Fig. 19.41 was too sloppy to be hauled in trucks before treatment. One could walk on the material only by means of plywood. After treatment with the vacuum well point grid, the ash was firm enough to be excavated on a near vertical slope…*"

Well points are typically spaced at about 5 to 10 feet on centers, each connected into a header system which is joined to a vacuum pump system. On the Pennsylvania Electric Company lagoon, rows of well points were deployed spaced in the order of 80 feet apart across the surface, with individual well points spaced approximately 5 to 10 feet on centers along each row. The rows of well points were connected to a perimeter header system with vacuum pumping arrangements and achieved a drawdown of about 3 to 5 feet within one month of operation. For a typical 50 hp well point system, unit costs for installation may be estimated at about $100 per linear foot of header, with running costs at about $6,000 per week. For deep ash deposits requiring excavation ('clean closure") then it can be expected that multiple levels of well points may be required. An alternate to this multiple stage well point system for deep ash deposits would be to install deep wells or ejectors.

Conceptual cost estimates for the surface stabilization can vary widely, based on the geotechnical analysis of the ash body, age, water content, and choice of stabilization method. For the purposes of this evaluation, installation of a well point system at 100-foot line spacing was considered. In the case of the lower pond, approximately 40,800 linear feet of header would be installed. The system would need to be operated from the time of installation through construction of the final closure system in order to maintain stability during construction activities. Water recovered from the system would likely require treatment prior to release. A conceptual cost of **$4,100,000** has been established to install the system, and a conceptual operating cost of **$2,300,000** for the duration of construction (approximately 24 months). Water treatment costs were estimated at $0.02 per gallon. The schedule for installation of the dewatering system is highly dependent on the ash condition and methods employed by the contractor. A base duration of **8 weeks** has been established for conceptual scheduling, knowing that once an area has begun to stabilize, other work can progress while the dewatering installation continues elsewhere.

7.2.2.2 Installation of Seepage Collection

If, following subsurface exploration and hydrogeologic evaluation of the pond site, it is determined that conditions are favorable for a closure in place, a significant engineering challenge remains in controlling seepage of the leachate from the ash body over the long term post-closure care period. No matter how effective the construction dewatering is during the cap construction period (be it by rim ditching and sump pumping, or wellpoints), it is unlikely to remove significant volumes of water from the body of the ash. Some form of seepage collection system is therefore recommended and likely to be required by the regulatory agency within the overall closure design.

The elements of a seepage collection system for capture of leachate from within the body of the CCR impoundment over the 30 year post-closure care period would be subject to subsurface exploration, design and analysis. At this stage it is only possible to discuss the type of design components in very general terms, because much will depend on the following factors:

- Permeability characteristics of the CCR which will be different depending on the mix of fly ash, bottom ash, slimes, and boiler slag;
- Effective porosity (specific yield) of the CCR that governs how much interconnected pore space there is for water to drain out under gravity;
- Degree of layering (anisotropy) of the CCR that is governed by the pond specific history of hydraulic filling;
- Impoundment geometry (berm heights, perimeter lengths, slope gradients, plan area, distance to water treatment plant;

- Hydrogeologic conditions in the foundation; and
- Surface water drainage conditions at the toe of the impoundments.

A seepage collection system might include geosynthetic panel drains that comprise sheets of geocomposite drainage net with integral collection pipes at the bottom edge. Panel drains provide a means by which to lower the water table within the impoundment, enhancing slope stability and helping to mitigate the risk of seepage 'break-outs' on the side slopes or toe of the final cover.

Panel drains are placed vertically in trenches excavated into the CCR body from temporary benches by hydraulic excavators or possibly trenching machines. The excavated trenches might be up to 15 feet deep by two feet wide. Slotted flexible pipes can be sewn into the bottom of panel drains, forming a 'sheet drain' to capture liquid from the drainage nets. Flows are then conveyed to collector drains and so called 'down-drains' that would be located at intervals around the impoundment. This kind of arrangement would also require cleanout risers at various locations for maintenance (e.g. hydro-blasting to clear blockages) and inspection purposes (e.g. video camera surveys). Down-drains typically connect into a perimeter drain system around the toe or lowest point of the impoundment. Flows from the perimeter toe drain are routed to a permanent sump pump station, and then to a wastewater treatment plant prior to discharge.

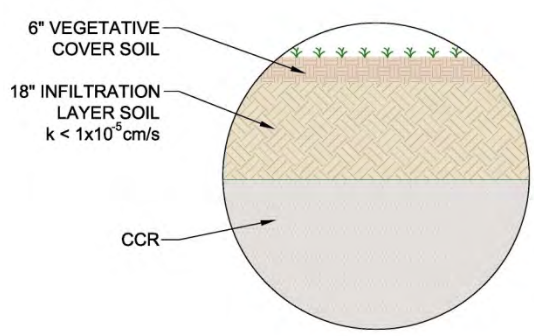
A significant issue arising from installation that needs careful consideration during the design phase is constructability. Loose, wet fly ash typically does not stand unsupported in excavations. The material readily takes in water, but does not release it easily. When disturbed during excavations and under the equipment loads, it turns into a relatively loose, flowable slurry. Unsafe cave-in conditions and equipment stability need to be addressed in a proactive and preemptive manner during design and construction. Dewatering by vacuum assisted well point pumping adjacent to excavations to facilitate drain installation is likely to be required and may be a significant extra cost to be factor into the planning for long term seepage control.

Estimating the schedule duration for installation of a seepage collection system is possible only on a conceptual basis with the limited information currently available. Based on engineering judgment, it is suggested that a period of between 12 and 18 months may be required for construction of a seepage collection systems for closure of ponds in the 100-acre size range. At this strategic planning stage, a conceptual cost estimate for a seepage collection system was developed based upon unit rates that have been developed from an impoundment closure project in 2005 in the southeastern USA, escalated to 2010 prices using ENR Construction Cost indices. For conceptual planning, unit costs of $13,500 per acre, or alternatively $85 per linear foot of drainage system installed are suggested. For the lower ash pond, a conceptual cost for the installation of a seepage collection system based on 98 acres is $1,350,000 and would take approximately one year to install. This conceptual cost does not include the previously-discussed costs that are likely to be required for well point dewatering in the CCR body to facilitate installation of drains.

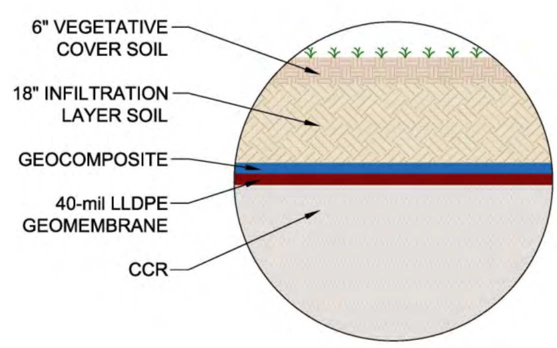
7.2.2.3 Closure Cap Construction

Once the CCRs are stabilized and prior to placement of the final cap, the surface of the CCR will be shaped to promote positive drainage and prevent infiltration of precipitation. Additional fill material will be needed to adjust the top of the pond from a relatively flat surface to one containing slopes of 2% or more for drainage. The initial as-constructed slope may be steeper than 2% depending on the amount of settling that is anticipated. The goal is have a post-settlement slope of at least 2%. For the lower pond, an estimate of 5,000 CY/acre was used for material import.

The final cap system is required to have a permeability (k) of $1x10^{-5}$ cm/s or be less than the bottom liner system, whichever is less permeable. Since the lower ash pond is unlined, a soil-only cover system consisting of 6-inches of vegetative support soil and 18-inches of soil (k < $1x10^{-5}$ cm/s) would meet the minimum requirements. The final cover could also be constructed with geosynthetic components to decrease the permeability of the system, or if sufficient quantities of suitable soil are not available. However; the cover system would still likely require 24 inches of soil cover to protect the geosynthetic materials. Regulatory approval of an exposed geomembrane cover in Virginia is uncertain. Stormwater run-on and run-off controls will be designed to adequately convey the 25-year, 24-hour storm at a minimum. Two typical closure cap sections are shown below.



Soil Only Cap



Geomembrane Cap

Golder strongly recommends the cap section containing the geosynthetic materials, as they provide permeability up to 5 orders of magnitude less than the soil-only systems. A significant decrease in infiltration and consequently an increase in groundwater protection can be had for a relatively small increase in cost. For the dewatering and closure cap construction sequence outlined above, Golder estimates concept-level costs of **$29,977,050** with engineering and construction duration of approximately **28 to 32 months**. This conceptual cost includes construction of the slurry wall.

7.3 Recommendations for Ash Pond Closure

Golder recommends the following course of action:

- Continue to close the upper pond per the progressive closure plan;
- Continue to permit a new CCR landfill;
- Request a two-year extension for closure of the lower pond; and,
- Close the lower ash pond **in-place** when other infrastructure has been completed.

The upper pond should be available for continued use under the proposed regulations, pending a successful demonstration for unstable areas. Golder recommends closing the lower pond in place rather than a clean closure for the following reasons:

- Closure in place is more clearly defined in the proposed regulations and is less open to interpretation as to what constitutes “clean closure”;
- No additional space in the upper pond closure will be consumed;
- Post-closure uses could be incorporated into the design, freeing up useable space at the station for future use; and,
- The conceptual schedule for in-place closure of the lower ash pond is approximately **30 months**, which is 12 months shorter than clean closure.

Golder recommends **against** clean closure of the lower pond for several reasons:

- The hydrogeological conditions in the lower pond are strongly influenced by the James River and the presumed risk of offsite contaminant transport is high, which may increase the monitoring and excavation costs beyond this conceptual estimate;
- Clean closure is not assured; the risk exists that contaminants have spread beyond the pond boundary and would be very difficult, if not impossible, to remediate;
- Clean closure would consume much-needed airspace in the upper pond, shortening its life by approximately 1.5 years, which would then require advancing the landfill schedule to accommodate;
- The base clean closure construction of the lower pond would result in a 98-acre (±) open pond. To return the land to useable condition, the import of nearly 2 million cubic yards of fill material would be required; and,
- To restore the land to useable condition, the conceptual cost is estimated at **$25,180,000** and would take approximately **42 months** to complete.

8.0 CONSEQUENCES OF POND CLOSURE

Closing the lower ash pond would trigger two additional significant changes at the Chesterfield Station. First, the station would be required to change the ash and pyrite handling systems to dry systems, and second, the 5 MGD of "other plant waters" would require a treatment process prior to discharge.

8.1 Dry Ash Handling

In a study completed in 2009 for the conceptual design and preliminary opinion of cost for a wet to dry ash handling system conversion, Golder presented the conceptual project scope, schedule and costs to retrofit the ash handling systems at the Chesterfield Station. Dominion F&H Projects applied other costs and scheduling factors to the project and prepared the final deliverable. This study is titled "Chesterfield Dry Ash System Installation" and an abbreviated version of the study is included in Appendix B. Readers are encouraged to reference the complete study for more detail. A synopsis of the study is presented here.

At various points in the station, the ash and pyrite handling systems will be intercepted and the flow diverted to a new system. Bottom ash from units 3 through 6 would continue to be collected and transported as a wet slurry, but be directed to a small transfer tank and then to dewatering bins to allow the sluice water to drain from the bottom ash. The pyrite transfer system will also continue to collect and transport the pyrite wet, and it will be directed to a separate dewatering bin for sluice water removal. The collected sluice water from the dewatering bins would be clarified and returned for reuse in a closed-loop water system for sluice water. The dewatered bottom ash and pyrites will be collected for loading into trucks or other transport for disposal or reuse.

The fly ash system will be modified to collect and transport the fly ash from the existing baghouse, ESP and economizer hoppers to new transfer hoppers. The fly ash will be conveyed pneumatically to new ash silos for storage. From the silos, the ash can be moisture conditioned if needed for open-truck transport, or loaded into tanker trucks dry for reuse.

The concept-level capital cost for the implementation of the dry ash conversion at the Chesterfield Station has been established at approximately $**65 million** and will take approximately **42 months** to complete. A cost-loaded schedule of the dry ash conversion project is presented in Appendix A.

The estimated annual O&M cost for the dry ash handling system as described is **$1,042,144** per year. This cost includes:

- 2 Full Time Equivalent (FTE) operators/maintenance staff at $100,000 each;
- Electrical usage at $0.02 per kWh; and,
- Maintenance.

8.2 Waste Water Treatment Plant (WWTP)

The lower ash pond serves as the receiving body for the bulk of non-cooling water related discharges from the station. A large quantity of water comes from the station master sump, which serves as the central collection point for stormwater, low volume wastewaters (floor drains, blowdowns, WWTP effluent, bearing cooling water, etc.). Additional sources of inflow for the lower ash pond include discharges from the coal pile runoff pond and the metals cleaning [neutralization] pond.

The station's Virginia Pollution Discharge Elimination System (VPDES) permit includes monitoring of the outfall of the lower ash pond (Outfall 004) for the following parameters:

- pH
- Total Suspended Solids (TSS) 3 0 mg/L avg, 100 mg/L max
- Oil and Grease 15 avg, and 20 mg/L max
- Total Phosphorus 2.0 mg/L
- Total Nitrogen NL (no limit)
- Dissolved Oxygen NL (no limit)
- Ammonia 13 avg, and 19 mg/L max
- Total Organic Carbon 110 mg/l max
- Whole Effluent Toxicity (WET) 50 TU_C

Historically, the volume of water and settling time provided by the lower ash pond has provided sufficient water quality at the outfall to consistently meet the permit limits. Closure of the pond will have a significant impact on the dilution and biological processes that contribute to a compliant discharge, and will likely prevent the discharge of most or all of these waters without some form of treatment. In addition to the above-listed constituents, future discharges may be subject to monitoring for additional parameters such as the metals manganese and selenium, with discharge limits as low as 50 and 5 parts per billion (ppb) respectively.

For development of the conceptual treatment process for these waters, Golder proposes a two-stage process. The first stage consists of gross solids removal and primary treatment to remove contaminants listed in the current permit. A second stage treatment process would then follow, targeting specific metal constituents in anticipation of the future discharge limits.

The lower pond currently receives wastewaters from the following sources:

- fly ash, bottom ash, ash haul truck wheel wash;
- compressor cooling tower blowdown;
- evaporator blowdown;
- bearing cooling, floor and roof drains;
- boiler blowdown;

- miscellaneous house service;
- demin wastewater, and water treatment plant blowdown;
- coal pile runoff;
- non-chemical cleaning waste;
- metals pond (consisting of chemical cleaning metal waste and lime slurry waste); and,
- stormwater runoff and tank contaminants from area 4, stormwater from unit 6 master sump system, and stormwater from areas 10 through 14.

The pond also functions as a sedimentation pond for plant wastewater. With 5 MGD in ash sluicing water uses terminated, the pond would need to be replaced with a wastewater treatment system of similar function, but at a new reduced flow rate of 5 MGD based on flow rate estimates from the "One Line Diagram, Station Water Flow Chesterfield Power Station" drawing number CH-VPDES-0004146-001. Golder understands that the Chesterfield Power Station is in compliance with the existing limits listed above. The new proposed primary wastewater treatment system is designed to achieve continuous compliance with pH and TSS limits, and will provide incidental treatment for O&G, as well as TOC. Compliance is assumed for O&G, TOC, as well as Ammonia, so unit processes have not been included in the design for these parameters. If there is a history of non-compliance with these additional parameters additional unit processes may be required.

8.2.1 Flow Reduction and Elimination

Prior to design and construction of a wastewater treatment plant, Golder recommends evaluation of the wastewater flows to identify potential methods to reduce the volume of flow to a new WWTP. Given the high unit costs for treatment that may be required, significant savings in both capital construction costs and long-term Operations and Maintenance (O&M) costs can be realized by such an evaluation. An evaluation of the plant's water use and the processes that produce wastewater should be conducted. Emphasis should be placed on identifying wastewater flows that could be segregated out and undergo only primary treatment and not a more expensive secondary or tertiary treatment. Water reuse opportunities could also be a target of this evaluation to identify sources of water that could be used again within the station.

8.2.2 Primary Wastewater Treatment

The sequence of unit processes and equipment to provide the primary level of wastewater treatment for discharge in accordance with the existing permit will include the following:

1) Remote control system;
2) Pump stations at Metal Pond (2.7 MGD), Master Sump (1.7 MGD), and Coal Pile (1.1 MGD);
3) Equalization Tank of 1 million gallons capacity (with a remote control storage and bleed system to provide less variation in flow to the treatment process);

4) pH adjust tanks, mixers, and controls (with sulfuric acid and sodium hydroxide reagent day tanks and bulk holding tanks);

5) Coagulant addition with rapid mix;

6) Polymer feed with flash mix, and slow mix agglomeration;

7) Lamella style clarifiers with sludge thickener tanks (assuming 500 mg/L TSS after pH adjustment, due to metals precipitation and solids in the source waters, especially coal pile and ash landfill area runoff);

8) Concrete foundations and metal building.

A list of systems and equipment for primary wastewater treatment is shown on Table 4. Sludge dewatering is omitted as facilities are assumed to already exist at Chesterfield Station for sludge storage in ponds and periodic dewatering.

8.2.3 Secondary Wastewater Treatment

Secondary wastewater treatment may become necessary following issuance of new effluent limitations guidelines for metals, including manganese and selenium. Removal of manganese and selenium to 50 and 5 ppb, respectively, will require the addition of two distinctly different treatment process trains. Treatment for manganese will require integration with the primary treatment process, as follows:

1) Oxidant feed system and reaction tank with 30 minutes hydraulic retention time;

2) Larger caustic feed system to raise pH to 10.5 for manganese removal;

3) Enlarge pH adjustment tank to provide 30 minutes retention time;

4) Substitute for or replace lamella clarifiers (depending on timing of the installation of primary and secondary treatment facilities) with conventional circular, solids contact clarifiers;

5) Add sludge thickening tankage (increase solids content to 5%) to reduce sludge volume going to existing on-site sludge handling system, assumed to include ponds;

6) Multi-media filters for polishing of particulate manganese removal; and

7) pH adjustment tank and sulfuric acid feed system to reduce pH into the 6 to 9 range (target will be 7.5 to 8.0).

Removal of selenium will occur downstream of the manganese removal filters because selenium is removed to meet the low limit of 5 ppb using an anaerobic process that would re-solubilize any residual manganese not removed from the clarifier effluent upstream. The selenium treatment process will include the following treatment processes:

1) Storage and feeding system for a carbon source, such as molasses;
2) Modular anaerobic bioreactors for biological reduction of selenium, which deposits in the bioreactors, with modular tanks sized for 0.2 MGD of the wastewater flow;
3) Reaeration tanks, with 2 hours of retention time; and
4) Auto-backwashing screen filters for sloughed solids removal prior to discharge.

A list of systems and equipment for secondary wastewater treatment is shown on Table 5. The pH control tankage of the primary treatment process are replaced by larger mix tankage for addition of oxidant and caustic chemicals in the pH 10.5 treatment process for manganese removal. Also,, conventional solids contact clarifiers take the place of the lamella clarifiers.

8.2.4 Conceptual Budget and Schedule

The capital cost of the primary wastewater treatment system is dominated by the lamella clarifiers, with the following total capital costs:

TABLE 2

PRIMARY WASTEWATER TREATMENT

Item	Cost
Equipment Costs	$7,800,000
Building and Installation Costs	$9,000,000
Markups, Engineering and Contingency	$12,100,000
Total Primary Treatment	**$28,900,000**

The capital cost of the secondary wastewater treatment system reflects the expansion or replacement of major equipment and tankage from the primary treatment system in order to remove manganese at a high efficiency. Also, a major addition to the treatment plant, with a large additional space requirement, would be required for very high efficiency selenium removal. The following capital costs are estimated for secondary treatment for manganese and selenium:

TABLE 3

SECONDARY WASTEWATER TREATMENT

Item	Cost
Manganese Removal Capital Costs	$29,000,000
Selenium Removal Capital Cost	$72,000,000
Total Secondary Treatment	**$101,000,000**

The cost of selenium treatment is high because treatment of all 5 MGD of wastewater is assumed to require selenium removal treatment. If selenium treatment can be installed for a smaller subset of wastewater streams upstream where all wastewater is equalized in the equalization tank, then lower costs may be achievable. In the cost-loaded schedules, the Selenium removal capital cost is not included.

Including Selenium removal, the conceptual combined treatment capital cost for Chesterfield Station is approximately **$130 million**.

If secondary and primary treatment facilities are constructed concurrently, then a deduct of $19.0 million will be realized on the $29.0 million estimate for primary treatment, because the smaller chemical mixing tankage and lamella clarifiers indentified as adequate for compliance with the existing permit would not be constructed and then replaced in secondary treatment. Total capital cost in that instance would decrease to $111 million.

The implementation schedule for wastewater treatment will be controlled by long-lead times for some of the major equipment, such as the equalization tank, clarifiers and bioreactors, which would range from 7 to 10 months:

- Pre-engineering studies and Design – 7 months, plus 1 month overlap with Procurement
- Procurement of long-lead equipment – 10 months
- Construction (after delivery of long-lead equipment) – 5 months
- Startup and Commissioning – 2 months
- **Total implementation time – 24 months**

This schedule would be shortened by about 3 months if only primary treatment is implemented

8.2.5 Operations and Maintenance (O&M) Costs

The estimated annual O&M cost for the 5 MGD treatment system as described is **$1,402,000** per year. This cost includes:

- 1.5 Full Time Equivalent (FTE) operators/maintenance staff at $100,000 each;
- Electrical usage at $0.02 per kWh;
- Waste disposal for processed sludge;
- Chemical and other supply consumption; and,
- Maintenance.

8.3 Summary of Pond Closure Consequences

Closure of the lower pond cannot commence until both the WWTP and dry ash handling systems are in operation. Conceptual costs associated with the construction of the systems as described are summarized in Table 4 below:

TABLE 4

WWTP AND DRY ASH COSTS

Activity	Duration	Conceptual Cost
WWTP Construction - Primary	24 months	$28,900,000
WWTP Construction – Secondary*	(each)	$29,000,000
Dry Ash Conversion	42 months	$65,000,000
Operations and Maintenance	Annual	$2,444,144
Total		**$125,344,144**

* Capital cost for selenium treatment not included

In preparation for closure of the lower pond, Golder recommends starting of planning for a new WWTP and dry handling system at the Chesterfield Power Station. Potential activities that can be undertaken in advance of the effective date of the regulations include:

- Identify wastewater flows for reduction, reuse or those needing primary treatment only;
- Refine wastewater treatment processes, including bench-scale testing;
- Identification of dry ash handling systems;
- Work with potential vendors and contractors to secure capacity for upcoming projects; and,
- Identify and reserve areas at the station where each of these facilities could be built.

9.0 POST-CLOSURE CARE AND MONITORING

Following closure of a surface impoundment, Dominion will be required to provide post-closure care and monitoring of the impoundment for a period of 30 years. This 30-year period may be adjusted (up or down) depending on the nature of the impoundment and the continued protection of human health and the environment. The goal of the post-closure care program is to maintain the integrity of the surface impoundment closure systems (i.e. cover, leachate, groundwater, etc.) and provide monitoring of groundwater quality around the impoundment. Post-closure care activities are required for the option of closure in place. If a clean closure of the lower ash pond is pursued, this section will only apply to the upper pond.

9.1 Post-Closure Care Requirements

Requirements during the post-closure care period can be grouped into two major categories: systems integrity and monitoring. The final cover system constructed on the impoundment must be maintained to correct the effects of settlement, erosion, animal burrows, human activity, etc. The final cover drainage systems are of key importance, as failure of a stormwater system during a large storm event could damage large portions of the cover and allow contained materials to be exposed to the environment. Routine inspections and mowing of the vegetation will be required.

The seepage collection system will require periodic maintenance to ensure it continues to function and drain accumulated liquids from the ash body. Routine visual inspections of the leachate system and monitoring of the volume of flow will help spot potential problems before they develop into major issues. Treatment of the collected seepage is presumed to be at the station's on-site wastewater treatment facility, at a conceptual cost of $0.02 per gallon. The initial cost for treatment will be higher, but as less seepage is collected these costs are expected to decrease.

The groundwater monitoring network will require periodic inspection to ensure the wells are functional and in good repair. Damaged wells will need to be replaced and developed to continue the statistical background of the overall monitoring network. Monitoring of the groundwater network will be in accordance with the facility's approved groundwater monitoring plan. For this conceptual evaluation, Golder has assumed a semi-annual monitoring frequency and a standard baseline analytical program.

9.2 Conceptual Post-Closure Care Costs

Conceptual costs for the post-closure care period were evaluated using guidance from the Virginia DEQ relating to post-closure care of landfill facilities. The 30-year post-closure care period of the lower ash pond was presumed to start at the beginning of the 6th year (2016) in the overall project schedule; whereas the post-closure care period for the upper pond is presumed to start at the 9th year (2019). The costs for the upper pond are lower since there are no treatment costs for seepage collection included. Costs are shown in year 2010 dollars and are not escalated.

TABLE 5
CONCEPTUAL POST-CLOSURE CARE COST ESTIMATE (30-YEAR)

Pond	Begin Year	End Year	Annual Cost	Total Cost
Lower	2016	2036	$135,000	$4,050,000
Upper	2019	2049	$83,250	$2,500,000

10.0 OVERALL PROJECT CONCEPTUAL COST AND SCHEDULE

The conceptual project costs and schedules presented in this section are based on the following assumptions:

- Conversion to dry ash conveyances per the 2009 Golder study;
- Construction of an on-site wastewater treatment plant of approximately 5 MGD capacity;
- Closure of the lower ash pond in-place; and,
- Other regulatory-driven tasks (GW monitoring, posting of plans, etc.).

The sequencing of the projects is important, and mainly hinges on the functions provided by the lower ash pond. Both functions of the receipt of ash slurry and bulk wastewater treatment need to be replaced and in service prior to beginning closure of the lower pond. If closure of the lower pond is selected as the course of action, it will need to be completed within five years of the effective date of the regulations unless a waiver is granted for an extension. A conceptual overall project schedule has been developed for the Chesterfield station, and the estimated time required to complete all three major projects is approximately 5.5 years, or approximately 6 months longer than the anticipated regulatory required deadline. Either the schedule for these activities can be compressed, or an extension sought. Considering that the entire fossil power generation industry will be attempting to make these types of system changes in the same timeframe, Golder recommends seeking an extension as allowed in the regulations rather than attempting to compress the schedule.

TABLE 6
CONCEPTUAL PROJECT DURATIONS

Activity	Duration	End Date
WWTP Construction	45 months	3Q 2014
Dry Ash Conversion	42 months	2Q 2014
Lower Ash Pond Closure	30 months	2Q 2016
Total	66 months	

TABLE 7
COST-LOADED SCHEDULE

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Totals
WWTP Construction *	$11,431,250	$22,317,010	$17,567,330	$6,714,410	$ -	$ -	**$58,030,000**
Dry Ash Conversion	$2,606,751	$19,462,004	$36,592,263	$6,604,582	$ -	$ -	**$65,265,600**
Lower Ash Pond Closure	$ -	$ -	$ -	$9,435,288	$15,635,616	$4,906,146	**$29,977,050**
Other Regulatory Tasks	$39,900	$ -	$ -	$ -	$ -	$ -	**$39,900**
Additional O&M costs		$14,000	$14,000	$1,496,608	$2,458,144	$2,458,144	**$2,458,144 (annually)**
Total	**$14,077,901**	**$41,793,014**	**$54,173,594**	**$24,250,887**	**$18,093,760**	**$7,364,290**	**$159,753,446**

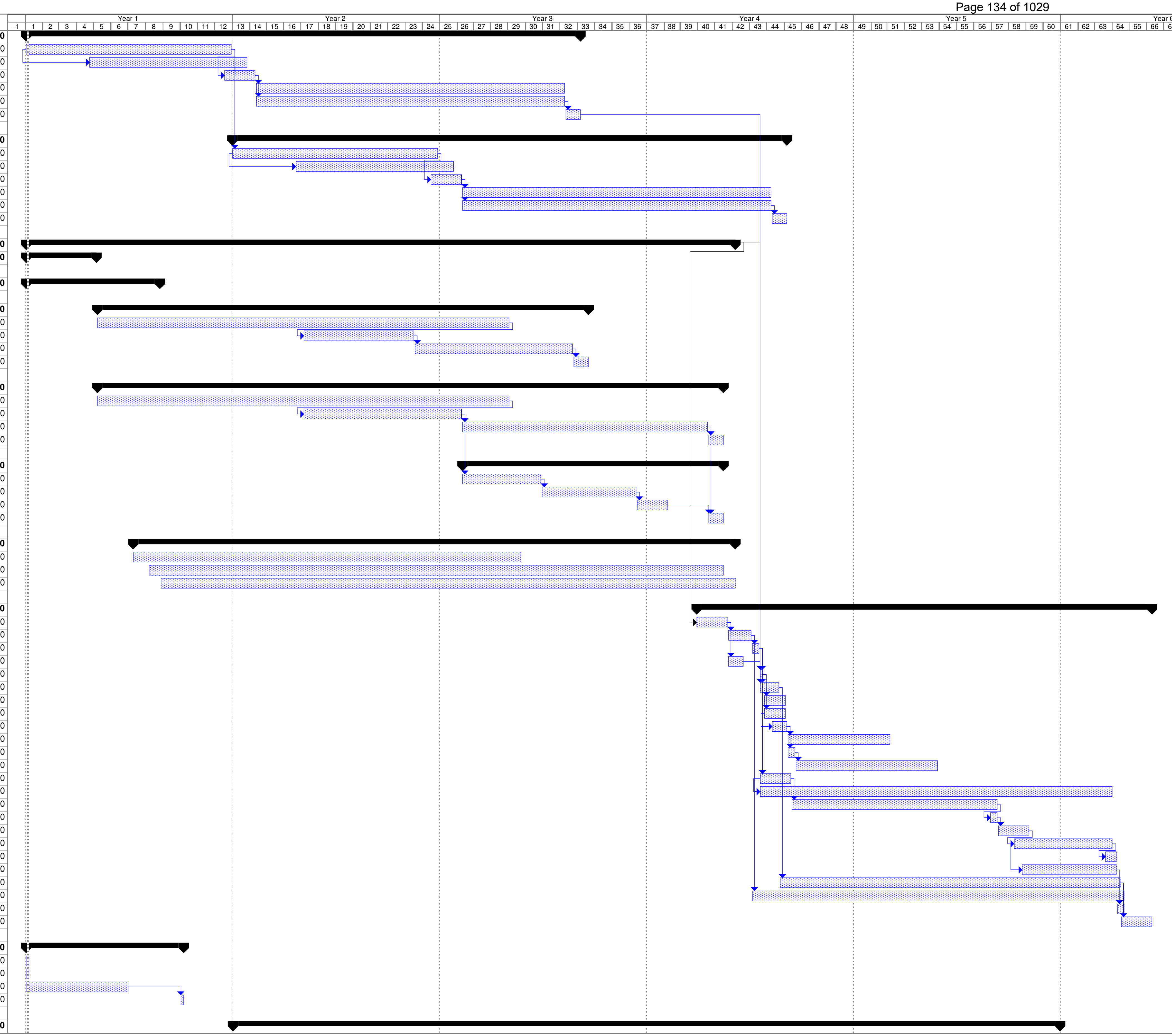
* Capital costs for selenium treatment not included
All values are anticipation of the proposed Subtitle D rulings

FINAL

APPENDIX A

Cost Loaded Schedules
WWTP Equipment Tables

ID	Task Name	Duration	Start	Finish	Predecessors	Cost
1	**CH Waste Water Treatment Plant - primary**	**140 wks**	**1/3/11**	**9/6/13**		**$29,015,000.00**
2	Engineering & pilot testing	52 wks	1/3/11	12/30/11		$1,500,000.00
3	Procurement, long lead items	40 wks	4/25/11	1/27/12	2SS+16 wks	$11,000,000.00
4	DOM procurement, bid award	8 wks	12/19/11	2/10/12	2FS-2 wks	$125,000.00
5	Construction	78 wks	2/13/12	8/9/13	4	$16,000,000.00
6	Engineering Support during construction	78 wks	2/13/12	8/9/13	4	$265,000.00
7	Startup	4 wks	8/12/13	9/6/13	6	$125,000.00
8						
9	**CH Waste Water Treatment Plant - secondary**	**140 wks**	**1/2/12**	**9/5/14**		**$29,015,000.00**
10	Engineering & pilot testing	52 wks	1/2/12	12/28/12	2	$1,500,000.00
11	Procurement, long lead items	40 wks	4/23/12	1/25/13	10SS+16 wk	$11,000,000.00
12	DOM procurement, bid award	8 wks	12/17/12	2/8/13	10FS-2 wks	$125,000.00
13	Construction	78 wks	2/11/13	8/8/14	12	$16,000,000.00
14	Engineering Support during construction	78 wks	2/11/13	8/8/14	12	$265,000.00
15	Startup	4 wks	8/11/14	9/5/14	14	$125,000.00
16						
17	**CH Dry Ash Conversion**	**179 wks**	**1/3/11**	**6/6/14**		**$65,265,600.00**
18	**Pre-Project Activities**	**18 wks**	**1/3/11**	**5/6/11**		**$0.00**
23						
24	**Permitting**	**34 wks**	**1/3/11**	**8/26/11**		**$0.00**
31						
32	**Fly Ash System**	**124 wks**	**5/9/11**	**9/20/13**		**$29,290,000.00**
33	Engineering & project support	104 wks	5/9/11	5/3/13	22	$1,270,000.00
34	Procurement and fabrication	28 wks	5/7/12	11/16/12	33FS-52 wks	$6,350,000.00
35	Construction and installation	40 wks	11/19/12	8/23/13	34	$21,590,000.00
36	Startup	4 wks	8/26/13	9/20/13	35	$80,000.00
37						
38	**Bottom Ash System**	**158 wks**	**5/9/11**	**5/16/14**		**$20,845,000.00**
39	Engineering & project support	104 wks	5/9/11	5/3/13	22	$900,000.00
40	Procurement and fabrication	40 wks	5/7/12	2/8/13	39FS-52 wks	$4,500,000.00
41	Construction and installation	62 wks	2/11/13	4/18/14	40	$15,365,000.00
42	Startup	4 wks	4/21/14	5/16/14	41	$80,000.00
43						
44	**Pyrite System**	**66 wks**	**2/11/13**	**5/16/14**		**$1,765,000.00**
45	Engineering	20 wks	2/11/13	6/28/13	40	$65,000.00
46	Procurement and fabrication	24 wks	7/1/13	12/13/13	45	$650,000.00
47	Construction and installation	8 wks	12/16/13	2/7/14	46	$780,000.00
48	Startup	4 wks	4/21/14	5/16/14	47,41	$270,000.00
49						
50	**Dominion E&I Scope**	**152 wks**	**7/11/11**	**6/6/14**		**$13,365,600.00**
51	Engineering	98 wks	7/11/11	5/24/13	28	$100,000.00
52	Procurement, design changes	145 wks	8/8/11	5/16/14	29	$10,877,600.00
53	Construction Management	145 wks	8/29/11	6/6/14	30	$2,388,000.00
54						
55	**CH Lower Ash Pond Closure**	**115 wks**	**3/31/14**	**6/10/16**		**$29,977,050.00**
56	Engineering	8 wks	3/31/14	5/23/14	17FS-10 wks	$171,000.00
57	DOM procurement, bid award	6 wks	5/26/14	7/4/14	56	$0.00
58	Mobilization, initial survey	2 wks	7/7/14	7/18/14	57	$75,000.00
59	E&S, stormwater permits	4 wks	5/26/14	6/20/14	56	$5,500.00
60	Initial erosion control	1 wk	7/21/14	7/25/14	58,59	$25,000.00
61	Initial dewatering	5 wks	7/21/14	8/22/14	7,17,59,58	$60,000.00
62	Geotechnical Drilling	5.5 wks	7/28/14	9/3/14	60	$82,500.00
63	Geotechnical monitoring	5.5 wks	7/28/14	9/3/14	60	$32,450.00
64	Lab testing	4 wks	8/11/14	9/5/14	63SS+2 wks	$27,000.00
65	Reporting, pilot testing	26 wks	9/8/14	3/6/15	64	$125,000.00
66	Slurry wall contractor mobilization	2 wks	9/8/14	9/19/14	64	$150,000.00
67	Install slurry wall	36 wks	9/22/14	5/29/15	66	$6,885,000.00
68	Install surface dewatering system	8 wks	7/21/14	9/12/14	58	$4,076,800.00
69	Operate dewatering system + treatment	89 wks	7/21/14	4/1/16	68SS	$3,720,000.00
70	Install seepage collection system	52 wks	9/15/14	9/11/15	68	$1,323,000.00
71	Closure contractor mobilization	2 wks	8/31/15	9/11/15	70FS-2 wks	$250,000.00
72	Grading, material import	8 wks	9/14/15	11/6/15	71	$3,460,000.00
73	Cover Construction	25 wks	10/12/15	4/1/16	72FS-4 wks	$7,350,000.00
74	Drainage features	3 wks	3/21/16	4/8/16	73FS-2 wks	$0.00
75	Seeding	24 wks	10/26/15	4/8/16	73SS+2 wks	$196,000.00
76	Construction Quality Assurance (CQA)	86 wks	8/25/14	4/15/16	61	$980,000.00
77	Construction Management	94 wks	7/7/14	4/22/16	57	$964,600.00
78	Project close out	2 wks	4/11/16	4/22/16	75	$18,200.00
79	DEQ Certification of closure	8 wks	4/18/16	6/10/16	76	$0.00
80						
81	**Other Regulatory-Driven Tasks**	**40 wks**	**1/3/11**	**10/7/11**		**$39,900.00**
82	Prepare closure plan	1 wk	1/3/11	1/7/11		$5,500.00
83	Prepare post-closure care plan	1 wk	1/3/11	1/7/11		$5,500.00
84	Conduct GW sampling & testing 4rds	26 wks	1/3/11	7/1/11		$24,000.00
85	Conduct GW sampling & testing rd2	1 wk	10/3/11	10/7/11	84FS+13 wk:	$4,900.00
86						
87	**Regulatory Deadlines**	**208.6 wks**	**1/3/12**	**12/31/15**		**$0.00**



Project: Chesterfield Master Schedule
Date: 1/5/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Chesterfield Power Station
Overall Cost-Loaded Schedule

January 2011

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Totals
CH Waste Water Treatment Plant	$ 11,431,250	$ 22,317,010	$ 17,567,331	$ 6,714,410	$ -	$ -	$ 58,030,001
CH Dry Ash Conversion	$ 2,606,751	$ 19,462,004	$ 36,592,263	$ 6,604,581	$ -	$ -	$ 65,265,599
CH Lower Ash Pond Closure	$ -	$ -	$ -	$ 9,435,288	$ 15,635,616	$ 4,906,146	$ 29,977,050
Other Regulatory-Driven Tasks	$ 39,900	$ -	$ -	$ -	$ -	$ -	$ 39,900
Totals	**$ 14,077,901**	**$ 41,779,014**	**$ 54,159,594**	**$ 22,754,279**	**$ 15,635,616**	**$ 4,906,146**	**$ 153,312,550**

							Annual Cost
CH O&M Costs	$ -	$ 14,000	$ 14,000	$ 1,496,608	$ 2,458,144	$ 2,458,144	$ 2,458,144
	$ 14,077,901	$ 41,793,014	$ 54,173,594	$ 24,250,887	$ 18,093,760	$ 7,364,290	$ 155,770,694

Chesterfield Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	2011	2012	2013	2014	2015	2016
CH Waste Water Treatment Plant							
Engineering & pilot testing	$ 1,500,000	$ 1,500,000					
Procurement, long lead items	$ 11,000,000	$ 9,900,000	$ 1,100,000				
DOM procurement, bid award	$ 125,000	$ 31,250	$ 93,750				
Construction	$ 16,000,000		$ 9,476,923	$ 6,523,078			
Engineering Support during construction	$ 265,000		$ 156,962	$ 108,038			
Startup	$ 125,000			$ 125,000			
CH Waste Water Treatment Plant-secondary							
Engineering & pilot testing	$ 1,500,000		$ 1,500,000				
Procurement, long lead items	$ 11,000,000		$ 9,955,000	$ 1,045,000			
DOM procurement, bid award	$ 125,000		$ 34,375	$ 90,625			
Construction	$ 16,000,000			$ 9,517,949	$ 6,482,051		
Engineering Support during construction	$ 265,000			$ 157,641	$ 107,359		
Startup	$ 125,000				$ 125,000		
WWTP Totals	**$ 58,030,001**	**$ 11,431,250**	**$ 22,317,010**	**$ 17,567,331**	**$ 6,714,410**	**$ -**	

CH Dry Ash Conversion							
Pre-Project Activities	$ -						
Permitting	$ -						
Fly Ash System	$ 29,290,000						
Engineering & project support	$ 1,270,000	$ 415,192	$ 637,442	$ 217,366			
Procurement and fabrication	$ 6,350,000		$ 6,350,000				
Construction and installation	$ 21,590,000		$ 3,346,450	$ 18,243,550			
Startup	$ 80,000			$ 80,000			
Bottom Ash System	$ 20,845,000						
Engineering & project support	$ 900,000	$ 294,231	$ 451,731	$ 154,038			
Procurement and fabrication	$ 4,500,000		$ 3,847,500	$ 652,500			
Construction and installation	$ 15,365,000			$ 11,498,968	$ 3,866,032		
Startup	$ 80,000				$ 80,000		
Pyrite System	$ 1,765,000						
Engineering	$ 65,000			$ 65,000			
Procurement and fabrication	$ 650,000			$ 650,000			
Construction and installation	$ 780,000			$ 234,000	$ 546,000		
Startup	$ 270,000				$ 270,000		

Chesterfield Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	2011	2012	2013	2014	2015	2016
Dominion E&I Scope	$ 13,365,600						
Engineering	$ 100,000	$ 25,510	$ 53,265	$ 21,225			
Procurement	$ 10,877,600	$ 1,575,377	$ 3,915,936	$ 3,915,936	$ 1,470,351		
Construction Management	$ 2,388,000	$ 296,441	$ 859,680	$ 859,680	$ 372,198		
Dry Ash Totals	**$ 65,265,599**	**$ 2,606,751**	**$ 19,462,004**	**$ 36,592,263**	**$ 6,604,581**		

Chesterfield Power Station
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	2011	2012	2013	2014	2015	2016
CH Lower Ash Pond Closure							
Engineering	$ 171,000				$ 171,000		
DOM procurement, bid award	$ -						
Mobilization, initial survey	$ 75,000				$ 75,000		
E&S, stormwater permits	$ 5,500				$ 5,500		
Initial erosion control	$ 25,000				$ 25,000		
Initial dewatering	$ 60,000				$ 60,000		
Geotechnical Drilling	$ 82,500				$ 82,500		
Geotechnical monitoring	$ 32,450				$ 32,450		
Lab testing	$ 27,000				$ 27,000		
Reporting, pilot testing	$ 125,000				$ 79,808	$ 45,192	
Slurry wall contractor mobilization	$ 150,000				$ 150,000		
Install slurry wall	$ 6,885,000				$ 2,792,250	$ 4,092,750	
Install surface dewatering system	$ 4,076,800				$ 4,076,800		
Operate dewatering system + treatment	$ 3,720,000				$ 986,427	$ 2,181,843	$ 551,730
Install seepage collection system	$ 1,323,000				$ 396,900	$ 926,100	
Closure contractor mobilization	$ 250,000					$ 250,000	
Grading, material import	$ 3,460,000					$ 3,460,000	
Cover Construction	$ 7,350,000					$ 3,469,200	$ 3,880,800
Drainage features	$ -						
Seeding	$ 196,000					$ 80,033	$ 115,967
Construction Quality Assurance (CQA)	$ 980,000				$ 211,953	$ 594,837	$ 173,209
Construction Management	$ 964,600				$ 262,700	$ 535,661	$ 166,240
Project close out	$ 18,200						$ 18,200
DEQ Certification of closure	$ -						
Lower Pond CIP Totals	**$ 29,977,050**	**$ -**	**$ -**	**$ -**	**$ 9,435,288**	**$ 15,635,616**	**$ 4,906,146**

Activity	Total	2011	2012	2013	2014	2015	2016
Other Regulatory-Driven Tasks							
Prepare closure plan	$ 5,500	$ 5,500					
Prepare post-closure care plan	$ 5,500	$ 5,500					
Conduct GW sampling & testing 4rds	$ 24,000	$ 24,000					
Conduct GW sampling & testing rd2	$ 4,900	$ 4,900					
Regulatory Req Totals	**$ 39,900**	**$ 39,900**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**

Overall Totals	**$ 153,312,550**	**$ 14,077,901**	**$ 41,779,014**	**$ 54,159,594**	**$ 22,754,279**	**$ 15,635,616**	**$ 4,906,146**

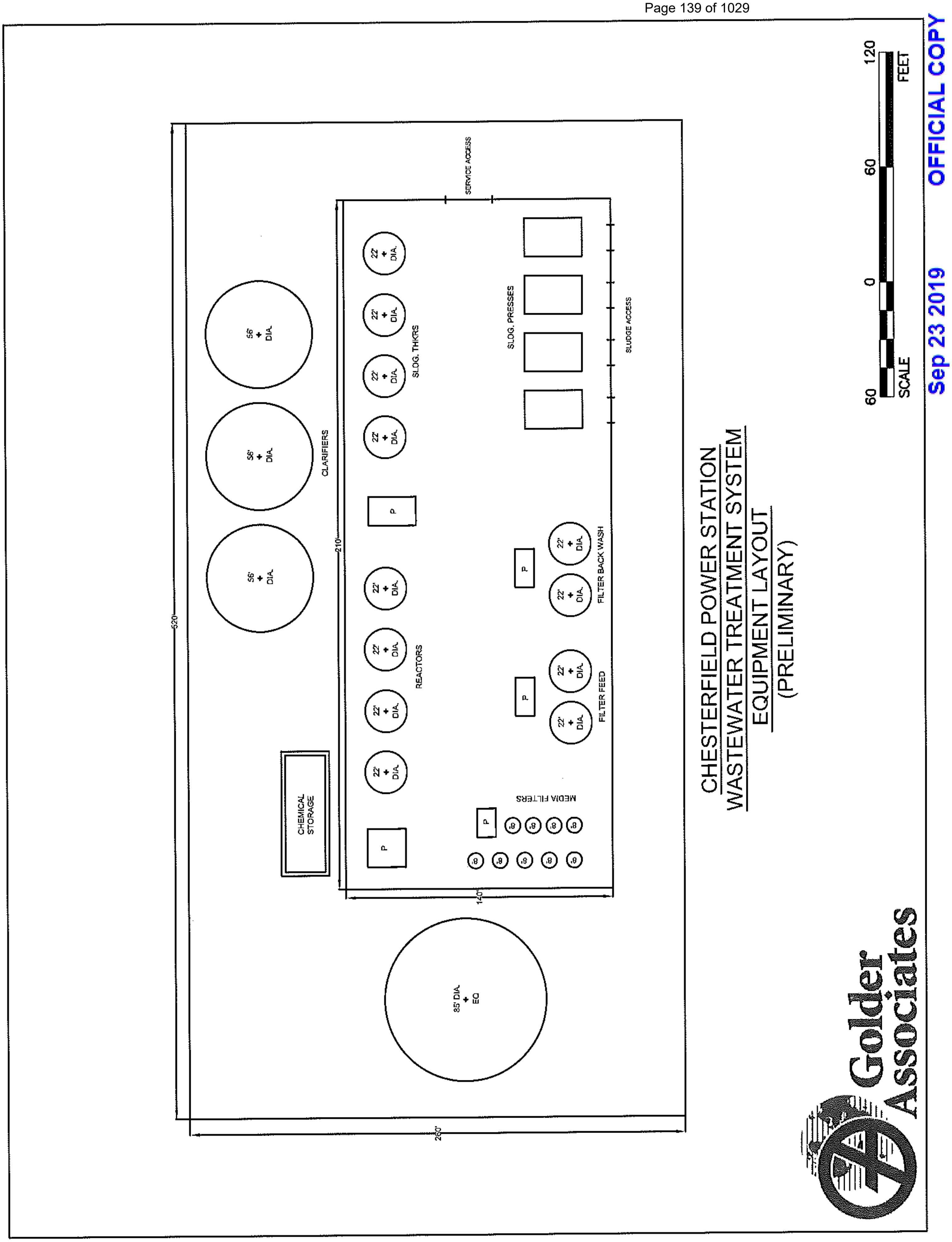

CHESTERFIELD POWER STATION
WASTEWATER TREATMENT SYSTEM
EQUIPMENT LAYOUT
(PRELIMINARY)
SCALE
FEET
60
0
60
120
OFFICIAL COPY
Sep 23 2019
520'
260'
210'
140'
85' DIA.
EQ
CHEMICAL STORAGE
56' DIA.
CLARIFIERS
22' DIA.
REACTORS
SLDG. THKRS
SLDG. PRESSES
SERVICE ACCESS
SLUDGE ACCESS
FILTER FEED
FILTER BACK WASH
MEDIA FILTERS
8'
P
Golder Associates

Table 4: Equipment List – Primary Wastewater Treatment

Identification	Name	Flow		
		Each	Total	Unit
Process Equipment				
P-010	Metals Pond Pumps (Total 3) Each	625	1,875	gpm
P-020	Master Sump Pumps (Total 3) Each	400	1,200	gpm
P-030	Coal Pile Runoff Pumps (Total 3) Each	250	750	gpm
P-100	Equalization Tank Pumps (Total 3) Each	1,275	3,800	gpm
MX-200, 300, 400	pH Neutralization Tank Mixers		--	
CL-500	Lamella Package (w/ Floc and Thickener)	1.67	5.0	MGD
P-500	Sludge Transfer Pumps	70	210	gpm
Process Tanks				
TK-100	Equalization Tank		1,000,000	Gallons
	Retention Time	-	0.2	Days
TK-200, 300, & 400	pH Neutralization Tanks (Each)		40,000	Gallons
	Retention Time	10	30	Minutes
CL-500 (2 or 3)	Clarifier Loading (@ 500 mg/l Feed TSS)		0.5	GPM/ eq ft^2
	Clarifier Area		9,600	Total Plate Area / ft^2
Chemical Tanks				
TK-700	Caustic		15	Gal/hr
	Solution		50%	
	Chemical Storage Tank		10,000	gallons
	Chemical Addition Rate		360	Gal/day
	Retention Time		28	days
TK-800	Neat Floc		4	mg/L
	Neat Chemical Storage Tote		55	Gallons
	Neat Chemical Addition Rate		56	Gal/mo
	Retention Time		30	Days
TK-900	Sulfuric Acid		8.4	Gal/hr
	Solution		96%	
	Chemical Storage Tank		6,000	Gallons
	Chemical Addition Rate		202	Gal/day
	Retention Time		30	Days
Chemical Pumps				
P-700 (3)	Caustic Metering Pumps		15	Gal/hr
P-800 (3)	Neat Flocculant Metering Pump		0.08	Gal/hr
P-900 (3)	Acid Metering Pump		8.4	Gal/hr

Table 5: Equipment List – Secondary Wastewater Treatment

Identification	Name	Flow		
		Each	Total	Unit
Process Equipment				
BR-1000 (4)	Anaerobic Bioreactors – Se Removal	1.25	5.0	MGD
BX-1000 (4)	Off-Gas Scrubbers	--	--	--
RA-1100 (4)	Bioreactor Effluent Re-aeration	1.25	5.0	MGD
RX-1100 (8)	Re-aeration Blower Packages (2 each)			
MX-200, 300	Oxidation & pH 10.5 Tank Mixers	7.5	30	HP
CL-500 (4)	Solids Contact Clarifiers	1.25	5.0	MGD
MF-700 (8)	Multi-Media Filters	0.625	5.0	MGD
SP-500 (8)	Sludge Transfer Pumps (2 each Clarifier)	150	600	gpm
Process Tanks				
TK-200, 300	Oxidation and pH 10.5 Tanks		4@53,000	Gallons
	Retention Times (each system)	30	60	Minutes
CL-500 (4)	Clarifier Loading (@ 2 g/l Feed TSS)		250	ft^2/ton/day
	Clarifier Area (total of 4 units)		11,000	ft^2
	Clarifier Size (diameter)		59	Feet
MF-700 (8)	Multi-Media Filters, Pressure Tanks (diameter)		8	Feet
FP-600 (2)	Thickening Tanks – 6 hours Retention Time (each)		600	gpm
			108,000	Gallons
RA-1100 (4)	Re-aeration Tanks, 2 hours Retention Time		105,000	Gallons
	Tank Sizing (diameter)		40	Feet
Chemical Tanks				
TK-600	Hydrogen Peroxide		10	Gal/hr
	Solution		35%	
	Chemical Storage Tank		10,000	Gallons
	Chemical Addition Rate		240	Gal/day
	Retention Time		40	Days
TK-700	Caustic		150	Gal/hr
	Solution		50%	
	Chemical Storage Tank		52,000	gallons
	Chemical Addition Rate		3,600	Gal/day
	Retention Time		14	Days
TK-900	Sulfuric Acid		21	Gal/hr
	Solution		96%	
	Chemical Storage Tank		10,000	Gallons
	Chemical Addition Rate		500	Gal/day
	Retention Time		20	Days
TK-1000	Molasses (Carbon Source)		75	Gal/hr
	Solution (dilute 5:1)		20%	
	Chemical Storage Tank		11,000	Gallons
	Chemical Addition Rate (neat)		360	Gal/day
	Retention Time		30	Days

Table 5: Equipment List – Secondary Wastewater Treatment			
Chemical Pumps (Total Feed Rates)			
P-600 (4)	Hydrogen Peroxide Metering Pumps	10	Gal/hr
P-700 (4)	Caustic Metering Pumps	150	Gal/hr
P-900 (4)	Acid Metering Pump	21	Gal/hr
P-1000 (4)	Molasses Metering Pumps, with dilution	75	Gal/hr

FINAL

APPENDIX B

Slurry Wall Construction

SLURRY WALL BARRIER

Assuming that the risks to groundwater are evaluated and that decisions are made to implement a closure with the impounded CCR left in place, then it may be anticipated that a low permeability barrier such as a soil bentonite slurry wall may be required around the entire perimeter of the pond. The consideration for a slurry wall can be made after an evaluation of the initial rounds of groundwater testing to determine the nature and extent of possible contaminant migration. The function of the slurry wall is to minimize the risk of offsite migration of leachate from the impounded CCR materials. Soil bentonite slurry walls have been used by EPA on CERCLA (Superfund) site remediation projects for many years. Technical guidance is provided in the report by EPA entitled "*Slurry Trench Construction for Pollution Migration Control, EPA-540/2-84-001"* (Feb. 1984).

There are various civil engineering construction methods available for installation of slurry walls. The means and methods selected are dependent on the project specific ground conditions, performance requirements for the wall (permeability and strength criteria), depth to a low permeability zone into which the wall is keyed, the wall thickness, and the particular preferences of the specialty geotechnical contractor selected.

Typical installation of a soil bentonite slurry wall in the southeastern USA is by a long reach tracked hydraulic excavator, with maximum wall depths in the 70 to 90 feet range and widths typically in the 2 to 3 feet range. The long reach equipment is deployed to excavate a deep trench into the ground to a design depth that provides for an adequate cutoff into a low permeability stratum in the foundation. Bentonite slurry ('mud') is used to support the trench during the excavation. Bentonite is also mixed with the excavated soils, and sometimes other additives such as Portland cement. These materials are blended together as backfill that is pushed into the trench from one end using a dozer.

Where deeper slurry walls are required, or where conditions are such that a more effective 'milling' of the ground is needed, excavation of the wall can be performed using clam shell buckets suspended from crawler cranes, or various forms of hydraulic grab. Soil cutter mixing (CSM) and auger mixing rigs can also be deployed to mix bentonite and cement with the *in-situ* material.

As part of the design of the wall, a treatability study is required involving indicator tests to 'screen' various commercially available bentonite products for their chemical compatibility with the site specific ground and groundwater conditions, and the site specific CCR leachate. Following this step, a mix design is undertaken that involves various laboratory tests on different batches of soil-cement-bentonite blends to evaluate and optimize the mix to achieve project specific performance criteria. It would not be unreasonable to plan on this slurry wall design and treatability testing phase taking between 6 and 12 months for large, complex and environmentally sensitive projects, and perhaps 3 to 6 months for smaller

FINAL

straightforward projects. Costs for the treatability studies vary widely depending on site specific conditions and performance criteria, and may be in the approximate range of $30,000 to $125,000 per project.

Whichever form of slurry wall construction is selected, there are significant mobilization, set-up and demobilization costs involved with deployment of the large excavating equipment, dozers, batching plant, material silos, mud hydration tanks, mixers, agitators, and screw pumps. For planning purposes, these associated costs may range between about $100,000 to $250,000 depending on means and methods of construction.

For the conceptual costs for installation, a conventional soil bentonite slurry wall that is assumed to be 50 feet deep by 2 feet wide, surrounding the entire perimeter of the pond is presumed. Subsurface exploration borings along the wall alignment, at perhaps 150 feet intervals, will be required to determine the design depth. Geotechnical data for this site is not currently available; therefore conceptual cost for a geotechnical investigation specifically for the wall has been included. A unit rate of $17 per vertical square foot of wall has been used in estimating the costs, but it is worth noting that unit rates may range between about $10/SF to $25/SF depending on the specific wall requirements, ground conditions and means and methods of construction. Production rates vary widely depending on these same variables and could be in the range of 25 to 50 linear ft per day per piece of excavating equipment. For an 8,100 foot long, by 50 foot deep slurry wall around the perimeter of the lower ash pond, a conceptual cost estimate of **$7,300,000** and project duration of **16 to 18 months** has been established. Conceptual cost details and cost-loaded schedules are included in Appendix A.

DRAFT

APPENDIX C

Chesterfield Dry Ash Conversion (abbreviated)

Chesterfield Unit 0
Dry Ash System Project
1-Page Summary

Project Background and Objective:

There is a potential Regulatory requirement that the active ash sluicing pond at the station be closed, and all site ash no longer be sluiced to storage. In response to this possibility, F&H Projects has engaged Golder Associates of Philadelphia in project development for a dry ash system conversion. Project scoping, engineering, and cost estimating has lead to Golder delivering a study that provided a system description, site plan drawings, P&ID's, and an equipment list for a potential project. The boundary of this project is where the ash leaves the silos or hydrobins and falls into Trucks. The Trucking and dry ash landfilling are included in a separate project.

There was also a site visit by Progress Materials (PMI) to describe to site management the benefits of a Carbon Burnout (CBO) process. For this study the dry ash system project site footprint has been chosen to take advantage of close proximity of a future CBO operation.

Major Work Description (Depends on Case):

- For the flyash system conversion, install 3 concrete silos, a pressure / vacuum blower building, and associated equipment to allow pneumatic transport of ash to the silos
- For the bottom ash system, install hydrobins, surge tanks, settling tank, collection tanks, sluicing pumps, and associated equipment to allow hydraulic transport of ash to the hydrobins
- For the pyrite system, install a collection tank and transport pumps and associated equipment to allow hydraulic transport of ash to the hydrobins

Clarifications, Exclusions, and Assumptions:

- Costs are escalated to year spent
- Engineering is assumed to start in year 2010
- Construction and tie-in work do not require major planned unit outages
- A high level project schedule based on a 2010 start has been developed
- This is an environmental project, and no business case is required

Project Schedule:

Conceptual Engineering:	2009
Permitting Start:	2010
Final Engineering Start:	2010
Material and Fabrication Award:	2011
Construction:	2012-2013
Total Project Duration:	about 42 months

Financial:

Cost of Removal:	currently identified as $300K
Total Capital:	$84,174K
Asset Retirement:	NA
Project O&M:	Insignificant
IRR:	NA

Golder Associates Inc.
3719 Saunders Avenue
Richmond, Virginia 23227
Telephone: (804) 358-7900
Fax: (804) 358-2900

June 10, 2009 Project No.: 073-660709

Dominion
5000 Dominion Boulevard
Glen Allen, VA 23060

Attention: Mr. Bob Jackson, Project Manager

RE: **CONCEPTUAL DESIGN AND PRELIMINARY OPINION OF COST FOR WET-DRY ASH HANDLING SYSTEM CONVERSION CHESTERFIELD POWER STATION, CHESTER, VIRGINIA**

Dear Bob:

Golder Associates Inc. (Golder) is pleased to present this letter regarding for a wet-dry ash handling system conversion at Dominion's Chesterfield Power Station (Station) and to present a conceptual design and preliminary opinion of cost for the construction of the ash conveyance systems.

BACKGROUND

Dominion's Chesterfield Power Station, located in Chester, Virginia, has six units with a net generating capacity of more than 1,700 megawatts (MW). The four coal-fired units at the Station have a combined capacity of approximately 1,350 MW. Currently, the fossil fuel combustion products (FFCPs) produced by the Station, primarily coal ash (herein referred to collectively as ash), are mixed with water and conveyed by slurry pipes to a settling pond located south of the station. The slurry consists of approximately 80% water and 20% ash. The settled ash is collected from the pond and piled up to dewater. It is then loaded into trucks for disposal in the Upper Pond Closure Project (UPCP), located approximately 0.9 miles away.

Dominion is currently in the permitting process for a new ash disposal facility, the Chesterfield Power Station Fossil Fuel Combustion Products Management Facility (Facility), on a parcel adjacent to the Station. Due to a recent catastrophic spill event in Tennessee and the changing political climate with regard to open ash ponds, Dominion has chosen to evaluate alternatives to the ash handling system at the Station should the lower ash pond be closed and no longer available to receive the ash slurry. Golder was asked to analyze possible ash conveyance system alternatives for transporting an estimated 550,000 tons of ash per year to the proposed Facility and to develop a budgetary cost estimate for the conversion.

SYSTEM DESCRIPTION FOR A CONCEPTUAL DRY ASH CONVERSION

Based on a review of available Station information, two site visits, and discussions with Dominion, Golder believes a conventional wet-dry ash conversion is practical for the Station. A conceptual design of a conventional wet-dry conversion is presented in figures S1, S2, F1, F2, F3 and F4.

The existing ash handling systems at the facility transport ash to the existing ash ponds through sluice pipes using eductors and hydrovactors. In the proposed design, the bottom ash removal system will continue to collect and transport the ash wet. The bottom ash from the four units will be sluiced to a small transfer tank where slurry pumps will transfer the bottom ash slurry to dewatering bins to allow the sluice water to drain from the bottom ash. The pyrite removal system will continue to collect and transport the pyrite wet. The pyrite transfer tanks for Units 3 and 4 (combined), Unit 5, and Unit 6 will discharge to a new pyrite transfer tank located northwest of the existing Unit 5 pyrite tank. The pyrite collected in the transfer tank will be transported to a separate dewatering bin. The collected bottom ash and pyrites will be loaded into open-bed trucks. The accumulated sluice water from the dewatering bins will be clarified and reused in a closed-loop water system and stored in two new transfer tanks located near Unit 6's baghouse.

The existing fly ash removal system will be modified to enable the fly ash to be stored dry. Vacuum conveying systems will transport the dry fly ash from the existing baghouse, ESP, and economizer hoppers to new transfer hoppers through new filter separators. Pressure conveying systems will move the dry ash from the feeder hoppers to the new silos. The silos will be equipped with dry spouts for filling tanker trucks and ash conditioner unloader units for filling open-bed trucks. Three new silos are proposed to create operational flexibility and to allow a minimum of three continuous days of fly ash storage. The controls arrangement will allow fly ash from each boiler unit to be removed simultaneously if desired.

Fly ash from Units 3 and 4 will be removed using a common pneumatic conveying system. Fly ash will be removed from Unit 5 using two dedicated pneumatic conveying systems; a similar system of two pneumatic conveyors will remove fly ash from Unit 6. Fly ash from Unit 6's economizer hopper will be collected and transferred using Unit 5's conveying system

The conceptual wet-dry ash conversion includes the following major equipment for the pyrite and bottom ash system:

- One (1) settling tank
- One (1) reclaimed water tank
- Two (2) surge water tanks
- One (1) bottom ash transfer tank
- Four (4) pyrite transfer pumps
- Two (2) bottom ash transfer pumps
- Two (2) sludge return pumps with motors
- Two (2) intermittent low-pressure, high-volume transfer water pumps with motors
- Two (2) continuous low-pressure ash water pumps with motors
- Two (2) intermittent low-pressure ash water pumps with motors
- Two (2) intermittent high-pressure pumps ash water pumps with motors
- Two (2) ash conditioner pumps with motors
- Two (2) surge tank overflow sump pumps with motors
- Two (2) dewatering bin sump pumps with motors
- Two (2) seal water pumps with motors
- Two (2) pump houses

The conceptual fly ash conversion includes the following major equipment for the fly ash system:

- Three (3) silos with complete accessories and system for ash storage and removal
- Three (3) ash conditioner feeders (pug mills) with motors and complete system of ash removal
- Three (3) silo vent filters
- Three (3) silo exhaust fans with motors
- Three (3) retractable dry spouts with motors
- Three (3) spout vent fans with motors
- Four (4) silo fluidizing blowers with motors
- Four (4) electrical heaters for silo fluidizing air
- Three (3) fluidizing air distribution systems
- Five (5) mechanical (filter) separators including discharge gates with feeder hoppers, equalizing valves, and ancillaries
- Six (6) vacuum blowers with motors
- Six (6) pressure blowers with motors
- Two (2) air compressors shared by filter separators
- Two (2) air compressors shared by the silo vent filters
- Two (2) air receiver tanks for filter separators – one for wet air and the other for dry air with dryer and filters
- Two (2) air receiver tanks for vent filters – one for wet air and the other for dry air with dryer and filters
- Two (2) ash conditioner water pumps
- Blower building

COST ESTIMATE SUMMARY

Budgetary pricing for design and installation of a wet-dry ash conversion was requested from three major power plant equipment vendors – Allen Sherman Hoff (ASH), United Conveyor Corporation (UCC) and Clyde Bergemann-Delta-Ducon (Delta Ducon). Golder provided the three companies a conceptual design and technical specifications for use in evaluating the existing and proposed systems. Two vendors, ASH and Delta-Ducon, responded with detail proposals for the supply of the major equipment and provided rule-of-thumb estimates for the installation cost. UCC provide a summary budget cost with total installed cost. Refer to Attachment 3 for details on vendor responses.

Based on the vendor responses, the estimated budgetary cost to supply the major equipment and ancillary support systems may range from $15.8MM to $24.3MM, plus an additional $8MM for concrete silos. Using the rule-of-thumb estimate that installation cost is roughly 50% of equipment cost, the installation may range from $15.8MM to $24.3MM. Combining the three costs, the estimated total installed cost may range from $39.6MM to $56.3MM.

To further narrow the cost range, Golder is developing a second conceptual cost estimate using equipment costs from ASH and Delta Ducon; installation costs from a local contractor, Gibson Industries; an average concrete silo cost; and general estimating guidelines. The second conceptual cost estimate will be provided under separate cover.

CLOSING

Golder appreciates the opportunity to serve as your consultant on this project. If you have any questions concerning this document, please contact Mr. Kevin Killoran at (610) 941-8173 or Kevin_Killoran@Golder.com .

Very truly yours,

GOLDER ASSOCIATES INC.

Kevin G. Killoran
Senior Project Manager

KGK/klh

Cc: R. DiFrancesco Jr., Golder Associates Inc.
D. McGrath, Golder Associates Inc.

Attachments:	Drawing	Figure S-1
	Drawing	Figure S-2
	Drawing	Figure F-1, Sheet 1 of 2
	Drawing	Figure F-1, Sheet 2 of 2
	Drawing	Figure F-2
	Drawing	Figure F-3
	Drawing	Figure F-4
	Attachment 1	Design Criteria
	Attachment 2	Bid Summary
	Attachment 3	Equipment Supplier Responses
	Attachment 4	Preliminary Motor List, Revision 1

MEMORANDUM

To: Bob Jackson — Innsbrook Technical Center

From: Donald H. Smith — 7/8/09

COMPLETED ESTIMATE

Station: CHESTERFIELD POWER STATION

Project Title: DRY ASH CONVERSION

Estimate No. : CF0318_C00

CONCEPTUAL ESTIMATE

☐ Feasibility Study (+50%- 30%) ☒ Conceptual (+ 30%/-10%) ☐ Definitive (+/- 10%)

Enclosed, please find the Completed Estimate for the above project. This estimate is prepared on the basis of documents supplied and other documents retained in the records of the Fossil & Hydro Technical Services.

For the purpose of further explanation, please read the enclosed Assumptions/ Qualifications and Methodology used during the course of the development of this estimate.

If I can be of further assistance, please call me at ext. 2554.

Donald H. Smith

cc: Christine Harris

CHESTERFIELD POWER STATION
DRY ASH CONVERSION
CONCEPTUAL ESTIMATE
CF0318_C00

SUMMARY

DATA SOURCES
----

1) This estimate is based on the Scoping study provided by Golder Associates.

METHODOLOGY

This estimate was prepared based on the data sources listed above. Bulk materials were priced using estimating manuals, vendor quotes and historical data. Quantities for this estimate were based on the information provided in the data sources.

Labor rates were applied based on bidding the project to contractors who have done this work for Dominion Power in the past.

ASSUMPTIONS & QUALIFICATIONS
----

1) Allowances have been included in this estimate for items or activities that can't be quantified but will be required.

2) No utility relocations will be required at this time.

3) It is assumed that this will be a capital project.

4) There will be minimal lead paint removal required to support interference removal.

5) This estimate is in 2009 and escalated 8% annually through 2012.

6) No rock excavation is included in this estimate

CHESTERFIELD POWER STATION
DRY ASH CONVERSION
CONCEPTUAL ESTIMATE
CF0318_C00

DESIGN REFINEMENTS

Based on the potential for design refinements and additional bulk quantity increases an allowance of 20% has been included to cover any additional cost that may be incurred.	$ 10,877,600

ESTIMATE COST SUMMARY
CHESTERFIELD POWER STATION
DRY ASH CONVERSION
CONCEPTUAL ESTIMATE
CF0318_C00

DIRECT COST SUMMARY

	2010	2011	2012	2013
Fly Ash System				
Engineering	$ 635,000	$ 635,000		
Equipment & Silo's		$ 6,350,000	$ 6,350,000	
Construction			$ 8,166,667	$ 6,773,333
Cost of Removal			$ 300,000	
Startup & Commissioning				$ 80,000
Bottom Ash System				
Engineering	$ 450,000	$ 450,000		
Equipment + Bins/Tanks		$ 4,500,000	$ 4,500,000	
Construction			$ 3,600,000	$ 7,200,000
Startup & Commissioning				$ 80,000
Pyrites System				
Engineering			$ 65,000	
Equipment			$ 650,000	
Construction				$ 780,000
Startup & Commissioning				$ 40,000
Power Supply (Dominion)			$ 50,000	$ 200,000
DCS Communication (Dom)			$ 15,000	$ 30,000
Sub-Total	**$ 1,085,000**	**$ 11,935,000**	**$ 23,696,667**	**$ 15,183,333**
Dominion Engineering		$ 40,000	$ 40,000	$ 20,000
Project Management	$ 100,000	$ 208,000	$ 1,040,000	$ 1,040,000
Design Refinements	$ 237,000	$ 2,436,600	$ 4,955,333	$ 3,248,667
AFUDC	$ 28,440	$ 292,392	$ 594,640	$ 389,840
Escalation	$ 116,035	$ 2,475,391	$ 7,854,600	$ 7,157,462
Total Project by Year	**$ 1,566,475**	**$ 17,387,383**	**$ 38,181,240**	**$ 27,039,302**

Total Project	**$ 84,174,400**

Chesterfield Dry Ash Conversion Project

High Level Project Schedule

ACTIVITY	Duration
Project refocus meetings	2 weeks
PAR submission and approval	6 weeks
Bid and award contract	8 weeks
Project kickoff	2 weeks
Permitting	
Design data received for permit application	
prepare and submit application	30 days
30 day DEQ review	30 days
DEQ permit preparation	120 days
Public comment period	30 days
DEQ comment and issue	15 days
Flyash System	
engineering	52 weeks
Procurement/fabrication	24 weeks
Construction/installation	36 weeks
Startup	4 weeks
Bottom Ash System	
engineering	52 weeks
Procurement/fabrication	36 weeks
Construction/installation	60 weeks
Startup	4 weeks
Pyrite System	
engineering	16 weeks
Procurement/fabrication	24 weeks
Construction/installation	8 weeks
Startup	2 weeks
Dominion E&I Scope	
Engineering	12 weeks
Procurement	12 weeks
Construction	8 weeks

ASSUMPTIONS

assumes no unit major outage interface
assumes EPC approach, probably could be shortened by paralleling activities
any County / local permitting will fit inside the DEQ permitting duration

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APPENDIX D

Acronyms Used

FINAL

AMSL	Above Mean Sea Level
CCR	Coal Combustion Residues
CY	Cubic Yard
E&S	Erosion and Sediment
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
g	gravitational constant
GPM	Gallons Per Minute
HDPE	High Density Polyethylene
MGD	Million Gallons per Day
MHA	Maximum Horizontal Acceleration
mil	one-thousandth of one inch (0.001")
MSW	Municipal Solid Waste
NPDES	National Pollution Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
TOC	Total Organic Carbon
TSS	Total Suspended Solids
VPDES	Virginia Pollution Discharge Elimination System
VSMP	Virginia Stormwater Management Program
VSWMR	Virginia Solid Waste Management Regulations
WET	Whole Effluent Toxicity

FINAL REPORT

FINAL

WET ASH IMPOUNDMENT EVALUATION

CHESAPEAKE ENERGY CENTER

Submitted to:

Dominion
5000 Dominion Blvd
Glen Allen, VA 23060

Submitted by: **Golder Associates Inc.**
2108 W. Laburnum Avenue, Suite 200
Richmond, Virginia 23227

Distribution:
1 Copy Dominion
1 Copy Golder Associates Inc.

A world of capabilities delivered locally

January, 2011

1039-6867

TABLE OF CONTENTS

List of Appendices

1.0 EXECUTIVE SUMMARY

Golder Associates Inc. (Golder) is assisting Dominion with the evaluation of the impacts to station operations from the EPA's proposed regulations regarding disposal of coal combustion residuals (CCR) from electric utilities as published in the Federal Register on June 21, 2010. Consideration was given only to the Co-Proposal under authority of Subtitle D of the Resource Conservation and Recovery Act (RCRA) as it represents a baseline cost and schedule basis for either of the co-proposals presented by the EPA.

This evaluation identifies three major systems at the Chesapeake Energy Center (CEC) that will be directly or indirectly impacted by the regulations, and are tied to the regulation effectively eliminating wet ash impoundments as a means of CCR disposal. Closure of the bottom ash pond will force a system change by requiring the bottom ash system to be converted to dry handling and also the construction of an approximate 2.6 million gallon per day (MGD) wastewater treatment plant (WWTP).

The conceptual project costs and schedules presented in this report are based on the following assumptions:

- Construction of an on-site wastewater treatment plant of approximately 2.6 MGD capacity;
- Closure of the bottom ash pond in-place;
- Conversion of the bottom ash handling system to dry handling;
- Additional O&M costs related to the dry handling and WWTP systems; and,
- Other regulatory-driven tasks (posting of plans, etc.).

CHESAPEAKE ENERGY CENTER
CONCEPTUAL COST-LOADED SCHEDULE

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
WWTP Construction *	$5,181,250	$14,959,825	$12,642,992	$2,835,933	$ -	**$35,620,000**
Bottom Ash Conversion	$6,180,000	$8,449,039	$1,950,961	$ -	$ -	**$16,580,000**
Bottom Ash Pond Closure	$ -	$ -	$1,420,850	$ -	$ -	**$1,420,850**
Additional O&M Costs	$ -	$ -	$189,940	$1,248,503	$1,580,253	**$1,580,253**
Total	**$11,361,250**	**$23,408,864**	**$16,204,743**	**$4,084,436**	**$1,580,253**	**$55,201,103**

* Capital costs for selenium treatment not included
All values are anticipation of the proposed Subtitle D rulings

A conceptual overall project schedule has been developed for the CEC, and the estimated time required to complete all three major projects is approximately **3.5 years**, or approximately 18 months ahead of the anticipated regulatory required deadline.

2.0 DESCRIPTION OF THE STATION

The Chesapeake Energy Center (CEC) is located in the city of Chesapeake, Virginia, on the Elizabeth River. The station has four coal-fired and eight gas turbines for a combined total production capacity of 760 megawatts (MW). The station has been in commercial operation since 1953. Immediately south of the station is the ash landfill, permitted as a solid waste landfill by the Virginia Department of Environmental Quality (VDEQ). The ash landfill was built on top of the old ash pond that previously received ash slurry from the station. In 2006, Dominion and PMI Ash Technologies, Inc. (PMI) formed a partnership that allows PMI to receive and process the fly ash from CEC for reuse. As a result, nearly all the fly ash from CEC has been recycled through PMI. The bottom ash is handled wet and slurried to the ash pond at the landfill for disposal.

2.1 Bottom Ash Pond

The station operates the bottom ash pond at the landfill, where it receives slurried bottom ash for gravity settling. The bottom ash pond is included as an operational component of the landfill due it being the receptor for landfill leachate (effectively a “leachate collection surface impoundment”) and is therefore regulated as part of the solid waste permit. The pond does not have a bottom liner system. Sluice water from the bottom ash pond is decanted into the adjacent sediment basin, where it is then discharged under a VPDES permit to Deep Creek.

TABLE 1
CEC ASH POND CAPACITY

Pond	Size (acres)	Capacity (CY) Total / Remaining	Percent full
Bottom ash	3.5	38,000 / varies	varies

2.2 Waste Streams

2.2.1 Bottom Ash

Bottom ash is slurried to the pond for gravity settling at an approximate annual average rate of 1.2 million gallons per day (MGD). After settling, the bottom ash is dredged by the operations contractor using a hydraulic excavator and placed in windrows for dewatering by gravity. Once the bottom ash has reached an acceptable moisture content, it is hauled and placed in the landfill.

2.2.2 Other Plant Waters

The pond receives stormwater and mixed “other” wastewaters from the station. These “other” waters consist primarily of discharge from the station sumps, the metals cleaning pond, coal pile runoff (indirectly), landfill leachate, and most of the stormwater runoff from the landfill. Excluding ash sluice water, the pond receives an approximate annual average of 2.6 MGD of “other waters”.

TITLE

AERIAL OF POWER STATION

PROJECT

DOMINION
CHESAPEAKE ENERGY CENTER
CHESAPEAKE, VA

Golder Associates
Richmond, Virginia

PROJECT No. 103-96868		
FILE No. 10396868A06		
REV. 0	SCALE AS SHOWN	
DESIGN	DPM	09/22/10
CADD	OSY	09/22/10
CHECK		
REVIEW		

FIGURE 1

3.0 DECISION TREE

During the early work sessions for this evaluation, the project team developed a method of analysis that would be used to systematically evaluate the options available at each station with regards to ash impoundments (Figure 2). The first level of evaluation is to determine if there are impoundments that could be considered for early closure using an anticipated effective date of the EPA regulations of December 31, 2011. The evaluation considered if an impoundment could be fully closed in advance of the effective date, and thereby not be subject to the proposed regulations. The bottom ash pond was considered for early closure, and this evaluation is presented in Section 4.

The second level of evaluation is to look at the impoundment with regards to the siting requirements proposed in Section 257.64 of the proposed regulations. The bottom ash pond is part of an operational, regulatory permitted landfill; however, the siting requirements are presumed to still be in force and will need to be evaluated.

The evaluations carried out in this report are based on the EPA's proposed regulations as published in the Federal Register on June 21, 2010. Consideration was given only to the Co-Proposal under authority of Subtitle D of the Resource Conservation and Recovery Act (RCRA), as it represents a baseline cost and schedule requirement for the proposed regulations.

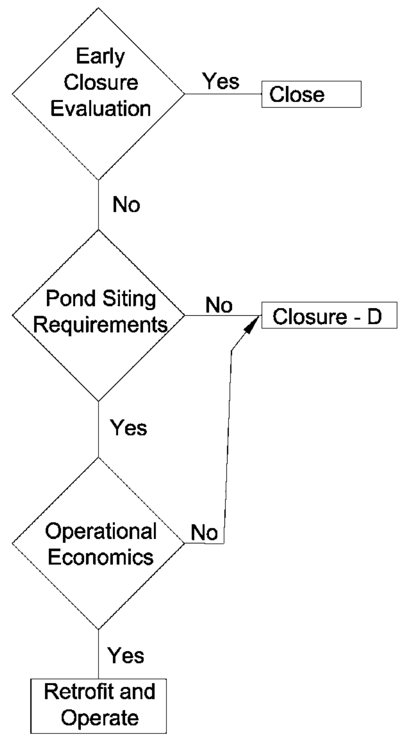


Figure 2 – Decision Tree

4.0 EARLY CLOSURE EVALUATION

4.1 Pond Description

The bottom ash pond at the Chesapeake Energy Center (CEC) is located on the southern end of the ash landfill facility at the CEC. The bottom ash pond is an excavated pond approximately 3.5 acres in area, ranging in elevation from 9 to 20 feet above sea level at its perimeter, and has a capacity of approximately 38,000 cubic yards (CY). The pond is divided by a berm installed in approximately 2001 to provide two working basins in which to manage the bottom ash sluice. The bottom ash pond does not have a liner system.

The pond is used in the daily operations of the station to receive bottom ash sluice flow and promote settling of ash materials for ultimate removal. The bottom ash pond also receives the majority of stormwater flows from the landfill surface, encompassing a drainage area of approximately 31.7 acres. Water from the bottom ash pond decants into the sediment basin for eventual discharge into the Elizabeth River.

4.2 Possible Pond Closure Scenario

The bottom ash pond is an integral part of the station's daily operations, and therefore cannot be closed completely without modifying the station's bottom ash handling system. The evaluated alternative is to perform a partial closure of the pond, leaving approximately one-half of the pond open for bottom ash sluice operations. One half of the pond would be closed by filling with excess ash material and constructing a closure cap in accordance with current regulatory requirements. This closure cap could consist of low permeability soils and/or a geomembrane.

4.3 Closure Scenario Challenges

Since the bottom ash pond is also part of the landfill facility, it is subject to the facility's solid waste permit issued by the Virginia Department of Environmental Quality (DEQ). The planned closure of a portion of the pond would trigger a major permit amendment to the facility's solid waste permit under the "alterations to a leachate collection surface impoundment" criteria. A major permit amendment would take approximately 12 to 18 months to complete. In addition, the entire landfill facility would be open to regulatory scrutiny during the permit amendment process and there may be unforeseen consequences unrelated to the bottom ash pond.

As previously mentioned, the pond is integral to the station's bottom ash sluicing operations, and reducing the volume by one-half would likely result in larger solids volume carryover into the sediment basin. Increased solids in the sediment basin would require more frequent cleanings, and could result in a loss of water quality at the basin's permitted outfall. The bottom ash pond also receives a significant portion of stormwater from the landfill surface, which provides some initial flow attenuation and solids removal for this stormwater. This beneficial effect would be reduced with a decreased pond volume.

The closure of one-half of the pond would require placement of approximately 19,000 CY of fill material (ash or soil) and 1.75 acres of closure cap construction, a relatively small project. Unit construction costs for this small of a project would be disproportionally high. Considering the small area to be closed, it would not provide a significant cost savings versus being closed as part of the overall facility closure at some point in the future.

4.4 Recommendations

Golder recommends not pursuing a partial closure of the CEC bottom ash pond, namely to avoid the possible regulatory exposure of a major solid waste permit amendment, detrimental stormwater quality effects, and the expense relative to closure of such a small area. The overall costs associated with the permitting, design and construction would be disproportionally high, and the cost future savings would likely be inconsequential.

5.0 SITING EVALUATION (§257.64)

For an operator of an existing surface impoundment to continue operating the impoundment under the proposed rules, the operator must make a demonstration that the surface impoundment is not located in an unstable area, or that engineering measures have been incorporated into the design to ensure that the integrity of the structural components of the surface impoundment will not be disrupted. An unstable area is defined as an area that is susceptible to natural or human-induced events capable of impairing the integrity of a surface impoundment. Examples of such unstable areas are:

- Poor foundation conditions such as karst terrain, potential liquefaction areas, highly compressible soils, or man-made structures (mines) underneath the impoundment;
- Areas susceptible to mass movement (landslides, earthquakes); and,
- Flood-prone areas. While not specifically mentioned in the section, Golder chose to include floods due to the 100-year storm event or hurricane storm surge, as these could also be a significant impact to the existing impoundments.

It is important to note that although the bottom ash pond is considered part of the ash landfill facility and is therefore regulated under the landfill's solid waste permit. In preparing this evaluation, Golder reviewed components of the major permit amendment application prepared by Resource International, Ltd., dated February 29,200. Included as part of the application, in a report dated October 28, 1999, the landfill foundation conditions were investigated and stability analyses performed by Schnabel Engineering Associates Inc. (Schnabel).

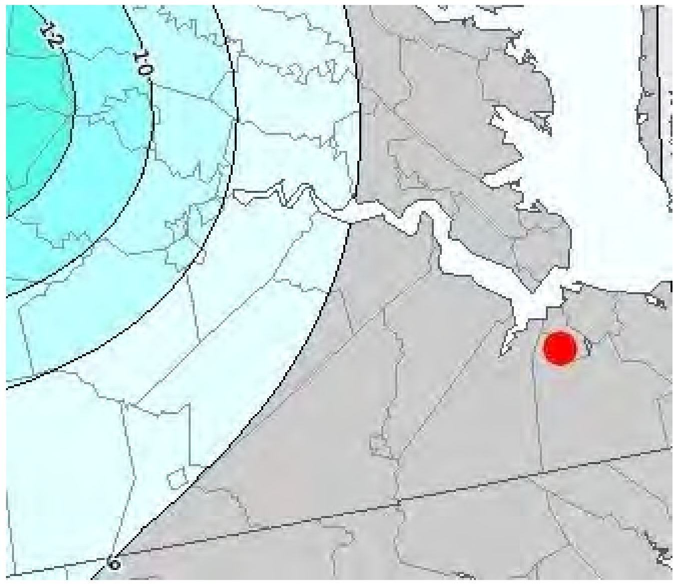
5.1 Evaluation of Foundation Conditions

The Schnabel report does not specifically address the bottom ash pond; however, there is pertinent boring log data for the southern edge of the bottom ash pond. The foundation under the pond's southern embankment generally consists of very soft to stiff clays underlain by very loose to compact clayey sand. The soft and loose materials are indicative of soils that are compressible given a large overburden loading, such as conditions that would exist under the landfill when filled to its design grade. The bottom ash pond; however, is not likely to exert forces of this magnitude on the layers below. The Schnabel report indicates acceptable factors of safety regarding global stability of the landfill.

There are no known mines or other underground structures under the bottom ash pond that could impair the integrity of the pond. The bottom ash pond area is not located in an area known to contain karst features such as solution caverns or sinkholes that would result in failure of containment structures at the facility. Karst topography in Virginia is mainly confined to the western third of the state.

5.2 Liquefaction or Active Faulting

The bottom ash pond is not located in an area of recent or active faulting. The closest fault system is the Paleocene age Dutch Gap Fault System located in central Virginia, which experienced displacement in Quaternary time (i.e., up to 1.8 million years ago) and is over 100 miles from the site. The site is not located in a seismic impact zone as defined in the United States Environmental Protection Agency (USEPA) Technical Manual. For the probability of occurrence (Pe) = 2 percent in 50 years, the peak ground acceleration in rock is less than 0.06g.



USGS Seismic Map – Peak Horizontal Acceleration (%g)
2% Probability of Exceedance in 50 years

5.3 Flood-Prone Areas

While not a defined criterion in §257.64, the site is near the Atlantic Ocean coast and therefore potentially subject to storm surge inundation from storms of category 3 or higher. The facility is not, however, located in the 100-year floodplain as shown on the Flood Insurance Rate Map (FIRM) community panel number 5100340023C, dated May 2, 1999.

5.4 Results of Siting Evaluation

The bottom ash pond appears to meet the requirements for unstable areas as stated in §257.64 of the proposed regulations. If elected to continue using the bottom ash pond, a formal evaluation, certified by a registered professional engineer, will need to be prepared and placed on a publicly available internet site.

Golder Associates

6.0 GROUNDWATER MONITORING SYSTEM

From review of the 2008 Site Map and Well Locations Figure 1b provided by Dominion, it appears that the facility has approximately 13 existing groundwater monitoring wells located around the CEC Landfill and bottom ash pond. There appear to be two upgradient monitoring wells and 11 downgradient monitoring wells within the groundwater monitoring network. Due to the proximity to the Elizabeth River, it is assumed that the estimated depth to groundwater ranges from ten to fifteen feet throughout the groundwater monitoring network. Based on general topography of the area, the groundwater flow direction is assumed to be to the southeast.

The Groundwater Monitoring Plan (GMP) is presumed to be consistent with the regulations, as the network is associated with the solid waste landfill, and no modifications to the plan are anticipated. However, Dominion will need to maintain and upload the GMP, as well as design, installation, development, and decommission activities for any monitoring wells, piezometers, and other measurement, sampling, and analytical device documentation in the operating record and on a publicly accessible internet site. (§257.91(d)1). Appropriate background statistical information is presumed to exist, and annual sampling costs are included in the overall landfill operations cost; therefore the conceptual cost for groundwater improvements at the CEC bottom ash pond is presented as **$0**.

7.0 EVALUATION OF CONTINUED USE

The purpose of this section of the evaluation is to consider, under the Subtitle D proposal of the proposed regulations, what the requirements are and what the estimated conceptual costs would be to retrofit and continue to use the bottom ash pond at the Chesapeake Energy Center.

7.1 Regulatory Impacts

7.1.1 Proposed CCR Regulations

The proposed CCR regulations, issued in draft form for comment on June 21, 2010, form the basis for the physical and operational changes required to ash surface impoundments for continued use. The retrofit actions required, conceptual costs and schedule are presented in the sections 7.2 and 7.3. Groundwater monitoring will be a new requirement for <u>all</u> CCR facilities, despite being targeted for closure or not. The groundwater monitoring system at CEC appears to meet the minimum requirements as outlined in §257.91; however the documentation of the well construction, commissioning and testing will need to be uploaded to the publicly-accessible internet site.

7.1.2 Virginia Solid Waste Management Regulations (VSWMR)

Due to the inclusion of the pond in the landfill solid waste permit, changes to the pond would constitute grounds for a “major” amendment of the solid waste permit (VSWMR 9VAC20-80-620, Table 7.2, section H.3) A major permit amendment would take approximately 12 to 18 months to complete. In addition, the entire landfill facility would be open to regulatory scrutiny during the permit amendment process and there may be unforeseen consequences unrelated to the bottom ash pond.

7.1.3 Potential Effluent Guidelines

On September 15, 2009, the USEPA announced a decision to proceed with rulemaking to review wastewater discharges from power plants and treatment technologies available to reduce pollutant discharges. EPA's decision to revise the current effluent guidelines is largely driven by the high level of toxic-weighted pollutant discharges from coal fired power plants and the expectation that these discharges will increase significantly in the next few years as new air pollution controls are installed. The new discharge standards may include extremely low limits for bioaccumulative metals such as arsenic, magnesium and selenium, as these can be indicative of CCR and/or FGD system runoff. Discharge limits in the 5 to 50 parts per billion (ppb) have been proposed, and in some instances, recently placed into effect. Additional limits may be placed on significant levels of chloride, total suspended solids (TSS), total dissolved solids (TDS), and nutrients.

Removal of these materials to the proposed levels from the wastewater generated by the station, including ash slurry wastewaters, may require new or a combination of existing treatment technologies and investment of millions of dollars in capital expenditures. Continuing to use the bottom ash pond for ash slurry represents a potentially large financial risk should the entire volume of water from the pond require treatment to the proposed levels. Further discussion about potential wastewater treatment infrastructure requirements is included in section 9.2 of this report.

7.2 Retrofit of the Bottom Ash Pond

In addition to solid waste permitting requirements under the VSWMR, the bottom ash pond meets the definition of a surface impoundment in the proposed regulations, and would therefore subject to the design criteria for existing surface impoundments (§257.71). In order to continue use of a surface impoundment, the following actions must take place:

Impoundment Retrofit:

- Demonstration for unstable areas (§257.64), certified by a professional engineer and posted on the operator's publicly-accessible internet site;
- Installation of a composite liner system, including dredging of CCR materials prior to liner placement;
- Development of the construction history and posting on the operator's publicly-accessible internet site;
- Development of and posting an emergency action plan (EAP) for the impoundment if it is determined to have a hazard potential rating of *high* or *significant*; and,
- Installation (or upgrade, if necessary) of a groundwater monitoring system.

Operating Criteria (§257.80 – §257.100):

- Fugitive dust and control plan: controls in place so that fugitive dusts do not exceed 35 $\mu g/m^3$;
- Stormwater management design to control run-on and run-off from the 25-year, 24-hour storm event;
- Surface water discharge permitting (NPDES);
- Inspections: 1 per 7 days by operating personnel, 1 per year by professional engineer;
- Recordkeeping (listed in §257.84.b.1 – b.7);
- Groundwater monitoring (semi-annual sampling); and,
- Preparation of a closure plan and post-closure care plan.

Several of the items in the above lists have prescriptive deadlines as to when they must be in place in order to continue operation of the impoundment. All durations are given as from the effective date of the regulations (EDR).

On or *before* EDR:

- Prepare and post the Closure and Post-Closure Care plans

1 year from EDR:

- Install groundwater monitoring network
- Begin groundwater monitoring to establish statistical background

5 years from EDR:

- Existing surface impoundments retrofitted in accordance with regulations; or,
- Surface Impoundments not destined for continued operation must be closed; however a two-year extension is possible.

The retrofit construction for the bottom ash pond would likely be accomplished by the installation of a commercially-available temporary bottom ash dewatering system to allow continued station operations during construction. Splitting the pond in half in an attempt to retrofit in phases while continuing to operate the pond would be difficult because of the very small size of each half (approximately 1.7 acres) and would likely make the overall project last longer than doing it all at once. The outlined approach in this evaluation considers diversion of the bottom ash slurry while the entire pond is retrofitted as one project. The retrofit process would consist of dewatering the pond, dredging all the bottom ash materials out, and construction of a bottom liner system.

Pumping the free liquid from the pond would be accomplished through self priming diesel powered centrifugal pump sets. Given the relatively small amount of water involved, the pond could be dewatered quickly. The pump discharge water could likely be directed to the adjacent sediment pond for solids settling and discharge. Treatment of the discharge water is likely not required and costs have not been developed for treatment.

After dewatering, the bottom ash in the pond could be excavated using normal hydraulic excavators, where it would be stockpiled in windrows for dewatering. After dewatering, the ash would be loaded and hauled to the adjacent landfill. Overexcavation of the pond bottom and sides is not recommended, due to the pond's location on a former ash pond. After removal of the bottom ash from the pond, continuous dewatering would likely be required for the duration of the project to collect the water that infiltrates the pond from the outside (groundwater inflow). Once design bottom grades are reached, the pond floor soils would be evaluated for competency to support the bottom liner construction. Additional stabilization may be required with reinforcing geosynthetic materials such as geogrid or in-situ soil mixing where a cement or other binder material is mixed into the soils to create a stronger material.

The composite liner system specified in the proposed regulations is very similar to that seen in a Municipal Solid Waste (MSW) landfill and the techniques to install it are well known and practiced in the waste industry. At this time, it is unclear whether or not alternative liner systems other than that specifically addressed in the proposed regulations will be allowed. From the top down, the regulatory-prescribed liner system components are:

- Geomembrane (minimum 30 mil thick or 60 mil if HDPE)
- Leachate collection system (likely a geonet composite material)
- 24” compacted clay (hydraulic conductivity (k) < 1×10^{-7} cm/s)

Once the bottom liner system is constructed, the presumption is that a Certificate to Operate (CTO) would be required from the Virginia DEQ before operations could commence in the newly-constructed, lined pond area. Golder presumes that an on-site construction manager and Construction Quality Assurance (CQA) consultant would be on site for the duration of the project. For the construction sequence outlined above, Golder estimates concept-level costs of **$1,900,000** with an engineering and construction duration of approximately **8 months**. This cost and duration does not include the major permit modification, it is for construction only.

7.3 Operational Requirements

The operational requirements for a retrofitted surface impoundment are detailed in §257.80 - §257.101 and have been outlined previously in section 7.3. Golder’s concept-level opinion of annual cost for operating the surface impoundment, over and above the ash management costs, is approximately **$22,000 per year**. This cost includes weekly inspections by operating personnel, an annual inspection by a professional engineer, and maintenance of the required data on the publicly-accessible internet site. Groundwater monitoring is presumed to be included in the operational costs of the adjacent ash landfill.

8.0 ASH POND CLOSURE

8.1 Regulatory Requirements

Since the bottom ash pond is an integral element of the ash landfill and is included in the solid waste permit, a significant change such as closure or modification of the ash pond would require a 'major' amendment of the landfill permit, as defined in the Virginia Solid Waste Management Regulations (VSWMR). Closure of the pond would also trigger a change in the landfill's leachate collection system, as it currently drains freely to the pond. A major permit amendment would take approximately 12 to 18 months to complete. In addition, the entire landfill facility would be open to regulatory scrutiny during the permit amendment process and there may be unforeseen consequences unrelated to the bottom ash pond.

8.2 Clean Closure

A clean closure, as presented in §257.100, involves the removal of CCR material from the surface impoundment and removal and/or decontamination of "all areas affected" by releases from the CCR surface impoundment to meet the state-specific numeric cleanup levels for constituents found in CCRs. Under the proposed EPA rules for disposal of CCR, 'Corrective Actions' will be imposed on station owners and operators of surface impoundments in the event that offsite impacts to groundwater and surface water occur. Golder understands that the CEC landfill is currently in the corrective action program (CAP) for offsite groundwater impacts, and additional groundwater monitoring has been implemented. Due to the existence of existing offsite groundwater impacts, a clean closure of the bottom ash pond is very doubtful, as it would be nearly impossible to distinguish and segregate the groundwater impacts of the landfill versus the bottom ash pond during material excavation. The pond's location on a point of land at the confluence of Deep Creek and the Elizabeth River, as well as immediately adjacent to the ash landfill is cause for stability concern should an excavation of the pond and surrounding soils be undertaken.

8.3 Closure With Wastes in Place

With a material such as CCR, closure in place involves a significant effort to dewater and stabilize the waste mass so that it will be stable and support the final closure cover. *In-situ* solidification of the entire ash body is considered impractical and unfeasible; however, targeted solidification measures may be considered to enhance the overall stability of the ash body. A thorough pre-design evaluation is recommended during initial closure planning to identify potential stabilization needs for the bottom ash pond. The general sequence of events for closure with the wastes in place is as follows:

- Removal of free liquids;
- Stabilization of the ash body surface;
- Installation of seepage collection system(s);

- Grading and shaping of ash surface for drainage;
- Lowering of the embankment height; and,
- Installation of the final cover system.

Pumping of the free liquid from the pond is feasible with normal self priming diesel powered centrifugal pump sets. Given the relatively small volume of free water involved, it is anticipated that trailer or skid mounted pumps would be required for this application, in the 8 to 12-inch size range. The water pumped from the pond may require treatment prior to release to meet VPDES permit conditions and an allowance of $0.02 per gallon for treatment has been made in the conceptual cost estimate. Pumping the initial free liquid from the pond is estimated to take approximately 1 week to complete.

8.3.1 Stabilization of the Waste Surface

Following removal of the supernatant pond water, or 'free liquid', the CCR will require dewatering to the extent needed to provide a firm, safe and trafficable surface on which equipment can be deployed construction of the closure cap system. To achieve a stable surface, it is anticipated that the water table within the impounded CCR would need to be lowered by about 5 feet below the surface or less, due to the nature of the bottom ash being relatively free draining.

With relatively young wet ash deposits or those under constant submergence, the need for dewatering is inevitable, working in conjunction with spreading out working platforms with LGP equipment. Dewatering may be achieved by excavating trenches (also known as rim ditches) that would drain seepage waters to strategically located sumps. The sumps would probably be lined with a perforated standpipe, wrapped in geotextile, and with a free draining aggregate collar surround. Centrifugal pumps would be required to continuously pump from the sumps. Depth, width and spacing of the rim ditches and sumps would depend greatly on the properties of the site specific CCR. On-site experience shows that the bottom ash drains relatively quickly and an extensive dewatering system for surface stabilization is not anticipated.

8.3.2 Installation of Seepage Collection

If, following subsurface exploration and hydrogeologic evaluation of the pond site, it is determined that conditions are favorable for a closure in place, a significant engineering challenge remains in controlling seepage of the leachate from the ash body over the long term post-closure care period. No matter how effective the construction dewatering is during the cap construction period (be it by rim ditching and sump pumping, or wellpoints), it is unlikely to remove significant volumes of water from the body of the ash. Some form of seepage collection system is therefore recommended and likely to be required by the regulatory agency within the overall closure design.

The elements of a seepage collection system for capture of leachate from within the body of the CCR impoundment over the 30 year post-closure care period would be subject to subsurface exploration, design

and analysis. At this stage it is only possible to discuss the type of design components in very general terms, because much will depend on the following factors:

- Permeability characteristics of the CCR which will be different depending on the mix of fly ash, bottom ash, slimes, and boiler slag;
- Effective porosity (specific yield) of the CCR that governs how much interconnected pore space there is for water to drain out under gravity;
- Degree of layering (anisotropy) of the CCR that is governed by the pond specific history of hydraulic filling;
- Impoundment geometry (berm heights, perimeter lengths, slope gradients, plan area, distance to water treatment plant;
- Hydrogeologic conditions in the foundation; and
- Surface water drainage conditions at the toe of the impoundments.

A seepage collection system might include geosynthetic panel drains that comprise sheets of geocomposite drainage net with integral collection pipes at the bottom edge. Panel drains provide a means by which to lower the water table within the impoundment, enhancing slope stability and helping to mitigate the risk of seepage ‘break-outs’ on the embankment side slopes.

Panel drains are placed vertically in trenches excavated into the CCR body from temporary benches by hydraulic excavators or possibly trenching machines. The excavated trenches might be up to 15 feet deep by two feet wide. Slotted flexible pipes can be sewn into the bottom of panel drains, forming a ‘sheet drain’ to capture liquid from the drainage nets. Flows are then conveyed to collector drains and so called ‘down-drains’ that would be located at intervals around the impoundment. This kind of arrangement would also require cleanout risers at various locations for maintenance (e.g. hydro-blasting to clear blockages) and inspection purposes (e.g. video camera surveys). Down-drains typically connect into a perimeter toe drain system around the toe or lowest point of the impoundment. Flows from the perimeter drain are routed to a permanent sump pump station, and then to a waste water treatment plant prior to discharge.

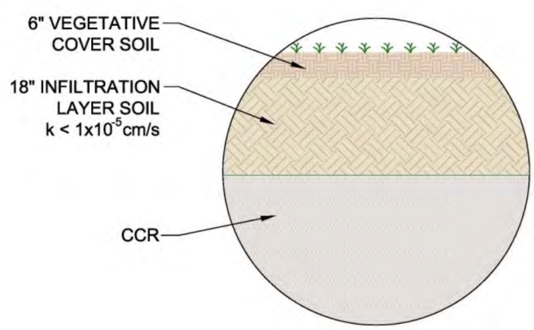
A significant issue arising from installation that needs careful consideration during the design phase is constructability. Dewatering by vacuum assisted well point pumping adjacent to excavations to facilitate drain installation is may be required and may be a significant extra cost to be factor into the planning for long term seepage control.

Estimating the schedule duration for installation of a seepage collection is possible only on a conceptual basis with the limited information currently available. Based on engineering judgment, it is suggested that a period of between 1 and 2 months may be required for construction of a seepage collection systems for closure of the relatively small bottom ash pond. At this strategic planning stage, a conceptual cost estimate for seepage collection drainage based upon unit rates that have been developed from an impoundment closure project in 2005 in the southeastern USA, escalated to 2010 prices using ENR Construction Cost indices. For conceptual planning, unit costs of $13,500 per acre, or alternatively $85 per linear foot of drainage installed are suggested. For the bottom ash pond, a conceptual cost for the installation of a seepage collection system based on 3.5 acres is **$47,500** and would take approximately **1 to 2 months** to install.

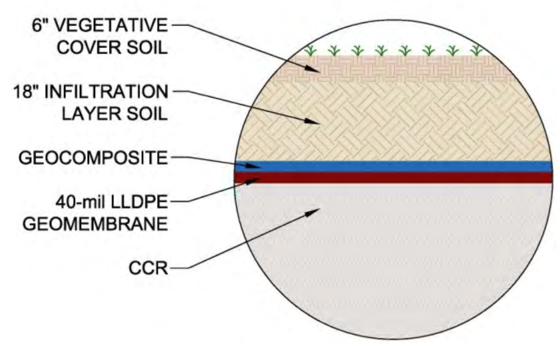
8.3.3 Closure Cap Construction

Once the CCRs are stabilized and prior to placement of the final cap, the surface of the CCR will be shaped to promote positive drainage and prevent infiltration of precipitation. Additional fill material will be needed to adjust the top of the pond from a relatively flat surface to one containing slopes of 2% or more for drainage. The initial as-constructed slope may be steeper than 2% depending on the amount of settling that is anticipated. The goal is have a post-settlement slope of at least 2%.

The final cap system is required to have a permeability (k) of 1×10^{-5} cm/s or be less than the bottom liner system, whichever is less permeable. Since both ponds are unlined, a soil-only cover system consisting of 6-inches of vegetative support soil and 18-inches of soil ($k < 1 \times 10^{-5}$ cm/s) would meet the minimum requirements. The final cover could also be constructed with geosynthetic components to decrease the permeability of the system, or if sufficient quantities of suitable soil are not available. However; the cover system would still likely require 24 inches of soil cover to protect the geosynthetic materials. Regulatory approval of an exposed geomembrane cover in Virginia is uncertain. Stormwater run-on and run-off controls will be designed to adequately convey the 25-year, 24-hour storm at a minimum. Two typical closure cap sections are shown in the figure below.



Soil Only Cap



Geomembrane Cap

Golder strongly recommends the cap section containing the geosynthetic materials, as they provide permeability up to 5 orders of magnitude less than the soil-only systems. A significant decrease in infiltration and consequently an increase in groundwater protection can be had for a relatively small increase in cost. For the dewatering and closure cap construction sequence for the bottom ash pond outlined above, Golder estimates concept-level costs of **$1,420,000** with a permitting, engineering and construction duration of approximately **24 to 30 months**.

8.4 Pond Closure with Landfill 'Piggyback' Expansion

In an effort to "repurpose" the bottom ash pond, consideration was given to using the bottom ash pond area as additional landfill space and "piggybacking" onto the existing landfill to create more on-site disposal volume. This option presents several regulatory permitting and engineering requirements that will need to be satisfied prior to plan approval.

8.4.1 Regulatory and Engineering Issues

Expansion of the captive industrial landfill without modification of the waste permit is allowed due to the facility being in operation prior to October 9, 1993. Expansion beyond the waste boundary existing on that date is allowed subject to the siting and setback requirements contained in the VSWMR (9VAC20-81-35.C). However, due to the bottom ash pond's function as a "leachate collection surface impoundment", modification of this pond may be cause for a major permit amendment for the solid waste permit. Prior to pursuing this option, Golder recommends consulting with the Virginia DEQ for the agency's opinion on the permitting steps to take. Consideration should also be given to the local siting requirements for the City of Chesapeake and if modifications to the Use Permit would be required or if the modification plan would encounter resistance from the general public.

Closure of the bottom ash pond and creation of a piggyback slope on the existing landfill presents two engineering requirements that will have to be evaluated and incorporated into the revised design. First, removal of the pond will require modification of the current leachate collection system to provide continuity of flow from the east side of the landfill into the remainder of the pond. Capturing the volume of the pond for disposal volume would require regrading of the base contours to preclude the need for a leachate pumping system. The second major modification for the piggyback slope would be to evaluate the global site stability given the significant additional loading. The site is known to have less than ideal subsurface conditions, and a thorough evaluation of the global stability of the site would be required. This evaluation would involve a geotechnical investigation program to collect subsurface data and then numerical modeling. The potential exists; however, that the results of the stability analysis may require a smaller disposal volume in order to maintain stability at the site and the possibility of ground improvements to support the additional loading. This reduction in volume and increased cost for foundation improvements could make the project unviable.

8.4.2 Piggyback Option Cost and Benefits

To prepare the values for this cost option, Golder used the approximate outline of the bottom ash pond in its current configuration, bounded on the west side by the separation berm in its current location. Consideration was given to a larger footprint, however siting setbacks and the powerlines on the site make the additional footprint approximately 4 acres. The additional footprint outside the landfill would have to be prepared with a liner system consisting of a geomembrane and leachate collection layer. Based on this conceptual footprint, piggybacking over the bottom ash pond would yield approximately 134,000 cubic yards (165,000 tons) of additional disposal capacity to the existing facility.

For the engineering, permitting and construction sequence outlined above, Golder estimates a concept-level cost of **$2,800,000** with an engineering, permitting and construction duration of approximately **24 to 30 months**. The main benefit of the additional capacity is the reduction in need to transport ash off-site for disposal. At an estimated $30 per ton for off-site disposal, the potential savings is approximately $1,700,000.

TABLE 2
BOTTOM ASH POND – PIGGYBACK DEVELOPMENT

Task	Quantity	Unit Cost	Conceptual Cost
Baseline – Offsite Disposal	165,000	$30 / ton	$4,950,000
On-site Development Cost	LS	$2,260,000	($2,800,000)
On-site Disposal Cost	165,000	$3 / ton	($495,000)
Potential Savings vs. Offsite			**$1,655,000**

8.5 Summary of Ash Pond Closure Options

In the preceding sections, three options were presented: clean closure, closure in place and piggyback development. Golder's initial recommendation is that clean closure is unlikely; however, a more thorough evaluation of the groundwater data would be needed to fully understand this option. Closure in place is the most clearly defined by the regulations; however it sacrifices useable disposal space that could be used if the pond was repurposed for piggyback disposal. Although it has an initial higher cost, repurposing the ash pond for disposal may prove to be the most desirable option by creating useable disposal space on site that would otherwise have to go off site at a significantly higher cost. Table 3 outlines the cost summary of the two most likely of the options presented. Both options are presented with a 28-month duration due to the potential Major Permit Modification for the facility's solid waste permit.

TABLE 3
BOTTOM ASH POND – CLOSURE OPTIONS

Scenario	Duration (months)	Conceptual Cost
Closure in-place	28	$1,420,000
Piggyback Development	28	$2,800,000

9.0 CONSEQUENCES OF POND CLOSURE

The decision to close the lower ash pond would trigger two additional significant changes at the Chesapeake Energy Center. First, the station would be required to change the bottom ash handling system to a dry system, and second, the 2.6 MGD of "other plant waters" would require a treatment process prior to discharge.

9.1 Dry Ash Conversion

The current bottom ash handling system at CEC consists of collection and transport of bottom ash via slurry to a pond located in the southwest section of the plant property. The bottom ash is collected in bottom ash hoppers where it is combined with water to form slurry and transported to the ash pond. The water from this pond is not recycled.

This system will be modified to eliminate and close the ash pond. Bottom ash would continue to be collected and transported as wet slurry, but will be directed to two new dewatering bins installed in a new ash compound constructed southeast of the existing fly ash silos. The dewatering bins to allow the sluice water to drain from the bottom ash slurry. The collected sluice water from the dewatering bins would be clarified in a settling tank and water stored in a large aboveground storage tank for reuse in a closed-loop sluice water system. The dewatered bottom ash would be collected for loading into trucks for disposal or reuse.

To accommodate the proposed modification, the existing ash sluice lines would be redirected to the new ash compound area. The new ash compound area would contain a pump house for new pumps (low pressure and high pressure) to supply water to the existing bottom ash hopper and sluice systems. The discharge from the existing bottom ash hopper overflow sumps would be redirected to the settling tank.

Golder estimates a conceptual cost to implement the bottom ash conversion at **$16,600,000**, with a project duration of **24 to 30 months**.

The estimated annual O&M cost for the dry ash handling system as described is **$253,250** per year. This cost includes:

- 0.75 Full Time Equivalent (FTE) operators/maintenance staff at $100,000 each;
- Electrical usage at $0.02 per kWh; and,
- Maintenance.

9.2 Waste Water Treatment Plant (WWTP)

The bottom ash pond serves as the receiving body for the metals treatment basin discharge, various sumps in the station, landfill leachate, and stormwater runoff from the landfill surface. The outfall for the bottom ash pond discharges into the sediment basin portion of the pond and then into Deep Creek under the station's Virginia Pollution Discharge Elimination System (VPDES) permit. This permit includes monitoring of the outfall for the following parameters:

- pH
- Total Recoverable Chromium (total and hexavalent)
- Total Suspended Solids (TSS)
- Oil and Grease
- Ammonia
- Dissolved Copper
- Total Phenolics
- Dissolved Nickel
- Total Vanadium

Historically, the volume of water and settling time provided by the bottom ash pond has provided sufficient water quality at the outfall to consistently meet the permit limits. Closure of the pond will have a significant impact on the dilution and biological processes that contributed to a compliant discharge, and will likely prevent the discharge of most or all of these waters without some form of treatment. In addition to the above-listed constituents, future discharges may be subject to monitoring for additional parameters such as the metals manganese and selenium, with discharge limits as low as 50 and 5 parts per billion (ppb) respectively.

For development of the conceptual treatment process for these waters, Golder proposes a two-stage process. The first stage consists of gross solids removal and primary treatment to remove contaminants listed in the current permit. A second stage treatment process would then follow, targeting specific metal constituents in anticipation of the future discharge limits.

The pond also functions as a sedimentation pond for plant wastewater and landfill runoff. With the ash sluicing water uses terminated, the pond would need to be replaced with a wastewater treatment system of similar function, but at a new reduced flow rate of 2.6 MGD. Golder understands that the CEC is in compliance with the existing limits listed above. The new proposed primary wastewater treatment system is designed to achieve continuous compliance with pH and TSS limits, and will provide incidental treatment for O&G, as well as TOC. Compliance is assumed for O&G, TOC, as well as Ammonia, so unit processes have not been included in the design for these parameters. If there is a history of non-compliance with these additional parameters additional unit processes may be required.

9.2.1 Flow Reduction and Elimination

Prior to design and construction of a wastewater treatment plant, Golder recommends evaluation of the wastewater flows to identify potential methods to reduce the volume of flow to a new WWTP. Given the high unit costs for treatment that may be required, significant savings in both capital construction costs and long-term Operations and Maintenance (O&M) costs can be realized by such an evaluation. An evaluation of the plant's water use and the processes that produce wastewater should be conducted. Emphasis should be placed on identifying wastewater flows that could be segregated out and undergo only primary treatment and not a more expensive secondary or tertiary treatment. Water reuse opportunities could also be a target of this evaluation to identify sources of water that could be used again within the station.

9.2.2 Primary Wastewater Treatment

The sequence of unit processes and equipment to provide the primary level of wastewater treatment for discharge in accordance with the existing permit will include the following:

1) Remote control system;
2) Pump stations at Metals Pond and stormwater pond;
3) Equalization Tank with a remote control storage and bleed system to provide less variation in flow to the treatment process;
4) pH adjust tanks, mixers, and controls (with sulfuric acid and sodium hydroxide reagent day tanks and bulk holding tanks);
5) Coagulant addition with rapid mix;
6) Polymer feed with flash mix, and slow mix agglomeration;
7) Lamella style clarifiers with sludge thickener tanks (assuming 500 mg/L TSS after pH adjustment, due to metals precipitation and solids in the source waters);
8) Concrete foundations and metal building.

9.2.3 Secondary Wastewater Treatment

Secondary wastewater treatment may become necessary following issuance of new effluent limitations guidelines for metals, including manganese and selenium. Removal of manganese and selenium to 50 and 5 ppb, respectively, will require the addition of two distinctly different treatment process trains. Treatment for manganese will require integration with the primary treatment process, as follows:

1) Oxidant feed system and reaction tank with 30 minutes hydraulic retention time;
2) Larger caustic feed system to raise pH to 10.5 for manganese removal;

3) Enlarge pH adjustment tank to provide 30 minutes retention time;

4) Substitute for or replace lamella clarifiers (depending on timing of the installation of primary and secondary treatment facilities) with conventional circular, solids contact clarifiers;

5) Add sludge thickening tankage (increase solids content to 5%) to reduce sludge volume going to sludge handling system;

6) Multi-media filters for polishing of particulate manganese removal; and

7) pH adjustment tank and sulfuric acid feed system to reduce pH into the 6 to 9 range (target will be 7.5 to 8.0).

Removal of selenium will occur downstream of the manganese removal filters because selenium is removed to meet the low limit of 5 ppb using an anaerobic process that would re-solubilize any residual manganese not removed from the clarifier effluent upstream. The selenium treatment process will include the following treatment processes:

1) Storage and feeding system for a carbon source, such as molasses;

2) Modular anaerobic bioreactors for biological reduction of selenium, which deposits in the bioreactors, with modular tanks sized for 0.2 MGD of the wastewater flow;

3) Reaeration tanks, with 2 hours of retention time; and

4) Auto-backwashing screen filters for sloughed solids removal prior to discharge.

9.2.4 Conceptual Budget and Schedule

The capital cost of the primary wastewater treatment system is dominated by the lamella clarifiers, with the following total conceptual capital costs estimated at:

Primary Wastewater Treatment System: **$18,000,000**

Secondary Wastewater Treatment System: **$18,000,000**

Secondary Treatment System for Selenium: **$46,000,000**

If the primary and secondary treatment systems are designed and constructed in sequence, an equipment savings of approximately $12,000,000 may be realized due to elimination of system redundancies. The implementation schedule for wastewater treatment will be controlled by long-lead times for some of the major equipment, such as the equalization tank, clarifiers and bioreactors, which would range from 7 to 10 months:

- Pre-engineering studies and Design – 7 months, plus 1 month overlap with Procurement

- Procurement of long-lead equipment – 10 months
- Construction (after delivery of long-lead equipment) – 5 months
- Startup and Commissioning – 2 months
- Total implementation time – **24 to 36** months

This schedule would be shortened by about 3 months if on primary treatment is implemented.

9.2.5 Operations and Maintenance (O&M) Costs

The estimated annual O&M cost for the 2.6 MGD treatment system as described is **$1,327,000** per year. This cost includes:

- 0.75 Full Time Equivalent (FTE) operators/maintenance staff at $100,000 each;
- Electrical usage at $0.02 per kWh;
- Waste disposal for processed sludge;
- Chemical and other supply consumption; and,
- Maintenance.

10.0 POST-CLOSURE CARE AND MONITORING

Following closure of a surface impoundment, Dominion will be required to provide post-closure care and monitoring of the impoundments that were closed in place for a period of 30 years. This 30-year period may be adjusted (up or down) depending on the nature of the impoundment and the continued protection of human health and the environment. The goal of the post-closure care program is to maintain the integrity of the surface impoundment closure systems (i.e. cover, leachate, groundwater, etc.) and provide monitoring of groundwater quality around the impoundment. Post-closure care activities are required for the option of closure in place.

10.1 Post-Closure Care Requirements

Requirements during the post-closure care period can be grouped into two major categories: systems integrity and monitoring. The final cover system constructed on the impoundment must be maintained to correct the effects of settlement, erosion, animal burrows, human activity, etc. The final cover drainage systems are of key importance, as failure of a stormwater system during a large storm event could damage large portions of the cover and allow contained materials to be exposed to the environment. Routine inspections and mowing of the vegetation will be required.

The seepage collection system will require periodic maintenance to ensure it continues to function and drain accumulated liquids from the ash body. Routine visual inspections of the leachate system and monitoring of the volume of flow will help spot potential problems before they develop into major issues. Treatment of the collected seepage is presumed to be at the station's on-site wastewater treatment facility, at a conceptual cost of $0.02 per gallon. The initial cost for treatment will be higher, but as less seepage is collected these costs are expected to decrease.

The groundwater monitoring network will require periodic inspection to ensure the wells are functional and in good repair. Damaged wells will need to be replaced and developed to continue the statistical background of the overall monitoring network. Monitoring of the groundwater network will be in accordance with the facility's approved groundwater monitoring plan. For this conceptual evaluation, Golder has assumed a semi-annual monitoring frequency and a standard baseline analytical program.

10.2 Conceptual Post-Closure Care Costs

Conceptual costs for the post-closure care period were evaluated using guidance from the Virginia DEQ relating to post-closure care of landfill facilities. Costs are shown in current-year (2010) dollars and are not escalated. The more likely case; however, is that the pond post-closure care costs will be rolled into the overall post-closure care cost of the landfill.

TABLE 4
CONCEPTUAL POST-CLOSURE CARE COST ESTIMATE (30-YEAR)

Pond	Begin Year	End Year	Annual Cost	Total Cost
Bottom Ash	2016	2036	$12,365	$370,950

11.0 OVERALL PROJECT CONCEPTUAL COST AND SCHEDULE

The conceptual project costs and schedules presented in this section are based on the following assumptions:

- Construction of an on-site wastewater treatment plant of approximately 2.6 MGD capacity;
- Closure of the bottom ash pond in-place;
- Conversion of the bottom ash handling system to dry handling;
- Additional O&M costs related to the dry handling and WWTP systems; and,
- Other regulatory-driven tasks (posting of plans, etc.).

The sequencing of the projects is important, and mainly hinges on the functions provided by the bottom ash pond. The wastewater treatment plant need and bottom ash conversion to be completed and in service prior to beginning closure of the bottom ash pond. Closure of the pond will need to be completed within five years of the effective date of the regulations unless a waiver is granted for an extension. A conceptual overall project schedule has been developed for the CEC, and the estimated time required to complete all major projects described in this evaluation is approximately **3.5 years**, or approximately 18 months ahead of the anticipated regulatory required deadline.

TABLE 5
CONCEPTUAL PROJECT COSTS

Activity	Duration	End Date
WWTP Construction	42 months	2Q 2014
Bottom Ash Pond Closure	28 months	2Q 2013
Dry Ash Conversion	10 months	1Q 2013
Total	42 months	

TABLE 6
COST-LOADED SCHEDULE

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
WWTP Construction *	$5,181,250	$14,959,825	$12,642,992	$2,835,933	$ -	**$35,620,000**
Bottom Ash Conversion	$6,180,000	$8,449,039	$1,950,961	$ -	$ -	**$16,580,000**
Bottom Ash Pond Closure	$ -	$ -	$1,420,850	$ -	$ -	**$1,420,850**
Additional O&M Costs	$ -	$ -	$189,940	$1,248,503	$1,580,253	**$1,580,253**
Total	**$11,361,250**	**$23,408,864**	**$16,204,743**	**$4,084,436**	**$1,580,253**	**$55,201,103**

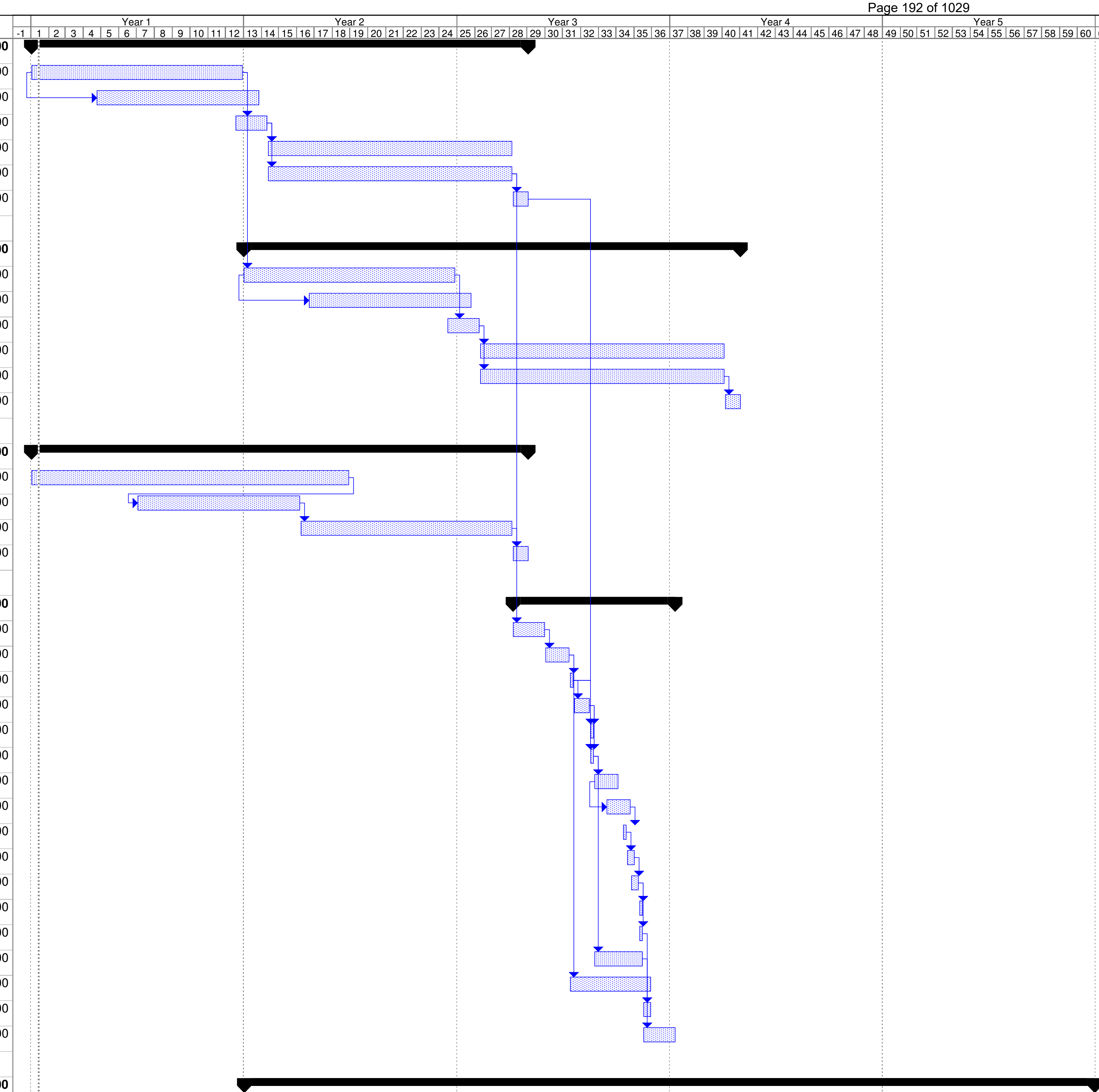
* Capital costs for selenium treatment not included
All values are anticipation of the proposed Subtitle D rulings

FINAL

APPENDIX A

Cost Loaded Schedules

ID	Task Name	Duration	Start	Finish	Predecessors	Cost
1	**CEC Waste Water Treatment Plant - primary**	**122 wks**	**1/3/11**	**5/3/13**		**$17,810,000.00**
2	Engineering & pilot testing	52 wks	1/3/11	12/30/11		$1,100,000.00
3	Procurement, long lead items	40 wks	4/25/11	1/27/12	2SS+16 wks	$4,500,000.00
4	DOM procurement, bid award	8 wks	12/19/11	2/10/12	2FS-2 wks	$125,000.00
5	Construction	60 wks	2/13/12	4/5/13	4	$11,750,000.00
6	Engineering Support during construction	60 wks	2/13/12	4/5/13	4	$210,000.00
7	Startup	4 wks	4/8/13	5/3/13	6	$125,000.00
8						
9	**CEC Waste Water Treatment Plant-secondary**	**122 wks**	**1/2/12**	**5/2/14**		**$17,810,000.00**
10	Engineering & pilot testing	52 wks	1/2/12	12/28/12	2	$1,100,000.00
11	Procurement, long lead items	40 wks	4/23/12	1/25/13	10SS+16 wk	$4,500,000.00
12	DOM procurement, bid award	8 wks	12/17/12	2/8/13	10FS-2 wks	$125,000.00
13	Construction	60 wks	2/11/13	4/4/14	12	$11,750,000.00
14	Engineering Support during construction	60 wks	2/11/13	4/4/14	12	$210,000.00
15	Startup	4 wks	4/7/14	5/2/14	14	$125,000.00
16						
17	**Bottom Ash System**	**122 wks**	**1/3/11**	**5/3/13**		**$16,580,000.00**
18	Engineering & project support	78 wks	1/3/11	6/29/12		$2,250,000.00
19	Procurement and fabrication	40 wks	7/4/11	4/6/12	18FS-52 wks	$7,200,000.00
20	Construction and installation	52 wks	4/9/12	4/5/13	19	$7,050,000.00
21	Startup	4 wks	4/8/13	5/3/13	20	$80,000.00
22						
23	**CEC Ash Pond Closure**	**40 wks**	**4/8/13**	**1/10/14**		**$1,420,850.00**
24	Engineering	8 wks	4/8/13	5/31/13	6	$112,000.00
25	DOM procurement, bid award	6 wks	6/3/13	7/12/13	24	$0.00
26	Mobilization, initial survey	1 wk	7/15/13	7/19/13	25	$15,000.00
27	E&S, stormwater permits	4 wks	7/22/13	8/16/13	26	$5,500.00
28	Initial erosion control	1 wk	8/19/13	8/23/13	26,27	$6,000.00
29	Initial dewatering	1 wk	8/19/13	8/23/13	7,27,26	$31,000.00
30	Operate dewatering system + treatment	6 wks	8/26/13	10/4/13	29	$88,000.00
31	Install seepage collection system	6 wks	9/16/13	10/25/13	30SS+3 wks	$47,250.00
32	Closure contractor mobilization	1 wk	10/14/13	10/18/13	31FS-2 wks	$35,000.00
33	Grading, material import	2 wks	10/21/13	11/1/13	32	$471,400.00
34	Cover Construction	2 wks	10/28/13	11/8/13	33FS-1 wk	$350,000.00
35	Drainage features	1 wk	11/11/13	11/15/13	34	$0.00
36	Seeding	1 wk	11/11/13	11/15/13	34	$7,000.00
37	Construction Quality Assurance (CQA)	12 wks	8/26/13	11/15/13	29	$52,500.00
38	Construction Management	20 wks	7/15/13	11/29/13	25	$182,000.00
39	Project close out	2 wks	11/18/13	11/29/13	36	$18,200.00
40	DEQ Certification of closure	8 wks	11/18/13	1/10/14	37	$0.00
41						
42	**Regulatory Deadlines**	**208.6 wks**	**1/3/12**	**12/31/15**		**$0.00**



Project: CEC Retrofit
Date: 1/14/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Chesapeake Energy Center
Overall Cost-Loaded Schedule

January 2011

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Totals
CEC Waste Water Treatment Plant	$ 5,181,250	$ 14,959,825	$ 12,642,992	$ 2,835,933	$ -	$ -	$ 35,620,000
CEC Bottom Ash System	$ 6,180,000	$ 8,449,039	$ 1,950,961	$ -	$ -	$ -	$ 16,580,000
CEC Bottom Ash Pond Closure	$ -	$ -	$ 1,420,850	$ -	$ -	$ -	$ 1,420,850
Totals	**$ 11,361,250**	**$ 23,408,864**	**$ 16,014,803**	**$ 2,835,933**	**$ -**	**$ -**	**$ 53,620,850**

							Annual Cost
CEC O&M Costs	$ -	$ -	$ 189,940	$ 1,248,503	$ 1,580,253	$ 1,580,253	**$ 1,580,253**

Chesapeake Energy Center
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	2011	2012	2013	2014	2015
CEC Waste Water Treatment Plant						
Engineering & pilot testing	$ 1,100,000	$ 1,100,000				
Procurement, long lead items	$ 4,500,000	$ 4,050,000	$ 450,000			
DOM procurement, bid award	$ 125,000	$ 31,250	$ 93,750			
Construction	$ 11,750,000		$ 9,047,500	$ 2,702,500		
Engineering Support during construction	$ 210,000		$ 161,700	$ 48,300		
Startup	$ 125,000			$ 125,000		
CEC Waste Water Treatment Plant						
Engineering & pilot testing	$ 1,100,000		$ 1,100,000			
Procurement, long lead items	$ 4,500,000		$ 4,072,500	$ 427,500		
DOM procurement, bid award	$ 125,000		$ 34,375	$ 90,625		
Construction	$ 11,750,000			$ 9,086,667	$ 2,663,333	
Engineering Support during construction	$ 210,000			$ 162,400	$ 47,600	
Startup	$ 125,000				$ 125,000	
WWTP Totals	**$ 35,620,000**	**$ 5,181,250**	**$ 14,959,825**	**$ 12,642,992**	**$ 2,835,933**	**$ -**
CEC Bottom Ash System						
Engineering & project support	$ 2,250,000	$ 1,500,000	$ 750,000			
Procurement and fabrication	$ 7,200,000	$ 4,680,000	$ 2,520,000			
Construction and installation	$ 7,050,000		$ 5,179,039	$ 1,870,961		
Startup	$ 80,000			$ 80,000		
Dry Ash Totals	**$ 16,580,000**	**$ 6,180,000**	**$ 8,449,039**	**$ 1,950,961**	**$ -**	

Chesapeake Energy Center
Conceptual Cost-Loaded Schedules

January 2011

Activity	Total	2011	2012	2013	2014	2015
CEC Bottom Ash Pond Closure						
Engineering	$ 112,000			$ 112,000		
DOM procurement, bid award	$ -			$ -		
Mobilization, initial survey	$ 15,000			$ 15,000		
E&S, stormwater permits	$ 5,500			$ 5,500		
Initial erosion control	$ 6,000			$ 6,000		
Initial dewatering	$ 31,000			$ 31,000		
Operate dewatering system + treatment	$ 88,000			$ 88,000		
Install seepage collection system	$ 47,250			$ 47,250		
Closure contractor mobilization	$ 35,000			$ 35,000		
Grading, material import	$ 471,400			$ 471,400		
Cover Construction	$ 350,000			$ 350,000		
Drainage features	$ -			$ -		
Seeding	$ 7,000			$ 7,000		
Construction Quality Assurance (CQA)	$ 52,500			$ 52,500		
Construction Management	$ 182,000			$ 182,000		
Project close out	$ 18,200			$ 18,200		
DEQ Certification of closure	$ -					
BA Pond CIP Totals	**$ 1,420,850**	**$ -**	**$ -**	**$ 1,420,850**	**$ -**	**$ -**

Overall Totals	**$ 53,620,850**	**$ 11,361,250**	**$ 23,408,864**	**$ 16,014,803**	**$ 2,835,933**	**$ -**

CEC Bottom Ash Pond Liner Construction (Retrofit for continued operation)

Task	Duration (wk)	Qty	U/M	Unit Price	Total	Notes
Engineering & permitting costs	16	1	LS	$ 100,000.00		
Mobilization	1	1	LS	$ 75,000.00	$ 75,000	
Temporary BA dewatering system	22	22	Wk	$ 20,000.00	$ 440,000	
Initial dewatering	1	1	Wk	$ 6,000.00	$ 6,000	Remove ~ 2.5MG
ash dredge	2	28,500	CY	$ 5.00	$ 142,500	Assumed 75% full
Install and operate dewatering system	15	15	Wk	$ 3,000.00	$ 45,000	Duration of construction thru CTO
Haul material to upper pond	2	28,500	CY	$ 3.00	$ 85,500	3,000 CY/D
Stabilize pond liner foundation	4	3.5	Ac	$ 87,120.00	$ 304,920	Assumes geosynthetic reinforcement, $2/SF
Install composite liner system	3	3.5	Ac	$ 175,000.00	$ 612,500	2 Ac / wk to install
Construction Management (DOM)	15	15	Wk	$ 9,100.00	$ 136,500	60 hrs/wk x $135/hr + $1,000/wk
Construction quality assurance	10	3.5	Ac	$ 15,000.00	$ 52,500	
DEQ review CQA report / CTO	6				$ -	prior to operation

Project Totals	**$ 1,900,420**	
	$ 542,977	per acre (3.5 acres)

Made By: DPM
Checked:
Reviewed:

CEC Bottom Ash Pond Piggyback Construction

Task	Duration (wk)	Qty	U/M	Unit Price	Total	Notes
Engineering & permitting costs	16	1	LS	$ 250,000.00	$ 250,000	Major Permit Mod
Stability Analysis	8	1	LS	$ 150,000.00	$ 150,000	
Contractor Mobilization	1	1	LS	$ 75,000.00	$ 75,000	
Temporary BA dewatering system	22	22	Wk	$ 20,000.00	$ 440,000	
Initial dewatering	1	1	Wk	$ 6,000.00	$ 6,000	Remove ~ 2.5MG
ash dredge	2	28,500	CY	$ 5.00	$ 142,500	Assumed 75% full
Install and operate dewatering system	15	15	Wk	$ 3,000.00	$ 45,000	Duration of construction thru CTO
Haul material to upper pond	2	28,500	CY	$ 3.00	$ 85,500	3,000 CY/D
Pond liner foundation ground improvements	8	4.0	Ac	$ 160,000.00	$ 640,000	Wick drains + geogrid @ $160k / acre
Install composite liner system	3	4.0	Ac	$ 175,000.00	$ 700,000	2 Ac / wk to install
Construction Management (DOM)	20	20	Wk	$ 9,100.00	$ 182,000	60 hrs/wk x $135/hr + $1,000/wk
Construction quality assurance	15	4.0	Ac	$ 20,000.00	$ 80,000	including wick drain CQA
DEQ review CQA report / CTO	6				$ -	prior to operation
				Project Totals	**$ 2,796,000**	
					$ 699,000	per acre (4.0 acres)

Gross Volume	168,452	CY
(5 Acre Cap Volume)	(24,200)	CY
(4 Acre liner volume)	(9,680)	CY
Net Disposal Volume	134,572	CY

Alternative - Haul to C&D Landfill

Compacted CY to loose tons	1.23	ton/CY
loose tons	165,524	ton
Disposal cost ($/ton)	30	$
Off-Site Disposal Cost - total	4,965,707	$

2,796,000	Fixed Development Cost
496,571	on-site disposal cost @ $3/ton
3,292,571	On-Site Disposal Cost - total
1,673,136	Potential Net Savings vs. Off-Site

DRAFT

APPENDIX B

Acronyms Used

FINAL

AMSL	Above Mean Sea Level
CCR	Coal Combustion Residues
CY	Cubic Yard
E&S	Erosion and Sediment
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
g	gravitational constant
GPM	Gallons Per Minute
HDPE	High Density Polyethylene
MGD	Million Gallons per Day
MHA	Maximum Horizontal Acceleration
mil	one-thousandth of one inch (0.001")
MSW	Municipal Solid Waste
NPDES	National Pollution Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
TOC	Total Organic Carbon
TSS	Total Suspended Solids
VPDES	Virginia Pollution Discharge Elimination System
VSMP	Virginia Stormwater Management Program
VSWMR	Virginia Solid Waste Management Regulations
WET	Whole Effluent Toxicity

Senate Bill 1398 Response

Coal Combustion Residuals Ash Pond Closure Assessment

November 2017

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Senate Bill 1398 Response

Coal Combustion Residuals
Ash Pond Closure Assessment

Prepared for:

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Executive Summary

Coal ash, also referred to as coal combustion residuals (CCR), is stored in surface impoundments (ash ponds) and in dry landfills. Following large coal ash spills with environmental impacts in Tennessee (2008) and North Carolina (2014), the U.S. Environmental Protection Agency (USEPA) established national rules for coal ash storage and strengthened existing controls to ensure the long-term safety and structural integrity of existing ash ponds to help prevent future releases. On April 17, 2015, the USEPA issued the Final CCR Rule, which establishes regulations for the management of CCR in ash ponds and landfills as well as for beneficial use (recycling/reuse). The CCR Rule was incorporated into the Virginia Solid Waste Management Regulations (VSWMR) on January 27, 2016. By adopting the CCR Rule, the Virginia Department of Environmental Quality (DEQ) is authorized to issue solid waste permits to govern the closure of regulated CCR units in Virginia.

Through permitting and regulatory programs, Virginia has implemented rules that are more comprehensive than the federal rules. The DEQ regulates solid waste and water discharge related to ash ponds, and the Virginia Department of Conservation and Recreation regulates the structural integrity of ash ponds.

The Virginia General Assembly enacted Senate Bill 1398 (SB 1398) on April 5, 2017, to require a study of all ash ponds in the Chesapeake Bay watershed and determine available closure options that would effectively manage these ponds in accordance with applicable state and federal regulations, while ensuring that the safety, environmental, and community impacts of the pond closures are managed. The objective of the study was to comply with the following SB 1398 requirements:

- Evaluate closure by removal with recycling or reuse (beneficial use) of the CCR material
- Evaluate closure by removal with placement of CCR material in a permitted landfill
- Evaluate closure-in-place addressing long-term safety, structural, and extreme weather event resiliency
- Describe groundwater and surface water quality surrounding each ash pond and evaluate corrective measures if needed

SB 1398 is applicable to eleven ash ponds at four Dominion Energy (Dominion) power stations, as shown in Table ES-1. On behalf of Dominion, AECOM conducted a study consisting of an evaluation of the groundwater and surface water for all eleven ponds and an assessment of closure options for the five of the eleven ponds that have been slated for closure. Ash has been removed or is in the process of being removed from the other six ponds; therefore, these ponds are being closed by removal. This report presents the results of the study and also describes historical pond closure and closure trends across the U.S. power industry.

Ash ponds can be closed by removing the CCR materials or closing the pond in place. Closure by removal options include recycling/beneficial use or relocation of CCR to a lined, permitted landfill. Potential landfill options include expansion of an existing on-site landfill, construction of a new on-site landfill, transporting the materials off site to a permitted commercial landfill, or transporting the materials off site to a new landfill that would need to be permitted and constructed.

Table ES-1: Ash Ponds included in the Study

Power Station	CCR Units	Remaining CCR Volume (CY)[1]	Operating Status	Area (acres)
Bremo Power Station	North Ash Pond[2]	4,800,000	Slated for closure	68
	East Ash Pond	1,400,000	Ash being actively removed and transported to North Ash Pond	27
	West Ash Pond	0	Ash removed	22
Chesapeake Energy Center[3]	Bottom Ash Pond[2]	60,000	Committed to closure by removal	5
Chesterfield Power Station	Lower Ash Pond[2]	3,600,000	Slated for closure	101
	Upper Ash Pond[2]	11,300,000	Slated for closure	112
Possum Point Power Station	Ash Pond A Ash Pond B Ash Pond C	40,000	Residual ash to be removed from Ash Ponds A, B, and C and transported to Ash Pond D	18
	Ash Pond D[2]	4,009,250	Slated for closure	70
	Ash Pond E	2,250	Residual ash to be removed and transported to Ash Pond D	38
	Total Volume	**25,211,500**		

(1) CCR volumes are based on Dominion estimates as of July 10, 2017

(2) Assessed for closure options

(3) While not subject to the assessment required by SB 1398, the CCR landfill at the Chesapeake Energy Center is slated for closure in accordance with VSWMR. Virginia DEQ issued a draft solid waste permit in June 2016 for closure of the landfill, which process was later suspended at Dominion's request. The draft permit required Dominion to evaluate and propose alternative corrective measures to address groundwater impacts. In addition, in connection with a July 31, 2017, court order, Dominion will submit a revised solid waste permit application to DEQ by March 31, 2018, to include proposed additional corrective measures to address site-wide groundwater impacts.

CCR = coal combustion residuals; CY = cubic yards; DEQ = Department of Environmental Quality; VSWMR = Virginia Solid Waste Management Regulations

Summary of Findings

Various closure options could be implemented at each station to address the safety, environmental, and community impacts related to the ash ponds. All of the options have inherent challenges, risks, schedules, and costs. For the larger volume ponds at Bremo, Chesterfield, and Possum Point Power Stations, removal options compared to closure-in-place would generally take longer and include off-site transportation that would introduce additional safety, environmental, and community impacts. Closure by removal costs for these ponds would also be an order-of-magnitude larger than closure-in-place.

CCR materials from smaller volume ponds such as the Chesapeake Energy Center Bottom Ash Pond could be removed in shorter durations with fewer safety, environmental, and community impacts. Dominion has committed to removing the materials from the Chesapeake pond for beneficial use or off-site disposal.

Preliminary groundwater results indicate that CCR constituent concentrations were detected above USEPA Maximum Contaminant Levels (MCLs) or background levels in groundwater monitoring wells associated with the ash ponds at all four stations. Additional monitoring is required before these results are confirmed. However, the detections were isolated to areas adjacent to the ash ponds and do not affect drinking water supplies. Additionally, surface water data indicate that all constituent concentrations are below Virginia Surface Water Quality Standards (aquatic and human health) at each of the four stations. Based on the groundwater data and site-specific conditions, various potential corrective measure technologies could be implemented in conjunction with closure-in-place to address the groundwater conditions surrounding the ash ponds.

The findings of the study are summarized below:

- **Beneficial Use** – The beneficial use market study indicated a projected regional excess of ash supply that would result in recycling options for the large volume of ponded coal ash having prolonged time frames for processing and placement in the marketplace. Many potential beneficial use technologies were evaluated to assess the feasibility of processing ponded ash. Although this market is rapidly evolving, many technologies are still in the research stage or are unproven for large-scale coal ash beneficiation. Four potentially viable technologies were further evaluated for coal ash quality requirements, processing duration, costs, and other considerations. None of the unprocessed CCR materials sampled from the ash ponds met all of the ASTM International specifications for beneficial use in concrete; additional processing may be needed for the ash to be beneficially used, and some of the material unsuitable for beneficiation may require landfill disposal.
- **Closure by Removal to On-Site Landfill** – The feasibility of either expanding an existing on-site landfill or constructing a new on-site landfill cell was evaluated adhering to state and federal siting requirements. None of the power stations have existing landfills that could be expanded to meet these requirements, nor do any stations have available space to meet requirements for constructing a new landfill. Chesterfield and Possum Point Power Stations could potentially site a new landfill on the footprint of existing ash ponds, but only if the DEQ and local authorities grant a variance for setback requirements from county roads.
- **Closure by Removal to Existing Off-Site Permitted Landfill** – Several commercial solid waste landfills are within 50 miles of the Bremo, Chesapeake, and Chesterfield stations, while the closest suitable landfill to Possum Point is approximately 100 miles away. There are limited landfills with the permitted capacity to accept the large volumes of CCR from the Dominion stations. This evaluation considered landfills within a 50-mile radius of the power stations for transportation logistic practicalities. Landfills beyond 50 miles could be considered but costs would increase.
- **Closure by Removal to New Off-Site Landfill** – A new centrally located off-site landfill could be developed, designed, and constructed to manage coal ash from the three Dominion stations. This option would likely be more costly than hauling the ash to existing, permitted landfills.
- **Transporting CCR Off-Site by Truck or Rail** – CCR from Bremo, Chesterfield, and Possum Point could be transported by truck or by rail. Based on the limited ash volume at Chesapeake, trucking would be most cost-effective and practical at Chesapeake. Both hauling options present safety, environmental, and community considerations with differing durations and costs. Rail transportation would require significant infrastructure upgrades at Chesterfield and Possum Point Power Stations.
- **Transporting CCR Material Off-Site by Barge** – Barge options are not feasible at Bremo (shallow river), Chesapeake (small volume), or Chesterfield. Barging from Chesterfield would require extensive infrastructure upgrades, and after the CCR was barged 18 miles downriver, it would then have to be loaded onto trucks and hauled 12 miles to the closest landfill. That landfill is 29 miles by truck from the Chesterfield Power Station, and another landfill is only 7 miles from the Chesterfield Station. CCR could potentially be barged from Possum Point down the Potomac River to the Chesapeake Bay and up the James River to the Port of Weanack in Charles City County. To

implement the barge option, DEQ regulations require certified watertight containers that would be loaded and unloaded on barges by crane, and moving the ash to the disposal facility would require that the CCR material be loaded on trucks and transported 18 miles on public roads to the landfill after the barge was unloaded. The infrastructure upgrades and extensive requirements would make this option significantly more expensive than transport by truck or rail.

- **Closure-in-Place** – Existing closure-in-place designs at all four power stations would provide structural integrity of the CCR units by addressing the long-term risks described in the closure plans, meeting siting requirements, and having the ability to withstand extreme weather events (including flooding, hurricanes, storm surges, and erosive forces) and earthquakes.

Industry-Wide Compliance Efforts

Based on national data available on CCR websites and other publicly available data, as of September 2017, there were approximately 500 ash ponds in the United States covering a total of more than 23,500 acres and storing a total of more than 1 billion cubic yards (CY) of CCR material. Closure-in-place is being pursued for more than 93% of ponds with CCR volumes greater than 5 million CY and 75% of ponds between 1 and 5 million CY and more than 80% of ash ponds larger than 20 acres. Closure by removal has generally been reserved for low volume (less than 1 million CY) and small acreage (less than 20 acres) ash ponds.

Currently, there are approximately 140 ash ponds in the southeastern United States (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia). Of these ponds, more than 92% with CCR volumes greater than 5 million CY and more than half of ponds with between 1 and 5 million CY are being closed in place. Sixty-seven percent (67%) of ash ponds with CCR volumes of less than 1 million CY are being closed by removal. Similarly, more than 70% of ash ponds with more than 100 acres and more than 55% between 20 and 100 acres are being closed in place. More than 65% of the smaller ash ponds (less than 20 acres) are being closed by removal.

Closure Options

This report evaluates the following key considerations for ash pond closure alternatives:

- Regulations – all federal, state, and local regulations and requirements must be met
- Risk – potential safety, environmental, and community impacts are described
- Feasibility – all options must be technically feasible
- Schedule – the duration of the option directly affects the safety and community impacts; some of the option durations exceed the compliance schedule set forth by the CCR Rule
- Cost – costs for each option are provided

Tables ES-2 through ES-5 summarize the closure options that were assessed for the four Dominion power stations, including the anticipated length of time to complete the option, estimated cost, and implementation considerations. Table ES-6 provides similar information for a potential new regional off-site landfill that would be designed to manage coal ash from the Bremo, Chesterfield, and Possum Point Power Stations.

Costs are Class 5 estimates (+100%, -50%) that include taxes, overhead, escalation, contingency, and typical contractor mark-ups to reflect potential market values for the corresponding closure options over their full durations. The estimates are preliminary and represent AECOM's opinion of the probable costs based on information available at the time of this study. Actual costs may vary significantly if market conditions and pricing assumptions change.

Table ES-2: Summary of Closure Options for Bremo Power Station

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Beneficial Use	11 to 27 years	\$593M to \$1.34B	• Ash pond stays open for 11+ years (3 years design/permit/construct, remaining years to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *Duration to implement several evaluated technologies exceeds CCR closure requirements of 15 years* • Time frames are driven by available market and throughput of beneficiation technologies • Safety and community risks from excavation and over-the-road hauling due to significant volume, multi-year duration removal project; up to 150 trucks/day each way for 8+ years • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Engineering challenges for CCR dewatering and excavation • Greater potential for groundwater migration during CCR removal • Removes source of potential groundwater impacts
Closure by Removal and On-Site Landfilling	NA	NA	Alternative not feasible because there is no location to temporarily store materials during new landfill construction
Closure by Removal and Off-Site Commercial Landfilling by Truck	13 years	\$1.03B	• Ash pond stays open for 13 years (1 year design/permit/construct, remaining to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety and community risks from excavation and over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks/day each way for 12 years; truck leaving site approximately every 3 minutes for 10 hours/day Monday through Friday) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and Off-Site Commercial Landfilling by Rail	10 years	\$1.53B	• Ash pond stays open for 10 years (2 years design/permit/construct, remaining transport), increases safety risk, results in prolonged duration for dewatering/water treatment • Safety and community risks from excavation and rail hauling due to significant volume and multi-year duration removal project (200+ railcars per week for 8 years) • Reduced hauling risks for rail vs. trucking • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation

Table ES-2 (cont.): Summary of Closure Options for Bremo Power Station

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Off-Site Commercial Landfilling by Barge	NA	NA	Alternative not feasible due to shallow depth of James River
Closure-in-Place with Potential Groundwater Corrective Measures	3 to 5 years	\$98M to \$173M	• No impacts for CCR removal or off-site hauling • Lowest risk for safety, community, schedule, and cost • Lower groundwater migration potential for CCR remaining in place once closure is complete, which is addressed by corrective measures • Includes cost range for corrective measures • 2-year corrective measure construction duration • Estimated 10- to 30-year duration for groundwater corrective measures

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CCR = coal combustion residuals; B = billion; M = million; NA = not applicable

Table ES-3: Summary of Closure Options for Chesapeake Energy Center

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Beneficial Use	Up to 1 year	\$10.6M	• Safety and community risks from over-the-road hauling (25 to 90 trucks per day intermittently for up to 1 year) • Increased noise, emissions, truck traffic, accident potential • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Market risks (there may be insufficient demand)
Closure by Removal and On-Site Landfilling	NA	NA	• Dominion has committed to removing the CCR materials from the Bottom Ash Pond at the Chesapeake Energy Center • Landfill no longer receiving ash
Closure by Removal and Off-Site Commercial Landfilling by Truck	2 to 3 months	\$13.3M	• Safety and community risks from over-the-road hauling • Increased noise, emissions, truck traffic, accident potential • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Engineering challenges for CCR dewatering and excavation
Closure by Removal and Off-Site Commercial Landfilling by Rail	NA	NA	Alternative not practical due to small volume of CCR
Closure by Removal and Off-Site Commercial Landfilling by Barge	NA	NA	Alternative not practical due to small volume of CCR
Potential Groundwater Corrective Measures for the Peninsula	3 to 5 years	\$2.4M to \$161M	• Dominion has committed to removing the CCR materials from the Bottom Ash Pond at the Chesapeake Energy Center • Corrective action will be necessary for the peninsula

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CCR = coal combustion residuals; M = million; NA = not applicable

Table ES-4: Summary of Closure Options for Chesterfield Power Station

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Beneficial Use	21 to 53 years	$1.49B to $4.25B	• Ash pond stays open for 21+ years (3 years design/permit/ construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *21+ years duration to implement exceeds CCR closure requirements of 15 years* • The time frames are driven by the available market and throughput of beneficiation technologies • Safety and community risks from over-the-road hauling due to significant volume and multi-year duration removal project; up to 150 trucks per day each way for 18+ years • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and On-Site Landfilling	20 years	$1.28B	• Ash pond stays open for 20 years, increases safety risk, and results in prolonged duration for dewatering/water treatment • *20 years duration to implement exceeds CCR closure requirements of 15 years* • Only feasible if the DEQ and local authorities grant a variance to allow the setback from the road to be reduced from 500 to 100 feet; the presence of Henricus Park and Aiken Swamp adjacent to the area in question would need to be considered in this determination • Eliminates risks associated with off-site hauling, truck traffic • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering, excavation, and staging
Closure by Removal and Off-Site Commercial Landfilling by Truck	29 years	$2.68B	• Ash pond stays open for 29 years (1 year design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *29 years duration to implement exceeds CCR closure requirements of 15 years* • Safety and community risks from over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day each way for 28 years; truck leaving site approximately every 3 minutes for 10 hours per day Monday through Friday) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation

Table ES-4 (cont.): Summary of Closure Options for Chesterfield Power Station

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Off-Site Commercial Landfilling by Rail	24 years	$4.63B	• Ash pond stays open for 24 years (4 years design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *24 years duration to implement exceeds CCR closure requirements of 15 years* • Safety and community risks from excavation and rail hauling due to significant volume and multi-year duration removal project (200+ railcars per week for 20 years) • Reduced hauling risks for rail vs. trucking • Increased noise, emissions, accident potential • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and Off-Site Commercial Landfilling by Barge	N/A	N/A	• Alternative not practical • Virginia regulations require sealed containers that would need to be loaded onto and off of barges by crane, requiring infrastructure construction at both ends • Disposal facility not adjacent to barge unloading facility; requires barging for 20 miles, unloading of containers, transfer materials to trucks, and additional 20 miles of truck hauling to landfill after unloading barge • Same disposal facility is only 29 miles by truck from Chesterfield Power Station, while another facility is only 7 miles away from the station
Closure-in-Place with Potential Groundwater Corrective Measures	3 to 5 years	$246M to $1.11B	• No impacts for CCR removal or off-site hauling • Lowest risk for safety, community, schedule, and cost • Lower groundwater migration potential for CCR remaining in place once closure is complete, which is addressed by corrective measures • Includes cost range for corrective measures • 2-year corrective measure construction duration • Estimated 10- to 30-year duration for groundwater corrective measures
New Regional Off-Site Landfill for Ponds at Bremo, Chesterfield, and Possum Point	21 years	$4.15B	• Would be located in a centralized area to accept materials from all Dominion ash ponds • Ash ponds stays open for up to 20 years (6 years design/permit/construct new landfill, remaining time to transport from all three sites), increases safety risk, and results in prolonged duration for dewatering/water treatment • *Duration will exceed CCR closure requirements of 15 years at Chesterfield Power Station* • Safety and community risks from excavation and over-the-road hauling due to significant volume, multi-year duration removal project (up to 150 trucks/day each way from all 3 stations for 15+ years) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Construction of new landfill and hauling ash to new location will affect local communities • Extensive permitting and design required

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B = billion; CCR = coal combustion residuals; DEQ = Virginia Department of Environmental Protection; M = million; NA = not applicable

Table ES-5: Summary of Closure Options for Possum Point Power Station

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Beneficial Use	8 to 17 years	\$471M to \$899M	• Ash pond stays open for 8+ years (3 years design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *Duration to implement several evaluated technologies may exceed CCR closure requirements of 15 years* • The time frames are driven by the available market and throughput of beneficiation technologies • Safety and community risks from excavation and over-the-road hauling due to significant volume, multi-year duration removal project (up to 150 trucks/day each way for 5+ years) • Truck traffic may result in increased noise, emissions, truck traffic, and vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and On-Site Landfilling	8 years	\$380M	• Ash pond stays open for 8 years, increases safety risk, and results in prolonged duration for dewatering/water treatment • Only feasible if the DEQ and local authorities grant a variance to allow the setback from the road to be reduced from 500 to 200 feet • Eliminates risks associated with off-site hauling, truck traffic • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering, excavation, and staging
Closure by Removal and Off-Site Commercial Landfilling by Truck	9 years	\$799M	• Ash pond stays open for 9 years (1 year design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety and community risks from excavating and over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day each way for 8 years; truck leaving site approximately every 3 minutes for 10 hours per day Monday through Friday) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation

Table ES-5 (cont.): Summary of Closure Options for Possum Point Power Station

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Off-Site Commercial Landfilling by Rail	9 years	$1.11B	• Ash pond stays open for 9 years (2 years design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety and community risks from excavation and rail hauling due to significant volume and multi-year duration removal project (180 railcars per week for 7 years) • Reduced hauling risks for rail vs. trucking • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and Off-Site Commercial Landfilling by Barge and Trucking	15 years	$1.7B+	• Ash pond stays open for at least 15 years (4 years design/permit/construct, remaining transport), increases safety risk, results in prolonged duration for dewatering/water treatment • Safety and community risks from CCR removal; excavation and construction noise and traffic • Option involves trucking of CCR material to barge facility and once barge reaches its destination, CCR material would be trucked an additional 18 miles on public roads to landfill • Virginia regulations require sealed containers that would need to be loaded onto and off of barges by crane, requiring infrastructure construction at both ends • Engineering risks for CCR dewatering and excavation • Lower groundwater risks after removal is completed; higher groundwater risk during removal
Closure-in-Place with Potential Groundwater Corrective Measures	3 to 5 years	$137M to $418M	• No impacts for CCR removal or off-site hauling • Lowest risk for safety, community, schedule, and cost • Lower groundwater migration potential for CCR remaining in place once closure is complete, which is addressed by corrective measures • Includes cost range for corrective measures • 2-year corrective measure construction duration • Estimated 10- to 30-year duration for groundwater corrective measures

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B = billion; CCR = coal combustion residuals; DEQ = Virginia Department of Environmental Quality; M = million; NA = not applicable

Table ES-6: New Regional Landfill Summary

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
New Regional Off-Site Landfill for Ponds at Bremo, Chesterfield, and Possum Point	21 years	$4.15B	• Would be located in a centralized area to accept materials from all Dominion ash ponds • Ash ponds stays open for up to 20 years (6 years design/permit/construct new landfill, remaining time to transport from all three sites), increases safety risk, and results in prolonged duration for dewatering/water treatment • *Duration will exceed CCR closure requirements of 15 years at Chesterfield Power Station* • Safety and community risks from excavation and over-the-road hauling due to significant volume, multi-year duration removal project (up to 150 trucks/day each way from all 3 stations for 15+ years) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Construction of new landfill and hauling ash to new location will affect local communities • Extensive permitting and design required

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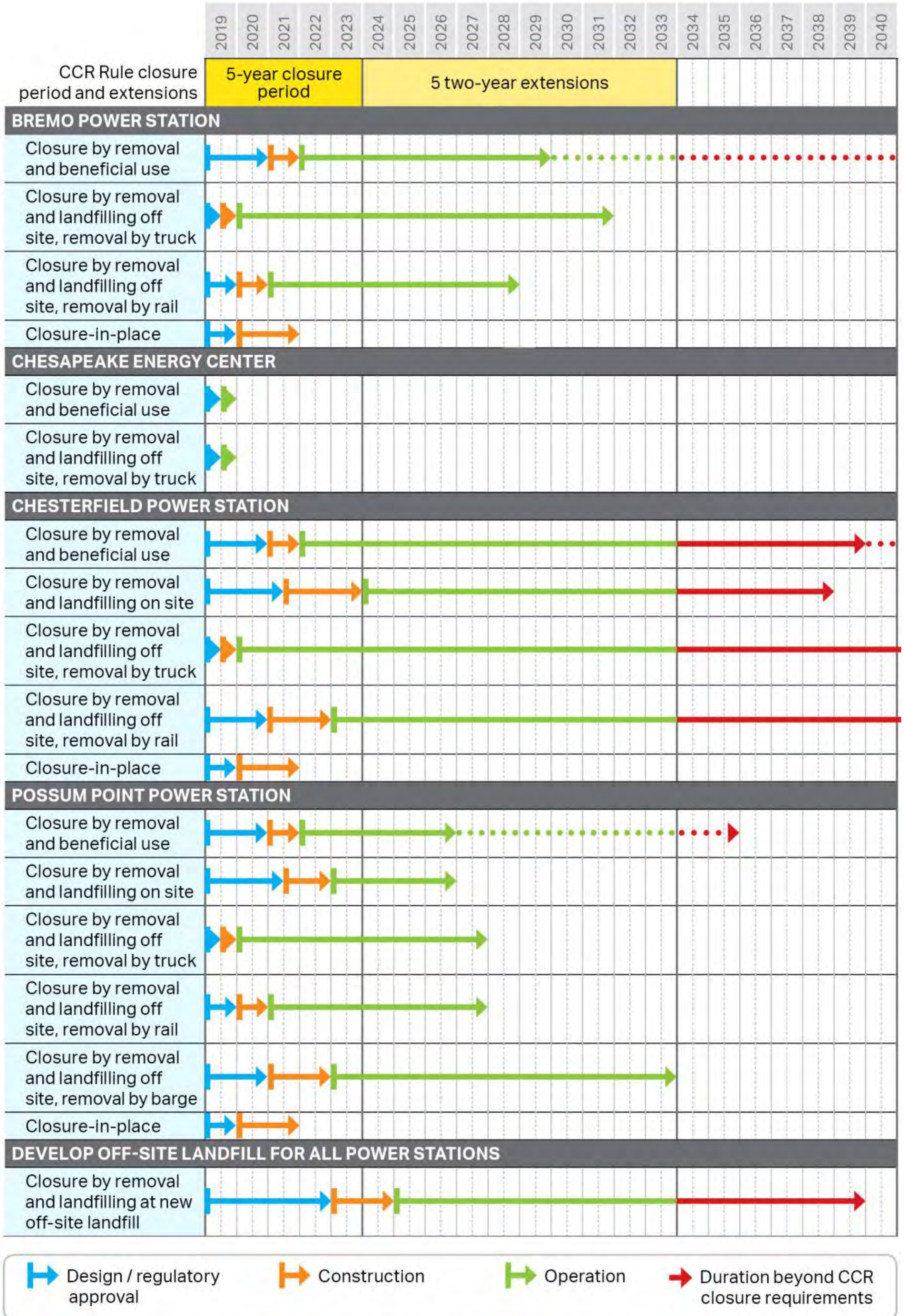
Costs are for one landfill facility that will accept all ponded ash from Bremo, Chesterfield, and Possum Point Power Stations; includes permitting, design, construction of new landfill, along with excavation, materials handling, trucking from the stations and placement into the new landfill

Chesapeake Energy Center not included as alternative is not practical due to small volume of CCR

B = billion; CCR = coal combustion residuals

In accordance with the CCR Rule, closure of ash ponds greater than 40 acres, which includes Bremo North Ash Pond, Chesterfield Lower and Upper Ash Ponds, and Possum Point Ash Pond D, must be completed within 15 years (5-year base period plus up to five extensions in 2-year increments). For ponds less than 40 acres (Chesapeake Bottom Ash Pond), closure must be completed within 7 years (5-year base period plus one 2-year extension). Exhibit ES-1 shows the estimated timelines for the closure options at the four power stations compared to the required CCR Rule timelines. Note that some of the closure options are estimated to take longer than 15 years.



(Note: Solid line represents minimum duration and dotted line represents maximum duration for beneficial use technologies)

Exhibit ES-1: Closure Implementation Timeline

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1. Introduction and Objective

Virginia Senate Bill 1398 (SB 1398) requires “that every owner or operator of a coal combustion residuals (CCR) surface impoundment that is located within the Chesapeake Bay watershed … conduct an assessment of each such CCR surface impoundment (CCR unit) regarding the closure of any such unit.” The assessment must include describing groundwater and surface water conditions surrounding the surface impoundments (ash ponds) and evaluating corrective measures to restore water quality (if needed), evaluating the clean closure (closure by removal) of the CCR unit by recycling/reusing the ash or moving it to a landfill and demonstrating the long-term safety of the CCR unit if it is closed in place.

SB 1398 is applicable to eleven CCR surface impoundments (referred to as ash ponds in this report) at four Dominion Energy (Dominion) power stations. On behalf of Dominion, AECOM conducted an evaluation of the groundwater and surface water on all eleven ponds and an assessment of closure options on the five ponds that have been slated for closure. Ash has been removed or is in the process of being removed from the other six ponds, and the closure options are therefore not applicable to these ponds. Table 1 provides information on the Dominion power stations and ash ponds that were included in the study.

Table 1: Ash Ponds included in the Study

Power Station	CCR Units	Remaining CCR Volume (CY)[1]	Operating Status	Area (acres)
Bremo Power Station	North Ash Pond[2]	4,800,000	Slated for closure	68
	East Ash Pond	1,400,000	Ash being actively removed and transported to North Ash Pond	27
	West Ash Pond	0	Ash removed	22
Chesapeake Energy Center[3]	Bottom Ash Pond[2]	60,000	Committed to closure by removal	5
Chesterfield Power Station	Lower Ash Pond[2]	3,600,000	Slated for closure	101
	Upper Ash Pond[2]	11,300,000	Slated for closure	112
Possum Point Power Station	Ash Pond A Ash Pond B Ash Pond C	40,000	Residual ash to be removed from Ash Ponds A, B, and C and transported to Ash Pond D	18
	Ash Pond D[2]	4,009,250	Slated for closure	70
	Ash Pond E	2,250	Residual ash to be removed and transported to Ash Pond D	38
	Total Volume	**25,211,500**		

(1) CCR volumes are based on Dominion estimates as of July 10, 2017

(2) Assessed for closure options

(3) While not subject to the assessment required by SB 1398, the CCR landfill at the Chesapeake Energy Center is slated for closure in accordance with VSWMR. Virginia DEQ issued a draft solid waste permit in June 2016 for closure of the landfill, which process was later suspended at Dominion’s request. The draft permit required Dominion to evaluate and propose alternative corrective measures to address groundwater impacts. In addition, in connection with a July 31, 2017, court order, Dominion will submit a revised solid waste permit application to DEQ by March 31, 2018, to include proposed additional corrective measures to address site-wide groundwater impacts.

CCR = coal combustion residuals; CY = cubic yards; DEQ = Department of Environmental Quality; VSWMR = Virginia Solid Waste Management Regulations

1.1 Study Objective

The objective of the study was to comply with the following SB 1398 requirements to ensure the long-term safety of the ash ponds while protecting public health and the environment:

- Evaluate closure by removal with recycling or reuse (beneficial use) of the CCR material
- Evaluate closure by removal with placement of CCR material in a permitted landfill
- Evaluate closure-in-place addressing long-term safety, structural, and extreme weather event resiliency
- Describe groundwater and surface water quality surrounding each ash pond, and evaluate corrective measures if needed

The text of SB 1398, which was enacted on April 5, 2017, is as follows:

Be it enacted by the General Assembly of Virginia:

1. That every owner or operator of a coal combustion residuals (CCR) surface impoundment, as that term is defined at 40 CFR § 257.53, that is located within the Chesapeake Bay watershed shall conduct an assessment of each such CCR surface impoundment (CCR unit) regarding the closure of any such unit. At a minimum, an assessment shall, for each CCR unit:
   1. Identify and describe any groundwater or surface water pollution located at or stemming from the CCR unit, including pollution identified through past monitoring, and evaluate corrective measures to resolve such pollution. Any such evaluation shall address the issues set forth in 40 CFR § 257.96(c) and shall describe and demonstrate how the proposed corrective measures will restore groundwater or surface water quality.
   2. Evaluate the clean closure of the CCR unit through excavation and responsible recycling or reuse of coal ash residuals by incorporating them into concrete or other products in a manner that prevents the release into the environment of the pollutants contained within the coal ash residuals. Such evaluation shall consider the feasibility of the on-site processing of a CCR unit for cementitious purposes as well as the feasibility of creating a processing facility or facilities to serve multiple CCR units, including off-site CCR units.
   3. Evaluate the clean closure of the CCR unit through the excavation and removal of coal ash residuals to dry, lined storage in an appropriately permitted and monitored landfill, including an analysis of the impact that any responsible recycling or reuse options would have on such excavation and removal.
   4. Demonstrate the long-term safety of the CCR unit, addressing any long-term risks posed by the proposed closure plan and siting, including risks related to extreme weather events, flooding, hurricanes, storm surges, and erosive forces.
2. That no later than December 1, 2017, the owner or operator of any coal combustion residuals surface impoundment (CCR unit) subject to the assessment requirement of the first enactment of this act shall transmit such assessment to the Chairmen of the House Committee on Agriculture, Chesapeake and Natural Resources and the Senate Committee on Agriculture, Conservation and Natural Resources and to the Departments of Environmental Quality and Conservation and Recreation.
3. That notwithstanding the provisions of this act, the Director of the Department of Environmental Quality (the Director) shall suspend, delay, or defer the issuance of any permit to provide for the closure of any CCR unit until May 1, 2018, or the effective date of any legislation adopted during the 2018 Regular Session of the General Assembly that addresses the closure of a CCR unit in Virginia, whichever occurs later. In deciding whether to issue any such permit, the Director need not include or rely upon his review of any such assessment.

AECOM was tasked with critically reviewing existing information, identifying additional studies that may be needed, performing the studies, and preparing a report that addresses the requirements of SB 1398 for each of the eleven Dominion ash ponds listed in Table 1.

The objective of the SB 1398 requirements is to provide members of the legislature, environmental regulators, local government officials, and the local communities with an assessment of ash pond closure options as set forth in the legislation. Specifically, the report describes how the various options could meet the objectives of safe closure, compliance with applicable federal and state rules, and protection of public health and the environment. This report is not intended, and must not be construed, to provide recommendations or conclusions regarding the selection of the options detailed herein.

AECOM developed a series of Technical Memoranda that provide a detailed analysis of the primary technical information needed to comply with SB 1398 requirements. The Technical Memoranda provide an assessment of closure by removal options (including recycling/beneficial use and landfilling); ash sampling results to supplement the beneficial use study; and evaluations of closure-in-place, groundwater and surface water conditions, and potential groundwater corrective measures. The memoranda are included as attachments to the report and are referenced as appropriate.

1.2 Report Contents

This report first addresses the background of the CCR requirements, describing Commonwealth of Virginia and federal CCR regulations (Section 2). This discussion is followed by an overview of how other utilities have been addressing the CCR regulations (Section 3). Moving into the direct response to SB 1398, various closure alternatives are discussed (Section 4) and a comprehensive discussion of our beneficial use and ash market study is provided, outlining the benchmark surveying to identify the potential market for recycled CCR materials from the ash ponds (Section 5).

After the general discussion that addresses the SB 1398 response across the Dominion network, a response to each of the SB 1398 requirements is provided for each of the four power stations (Sections 6 through 9). Each section is designed to be self-contained for an individual station, allowing the reader to focus on the SB 1398 aspects as they apply to a single facility. Each section provides a description of the station and discusses the options that are available for that station to meet the requirements of SB 1398. All of the options address the long-term safety of ash ponds to protect public health and the environment by addressing risks posed by extreme weather events, flooding, hurricanes, storm surges, and erosive forces.

The following analyses are provided for each option:

- Ability to comply with state and federal CCR requirements
- Feasibility with regard to safety risks, community impacts, costs, and the timeline for implementation
- Environmental benefits and considerations
- For removal options, consideration of transportation by truck, rail, or barge
- Consideration of the available market for beneficial use

- Description of groundwater and surface water conditions at each station and the potential corrective action measures that could be implemented to address the conditions to provide a safe and environmentally sound solution

1.3 Technical Memoranda

To supplement this report, AECOM developed a series of technical memoranda that provide a detailed analysis of the primary technical aspects of the SB 1398 requirements. The memoranda are included as attachments to this report and are referenced as appropriate. References to documents prepared by Dominion or on behalf of Dominion by other consultants, publicly available information, or any other material referenced by AECOM are provided in the technical memoranda and are not provided in the body of this report.

Table 2 lists the technical memoranda prepared for this study and a brief description of each.

Table 2: Technical Memoranda Prepared for Study

Technical Memorandum	Description
1 Beneficial Use and Ash Market Study	Industry benchmarking and assessment of beneficial use options and potential market for Dominion ponded ash
2 Evaluation of CCR Characteristics	Summary of sampling and analysis of ash from existing ponds to obtain information on the material location, quantity, and characteristics
3 Closure by Removal to Off-Site Commercial Landfill	Materials handling (excavation, drying, loading), transportation (truck/rail/barge options evaluated), and disposal in a permitted commercial landfill
4 New or Expanded Landfill Analyses	Options for closure by removal and landfilling, including disposal in a new or expanded on-site landfill or disposal into a new off-site landfill permitted and constructed
5 Closure-in-Place	Analysis of closure-in-place designs to ensure the long-term safety of the ash ponds
6 Groundwater/Surface Water Evaluation	Groundwater and surface water conditions surrounding ash ponds
7 Groundwater Corrective Measures	Assessment of potential corrective measures to remediate groundwater conditions related to the ash ponds

This report, as well as the attached technical memoranda, contains site-specific assessments and findings that shall not be considered applicable to or relied on in the evaluation of other sites within or outside this report. All facts contained herein are based on information available at the time of the study and shall not be relied on without independent verification.

2. CCR Regulations

In performing the assessments under SB 1398, AECOM (on behalf of Dominion) followed the federal CCR Rule criteria (as implemented by the Commonwealth of Virginia) pertaining to CCR surface impoundments (ash ponds), closure, groundwater, and recycling/reuse (beneficial use). Ash ponds in Virginia are regulated by the Virginia Department of Environmental Quality (DEQ) and the Virginia Department of Conservation and Recreation (DCR).

Upon selection of preferred closure alternatives, Dominion will perform the closures in accordance with the Virginia Solid Waste Management Regulations (VSWMR), Virginia Pollutant Discharge Elimination System (VPDES), and DCR requirements in addition to the CCR Rule. The federal government and the Commonwealth of Virginia established these regulations to ensure the safe closure of CCR units such as ash ponds, and the majority of data and information reviewed for this SB 1398 response had already been compiled by Dominion under existing requirements.

The following sections discuss Commonwealth of Virginia and federal CCR regulations.

2.1 Commonwealth of Virginia Regulations

The CCR Rule was incorporated into the VSWMR on January 27, 2016. By adopting the CCR Rule, the Commonwealth can issue solid waste permits for CCR landfills and ash ponds operating in Virginia. Through permitting and regulatory programs, Virginia has implemented rules that are more stringent than the federal rules. Virginia CCR regulations and their state and federal references are summarized in Table 3.

Table 3: Summary of Virginia CCR Regulations

Regulation	Description	VA Regulation Reference	Federal Regulation Reference
VSWMR	Virginia Solid Waste Management Regulations	9VAC20-81	—
VSWMR	Incorporation of CCR Rule into VSWMR	9VAC20-81-8001	40 CFR § 257 Subpart D
VPDES	Administration of NPDES	9VAC25-31	40 CFR Parts 122–124
DCR Dam Safety	Impounding Structure Regulations	4VAC50-20 et seq.	—

2.1.1 Virginia Solid Waste Management Regulations

The Commonwealth of Virginia regulates the treatment, storage, disposal, and management of solid wastes. The DEQ regulates solid waste and water discharge aspects of ash ponds, and the DCR regulates the structural integrity of ash ponds.

2.1.2 Virginia Pollutant Discharge Elimination System

The National Pollutant Discharge Elimination System (NPDES) program was established by the Clean Water Act. It requires permits for the discharge of pollutants from any point source into waters of the United States. DEQ is responsible for administering the NPDES program in the Commonwealth of Virginia, which it does under the Virginia Pollutant Discharge Elimination System (VPDES) program. The discharge of water from ash ponds before and during closure requires VPDES permitting to ensure water quality is protected. The facilities addressed in this study are subject to individual permits, each with its own requirements, special conditions, effluent limitations, and monitoring requirements based on site-specific conditions and applicable water quality standards.

2.1.3 Virginia Department of Conservation and Recreation Dam Safety Regulations

The ash pond embankments (sidewalls) are regulated as dams by the Virginia Department of Conservation and Recreation (DCR) under the Impounding Structure (Dam Safety) Regulations, which were developed by the Commonwealth of Virginia to establish safe design, construction, and operation standards and to protect public safety. Impoundments built in accordance with the Dam Safety Regulations protect against severe weather events, seismic events, and other natural events.

2.2 Federal CCR Rule

As discussed above, the CCR Rule was incorporated by reference into SB 1398 and the VSWMR. The CCR Rule became effective on October 19, 2015, with an intended purpose to “regulate the disposal of coal combustion residuals as solid waste under subtitle D of the Resource Conservation and Recovery Act” (USEPA, 2015). The U.S. Environmental Protection Agency (USEPA) determined that “improperly constructed or managed coal ash disposal units have been linked to cases of harm to surface or ground water or to the air” (USEPA, 2017). The CCR Rule addresses “the risks from coal ash disposal identified in these cases—leaking of contaminants into groundwater, blowing of contaminants into the air as dust, and the catastrophic failure of coal ash surface impoundments by adding new requirements for coal ash surface impoundments and landfills” (USEPA, 2015).

The CCR Rule requires the following:

- For any existing, unlined CCR ash pond that is contaminating groundwater above a regulated constituent’s Groundwater Protection Standard (GPS), cease receiving CCR and either retrofit or closure, except in limited circumstances
- Closure of any CCR landfill or ash pond that cannot meet the applicable performance criteria for location restrictions or structural integrity
- Completion of the closure of an ash pond either by leaving the CCR in place and installing a final cover system or through removal of the CCR and decontamination of the ash pond. In the CCR Rule, the USEPA goes on to state, “both methods of closure (i.e., closure by removal and closure with waste in place) can be equally protective, provided they are conducted properly. Thus, consistent with the proposal, the final rule allows the owner or operator to determine whether closure by removal or closure with the waste in place is appropriate for their particular unit” (USEPA, 2015).

The CCR Rule also limits how CCR can be beneficially used (recycled). An overview of the CCR Rule is presented in Sections 2.2.1 through 2.2.3 as it pertains to key items from SB 1398 associated with ash ponds, closure, groundwater, and beneficial use.

2.2.1 CCR Surface Impoundments

This section describes the primary elements of the CCR Rule that apply to ash ponds.

2.2.1.1 General Requirements

Ash ponds are subject to several key design criteria as defined in the CCR Rule and summarized in Table 4.

Table 4: Summary of Key Design Criteria Requirements per CCR Rule

Key Design Criteria	Requirements	Dominion Status	Due/Start Date
Air quality	Complete fugitive dust control plan and initiate annual reporting	Posted on website (ongoing)	October 19, 2015
Inspections	Initiate weekly ash pond inspections and monthly monitoring of instrumentation	Initiated and ongoing	October 19, 2015
Vegetated slopes	Establish and maintain vegetated slopes	Established and maintenance ongoing	October 19, 2015
Permanent marker	Install permanent identification markers	Completed	December 17, 2015
Liner	Document presence of liner	Posted on website	October 17, 2016
Stability, including protection from erosion and earthquakes	Demonstrate that minimum safety factors are being met (additional evaluations required every 5 years)	Initial evaluations posted on website	October 17, 2016
Capacity to handle large rain events	Evaluate risers and outlet works (new inflow design flood control system plan required every 5 years)	Initial plans posted on website	October 17, 2016
History of construction	Compile a history of construction	Posted on website	October 17, 2016
Inspections	Initiate annual ash pond inspections	Initiated and ongoing	October 19, 2016
Emergency Action Plan	Prepare Emergency Action Plan for high hazard or significant hazard ash ponds (Updates required every 5 years)	Completed	April 17, 2017
Groundwater	Establish groundwater monitoring system and complete at least 8 rounds of sampling	Completed	October 17, 2017
Location	Assessment of location restrictions	Assessment underway	October 17, 2018

2.2.1.1 Criteria for Initiating Closure

The CCR Rule allows for operation of ash ponds as long as certain safety, environmental, operational, and locational criteria are met. If these criteria are not met, the ash ponds are required to be closed either by removal of the ash or by closure in place. In anticipation of these triggers for closure, all eleven Dominion ash ponds are slated for closure.

2.2.1.2 Closure-in-Place of Existing Ash Pond

As specified in the CCR Rule, an owner or operator may elect to close an ash pond by closure-in-place. The capping system (final cover) that is intended to keep rain water out of the ash must include an 18-inch layer to prevent rain water infiltration under a 6-inch layer of soil that can sustain vegetation to prevent erosion (alternatives are acceptable). The final cover criteria in the CCR Rule specify that “the permeability of the final cover system must be less than or equal to the permeability of any bottom liner system or natural subsoil’s present, or a permeability no greater than $1x10^{-5}$ cm/sec, whichever is less” (USEPA, 2015).

2.2.1.3 Closure/Post-Closure Criteria

As specified in the CCR Rule, by October 17, 2016, facilities must have prepared written closure and post-closure plans, which are defined below, for each ash pond and posted them to the operating record. Dominion has posted closure and post-closure plans for the ash ponds in this study on its website.

- **Closure plan:** The owner or operator of an ash pond must prepare a written closure plan that describes the steps necessary to close the ash pond at any point during the active life of the pond consistent with recognized and generally accepted good engineering practices.
- **Post-closure care:** The owner or operator of an existing ash pond must maintain the integrity and effectiveness of any final cover system, including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events and preventing run-on and runoff from eroding or otherwise damaging the final cover. Facilities must conduct post-closure care for all ash ponds for a minimum of 30 years, including groundwater monitoring.

2.2.1.4 Closure by Removal for an Existing Ash Pond

As specified in the CCR Rule, an owner or operator may elect to close an ash pond by removing and decontaminating all areas affected by releases from the ash pond. CCR removal and decontamination of the ash pond are complete when constituent concentrations throughout the ash pond and any areas affected by releases from the ash pond have been removed and groundwater monitoring concentrations meet groundwater requirements or are at background levels.

2.2.1.5 Closure Timeline

The owner or operator must complete closure of existing ash ponds within 5 years of commencing closure activities. Ash ponds larger than 40 acres may extend the time frame to complete closure up to five times, in 2-year increments, for a maximum closure timeline of 15 years. Ash ponds that cover less than 40 acres can only receive one 2-year extension, for a maximum total of 7 years. For each 2-year extension sought, the owner or operator must demonstrate the need for the extension.

2.2.2 Groundwater Monitoring and Corrective Action

All CCR units regulated under the CCR Rule, including landfills, ash ponds, and any lateral expansions, are subject to compliance with the groundwater monitoring and corrective action requirements in the CCR Rule. The first significant deadline was October 17, 2017, when a groundwater monitoring system must have been installed and eight baseline monitoring events conducted.

2.2.2.1 Monitoring Network

The monitoring system design requires thorough knowledge of the site hydrogeology, which may require a site investigation unless sufficient data already exist. The monitoring network is required to include, at a minimum, one upgradient or background well and three or more downgradient wells. Virginia DEQ monitoring requirements go beyond those required in the federal rule. The monitoring well networks installed at the Bremo North Ash Pond, Chesterfield Upper and Lower Ash Ponds, and Possum Point Ash Pond D exceed the federal requirements.

A professional engineer certifies that the network has been appropriately designed and that the samples that are collected are representative of the uppermost aquifer.

2.2.2.2 Detection Monitoring

A minimum of eight rounds of groundwater samples were required to have been collected by October 2017 and analyzed for both CCR Rule detection program constituents and assessment program constituents, as listed in Table 5.

Table 5: CCR Rule Detection and Assessment Monitoring Constituents

Detection Monitoring Constituents		Assessment Monitoring Constituents			
• Boron • Calcium • Chloride • Fluoride	• pH • Sulfate • Total Dissolved Solids	• Antimony • Arsenic • Barium • Beryllium	• Cadmium • Chromium • Cobalt • Fluoride	• Lead • Lithium • Mercury • Molybdenum	• Selenium • Thallium • Radium 226 and 228 combined

Background constituent levels are established using statistical analysis of the baseline data set from the upgradient/background wells.

If the initial eight background events or subsequent sampling identifies the presence of any detection monitoring constituents (metals and radium) above their Maximum Contaminant Level (MCL), then assessment monitoring and assessment of corrective measures are triggered, which can lead to implementation of a corrective action program unless an alternate source of the constituents is demonstrated (i.e., other than from the ash pond).

2.2.2.3 Assessment Monitoring

Assessment monitoring is required whenever a statistically significant increase (SSI) over background levels has been detected for one or more of the detection monitoring constituents shown in Table 5. The minimum requirement is to add annual assessment monitoring constituents to the sampling program. If an assessment monitoring constituent is detected above its MCL or has an SSI, the affected station is required to post the results on its CCR website, add the assessment constituents to the semi-annual monitoring program, and set a GPS for the detected constituent using the MCL (or a site-specific background concentration for constituents without an MCL). The owner can return to standard detection monitoring if all detection and assessment monitoring constituents are at or below background levels for two consecutive sampling events.

Additional assessment is also required if any assessment monitoring constituents show an SSI over the GPS for two consecutive events. The station must characterize the nature and extent of the release and then assess corrective measures. Characterization requires at least one new monitoring well at the downgradient property boundary.

2.2.2.4 Assessment of Corrective Measures

Assessment of corrective measures must be initiated within 90 days of determination of an SSI of any assessment monitoring (Table 5) constituent over GPS; one allowance for a 60-day extension is provided. Potentially applicable corrective measures are evaluated on the basis of performance, reliability, ease of implementation, potential considerations of the remedy, time to begin and complete, and institutional requirements such as state and local permit requirements. Cost and convenience are not allowed as a basis for the evaluation of corrective measures.

2.2.2.5 Selection of Remedy

The selected remedy must protect human health and the environment, restore groundwater to GPS, and treat or control the source of the release.

2.2.2.6 Implementation of Corrective Action Program

A remedy selection report is required. On selection, the remedy implementation must be initiated within 90 days. The remedy is complete when the facility is in compliance with GPS for 3 consecutive years and all other actions to achieve performance standards have been satisfied.

2.2.3 Beneficial Use

The CCR Rule does not regulate practices that meet the definition of beneficial use of CCR; rather, beneficial use applications must comply with the following criteria:

1. The CCR provides a functional benefit.
2. The CCR is used as a substitute for the use of a virgin material, conserving natural resources that would otherwise need to be obtained through practices such as extraction.
3. The use of the CCR meets relevant product specifications, regulatory standards, or design standards when available; when design standards are not available, the CCR is not used in excess quantities.
4. When unencapsulated use of CCR involves placement on the land of 12,400 tons or more of CCR in non-roadway applications, the user demonstrates (and keep records) that environmental releases to groundwater, surface water, soil, and air are comparable to or lower than those from analogous products made without CCR or that environmental releases to groundwater, surface water, soil, and air will be at or below relevant regulatory and health-based benchmarks for human and ecological receptors during use.

Encapsulated beneficial use is defined by the CCR Rule as a beneficial use of CCR that binds the material into a solid matrix that minimizes its mobilization into the surrounding environment. In this evaluation, Dominion is only considering beneficial use of CCR materials in encapsulated applications; therefore, the fourth criterion (unencapsulated use) will not apply. The ability of the CCR to meet the first three criteria is discussed in the Section 5 of this report.

3. Industry-Wide Compliance Efforts

3.1 Nationwide CCR Impoundment Inventory

Based on national data available on individual energy providers' CCR websites and other publicly available data, as of September 2017, there were approximately 500 surface impoundments (ash ponds) in the United States covering more than 23,500 acres and storing more than 1 billion CY of CCR material. Data obtained from these sources are subject to change. Most of the owners/operators of these ash ponds have submitted closure plans for closure by removal, closure-in-place, or a hybrid of the two methods.

Exhibit 1 is a comparison of closure methods for ash ponds nationwide by volume, area, and region (charts 1A, 1B, and 1C in the left column), summarized by the following:

- Nationwide, more than 93% of ponds with CCR volumes greater than 5 million CY and 75% of ponds with between 1 and 5 million CY are being closed in place. Closure-in-place and closure by removal are being used almost equally for ash ponds with CCR volumes of less than 1 million CY.
- Although closure by removal is used more than closure-in-place for ash ponds with areas of less than 20 acres, closure-in-place is the predominant option for ash ponds larger than 20 acres (75% to 95%).
- More than 60% of the ash ponds are being closed in place, and most of the ash ponds in every region of the country are being closed in place. The percentage of ash ponds closed by removal in the Southeast, Northeast, and West is higher than in the Midwest and Southwest (approximately 40% versus 30%).

In general, closure by removal may be achieved by consolidating CCR materials into other ponds on the same site, by disposal in lined landfills, or by beneficial use. Data from ash ponds that are not subject to the CCR Rule are not included. Non-CCR Rule ponds are typically smaller in volume and area than CCR Rule ponds.

3.2 Southeastern United States CCR Impoundment Inventory

Data obtained from energy providers' websites and other publicly available data indicate there are approximately 140 ash ponds in the U.S. Southeast (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia). These ash ponds are managed by approximately 20 owner/operators at more than 70 facilities and cover more than 10,000 acres. The right-hand column of Exhibit 1 (2A, 2B, and 2C) shows the percentage of the closure methods for ash ponds by volume, by area, and by state in the Southeastern United States, summarized as follows:

- More than 92% of ponds with CCR volumes greater than 5 million CY and more than half of ponds between 1 and 5 million CY are being closed in place. Sixty-seven percent of ash ponds with CCR volumes of less than 1 million CY are being closed by removal.
- Closure-in-place is the predominant option (more than 70%) for ash ponds with more than 100 acres; while more than 55% of the ash ponds between 20 and 100 acres are being closed in place. More than 65% of the smaller ash ponds (areas less than 20 acres) are being closed by removal.

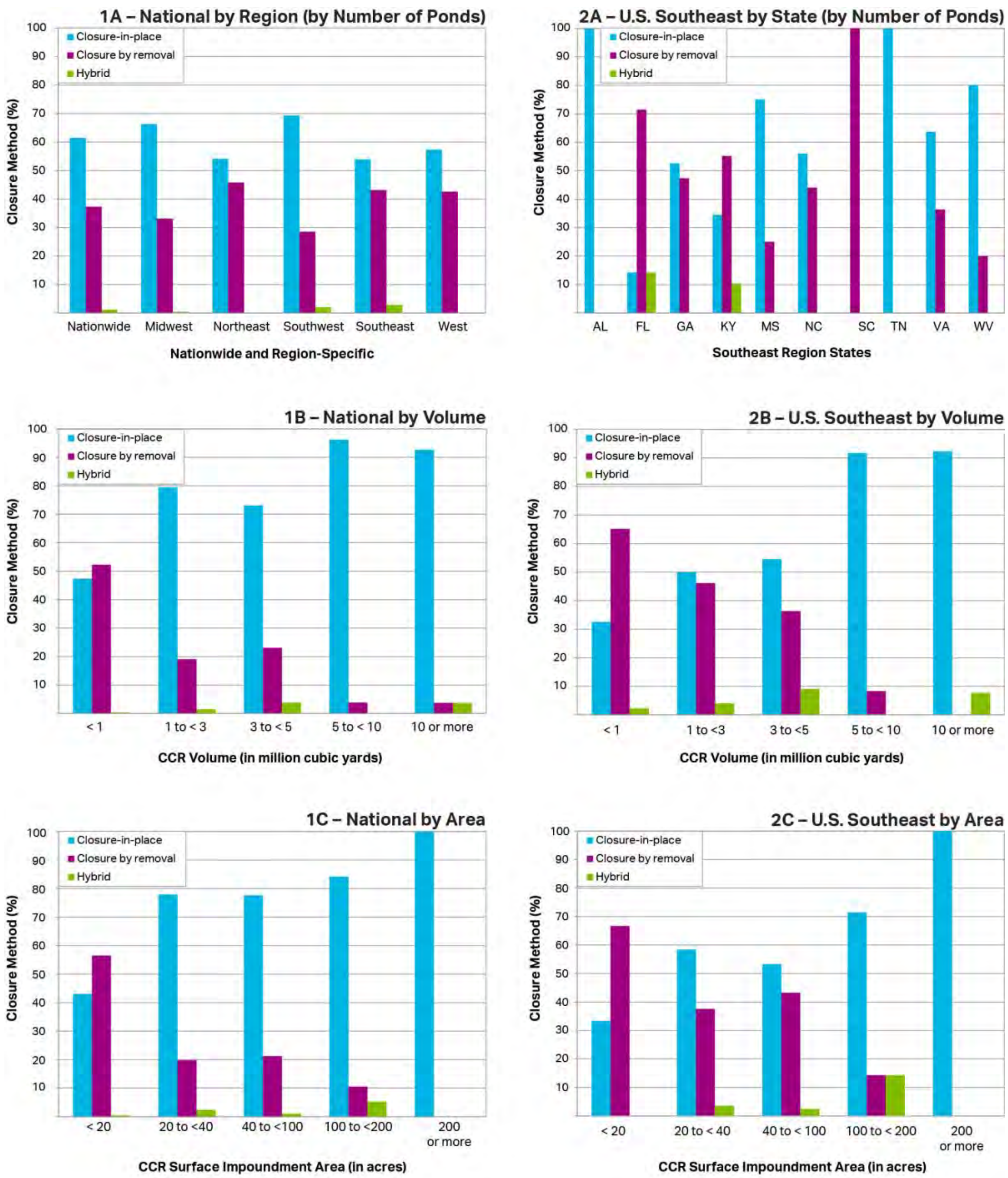

Exhibit 1: CCR Impoundment Inventory – Nationwide and Southeast Region

South Carolina electric utilities committed to closing all ponds by removal following a 2013 settlement with environmental groups. A recent federal court decision in Tennessee, now on appeal, requires the Tennessee Valley Authority to excavate and remove coal ash at the Gallatin Power Station, and pending state enforcement litigation could result in changes to current closure plans at other power stations in Tennessee as well.

4. Summary of Closure Assessment

The following closure alternatives are assessed in this report to address the long-term safety of the ash ponds, protecting public health and the environment:

- Closure by removal and beneficial use
- Closure by removal and landfilling
- Closure-in-place with potential groundwater corrective measures

Ash ponds can be closed by dewatering and either removing the CCR materials or closing the pond in place. Closure by removal options include recycling/beneficial use or relocation of CCR to a lined, permitted landfill. Landfill options assessed include expansion of an existing on-site landfill, construction of a new on-site landfill, transporting the materials off site to a permitted commercial landfill, or transporting the materials off site to a new landfill that would need to be permitted and constructed.

If it is not feasible to use an existing or new on-site landfill, an off-site landfill would be considered. For all closure by removal options, the risks associated with excavating and transporting CCR must be considered, including potential impacts to the community or the environment due to noise, truck traffic, potentials for accidents/spilled material, emissions, or potential for exposure to coal ash. Transportation of ash off site will result in large volumes of truck or train traffic in and out of the station and through the adjacent communities on a daily basis for multiple years.

For this assessment, AECOM considered the following closure by removal with landfill disposal alternatives in order of increasing impacts to the public and the environment:

- Disposal of CCR in an existing on-site landfill
- Development of a new on-site landfill
- Hauling and disposal in a permitted, commercial off-site landfill
- Hauling and disposal in a new off-site landfill developed by Dominion

This assessment also includes an analysis of groundwater and surface water conditions surrounding the ash ponds, along with an assessment of potential corrective measure technologies that could be implemented to address any groundwater impacts adjacent to the ash ponds. If necessary, corrective measures would be implemented in addition to closure of the ponds to manage the groundwater impacts associated with ash ponds that are closed in place.

4.1 Closure by Removal and Beneficial Use

A summary of the regional beneficial use and ash market analysis is provided in Section 5, and beneficial use is described in detail in Technical Memorandum 1. Technical Memorandum 2 provides a summary of the sampling and analysis of ash from each existing pond to obtain information on the material location, quantity, and characteristics.

As referenced in this report, beneficial use is defined as the process of substituting CCR materials for virgin, raw materials in a natural or commercial product. In this study, the CCR would either be used directly from the ash ponds or following additional processing. Beneficiation is the term describing the processing of fly ash to make it more suitable for a specific use, such as substitution for Portland cement used in the production of concrete. This processing can either be performed by constructing a beneficiation system on the power station site or at an off-site specialized facility.

An encapsulated beneficial use binds the CCR into a solid matrix that minimizes its mobilization into the surrounding environment (e.g., concrete or wallboard). All other beneficial uses (e.g., structural fill, flowable fill) are classified as unencapsulated and would require further assessment of potential releases to the environment.

AECOM's beneficial use and ash market study evaluated the market-wide demand for fly ash based on cement consumption and found that the regional (Virginia, Maryland, North Carolina, and the District of Columbia) fly ash supply is projected to exceed demand starting by 2019, without accounting for the more than 25 million tons of ponded ash at the four Dominion power stations. Regional supply is projected to be at least 2.3 million tons per year starting in 2019, while 2016 fly ash usage (demand) is estimated as 1.7 million tons, increasing to 2.3 million tons in 2035. Although some of the contacted fly ash consumers indicated desire and ability to use beneficiated fly ash, the demand quantities and market price were highly variable. While there may be pockets of demand in the region, the data indicate that with the additional 1 million tons per year of beneficiated ash that is projected to enter the North and South Carolina market starting in 2019, the market for large quantities of additional Dominion ash would appear to be limited.

AECOM also contacted potential technology vendors to assess the feasibility of constructing an on-site beneficiation processing facility. Numerous technologies were evaluated, and although this market is rapidly evolving, many technologies are still in the research stage or are unproven for large-scale coal ash beneficiation. A list of evaluated technologies is provided in Section 5.3. The technologies that were further considered as beneficiation options include Staged Turbulent Air Reactor (SEFA Group); Triboelectric Separation Technologies (Separation Technologies LLC) combined with Carbon Burnout (PMI Ash Technologies, LLC); Nu-Rock Technology (Nu-Rock); and Fly Ash Brick Plant (Belden-Eco Products, LLC). Processing rates and costs varied significantly for the different options, as discussed in Section 5.4.

This study also considered the development of a regional processing facility to be located at Chesterfield Power Station that would receive coal ash transported from the Bremo and Possum Point Power Stations for processing and beneficial use. Chesterfield is the most central of the three stations, and it also contains the majority of the ash (14.9 million of the 25.2 million CY), minimizing loading and hauling costs. In general, this is not considered to be a cost-effective option and would result in several of the ash ponds remaining open for at least three decades. The most expedient beneficiation technology would be able to process the ash from the Chesterfield Power Station in 21 years (3 years to design, obtain regulatory approval, and construct and 18 years to process the ash based on technology throughput). Since there is no available area on the Chesterfield station property to temporarily store ash from the other stations, ash would have to be transported on an as-needed basis. Based on throughput rates, it would take another 5 years to process the Possum Point Power Station ash and 8 additional years for Bremo ash, for a total of 34 years for all three stations.

In conclusion, there is a potential to beneficially use fly ash from the Dominion stations within the current market pricing. However, due to the variability in the market, the actual beneficiation quantity on an annual basis cannot be accurately projected. Initial testing on the ponded fly ash indicates that it may potentially be suitable for beneficiation with the technology vendors. However, there are test data currently outside the required ASTM International (ASTM) C618 standard limits for fly ash, requiring additional processing. If the decision were made to proceed further with beneficiation, additional steps would be required to select the appropriate technology including:

- More detailed market discussions with specific regional fly ash users to determine the actual quantity and market price they will commit to in order to supplant their current source
- More detailed characterization of the fly ash at a frequency prescribed by the technology vendors to determine which facilities and total quantity of ponded fly ash that could meet the vendor criteria
- Following completion of the detailed characterization, detailed cost and marketability discussions with the technology vendors to obtain firm commitments on the processing rates and costs provided in their initial estimates

4.2 Closure by Removal and Landfilling

The closure by removal analysis performed by AECOM is provided in Technical Memorandum 3, which describes the life-cycle process of on-site materials handling (excavation, drying, hauling to a consolidated loadout point, and loading for disposal), transportation options (truck, rail, and barge, as applicable), and disposal in an off-site commercial landfill. Technical Memorandum 4 describes the evaluation of using existing landfills located at the stations, development of new landfills on station property, and the feasibility of developing, permitting, and constructing a new off-site landfill.

4.2.1 New or Existing On-Site Landfill

Using available site information, visual observation of the sites, and regulatory criteria for siting and constructing CCR landfills, AECOM assessed each power station to determine the feasibility of either expanding an existing on-site landfill to accept the CCR material from the ponds or constructing a new landfill cell on site. New on-site landfill options include using either a currently undeveloped or “greenfield” area or the footprint of existing CCR ash ponds. A summary of this assessment is provided in Table 6.

4.2.2 Disposal in Permitted Off-Site Landfill

AECOM assessed the commercial and municipal landfills in Virginia, North Carolina, and Maryland that are currently permitted to accept CCR waste, identifying facilities capable of accepting large quantities of CCR material (5 to 15 million CY) with the operating life required (10 to 15 years) to facilitate removal from the four stations. County or regional public landfills generally lack the capacity and/or operating life to manage the Dominion CCR, so all identified potential sites are commercial municipal solid waste (MSW) landfills. These facilities are permitted (or could be readily permitted) and structured to accept CCR waste in a monofill where CCR materials are segregated from other waste materials and placed in a separate landfill cell.

This evaluation considered landfills within a 50-mile radius of the stations for transportation logistic practicalities. Landfills beyond 50 miles could be considered but costs would increase. Landfills served by rail were also considered, and no limit to the hauling distance was applied.

Table 6: Summary of Alternative Assessment for On-Site Landfills

Landfill Option	Feasibility of Landfill Option by Power Station			
	Bremo	**Chesapeake[1]**	**Chesterfield**	**Possum Point**
On Site Expansion of Existing Landfill	**Not feasible.** No existing facility.	NA	**Not feasible.** Insufficient capacity available in new FFCP landfill (9.4M CY) for the volumes of ash on site (14.9M CY). FFCP was constructed for storage of process ash; regulations prohibit FFCP from expanding from current size.	**Not feasible.** No existing facility.
On Site Development of New Landfill on Greenfield Area	**Not feasible**. Inadequate available property suitable for landfill development.	NA	**Not feasible.** Inadequate available property suitable for landfill development.	**Not feasible.** Inadequate available property suitable for landfill development.
On Site Development of New Landfill over Existing Ash Pond	**Not feasible**. Although North Ash Pond footprint is of sufficient size, there is no available location to temporarily store excavated CCR while constructing a new landfill.	NA	**Potentially feasible.** Only feasible on Lower Ash Pond footprint if the DEQ and local authorities grant a variance to allow the setback from the road to be reduced from 500 to 100 feet; design and construction estimate of 20 years would not meet the 15-year CCR Rule closure timeframe; also requires variance to County Conditional Use Permit to truck 3.6 million CY of CCR materials to new FFCP landfill	**Potentially feasible.** Only feasible within Ash Pond E if the DEQ and local authorities grant a variance to allow the setback from the road to be reduced from 500 to 200; or Pond E landfill is combined with other removal or landfill options.

(1) Dominion has committed to remove CCR materials from the Bottom Ash Pond at Chesapeake Energy Center

CCR = coal combustion residuals; CY = cubic yards; DEQ = Virginia Department of Environmental Quality; FFCP = Fossil Fuel Combustion Products; NA = not applicable

Although the Atlantic Waste Disposal facility in Waverly, VA, meets the proximity, reported capacity, and operating life requirements, the owner, Waste Management, has indicated that the facility is not an available option for coal ash due to existing long-term commitments. Additionally, if the USA Waste of Virginia Landfills (Bethel Sanitary Landfill) in Hampton, VA, is not available for CCR disposal, costs and hauling times from the Chesapeake Energy Center may increase significantly.

Transport by truck. The candidate landfills closest to the four stations are described for each station in Sections 6 through 9. Landfill information for the facilities closest to one or more of the stations is shown in Table 7. Approximate distances from each station to these same landfills are shown in Table 8.

Transport by rail. Bremo, Chesterfield, and Possum Point Power Stations are adjacent to mainline railroad tracks owned by CSX Corporation (CSX), while Norfolk Southern owns the rail line adjacent to Chesapeake Energy Center. Transportation by rail would likely include arrangements for dedicated unit trains to haul CCR from each station to a landfill with capability to accept CCR by rail. Transportation by rail would also entail significant upfront infrastructure investment, including design, permitting, and construction time and costs to install and expand sidings, switches, and spurs to facilitate efficient train handling. Specific rail options are discussed in the individual power station sections (Section 6 through 9). AECOM identified landfills in Virginia and surrounding states with capability to accept CCR by rail. Table 9 shows the facilities identified as feasible options to receive CCR by rail. Given the low cost per mile of rail transportation, the specific location of the landfill receiving CCR by rail is less critical than the rail infrastructure and expandability of the site to accept and unload trains in concert with excavation and

Table 7: Candidate Off-Site Permitted Landfills

Map ID[1]	Facility Name	Facility Owner	Reported Remaining: Operating Life (years)[2]	Reported Remaining: Capacity (M CY)[2]
1	Brunswick Waste Management Facility	Republic Services	168	7.5
2	Charles City County Landfill	Waste Management	54	9.5
3	King and Queen Sanitary Landfill	Republic Services	26	6.7
4	Maplewood Recycling and Waste Disposal[3]	Waste Management	148	11.6
5	USA Waste of Virginia Landfills–Bethel	Waste Management	89	17
6	Shoosmith Landfill	Shoosmith Brothers	32	14.8

(1) Map ID refers to locations shown on Figure 2
(2) Remaining permitted operating life and capacity as reported in Virginia DEQ Solid Waste Report as of end of 2016; reported capacity based on total current permitted capacity which may not be fully available for CCR disposal
(3) Facility with rail access
M = million; CY = cubic yards

Table 8: Approximate Distance to Candidate Off-Site Permitted Landfills (Road Miles)

Map ID[1]	Off-Site Landfill	Distance from Landfill to Power Station (in miles): Bremo	Chesapeake	Chesterfield	Possum Point
1	Brunswick Waste Management Facility	106	93	60	149
2	Charles City County Landfill	82	87	27	100
3	King and Queen Sanitary Landfill	108	88	60	99
4	Maplewood Recycling and Waste Disposal	55	126	43	121
5	USA Waste of Virginia Landfills–Bethel	132	33	83	150
6	Shoosmith Landfill	66	89	7	97

(1) Map ID refers to locations shown on Figure 2
Shading = landfill closest to power station

Table 9: Facilities with Capability to Accept CCR by Rail

Off-Site Landfill with Rail Access	Location	Capacity	Comments
Waste Management Maplewood Recycling and Waste Disposal	Amelia County, VA	12M CY, expandable	35 rail cars/day capacity; expandable
Brunswick Waste Management	Brunswick, VA	20M CY, expandable	Would need to construct 2-mile rail spur extension and offloading upgrades
Sunny Hill Farms	Fostoria, OH	30M CY	Owns fleet of 1,500 rail cars
Tunnel Hill Reclamation	New Lexington, OH	30M CY	Owns fleet of 1,500 rail cars
Waste Industries Taylor County Disposal	Mauk, GA	6.7M CY, expandable	Accepts 80 to 100 rail cars per day
Arrowhead Landfill	Uniontown, AL	62M CY; 34 M CY monofill expansion permitted	Accepts 150 gondola cars per day

CY= cubic yards; M = million

loadout rates from the power stations. The landfills listed in Table 9 have current or expandable rail access and infrastructure to handle the CCR generated during a closure by removal option.

Transport by barge. Transporting ash by barge must comply with 9VAC20-170 (Transportation of Solid and Medical Wastes on State Waters), which requires use of watertight containers meeting strict specifications to prevent the release of wastes in the event of an incident. Containers must comply with the testing and certification requirements by the U.S. Coast Guard, including the International Convention for Safe Containers standards for ocean shipping containers, and the American Bureau of Shipping general specifications for weather tightness, and all associated testing initially and at 6 month intervals thereafter.

Given the stringent requirements for containerizing CCR to meet the regulations and the associated infrastructure costs to load, handle, transport, and unload containers, the option to transport CCR in containers by barge is not considered to be a reasonable or cost-effective option for transporting CCR relative to trucking and rail options. In general, barge transportation would require adequate shoreline facilities with sufficient channel depth (typically greater than 12 feet mean low water); docking and mooring facilities; loading and unloading systems, including container cranes and container handling systems installed at the station and port facilities; transportation systems (truck chassis) to haul containers from the port facility to the landfill; and a system to dump containers and reseal them for the return trip. The certified watertight containers would need to be special ordered at least 1 year in advance. To accommodate barge transportation, facility upgrades would be necessary, including dredging, support facility designs, and subsequent marine construction.

4.2.3 Disposal in New Off-Site Landfill

AECOM performed a screening-level assessment of the feasibility of identifying an off-site location to serve as a future new landfill to serve multiple Dominion facilities. A study radius of 50 miles was established from each of the four power stations to establish a practical range for truck hauling to a newly developed landfill. Locations beyond 50 miles could be considered but transportation costs would increase. Since the CCR volume at Chesapeake Energy Center is much smaller than the total volume at the other three stations (60,000 CY versus 25 million CY), it was not included when determining possible locations. The primary area identified by this assessment was in central Virginia roughly centered along I-95 north of I-64 and south of Fredericksburg. This area covers portions of Madison, Culpeper, Orange, Louisa, Spotsylvania, Hanover, Caroline, King William, King and Queen, and Essex Counties.

To accommodate the CCR volumes, a landfill ranging in footprint from 150 to 200 acres would be required. In addition to the land required to establish the landfill itself, additional property would be needed to satisfy regulatory setbacks, avoid streams and wetlands, provide stormwater management, construct roads and support structures, and provide a source for borrow soil to construct the landfill and the final cover. These factors typically require a site to be at least three to four times greater in size than the total landfill footprint. Therefore, the target size for a candidate landfill site would be 500 to 800 acres.

In order to maximize transportation efficiency while avoiding residential areas, sites with direct access from a major roadway would be given higher priority. The landfill facility could consist of a single parcel or multiple parcels currently owned by multiple entities. A preliminary assessment of parcels in the target search area indicates only a limited number of single parcels that could meet the screening size threshold and siting criteria. Therefore, combinations of multiple parcels would likely be required.

Based on the preliminary screening-level assessment, developing a single new off-site landfill to manage CCR from one or more Dominion facilities would not meet the timeline required for CCR closure established by the regulatory authorities (maximum 15 years for Bremo, Chesterfield, and Possum Point ash ponds). Significant additional work would be required to identify candidate sites, assess the transportation routes to the sites, coordinate with local municipalities to determine development requirements, negotiate and purchase land, implement the 3- to 5-year permitting process for establishing a new landfill, and designing and constructing the facility.

An additional option would entail identifying properties within a 50-mile radius of the Dominion power stations that have already gone through preliminary zoning and permitting for waste acceptance. Depending upon the property owner and permit status, using such properties could potentially save 3 to 5 years from the timeline to purchase and permit a solid waste facility.

4.3 Closure-in-Place

The complete closure-in-place analyses performed by AECOM are provided in Technical Memorandum 5, including long-term resilience to extreme weather events such flooding, hurricanes, storm surges, and erosive forces. Structural stability under different loading conditions is evaluated, including seismic (earthquake) events. Considerations related to schedule and costs for the closure-in-place option for each of the stations are also presented. Dominion has committed to removing the CCR materials from the Bottom Ash Pond at the Chesapeake Energy Center, so closure-in-place is not an evaluated option at Chesapeake.

The closure-in-place option for the CCR ash ponds would include removal and treatment of free liquids; pore dewatering and treatment as needed for construction; stabilization of remaining CCR materials sufficient to support the final cover system; grading of the CCR materials to promote effective surface water runoff; installation of a final cover system with appropriate stormwater management systems; and post-closure groundwater monitoring, cover system maintenance, and compliance with dam safety regulations for the ash pond embankments, which are regulated as dams in Virginia. The final cover system would be designed to reduce infiltration, resist erosion, and meet regulatory requirements. If necessary, corrective measures would be implemented to manage the groundwater impacts associated with the closed-in-place ash ponds.

The long-term management for ash ponds that are closed in place, including closure, post-closure care, and groundwater monitoring, would be governed by a solid waste permit. The embankments would continue to be regulated by the Virginia DCR under the impounding structure regulations.

The assessment results demonstrate that the closure-in-place option at Bremo, Chesterfield, and Possum Point Power Stations would provide long-term safety of the CCR ash ponds and address the long-term risks posed by the proposed closure-in-place, siting, seismic (earthquake), and extreme weather events (including flooding, hurricanes, storm surges, and erosive forces). Table 10 summarizes the findings from the assessment.

CCR materials are being removed from six other ash ponds that are being assessed under SB 1398 (Bremo East and West Ash Ponds, and Possum Point Ash Ponds A, B, C, and E). Closure by removal is therefore the selected closure method for these units; groundwater related to these units will continue to be monitored as required by the CCR Rule and other federal or state regulations.

Table 10: Summary of Long-Term Safety Assessment for Closure-in-Place Option

Category	Bremo North Ash Pond	Chesapeake Bottom Ash Pond[(1)]	Chesterfield Lower and Upper Ash Ponds[(2)]	Possum Point Ash Pond D
Closure plan (meets CCR Rule, DEQ and DCR regulations)	Meets Acceptance Criteria	NA[(1)]	Meets Acceptance Criteria	Meets Acceptance Criteria
Siting (unstable areas, active faults, and earthquakes)	Meets Acceptance Criteria	NA[(1)]	Meets Acceptance Criteria	Meets Acceptance Criteria
Flooding (final cover and dam integrity)	Meets Acceptance Criteria	NA[(1)]	Meets Acceptance Criteria	Meets Acceptance Criteria
Hurricanes (final cover and dam integrity)	Meets Acceptance Criteria	NA[(1)]	Meets Acceptance Criteria	Meets Acceptance Criteria
100-year storm surge (final cover and dam integrity)	Meets Acceptance Criteria	NA[(1)]	Meets Acceptance Criteria	Meets Acceptance Criteria
Erosive forces (final cover and dam integrity)	Meets Acceptance Criteria	NA[(1)]	Meets Acceptance Criteria	Meets Acceptance Criteria

The assessment summarized in this table is based on several documents about the ash ponds at each site provided by Dominion. The sources are cited in Technical Memorandum 5.

(1) Dominion has committed to remove the CCR materials from the Bottom Ash Pond at Chesapeake Energy Center.

(2) The closure-in-place concept design for Chesterfield Lower Ash Pond would be supplemented by adding protection for the final cover for potential storm surge if needed.

CCR = coal combustion residuals; DCR = Virginia Department of Conservation and Recreation; DEQ = Virginia Department of Environmental Quality; NA = not applicable

4.4 Groundwater/Surface Water and Corrective Measure Considerations

AECOM's groundwater and surface water evaluations for the eleven ash ponds at the four power stations are provided in Technical Memorandum 6, and groundwater corrective measures for closure-in-place options are described in detail in Technical Memorandum 7.

Dominion has historically performed groundwater and surface water monitoring for compliance with VPDES and other permits, and has also been performing the monitoring events required by the CCR Rule since 2016.

Surface water quality data collected by Dominion and the Commonwealth of Virginia in 2016 and 2017 at each of the power stations indicate that the adjacent surface water bodies have not been impacted by ash pond dewatering activities or by the ash ponds themselves. The groundwater quality data associated with the ash ponds are summarized in each of the individual station sections. Groundwater impacts stemming from the CCR units are primarily from metals and inorganic compounds, constituents that are commonly found in coal and coal byproducts.

As described in the Gradient report, *The Relative Impact Framework for Evaluating Coal Combustion Residual Surface Impoundment Closure Options: Applications and Lessons Learned* (Lewis and Bittner, 2017), both closure-in-place and closure by removal "provide significant beneficial impacts to groundwater quality compared with continued surface impoundment operations and that neither of the closure options is always more beneficial, with respect to downgradient groundwater quality, than the other. These results are consistent with the USEPA position in the CCR Rule that both closure options can be equally protective, provided they are implemented properly." The report goes on to state "Moreover, it is possible that groundwater corrective actions, if instituted as part of a combined remedy with closure-in-place, would result in a greater and more rapid reduction of contaminant concentrations in downgradient groundwater than closure by removal in some assessments." The authors additionally note that surface water impacts under both closure by removal and closure-in-place are minimal.

Using the groundwater data and considering site-specific conditions, AECOM performed an evaluation of potential corrective measures to remediate the groundwater impacts for CCR ash ponds that are closed in place. The technologies that could potentially remediate the groundwater at the CCR ash ponds include the following:

- Permeable reactive barrier (PRB) – groundwater flows through a subsurface trench filled with reactive material and chemically reacts with the material to remove contaminants
- Complete in situ stabilization/solidification (ISS) – an agent is mixed into the ponded ash to physically and chemically bind the metals and other inorganic constituents, preventing them from leaching into the groundwater and thus effectively removing the source
- Containment ISS on the bottom and sides of the ash pond to create a containment cell – an agent is mixed into the CCR to physically and chemically bind the metals and other inorganic constituents. The binding agent is used to create an impermeable layer below and surrounding the ash; combined with a cover, it effectively creates a containment cell around the ash
- Vertical engineered barrier (VEB), which is containment via slurry walls – a subsurface wall is constructed to prevent groundwater from flowing out of the ash pond; if needed, hydraulic containment can supplement VEB
- Hydraulic containment via pump-and-treat methods – groundwater is pumped from a series of wells with overlapping influence to cut off groundwater flowing downgradient of the ash pond; extracted water is treated to below permit requirements and discharged
- Monitored natural attenuation (MNA) – employing physical processes that naturally reduce the concentration, toxicity, or mobility of CCR constituents in groundwater, attenuating the constituents by chemical reactions with other dissolved compounds and the soil media

All of these potential remedial options have relatively similar anticipated durations to reach groundwater cleanup standards, estimated between 10 and 30 years, varying based on concentrations, site-specific groundwater characteristics, and other variables. Some options are better suited than others for specific stations, depending on such variables as depth to confining layer immediately downgradient of the ash pond and hydraulic flow patterns from the ash pond. Chesapeake Bottom Ash Pond and Chesterfield Upper and Lower Ash Ponds have radial flow, requiring corrective measures around the entire perimeter as opposed to the downgradient sides of the Bremo North Ash Pond and Possum Point Ash Pond D.

Any potential corrective measure technology would require a comprehensive remedial design process that would include acquisition of additional data as needed, laboratory bench-scale testing, and potentially a pilot test before designing and implementing the full-scale construction of the selected remedial technology. Combinations of technologies could be tested, and additional emerging technologies could be evaluated as their effectiveness on CCR constituents such as metals is proven. Table 11 summarizes how these corrective measures could address the items required by SB 1398, lists the benefits and considerations for each option, and outlines how each technology could potentially be implemented to remediate groundwater as required to levels below station-specific cleanup goals.

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Table 11: Corrective Measures Technology Summary

Evaluation Factor		Permeable Reactive Barrier (PRB)	In Situ Solidification/ Stabilization (ISS)	ISS to Create Bottom and Side Containment around Cell	Vertical Engineered Barrier (VEB) – Slurry Wall	Pump and Treat with Multiple Treatment Technologies	Monitored Natural Attenuation (MNA) with Risk Assessment
General Technology Specifications		PRB wall to depth of confining layer installed downgradient of CCR unit; deep trenching technology for installation	Full-contact mixing of entire CCR volume in ash pond over full surface area to bottom depth of pond	Approximately 5-foot-thick ISS layer at bottom of CCR over the entire surface area; sidewalls to full depth around unit; cap on top	Slurry wall installed downgradient of CCR unit, keyed into confining layer if possible; deep trenching technology for installation	Multiple extraction wells with overlapping radii of influence; anticipated treatment technologies include aeration, pH adjustment, coagulation/flocculation, filtration, adsorptive media, and ion exchange resin	Downgradient of CCR unit using existing monitoring well network
Additional Requirements		May require up to three parallel walls with different reactive media to treat various constituents	Manage stability over standing water; large-diameter auger mixing ~10% Portland cement	Manage stability over standing water; large-diameter auger mixing ~10% Portland cement	Hydraulic control: multiple extraction wells behind VEB to prevent hydraulic pressure on VEB; includes groundwater treatment	Wells located along full downgradient edge of CCR unit	Risk assessment would be performed to verify that MNA would be protective of human health and the environment
Schedule	**Implementation**	Moderate duration for implementation	Moderate duration for implementation; rapid curing/reaction	Moderate duration for implementation; rapid curing/reaction	Moderate duration for implementation	Moderate duration for construction	No construction needed
	Anticipated Duration to Reach GPS	Removal of constituents as they pass through the PRB should allow downgradient constituent levels to quickly reach GPS; duration for remedial implementation depends on depletion of source contact with groundwater over time; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Continued indefinite monitoring; for the purposes of this evaluation, a 10- to 30-year time frame is assumed
Potential Corrective Measure Benefits		• Removes contamination within PRB amendments (in situ) • Designed to treat multiple constituents in situ to remove constituents and protect human health and the environment • Length of PRB could potentially be reduced with detailed delineation investigation	• Complete source immobilization by physical encapsulation and chemical stabilization • Solidified/stabilized matrix with leachate testing provides proven long-term reliability	• Complete source containment by constructing an impermeable cell • Solidified/stabilized containment with leachate testing provides proven long-term reliability • Impacts primarily limited to on-site	• Slurry wall combined with pumping will provide source containment • Extraction designed to minimize hydraulic pressure on slurry wall and prevent groundwater from flowing around the edges of the wall • Source containment by preventing groundwater flow from ash pond	• Proven technology for hydraulic control and removal of constituents from groundwater • Reduces downgradient risks to human health and the environment • Source containment by hydraulically controlling groundwater flow from ash pond footprint	• Relies on natural attenuation mechanisms for performance • No construction of technology is needed
Potential Corrective Measure Challenges		• Ash remains in place • Needs extensive bench-scale/pilot testing to verify the correct amendment mixtures/geochemistry • May require amendment replacement as capacity to remove constituents is consumed • Multiple amendments may be required to remove all contamination • Treating one constituent may mobilize others • Multiple passes could be needed to install multiple PRBs	• Ash fully encapsulated, but remains in place • Requires full, stable access across entire ash pond surface area • Requires deep augering to full depth of pond necessary in an overlapping pattern across the entire surface area • Requires trucking delivery of large volumes of Portland cement • Requires heat of reaction, dust, and odor control • Requires monitoring for remedial effectiveness • Becomes cost prohibitive if applied deeper than approximately 50 feet	• Ash remains in place • Unproven technology for CCR units • Difficult to prove continuous solidification along bottom surface with no gaps • Requires understanding of depth profile of ash • Requires full, stable access across the entire ash pond surface area • Requires deep augering to full depth of pond necessary in an overlapping pattern across the surface area • Requires trucking delivery of large volumes of Portland cement • Requires heat of reaction, dust, and odor control • Requires monitoring for remedial effectiveness • Becomes cost prohibitive if applied deeper than approximately 50 feet	• Ash remains in place • Geology dependent • Requires deep trenching • Entails complete source containment, not removal • Requires heat of reaction, dust, and odor control • May require additional measures for downgradient plume • Pump testing required to design extraction well network • Bench-scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems needed– duration unknown, ongoing O&M/treatment costs • Requires periodic changes in and/or regeneration of filtration/treatment media • Requires an approximately 20-foot wide corridor for installation	• Ash remains in place • Requires installation of multiple extraction wells and subsurface piping network to a centralized groundwater treatment system housed in a building • Pump testing required to design extraction well network • Bench-scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems needed– duration unknown, ongoing O&M/treatment costs • Requires periodic changes in and/or regeneration of filtration/treatment media • Limited downgradient space to install monitoring wells to verify constituent capture	• Ash remains in place • Monitoring/sampling required • Routinely evaluate for changing conditions

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4.5 Closure Cost Considerations and Timelines

4.5.1 Cost Estimate Assumptions

To support this closure assessment, AECOM developed cost estimates for the closure alternatives described in this report. These opinions of probable cost are estimates of potential construction costs for informational purposes. The costs are Class 5 estimates (see Table 12), are limited to the conditions existing at issuance, and are not a guarantee of actual price or cost. Uncertain market conditions such as but not limited to local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions may affect the accuracy of these estimates. AECOM is not responsible for any variance from costs presented in this document or actual prices and conditions obtained.

Table 12: Cost Estimate Classification Matrix

	Primary Characteristic	Secondary Characteristic			
Estimate Class	Level of Project Definition[(1)]	End Usage[(2)]	Methodology[(3)]	Expected Accuracy Range[(4)]	Preparation Effort[(5)]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: –20% to –50% H: +30% to +100%	1
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: –15% to –30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, authorization, or control	Semi-detailed unit costs with assembly level line items	L: –10% to –20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: –5% to –15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: –3% to –10% H: +3% to +15%	5 to 100

Source: AACE (2005)

(1) Expressed as percent of complete definition

(2) Typical purpose of estimate

(3) Typical estimating method

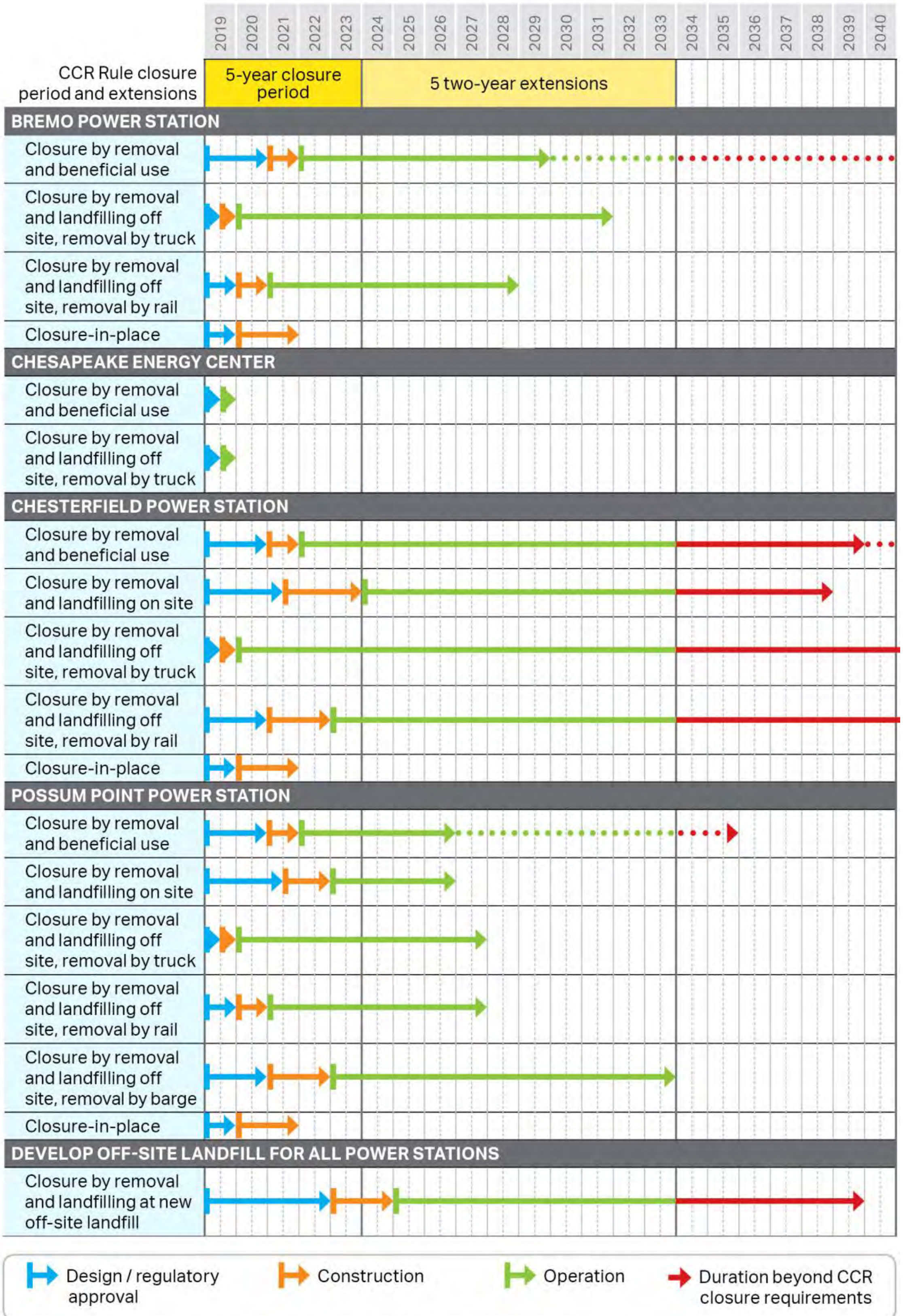
(4) Typical variation in low and high ranges. The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

(5) Typical degree of effort relative to least cost index of 1. If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

H = high; L = low

4.5.2 Closure Timelines

In accordance with the CCR Rule, closure of ash ponds greater than 40 acres, which includes Bremo North Ash Pond, Chesterfield Lower and Upper Ash Ponds, and Possum Point Ash Pond D, must be completed within 15 years (5-year base period plus up to five extensions in 2-year increments). Exhibit 2 shows the estimated timelines for the closure options at the four power stations compared to the required CCR Rule timelines. Note that some of the closure options are estimated to take longer than 15 years.



(Note: Solid line represents minimum duration and dotted line represents maximum duration for beneficial use technologies)

Exhibit 2: Closure Implementation Timeline

This page revised after the December 1, 2017 publication

5. Beneficial Use and Ash Market Assessment

AECOM performed a beneficial use and ash market study, which consisted of an evaluation of the demand for fly ash for use in concrete production in a 50-mile radius of each power station and an evaluation of the regional market in Virginia, Maryland, North Carolina, and the District of Columbia. A 50-mile radius was considered for transportation logistic practicalities. Markets beyond 50 miles could be considered but costs would increase. The study is provided in Technical Memorandum 1, and a summary is provided in the following sections.

Beneficial use is the process of substituting CCR materials for virgin, raw materials in a natural or commercial product. In this study, the CCR would either be used directly from the ash ponds or following additional processing. Beneficiation is the term describing the processing of fly ash to make it more suitable for a specific use, such as substitution for Portland cement used in the production of concrete, which is the most predominant beneficial use of fly ash. The processing can be performed by constructing a beneficiation system on the power station site or at an off-site specialized facility.

An encapsulated beneficial use binds the CCR into a solid matrix that minimizes its mobilization into the surrounding environment (e.g., concrete or wallboard). All other beneficial uses (e.g., structural fill, flowable fill) are classified as unencapsulated and would require further assessment of potential releases to the environment.

5.1 Summary of Key Findings

The results of the study show that the regional fly ash supply is likely to exceed demand starting by 2019, not including the more than 25 million CY of ponded ash stored at the four Dominion stations. Regional supply is projected to be at least 2.3 million tons per year starting in 2019, while 2016 fly ash usage (demand) is estimated as 1.2 to 1.9 million tons per year, increasing to 1.6 to 2.3 million tons per year in 2035, as shown in Exhibit 3.

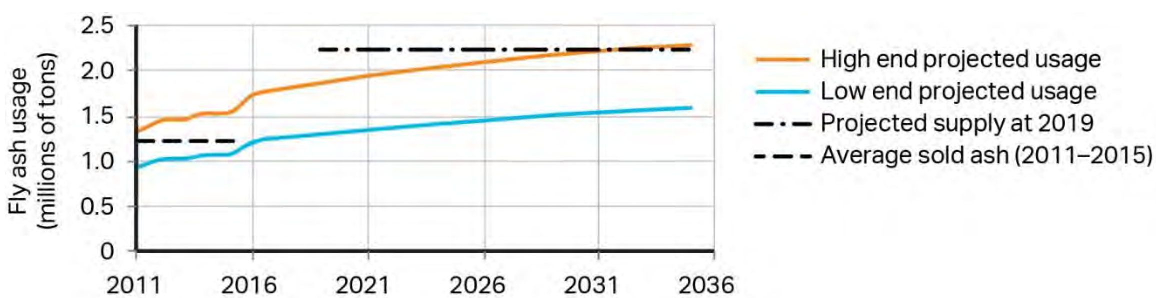


Exhibit 3: Comparison of Projected Fly Ash Usage and Supply

As part of the study's market evaluation, AECOM contacted regional and non-regional ready mix, concrete, and cement kiln facilities; utilities selling fly ash; and other CCR marketers. Some regional and non-regional fly ash consumers indicated that they could use additional beneficiated fly ash beyond their current supply, depending on the cost competitiveness compared to the market. Desired quantities of processed fly ash are highly variable, ranging from approximately 5,000 to 18,000 tons per year and for two ash marketers, 375,000 to 800,000 tons per year of unprocessed ash. The demand is highly variable, depending on the end user and whether the ash is processed. Competitive purchase price typically ranges from $30 to $60 per ton with added transportation costs of $7 to $33 per ton (total $37 to $93 per ton), and fly ash was transported between 60 and 200 miles.

AECOM also contacted potential beneficial use technology vendors to assess the feasibility of processing ponded ash at one centrally located Dominion station or at multiple stations. Numerous technologies were evaluated, and although this market is rapidly evolving, many technologies are still in the research stage or are unproven for large-scale coal ash beneficiation. Four technologies that were further considered in this evaluation include Staged Turbulent Air Reactor (SEFA Group); Triboelectric Separation Technologies (Separation Technologies LLC) combined with Carbon Burnout (PMI Ash Technologies, LLC); Nu-Rock Technology (Nu-Rock); and Fly Ash Brick Plant (Belden-Eco Products, LLC). The cost of the technologies range from $96 to $285 per ton excluding transportation, as shown in Exhibit 4.

Exhibit 4: Comparison of Beneficiation Technology Cost and Fly Ash Purchase Price

In addition, processing rates vary from 300,000 to 840,000 tons per year, indicating a beneficiation duration of between 11 and 24 years at Bremo, 21 to 53 years at Chesterfield, and 8 to 17 years at Possum Point, depending on the technology and ability of the market to use the ash, as shown in Exhibit 5. Durations are based on throughput rates for on-site processes at individual sites, including the approximately 3 years needed to design, obtain regulatory approval, and construct on-site processing units.

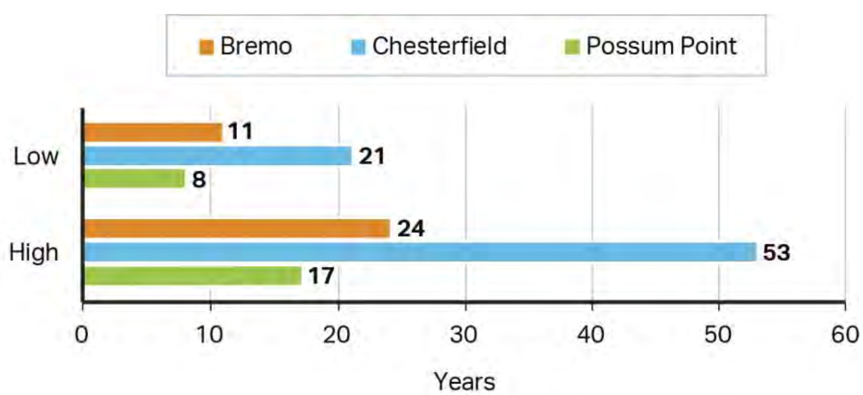


Exhibit 5: Comparison of Beneficiation Technology Timelines

The sample results evaluated in this study (results provided in Technical Memorandum 2) provide an initial indication of the CCR material characteristics within each impoundment and can be used to draw general conclusions regarding whether the unprocessed CCR material may meet ASTM C618 criteria for use in concrete or whether additional beneficiation may be warranted.

AECOM also performed initial testing of ponded fly ash to determine whether the unprocessed CCR material may meet ASTM C618 criteria for use in concrete or whether additional beneficiation may be warranted. None of the samples collected from the ash ponds at Bremo, Chesterfield, and Possum Point Power Stations met all of the ASTM C618 criteria. The ponded ash would likely need processing and/or screening to reduce moisture and increase fineness of the materials, to potentially include beneficiation technologies to reduce the carbon content. Material unsuitable for beneficiation may need to be placed in a landfill.

In summary, there is a potential to beneficially use fly ash from the Dominion stations on a regional and non-regional basis and within the current market pricing. However, due to the variability in the market, the actual beneficiation quantity on an annual basis cannot be accurately projected. Initial testing on the ponded fly ash indicates that it may potentially be suitable for beneficiation with the technology vendors. However, there are test data currently outside the required ASTM C618 standard limits. If the decision were made to proceed further with beneficiation, additional steps would be required to select the appropriate technology, including:

- More detailed market discussions with specific regional fly ash users to determine the actual quantity and market price they would commit to in order to supplant their current sources
- More detailed characterization of the fly ash at a frequency prescribed by the technology vendors to determine which facilities and total quantity of ponded fly ash could meet vendor criteria
- Following completion of the detailed characterization, detailed cost and marketability discussions with technology vendors to obtain firm commitments on the processing rates and costs provided in their initial estimates

The fly ash supply in the market is highly variable as a result of factors such as local sources being developed (including the ponded ash processing facilities under development by Duke Energy), loss in supply if existing coal plants sourcing fly ash in the region close or convert to natural gas, and loss of out-of-state sources if other local sources offer a consistent quality, quantity, and cost-competitive alternative.

5.2 Assessment and Characterization of Ponded CCR

AECOM performed preliminary ash sampling and characterization to assess and characterize the CCR in the existing ash ponds to determine whether the ponded ash could be used as a direct replacement for Portland cement without additional processing, and if not, to determine what properties would need to be addressed to make the ash suitable. A complete discussion of the sampling and results is provided in Technical Memorandum 2. Drilling at Bremo North Ash Pond, Chesterfield Lower and Upper Ash Ponds, and Possum Point Ash Pond D indicated that the ash depths used to establish CCR quantities (refer to Table 1 on page 1-1) appear to be generally representative of the depths obtained from the samples collected. None of the samples collected at the four sites evaluated in this study met all of the ASTM C618 criteria. The most common issues were excessive carbon content (as measured by loss on ignition [LOI]), high moisture content, insufficient material fineness, excessive water demand, and an insufficient rate of pozzolanic reactivity (as measured by the strength activity index [SAI]). These issues could possibly be addressed via processing to reduce moisture and increase fineness of the materials, as well as use of beneficiation technologies to reduce the carbon content. Material unsuitable for beneficiation may need to be placed in a landfill.

Based on the chemical analyses, the ash appears to generally be consistent with the LOI ranges required by selected technology vendors as a suitable source for ash processing. However, the wet fly ash moisture contents typically exceed the moisture contents specified by the technology vendors. Increased moisture contents indicate that additional drying efforts would be required prior to hauling the materials to the processing facility, including mechanical dewatering of the ash and/or stacking and drying operations prior to hauling.

5.3 Market Need and CCR Demand

In assessing the market need and demand for CCR, AECOM's study considered the following key factors and criteria:

- The regional market as defined by Virginia, North Carolina, Maryland, and the District of Columbia
- Fly ash consumption based on Portland cement and ready mix usage in the region and current and projected need from published sources
- Determination of need based on benchmarking surveys of regional ready mix, concrete, cement kiln, CCR marketers, and state departments of transportation.

In summary, the results of the market need evaluation indicate that based on Portland Cement Association projections, fly ash usage in 2016 ranged from 1.2 to 1.7 million tons per year. By 2035, the fly ash usage is projected to range from 1.6 million to 2.3 million tons per year, depending on the fly ash replacement rate achieved. However, based on the benchmarking surveys, some of the companies that were contacted indicated that there is currently a shortage of fly ash and that associated demand may exist. The regional quantity of fly ash that may be in demand is highly variable, ranging from 5,000 tons to 800,000 tons depending on the end user and whether the ash is processed. The higher quantities of ash are typically associated unprocessed ash. While there may be pockets of demand in the region, the data indicate that with the additional 1 million tons per year of beneficiated ash that is projected to enter the North and South Carolina market starting in 2019, the market for large quantities of additional Dominion ash would appear to be limited.

5.4 Market Supply

AECOM identified the coal-fired power plants and other independent power producers operating in the regional study area that used coal as a fuel source, reviewing published information for the power plants related to their production and sales data for fly ash between 2011 and 2015. During this period, regulated utilities and other power generators sold an average of 1.2 million tons per year of fly ash, which represented only 20 to 30% of the fly ash produced by the utilities. When forecasting future supply, the following additional factors must be considered:

- SEFA's goal of providing 300,000 tons per year of reclaimed and processed ponded coal ash from ponds at the Georgetown, SC, STAR facility to the South Carolina and other markets

- Unquantified quantities of fly ash from sources in Maryland, North Carolina, West Virginia, Pennsylvania, Georgia, Tennessee, and Ohio
- Unquantified alternative cementitious products such as cement slag being used in the regional study area and new sources starting operation
- Development of SEFA STAR facilities at the Goldsboro, Cape Fear, and Salisbury Duke Power Plants, with a planned processing capacity of 300,000 to 350,000 tons per year each that will beneficiate ponded coal ash from each of the generating stations; these facilities will likely be online in 2019 and operate until 2029, adding 1 million tons per year of fly ash to the market.

As discussed above, the 2016 forecast for fly ash usage (demand) was estimated as 1.2 to 1.7 million tons per year. By 2035, the fly ash usage is projected to range from 1.6 million to 2.3 million tons per year. When the Duke STAR facilities come online, the fly ash supply will increase to at least 2.3 million tons per year by 2019, excluding unknown quantities of out-of-state fly ash sources, resulting in a projected fly ash surplus in the regional study area. The surplus is projected to exist before Dominion would potentially enter the market to beneficially use its ponded ash from the Bremo, Possum Point, and Chesterfield Power Stations.

In addition, benchmarking surveys with regional CCR marketer Charah indicate that Charah expects a surplus of beneficiated fly ash in the study area region in the next 3 to 5 years when beneficiated ash from North Carolina enters the regional market. Charah anticipates that the regional supply (Virginia, Maryland, North Carolina, and South Carolina) will be approximately 1.6 million tons per year but that the demand will be 900,000 tons per year.

5.5 Beneficiation Technologies

AECOM also evaluated potential proven, developing, and research-stage technologies that may be feasible to process the ponded ash at Dominion facilities. The list of potential beneficiation technology vendors is substantial, and numerous technologies were considered in the information that was used for this assessment. Many of the technologies are in the research stage, or have never been proven for use in large-scale coal ash projects, including the following vendors and technologies:

- Boral/IDA – aggregate manufacturing
- CeraTech – alternative cement manufacturing
- Dominion, in collaboration with several non-government organizations and several government agencies – coal-ash pellet oyster reefs
- EnCAP-IT – encapsulated mechanically stabilized earth berms. a closure method that would beneficially use a small portion of the CCR material
- NAES Corporation/Circamix – dense slurry technology
- Progressive Industries, Inc. – progressive air classifier technology
- RJ Smith – aggregate manufacturing
- RSG, Inc. – air classifiers
- Sierra Energy FastOx – gasifier

- SonoAsh – sonic separation technology
- Spartan Materials – supplier of fly ash to the concrete industry
- Sturtevant, Inc. – air classifiers
- Turboden Organic Rankine Cycle (ORC) – turbogenerators

All of the beneficiation technologies listed above are market-limited, as they are dependent upon the market to utilize the ash generated by the technology. Descriptions of each technology and limitations of reliably and cost-effectively processing large volumes of ponded ash are provided in Technical Memorandum 1.

Four beneficiation technologies were evaluated further, including SEFA Group STAR, ST Triboelectric Separation Process/PMI Carbon Burnout, Nu-Rock Technology, and Belden-Eco Products Brick Plant. In performing the study, AECOM used the Response to Request for Information (RFI) packages obtained from beneficiation vendors from Dominion (2016 and 2017) and the Electric Power Research Institute (EPRI) *Duke Energy Coal Combustion Product Management Study* (EPRI, 2016) to supplement the benchmark survey information. AECOM conducted supplemental surveys to obtain additional information from companies discussed in both reports and other vendors that contacted Dominion directly. Emerging technologies and other vendors that were not contacted or included in the selected potential technologies for this report did not have operating facilities in the United States, were in early research stages, or had no experience applying their technology to ponded ash.

Based on information presented by the technology vendors, Table 13 presents a summary of the technology requirements, cost, and processing capabilities.

Table 13: Summary of Vendor Beneficiation Technologies

Parameter	SEFA STAR Technology	ST Triboelectric Separation Combined with PMI Carbon Burnout	Nu-Rock Technology USA	Belden-Eco Products
Wet ash acceptable LOI	8 to 19%	6 to 20%	24	NR
Dominion wet ash LOI	6 to 23%	6 to 23%	6 to 23%	6 to 23%
Wet ash acceptable moisture content	30%	25%	10%	NR
Dominion wet ash moisture content	15 to 51%	15 to 51%	15 to 51%	15 to 51%
Max market distance	150 miles	100 miles	250 miles	NR
Fly ash processing capacity	Throughput ranges from 300,000 to 840,000 tons/year			

LOI = Losses on Ignition; STAR = Staged Turbulent Air Reactor; NR = no response from vendor

In general, the listed technologies are capable of producing approximately 300,000 to 840,000 tons per year per facility of fly ash. There was limited response from the vendors on the selling price for the processed fly ash; however, available information indicates pricing ranges from $50 to under $100 per ton. Benchmarking surveys of regional ash users indicate ash pricing typically ranges from $30 to $60 per ton, excluding transportation.

5.6 Feasibility of On-site versus Regional Ash Processing Facilities

In accordance with SB 1398 requirements, the study also considered the feasibility of an on-site ash processing system to produce cementitious materials and the feasibility of creating a regional processing facility or facilities to service multiple ash ponds. In this study, each Dominion power station was considered for the development of a processing facility to beneficiate ash for cementitious purposes. The criteria to be considered included:

- Quantity of ash to be removed at each station
- Market for the materials
- Technologies to be considered
- Timing for the facility to be online
- Costs:
  - Cost for technology
  - Cost for excavating, screening, drying, and transporting
  - Operations and maintenance (O&M) costs for the technology and site operations
- Community impacts

A discussion of the site-specific processing facilities at each Dominion power station is provided in individual power station summary in Sections 6 through 9 (as well as in Technical Memorandum 1). In addition, the study considered the development of a regional processing facility at Chesterfield Power Station that would receive coal ash transported from the Bremo and Possum Point Stations for processing and beneficial use. For the purpose of this study, only one unit for each processing technology evaluated was proposed to be developed at each power station. The cost model does not include loading or transportation costs to the end user and does not consider potential revenue from selling the ash for beneficial use or recycling. The projected total cost range for beneficiation processing facilities at each Dominion power station is:

- $96 to $217 per ton at Bremo Power Station
- $100 to $285 per ton at Chesterfield Power Station
- $118 to $225 per ton at Possum Point Power Station

Based on the benchmarking results, fly ash is selling on average for $30 to $60 per ton plus $7 to $33 per ton for transportation. The estimated costs for beneficiation are approximately 1.5 to 4.8 times greater than the current regional market price for the ash.

The regional beneficiation study indicates a wide variability in the market, such that the actual beneficiation demand cannot be accurately estimated. Initial testing on the ponded fly ash indicates that it may potentially be suitable for beneficiation with the technology vendors. However, there are test data currently outside the vendor required limits.

If the decision were made to proceed further with beneficiation, additional steps would be required to select the appropriate technology, including:

- More detailed market discussions with specific regional fly ash users to determine the actual quantity and market price they will commit to in order to supplant their current source
- More detailed characterization of the fly ash at a frequency prescribed by the technology vendors to determine which facilities and total quantity of ponded fly ash that could meet the vendor criteria
- Following completion of the detailed characterization, detailed cost and marketability discussions with the technology vendors to obtain firm commitments on the processing rates and costs provided in their initial estimates

Senate Bill 1398 Response

Coal Combustion Residuals
Ash Pond Closure Assessment

SECTION 6:
BREMO POWER STATION

November 2017

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6. Bremo Power Station

6.1 Summary for Bremo Power Station

This closure assessment focuses on the Bremo Power Station North Ash Pond, where coal combustion residual (CCR) materials from the East and West Ash Ponds are actively being consolidated, as summarized in Table 14. Ash ponds can be closed by dewatering and then either removing the CCR materials or closing the pond in place. In the closure by removal option, CCR can be recycled/beneficially used or relocated to a lined, permitted landfill. Landfill options could include expansion of an existing on-site landfill, construction of a new on-site landfill, transporting the materials off site to a permitted commercial landfill, or transporting off site to a new landfill.

Table 14: Bremo Power Station Ash Ponds

CCR Unit	Remaining CCR Volume (CY)	Operating Status	Area (acres)
North Ash Pond	4,800,000	Slated for closure	68
East Ash Pond	1,400,000	Ash being actively removed and transported to North Ash Pond	27
West Ash Pond	0	Ash removed	22
Total Volume	**6,200,000**		

CCR volumes are based on Dominion estimates as of July 10, 2017
CCR = coal combustion residuals; CY = cubic yards

AECOM assessed the following closure alternatives to address the long-term safety of the North Ash Pond and protect public health and the environment:

- Closure by removal and beneficial use
- Closure by removal and landfilling
- Closure-in-place with groundwater corrective measures, if applicable

Table 15 provides a summary of the assessed closure options for the Bremo North Ash Pond, including an approximate duration to complete each option, estimated costs, and potential safety, community, and environmental considerations. All of these closure options have inherent risks that must be considered in the evaluation, including potential impacts to the community or the environment due to noise, truck traffic, potentials for accidents/spilled material, emissions, or potential for exposure to coal ash. As shown in Table 15, the options that include materials leaving the site would be implemented over 10+ years, resulting in large volumes of truck and potentially train traffic in and out of the station and through the adjacent communities on a daily basis for multiple years.

CCR materials are being removed from the Bremo East and West Ash Ponds; therefore, closure by removal is the selected closure method for these units. Groundwater related to these ash ponds will continue to be monitored as required by the CCR Rule and other federal and state regulations.

To support this closure assessment, AECOM developed cost estimates for the closure alternatives listed in Table 15. These Opinions of Probable Cost are estimates of potential construction costs for informational purposes. The costs are Class 5 Estimates (+100%, -50%) and are limited to the conditions existing at issuance and not a guarantee of actual price or cost. Uncertain market conditions such as, but not limited to, local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions may affect the accuracy of these estimates.

In accordance with the CCR Rule, closure of the North Ash Pond must be completed within 15 years (5-year base period plus up to five extensions in 2-year increments). Exhibit 6 shows the estimated timeline for each of the closure options compared to the CCR Rule durations.

Table 15: Summary of Closure Options for Bremo Power Station

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Beneficial Use	11 to 27 years	\$593M to \$1.34B	• Ash pond stays open for 11+ years (3 years design/permit/construct, remaining years to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *Duration to implement several evaluated technologies exceeds CCR closure requirements of 15 years* • Time frames are driven by available market and throughput of beneficiation technologies • Safety and community risks from excavation and over-the-road hauling due to significant volume, multi-year duration removal project; up to 150 trucks/day each way for 8+ years • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Engineering challenges for CCR dewatering and excavation • Greater potential for groundwater migration during CCR removal • Removes source of potential groundwater impacts
Closure by Removal and On-Site Landfilling	NA	NA	Alternative not feasible because there is no location to temporarily store materials during new landfill construction
Closure by Removal and Off-Site Commercial Landfilling by Truck	13 years	\$1.03B	• Ash pond stays open for 13 years (1 year design/permit/ construct, remaining to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety and community risks from excavation and over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks/day each way for 12 years; truck leaving site approximately every 3 minutes for 10 hours/day Monday through Friday) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation

Table 15 (cont.): Summary of Closure Options for Bremo Power Station

Closure Option	Est. Time Frame	Est. Cost[1]	Implementation Considerations
Closure by Removal and Off-Site Commercial Landfilling by Rail	10 years	$1.53B	• Ash pond stays open for 10 years (2 years design/permit/ construct, remaining transport), increases safety risk, results in prolonged duration for dewatering/water treatment • Safety and community risks from excavation and rail hauling due to significant volume and multi-year duration removal project (200+ railcars per week for 8 years) • Reduced hauling risks for rail vs. trucking • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and Off-Site Commercial Landfilling by Barge	NA	NA	Alternative not feasible due to shallow depth of James River
Closure-in-Place with Potential Groundwater Corrective Measures	3 to 5 years	$98M to $173M	• No impacts for CCR removal or off-site hauling • Lowest risk for safety, community, schedule, and cost • Lower groundwater migration potential for CCR remaining in place once closure is complete, which is addressed by corrective measures • Includes cost range for corrective measures • 2-year corrective measure construction duration • Estimated 10- to 30-year duration for groundwater corrective measures

(1) All costs in this report are Class 5 estimates (+100%, –50%) and represent opinions of probable cost based on information available at the time of this study. AECOM is not responsible for any variance from costs presented in this document or actual prices and conditions obtained.

CCR = coal combustion residuals; B = billion; M = million; NA = not applicable

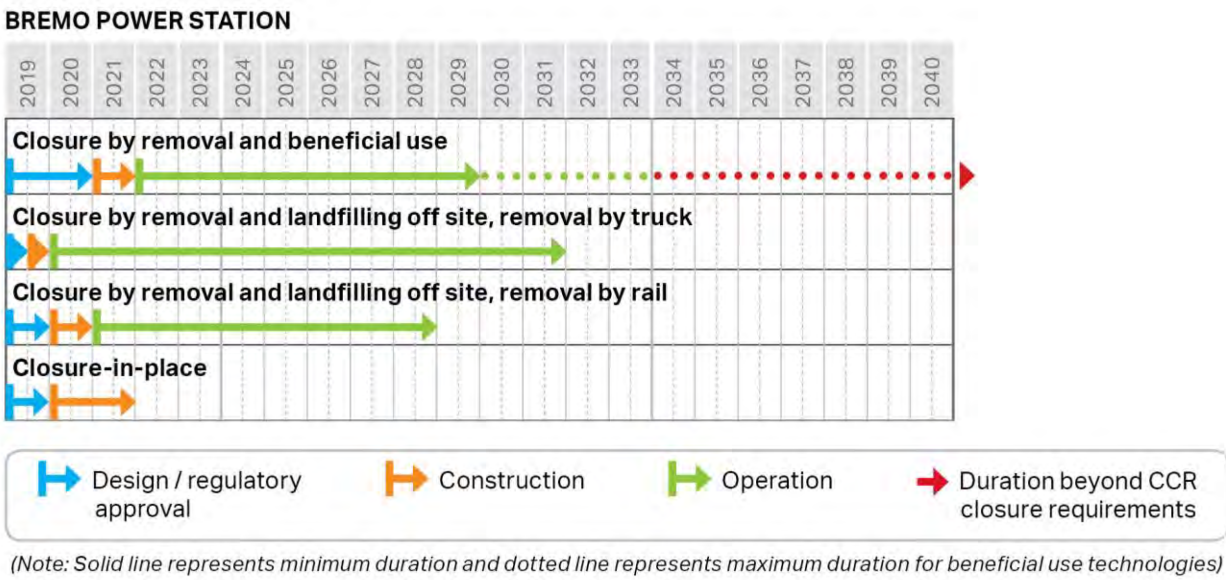

Exhibit 6: Closure Implementation Timeline – Bremo Power Station

6.2 Site Background

The Bremo Power Station is located in Fluvanna County, VA at 1038 Bremo Bluff Road in Bremo Bluff. Figure 1 shows the station location and the primary site features. The power station is located on the northern bank of the James River and is separated from the river by a CSX Corporation (CSX) railroad track and easement. Properties surrounding the station are zoned agricultural. Land immediately adjacent to the station consists of predominantly wooded parcels and a few single-family residences.

The station was first operational in 1931. In 2014, the Bremo Power Station converted its boilers from coal-fired to natural gas-fired and decommissioned the coal and coal ash handling infrastructure.

Three on-site surface impoundments (North Ash Pond, West Ash Pond, and East Ash Pond) are subject to the requirements of SB 1398 and the CCR Rule. CCR materials are being consolidated in the North Ash Pond. Materials from the West Ash Pond have been transferred to the North Ash Pond, and CCR from the East Ash Pond is actively being moved to the North Ash Pond. Once the consolidation is completed, approximately 6.2 million CY of CCR will be stored in the North Ash Pond.

The North Ash Pond is impounded by an earthen berm approximately 96 feet tall and covers approximately 68 acres. The majority of the impoundment is underlain by approximately 15 to 50 feet of native soils (predominantly clay and silt). The East Ash Pond is impounded by an earthen berm approximately 24 feet tall and covers approximately 27 acres. This pond is underlain by predominantly clay and silt alluvium (approximately 25 feet thick) with a thin gravel layer present just above the bedrock surface. The 22-acre West Ash Pond is impounded by an earthen berm approximately 18 feet tall. This impoundment is underlain by clay, silt, and sand alluvium with a thin gravel/cobble layer present immediately above the bedrock surface.

6.3 Closure by Removal

Closure by removal entails excavating the CCR materials from the ash pond and either beneficially reusing or placing them in a lined, permitted landfill. Primary components in this process include materials handling to remove the CCR from the ash pond and load the materials in trucks or railcars, transporting the materials to an off-site beneficial use or landfill facility, restoring the former ash pond to facilitate stormwater flow; and monitoring the groundwater to ensure continued protectiveness as required by the CCR Rule. These processes are described in the following sections.

6.3.1 Materials Handling

Closure by removal involves dewatering the ash ponds and treating the removed water, excavating the material and transporting it to staging/loadout areas, drying and stockpiling it for off-site transportation, loading for transport, and then backfilling and restoring the ash pond footprint once all CCR materials have been removed.

6.3.1.1 Dewatering and Water Treatment

Surface water and pore water would be removed and treated to prepare for excavation and material handling. Well points and deep wells that have been installed in the North Ash Pond would be used to dewater the full CCR thickness, with temporary trenches and CCR grading implemented to direct water to low points within the impoundments prior to removal. Dewatering activities would be initiated prior to excavation work and continue as long as necessary to ensure workable site conditions.

A specialized water treatment system would be installed to treat all CCR contact water to meet the discharge requirements of the Virginia Pollutant Discharge Elimination System (VPDES) permit. The water currently being treated at the Bremo Power Station has been discharging below permit limits based on the design, construction, and operation of existing on-site systems. The dewatering and treatment system would be required to operate until all closure activities are complete.

6.3.1.2 CCR Excavation

Closure by removal would involve excavating ash from the pond such that no residual materials remain visible, followed by over-excavating the removal footprints by 6 inches as required by the Virginia Department of Environmental Quality (DEQ), which is more stringent than federal requirements.

6.3.1.3 Transportation to On-Site Staging/Loadout Areas

Once excavated, CCR would be loaded into dump trucks and hauled from the excavation to a staging area either within the ash pond or at a dedicated on-site stockpile area with proper containment, dust control, and water collection and treatment systems. On-site haul routes would likely need to be constructed or improved to be wide enough and have sufficient turning radii for efficient and safe operation of dump trucks. Water trucks would be necessary to reduce fugitive dust for the duration of hauling.

6.3.1.4 Drying and Stockpiling for Off-Site Transportation

In some cases, the CCR may need to be temporarily stockpiled to gravity drain and/or air dry to meet acceptable moisture content prior to loadout for off-site transportation. The CCR is typically required to have no more than 25% to 35% moisture content for transport and placement in a dry landfill. Drying areas may be near excavation or loadout areas, but sufficient laydown area would be planned to provide at least a week or more of drying time prior to loadout. Wind-rowed CCR may require re-handling several times to rotate the materials for maximum drying potential and to achieve desired moisture content prior to loadout.

6.3.1.5 CCR Loadout for Off-Site Transportation

Designated loadout areas would be established adjacent to truck or rail car staging areas for efficient loading operations. CCR would be loaded into trucks or rail cars using rubber-tired loaders or conveyors.

Truck loadout would include an on-site one-way loop road to provide safe exit from the adjacent public road, and areas for stacking and loading trucks, replacing covers, weight scaling, tire washing, and safe re-entry to the adjacent public road.

Rail loadout would generally involve using new or existing rail sidings and spur tracks to receive empty unit trains (85 gondola cars), splitting unit trains into smaller groups of gondola cars for on-site handling using a locomotive, installing disposable liners and covers, loading gondolas, re-assembling trains of filled gondola cars, and staging on the adjacent siding for pickup by a freight rail firm.

6.3.2 Closure by Removal and Beneficial Use

AECOM's beneficial use and ash market study evaluated the market-wide demand for fly ash based on cement consumption and found that the regional (Virginia, Maryland, North Carolina, and the District of

Columbia) fly ash supply is projected to exceed demand starting by 2019 without accounting for the more than 25 million tons of ponded ash stored at the four Dominion power stations. Regional supply is projected to be at least 2.3 million tons per year starting in 2019, while 2016 fly ash usage (demand) is estimated as 1.7 million tons, increasing to 2.3 million tons in 2035. Some of the regional fly ash consumers that were contacted by AECOM indicated desire and ability to use beneficiated fly ash. However, the demand quantities and market purchase price of the processed fly ash were highly variable, so Dominion would need to negotiate contracts with specific consumers prior to committing to beneficially use the ponded ash.

On the supply side, AECOM evaluated potential proven, developing, and research stage technologies that may be feasible to process the ponded ash at Dominion facilities. The list of potential beneficiation technology vendors is substantial and numerous technologies were considered in prior studies that were used for this assessment. Four technologies were further evaluated, including:

- The SEFA Group Staged Turbulent Air Reactor (STAR) process to refine the ash into a Portland cement replacement
- ST Triboelectric Separation Technology, which separates ash particles using electrodes into positively charged carbon materials that can be re-burned and negatively charged materials which can be used in cement, combined with PMI's Carbon Burnout (CBO) process, which combusts CCR to produce materials to be used for the manufacture of cement products
- Nu-Rock Technology, which uses binding agents to manufacture masonry blocks, pavers, pipe, and similar products from CCR
- Belden-Eco Products, which fires CCR in a kiln to render it inert and mixes it with other materials to form ceramic bricks

6.3.2.1 Site-Specific Beneficial Use Options

Bremo Power Station is accessible to nearby central and western Virginia cement markets, with several ready mixed and precast concrete companies within a 50-mile radius. The timing for excavating the North Ash Pond is dependent on the processing rate per year (throughput) identified for each beneficiation technology option. The timing to develop each beneficiation facility is typically 3 years, including permitting and construction. Costs include capital costs for the processing equipment; operations and maintenance (O&M) for the beneficiation facility; and ongoing materials handling, dewatering, and water treatment costs. Materials handling includes excavation, drying, screening (if needed), and transporting the ponded ash to the on-site beneficiation facility. Costs do not include marketing of the materials or transporting the processed ash to an end user. Table 16 provides a summary of the potential beneficiation options at Bremo Power Station, including duration and costs.

Based on the benchmarking results, fly ash is selling on average for $30 to $60 per ton plus $7 to $33 per ton for transportation. The estimated costs for beneficiation are approximately 1.5 to 3.6 times greater than the current regional market price for the ash.

Table 16: Closure by Removal with Beneficiation Technology Options at Bremo Power Station

Technology	End Product	Throughput (tons/year)	Time to Excavate North Ash Pond(1) (years)	Range of Costs for Technologies
SEFA STAR	PC substitute	430,000 to 840,000	11 to 21	Technology Capital = $17M to $244M
PMI/STI	PC substitute			Technology O&M = $141M to $801M
Nu-Rock	Masonry blocks, pavers, pipes, etc.	300,000 to 550,000	14 to 24	Materials Handling = $241M to $607M
				Total Projected = $593M to $1,345M
Belden-Eco Products	Brick			Estimated Cost/Ton = $96 to $217

(1) Time to excavate the pond is estimated based on the throughput of the technologies; excavation and processing rates may vary based on market demand of the beneficiated product

M = million; O&M = operations and maintenance; PC = Portland cement; SEFA = SEFA Group; STAR = Staged Turbulent Air Reactor

6.3.2.2 Consolidated Beneficiation Facility

This study considered the development of a regional processing facility to be located at Chesterfield Power Station that would receive coal ash transported from the Bremo and Possum Point Power Stations for processing and beneficial use. Chesterfield is the most central of the three stations, and it also contains the majority of the ash (14.9 million of the 25.2 million CY), minimizing loading and hauling costs. In general, this is not considered to be a cost-effective option and would result in several of the ash ponds remaining open for at least 3 decades. The most expedient beneficiation technology would be able to process the ash from the Chesterfield Power Station in 26 years (3 years to design, obtain regulatory approval, and construct and 23 years to process the ash based on technology throughput). Since there is no available space on the Chesterfield station property to temporarily store ash from the other stations (and the FFCP landfill is not permitted to have waste stored and then removed), ash would have to be transported on an as-needed basis. Based on throughput rates, it would take another 6 years to process the Possum Point Power Station ash and 10 additional years for Bremo ash, for a total of 42 years for all three stations. The Chesterfield County Conditional Use Permit (CUP) would also need to be amended to allow ash to be trucked to the station.

6.3.2.3 Beneficial Use Considerations

The primary considerations associated with beneficial use options are related to excavating, handling, processing, and transporting the ash off site. These activities result in safety, noise, and emissions challenges associated with heavy construction equipment operating on the site and up to 150 trucks per day arriving at and leaving the site on a daily basis for 8 or more years. Additional considerations include the limited amount of demand for beneficiated ash in the local market, along with engineering and safety concerns associated with continuously dewatering and leaving the ash pond open for 10 or more years.

Removal of the CCR materials from the North Ash Pond would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality. However, these benefits would not be realized until the removal and beneficiation was completed and the groundwater naturally attenuated over time. Table 17 summarizes some of the considerations associated with the beneficial use option for Bremo Power Station.

Table 17: Beneficial Use Considerations – Bremo Power Station

Category	Considerations
Safety	• Ash pond stays open for 11+ years (3 years design/permit/construct, remaining years to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety risks from excavation and over-the-road hauling due to significant volume and multi-year duration removal project (up to 150 trucks per day each way for 8+ years) • Excavation/construction safety during 8+ years of operating heavy equipment and dump trucks on and adjacent to the station
Environmental	• Ash pond stays open for 11+ years, with resulting prolonged duration for dewatering and water treatment • Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Removes source of potential groundwater impacts
Community	• Community impacts from over-the-road hauling due to significant volume and multi-year duration removal project (up to 150 trucks per day each way for 8+ years) • Truck traffic may result in increased noise, emissions, traffic congestion, and vehicle accidents • Transportation by rail may decrease community impacts as compared to truck transportation, but noise, safety, and emissions would remain concerns
Schedule	• Duration to implement several evaluated technologies exceeds CCR closure requirements of 15 years • Market risks (there may be insufficient demand) • No on-site storage space is available for beneficiated ash, requiring “on demand” processing that limits production/removal to what the market would accept

CCR = coal combustion residuals

6.3.3 Closure by Removal and Landfilling

AECOM’s landfill assessment included reviewing the feasibility of expanding an existing on-site landfill, either by constructing a new landfill in an undeveloped (“greenfield”) area of the site or using the footprint of an existing ash pond, or sending the materials off site to either an existing permitted landfill or a new permitted and constructed landfill. These options are summarized in Table 18 and discussed in greater detail in the following sections.

Table 18: Summary of Landfill Assessment for Bremo Power Station

Location	Landfill Option	Feasibility	Comments
On site	Expansion of Existing Landfill	Not feasible	No existing facility.
On site	Development of New Landfill on Greenfield Area	Not feasible	Inadequate available property suitable for landfill development.
On site	Development of New Landfill over Existing Ash Pond	Not feasible	Although North Ash Pond footprint is of sufficient size, there is no available location to temporarily store excavated CCR while constructing a new landfill. CCR Rule restricts reuse of former ash ponds until demonstration that closure-by-removal criteria are met; unlikely to meet groundwater criteria quickly enough for this option to meet the 15-year CCR Rule closure timeframe.
Off site	Siting and Development of New Dominion-Owned Landfill	Potentially feasible	Centrally located landfill to house ash from all Dominion ash ponds would require a 500- to 800-acre site composed of multiple parcels. Could potentially site new landfill in central Virginia.
Off site	Transporting to Existing Commercial Landfill	Feasible	Options are available within 50 miles for trucking. Rail options both in and out of state exist. Barge option is not feasible.

CCR = coal combustion residuals

6.3.3.1 Expansion of Existing On-Site Landfill

The Bremo Power Station no longer burns coal for power generation and no landfills are located on the site. Therefore, an on-site landfill expansion alternative was not considered for Bremo Power Station.

6.3.3.2 Development of New On-Site Landfill

To accommodate the volume of CCR currently at the site, a landfill footprint of approximately 50 acres would be required. AECOM evaluated developing a new on-site landfill in a greenfield area and over an existing ash pond.

Landfill on greenfield area. Siting restrictions such as floodplains, streams, wetlands, and property line setbacks limit area for development of a new “greenfield” CCR landfill to an approximately 13-acre area northeast of the North Ash Pond. This area has an irregular shape that restricts the available storage capacity to less than 500,000 CY, well below the volume of CCR currently stored on site.

Landfill over existing Ash Pond. The feasibility of using the footprint of one of the existing ash ponds to develop a new CCR landfill was considered. The East and West Ash Pond areas are too small to accommodate the CCR volume.

A conceptual assessment showed that a 53-acre landfill could be developed in the footprint of the North Ash Pond to contain the 6.2 million CY of CCR plus a 20% engineering design factor to include DEQ-required over-excavation. The materials would need to be excavated from the North Ash Pond and temporarily stored elsewhere on site while the new landfill was constructed in the North Ash Pond footprint, then moved back to the new landfill cell. There is not adequate space on the station property where the ash could be temporarily stored during landfill construction, so this alternative is not considered feasible.

Additionally, the CCR Rule restricts reuse of former ash ponds until it can be demonstrated that closure by removal criteria, including those for groundwater, are met. Addressing CCR Rule groundwater criteria could potentially be accomplished by isolating the new landfill with a double liner system, which could potentially add time to the landfill construction process.

For these reasons, development of an on-site landfill is not considered feasible at Bremo Power Station.

6.3.3.3 Disposal in Off-Site Commercial Landfill

AECOM evaluated commercial and municipal landfills in Virginia, North Carolina, and Maryland that are currently permitted to accept CCR waste to identify facilities capable of accepting large quantities of CCR material (5 to 15 million CY) within a 10 to 15 year operating life required. This would allow for potential landfill disposal of CCR from one or all of the ash ponds.

County or regional public landfills generally lacked the capacity and/or operating life to manage the Dominion CCR. The potential sites identified are therefore all commercial municipal solid waste (MSW) landfills. These facilities are currently permitted and would be structured to accept CCR waste in a monofill configuration, where CCR materials are segregated from other waste materials and placed in a separate landfill cell.

The three commercial MSW landfill options closest to Bremo Power Station are summarized in Table 19 and locations are shown on Figure 2. Table 20 shows the facilities identified as feasible options to receive CCR by rail.

Table 19: Candidate Off-Site Permitted Landfills for Bremo Power Station

Landfill Features	Maplewood Recycling and Waste Disposal[(1)]	Charles City County Landfill	Brunswick Waste Management Facility LLC
Facility Owner	Waste Management	Waste Management	Republic Services
Distance from Power Station	55 miles	82 miles	106 miles
Reported Remaining Operating Life[(2)]	148 years	54 years	168 years
Reported Remaining Capacity[(2)]	11.6M CY	9.5M CY	6.7M CY

(1) Facility with rail access
(2) Remaining permitted operating life and capacity as reported in Virginia DEQ Solid Waste Report as of end of 2016; reported capacity based on total current permitted capacity which may not be fully available for CCR disposal
M = million; CY = cubic yards

Table 20: Candidate Facilities with Capability to Accept CCR by Rail

Off-Site Landfill with Rail Access	Location	Capacity	Comments
Maplewood Recycling and Waste Disposal	Amelia County, VA	12M CY, expandable	35 rail cars/day capacity; expandable
Brunswick Waste Management	Brunswick, VA	20M CY, expandable	Need to construct 2 mile rail spur extension and offloading upgrades
Sunny Hill Farms	Fostoria, OH	30M CY over next 20 years	Owns a fleet of 1,500 rail cars
Tunnel Hill Reclamation	New Lexington, OH	30M CY over next 20 years	Owns a fleet of 1,500 rail cars
Waste Industries Taylor County Disposal	Mauk, GA	6.7M CY, expandable	Accepts 80 to 100 rail cars per day
Arrowhead Landfill	Uniontown, AL	• 62M CY, additional • 34M CY monofill expansion permitted	Accepts 150 gondola cars per day

CCR = coal combustion residuals; M = million; CY = cubic yards

6.3.3.4 Development of New Off-Site Landfill

AECOM performed a preliminary screening-level assessment to identify potential off-site locations where a new landfill could be developed to serve multiple Dominion facilities. A study radius of 50 miles from each of the four power stations was used as a practical range for truck hauling to a new landfill. Landfills beyond 50 miles could be considered but costs would increase. Since the CCR volume at Chesapeake Energy Center is much smaller than the other facilities (60,000 CY out of a total of 25 million CY), the study area considered only Bremo, Chesterfield, and Possum Point Power Stations. AECOM's assessment identified the optimal area for a landfill as central Virginia in the vicinity of I-95, north of I-64, and south of Fredericksburg. This covers portions of Madison, Culpeper, Orange, Louisa, Spotsylvania, Hanover, Caroline, King William, King and Queen, and Essex Counties. The general location is shown on Figure 3.

A landfill footprint between 150 to 200 acres would be required to accommodate the CCR volumes from the three stations. In addition to the land required for the lined landfill, additional property would be needed to satisfy regulatory setbacks, avoid streams and wetlands, provide stormwater management, construct roads and support structures, and provide a source for borrow soil for landfill and final cover construction. These factors typically require a site to be at least three to four times greater in size than the total landfill footprint. Therefore, the target candidate landfill site would need to be 500 to 800 acres.

Sites with direct access from a major roadway would be preferred, to maximize transportation efficiency while avoiding residential areas. A preliminary assessment of parcels in the target search area indicates a limited number of single parcels that may meet the screening size threshold and siting criteria. Therefore, combinations of multiple parcels would likely be required.

Based on the preliminary screening-level assessment, development of a single new off-site landfill to manage CCR from one or more Dominion facilities could potentially meet the timeline required for CCR closure established by the CCR Rule (maximum 15 years). In order to implement this option, significant additional work would be required to identify candidate sites, assess the transportation routes to the sites, coordinate with local municipalities to determine development requirements, negotiate and purchase land, implement the 3 to 5 year permitting process for establishing a new landfill, and design and construct the landfill.

The most streamlined option for constructing a new landfill would entail identifying properties within a 50-mile radius of the Dominion power stations that have already gone through preliminary zoning and permitting for waste acceptance. Depending upon the property owner and permit status, this could potentially save 3 to 5 years from the timeline to purchase an undeveloped property and permit it as a solid waste facility.

6.3.4 Transportation

Transportation options to remove CCR from Bremo Power Station include trucking and rail. Based on the location of the Bremo Station on the upper James River, barging CCR off site is not a feasible option due to shallow water, rapids and rock ledges, and bridges.

6.3.4.1 Transport by Truck

Transportation by 15 CY to 18 CY dump trucks and trailers with maximum 18- to 22-ton capacities would be the most efficient means of trucking CCR. The ability to load and manage trucks efficiently at the impoundment is the primary variable for determining the number of truck loads that can reasonably be transported off the site per day. Based on experience and discussions with industry representatives, AECOM has assumed an aggressive rate of 150 truckloads per day being transported off site. Based on a 10-hour workday, this equates to a loaded truck leaving the site every 3 minutes for 5 days per week, on average. The haul distance to the chosen landfill and turnaround times would determine the number of trucks in rotation to support this production rate. Maintaining this production rate would require very efficient and well-designed plans for safely managing truck traffic, loading, weighing, washing, and re-entry to the local road network.

A CCR stockpiling and truck loading area could be set up within the northern footprint of the North Ash Pond or in an immediately adjacent area to the north. Truck access to the North Ash Pond is via an existing entrance to State Route 656 immediately north of the North Ash Pond. Truck hauling would likely proceed to the east on Route 656, in part due to an 18-ton bridge weight limit on Route 656 west of the site and other limitations, unless the cost and duration to upgrade the bridge were determined to benefit the project. A general arrangement for material handling for the trucking option is shown on Figure 4.

The closest reasonable landfill options for disposal of CCR by truck from Bremo are the Waste Management Maplewood Recycling and Waste Disposal facility in Amelia County (46 miles) and the Waste Management Charles City County Landfill (80 miles). Potential trucking routes for these landfills are shown on Figure 5.

6.3.4.2 Transport by Rail

Transportation by rail would include arrangements for dedicated unit trains to haul CCR to a landfill with rail capability. Based on discussions with landfill operators, acceptance rates of CCR by rail is generally not a constraining factor as long as sufficient lead time (6 to 12 months) is provided in the project for permit modifications and physical expansion of monofills and rail infrastructure to match acceptance rate needs.

Transportation by rail would entail up-front infrastructure investment to install and expand sidings, switches, and spurs to facilitate efficient train handling, loading, and staging; these activities would require several years to permit and construct. Rail cars would be loaded using rubber-tired wheel loaders or conveyor systems fed with loaders. High-sided, flat-bottom gondola cars with disposable liners and covers would likely be the most efficient for CCR hauling and unloading at the landfill.

The existing rail facilities at the Bremo station are well suited for re-purposing to transport CCR off site, although the yard has not been used since the plant ceased burning coal in 2014. Rail facilities include a CSX mainline to the south, with a siding on the north side of the mainline capable of storing up to 100 gondola cars, as shown in Figure 6. A spur from the siding leads to a small on-site rail yard located adjacent to the former coal pile. A small locomotive would be used to handle empty and loaded rail cars. A temporary CCR staging area could be constructed in the former coal pile area to load rail cars with a ramp and rubber tire loader or conveyor system.

In-state landfill options for accepting CCR by rail include the Maplewood Landfill in Amelia County (46 miles from the station). Out-of-state facilities that can accept CCR by rail include landfills in Ohio, Alabama, and Georgia. Major rail transporters have estimated the optimal rail loading and transport rate at ten unit trains every four weeks (85 gondola cars with a 90-ton capacity each), which is the equivalent of shipping out approximately 19,125 tons per week (995 thousand tons/year) via rail.

6.3.5 Backfilling and Restoration of Former Ash Ponds

Restoration would depend on future site needs and conditions. Restoration activities could include reusing former ash pond areas as stormwater management facilities, backfilling pond areas for re-development, removing dikes and restoring original grades, creating wetlands, or restoring habitat. Restored former ash ponds could also be used to support ongoing power generating activities by serving as equipment or material storage areas, parking or staging areas, or maintenance areas. Post-removal use of the site would be included in the closure by removal design.

Restoration of the Bremo North Ash Pond would include removing and re-grading the dam (approximately 1.2 million CY) into the footprint of the former pond to restore the area as a small valley. The closure by removal work plan would also provide for decommissioning and de-classification of the impoundment dams to remove them from regulatory oversight. Decommissioning and de-classification would involve breaching or completely removing the earthen embankment so that it can no longer impound water. Spillway structures could be abandoned in place by grouting or other approved means, or completely removed. Remaining soil removed from the embankments that meets regulatory criteria to allow it to remain in place would be used during the closure by removal process or as part of the site restoration. During restoration, the embankment soil can be used to restore pre-development lines and grades and to promote effective surface water runoff.

Restoration activities would result in a site that requires minimum long-term maintenance. Establishment of vegetation, restoration of effective surface water conveyance, and providing for erosion and sediment control would be included in the design.

6.3.6 Summary of Closure by Removal and Landfilling Considerations

Removal of the CCR materials from the North Ash Pond would eliminate the source of potential groundwater impacts, eventually benefitting the groundwater quality. However, these benefits would not be realized until the removal was completed and the groundwater naturally attenuated over time.

The primary considerations associated with off-site landfill options are related to excavating, handling, processing, and transporting the ash off site. These activities result in safety, noise, and emissions challenges associated with heavy construction equipment operating on the site and up to 150 trucks per day leaving the site on a daily basis for 12 or more years. Transport by rail could potentially decrease the transportation duration to approximately 8 years.

Additional considerations include the engineering and safety concerns associated with continuously dewatering and leaving the ash pond open for up to 10+ years.

Additional impacts associated with constructing a new off-site landfill (as opposed to using an existing off-site permitted facility) include community and environmental concerns with constructing a 150- to 200-acre landfill, and the time required for site selection, land acquisition, permitting, and construction (estimated at 5 to 7 years), followed by hauling the ash to the new landfill; these activities would likely exceed the CCR Rule closure requirements of 15 years.

Table 21 summarizes some of the considerations associated with closure by removal to a landfill at Bremo Power Station.

6.4 Closure-in-Place

All CCR materials from the West and East Ash Ponds are being consolidated into the North Ash Pond. Under the closure-in-place option, the North Ash Pond would achieve closure in accordance with the CCR Rule by leaving the ash in place, removing free liquids, and installing an engineered final cover system.

As required by federal and state solid waste regulations, engineering investigations and evaluations have been completed for the Bremo North Ash Pond, including the original design, subsequent evaluations, USEPA dam safety assessment, CCR Rule certifications, and closure plans. AECOM also performed a storm surge analysis to supplement existing evaluations to meet SB 1398 requirements (included as an appendix in Technical Memorandum 5).

Table 21: Closure by Removal with Landfill Considerations for Bremo Power Station

Category	Considerations
Safety	• Ash pond stays open for 13 years (1 year to obtain regulatory approval and construct loading facilities, remaining to transport), increases safety risk, results in prolonged duration for dewatering/water treatment • Safety risks from excavation and over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day for 12 years) • Excavation/construction safety during 9 years of operating heavy equipment and dump trucks on and adjacent to the station • Rail may decrease the duration to 10 years (2 years to design, permit, and construct, remaining years to transport), potentially decreases the transportation-related risks
Environmental	• Ash pond stays open for 13 years, with resulting prolonged duration for dewatering and water treatment • Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required • Rail may decrease the duration to 10 years, potentially decreases the transportation-related risks • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time • For development of new off-site landfill, potential impacts to wetlands, environment; loss of trees; dust, leachate control; groundwater protection
Community	• Community impacts from over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day for 12 years) • Increased noise, emissions, truck traffic, accident potential • Transportation by rail may decrease community impacts; noise, safety, and emissions remain concerns • For development of new off-site landfill, community concerns with developing landfill “in their backyard”; construction impacts; multiple truck impacts once operational
Schedule	• Significant delays could cause options to exceed CCR closure requirements of 15 years • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time • For development of new off-site landfill, site selection, land acquisition, permitting, and construction schedule could take 5 to 7 years, followed by hauling/placement, which would likely exceed CCR closure requirements of 15 years

CCR = coal combustion residuals

AECOM’s assessment of the cumulative information shows that closure-in-place at the Bremo Power Station would provide long-term safety of the CCR units and would address the long-term risks as described in the closure plan previously submitted to the Virginia Department of Conservation and Recreation (DCR), siting requirements, and the ability to withstand extreme weather events (including flooding, hurricanes, storm surges, and erosive forces) and earthquakes. The current closure design meets the following requirements that would ensure long-term safety after the ash pond has been closed in place:

- Designed to withstand a 100-year flood (top of cap is above 100-year flood elevation)
- Stormwater drainage for the Probable Maximum Flood (PMF), the potentially largest flood resulting from a combination of the most severe rainstorm events for a given area
- No downstream water quality or flow impacts resulting from the closed ash pond
- No effect on the structural stability of the closed ash pond from receding floodwater or rapid water drawdown

- Final cover design would withstand wind uplift and flooding from a Category 4 hurricane
- The final cover elevation and stormwater measures would protect against erosion from 100-year flooding or storm events, along with potential storm surges from the river
- Structural stability of the fill (ash), embankments (sides), and final cover would be maintained under a wide range of potential conditions, including earthquakes and storm events
- The facility would continue to maintain an Emergency Action Plan (EAP) to protect downstream areas from a potential breach

Primary safety and engineering considerations associated with closure-in-place are related to dewatering and water treatment during the closure operations, community impacts during the approximately 2 years of construction (noise, emissions, dust), and construction quality control for the installation of the final cover material (geosynthetic liner, soil cover, and vegetation). The cover is designed to protect groundwater from future infiltration, which should have a positive benefit on long-term groundwater quality. Long-term considerations also include the ongoing O&M of a corrective measure technology, if needed. The CCR Rule also requires a minimum of 30 years of post-closure care, to include groundwater monitoring, maintenance of the cover system, and continued compliance with dam safety regulations, in accordance with a DEQ Solid Waste Management Regulations (VSWMR) Permit.

Table 22 summarizes some of the considerations associated with closure-in-place at Bremo Power Station.

Table 22: Closure-in-Place Considerations at Bremo Power Station

Category	Considerations
Safety	• Excavation/construction safety during 3 to 5 years of operating heavy equipment and dump trucks on and adjacent to the station • No impacts for CCR removal or off-site hauling
Environmental	• No impacts for CCR removal or off-site hauling • Noise and emissions from excavation equipment • Dust and odor control may be required • Ash pond stays open for 3+ years, requiring dewatering and water treatment • Engineering challenges for CCR dewatering and excavation • Once closure is complete, decreased potential for groundwater migration from CCR materials remaining in place
Community	• No impacts for CCR removal or off-site hauling • Potential noise, emissions, and truck traffic associated with on-site construction
Schedule	• 3 to 5 years for closure much shorter duration than other options • Installation of corrective measures may take 2 years • Estimated 10- to 30-year duration for groundwater corrective measures

CCR = coal combustion residuals

6.5 Groundwater and Surface Water

Site geology consists of residual soil and alluvium overlying weathered bedrock. Soils in the lowland areas along the James River extend to depths of approximately 20 to 40 feet below ground surface (bgs), while soils in the upland areas near the North Ash Pond extend to depths of approximately 20 to

70 feet bgs. The North Ash Pond is situated in a former stream valley and is underlain by highly weathered bedrock.

6.5.1 Groundwater

In upland areas of the power station, the uppermost aquifer occurs within the overburden and fractured bedrock. Groundwater flow generally mimics the topographic slope, flowing from areas of high surface elevation (northeast) to low (along the James River). Figure 7 shows the bedrock potentiometric map, along with the locations of monitoring wells. Groundwater within and downgradient of the station is not used as drinking water.

The station has been monitoring groundwater in accordance with the VPDES Permit and associated Groundwater Monitoring Plan (GMP). Historic VPDES monitoring indicated several parameters at concentrations greater than station background, and limited detections of arsenic above the Maximum Contaminant Level (MCL) associated with the east pond where the ash is being removed. Based on the results of background sampling, a Corrective Action Plan (CAP) was submitted to DEQ in April 2015. The CAP included plans for an assessment of the East Ash Pond and for corrective measures for all three ash ponds in conformance with the Final CCR Rule. The subsequent Risk Assessment Report concluded that constituents detected downgradient of the East Ash Pond do not pose risks in excess of regulatory levels to human health or the environment.

Background groundwater sampling was performed in 2016 and 2017 in accordance with the CCR Rule. The USEPA established MCLs as the maximum level of a constituent in drinking water at which no known or anticipated adverse effect on the health of persons would occur, allowing an adequate margin of safety. For constituents that do not have USEPA-established MCLs, analytical results are compared to the background levels established during baseline sampling.

CCR sampling results for the North Ash Pond were below MCLs for all constituents. Several constituents were detected above background levels downgradient of the North Ash Pond. However, these detections were isolated to areas adjacent to the ash ponds and do not affect drinking water supplies. Previous investigations indicate that groundwater beneath and downgradient of the station is not used as drinking water, and no residential or other water supply wells were identified immediately downgradient of the station.

6.5.2 Surface Water

Samples collected from the James River upstream and downstream of the station between April 2016 and March 2017 were below Virginia Surface Water Quality Standards for aquatic life and human health for all constituents.

No matter which closure option is implemented, the CCR Rule requires post-closure groundwater monitoring to assure that groundwater conditions surrounding the ash ponds continue to be protective of human health and the environment.

6.6 Groundwater Corrective Measures

Preliminary groundwater results show detections of CCR related constituents above background levels. Additional monitoring is required before these results are confirmed. Based on that data and site-specific conditions, AECOM evaluated potential corrective measures to remediate the groundwater related to the North Ash Pond. The technologies that could potentially remediate the groundwater associated with the North Ash Pond are the following:

- Permeable reactive barrier (PRB) – groundwater flows through a subsurface trench filled with reactive material and chemically reacts with the material to remove contaminants
- Vertical engineered barrier (VEB), which is containment via slurry walls – a subsurface wall is constructed to prevent groundwater from flowing out of the ash pond; if needed, hydraulic containment can supplement VEB
- Hydraulic containment via pump-and-treat methods – groundwater is pumped from a series of wells with overlapping influence to cut off groundwater from flowing downgradient; extracted water is treated to below-permit requirements and discharged
- Monitored natural attenuation (MNA) – employing physical processes that naturally reduce the concentration, toxicity, or mobility of CCR constituents in groundwater, attenuating the constituents by chemical reactions with other dissolved constituents and the soil media

Table 23 describes how these corrective measures could address the items outlined in 40 CFR § 257.96 and outlines how each technology could potentially be implemented to remediate groundwater to levels below station-specific cleanup goals.

The potential remedial options have relatively similar anticipated durations to reach groundwater cleanup standards. As described in Technical Memorandum 7, ISS becomes cost-prohibitive deeper than approximately 50 feet, due to the specialty auger equipment necessary to produce enough torque to move through the materials at depth, and the requirement for smaller auger diameters to generate that torque. Smaller diameter augers, with the requirement to overlap holes, result in a much smaller grid size and thus an order of magnitude more auger holes required to contact the entire volume of ash, resulting in a much higher cost. Therefore, ISS is not feasible for the 75 foot depth of the North Ash Pond.

Any potential corrective measure technology would require a comprehensive remedial design process that would include acquisition of additional data as needed, laboratory bench-scale testing, and potentially a pilot test before designing and implementing the full-scale construction of the selected remedial technology. Combinations of technologies could be tested, and additional emerging technologies could be evaluated as their effectiveness on CCR constituents, such as metals, is proven.

As described in the Gradient report, The Relative Impact Framework for Evaluating Coal Combustion Residual Surface Impoundment Closure Options: Applications and Lessons Learned (Lewis and Bittner, 2017), both closure-in-place and closure by removal “provide significant beneficial impacts to groundwater quality compared with continued surface impoundment operations and that neither of the closure options is always more beneficial, with respect to downgradient groundwater quality, than the other. These results are consistent with the USEPA position in the CCR Rule that both closure options can be equally protective, provided they are implemented properly.” The report goes on to state, “Moreover, it is possible that groundwater corrective actions, if instituted as part of a combined remedy with closure-in-place, would result in a greater and more rapid reduction of contaminant concentrations in downgradient groundwater than closure by removal in some assessments.” The authors additionally note that surface water impacts under both closure by removal and closure-in-place are minimal.

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Table 23: Bremo Power Station Groundwater Corrective Measures Summary

Evaluation Factor		Permeable Reactive Barrier (PRB)	Vertical Engineered Barrier (VEB) – Slurry Wall	Pump and Treat with Multiple Treatment Technologies	Monitored Natural Attenuation (MNA) with Risk Assessment
General Technology Specifications		An approximately 4,000 LF wall 30 feet deep downgradient of CCR unit; deep trenching technology for installation	An approximately 4,000 LF wall 30 feet deep downgradient of CCR unit; deep trenching technology for installation	Approx. 80 extraction wells, 80 gpm total flow; anticipated treatment technologies include pH adjustment, aeration, coagulation/flocculation, bag/cartridge filtration, adsorptive media (crushed limestone and activated alumina) resin	Downgradient of CCR unit using existing monitoring well network
Additional Requirements		May require up to 3 parallel walls with different reactive media to treat various constituents	Hydraulic control using approx. 80 extraction wells @40 gpm total flow behind VEB with groundwater treatment	Wells located along approx. 7,500 LF downgradient edge of CCR unit	Risk assessment would be performed to verify that MNA would be protective of human health and the environment
Cost Estimate		$77M	$59M	$65M	$2.4M
Schedule	**Construction**	Moderate duration for implementation (approx. 1 year)	Moderate duration for implementation (approx. 1 year)	Moderate duration for construction (approx. 1-2 years)	No construction needed
	Anticipated Duration to Reach GPS	Removal of constituents as they pass through the PRB should allow downgradient constituent levels to quickly reach GPS; duration for remedial implementation depends on depletion of source contact with groundwater over time; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Continued indefinite monitoring; for the purposes of this evaluation, a 10- to 30-year time frame is assumed
Potential Corrective Measure Benefits		• Removes contamination within PRB amendments (in situ) • Designed to treat multiple contaminants in situ to remove contaminants and protect human health and environment • Length of PRB could potentially be reduced with detailed delineation investigation • Impacts primarily limited to on-site	• Slurry wall combined with pumping designed to provide source containment • Extraction designed to minimize hydraulic pressure on slurry wall and prevent groundwater from flowing around the edges of the wall • Complete source containment by preventing groundwater flow from ash pond footprint, allowing downgradient impacts to decrease • Impacts primarily limited to on-site	• Pump-and-treat proven technology for hydraulic control and removal of contaminants from groundwater, reducing downgradient risks to human health and environment • Complete source containment by hydraulically controlling groundwater flow from ash pond footprint, allowing downgradient impacts to decrease • Impacts primarily limited to on-site	• Relies on natural attenuation mechanisms for performance • No technology construction is required
Potential Corrective Measure Considerations		• Ash remains in place • Greatly depends on bench scale/pilot testing to verify the correct amendment mixtures/geochemistry • May require amendment replacement as capacity to reduce/remove contaminants is consumed • Multiple amendments may be required to remove all contamination • Treating one constituent may mobilize others • Potentially multiple passes to install multiple PRBs	• Ash remains in place • Requires deep trenching along 4,000 LF length • Complete source containment but not removal • Requires heat of reaction control, dust control; reaction may produce odors • May require additional measures for downgradient plume • Monitoring/sampling required • Pump testing required to design extraction well network • Bench scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems – duration unknown, ongoing O&M/treatment costs • Extraction network and treatment system periodically evaluated for effectiveness, would require periodic changes in and/or regeneration of filtration/treatment media • Requires an approximately 20-foot wide corridor for installation	• Ash remains in place • Requires installation of 80 extraction wells and subsurface piping network to centralized groundwater treatment system housed in a building • Pump testing required to design extraction well network • Bench scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems – duration unknown, ongoing O&M/treatment costs • Extraction network and treatment system periodically evaluated for effectiveness, would require periodic changes in and/or regeneration of filtration/treatment media • Limited downgradient space to install monitoring wells to verify constituent capture	• Ash remains in place • Monitoring/sampling required • Routinely evaluate for changing conditions

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Figures

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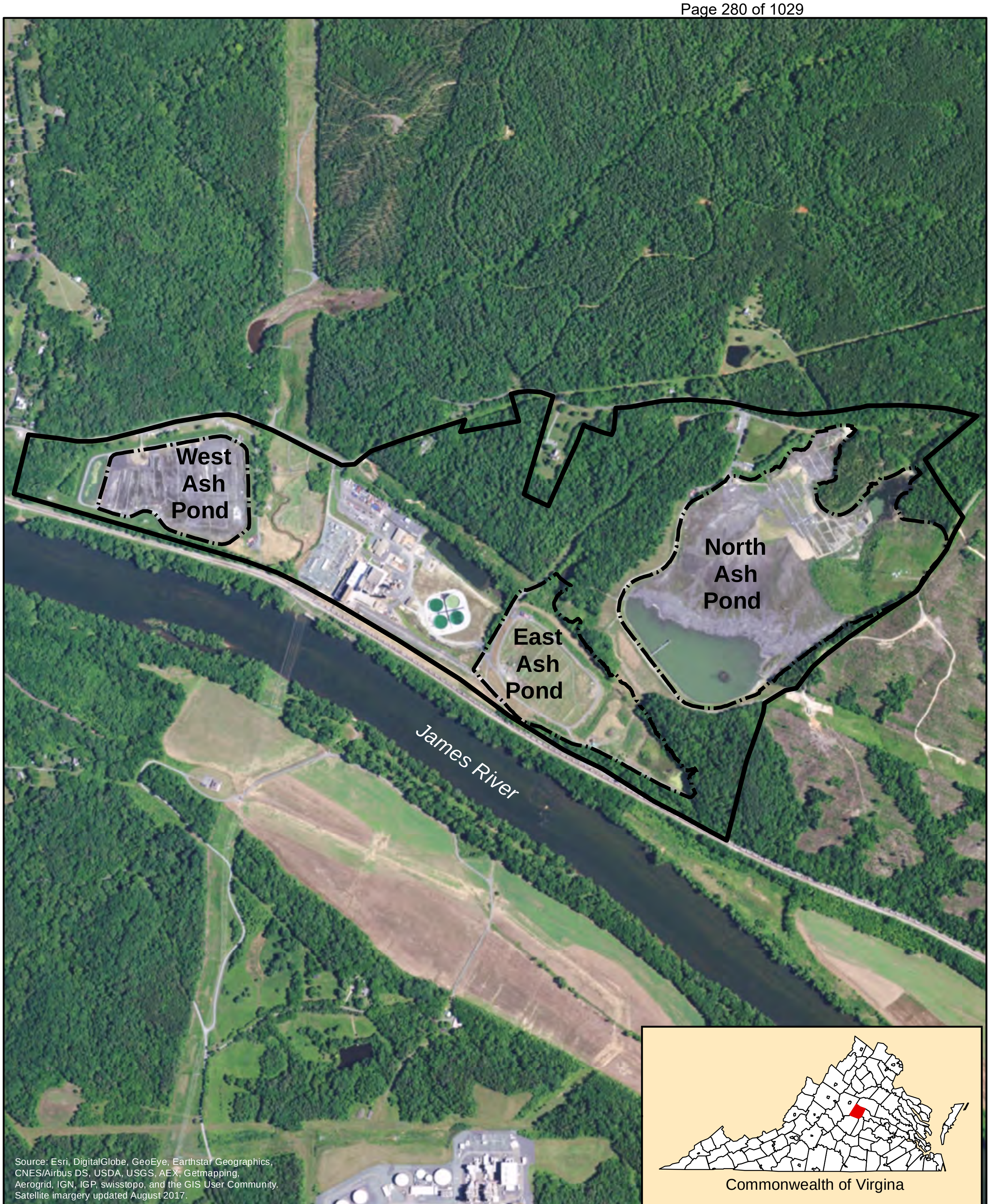

LEGEND

Approximate Property Boundary

Approximate Pond Boundary

N

0 550 1,100 2,200

Feet

AECOM

Figure 1
Site Location

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
RIP	CTM	DFM	REV. 0

Bremo Power Station

DATE:	DEPT:
10/3/2017	Environment

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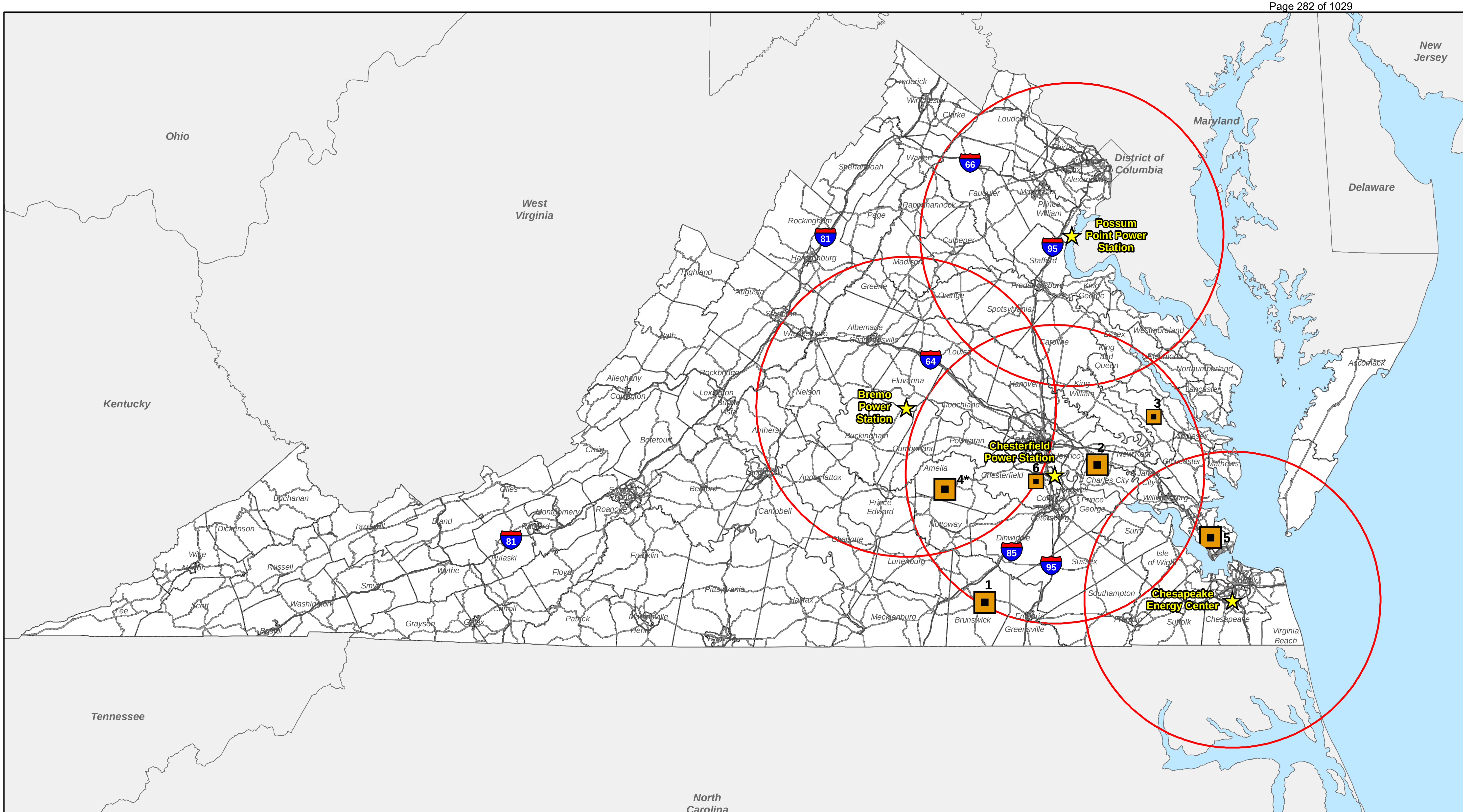

LEGEND
- Limited Access Highway
- High Occupancy Vehicle (HOV) Lane
- US Primary Highway
- 50 Mile Radius
- Virginia County

Landfill Location (remaining life)
- 10 - 25 yrs.
- 25 - 50 yrs.
- > 50 yrs.
- Dominion Plant Location

N

0 12.5 25 50
Miles

AECOM

Figure 2
Off-site Commercial Landfill Locations

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MPS	JAB	DOS	REV. 0

Bremo Power Station

DATE:	DEPT:
11/14/2017	Environment

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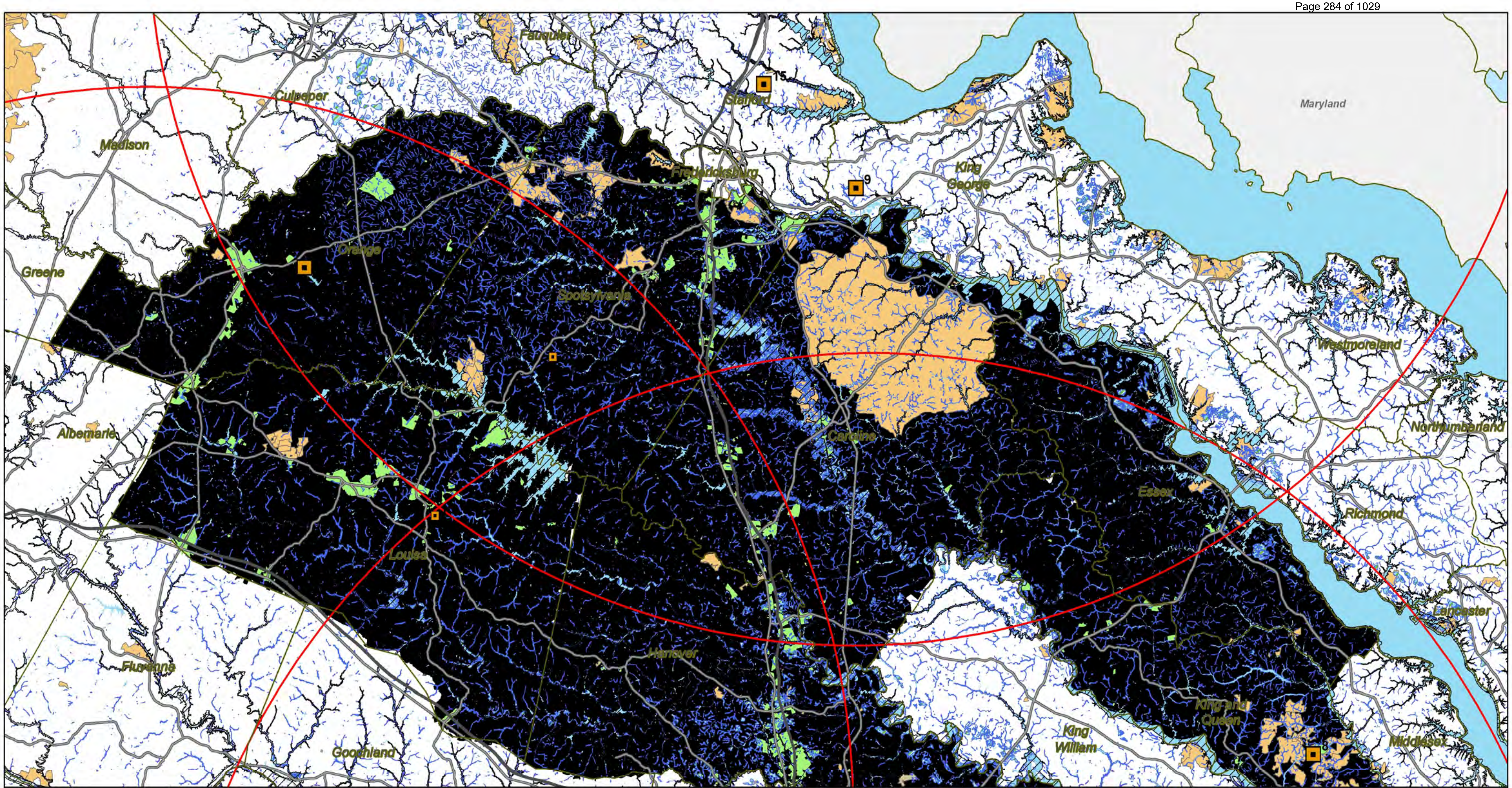

LEGEND

- Railroad
- Limited Access Highway
- High Occupancy Vehicle (HOV) Lane
- US Primary Highway
- 50 Mile Radius
- 100 yr. Flood Zone
- Wetland
- National Park Land
- US Forest Service Land
- Federal/State/Local Owned Land
- Virginia County

Zoning

- Non-Residential
- Residential and Agricultural

N

0 8 16
Miles

AECOM

Figure 3
Potential New Off-site Landfill General Location

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK P. SMITH	JOHN BOVE		

Bremo Power Station

DATE:	DEPT:
9/12/2017	Environment

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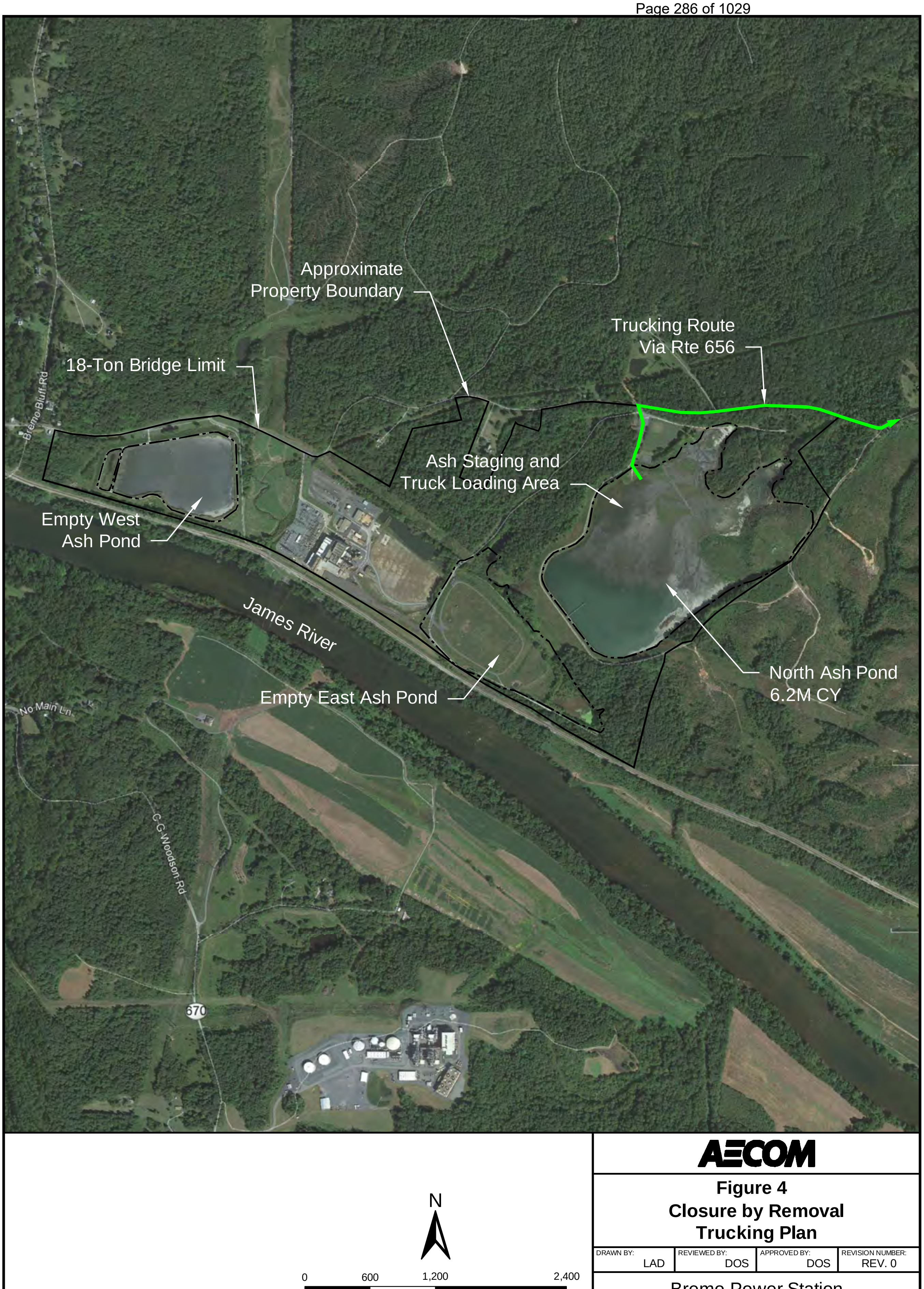

AECOM

Figure 4
Closure by Removal
Trucking Plan

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
LAD	DOS	DOS	REV. 0

Bremo Power Station

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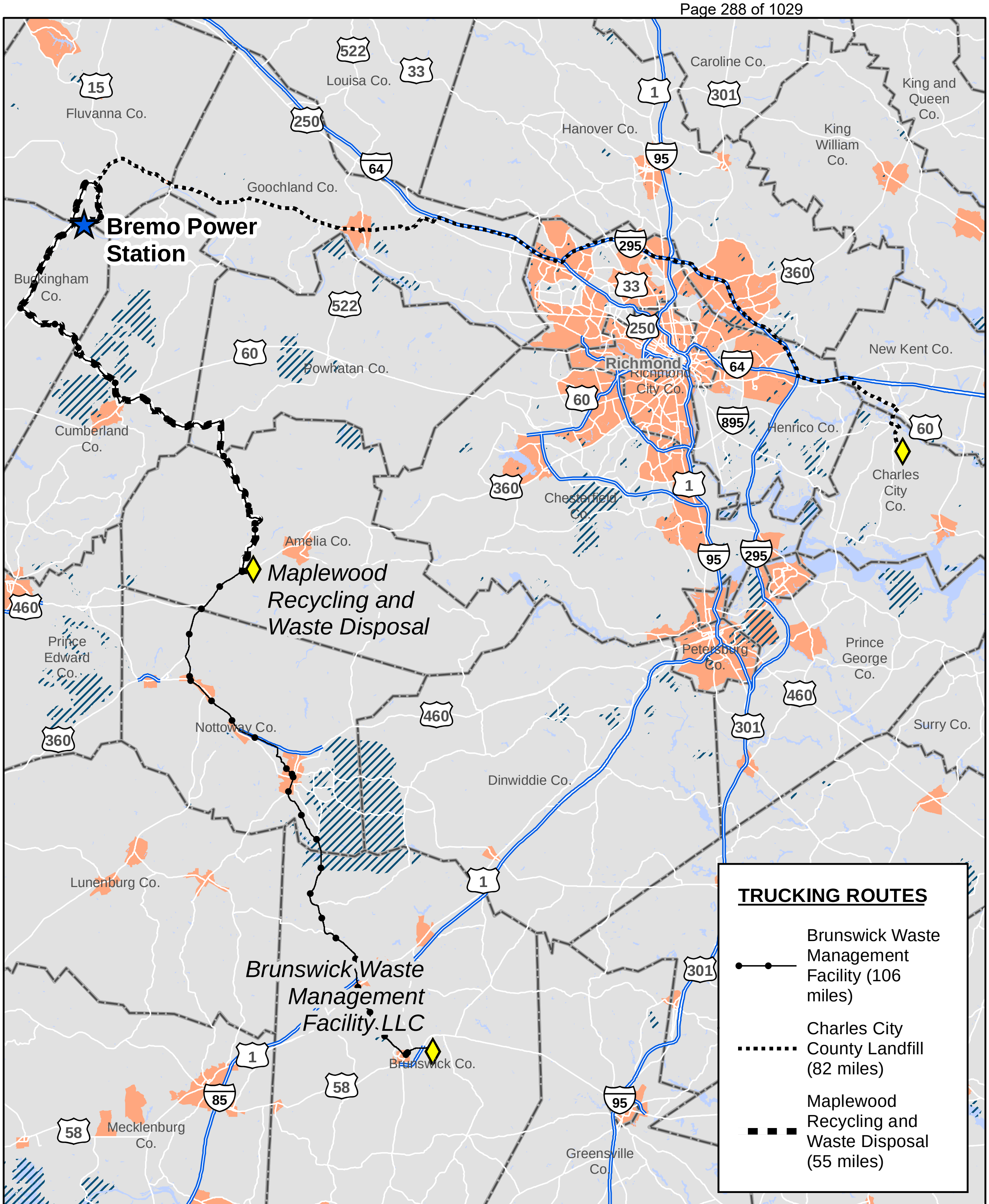

LEGEND

- Dominion Energy Facility
- Candidate Landfill
- Interstate Highway
- State Routes and Major Roads
- US Census Populated Place
- State Conservation Land
- County

N

0 40,000 80,000
Feet

AECOM

Figure 5
Truck Routes to Landfills

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
ACC	DOS	DOS	REV. 0

Bremo Power Station

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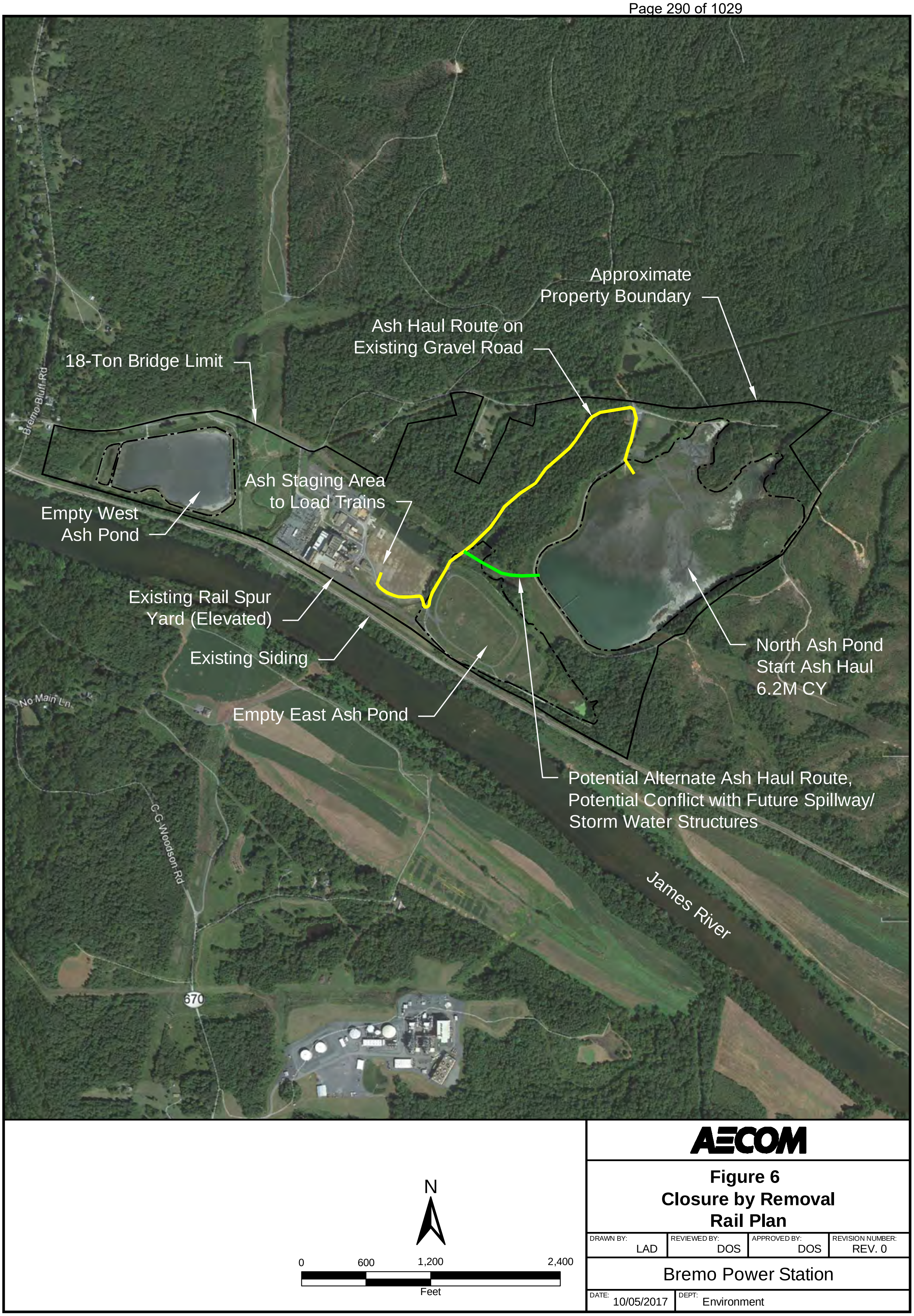

AECOM

Figure 6
Closure by Removal
Rail Plan

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
LAD	DOS	DOS	REV. 0

Bremo Power Station

DATE: 10/05/2017 DEPT: Environment

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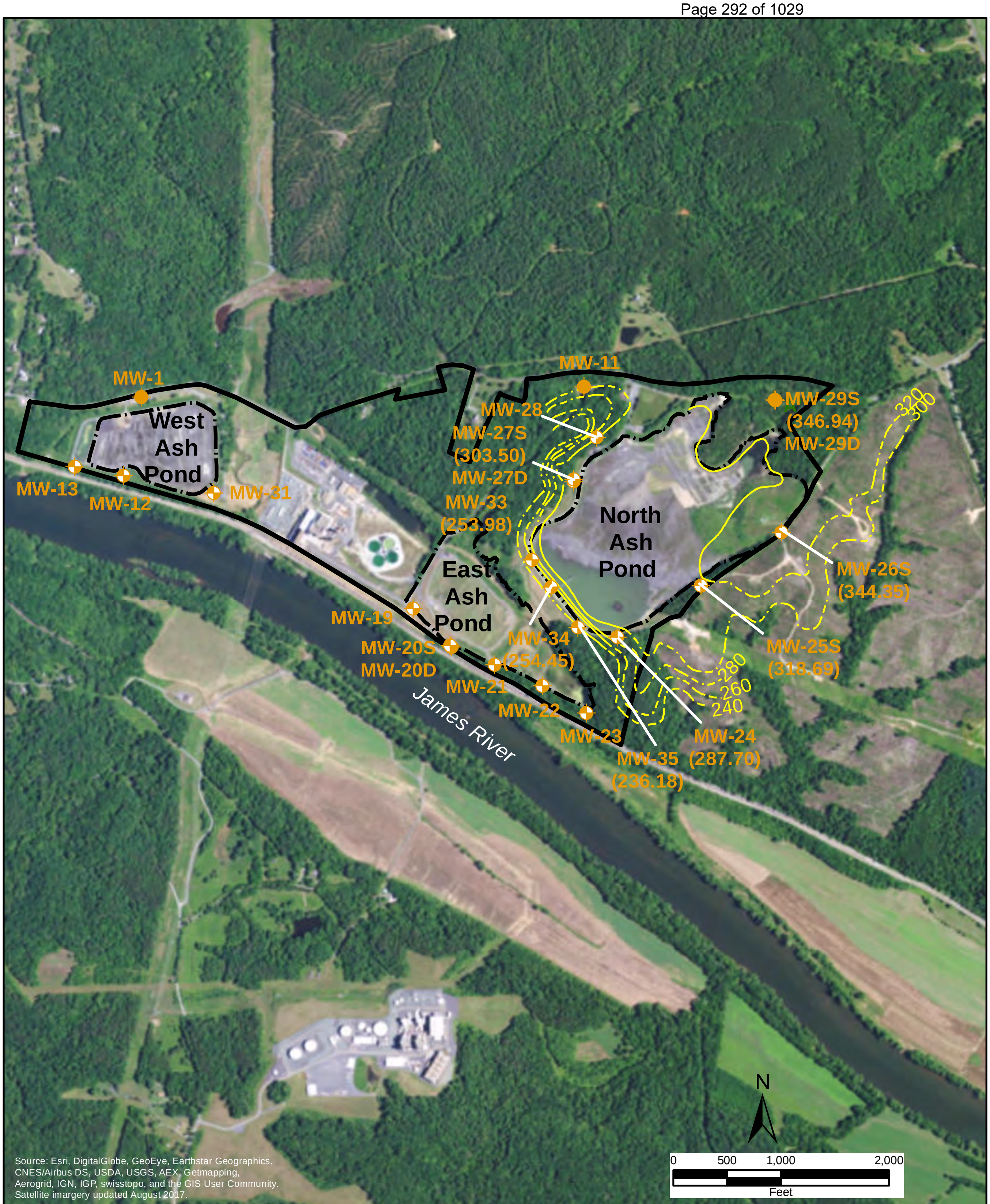

LEGEND

- Approximate Property Boundary
- Approximate Pond Boundary
- Potentiometric Contours
- Inferred Potentiometric Contours

Compliance Program

- CCR Network Well
- CCR Network Background Well

AECOM

Figure 7
Potentiometric Surface, Bedrock
April 2017

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
RIP	CTM	DFM	REV. 0

Bremo Power Station

DATE:	DEPT:
10/26/2017	Environment

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Senate Bill 1398 Response

Coal Combustion Residuals
Ash Pond Closure Assessment

SECTION 7:
CHESAPEAKE ENERGY CENTER

November 2017

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7. Chesapeake Energy Center

7.1 Summary for Chesapeake Energy Center

This closure assessment focuses on the Chesapeake Energy Center Bottom Ash Pond, as summarized in Table 24. Ash ponds can be closed by dewatering and then either removing the CCR materials or closing the pond in place. Dominion has committed to removing the coal combustion residual (CCR) materials from the Bottom Ash Pond for beneficial use or off-site disposal, so closure-in-place is not an evaluated option at this station. Dominion has committed to remove the ash from the Bottom Ash Pond and will close the pond in accordance with the CCR Rule.

Table 24: Chesapeake Energy Center Ash Pond

CCR Unit	Remaining CCR Volume (CY)	Operating Status	Area (acres)
Bottom Ash Pond	60,000	Committed to closure by removal	5

CCR volume based on Dominion estimates as of July 10, 2017
CCR = coal combustion residuals; CY = cubic yards

While not subject to the assessment required by SB 1398, the CCR landfill at the Chesapeake Energy Center is slated for closure in accordance with Virginia Solid Waste Management Regulations (VSWMR). The Virginia Department of Environmental Quality (DEQ) issued a draft solid waste permit in June 2016 for closure of the landfill, which process was later suspended at Dominion's request. The draft permit required Dominion to evaluate and propose alternative corrective measures to address groundwater impacts. In addition, in connection with a July 31, 2017, court order, Dominion will submit a revised solid waste permit application to DEQ by March 31, 2018, to include proposed additional corrective measures beyond monitored natural attenuation (MNA) to address site-wide groundwater impacts.

AECOM assessed the following closure alternatives to address the long-term safety of the Bottom Ash Pond and protect public health and the environment:

- Closure by removal and beneficial use
- Closure by removal and landfilling

Closure-in-place with groundwater corrective measures was not considered, as Dominion has committed to removal of the ash from the Bottom Ash Pond.

Table 25 provides a summary of the assessed closure options for the Bottom Ash Pond, including an approximate duration to complete each option, estimated costs, and the potential safety, community, and environmental considerations. All of these closure options have inherent risks that must be considered in the evaluation, including potential impacts to the community or the environment due to noise, truck traffic, potential for accidents/spilled material, emissions, or potential for exposure to coal ash. As shown in Table 25, the options would be implemented over a period of several months to a year, resulting in truck traffic in and out of the station and through the adjacent communities on a daily basis.

To support this closure assessment, AECOM developed cost estimates for the closure alternatives listed in Table 25. These opinions of probable cost are estimates of potential construction costs for informational purposes. The costs are Class 5 Estimates (+100%, -50%) and are limited to the conditions existing at issuance and not a guarantee of actual price or cost. Uncertain market conditions such as, but not limited to local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions may affect the accuracy of these estimates.

Table 25: Summary of Closure Options for Chesapeake Energy Center

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Beneficial Use	Up to 1 year	$10.6M	• Safety and community risks from over-the-road hauling (25 to 90 trucks per day intermittently for up to 1 year) • Increased noise, emissions, truck traffic, accident potential • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Market risks (there may be insufficient demand)
Closure by Removal and On-Site Landfilling	NA	NA	Dominion has committed to removing the CCR materials from the Bottom Ash Pond at the Chesapeake Energy Center
Closure by Removal and Off-Site ommercial Landfilling by Truck	2 to 3 months	$13.3M	• Safety and community risks from over-the-road hauling • Increased noise, emissions, truck traffic, accident potential • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Engineering challenges for CCR dewatering and excavation
Closure by Removal and Off-Site Commercial Landfilling by Rail	NA	NA	Alternative not practical due to small volume of CCR
Closure by Removal and Off-Site Commercial Landfilling by Barge	NA	NA	Alternative not practical due to small volume of CCR
Closure-in-Place	NA	NA	Dominion has committed to removing the CCR materials from the Bottom Ash Pond at the Chesapeake Energy Center
Potential Groundwater Corrective Measures for the Peninsula	3 to 5 years	$2.4M to $161M	• Dominion has committed to removing the CCR materials from the Bottom Ash Pond at the Chesapeake Energy Center • Corrective action will be necessary for the peninsula; corrective measure alternatives are discussed in Technical Memorandum 7

(1) All costs in this report are Class 5 estimates (+100%, –50%) and represent opinions of probable cost based on information available at the time of this study. AECOM is not responsible for any variance from costs presented in this document or actual prices and conditions obtained.

CCR = coal combustion residuals; M = million; NA = not applicable

In accordance with the CCR Rule, closure of the Bottom Ash Pond must be completed within 7 years (5-year base period plus one potential 2-year extension). Exhibit 7 shows the estimated timeline for each of the closure options compared to the CCR Rule durations.

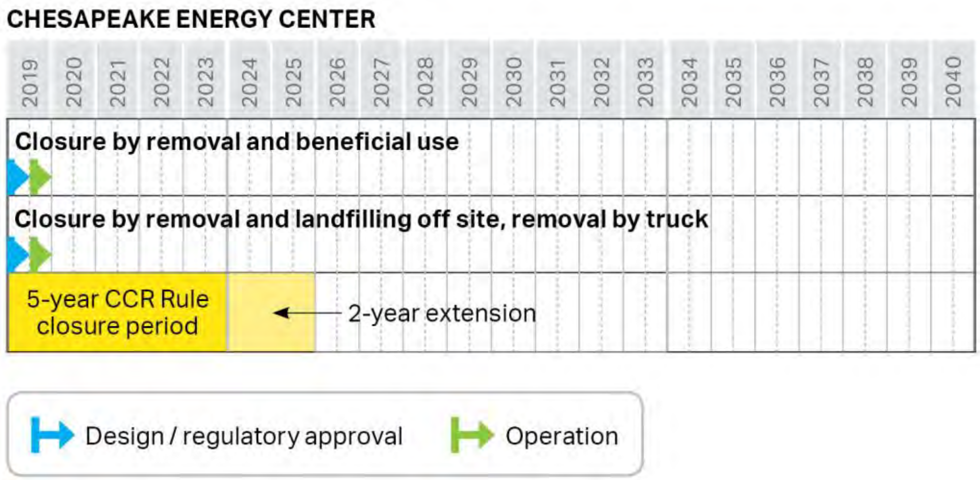

Exhibit 7: Closure Implementation Timeline – Chesapeake Energy Center

7.2 Site Background

The Chesapeake Energy Center is located at 2701 Vepco Street, in the City of Chesapeake, VA, along the western bank of the South Branch of the Elizabeth River. Figure 8 shows the station location and primary site features. The Norfolk Southern rail line and State Route 13/460 (Military Highway) border the station to the north, and an inactive cooling water discharge channel lies to the west. Most of the land surrounding the Chesapeake Energy Center is designated as a general industrial district, designed for manufacturing and related functions. All four coal-fired generation units were retired in 2014, and the site is inactive for power production.

There is one on-site surface impoundment (Bottom Ash Pond) that is subject to the requirements of SB 1398 and the CCR Rule. The 5-acre Bottom Ash Pond is located just south of a 22-acre CCR landfill on a peninsula in the southern portion of the Chesapeake Energy Center. Both the lined landfill and the unlined Bottom Ash Pond were developed within the footprint of the station’s original ash pond. The peninsula is approximately 6,000 feet from north to south and 1,200 to 4,000 feet from east to west. While in active operation, CCR was sluiced into the Bottom Ash Pond located at the south end of the facility and excavated and hauled to the adjacent CCR landfill for disposal.

The Bottom Ash Pond contains 60,000 CY of CCR. A temporary cover is currently in place over the Bottom Ash Pond, and the adjacent sedimentation basin is being used to actively manage landfill leachate and stormwater. A temporary cover is also in place over the landfill.

7.3 Closure by Removal

Closure by removal entails excavating the CCR materials from the ash pond and either beneficially reusing or placing them in a lined, permitted landfill. Primary components in this process include materials handling to remove the CCR from the ash pond and load the materials in trucks, transporting the materials to an off-site beneficial use or landfill facility, restoring the former ash pond to facilitate stormwater flow; and monitoring the groundwater to ensure continued protectiveness as required by the CCR Rule. These processes are described in the following sections. Dominion has committed to closing the Bottom Ash Pond by removal, either for beneficial use or to an off-site landfill.

7.3.1 Materials Handling

Closure by removal involves dewatering the ash ponds and treating the removed water, excavating the material and transporting it to staging/loadout areas, drying and stockpiling it for off-site transportation, loading for transport, and then backfilling and restoring the ash pond footprint once all CCR materials have been removed.

7.3.1.1 Dewatering and Water Treatment

Surface water and pore water would be removed using well points or dewatering trenches and transported to an off-site treatment facility for disposal. Dewatering activities would be initiated prior to excavation work and continue as long as necessary to ensure workable site conditions.

7.3.1.2 CCR Excavation

Closure by removal would involve excavating the bottom ash from the footprint of the original design of the pond. The area would be filled and capped after removal.

7.3.1.3 Transportation to On-Site Staging/Loadout Areas

Once excavated, CCR would be loaded into dump trucks and hauled from the excavation to a staging area either within the ash pond or at a dedicated on-site stockpile area with proper containment, dust control, and water collection and treatment systems. On-site haul routes would likely need to be constructed or improved at each site to be wide enough and have sufficient turning radii for efficient and safe operation of dump trucks. Water trucks would be necessary to reduce fugitive dust for the duration of hauling.

7.3.1.4 Drying and Stockpiling for Off-Site Transportation

In some cases, the CCR may need to be temporarily stockpiled to gravity drain and/or air dry to meet acceptable moisture content prior to loadout for off-site transportation. The CCR is typically required to have no more than 25% to 35% moisture content for transport and placement in a dry landfill. Drying areas may be near excavation or loadout areas, but sufficient laydown area would be planned to provide at least a week or more of drying time prior to loadout. Wind-rowed CCR may require re-handling several times to rotate the materials for maximum drying potential and to achieve desired moisture content prior to loadout.

7.3.1.5 CCR Loadout for Off-Site Transportation

Designated loadout areas would be established adjacent to truck staging areas for efficient loading operations. CCR would be loaded into trucks using rubber-tired loaders or conveyors. Truck loadout would include an on-site one-way loop road to provide safe exit from the adjacent public road, and areas for stacking and loading trucks, replacing covers, weight scaling, tire washing, and safe re-entry to the adjacent public road.

7.3.2 Closure by Removal and Beneficial Use

A third party has expressed interest in accepting the 60,000 CY of ponded material from Chesapeake Energy Center and would only require dewatering to allow safe transport to their facility. The excavation of the CCR is expected to take up to 1 year to complete. The time frame depends on how much the ash needs to be dewatered before being shipped and limitations on the maximum weekly quantity of ash that the user can receive.

7.3.2.1 Beneficial Use Considerations

The primary considerations associated with beneficial use options are related to excavating, handling, processing, and transporting the ash off site. These activities result in safety, noise, and emissions challenges associated with heavy construction equipment operating on the site and up to 90 trucks per day leaving the site on a daily basis for up to 1 year. Table 26 summarizes some of the considerations associated with the beneficial use option for Chesapeake Energy Center.

Table 26: Beneficiation Use Considerations – Chesapeake Energy Center

Category	Considerations
Safety	• Safety risks from excavation and over-the-road hauling (25 to 90 trucks per day intermittently for up to 1 year) • Excavation/construction safety of operating heavy equipment and dump trucks on and adjacent to the station
Environmental	• Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required • Potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Community	• Community impacts from over-the-road hauling (25 to 90 trucks per day intermittently for up to 1 year) • Increased noise, emissions, truck traffic, accident potential
Schedule	Market risks appear limited, since a third party has expressed interest in receiving the entire 60,000 CY volume with only drying required prior to CCR leaving the site

7.3.3 Closure by Removal and Landfilling

AECOM's landfill assessment included reviewing the feasibility of expanding an existing on-site landfill, either by constructing a new on-site landfill in an undeveloped ("greenfield") area of the site or using the footprint of an existing ash pond, or sending the materials off site to either an existing permitted landfill or a new permitted and constructed landfill. These options are summarized in Table 27 and discussed in greater detail in the following sections.

Table 27: Summary of Landfill Assessment for Chesapeake Energy Center

Location	Option	Feasibility	Comments
On site	Expansion of Existing Landfill	Not feasible	On site landfill is no longer receiving ash nor is it a candidate for expansion.
On site	Development of New Landfill on Greenfield Area	Not feasible	Not practical for small volume of CCR being removed.
On site	Development of New Landfill within Existing Ash Pond	Not feasible	Not practical for small volume of CCR being removed.
Off site	Siting and Development of New Dominion-Owned Landfill	Not feasible	Not practical for small volume of CCR being removed.
Off site	Transporting to Existing Commercial Landfill	Feasible	Options are available within 50 miles for trucking. Rail and barge options are not cost-effective due to small CCR volume.

CCR = coal combustion residuals

7.3.3.1 Expansion of Existing On-Site Landfill

The Chesapeake Energy Center no longer burns coal for power generation. The existing on-site landfill is slated for closure and is not a candidate for expansion.

7.3.3.2 Development of New Landfill (On-Site or Off-Site)

It is not considered practical from an economic and schedule standpoint to develop a disposal facility for the estimated 60,000 CY of CCR at Chesapeake Energy Center.

7.3.3.3 Dispose in Off-Site Commercial Landfill

AECOM evaluated commercial and municipal landfills in Virginia, North Carolina, and Maryland that are currently permitted to accept CCR waste to identify facilities capable of accepting large quantities of CCR material (5 to 15 million CY) within a 10 to 15 year operating life required. This would allow for potential landfill disposal of CCR from one or all of the ash ponds.

County or regional public landfills generally lacked the capacity and/or operating life to manage the Dominion CCR. The potential sites identified are therefore all commercial municipal solid waste (MSW) landfills. These facilities are currently permitted and would be structured to accept CCR waste in a monofill configuration, where CCR materials are segregated from other waste materials and placed in a separate landfill cell.

The two commercial MSW landfill options closest to Chesapeake Energy Center are summarized in Table 28 and locations are shown on Figure 9. These facilities are permitted and would be structured to accept CCR waste in a monofill configuration, where CCR materials are segregated from other waste materials and placed in a separate landfill cell.

Table 28: Candidate Off-Site Permitted Landfills for Chesapeake Energy Center

Landfill Features	USA Waste of Virginia Landfills-Bethel	Brunswick Waste Management Facility LLC
Facility Owner	Waste Management	Republic Services
Distance from Power Station	33 miles	93 miles
Reported Remaining Operating Life[(1)]	89 years	168 years
Reported Remaining Capacity[(1)]	17M CY	6.7M CY

[(1)] Remaining permitted operating life and capacity as reported in Virginia DEQ Solid Waste Report as of end of 2016; reported capacity based on total current permitted capacity which may not be fully available for CCR disposal

M = million; CY = cubic yard

7.3.3.4 Prior Evaluation of CCR Landfill and Original Pond

As part of litigation brought by the Sierra Club in 2015, Dominion presented evidence at trial in June 2016 addressing the scope and cost of removal of CCR in the Bottom Ash Pond, landfill, and the footprint of the original pond. Dominion's expert estimated that the cost of removal of the CCR landfill, original pond, and Bottom Ash Pond by truck to an off-site landfill (assumed to be the Bethel landfill) would be $477 million and take at least 8 years.

7.3.4 Transportation

The CCR at Chesapeake Energy Center would likely be transported by truck. Due to the relatively small volume of CCR waste at Chesapeake Energy Center (60,000 CY), reconstruction of the historic rail spur or barge dock and loading facilities would be cost prohibitive. A general arrangement for material handling for the trucking option is shown on Figure 10.

7.3.4.1 Transport by Truck

The closest reasonable landfill option for disposal of CCR by truck from Chesapeake Energy Center is the USA Waste of Virginia Landfills (Bethel Sanitary Landfill) in Hampton, operated by Waste Management (33 miles). The potential trucking route for this landfill and the Brunswick Waste Management facility are shown on Figure 11.

7.3.5 Backfilling and Restoration of Former Ash Ponds

Restoration of the Bottom Ash Pond would depend on future site needs and conditions.

7.3.6 Summary of Closure by Removal and Landfilling Considerations

The primary considerations associated with off-site landfill options are related to excavating, handling, processing, and transporting the ash off site. These activities result in safety, noise, and emissions challenges associated with heavy construction equipment operating on the site and up to 150 trucks per day leaving the site on a daily basis for 2 to 3 months. Additional considerations include the engineering and safety concerns associated with dewatering and leaving the ash pond open during excavation.

Table 29 summarizes some of the considerations associated with closure by removal to a landfill at Chesapeake Energy Center.

Table 29: Closure by Removal with Landfill Considerations for Chesapeake Energy Center

Category	Considerations
Safety	• Safety risks from excavation and over-the-road hauling (up to 150 trucks per day for 2 to 3 months) • Excavation/construction safety operating heavy equipment and dump trucks on and adjacent to the station
Environmental	• Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required
Community	• Community impacts from over-the-road hauling (up to 150 trucks per day for 2 to 3 months) • Increased noise, emissions, truck traffic, accident potential
Schedule	• May be able to start hauling immediately with minimal design, permitting, or construction • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time

CCR = coal combustion residuals

7.4 Closure-in-Place

Dominion has committed to removing the CCR materials from the Bottom Ash Pond at the Chesapeake Energy Center, so closure-in-place was not evaluated at this station.

7.5 Groundwater and Surface Water

The ground surface at the Chesapeake Energy Center is relatively flat and, with the exception of the landfill, ranges approximately 5 to 12 feet in elevation above mean sea level (msl). Shallow soils are predominantly fill materials, including clayey sands that were used to construct the inner and outer perimeter berms surrounding the former ash pond and landfill, and natural alluvial deposits. The fill layer is approximately 2 to 16 feet thick, underlain by sediments of the approximately 25- to 39-foot-thick Norfolk Formation.

7.5.1 Groundwater

Groundwater primarily flows in radial patterns closer to the surface, flowing toward the surrounding surface water adjacent to the site. Groundwater flow in the shallow and deep zones is influenced by the site topography and tends to permeate outward toward the South Branch of the Elizabeth River, Deep Creek, and a cooling channel. The peninsula's geology creates primary flow paths that link the shallow and deep zones with no continuous confining layers. Figures 12 and 13 show bedrock potentiometric maps for shallow and deep groundwater, along with the locations of monitoring wells.

A Risk Assessment prepared in 2003 found the nearest residences to the Chesapeake Energy Center located approximately 2,000 feet to the west (upgradient). Previous investigations indicate that local groundwater is not being used as a source of drinking water.

Groundwater sampling for CCR-related constituents has been performed under Virginia solid waste permit requirements since the landfill was permitted in the 1980s. In 2002, the site triggered corrective action, and DEQ approved an MNA remedy in 2008. Quarterly and/or semi-annual sampling has been performed under the Corrective Action Plan (CAP) since 2008. Groundwater monitoring wells are located around the peninsula and thus monitor conditions around both the Bottom Ash Pond and the landfill, which overlay the original ash pond location.

7.5.2 Surface Water

Since the MNA remedy was implemented in 2008, the four CAP surface water locations have been sampled at least twice per year, and all of the results have been below the site-specific Groundwater Protection Standards (GPS). In addition, nine locations upstream and downstream of the station were sampled in 2016; the results of all samples collected within a 1-mile radius of the station were below the Virginia Surface Water Quality Standards for aquatic life and human health.

7.6 Groundwater Corrective Measures

The Chesapeake Energy Center has been in corrective action driven by DEQ solid waste regulations since 2011. The removal of the Bottom Ash Pond will address the SB 1398 corrective measures requirement. However, the pond is underlain and surrounded by historical ash that is not subject to the CCR Rule but is being addressed under the VSWMR due to the adjacent permitted landfill. Dominion will submit a revised solid waste permit application to DEQ by March 31, 2018, to include proposed additional corrective measures to address site-wide groundwater impacts.

Groundwater results show detections of CCR related constituents above background levels around the peninsula. Based on that data and site-specific conditions, the following technologies could potentially remediate the groundwater around the peninsula; additional details on corrective measure options for the Chesapeake Energy Center peninsula are presented in Technical Memorandum 7:

- Permeable reactive barrier (PRB) – Groundwater flows through a subsurface trench filled with reactive material and chemically reacts with the material to remove contaminants; impractical to effectively install around the perimeter of the peninsula; insufficient space to install multiple barrier walls
- Complete in situ stabilization/solidification (ISS) – An agent is mixed into the CCR to physically and chemically bind the metals and other inorganic constituents, preventing them from leaching into the groundwater and thus effectively removing the source
- Vertical engineered barrier (VEB), which is containment via slurry walls – A subsurface wall is constructed to prevent groundwater from flowing out of the ash pond; if needed, hydraulic containment can supplement VEB; may be impractical to effectively install around the perimeter of the peninsula
- Hydraulic containment via pump-and-treat methods – Groundwater is pumped from a series of wells with overlapping influence to cut off groundwater from flowing downgradient; extracted water is treated to below permit requirements and discharged
- Monitored natural attenuation (MNA) – Physical processes that naturally reduce the concentration, toxicity, or mobility of CCR constituents in groundwater, attenuating the constituents by chemical reactions with other dissolved constituents and the soil media which is currently the DEQ-approved corrective action measure at Chesapeake Energy Center

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Figures

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. Satellite imagery updated August 2017.

LEGEND

- Approximate Property Boundary
- Limit of Waste
- Approximate Pond Boundary

AECOM

Figure 8
Site Location

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RIP	CAG	NMP	REV. 0

Chesapeake Energy Center

DATE:	DEPT:
10/3/2017	Environment

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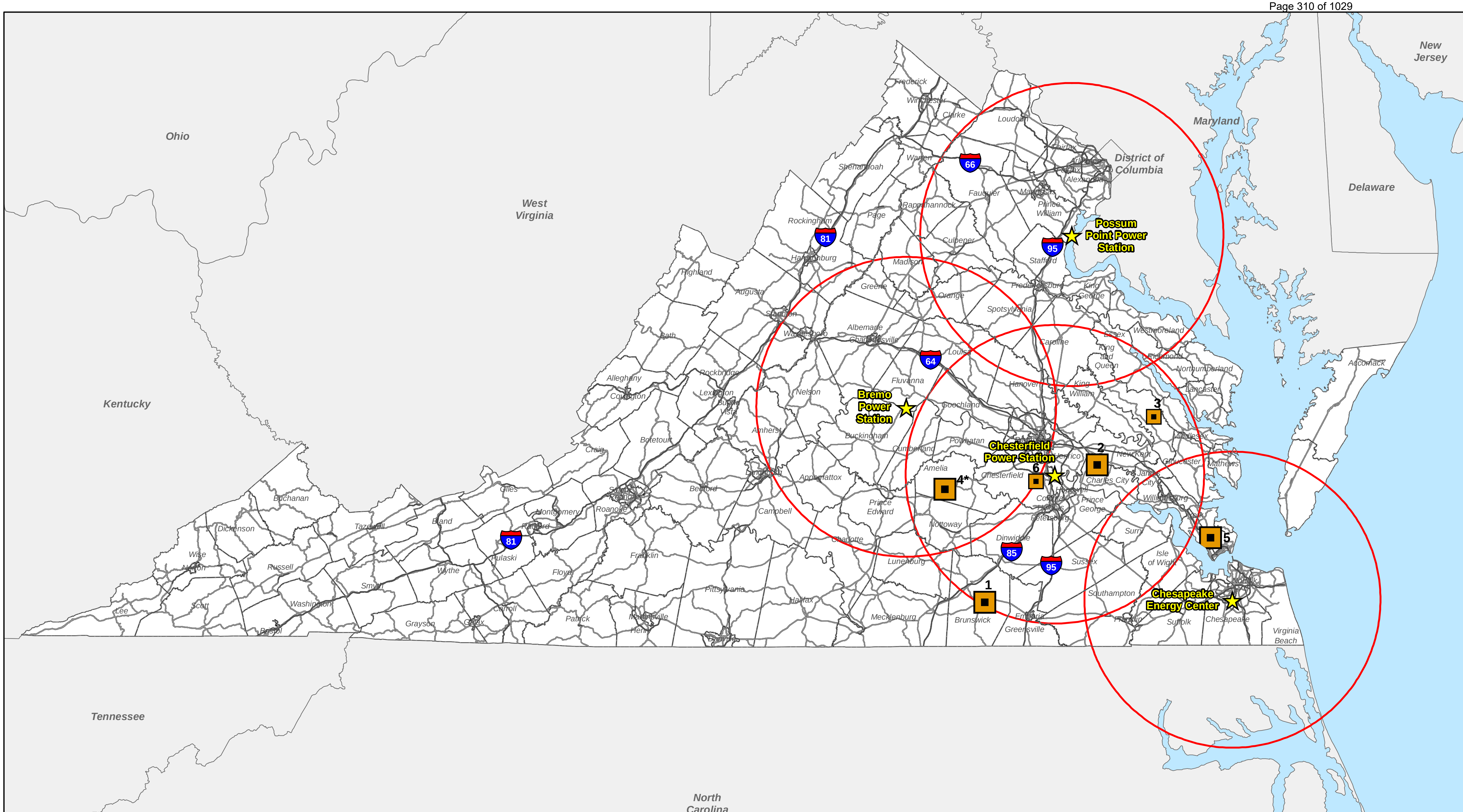

LEGEND

Limited Access Highway
High Occupancy Vehicle (HOV) Lane
US Primary Highway
50 Mile Radius
Virginia County

Landfill Location (remaining life)

10 - 25 yrs.
25 - 50 yrs.
> 50 yrs.
Dominion Plant Location

N
0 12.5 25 50
Miles

AECOM

Figure 9
Off-site Commercial Landfill Locations

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MPS	JAB	DOS	REV. 0

Chesapeake Energy Center

DATE:	DEPT:
11/14/2017	Environment

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AECOM

Figure 10
Closure by Removal
Trucking Plan

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LAD	DOS	DOS	REV. 0

Chesapeake Energy Center

DATE: 10/05/2017 DEPT: Environment

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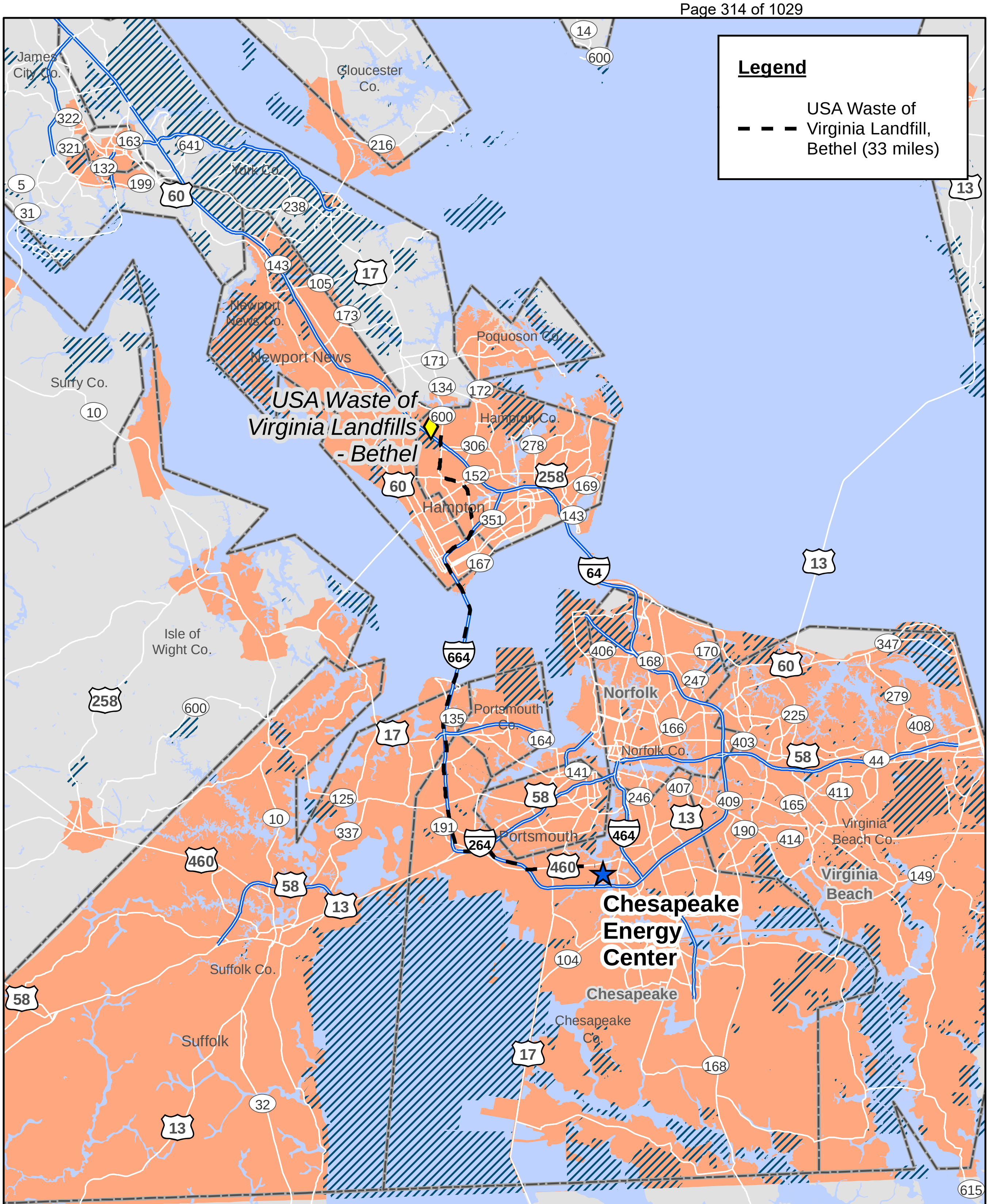

LEGEND

- Dominion Energy Facility
- Candidate Landfill
- Interstate Highway
- State Routes and Major Roads
- US Census Populated Place
- State Conservation Land
- County

N

0 24,000 48,000
Feet

AECOM

Figure 11
Truck Route to Landfill

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Chesapeake Energy Center

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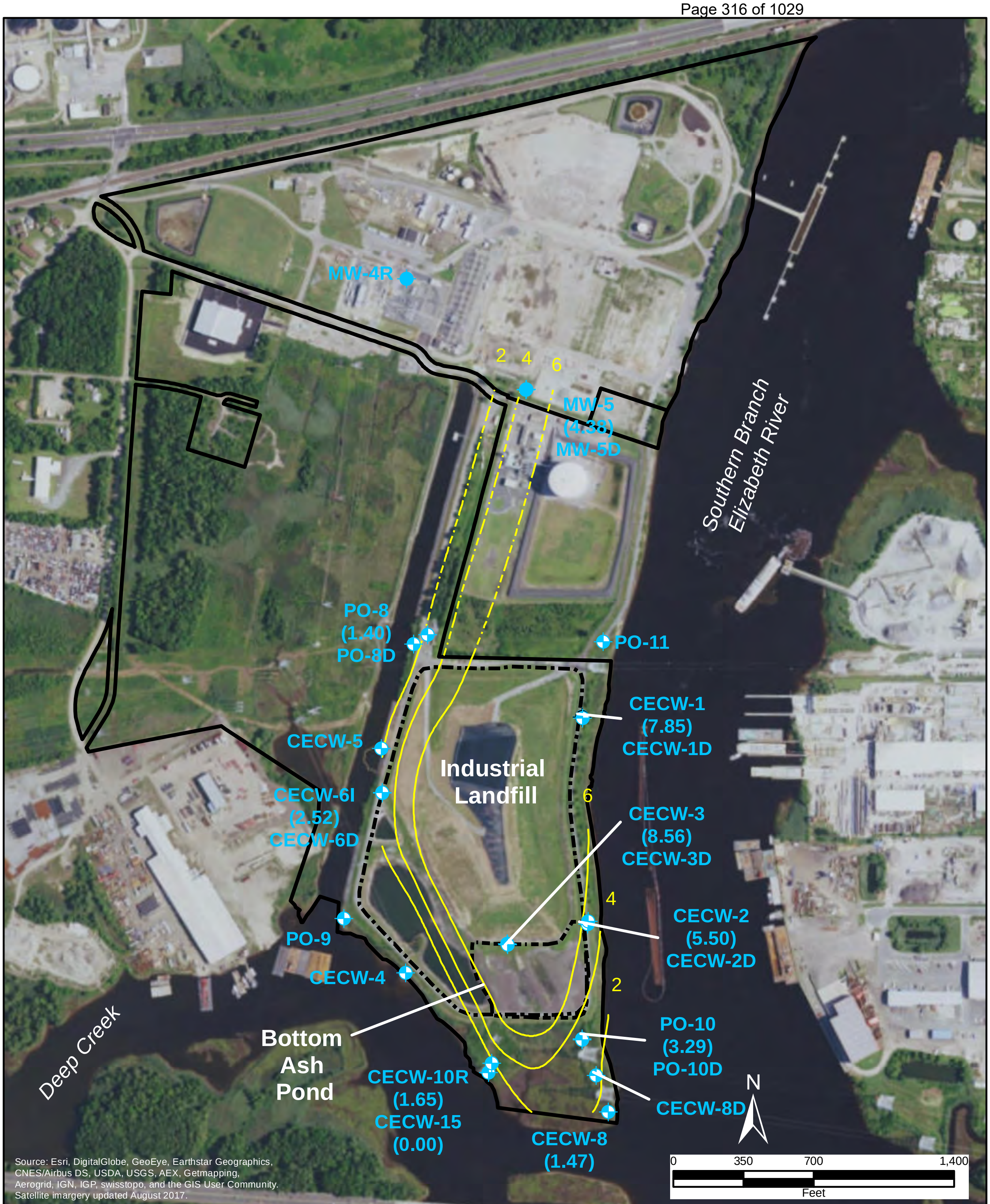

LEGEND

- Approximate Property Boundary
- Limit of Waste
- Approximate Pond Boundary
- Potentiometric Contours
- Inferred Potentiometric Contours

Compliance Program

- VSWMR Network Well
- VSWMR Network Background Well

AECOM

Figure 12
Potentiometric Surface, Shallow
March 2016

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RIP	CAG	DFM	REV. 0

Chesapeake Energy Center

DATE:	DEPT:
10/3/2017	Environment

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Senate Bill 1398 Response

Coal Combustion Residuals
Ash Pond Closure Assessment

SECTION 8:
CHESTERFIELD POWER STATION

November 2017







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8. Chesterfield Power Station

8.1 Summary for Chesterfield Power Station

This closure assessment focuses on the coal combustion residuals (CCR) at Chesterfield Power Station Lower and Upper Ash Ponds, as summarized in Table 30. Ash ponds can be closed by dewatering and then either removing the CCR materials or closing the pond in place. In the closure by removal option, CCR can be recycled/ beneficially used or relocated to a lined, permitted landfill. Landfill options could include expansion of an existing on-site landfill, construction of a new on-site landfill, transporting the materials off site to a permitted commercial landfill, or transporting off site to a new landfill.

Table 30: Chesterfield Power Station Ash Ponds

CCR Unit	Remaining CCR Volume (CY)	Operating Status	Area (acres)
Lower Ash Pond	3,600,000	Slated for closure	101
Upper Ash Pond	11,300,000	Slated for closure	112
Total Volume	**14,900,000**		

CCR volumes are based on Dominion estimates as of July 10, 2017
CCR = coal combustion residuals; CY = cubic yards

AECOM assessed the following closure alternatives to address the long-term safety of the Lower and Upper Ash Ponds and protect public health and the environment:

- Closure by removal and beneficial use
- Closure by removal and landfilling
- Closure-in-place with groundwater corrective measures, if applicable

Table 31 provides a summary of the assessed closure options for the Lower and Upper Ash Ponds at Chesterfield Power Station, including an approximate duration to complete each option, estimated costs, and the potential safety, community, and environmental considerations. All of these closure options have inherent risks that must be considered in the evaluation, including potential impacts to the community or the environment due to noise, truck traffic, potentials for accidents/spilled material, emissions, or potential for exposure to coal ash. As shown in Table 31, the options that include materials leaving the site would be implemented over 20+ years, resulting in large volumes of truck and potentially train traffic in and out of the station and through the adjacent communities on a daily basis for a decade or more.

To support this closure assessment, AECOM developed cost estimates for the closure alternatives listed in Table 31. These opinions of probable cost are estimates of potential construction costs for informational purposes. The costs are Class 5 Estimates (+100%, -50%) and are limited to the conditions existing at issuance and not a guarantee of actual price or cost. Uncertain market conditions such as, but not limited to: local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions may affect the accuracy of these estimates.

Table 31: Summary of Closure Options for Chesterfield Power Station

Closure Option	Est. Time Frame	Est. Cost(1)	Implementation Considerations
Closure by Removal and Beneficial Use	21 to 53 years	$1.49B to $4.25B	• Ash pond stays open for 21+ years (3 years design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *21+ years duration to implement exceeds CCR closure requirements of 15 years* • The time frames are driven by the available market and throughput of beneficiation technologies • Safety and community risks from over-the-road hauling due to significant volume and multi-year duration removal project; up to 150 trucks per day each way for 18+ years • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and On-Site Landfilling	20 years	$1.28B	• Ash pond stays open for 20 years, increases safety risk, and results in prolonged duration for dewatering/water treatment • *20 years duration to implement exceeds CCR closure requirements of 15 years* • Only feasible if the DEQ and local authorities grant a variance to allow the setback from the road to be reduced from 500 to 100 feet; the presence of Henricus Park and Aiken Swamp adjacent to the area in question would need to be considered in this determination • Eliminates risks associated with off-site hauling, truck traffic • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering, excavation, and staging
Closure by Removal and Off-Site Commercial Landfilling by Truck	29 years	$2.68B	• Ash pond stays open for 29 years (1 year design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *29 years duration to implement exceeds CCR closure requirements of 15 years* • Safety and community risks from over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day each way for 28 years; truck leaving site approximately every 3 minutes for 10 hours per day Monday through Friday) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation

Table 31 (cont.): Summary of Closure Options for Chesterfield Power Station

Closure Option	Est. Time Frame	Est. Cost[1]	Implementation Considerations
Closure by Removal and Off-Site Commercial Landfilling by Rail	24 years	$4.63B	• Ash pond stays open for 24 years (4 years design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *24 years duration to implement exceeds CCR closure requirements of 15 years* • Safety and community risks from excavation and rail hauling due to significant volume and multi-year duration removal project (200+ railcars per week for 20 years) • Reduced hauling risks for rail vs. trucking • Increased noise, emissions, accident potential • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and Off-Site Commercial Landfilling by Barge	N/A	N/A	• Alternative not practical • Virginia regulations require sealed containers that would need to be loaded onto and off of barges by crane, requiring infrastructure construction at both ends • Disposal facility not adjacent to barge unloading facility; requires barging for 20 miles, unloading of containers, transfer materials to trucks, and additional 20 miles of truck hauling to landfill after unloading barge • Same disposal facility is only 29 miles by truck from Chesterfield Power Station, while another facility is only 7 miles away from the station
Closure-in-Place with Potential Groundwater Corrective Measures	3 to 5 years	$246M to $1.11B	• No impacts for CCR removal or off-site hauling • Lowest risk for safety, community, schedule, and cost • Lower groundwater migration potential for CCR remaining in place once closure is complete, which is addressed by corrective measures • Includes cost range for corrective measures • 2-year corrective measure construction duration • Estimated 10- to 30-year duration for groundwater corrective measures
New Regional Off-Site Landfill for Ponds at Bremo, Chesterfield, and Possum Point	21 years	$4.15B	• Would be located in a centralized area to accept materials from all Dominion ash ponds • Ash ponds stays open for up to 20 years (6 years design/permit/construct new landfill, remaining time to transport from all three sites), increases safety risk, and results in prolonged duration for dewatering/water treatment • *Duration will exceed CCR closure requirements of 15 years at Chesterfield Power Station* • Safety and community risks from excavation and over-the-road hauling due to significant volume, multi-year duration removal project (up to 150 trucks/day each way from all 3 stations for 15+ years) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Construction of new landfill and hauling ash to new location will affect local communities • Extensive permitting and design required

(1) All costs in this report are Class 5 estimates (+100%, - 50%) and represent opinions of probable cost based on information available at the time of this study. AECOM is not responsible for any variance from costs presented in this document or actual prices and conditions obtained.

B = billion; CCR = coal combustion residuals; DEQ = Virginia Department of Environmental Protection; M = million; NA = not applicable

In accordance with the CCR Rule, closure of the North Ash Pond must be completed within 15 years (5-year base period plus up to five extensions in 5-year increments). Exhibit 8 shows the estimated timeline for each of the closure options compared to the CCR Rule durations; note that some of the beneficial use technologies and off-site landfill options cannot meet the 15-year closure timeline.

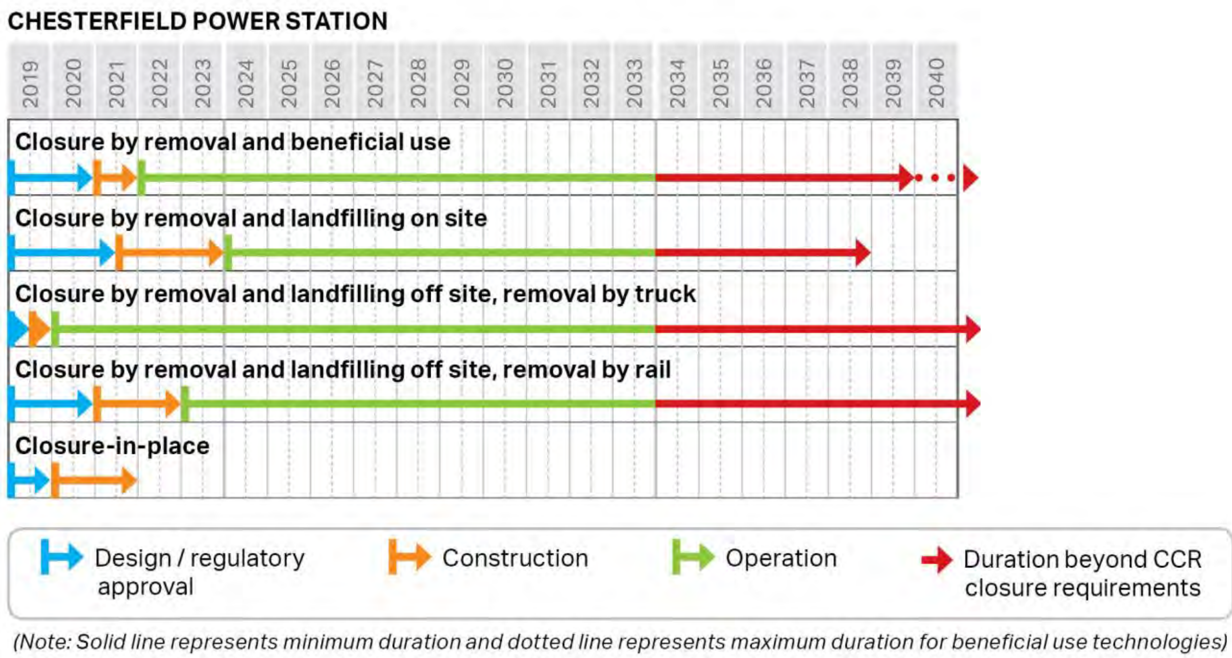

Exhibit 8: Closure Implementation Timeline – Chesterfield Power Station

8.2 Site Background

The Chesterfield Power Station is located at 500 Coxendale Road, Chesterfield, VA, approximately 20 miles south of Richmond, on the southern bank of the James River. Figure 13 shows the station location and primary site features. The station is surrounded on three sides (north, east, and south) by the James River, its tributaries, and wetlands/conservation areas. Aiken Swamp and the Dutch Gap cutoff lie to the north/northeast of the ash ponds, with public access for boat launching and birding. Henricus Park (owned and operated by Chesterfield County) is on the northeast corner of the station. To the south of the station, the Dutch Gap Conservation Area runs along the south bank of the Old Channel of the James River. Farther south across the banks of the Old Channel of the James River, parcels are variously designated as agricultural, community business, and several residential districts. Most of the surrounding land is zoned as a heavy industrial district.

The Chesterfield Power Station is a coal-fired power plant that started operations in 1944. Along with being the largest fossil-fueled power station in Virginia with four active coal combustion units, Chesterfield houses two combined cycle units that burn natural gas and distillate oil. In October 2017, the station converted its ash handling processes to generate dry fly ash, in preparation for ash pond closure.

The topographic surface at the facility is level and falls within the James River floodplain. Elevations range from approximately 10 to 30 feet above mean sea level (msl) with the exception of the Upper Ash Pond, which sits at 70 to 80 feet msl.

Two on-site surface impoundments (Lower Ash Pond and Upper Ash Pond) are subject to the requirements of SB 1398 and the CCR Rule. The 100-acre Lower Ash Pond was constructed in 1964 and the 112-acre Upper Ash Pond in 1983. Both ponds are unlined storage units that have received CCR and associated coal combustion process waste for disposal. Settled CCR in the Lower Ash Pond has historically been excavated, dewatered, and transferred to the Upper Ash Pond.

8.3 Closure by Removal

Closure by removal entails excavating the CCR materials from the ash pond and either beneficially reusing or placing them in a lined, permitted landfill. Primary components in this process include materials handling to remove the CCR from the ash pond and load the materials in trucks or railcars, transporting the materials to an off-site beneficial use or landfill facility, restoring the former ash pond to facilitate stormwater flow; and monitoring the groundwater to ensure continued protectiveness as required by the CCR Rule. These processes are described in the following sections.

8.3.1 Materials Handling

Closure by removal involves dewatering the ash ponds and treating the removed water, excavating the material and transporting it to staging/loadout areas, drying and stockpiling it for off-site transportation, loading for transport, and then backfilling and restoring the ash pond footprint once all CCR materials have been removed.

8.3.1.1 Dewatering and Water Treatment

Surface water and pore water would be removed and treated to prepare for excavation and material handling. Well points and deep wells that have been installed in the Lower and Upper Ash Ponds would be used to dewater the full CCR thickness, with temporary trenches and CCR grading implemented to direct water to low points within the impoundments prior to removal. Dewatering activities would be initiated prior to excavation work and continue as long as necessary to ensure workable site conditions.

A specialized water treatment system would be installed to treat all CCR contact water to meet the discharge requirements of the Virginia Pollutant Discharge Elimination System (VPDES) permit. The dewatering and treatment system would be required to operate until all closure activities are complete.

8.3.1.2 CCR Excavation

Closure by removal would involve excavating ash from the pond such that no residual materials remain visible, followed by over-excavating the removal footprints by 6 inches as required by the Virginia Department of Environmental Quality (DEQ), which is more stringent than federal requirements.

8.3.1.3 Transportation to On-Site Staging/Loadout Areas

Once excavated, CCR would be loaded into dump trucks and hauled from the excavation to a staging area either within the ash pond or at a dedicated on-site stockpile area with proper containment, dust control, and water collection and treatment systems. On-site haul routes would likely need to be constructed or improved to be wide enough and have sufficient turning radii for efficient and safe operation of dump trucks. Water trucks would be necessary to reduce fugitive dust for the duration of hauling.

8.3.1.4 Drying and Stockpiling for Off-Site Transportation

In some cases, the CCR may need to be temporarily stockpiled to gravity drain and/or air dry to meet acceptable moisture content prior to loadout for off-site transportation. The CCR is typically required to have no more than 25% to 35% moisture content for transport and placement in a dry landfill. Drying areas may be near excavation or loadout areas, but sufficient laydown area would be planned to provide at least a week or more of drying time prior to loadout. Wind-rowed CCR may require re-handling several times to rotate the materials for maximum drying potential and to achieve desired moisture content prior to loadout.

8.3.1.5 CCR Loadout for Off-Site Transportation

Designated loadout areas would be established adjacent to truck or rail car staging areas for efficient loading operations. CCR would be loaded into trucks or rail cars using rubber-tired loaders or conveyors.

Truck loadout would include an on-site one-way loop road to provide safe exit from the adjacent public road, and areas for stacking and loading trucks, replacing covers, weight scaling, tire washing, and safe re-entry to the adjacent public road.

Rail loadout would generally involve using new or existing rail sidings and spur tracks to receive empty unit trains (85 gondola cars), splitting unit trains into smaller groups of gondola cars for on-site handling using a locomotive, installing disposable liners and covers, loading gondolas, re-assembling trains of filled gondola cars, and staging on the adjacent siding for pickup by a freight rail firm. As described in Section 8.3.4.2, the existing rail lines are used for delivery of coal and adding rail disposal of CCR would increase the current rail congestion on the station property.

8.3.2 Closure by Removal and Beneficial Use

AECOM's beneficial use and ash market study evaluated the market-wide demand for fly ash based on cement consumption and found that the regional (Virginia, Maryland, North Carolina, and the District of Columbia) fly ash supply is projected to exceed demand starting by 2019 without accounting for the more than 25 million tons of ponded ash stored at the four Dominion power stations. Regional supply is projected to be at least 2.3 million tons per year starting in 2019, while 2016 fly ash usage (demand) is estimated as 1.7 million tons, increasing to 2.3 million tons in 2035. Some of the regional fly ash consumers that were contacted by AECOM indicated desire and ability to use beneficiated fly ash. However, the demand quantities and market purchase price of the processed fly ash were highly variable, so Dominion would need to negotiate contracts with specific consumers prior to committing to beneficially use the ponded ash.

On the supply side, AECOM evaluated potential proven, developing, and research stage technologies that may be feasible to process the ponded ash at Dominion facilities. The list of potential beneficiation technology vendors is substantial and numerous technologies were considered in prior studies that were used for this assessment. Four beneficiation technologies were selected, representing the proven and developing stages of technologies, including:

- The SEFA Group Staged Turbulent Air Reactor (STAR) process to refine the ash into a Portland cement replacement
- ST Triboelectric Separation Technology, which separates ash particles using electrodes into positively charged carbon materials that can be re-burned and negatively charged materials which can be used in cement, combined with PMI's Carbon Burnout (CBO) process, which combusts CCR to produce materials to be used for the manufacture of cement products
- Nu-Rock Technology, which uses binding agents to manufacture masonry blocks, pavers, pipe, and similar products from CCR

- Belden-Eco Products, which fires CCR in a kiln to render it inert and mixes it with other materials to form ceramic bricks

8.3.2.1 Site-Specific Beneficial Use Options

Chesterfield Power Station is accessible to nearby southern and central Virginia and North Carolina cement markets, and a substantial number of ready mixed and precast concrete companies are within a 50-mile radius. The timing for excavating the Lower and Upper Ash Ponds is dependent on the processing rate per year (throughput) identified for each beneficiation technology option. The timing to develop each beneficiation facility is typically 3 years, including permitting and construction. Costs include capital costs for the processing equipment; operations and maintenance (O&M) for the beneficiation facility; and ongoing materials handling, dewatering, and water treatment costs. Materials handling includes excavation, drying, screening (if needed), and transporting the ponded ash to the on-site beneficiation facility. Costs do not include marketing of the materials or transporting the processed ash to an end user. Table 32 provides a summary of the potential beneficiation options at Chesterfield Power Station, including duration and costs.

Table 32: Closure by Removal with Beneficiation Technology Options at Chesterfield Power Station

Technology	End Product	Throughput (tons/year)	Time to Excavate Ash Ponds[1] (years)	Range of Costs for Technologies
SEFA STAR	PC substitute	430,000 to 840,000	21 to 46	Technology Capital = $17M to $244M
PMI/STI	PC substitute			Technology O&M = $441M to $3,012M
				Materials Handling = $820M to $1,764M
Nu-Rock	Masonry blocks, pavers, pipes, etc.	300,000 to 550,000	30 to 53	**Total Projected = $1,486 M to $4,251M**
Belden-Eco Products	Brick			Estimated Cost/Ton = $100 to $285

[1] Time to excavate the pond is estimated based on the throughput of the technologies; excavation and processing rates may vary based on market demand of the beneficiated product

M = million; O&M = operations and maintenance; PC = Portland cement; SEFA = SEFA Group; STAR = Staged Turbulent Air Reactor

Based on the benchmarking results, fly ash is selling on average for $30 to $60 per ton plus $7 to $33 per ton for transportation. The estimated costs for beneficiation are approximately 1.7 to 4.8 times greater than the current regional market price for the ash.

8.3.2.2 Consolidated Beneficiation Facility

This study considered the development of a regional processing facility to be located at Chesterfield Power Station that would receive coal ash transported from the Bremo and Possum Point Power Stations for processing and beneficial use. Chesterfield is the most central of the three stations, and it also contains the majority of the ash (14.9 million of the 25.2 million CY), minimizing loading and hauling costs. In general, this is not considered to be a cost-effective option and would result in several of the ash ponds remaining open for at least three decades. The most expedient beneficiation technology would be able to process the ash from the Chesterfield Power Station in 26 years (3 years to design, obtain regulatory approval, and construct and 23 years to process the ash based on technology throughput). Since there is no available space on the Chesterfield station property to temporarily store ash from the other stations (and the FFCP landfill is not permitted to have waste stored and then removed), ash would have to be transported on an as-needed basis. Based on throughput rates, it would take another 6 years to process the Possum Point Power Station ash and 10 additional years for Bremo ash, for a total of 42 years for all three stations. The Chesterfield County Conditional Use Permit (CUP) would also need to be amended to allow ash to be trucked to the station.

8.3.2.3 Beneficial Use Considerations

The primary considerations associated with beneficial use options are related to excavating, handling, processing, and transporting the ash off site. These activities result in safety, noise, and emissions challenges associated with heavy construction equipment operating on the site and up to 150 trucks per day arriving at and leaving the site on a daily basis for 28 or more years. Additional considerations include the limited amount of demand for beneficiated ash in the local market, along with engineering and safety concerns associated with continuously dewatering and leaving the ash ponds open for more than 20 years.

Removal of the CCR materials from the Lower and Upper Ash Ponds would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality. However, these benefits would not be realized until the removal and beneficiation was completed and the groundwater naturally attenuated over time. Table 33 summarizes some of the considerations associated with the beneficial use option for Chesterfield Power Station.

Table 33: Beneficial Use Considerations – Chesterfield Power Station

Category	Considerations
Safety	• Ash pond stays open for 21+ years (3 years to obtain regulatory approval and construct loading facilities, remaining years to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety risks from excavation and over-the-road hauling due to significant volume and multi-year duration removal project (up to 150 trucks per day each way for 18+ years) • Excavation/construction safety during 18+ years of operating heavy equipment and dump trucks on and adjacent to the station
Environmental	• Ash pond stays open for 21+ years, with resulting prolonged duration for dewatering and water treatment • Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time
Community	• Community impacts from over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day each way for 18+ years) • Increased noise, emissions, truck traffic, accident potential • Transportation by rail may decrease community impacts as compared to truck transportation, but noise, safety, and emissions would remain concerns
Schedule	• Duration to implement all evaluated technologies exceeds CCR closure requirements of 15 years • Market risks (there may be insufficient demand) • No on-site storage space is available for beneficiated ash, requiring “on demand” processing that limits production/removal to what the market would accept • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time

CCR = coal combustion residuals

8.3.3 Closure by Removal and Landfilling

AECOM's landfill assessment included reviewing the feasibility of expanding an existing on-site landfill, either by constructing a new landfill in an undeveloped ("greenfield") area of the site or using the footprint of an existing ash pond, or sending the materials off site to either an existing permitted landfill or a new permitted and constructed landfill. These options are summarized in Table 34 and discussed in greater detail in the following sections.

Table 34: Summary of Landfill Assessment for Chesterfield Power Station

Location	Landfill Option	Feasibility	Comments
On site	Expansion of Existing Landfill	Not feasible	Insufficient capacity available in new FFCP landfill (9.4M CY) for the volumes of ash on site (14.9M CY). FFCP was constructed for storage of process ash; regulations prohibit expansion of FFCP.
On site	Development of New Landfill on Greenfield Area	Not feasible	Inadequate available property suitable for landfill development.
On site	Development of New Landfill over Existing Ash Pond	Potentially feasible	Only feasible on Lower Ash Pond if the DEQ and local authorities grant a variance to allow the setback from the road to be reduced from 500 feet to 100 feet; design and construction estimate of 20 years would not meet the 15-year CCR Rule closure timeframe; also requires variance to County Conditional Use Permit to truck 3.6 million CY of CCR materials to new FFCP landfill
Off site	Siting and Development of New Dominion-Owned Landfill	Potentially feasible	Centrally located landfill to house ash from all Dominion ash ponds would require a 500- to 800-acre site composed of multiple parcels. Could potentially site new landfill in central Virginia.
Off site	Transporting to Existing Commercial Landfill	Feasible	Options are available within 50 miles for trucking. Rail options exist; barge not cost feasible.

CCR = coal combustion residuals; DEQ = Virginia Department of Environmental Protection; FFCP = fossil fuel combustion products

8.3.3.1 Expansion of Existing On-Site Landfill

In preparation for the future closure of the CCR ash ponds, Dominion has constructed an on-site, lined Fossil Fuel Combustion Products (FFCP) landfill that is essential for the continued operation of the coal-fired power station. The FFCP began operating in October 2017, with a permitted capacity of 9.4 million CY, and is designed to serve the existing generating units for 20 years.

AECOM evaluated the potential for laterally and/or vertically expanding the storage capacity of the FFCP to verify whether excavated CCR from the ash ponds could be placed in the FFCP without adversely affecting the future operations of the power station. Further, AECOM verified that the original landfill design optimized the space available for vertical expansion options using traditional methods.

Based on the quantity of CCR at the Chesterfield Power Station and the size and capacity of the FFCP, it is not feasible to expand it to manage CCR removed from the ash ponds.

8.3.3.2 Development of New On-Site Landfill

A landfill footprint of approximately 85 acres would be required to accommodate the 14.9 million CY of CCR in the ash ponds including an industry standard 25% engineering safety factor applied to the volumes of ponded ash to obtain a target volume for potential landfill design. This safety factor is to account for disposal of soil below the in-place CCR excavated as part of closure by removal, uncertainty in estimation of the volume of in-place CCR to be disposed of, and engineering uncertainty regarding site conditions in this conceptual level assessment. AECOM evaluated developing a new on-site landfill in a greenfield area and over an existing ash pond.

Landfill on greenfield area. AECOM evaluated potentially available land outside of active CCR management areas or power generating facilities that would be large enough to meet landfill siting criteria. The Chesterfield Power Station is heavily built up with facilities to support electricity generation. The ongoing development of new wastewater treatment facilities to meet compliance requirements after the closure of CCR ash ponds have taken up the smaller undeveloped areas on the property. Because of siting restrictions in locations such as floodplains, wetlands, and areas with overhead power lines, insufficient open space is available for developing a new landfill.

Landfill over existing ash pond. Developing a new landfill within the footprint of an existing ash pond would require overcoming several significant regulatory and engineering challenges. Construction sequencing would require dewatering and stabilization of the ash pond; excavation of the CCR; temporary storage of the CCR during landfill construction; and conditioning, placement, and compaction of the CCR into the landfill. Constructing a landfill would also require trucking in significant quantities of soil from off-site sources (a landfill in the Lower Ash Pond footprint would require approximately 3.2 million CY of soil to construct the new landfill and restore the Upper Ash Pond area).

Temporary storage of the CCR would create a significant regulatory challenge. Neither ash pond could be used for temporary storage while constructing a new landfill on the footprint of the other pond, as CCR Rules prohibit placement of new CCR materials in either of the ash ponds after October 2018. There is no suitable location on the station property to temporarily store the volume of CCR currently located in the Upper Ash Pond (11.3 million CY). However, there may be a viable option for temporary storage of the smaller Lower Ash Pond volume (3.6 million CY) using the newly constructed 9.3 million CY FFCP landfill (see Section 2.4.1). The FFCP landfill would concurrently be used to dispose of CCR associated with on-going power generation, as designed. Once Lower Ash Pond closure conditions were met and the new lined CCR landfill was constructed within the former Lower Ash Pond, CCR could be excavated from the Upper Ash Pond directly to this new conceptual landfill.

Virginia Solid Waste Management Regulations (VSWMR) landfill siting requirements require a 500-foot setback from public roadways, with an exception for “units that are located in areas that are zoned for industrial use under authority of state law or in unzoned industrial areas as determined by the Commonwealth Transportation Board” (9VAC20-81-120). Constructing a new landfill on the Lower Ash Pond footprint would not provide enough volume for the CCR materials unless the DEQ and local authorities grant a variance to the setback requirements from Coxendale Road and Henricus Road from 500 feet to 100 feet. The presence of Henricus Park and Aiken Swamp adjacent to the area in question would be considered in this determination. If the DEQ and local authorities grant a variance to reduce the setback, the preliminary layout on the footprint of the Lower Ash Pond (shown in Figure TM4-2) would provide a landfill area of 85 acres with a sufficient disposal capacity of approximately 19 million CY.

Another consideration is that the facility’s Conditional Use Permit issued by Chesterfield County prohibits hauling CCR on public roadways, including Coxendale Road and Henricus Road. This could restrict both hauling of CCR to the FFCP landfill from the Lower Ash Pond and future hauling of CCR from the plant to the new conceptual landfill developed in the Lower Ash Pond site. The use of Coxendale Road and/or Henricus Road to haul CCR would impact public access to the Henricus Park and the public boat ramp.

Crossing or use of public roadways could also restrict the rate that CCR is hauled to the disposal units. An assessment of whether the Conditional Use Permit could be amended and the potential resulting impacts on the public would determine the feasibility of this alternative.

Additionally, the CCR Rule restricts reuse of former ash ponds until it can be demonstrated that closure by removal criteria, including those for groundwater, are met. Addressing CCR Rule groundwater criteria could potentially be accomplished by isolating the new landfill with a double liner system, but could potentially add time to the landfill construction process.

Constructing a landfill in the footprint of the Lower Ash Pond is projected to take 20 years to complete, exceeding the maximum allowable CCR Rule closure timeline of 15 years. Design and permitting is projected to take 2 to 3 years, construction of the new landfill an additional 2 to 3 years, and moving of the ash is expected to take approximately 15 years.

Based on the conceptual assessment presented above, it could potentially be feasible to construct a new lined CCR landfill within the Lower Ash Pond, using the reduced roadway setback, although the challenges described above would all need to be addressed in order to make this a viable option compared to other closure alternatives.

8.3.3.3 Disposal in Off-Site Commercial Landfill

AECOM evaluated commercial and municipal landfills in Virginia, North Carolina, and Maryland that are currently permitted to accept CCR waste to identify facilities capable of accepting large quantities of CCR material (5 to 15 million CY) within a 10 to 15 year operating life required. This would allow for potential landfill disposal of CCR from one or all of the ash ponds.

County or regional public landfills generally lacked the capacity and/or operating life to manage the Dominion CCR. The potential sites identified are therefore all commercial municipal solid waste (MSW) landfills. These facilities are currently permitted and would be structured to accept CCR waste in a monofill configuration, where CCR materials are segregated from other waste materials and placed in a separate landfill cell.

Based on the large volume of ponded ash at the Chesterfield Power Station (14.9 million CY), offsite disposal would likely require multiple landfill locations to provide the long-term capacity to accept all of the waste. The five commercial MSW landfill options closest to Chesterfield Power Station are summarized in Table 35 and locations are shown on Figure 15. Table 36 shows the facilities identified as feasible options to receive CCR by rail.

8.3.3.4 Development of New Off-Site Landfill

AECOM performed a preliminary screening-level assessment to identify potential off-site locations where a new landfill could be developed to serve multiple Dominion facilities. A study radius of 50 miles from each of the four power stations was used as a practical range for truck hauling to a new landfill. Landfills beyond 50 miles could be considered but costs would increase. Since the CCR volume at Chesapeake Energy Center is much smaller than at the other facilities (60,000 CY out of a total of 25 million CY), the study area considered only Bremo, Chesterfield, and Possum Point Power Stations. AECOM’s assessment identified the optimal area for a landfill as central Virginia in the vicinity of I-95, north of I-64, and south of Fredericksburg. The study area covers portions of Madison, Culpeper, Orange, Louisa, Spotsylvania, Hanover, Caroline, King William, King and Queen, and Essex Counties. The general location is shown on Figure 16.

Table 35: Candidate Off-Site Permitted Landfills for Chesterfield Power Station

Landfill Features	Shoosmith Landfill	Charles City County Landfill	Maplewood Recycling and Waste Disposal[(1)]	Brunswick Waste Management Facility LLC
Facility owner	Shoosmith Brothers	Waste Management	Waste Management	Republic Services
Distance from power station	7 miles	27 miles	43 miles	60 miles
Reported remaining operating life[(2)]	32 years	54 years	148 years	168 years
Reported Remaining Capacity[(2)]	14.8M CY	34M CY	7.5M CY	6.7M CY

[(1)] Facility with rail access
[(2)] Remaining permitted operating life and capacity as reported in Virginia DEQ Solid Waste Report as of end of 2016; reported capacity based on total current permitted capacity which may not be fully available for CCR disposal
M = million ; CY = cubic yards

Table 36: Candidate Facilities with Capability to Accept CCR by Rail

Off-Site Landfill with Rail Access	Location	Capacity	Comments
Maplewood Recycling and Waste Disposal	Amelia County, VA	12M CY, expandable	35 rail cars/day capacity; expandable
Brunswick Waste Management	Brunswick, VA	20M CY, expandable	Need to construct 2-mile rail spur extension
Sunny Hill Farms	Fostoria, OH	30M CY over next 20 years	Owns a fleet of 1,500 rail cars
Tunnel Hill Reclamation	New Lexington, OH	30M CY over next 20 years	Owns a fleet of 1,500 rail cars
Waste Industries Taylor County Disposal	Mauk, GA	6.7M CY, expandable	Accepts 80 to100 rail cars per day
Arrowhead Landfill	Uniontown, AL	62M CY, additional 34M CY monofill expansion permitted	Accepts 150 gondola cars per day

CCR = coal combustion residuals; M = million; CY = cubic yards

A landfill footprint between 150 to 200 acres would be required to accommodate the CCR volumes from the three stations. In addition to the land required for the lined landfill, additional property would be needed to satisfy regulatory setbacks, avoid streams and wetlands, provide stormwater management, construct roads and support structures, and provide a source for borrow soil for landfill and final cover construction. These factors typically require a site to be at least three to four times greater in size than the total landfill footprint. Therefore, the target candidate landfill site would need to be 500 to 800 acres.

Sites with direct access from a major roadway would be preferred, to maximize transportation efficiency while avoiding residential areas. A preliminary assessment of parcels in the target search area indicates a limited number of single parcels that may meet the screening size threshold and siting criteria. Therefore, combinations of multiple parcels would likely be required.

Based on the preliminary screening-level assessment, development of a single new off-site landfill to manage CCR from one or more Dominion facilities could potentially meet the timeline required for CCR closure established by the CCR Rule (maximum 15 years). In order to implement this option, significant additional work would be required to identify candidate sites, assess the transportation routes to the sites, coordinate with local municipalities to determine development requirements, negotiate and purchase land, implement the 3 to 5 year permitting process for establishing a new landfill, and design and construct the landfill.

The most streamlined option for constructing a new landfill would entail identifying properties within a 50-mile radius of the Dominion power stations that have already gone through preliminary zoning and permitting for waste acceptance. Depending upon the property owner and permit status, this could potentially save 3 to 5 years from the timeline to purchase an undeveloped property and permit it as a solid waste facility.

8.3.4 Transportation

Transportation options to remove CCR from Chesterfield Power Station include trucking, rail, and barge.

8.3.4.1 Transport by Truck

Transportation by 15- to 18-cubic yard dump trucks and trailers with maximum 18- to 22-ton capacities would be the most efficient means of trucking CCR. The ability to load and manage trucks efficiently at the impoundment is the primary variable for determining the number of truck loads that can reasonably be transported off the site per day. Based on experience and discussions with industry representatives, AECOM has assumed an aggressive rate of 150 truckloads per day being transported off site. Based on a 10-hour workday, this equates to a loaded truck leaving the site every 3 minutes for 5 days per week, on average. The haul distance to the chosen landfill and turnaround times would determine the number of trucks in rotation to support this production rate. Maintaining this production rate would require very efficient and well-designed plans for safely managing truck traffic, loading, weighing, washing, and re-entry to the local road network.

CCR stockpiling and truck loading area(s) could be constructed within the northern footprint of the Lower Ash Pond, or at the western end of the Upper Ash Pond. Truck access would be via Coxendale Road and Old Stage Road, which also serve the Henricus Historical Park and a county boat ramp. The truck routing around Chesterfield Power Station could create local traffic conditions that would impact public access, and would require amendment of the current Conditional Use Permit to allow hauling of CCR on county roads. A general arrangement for material handing for the trucking option is shown on Figure 17.

The closest landfill options for disposal of CCR by truck from Chesterfield Power Station are the Shoosmith Landfill in Chester (8 miles), the Waste Management Charles City County Landfill (29 miles), and the Waste Management Maplewood Recycling and Waste Disposal facility in Amelia County (43 miles). Potential trucking routes for the Shoosmith and Charles City landfills are shown on Figure 18.

8.3.4.2 Transport by Rail

Transportation by rail would include arrangements for dedicated unit trains to haul CCR to a landfill with rail capability. Based on discussions with landfill operators, acceptance rates of CCR by rail is generally not a constraining factor as long as sufficient lead time (6 to 12 months) is provided in the project for permit modifications and physical expansion of monofills and rail infrastructure to match acceptance rate needs.

The existing rail facilities at Chesterfield Power Station are fully utilized for transporting coal to the power station. A new rail network would need to be constructed to receive, stage, load, and re-assemble gondolas for CCR loading and transportation. Sufficient space appears to be available for a new siding adjacent to the existing sidings west of the station, and a new spur to the south with four to six switched tracks for loading CCR adjacent to the lower and upper ash ponds. However, space is extremely limited for constructing a dedicated rail connection between a new siding to the west and spurs to the south. This connection may require moving current tracks or adding switches to share a portion of track with the inbound coal trains. Close coordination during movement of coal and CCR rail cars would be required to minimize delays to either operation. A general concept for adding additional siding and spurs at Chesterfield Power Station is provided in Figure 19. On-site rail improvements to facilitate transporting CCR by rail are estimated to cost approximately $14 million and would take approximately 3 years to permit and construct.

Given the ongoing use of coal at Chesterfield Power Station, an option for using the empty coal trains to backhaul CCR was considered and determined to be non-viable for numerous reasons. First, CCR and coal are fundamentally different materials with different handling properties and would require different types of rail cars. Coal hopper cars loaded with CCR would likely experience problems with the CCR bridging and jamming the hopper systems, and would require extensive cleaning before the car could be used for coal again. The locations for coal loading and unloading would differ from the locations for CCR loading and unloading, so separate handling systems would be required regardless of whether the same trains and cars were used for both hauls. Coordination of coal trains and power demands requires accurate scheduling. Using coal trains to haul CCR would hamper and complicate coal shipments and create inefficiencies in coal delivery. For these reasons, backhauling CCR in empty coal trains was eliminated from further consideration as an option for CCR transportation.

In-state landfill options for accepting CCR by rail include the Maplewood Landfill in Amelia County. Out-of-state facilities that can accept CCR by rail include landfills in Ohio, Alabama, and Georgia. Major rail transporters have estimated the optimal rail loading and transport rate at ten unit trains every four weeks (85 gondola cars with a 90-ton capacity each), which is the equivalent of shipping out approximately 19,125 tons per week (995 thousand tons/year) via rail.

8.3.4.3 Transport by Barge

Given the stringent requirements for containerizing CCR to meet the regulations and the associated infrastructure costs to load, handle, transport, and unload containers, the option to transport CCR in containers by barge is not considered to be a reasonable or cost-effective option for transporting CCR relative to trucking and rail options. In general, barge transportation would require adequate shoreline facilities with sufficient channel depth (typically greater than 12 feet mean low water); docking and mooring facilities; loading and unloading systems, including container cranes and container handling systems installed at the station and port facilities; transportation systems (truck chassis) to haul containers from the port facility to the landfill; and a system to dump containers and reseal them for the return trip. The certified watertight containers would need to be special ordered at least 1 year in advance. To accommodate barge transportation, facility upgrades would be necessary, including dredging, support facility designs, and subsequent marine construction.

The Chesterfield Power Station is approximately 18 nautical miles northwest of Port of Weanack in Charles City, VA, which is a viable port location to support CCR offloading and trucking another 12 miles to the Charles City Landfill. However, given the extensive infrastructure requirements and inefficient handling required to support a container by barge option for such a short distance and large volume of CCR, barging is not considered feasible for Chesterfield Power Station.

A preliminary option to transport CCR to a barge port on the Mississippi River was also considered, but eliminated based on the excessive costs to handle CCR. Under this option, CCR would have to be transferred from a river barge to an ocean-going barge to make the trip around to the Gulf of Mexico and up the Mississippi, where it would be offloaded at a barge port onto trucks and transported to a landfill in the Midwest. Given viable rail and trucking options for CCR transportation and disposal, transportation by barge from Chesterfield Power Station was not considered to be viable.

8.3.5 Backfilling and Restoration of Former Ash Ponds

Restoration would depend on future site needs and conditions. Restoration activities could include reusing the former ash pond areas as stormwater management facilities, backfilling pond areas for re-development, removing dikes and restoring original grades, creating wetlands, or restoring habitat. Restored former ash ponds could also be used to support ongoing power generating activities by serving as equipment or material storage areas, parking or staging areas, or maintenance areas. Post-removal use of the site would be included in the closure by removal design.

Restoration for Chesterfield Power Station would include restoring the footprints of the Upper and Lower Ash Ponds to a grade above the floodplain, or approximately 18 feet msl. The remaining berms around the Upper Ash Pond would be pushed into the pond and re-graded to restore the area to a flat surface. Due to its lower elevation, the Lower Ash Pond would require transporting approximately 3 million CY of clean fill from off site to replace the removed CCR and restore the site to an elevation of 18 feet msl.

The closure by removal work plan would also provide for decommissioning and de-classification of the impoundment dams to remove them from regulatory oversight. Decommissioning and de-classification would involve breaching or completely removing the earthen embankment so that it could no longer impound water. Spillway structures could be abandoned in place by grouting or other approved means, or completely removed. Remaining soil removed from the embankments that meets regulatory criteria to allow it to remain in place would be used during the closure by removal process or as part of the site restoration. During restoration, the embankment soil could be used to restore pre-development lines and grades and to promote effective surface water runoff.

Restoration activities would result in a site that requires minimum long-term maintenance. Establishment of vegetation, restoration of effective surface water conveyance, and providing for erosion and sediment control would be included in the design.

8.3.6 Summary of Closure by Removal and Landfilling Considerations

Removal of the CCR materials from the Lower and Upper Ash Ponds would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality. However, these benefits would not be realized until the removal was completed and the groundwater naturally attenuated over time. The primary considerations associated with off-site landfill options are related to excavating, handling, processing, and transporting the ash off site. These activities result in safety, noise, and emissions challenges associated with heavy construction equipment operating on the site and up to 150 trucks per day leaving the site on a daily basis for 28 or more years. Transport by rail could potentially decrease the transportation duration to approximately 20 years. Additional considerations include the engineering and safety concerns associated with continuously dewatering and leaving the ash pond open for more than 20 years.

Additional impacts associated with constructing a new off-site landfill (as opposed to using an existing off-site permitted facility) include community and environmental concerns with constructing a 150- to 200-acre landfill, and the time required for site selection, land acquisition, permitting, and construction (estimated at 5 to 7 years), followed by hauling the ash to the new landfill; these activities would likely exceed the CCR Rule closure requirements of 15 years.

Table 37 summarizes some of the considerations associated with closure by removal to a landfill at Chesterfield Power Station.

Table 37: Closure by Removal with Landfill Considerations for Chesterfield Power Station

Category	Considerations
Safety	• Ash pond stays open for 29 years (1 year to obtain regulatory approval and construct loading facilities, remaining years to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety risks from excavation and over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day for 28 years) • Excavation/construction safety during 28 years of operating heavy equipment and dump trucks on and adjacent to the station • Rail decreases the duration to 24 years (4 years to design, permit, and construct, remaining years to transport), potentially decreases the transportation-related risks
Environmental	• Ash pond stays open for 29 years, with resulting prolonged duration for dewatering and water treatment • Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required • Rail decreases the duration to 24 years, potentially decreases the transportation-related risks • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time • For development of new off-site landfill, potential impacts to wetlands, environment; loss of trees; dust, leachate control; groundwater protection
Community	• Community impacts from over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day for 28 years) • Increased noise, emissions, truck traffic, accident potential • Transportation by rail may decrease community impacts; noise, safety, and emissions remain concerns • For development of new off-site landfill, community concerns with developing landfill “in their backyard”; construction impacts; multiple truck impacts once operational
Schedule	• 29-year duration for truck hauling exceeds CCR closure requirements of 15 years • Rail decreases the duration to 24 years, also exceeding the 15-year closure requirement • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time • For development of new off-site landfill, site selection, land acquisition, permitting, and construction schedule could take 5 to 7 years, followed by hauling/placement, which would likely exceed CCR closure requirements of 15 years

CCR = coal combustion residuals

8.4 Closure-in-Place

The station contains two CCR surface impoundments as defined by the CCR Rules, the Lower Ash Pond and the Upper Ash Pond. Under the closure-in-place option, both ash ponds are proposed to be closed in accordance with the CCR Rule by leaving the ash in place, removing free liquids, and installing an engineered final cover system.

As required by federal and state solid waste regulations, engineering investigations and evaluations have been completed for the Lower and Upper Ash Ponds at the Chesterfield Power Station, including the original design, subsequent evaluations, U.S. Environmental Protection Agency (USEPA) dam safety assessment, CCR Rule certifications, and closure plans. AECOM also performed a storm surge analysis to supplement existing evaluations to meet SB 1398 requirements (included as an appendix in Technical Memorandum 5).

AECOM's assessment of the cumulative information shows that closure-in-place at Chesterfield Power Station would provide long-term safety of the CCR units and would address the long-term risks as described in the closure plan previously submitted to the Virginia Department of Conservation and Recreation (DCR), siting requirements, and the ability to withstand extreme weather events (including flooding, hurricanes, storm surges, and erosive forces) and earthquakes. The closure-in-place design for the Lower Ash Pond may need to be supplemented to provide additional protection for the final cover for potential storm surge, which could entail adding riprap or protective measures to the top surface of the cover. The current closure design meets the following requirements that would ensure long-term safety after the ash ponds have been closed in place:

- Designed to withstand a 100-year flood (top of cap is above 100-year flood elevation)
- Stormwater drainage for a Probable Maximum Flood (PMF), the potentially largest flood resulting from a combination of the most severe rainstorm events for a given area
- No downstream water quality or flow impacts resulting from the closed ash pond
- No effect on the structural stability of the closed ash pond from receding floodwater or rapid water drawdown
- Final cover design to withstand wind uplift and flooding from a Category 4 hurricane
- The final cover elevation and stormwater measures would protect against erosion from 100-year flooding or storm events, along with potential storm surges from the river
- Structural stability of the fill (ash), embankments (sides), and final cover maintained under a wide range of potential conditions, including earthquakes and storm events
- The facility would continue to maintain an Emergency Action Plan (EAP) to protect downstream areas from a potential breach

Primary safety and engineering considerations associated with closure-in-place are related to dewatering and water treatment during the closure operations, community impacts during the approximately 2 to 3 years of construction (noise, emissions, dust), and construction quality control for the installation of the final cover material (geosynthetic liner, soil cover, and vegetation). The cover is designed to protect groundwater from future infiltration, which should have a positive benefit on long-term groundwater quality. Long-term considerations also include the ongoing O&M of a corrective measure technology, if needed. The CCR Rule also requires a minimum of 30 years of post-closure care, to include groundwater monitoring, maintenance of the cover system, and continued compliance with dam safety regulations, in accordance with a DEQ Solid Waste Management Regulations (VSWMR) Permit.

Table 38 summarizes some of the considerations associated with closure-in-place at Chesterfield Power Station.

Table 38: Closure-in-Place Considerations at Chesterfield Power Station

Category	Considerations
Safety	• Excavation/construction safety during 3 to 5 years of operating heavy equipment and dump trucks on and adjacent to the station • No impacts for CCR removal or off-site hauling • May require additional design features to protect covered final surface from storm surge, likely riprap protective material
Environmental	• No impacts for CCR removal or off-site hauling • Noise and emissions from excavation equipment • Dust and odor control may be required • Ash pond stays open for 3+ years, requiring dewatering and water treatment • Engineering challenges for CCR dewatering and excavation • Once closure is complete, decreased potential for groundwater migration from CCR materials remaining in place
Community	• No impacts for CCR removal or off-site hauling • Potential noise, emissions, and truck traffic associated with on-site construction
Schedule	• 3 to 5 years for closure much shorter duration than other options • Installation of corrective measures may take 2 years • Estimated 10- to 30-year duration for groundwater corrective measures

CCR = coal combustion residuals

8.5 Groundwater and Surface Water

The uppermost sediments at the station are alluvial materials associated with the present-day James River. Ground surface topography in the area of the station is typically level, with some slightly sloping grades adjacent to the banks of the James River, and groundwater in the uppermost aquifer generally flows radially from beneath the Lower Ash Pond and Upper Ash Pond.

8.5.1 Groundwater

The uppermost groundwater aquifer is unconfined within surficial overburden and sediments (Columbia Aquifer). This aquifer is hydrologically connected to the lower Potomac Formation, which has a fine-grained confining unit present at the top of the formation across most of the station. A fractured bedrock aquifer (Potomac Aquifer) lies below the Potomac. Triassic formation sediments are considered to be part of the bedrock aquifer system, serving as a confining layer. Figure 20 shows the potentiometric map. There are no surveyed drinking water wells downgradient from the station, and no drinking water supply wells on the property.

The station has historically monitored groundwater in accordance with their VPDES Permit and the associated Groundwater Monitoring Plan (GMP). One dissolved metal (manganese) and several water quality parameters have been detected at concentrations greater than background downgradient of the Upper Ash Pond. There were no constituents with detected concentrations above an MCL.

Background groundwater sampling was performed in 2016 and 2017 in accordance with the CCR Rule. The USEPA established Maximum Contaminant Levels (MCLs) as the maximum level of a constituent in drinking water at which no known or anticipated adverse effect on the health of persons would occur, allowing an adequate margin of safety. For constituents that do not have USEPA-established MCLs, analytical results are compared to the background levels established during baseline sampling.

Preliminary groundwater sampling results show detections above background levels of several CCR constituents in the uppermost aquifers downgradient of the Lower Ash Pond and Upper Ash Pond. Additional monitoring is required before these results are confirmed. Several constituents have also been detected above background in the bedrock aquifer downgradient of the Upper Ash Pond. Arsenic and combined radium (isotopes 226 and 228) have been detected above MCL at the Lower Ash Pond, and arsenic, beryllium, chromium, and combined radium have been detected above MCL at the Upper Ash Pond. Arsenic was detected above MCL in a background well, indicating that there may be a naturally-occurring source of arsenic.

8.5.2 Surface Water

The surface water samples collected by Dominion and the Commonwealth of Virginia from the James River in June 2016 and April 2017 were all below Virginia Surface Water Quality Standards for aquatic life and human health.

8.6 Groundwater Corrective Measures

Preliminary groundwater results show detections of CCR related constituents above background levels. Based on that data and site-specific conditions, AECOM performed an evaluation of potential corrective measures to remediate the groundwater related to the Lower and Upper Ash Ponds. Additional monitoring is required before these results are confirmed. The technologies that could potentially remediate the groundwater associated with these ponds are the following:

- Complete in situ stabilization/solidification (ISS) – an agent is mixed into the CCR to physically and chemically bind the metals and other inorganic constituents, preventing them from leaching into the groundwater and thus effectively removing the source; only potentially viable for the Lower Ash Pond
- Containment ISS on bottom and side of ash pond to create containment cell – an agent is mixed into the CCR to physically and chemically bind the metals and other inorganic constituents. The binding agent is used to create an impermeable layer below and surrounding the ash; combined with a cover, it effectively creates a containment cell around the ash; only potentially viable for the Lower Ash Pond
- Vertical engineered barrier (VEB), which is containment via slurry walls – a subsurface wall is constructed to prevent groundwater from flowing out of the ash pond; if needed, hydraulic containment can supplement VEB
- Hydraulic containment via pump-and-treat methods – groundwater is pumped from a series of wells with overlapping influence to cut off groundwater from flowing downgradient; extracted water is treated to below permit requirements and discharged

- Monitored natural attenuation (MNA) – employing physical processes that naturally reduce the concentration, toxicity, or mobility of CCR constituents in groundwater, attenuating the constituents by chemical reactions with other dissolved constituents and the soil media

Tables 39 and 40 describe how these corrective measures can address the items in 40 CFR § 257.96 and outline how each technology could potentially be implemented to remediate groundwater to levels below station-specific cleanup goals.

All of the potential options have relatively similar anticipated durations to reach groundwater cleanup standards. In general, due to the depth of the confining layer immediately downgradient of the Upper and Lower Ash Ponds, options such as a slurry wall, or pump-and-treat would incur high costs. Hydraulic flow patterns from the Upper and Lower Ash Ponds are radial in nature, which could require corrective measures around the entire perimeter of each pond. Permeable reactive barriers (PRBs) are not feasible at the Chesterfield Ash Ponds due to the depth to confining layer immediately downgradient of the ponds (80 to 100 feet) and the limited space available to install multiple barrier walls that would likely be required to adequately treat the groundwater.

ISS becomes cost-prohibitive deeper than approximately 50 feet, due to the specialty auger equipment necessary to produce enough torque to move through the materials at depth, and the requirement for smaller auger diameters to generate that torque. Smaller diameter augers, with the requirement to overlap holes, results in a much smaller grid size and thus an order of magnitude more auger holes required to contact the entire volume of ash, resulting in a much higher cost. Therefore, ISS is not feasible for the 100 foot depth at the Upper Ash Pond.

Any potential corrective measure technology would require a comprehensive remedial design process that would include acquisition of additional data as needed, laboratory bench-scale testing, and potentially a pilot test before designing and implementing the full-scale construction of the selected remedial technology. Combinations of technologies could be tested, and additional emerging technologies could be evaluated as their effectiveness on CCR constituents, such as metals, is proven.

As described in the Gradient report, *The Relative Impact Framework for Evaluating Coal Combustion Residual Surface Impoundment Closure Options: Applications and Lessons Learned* (Lewis and Bittner, 2017), both closure-in-place and closure by removal “provide significant beneficial impacts to groundwater quality compared with continued surface impoundment operations and that neither of the closure options is always more beneficial, with respect to downgradient groundwater quality, than the other. These results are consistent with the USEPA position in the CCR Rule that both closure options can be equally protective, provided they are implemented properly.” The report goes on to state, “Moreover, it is possible that groundwater corrective actions, if instituted as part of a combined remedy with closure-in-place, would result in a greater and more rapid reduction of contaminant concentrations in downgradient groundwater than closure by removal in some assessments.” The authors additionally note that surface water impacts under both closure by removal and closure-in-place are minimal.

Table 39: Chesterfield Power Station Lower Ash Pond Groundwater Corrective Measures Summary

Evaluation Factor		In Situ Stabilization/Stabilization (ISS)	ISS to Create Bottom and Side Containment around Cell	Vertical Engineered Barrier (VEB) – Slurry Wall	Pump and Treat with Multiple Treatment Technologies	Monitored Natural Attenuation (MNA) with Risk Assessment
General Technology Specifications		Approximately 3.6M CY CCR over 101 acres, 20 feet deep	Approximately 5-foot-thick ISS layer at bottom of CCR over 101 acres, 20-foot-deep sidewalls around unit, cap on top	Approximately 9,600 LF wall 80 feet deep surrounding CCR unit; deep trenching technology for installation	Approx. 10 extraction wells, 200 gpm total flow; anticipated treatment technologies include chemical oxidation or aeration, pH adjustment, coagulation/ flocculation, bag/cartridge filtration, targeted adsorptive media	Downgradient of CCR unit using existing monitoring well network
Additional Requirements		Approximately 41 acres currently has standing water; large-diameter auger mixing ~10% Portland cement	Approximately 41 acres currently has standing water; large-diameter auger mixing ~10% Portland cement	Hydraulic control; approx. 10 extraction wells @100 gpm total flow behind VEB with groundwater treatment	Wells located along approx. 9,600 LF along perimeter of CCR unit	Risk assessment would be performed to verify that MNA would be protective of human health and the environment
Cost Estimate		$791M	$284M	$126M	$96M	$4.5M
Schedule	**Construction**	Moderate duration for implementation (approx. 2-3 years); rapid curing/reaction	Moderate duration for implementation (approx. 2-3 years); rapid curing/reaction	Moderate duration for implementation (approx. 1-2 years)	Moderate duration for construction (approx. 1-2 years)	No construction needed
	Anticipated Duration to Reach GPS	Source removal designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this evaluation, a 10- to 30-year time frame is assumed	Continued indefinite monitoring; for the purposes of this evaluation, a 10- to 30-year time frame is assumed
Potential Corrective Measure Benefits		• Complete source immobilization by physical encapsulation and chemical stabilization • Solidified/stabilized matrix with leachate testing provides proven long-term reliability • Impacts primarily limited to on-site	• Complete source containment by constructing an impermeable cell • Solidified/stabilized containment with leachate testing provides proven long-term reliability • Impacts primarily limited to on-site	• Slurry wall combined with pumping designed to provide source containment • Extraction designed to minimize hydraulic pressure on slurry wall and prevent groundwater from flowing around the edges of the wall • Complete source containment by preventing groundwater flow from ash pond footprint, allowing downgradient impacts to decrease • Impacts primarily limited to on-site	• Pump-and-treat proven technology for hydraulic control and removal of contaminants from groundwater, reducing downgradient risks to human health and environment • Complete source containment by hydraulically controlling groundwater flow from ash pond footprint, allowing downgradient impacts to decrease • Impacts primarily limited to on-site	• Relies on natural attenuation mechanisms for performance • No technology construction is required
Potential Corrective Measure Considerations		• Ash remains in place • Requires full, stable access across the entire ash pond surface area • Augering to approximately 20 feet in an overlapping pattern across a 101-acre area • Trucking delivery of large volumes of Portland cement • Requires heat of reaction control, dust control; reaction may produce odors • Requires monitoring for remedial effectiveness • Becomes cost prohibitive if applied deeper than approximately 50 feet	• Ash remains in place • Unproven technology for CCR units • Difficult to prove continuous solidification along bottom surface with no gaps • Requires understanding of depth profile of ash within pond • Requires full, stable access across the entire ash pond surface area • Augering to approximately 20 feet in an overlapping pattern across a 101-acre area • Trucking delivery of large volumes of Portland cement • Requires heat of reaction control, dust control; reaction may produce odors • Requires monitoring for remedial effectiveness • Becomes cost prohibitive if applied deeper than approximately 50 feet	• Ash remains in place • Geology dependent • Requires deep trenching along 9,600 LF length • Complete source containment, but not removal • Requires heat of reaction control, dust control; reaction may produce odors • Monitoring/sampling required • Pump testing required to design extraction well network • Bench scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems – duration unknown, ongoing O&M/treatment costs • Extraction network and treatment system periodically evaluated for effectiveness, would require periodic changes in and/or regeneration of filtration/treatment media	• Ash remains in place • Requires installation of 10 extraction wells and subsurface piping network to centralized groundwater treatment system housed in a building • Pump testing required to design extraction well network • Bench scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems – duration unknown, ongoing O&M/treatment costs • Extraction network and treatment system periodically evaluated for effectiveness, would require periodic changes in and/or regeneration of filtration/treatment media	• Ash remains in place • Monitoring/sampling required • Routinely evaluate for changing conditions

Table 40: Chesterfield Power Station Upper Ash Pond Groundwater Corrective Measures Summary

Evaluation Factor		Vertical Engineered Barrier (VEB) - Slurry Wall	Pump and Treat with Multiple Treatment Technologies	Monitored Natural Attenuation (MNA) with Risk Assessment
General Technology Specifications		Approximately 12,000 LF wall 100 feet deep surrounding CCR unit; deep trenching technology for installation	Approx. 12 extraction wells, 350 gpm total flow; anticipated treatment technologies include chemical oxidation or aeration, pH adjustment, coagulation/ flocculation, bag/cartridge filtration, targeted adsorptive media	Downgradient of CCR unit using existing monitoring well network
Additional Requirements		Hydraulic control: approx. 12 extraction wells @175 gpm total flow behind VEB with groundwater treatment	Wells located along approx. 9,600 LF surrounding CCR unit	Risk assessment would be performed to verify that MNA would be protective of human health and the environment
Cost Estimate		$208M	$145M	$4.5M
Schedule	**Construction Schedule**	Moderate duration for implementation (approx. 2-3 years)	Moderate duration for construction (approx. 1-2 years)	No construction needed
	Anticipated Duration to Reach GPS	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this assessment, a 10- to 30-year time frame is assumed	Source removal/ control designed for downgradient constituent levels to reach GPS; for the purposes of this assessment, a 10- to 30-year time frame is assumed	Continued indefinite monitoring; for the purposes of this assessment, a 10- to 30-year time frame is assumed
Potential Corrective Measure Benefits		• Slurry wall combined with pumping designed to provide source containment • Extraction designed to minimize hydraulic pressure on slurry wall and prevent groundwater from flowing around the edges • Complete source containment by preventing groundwater flow from ash pond footprint, allowing downgradient impacts to decrease • Impacts primarily limited to on-site	• Pump-and-treat proven technology for hydraulic control and removal of contaminants from groundwater, reducing downgradient risks to human health and environment • Complete source containment by hydraulically controlling groundwater flow from ash pond footprint, allowing downgradient impacts to decrease • Impacts primarily limited to on-site	• Relies on natural attenuation mechanisms for performance • No technology to require reliability • Easy to implement; only requires continued groundwater monitoring
Potential Corrective Measure Considerations		• Ash remains in place • Geology dependent • Complete source containment, but not removal • Requires deep trenching along 12,000 LF • Requires heat of reaction control, dust control; reaction may produce odors • May require additional measures for downgradient plume • Monitoring/sampling required • Pump testing required to design extraction well network • Bench scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems – duration unknown, ongoing O&M/treatment costs • Extraction network and treatment system periodically evaluated for effectiveness, would require periodic changes in and/or regeneration of filtration/treatment media	• Ash remains in place • Requires installation of 12 extraction wells and subsurface piping network to centralized groundwater treatment system housed in a building • Pump testing required to design extraction well network • Bench scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems – duration unknown, ongoing O&M/treatment costs • Extraction network and treatment system periodically evaluated for effectiveness, would require periodic changes in and/or regeneration of filtration/treatment media • Requires an approximately 20-foot wide corridor for installation	• Ash remains in place • Monitoring/sampling required • Routinely evaluate for changing conditions

Figures

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LEGEND

Approximate Property Boundary

Approximate Pond Boundary

N

0 1,000 2,000 4,000
Feet

AECOM

Figure 13
Site Location

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RIP	CTM	NMP	REV. 0

Chesterfield Power Station

DATE:	DEPT:
10/3/2017	Environment

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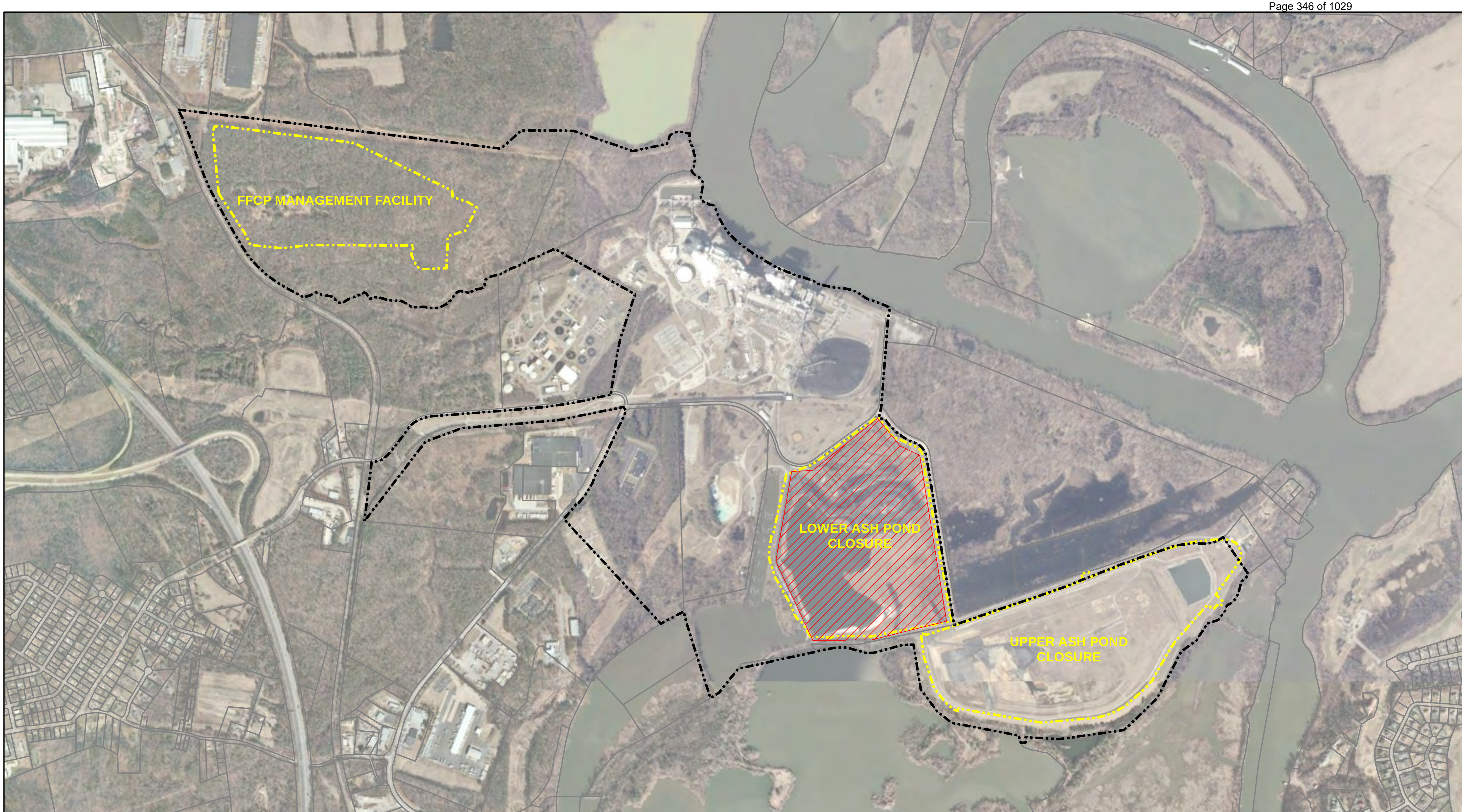

Legend

- Proposed Landfill Boundary
- Chesterfield Power Station Boundary
- Boundary
- Parcel Boundary

AECOM

Figure 14
New On-site Landfill Potential Location

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MPS	JAB	DOS	REV. 0

Chesterfield Power Station

DATE:	DEPT:
10/25/2017	Environment

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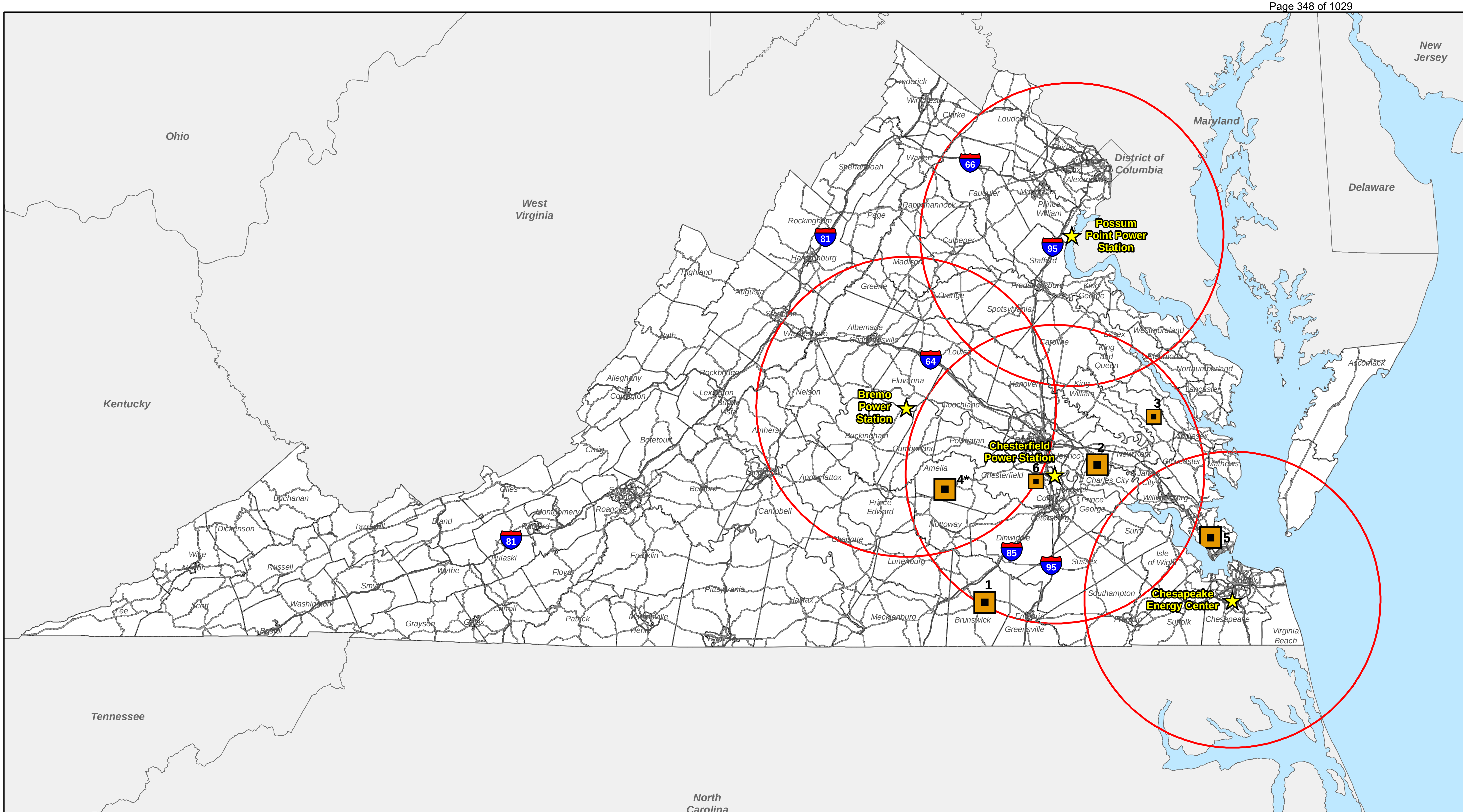

LEGEND

Limited Access Highway
High Occupancy Vehicle (HOV) Lane
US Primary Highway
50 Mile Radius
Virginia County

Landfill Location (remaining life)

10 - 25 yrs.
25 - 50 yrs.
> 50 yrs.
Dominion Plant Location

N

0 12.5 25 50
Miles

AECOM

Figure 15
Off-site Commercial Landfill Locations

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MPS	JAB	DOS	REV. 0

Chesterfield Power Station

DATE:	DEPT:
11/14/2017	Environment

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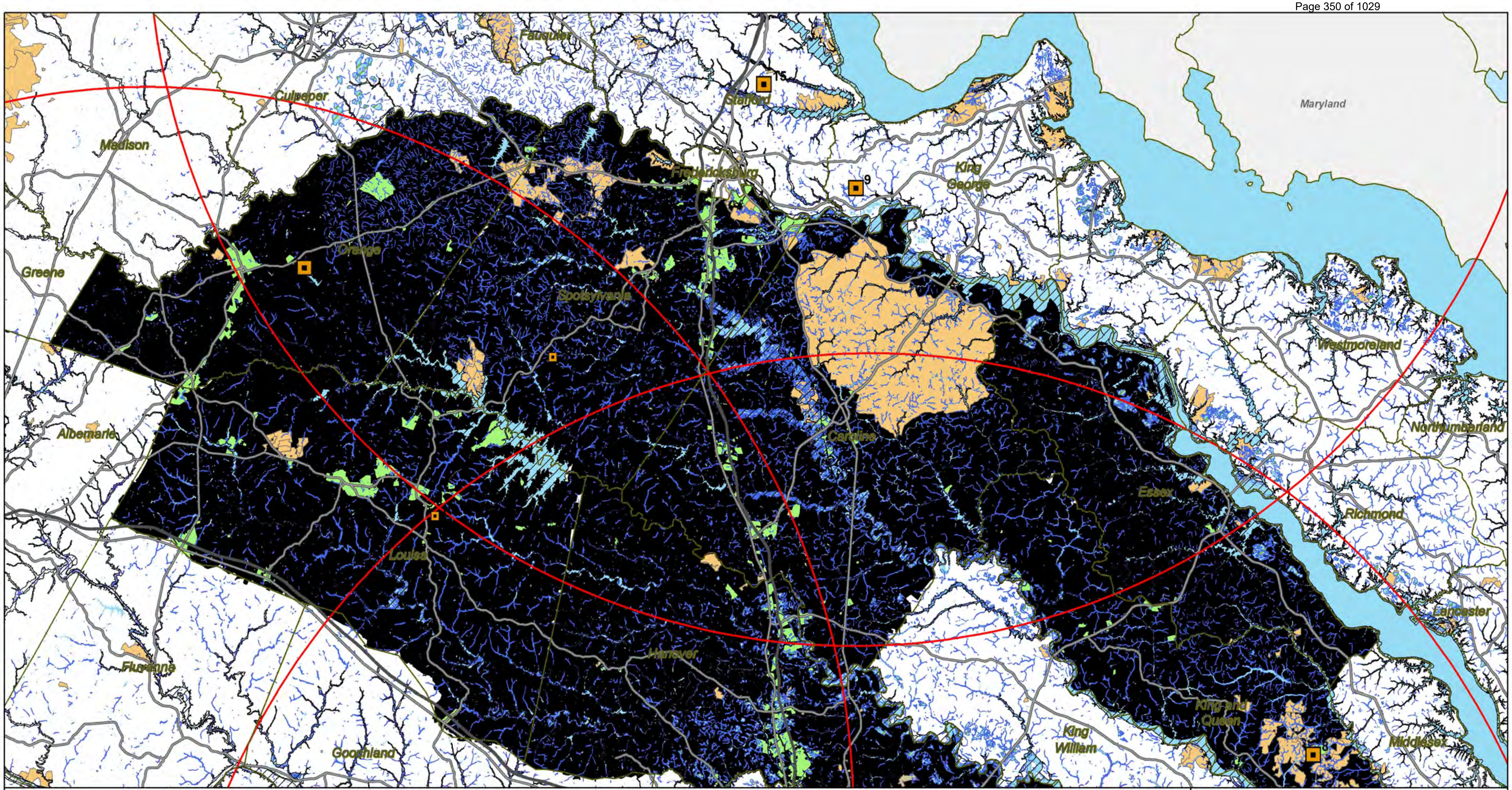

LEGEND

- Railroad
- Limited Access Highway
- High Occupancy Vehicle (HOV) Lane
- US Primary Highway
- 50 Mile Radius
- 100 yr. Flood Zone
- Wetland
- National Park Land
- US Forest Service Land
- Federal/State/Local Owned Land
- Virginia County

Zoning

- Non-Residential
- Residential and Agricultural

N

0 8 16
Miles

AECOM

Figure 16
Potential New Off-site Landfill General Location

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MARK P. SMITH	JOHN BOVE		

Chesterfield Power Station

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9/12/2017	Environment

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Figure 17
Closure by Removal Trucking Plan

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Chesterfield Power Station

DATE:	DEPT:
10/05/2017	Environment

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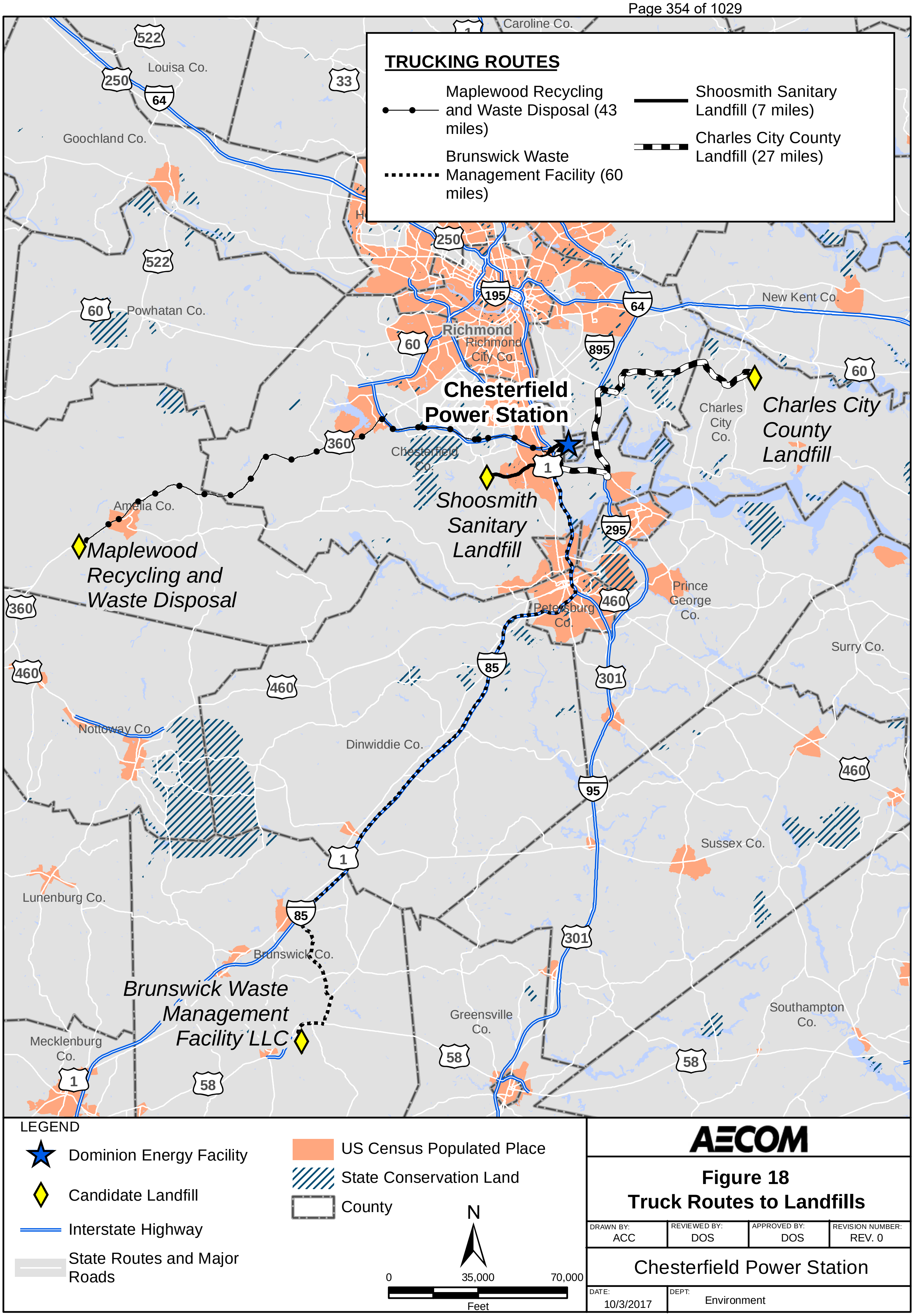

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Figure 18
Truck Routes to Landfills

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ACC	DOS	DOS	REV. 0

Chesterfield Power Station

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10/3/2017	Environment

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N

0 1,000 2,000 4,000
Feet

AECOM

Figure 19
Closure by Removal
Rail Plan

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Chesterfield Power Station

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LEGEND

- Approximate Property Boundary
- Approximate Ash Pond Boundary
- Potentiometric Contours

Compliance Program

- CCR Network Well
- CCR Network Background Well

AECOM

Figure 20
Potentiometric Surface
Shallow, April 2017

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Chesterfield Power Station

DATE:	DEPT:
10/3/2017	Environment

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Senate Bill 1398 Response

Coal Combustion Residuals
Ash Pond Closure Assessment

SECTION 9:
POSSUM POINT POWER STATION

November 2017

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9. Possum Point Power Station

9.1 Summary for Possum Point Power Station

This closure assessment focuses on the Possum Point Power Station Ash Pond D, where coal combustion residual (CCR) materials from Ash Ponds A, B, C, and E are actively being consolidated, as summarized in Table 41. Ash ponds can be closed by dewatering and then either removing the CCR materials or closing the pond in place. In the closure by removal option, CCR can be recycled/beneficially used or relocated to a lined, permitted landfill. Landfill options could include expansion of an existing on-site landfill, construction of a new on-site landfill, transporting the materials off site to a permitted commercial landfill, or transporting off site to a new landfill.

Table 41: Possum Point Power Station Ash Ponds

CCR Unit	Remaining CCR Volume (CY)	Operating Status	Area (acres)
Ash Pond A Ash Pond B Ash Pond C	40,000	Residual ash to be removed from Ash Ponds A, B, and C and transported to Ash Pond D	18
Ash Pond D	4,009,250	Slated for closure	70
Ash Pond E	2,250	Residual ash to be removed and transported to Ash Pond D	38
Total Volume	**4,051,500**		

CCR volumes are based on Dominion estimates as of July 10, 2017
CCR = coal combustion residuals; CY = cubic yards

AECOM assessed the following closure alternatives to address the long-term safety of Ash Pond D and protect public health and the environment:

- Closure by removal and beneficial use
- Closure by removal and landfilling
- Closure-in-place with groundwater corrective measures, if applicable

Table 42 provides a summary of the evaluated closure options for Ash Pond D at Possum Point Power Station, including an estimate of duration to complete each option, estimated costs, and the potential safety, community, and environmental considerations. All of these closure options have inherent risks that must be considered in the evaluation, including potential impacts to the community or the environment due to noise, truck traffic, potentials for accidents/spilled material, emissions, or potential for exposure to coal ash. As shown in Table 42, the options that include materials leaving the site would be implemented over 8+ years, resulting in large volumes of truck and potentially train traffic in and out of the station and through the adjacent communities on a daily basis for multiple years.

CCR materials are being removed Possum Point Ash Ponds A, B, C, and E. Closure by removal is therefore the selected closure method for these units; groundwater related to these units will continue to be monitored as required by the CCR Rule and other federal or state regulations.

Table 42: Summary of Closure Options for Possum Point Power Station

Closure Option	Est. Time Frame	Est. Cost[1]	Implementation Considerations
Closure by Removal and Beneficial Use	8 to 17 years	$471M to $899M	• Ash pond stays open for 8+ years (3 years design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • *Duration to implement several evaluated technologies may exceed CCR closure requirements of 15 years* • The time frames are driven by the available market and throughput of beneficiation technologies • Safety and community risks from excavation and over-the-road hauling due to significant volume, multi-year duration removal project (up to 150 trucks/day each way for 5+ years) • Truck traffic may result in increased noise, emissions, truck traffic, and vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and On-Site Landfilling	8 years	$380M	• Ash pond stays open for 8 years, increases safety risk, and results in prolonged duration for dewatering/water treatment • Only feasible if the DEQ and local authorities grant a variance to allow the setback from the road to be reduced from 500 to 200 feet • Eliminates risks associated with off-site hauling, truck traffic • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering, excavation, and staging
Closure by Removal and Off-Site Commercial Landfilling by Truck	9 years	$799M	• Ash pond stays open for 9 years (1 year design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety and community risks from excavating and over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day each way for 8 years; truck leaving site approximately every 3 minutes for 10 hours per day Monday through Friday) • Truck traffic may result in increased noise, emissions, traffic congestion, vehicle accidents • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation

Table 42 (cont.): Summary of Closure Options for Possum Point Power Station

Closure Option	Est. Time Frame	Est. Cost[(1)]	Implementation Considerations
Closure by Removal and Off-Site Commercial Landfilling by Rail	9 years	$1.11B	• Ash pond stays open for 9 years (2 years design/permit/construct, remaining transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety and community risks from excavation and rail hauling due to significant volume and multi-year duration removal project (180 railcars per week for 7 years) • Reduced hauling risks for rail vs. trucking • Excavation and construction noise and traffic • Removes source of potential groundwater impacts • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation
Closure by Removal and Off-Site Commercial Landfilling by Barge and Trucking	15 years	$1.7B+	• Ash pond stays open for at least 15 years (4 years design/permit/construct, remaining transport), increases safety risk, results in prolonged duration for dewatering/water treatment • Safety and community risks from CCR removal; excavation and construction noise and traffic • Option involves trucking of CCR material to barge facility and once barge reaches its destination, CCR material would be trucked an additional 18 miles on public roads to landfill • Virginia regulations require sealed containers that would need to be loaded onto and off of barges by crane, requiring infrastructure construction at both ends • Engineering risks for CCR dewatering and excavation • Lower groundwater risks after removal is completed; higher groundwater risk during removal
Closure-in-Place with Potential Groundwater Corrective Measures	3 to 5 years	$137M to $418M	• No impacts for CCR removal or off-site hauling • Lowest risk for safety, community, schedule, and cost • Lower groundwater migration potential for CCR remaining in place once closure is complete, which is addressed by corrective measures • Includes cost range for corrective measures • 2-year corrective measure construction duration • Estimated 10- to 30-year duration for groundwater corrective measures

(1) All costs in this report are Class 5 estimates (+100%, –50%) and represent opinions of probable cost based on information available at the time of this study. AECOM is not responsible for any variance from costs presented in this document or actual prices and conditions obtained.

B = billion; CCR = coal combustion residuals; DEQ = Virginia Department of Environmental Quality; M = million; NA = not applicable

To support this closure assessment, AECOM developed cost estimates for the closure alternatives listed above. These Opinions of Probable Cost are estimates of potential construction costs for informational purposes. The costs are Class 5 Estimates (+100%, -50%) and are limited to the conditions existing at issuance and not a guarantee of actual price or cost. Uncertain market conditions such as, but not limited to: local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions may affect the accuracy of these estimates.

In accordance with the CCR Rule, closure of the Ash Pond D must be completed within 15 years (5-year base period plus up to five extensions in 2-year increments). Exhibit 9 shows the estimated timeline for each of the closure options compared to the CCR Rule durations; note that some of the beneficial use technologies cannot meet the 15-year closure timeline.

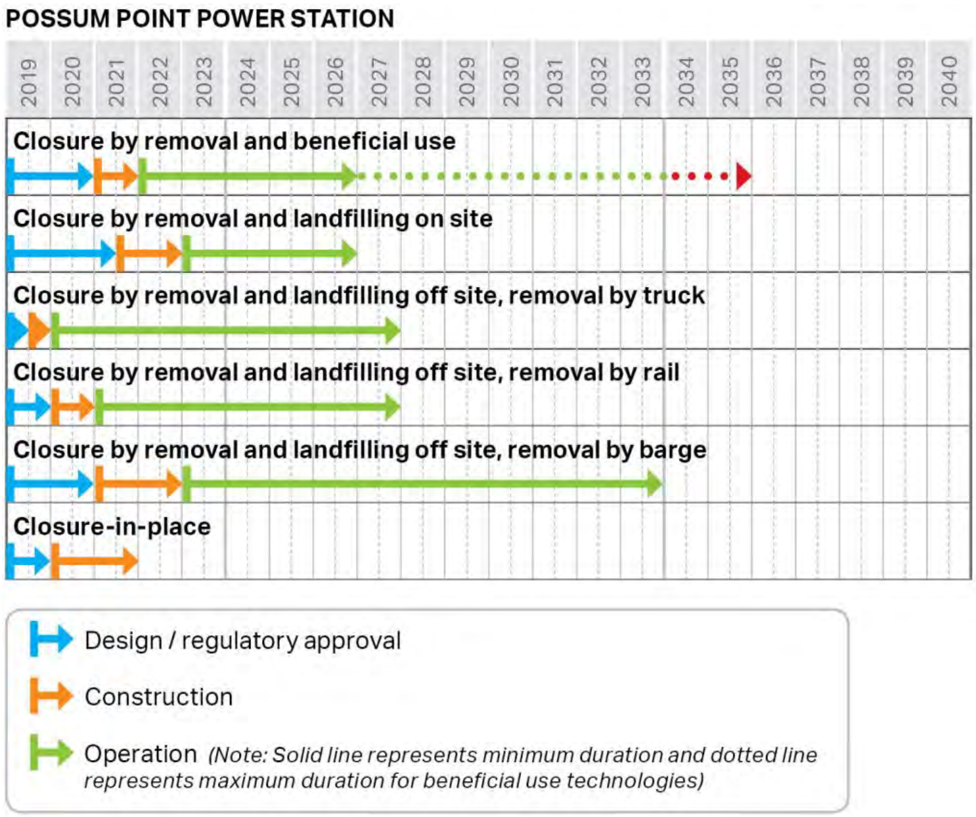

Exhibit 9: Closure Implementation Timeline – Possum Point Power Station

9.2 Site Background

The Possum Point Power Station is located in Prince William County, VA, at 19000 Possum Point Road, Dumfries. Figure 21 provides the station location and primary site features. The power station includes 650 acres of land bordered by suburban and rural properties. The station is located at the southern tip of Possum Point peninsula, adjacent to the western bank of the Potomac River and the northern bank of Quantico Creek. Residential properties are located to the northwest of the station, separated from Pond E by Beaver Pond. A residential neighborhood is currently being developed immediately north of the station.

The station began operating in 1948 and ceased coal-burning operations in 2003; no CCR has been generated since that time. Two active units burn natural gas, one unit burns oil, and two additional combined cycle units burn a combination of natural gas and oil to generate power.

Five on-site surface impoundments (Ponds A, B, C, D, and E) are subject to the requirements of SB 1398 and the CCR Rule. CCR materials have been substantially removed from four of the five ash ponds at the station (Ponds A, B, C, and E) and consolidated in lined Ash Pond D, which was constructed in 1988 to replace an unlined ash pond at the same location. A slurry wall was installed as a barrier between the deposits of the pre-existing ash pond and the adjacent groundwater-bearing zone. Ash Pond D is lined with a low-permeability clay liner consisting of a 2-foot-thick compacted clay liner along the pond slopes and a clay bottom over the previous impoundment. Ash Pond D has an approximate footprint of 70 acres and is up to 120 feet deep, containing approximately 4 million CY of CCR materials.

Ash Ponds A, B, and C are small, adjacent, unlined ponds with a total footprint of approximately 18 acres. These impoundments were constructed in 1955, were taken out of service in the mid-1960s, and are currently managed together. Approximately 40,000 CY of residual ash remaining in Ponds A, B, and C will be relocated to Pond D.

The 38-acre Ash Pond E was constructed in 1967 and used until 2003, when it stopped receiving ash. Approximately 2,500 cubic yards of CCR remains in Pond E beneath temporary water storage tanks; this material will be relocated to Pond D.

9.3 Closure by Removal

Closure by removal entails excavating the CCR materials from the ash pond and either beneficially reusing or placing them in a lined, permitted landfill. Primary components in this process include materials handling to remove the CCR from the ash pond and load the materials in trucks or railcars, transporting the materials to an off-site beneficial use or landfill facility, restoring the former ash pond to facilitate stormwater flow; and monitoring the groundwater to ensure continued protectiveness as required by the CCR Rule. These processes are described in the following sections.

9.3.1 Materials Handling

Closure by removal involves dewatering the ash ponds and treating the removed water, excavating the material and transporting it to staging/loadout areas, drying and stockpiling it for off-site transportation, loading for transport, and then restoring the ash pond footprint once all CCR materials have been removed.

9.3.1.1 Dewatering and Water Treatment

Surface water and pore water would be removed and treated to prepare for excavation and material handling. Well points and deep wells that have been installed in Ash Pond D would be used to dewater the full CCR thickness, with temporary trenches and CCR grading implemented to direct water to low points within the impoundments prior to removal. Dewatering activities would be initiated prior to excavation work and continue as long as necessary to ensure workable site conditions.

A specialized water treatment system would be installed to treat all CCR contact water to meet the discharge requirements of the Virginia Pollutant Discharge Elimination System (VPDES) permit. The water currently being treated at the Possum Point Power Station has been discharging below permit limits based on the design, construction, and operation of existing on-site systems. The dewatering and treatment system would be required to operate until all closure activities are complete.

9.3.1.2 CCR Excavation

Closure by removal would involve excavating ash from the pond such that no residual materials remain visible, followed by over-excavating the removal footprints by 6 inches as required by the Virginia Department of Environmental Quality (DEQ), which is more stringent than federal requirements.

9.3.1.3 Transportation to On-Site Staging/Loadout Areas

Once excavated, CCR would be loaded into dump trucks and hauled from the excavation to a staging area either within the ash pond or at a dedicated on-site stockpile area with proper containment, dust control, and water collection and treatment systems. On-site haul routes would likely need to be constructed or improved to be wide enough and have sufficient turning radii for efficient and safe operation of dump trucks. Water trucks would be necessary to reduce fugitive dust for the duration of hauling.

9.3.1.4 Drying and Stockpiling for Off-Site Transportation

In some cases, the CCR may need to be temporarily stockpiled to gravity drain and/or air dry to meet acceptable moisture content prior to loadout for off-site transportation. The CCR is typically required to have no more than 25% to 35% moisture content for transport and placement in a dry landfill. Drying areas may be near excavation or loadout areas, but sufficient laydown area would be planned to provide at least a week or more of drying time prior to loadout. Wind-rowed CCR may require re-handling several times to rotate the materials for maximum drying potential and to achieve desired moisture content prior to loadout.

9.3.1.5 CCR Loadout for Off-Site Transportation

Designated loadout areas would be established adjacent to truck or rail car staging areas for efficient loading operations. CCR would be loaded into trucks or rail cars using rubber-tired loaders or conveyors.

Truck loadout would include an on-site one-way loop road to provide safe exit from the adjacent public road, and areas for stacking and loading trucks, replacing covers, weight scaling, tire washing, and safe re-entry to the adjacent public road.

Rail loadout would involve using new and existing rail sidings and spur tracks to receive empty unit trains (85 gondola cars), splitting unit trains into smaller groups of gondola cars for on-site handling using a locomotive, installing disposable liners and covers, and loading gondolas, re-assembling trains of filled gondola cars, and staging on the adjacent siding for pickup by a freight rail firm.

9.3.2 Closure by Removal and Beneficial Use

AECOM's beneficial use and ash market study evaluated the market-wide demand for fly ash based on cement consumption and found that the regional (Virginia, Maryland, North Carolina, and the District of Columbia) fly ash supply is projected to exceed demand starting by 2019 without accounting for the more than 25 million tons of ponded ash stored at the four Dominion power stations. Regional supply is projected to be at least 2.3 million tons per year starting in 2019, while 2016 fly ash usage (demand) is estimated as 1.7 million tons, increasing to 2.3 million tons in 2035. Some of the regional fly ash consumers that were contacted by AECOM indicated desire and ability to use beneficiated fly ash. However, the demand quantities and market purchase price of the processed fly ash were highly variable, so Dominion would need to negotiate contracts with specific consumers prior to committing to beneficially use the ponded ash.

On the supply side, AECOM evaluated potential proven, developing, and research stage technologies that may be feasible to process the ponded ash at Dominion facilities. The list of potential beneficiation technology vendors is substantial and numerous technologies were considered in prior studies that were used for this assessment. Four technologies were further evaluated, including:

- The SEFA Group Staged Turbulent Air Reactor (STAR) process to refine the ash into a Portland cement replacement
- ST Triboelectric Separation Technology, which separates ash particles using electrodes into positively charged carbon materials that can be re-burned and negatively charged materials which can be used in cement, combined with PMI's Carbon Burnout (CBO) process, which combusts CCR to produce materials to be used for the manufacture of cement products
- Nu-Rock Technology, which uses binding agents to manufacture masonry blocks, pavers, pipe, and similar products from CCR
- Belden-Eco Products, which fires CCR in a kiln to render it inert and mixes it with other materials to form ceramic bricks

9.3.2.1 Site-Specific Beneficial Use Options

Possum Point is accessible to Northern Virginia, Maryland, and the District of Columbia cement markets, with a substantial number of ready mixed and precast concrete companies within 50 miles. The timing for excavating Ash Pond D is dependent on the processing rate per year (throughput) identified for each beneficiation technology option. The timing to develop each beneficiation facility is typically 3 years, including permitting and construction. Costs include capital costs for the processing equipment; operations and maintenance (O&M) for the beneficiation facility; and ongoing materials handling, dewatering, and water treatment costs. Materials handling includes excavation, drying, screening (if needed), and transporting the ponded ash to the on-site beneficiation facility. Costs do not include marketing of the materials or transporting the processed ash to an end user. Table 43 provides a summary of the potential beneficiation options at Possum Point Power Station, including duration and costs.

Table 43: Closure by Removal with Beneficiation Technology Options at Possum Point

<table>
<tr><th>Technology</th><th>End Product</th><th>Throughput (tons/year)</th><th>Time to Excavate Ash Pond D(1) (years)</th><th colspan="3">Range of Costs for Technologies</th></tr>
<tr><td>SEFA STAR</td><td>PC substitute</td><td rowspan="2">430,000 to 840,000</td><td rowspan="2">8 to 15</td><td>Technology Capital</td><td>=</td><td>$17M to $244M</td></tr>
<tr><td>PMI/STI</td><td>PC substitute</td><td>Technology O&M</td><td>=</td><td>$74M to $507M</td></tr>
<tr><td>Nu-Rock</td><td>Masonry blocks, pavers, pipes, etc.</td><td rowspan="2">300,000 to 550,000</td><td rowspan="2">11 to 17</td><td>Materials Handling</td><td>=</td><td>$188M to $404M</td></tr>
<tr><td>Belden</td><td>Brick</td><td>Total Projected
Estimated Cost/Ton</td><td>=
=</td><td>$471M to $899M
$118 to $225</td></tr>
</table>

(1) Time to excavate the pond is estimated based on the throughput of the technologies; excavation and processing rates may vary based on market demand of the beneficiated product

M = million; O&M = operations and maintenance; PC = Portland cement; SEFA = SEFA Group; STAR = Staged Turbulent Air Reactor

Based on the benchmarking results, fly ash is selling on average for $30 to $60 per ton plus $7 to $33 per ton for transportation. The estimated costs for beneficiation are approximately 2 to 3.8 times greater than the current regional market price for the ash.

9.3.2.2 Consolidated Beneficiation Facility

This study considered the development of a regional processing facility to be located at Chesterfield Power Station that would receive coal ash transported from the Bremo and Possum Point Power Stations for processing and beneficial use. Chesterfield is the most central of the three stations, and it also contains the majority of the ash (14.9 million of the 25.2 million CY), minimizing loading and hauling costs. In general, this is not considered to be a cost-effective option and would result in several of the ash ponds remaining open for at least three decades. The most expedient beneficiation technology would be able to process the ash from the Chesterfield Power Station in 26 years (3 years to design, obtain regulatory approval, and construct and 23 years to process the ash based on technology throughput). Since there is no available space on the Chesterfield station property to temporarily store ash from the other stations (and the FFCP landfill is not permitted to have waste stored and then removed), ash would have to be transported on an as-needed basis. Based on throughput rates, it would take another 6 years to process the Possum Point Power Station ash and 10 additional years for Bremo ash, for a total of 42 years for all three stations. The Chesterfield County Conditional Use Permit (CUP) would also need to be amended to allow ash to be trucked to the station.

9.3.2.3 Beneficial Use Considerations

The primary considerations associated with beneficial use options are related to excavating, handling, processing, and transporting the ash off site. These activities result in safety, noise, and emissions challenges associated with heavy construction equipment operating on the site and up to 150 trucks per day arriving at and leaving the site on a daily basis for 5 or more years. Additional considerations include the limited amount of demand for beneficiated ash in the local market, along with engineering and safety concerns associated with continuously dewatering and leaving the ash pond open for 8 or more years.

Removal of the CCR materials from the Ash Pond D would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality. However, these benefits would not be realized until the removal and beneficiation was completed and the groundwater naturally attenuated over time. Table 44 summarizes some of the considerations associated with the beneficial use option for Possum Point Power Station.

9.3.3 Closure by Removal and Landfilling

AECOM's landfill assessment included reviewing the feasibility of expanding an existing on-site landfill, either by constructing a new landfill in an undeveloped ("greenfield") area of the site or using the footprint of an existing ash pond, or sending the materials off site to either an existing permitted landfill or a new permitted and constructed landfill. These options are summarized in Table 45 and discussed in greater detail in the following sections.

9.3.3.1 Expansion of Existing On-Site Landfill

The Possum Point Power Station no longer burns coal for power generation and no landfills are located on the site. Therefore, an on-site landfill expansion alternative was not considered for Possum Point Power Station.

Table 44: Closure by Removal with Beneficial Use Considerations at Possum Point Power Station

Category	Considerations
Safety	• Ash pond stays open for 8+ years (3 years to obtain regulatory approval and construct loading facilities, remaining years to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety risks from excavation and over-the-road hauling due to significant volume and multi-year duration removal project (up to 150 trucks per day each way for 5+ years) • Excavation/construction safety during 6+ years of operating heavy equipment and dump trucks on and adjacent to the station
Environmental	• Ash pond stays open for 8+ years, with resulting prolonged duration for dewatering and water treatment • Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time
Community	• Community impacts from over-the-road hauling due to significant volume and multi-year duration removal project (up to 150 trucks per day each way for 5+ years) • Truck traffic may result in increased noise, emissions, traffic congestion, and vehicle accidents • Transportation by rail may decrease community impacts as compared to truck transportation, but noise, safety, and emissions would remain concerns
Schedule	• Duration to implement several evaluated technologies exceeds CCR closure requirements of 15 years • Market risks (there may be insufficient demand) • No on-site storage space is available for beneficiated ash, requiring “on demand” processing that limits production/removal to what the market would accept • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time

CCR = coal combustion residuals

Table 45: Summary of Landfill Assessment for Possum Point Power Station

Location	Option	Feasibility	Comments
On site	Expansion of Existing Landfill	Not feasible	No existing facility.
On site	Development of New Landfill on Greenfield Area	Not feasible	Inadequate available property suitable for landfill development.
On site	Development of New Landfill within CCR Ash Pond	Potentially feasible	Only feasible within Pond E if the DEQ and local authorities grant a variance to allow the setback from the road to be reduced from 500 feet to 200 feet or if Pond E landfill is combined with other removal or landfill options.
Off site	Siting and Development of New Dominion-Owned Landfill	Potentially feasible	Centrally located landfill to house ash from all Dominion ash ponds would require a 500- to 800-acre site composed of multiple parcels. Could potentially site new landfill in central Virginia.
Off site	Transporting to Existing Commercial Landfill	Feasible	Closest available landfill is 99 miles away. Trucking, rail, and barge could potentially be feasible; challenges are described in text.

CCR = coal combustion residuals; DEQ = Virginia Department of Environmental Quality

9.3.3.2 Development of New On-Site Landfill

For purposes of this assessment, a landfill capacity of 5.1 million CY was targeted (3.6 million CY of CCR in the ponds plus a 25% safety factor) which would require at least 50 acres of land. This safety factor is to account for disposal of soil below the in-place CCR excavated as part of closure by removal, uncertainty in estimation of the volume of in-place CCR to be disposed of, and engineering uncertainty regarding site conditions in this conceptual level assessment.

AECOM evaluated developing a new on-site landfill in a greenfield area and over an existing ash pond.

Landfill on greenfield area. AECOM evaluated potentially available land that would be large enough to meet landfill siting criteria. The largest undeveloped area is approximately 25 acres, which is not enough to manage the volume of CCR and meet regulatory siting criteria.

Landfill over existing ash pond. Developing a new landfill within the footprint of an existing ash pond would require overcoming several significant regulatory and engineering challenges. Construction sequencing would require dewatering and stabilization of the ash pond; excavation of the CCR; temporary storage of the CCR during landfill construction; and conditioning, placement, and compaction of the CCR into the landfill.

Considering setbacks from the property line, roadways, and floodplains, a landfill of less than 10 acres could be developed on the footprint of Ponds A, B, and C, which not would provide an adequate volume. Since more than 4 million CY of ash is currently stored in Pond D, constructing a new landfill in that area would require identifying and constructing a temporary ash storage area, moving the ash to that temporary location, constructing a new lined landfill on the Pond D footprint, and then moving the ash back. Along with the lack of storage space at the site, the presence of several large transmission corridors within the Pond D footprint makes this option not feasible.

However, a preliminary assessment determined that a 45-acre landfill could be developed in the area of the Pond E footprint, which would allow construction of a new landfill while maintaining the CCR in Pond D, hauling it directly to the new landfill once constructed and eliminating the need for temporary storage. AECOM's assessment included considerations of regulatory setbacks, avoidance of main power line easements, conservative assumptions regarding long-term groundwater levels, and a 500-foot setback from Possum Point Road to the limit of waste on the south side of the conceptual landfill. This landfill layout would have a capacity of up to 3.9 million CY, which is less than the target design capacity of 5.1 million CY. The layout of this conceptual landfill is shown in Figure TM4-3.

Virginia Solid Waste Management Regulations (VSWMR) landfill siting requirements require a 500-foot setback from public roadways, with an exception for "units that are located in areas that are zoned for industrial use under authority of state law or in unzoned industrial areas as determined by the Commonwealth Transportation Board" (9VAC20-81-120). If the DEQ and local authorities grant a variance to reduce the setback from Possum Point Road from 500 feet to 200 feet, a 53-acre landfill could conceptually be constructed in the Pond E footprint that would be sufficient to meet the entire 5.1 million CY target volume. The presence of residential areas adjacent to the station would need to be considered in this determination. The layout of this conceptual landfill (reducing the setback to 200 feet) is shown in Figure TM4-4.

Additionally, the CCR Rule restricts reuse of former ash ponds until it can be demonstrated that closure by removal criteria, including those for groundwater, are met. Addressing CCR Rule groundwater criteria could potentially be accomplished by isolating the new landfill with a double liner system, but could potentially add time to the landfill construction process.

Based on the conceptual assessment, it could be potentially feasible to construct a new lined CCR landfill within the Pond E Ash Pond footprint, using the reduced roadway setback, although the challenges described above would all need to be addressed in order to make this a viable option compared to other closure alternatives.

9.3.3.3 Disposal in Off-Site Commercial Landfill

AECOM evaluated commercial and municipal landfills in Virginia, North Carolina, and Maryland that are currently permitted to accept CCR waste to identify facilities capable of accepting large quantities of CCR material (5 to 15 million CY) within a 10- to 15-year operating life required. This would allow for potential landfill disposal of CCR from one or all of the ash ponds.

County or regional public landfills generally lacked the capacity and/or operating life to manage the Dominion CCR. The potential sites identified are therefore all commercial municipal solid waste (MSW) landfills. These facilities are currently permitted and would be structured to accept CCR waste in a monofill configuration, where CCR materials are segregated from other waste materials and placed in a separate landfill cell.

The four commercial MSW landfill options closest to Possum Point Power Station are summarized in Table 46 and their locations are shown on Figure 23. Table 47 shows the facilities identified as feasible options to receive CCR by rail.

9.3.3.4 Development of New Off-Site Landfill

AECOM performed a preliminary screening-level assessment to identify potential off-site locations where a new landfill could be developed to serve multiple Dominion facilities. A study radius of 50 miles from each of the four power stations was used as a practical range for truck hauling to a new landfill. Landfills beyond 50 miles could be considered but costs would increase. Since the CCR volume at Chesapeake Energy Center is much smaller than the other facilities (60,000 CY out of a total of 25 million CY), the study area considered only Bremo, Chesterfield, and Possum Point Power Stations. AECOM's assessment identified the optimal area for a landfill as central Virginia in the vicinity of I-95, north of I-64, and south of Fredericksburg. This covers portions of Madison, Culpeper, Orange, Louisa, Spotsylvania, Hanover, Caroline, King William, King and Queen, and Essex Counties. The general location is shown on Figure 24.

A landfill footprint between 150 to 200 acres would be required to accommodate the CCR volumes from the three stations. In addition to the land required for the lined landfill, additional property would be needed to satisfy regulatory setbacks, avoid streams and wetlands, provide stormwater management, construct roads and support structures, and provide a source for borrow soil for landfill and final cover construction. These factors typically require a site to be at least three to four times greater in size than the total landfill footprint. Therefore, the target candidate landfill site would need to be 500 to 800 acres.

Table 46: Candidate Off-Site Permitted Landfills for Possum Point

Landfill Features	Charles City County Landfill	King and Queen Sanitary Landfill	Maplewood Recycling and Waste Disposal[1]
Facility Owner	Waste Management	Republic Services	Waste Management
Distance from Power Station	100 miles	99 miles	121 miles
Reported Remaining Operating Life[2]	54 years	26 years	148 years
Reported Remaining Capacity[2]	9.5M CY	6.7M CY	11.6M CY

[1] Facility with rail access

[2] Remaining permitted operating life and capacity as reported in Virginia DEQ Solid Waste Report as of end of 2016; reported capacity based on total current permitted capacity which may not be fully available for CCR disposal

CY = cubic yards; M= million; DEQ = Virginia Department of Environmental Quality

Table 47: Facilities with Capability to Accept CCR by Rail

Off-Site Landfill with Rail Access	Location	Capacity	Comments
Maplewood Recycling and Waste Disposal	Amelia County, VA	12M CY, expandable	35 rail cars/day capacity; expandable
Brunswick Waste Management	Brunswick, VA	20M CY, expandable	Need to construct 2-mile rail spur extension
Sunny Hill Farms	Fostoria, OH	30M CY over next 20 years	Owns a fleet of 1,500 rail cars
Tunnel Hill Reclamation	New Lexington, OH	30M CY over next 20 years	Owns a fleet of 1,500 rail cars
Waste Industries Taylor County Disposal	Mauk, GA	6.7M CY, expandable	Accepts 80 to100 rail cars per day
Arrowhead Landfill	Uniontown, AL	62M CY, additional 34M CY monofill expansion permitted	Accepts 150 gondola cars per day

CCR = coal combustion residuals; M = million; CY = cubic yards

Sites with direct access from a major roadway would be preferred, to maximize transportation efficiency while avoiding residential areas. A preliminary assessment of parcels in the target search area indicates a limited number of single parcels that may meet the screening size threshold and siting criteria. Therefore, combinations of multiple parcels would likely be required.

Based on the preliminary screening-level assessment, development of a single new off-site landfill to manage CCR from one or more Dominion facilities could potentially meet the timeline required for CCR closure established by the CCR Rule (maximum 15 years). In order to implement this option, significant additional work would be required to identify candidate sites, assess the transportation routes to the sites, coordinate with local municipalities to determine development requirements, negotiate and purchase land, implement the 3 to 5 year permitting process for establishing a new landfill, and design and construct the landfill.

The most streamlined option for constructing a new landfill would entail identifying properties within a 50-mile radius of the Dominion power stations that have already gone through preliminary zoning and permitting for waste acceptance. Depending upon the property owner and permit status, this could potentially save 3 to 5 years from the timeline to purchase an undeveloped property and permit it as a solid waste facility.

9.3.4 Transportation

Transportation options to remove CCR from Possum Point Power Station include trucking, rail, and barge.

9.3.4.1 Transport by Truck

Transportation by 15 CY to 18 CY dump trucks and trailers with maximum 18- to 22-ton capacities would be the most efficient means of trucking CCR. The ability to load and manage trucks efficiently at the impoundment is the primary variable for determining the number of truck loads that can reasonably be transported off the site per day. Based on experience and discussions with industry representatives, AECOM has assumed an aggressive rate of 150 truckloads per day being transported off site. Based on a 10-hour workday, this equates to a loaded truck leaving the site every 3 minutes for 5 days per week, on average. The haul distance to the chosen landfill and turnaround times would determine the number of trucks in rotation to support this production rate. Maintaining this production rate would require very efficient and well-designed plans for safely managing truck traffic, loading, weighing, washing, and re-entry to the local road network.

A CCR stockpiling and truck loading area(s) could be set up within the footprint of Pond D, or the adjacent former Pond E. Truck access is via the existing Possum Point Road. A general arrangement for material handling for the trucking option is shown on Figure 25.

The closest reasonable landfill options for disposal of CCR by truck from Possum Point are the Charles City Landfill in Charles City County (100 miles) and the King and Queen Sanitary Landfill in King and Queen County (99 miles). Potential trucking routes for these landfills are shown on Figure 26.

9.3.4.2 Transport by Rail

Transportation by rail would include arrangements for dedicated unit trains to haul CCR to a landfill with rail capability. Based on discussions with landfill operators, acceptance rates of CCR by rail is generally not a constraining factor as long as sufficient lead time (6 to 12 months) is provided in the project for permit modifications and physical expansion of monofills and rail infrastructure to match acceptance rate needs.

Rail cars would be loaded using rubber-tired wheel loaders or conveyor systems fed with loaders. High-sided, flat-bottom gondola cars with disposable liners and covers would likely be the most efficient for CCR hauling and unloading at the landfill.

The existing rail facilities at the Possum Point Station consist of mainline tracks and a siding east of the plant. The former coal yard southwest of the plant is served by a rail spur and several yard tracks west of the main line, and is a viable location to stockpile CCR and load rail cars, as shown on Figure 27. This option would require transporting CCR from the impoundment to the train loading area using on-road trucks traveling on Possum Point Road. This extra transportation step is not ideal, but would be necessary to access the existing rail infrastructure at Possum Point.

An alternative option was considered to eliminate the hauling on Possum Point Road. The alternative would be to construct a new rail spur and track yard on the west side of the mainline, which would provide direct access to transport CCR from Pond D to the rail loading operation in one step, using off-road dump trucks. This option was eliminated due to the difficulty of switching CCR rail cars to and from a western spur; this switching would create untenable conflicts with frequent commuter trains and freight rail traffic on the main line.

In-state landfill options for accepting CCR by rail include the Maplewood landfill in Amelia County (46 miles from the station). Out-of-state facilities that can accept CCR by rail include landfills in Ohio, Alabama, and Georgia. Due to the rail congestion around the Possum Point Power Station, including both commuter and freight rail, major rail transporters have estimated the optimal rail loading and transport rate at eight unit trains every 4 weeks (85 gondola cars with a 90-ton capacity each), which is the equivalent of shipping out approximately 15,300 tons per week (795 thousand tons/year) via rail.

9.3.4.3 Transport by Barge

Given the stringent requirements for containerizing CCR to meet the regulations and the associated infrastructure costs to load, handle, transport, and unload containers, the option to transport CCR in containers by barge is not considered to be a reasonable or cost-effective option for transporting CCR relative to trucking and rail options. In general, barge transportation would require adequate shoreline facilities with sufficient channel depth (typically greater than 12 feet mean low water); docking and mooring facilities; loading and unloading systems, including container cranes and container handling systems installed at the station and port facilities; transportation systems (truck chassis) to haul containers from the port facility to the landfill; and a system to dump containers and reseal them for the return trip. The certified watertight containers would need to be special ordered at least 1 year in advance. To accommodate barge transportation, facility upgrades would be necessary, including dredging, support facility designs, and subsequent marine construction.

To comply with current state code, transportation of CCR by barge would require use of certified watertight containers meeting the required specifications in 9VAC20-170. Because the Possum Point Power Station is located on the Potomac River and the trucking distance to viable CCR landfills is relatively long (100 miles), a conceptual option of transporting CCR in containers by barge was developed. This option would entail placing CCR in 40-foot by 8-foot by 8-foot watertight steel containers (approximately 25 tons of CCR per container), transporting the containers to a staging area at Possum Point adjacent to the river, loading the containers onto deck barges using a crane system, transporting the barge with a tug down the Potomac River to Chesapeake Bay and up the James River to the Port of Weanack in Charles City County, offloading at Weanack using a container crane, staging containers and loading them on truck chassis, and transporting the containers by truck on public roads to the Charles City Landfill (12 miles) for offloading. The system would be reversed for concurrently transporting empty containers back to Possum Point for refilling. Figure 28 shows a conceptual arrangement for loading barges, and Figure 29 shows the potential barge route between Possum Point and the Port of Weanack, and subsequent truck route to the Charles City County Landfill.

Extensive infrastructure development would be required at Possum Point to enable container handling, including dredging in the Potomac River from the main channel to a barge loading area; constructing a mooring system, finger pier, and moorings for securing empty and full barges; constructing a container crane system or roll-on/roll-off ramp system at Possum Point to load full containers onto the barges; and removing and staging empty containers. Bulkhead construction, shoreline stabilization, or other geotechnical ground improvement would also likely be necessary to support the infrastructure. Dredging and marine construction would require full engineering design and permitting by the U.S. Army Corps of Engineers, Virginia DEQ, and likely the Virginia Marine Resources Commission. Infrastructure at the Port of Weanack is already in place including a bulkhead and mooring systems, a paved back lot with a heavy load rating, and existing crane rails. A container crane and yard carriers would need to be brought in for container handling.

If a container by barge option were pursued, and after all infrastructure was in place, feasible loadout production rates could be 100 containers per day, which would likely fill a moderate-sized deck barge and equate to approximately 2,500 tons per day of CCR. Given one barge leaving the site per day, 2 days travel to Weanack, 1 day to unload, and 2 days to return (which equates to six barges and tugs with containers in rotation at all times), the transportation and disposal activities under this option are expected to take approximately 11 years to complete, after the 3 to 4 year period of design, permitting, approval, and infrastructure upgrade construction has been completed.

9.3.5 Backfilling and Restoration of Former Ash Ponds

Restoration would depend on future site needs and conditions. Restoration activities could include reusing former ash pond areas as stormwater management facilities, backfilling pond areas for re-development, removing dikes and restoring original grades, creating wetlands, or restoring habitat. Restored former ash ponds could also be used to support ongoing power generating activities by serving as equipment or material storage areas, parking or staging areas, or maintenance areas. Post-removal use of the site would be included in the closure by removal design.

Restoration of the Possum Point Ash Pond D would include removing and re-grading the dam (approximately 2 million CY) into the footprint of the former pond to restore the area as a small valley. The closure by removal work plan would also provide for decommissioning and de-classification of the impoundment dams to remove them from regulatory oversight. Decommissioning and de-classification would involve breaching or completely removing the earthen embankment so that it can no longer impound water. Spillway structures could be abandoned in place by grouting or other approved means, or completely removed. Remaining soil removed from the embankments that meets regulatory criteria to allow it to remain in place would be used during the closure by removal process or as part of the site restoration. During restoration, the embankment soil can be used to restore pre-development lines and grades and to promote effective surface water runoff.

Restoration activities would result in a site that requires minimum long-term maintenance. Establishment of vegetation, restoration of effective surface water conveyance, and providing for erosion and sediment control would be included in the design.

9.3.6 Summary of Closure by Removal and Landfilling Considerations

Removal of the CCR materials from Ash Pond D would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality. However, these benefits would not be realized until the removal was completed and the groundwater naturally attenuated over time.

The primary considerations associated with off-site landfill options are related to the excavation, handling, processing, and transportation of the ash off site, producing safety, noise, and emissions challenges associated with heavy construction equipment on the site and up to 150 trucks per day leaving the site on a daily basis for 8 or more years. Transport by rail could potentially decrease the transportation duration to approximately 7 years. Additional considerations include the engineering and safety concerns associated with continuously dewatering and leaving the ash pond open for 9 or more years.

Additional impacts associated with constructing a new off-site landfill (as opposed to using an existing off-site permitted facility) include community and environmental concerns with constructing a 150- to 200-acre landfill, and the time required for site selection, land acquisition, permitting, and construction (estimated at 5 to 7 years), followed by hauling the ash to the new landfill; these activities would likely exceed the CCR Rule closure requirements of 15 years.

Table 48 summarizes some of the considerations associated with closure by removal to a landfill at Possum Point Power Station.

Table 48: Closure by Removal with Landfill Considerations for Possum Point Power Station

Category	Considerations
Safety	• Ash pond stays open for 9 years (1 year to obtain regulatory approval and construct loading facilities, remaining years to transport), increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety risks from over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day for 8 years) • Excavation/construction safety during 8 years of operating heavy equipment and dump trucks on and adjacent to the station • Rail duration is also 9 years (2 years to design, permit, and construct, remaining years to transport), potentially decreases the transportation-related risks
Environmental	• Ash pond stays open for 9 years, with resulting prolonged duration for dewatering and water treatment • Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required • Rail duration is also 9 years, potentially decreases the transportation-related risks • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time • For development of new off-site landfill, potential impacts to wetlands, environment; loss of trees; dust, leachate control; groundwater protection
Community	• Community impacts from over-the-road hauling due to significant volume and multi-year duration removal project (150 trucks per day for 8 years) • Increased noise, emissions, truck traffic, accident potential • Impacts from trucking are also associated with transportation by barge. • Transportation by rail may decrease community impacts; noise, safety, and emissions remain concerns • For development of new off-site landfill, community concerns with developing landfill "in their backyard"; construction impacts; multiple truck impacts once operational
Schedule	• May be able to start hauling with minimal design, permitting, or construction • Removal of the CCR materials would eliminate the source of potential groundwater impacts, which would eventually benefit the groundwater quality after ash removal is completed and groundwater undergoes natural attenuation over time • For development of new off-site landfill, site selection, land acquisition, permitting, and construction schedule could take 5 to 7 years, followed by hauling/placement, which would likely exceed CCR closure requirements of 15 years

CCR = coal combustion residuals

9.4 Closure-in-Place

All CCR materials from Ash Ponds A, B, C, and E are being consolidated into Ash Pond D; this will be completed prior to initiating closure activities. Under the closure-in-place option, Ash Pond D would achieve closure in accordance with the CCR Rule by leaving the ash in place, removing free liquids, and installing an engineered final cover system.

As required by federal and state solid waste regulations, engineering investigations and evaluations have been completed for the Possum Point Ash Pond D, including the original design, subsequent evaluations, U.S. Environmental Protection Agency (USEPA) dam safety assessment, CCR Rule certifications, and closure plans. AECOM also performed a storm surge analysis to supplement existing evaluations to meet SB 1398 requirements (included as an appendix in Technical Memorandum 5).

AECOM's assessment of the cumulative information shows that closure-in-place at the Possum Point Power Station would provide long-term safety of the CCR units and would address the long-term risks as described in the closure plan previously submitted to the Virginia Department of Conservation and Recreation (DCR), siting requirements, and the ability to withstand extreme weather events (including flooding, hurricanes, storm surges, and erosive forces) and earthquakes. The current closure design meets the following requirements that would ensure long-term safety after the ash ponds have been closed in place:

- Designed to withstand a 100-year flood (top of cap is above 100-year flood elevation)
- Stormwater drainage for the Probable Maximum Flood (PMF), the potentially largest flood resulting from a combination of the most severe rainstorm events for a given area
- No downstream water quality or flow impacts resulting from the closed ash pond
- No effect on the structural stability of the closed ash pond from receding floodwater or rapid water drawdown
- Final cover design to withstand wind uplift and flooding from a Category 4 hurricane
- The final cover elevation and stormwater measures would protect against erosion from 100-year flooding or storm events, along with potential storm surges from the river
- Structural stability of the fill (ash), embankments (sides), and final cover maintained under a wide range of potential conditions, including earthquakes and storm events
- The facility would continue to maintain an Emergency Action Plan (EAP) to protect downstream areas from a potential breach

Primary safety and engineering considerations associated with closure-in-place are related to dewatering and water treatment during the closure operations, community impacts during the approximately 2 years of construction (noise, emissions, dust), and construction quality control for the installation of the final cover material (geosynthetic liner, soil cover, and vegetation). The cover is designed to protect groundwater from future infiltration, which should have a positive benefit on long-term groundwater quality. Long-term considerations also include the ongoing O&M of a corrective measure technology, if needed. The CCR Rule also requires a minimum of 30 years of post-closure care, to include groundwater monitoring, maintenance of the cover system, and continued compliance with dam safety regulations, in accordance with a DEQ Solid Waste Management Regulations (VSWMR) Permit.

Table 49 summarizes some of the considerations associated with closure-in-place at Possum Point Power Station.

Table 49: Closure-in-Place Considerations at Possum Point Power Station

Category	Considerations
Safety	• Excavation/construction safety during 3 to 5 years of operating heavy equipment and dump trucks on and adjacent to the station • No impacts for CCR removal or off-site hauling
Environmental	• No impacts for CCR removal or off-site hauling • Noise and emissions from excavation equipment • Dust and odor control may be required • Ash pond stays open for 3+ years, requiring dewatering and water treatment • Engineering challenges for CCR dewatering and excavation • Once closure is complete, decreased potential for groundwater migration from CCR materials remaining in place
Community	• No impacts for CCR removal or off-site hauling • Potential noise, emissions, and truck traffic associated with on-site construction
Schedule	• 3 to 5 years for closure much shorter duration than other options • Installation of corrective measures may take 2 years • Estimated 10- to 30-year duration for groundwater corrective measures

CCR = coal combustion residuals

9.5 Groundwater and Surface Water

Site geology consists of a thick sequence of river sediments, dominated by alternating layers of silty sand and sandy clay, overlying a clay confining unit. Where saturated, these sediments represent the uppermost aquifer. The station has a topographic high point to the immediate north of Pond D, with elevations at 190 feet above mean sea level (msl) and transitioning to as low as 0 feet msl at the river banks.

9.5.1 Groundwater

Groundwater generally flows from topographic high points located north of the station toward the low-lying areas to the south and southwest. Figure 30 shows the bedrock potentiometric map along with the locations of the monitoring wells.

The station has historically monitored groundwater in accordance with their VPDES Permit and the associated Groundwater Monitoring Plan (GMP). Several dissolved metals have been detected at concentrations greater than background levels downgradient of Ponds D and E during the historic VPDES groundwater monitoring. These detections have become less frequent in recent years. Cadmium is the only constituent that has been historically detected above the MCL, and it has been below MCL since 2014.

Background groundwater sampling was performed in 2016 and 2017 in accordance with the CCR Rule. The USEPA established Maximum Contaminant Levels (MCLs) as the maximum level of a constituent in drinking water at which no known or anticipated adverse effect on the health of persons would occur, allowing an adequate margin of safety. For constituents that do not have USEPA-established MCLs, analytical results are compared to the background levels established during baseline sampling.

All constituents were below MCLs in wells adjacent to active Pond D during the background CCR sampling events. Arsenic is the only constituent that has been detected above MCL at the Possum Point

Station, in wells around Ponds A, B, and C. There were also detections above background levels of several CCR constituents in wells east, west, and south of Ponds D and E, as well as to the west of Ponds A, B, and C. There are no drinking water wells downgradient of the station, and the biweekly groundwater samples collected west of Pond E, in the vicinity of residences with private wells, have been below MCLs for all monitored constituents.

9.5.2 Surface Water

Dominion has been conducting surface water sampling at Quantico Creek, Potomac River, and Powell's Creek (approximately 2 miles north of Pond D) since May 2016 to monitor surface water quality during the discharge of treated water from the ash ponds. The surface water samples were collected to evaluate the potential for site closure operations to impact nearby waterways. Surface water samples have consistently been below Virginia Surface Water Quality Standards for aquatic life and human health.

No matter which closure option is implemented, the CCR Rule requires post-closure groundwater monitoring to assure that groundwater conditions surrounding the ash ponds continue to be protective of human health and the environment.

9.6 Groundwater Corrective Measures

Preliminary groundwater results show detections of CCR related constituents above background levels. Based on that data and site-specific conditions, AECOM performed an assessment of potential corrective measures to remediate the groundwater related to Ash Pond D. Additional monitoring is required before these results are confirmed. The technologies that could potentially remediate the groundwater associated with Ash Pond D are the following:

- Permeable reactive barrier (PRB) – groundwater flows through a subsurface trench filled with reactive material and chemically reacts with the material to remove contaminants
- Vertical engineered barrier (VEB), which is containment via slurry walls – a subsurface wall is constructed to prevent groundwater from flowing out of the ash pond; if needed, hydraulic containment can supplement VEB
- Hydraulic containment via pump-and-treat methods – groundwater is pumped from a series of wells with overlapping influence to cut off groundwater from flowing downgradient; extracted water is treated to below permit requirements and discharged
- Monitored natural attenuation (MNA) – employing physical processes that naturally reduce the concentration, toxicity, or mobility of CCR constituents in groundwater, attenuating the constituents by chemical reactions with other dissolved constituents and the soil media

Table 50 describes how these corrective measures can address the items outlined in 40 CFR § 257.96 and outlines how each technology could potentially be implemented to remediate groundwater to levels below station-specific cleanup goals. All four potential options have relatively similar anticipated durations to reach groundwater cleanup standards. In general, due to the depth of the confining layer immediately downgradient of Ash Pond D, options such as PRBs, a slurry wall, or pump-and-treat would incur high costs. As described in Technical Memorandum 7, ISS becomes cost-prohibitive deeper than approximately 50 feet, due to the specialty auger equipment necessary to produce enough torque to move through the materials at depth, and the requirement for smaller auger diameters to generate that torque. Smaller diameter augers, with the requirement to overlap holes, result in a much smaller grid size and thus an order of magnitude more auger holes required to contact the entire volume of ash, resulting in a much higher cost. Therefore, ISS is not feasible for the 60 foot depth of Ash Pond D.

Any potential corrective measure technology would require a comprehensive remedial design process that would include acquisition of additional data as needed, laboratory bench-scale testing, and potentially a pilot test before designing and implementing the full-scale construction of the selected remedial technology. Combinations of technologies could be tested, and additional emerging technologies could be evaluated as their effectiveness on CCR constituents, such as metals, is proven.

As described in the Gradient report, *The Relative Impact Framework for Evaluating Coal Combustion Residual Surface Impoundment Closure Options: Applications and Lessons Learned* (Lewis and Bittner, 2017), both closure-in-place and closure by removal “provide significant beneficial impacts to groundwater quality compared with continued surface impoundment operations and that neither of the closure options is always more beneficial, with respect to downgradient groundwater quality, than the other. These results are consistent with the USEPA position in the CCR Rule that both closure options can be equally protective, provided they are implemented properly.” The report goes on to state, “Moreover, it is possible that groundwater corrective actions, if instituted as part of a combined remedy with closure-in-place, would result in a greater and more rapid reduction of contaminant concentrations in downgradient groundwater than closure by removal in some assessments.” The authors additionally note that surface water impacts under both closure by removal and closure-in-place are minimal.

Table 50: Possum Point Power Station Groundwater Corrective Measures Summary

Evaluation Factor		Permeable Reactive Barrier (PRB)	Vertical Engineered Barrier (VEB) – Slurry Wall	Pump and Treat with Multiple Treatment Technologies	Monitored Natural Attenuation (MNA) with Risk Assessment
General Technology Specifications		Approximately 7,500 LF wall 60 feet deep downgradient of CCR unit; deep trenching technology for installation	Approximately 7,500 LF wall 60 feet deep downgradient of CCR unit; deep trenching technology for installation	Approx. 250 extraction wells, 50 gpm total flow; anticipated treatment technologies include aeration, pH adjustment, coagulation/flocculation, sand filtration, bag filtration, adsorptive media, ion exchange resin	Downgradient of CCR unit using existing monitoring well network
Additional Requirements		May require up to three parallel walls with different reactive media to treat various constituents	Hydraulic control - Approx. 250 extraction wells @ 25 gpm total flow behind VEB with groundwater treatment	Wells located along approx. 7,500 LF downgradient edge of CCR unit	Risk assessment would be performed to verify that MNA would be protective of human health and the environment
Cost Estimate		$286M	$88M	$61M	$2.5M
Schedule	**Construction**	Moderate duration for implementation (approx. 1-2 years)	Moderate duration for implementation (approx. 1-2 years)	Moderate duration for construction (approx. 1-2 years)	No construction needed
	Anticipated Duration to Reach GPS	Removal of constituents as they pass through the PRB should allow downgradient constituent levels to quickly reach GPS; duration for remedial implementation depends on depletion of source contact with groundwater over time; for the purposes of this assessment, a 10- to 30-year time frame is assumed	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this assessment, a 10- to 30-year time frame is assumed	Source removal/control designed for downgradient constituent levels to reach GPS; for the purposes of this assessment, a 10- to 30-year time frame is assumed	Continued indefinite monitoring; for the purposes of this assessment, a 10- to 30-year time frame is assumed
Potential Corrective Measure Benefits		• Removes contamination within PRB amendments (in situ) • Designed to treat multiple contaminants in situ to remove contaminants and protect human health and environment • Length of PRB could potentially be reduced with detailed delineation investigation • Impacts primarily limited to on-site	• Slurry wall combined with pumping designed to provide source containment • Extraction designed to minimize hydraulic pressure on slurry wall and prevent groundwater from flowing around the edges of the wall • Complete source containment by preventing groundwater flow from ash pond footprint, allowing downgradient impacts to decrease • Impacts primarily limited to on-site	• Pump-and-treat proven technology for hydraulic control and removal of contaminants from groundwater, reducing downgradient risks to human health and environment • Complete source containment by hydraulically controlling groundwater flow from ash pond footprint, allowing downgradient impacts to decrease • Impacts primarily limited to on-site	• Relies on natural attenuation mechanisms for performance • No technology construction is required
Potential Corrective Measure Considerations		• Ash remains in place • Greatly depends on bench scale/pilot testing to verify the correct amendment mixtures/geochemistry • May require amendment replacement as capacity to reduce/remove contaminants is consumed • Multiple amendments may be required to remove all contamination • Treating one constituent may mobilize others • Potentially multiple passes to install multiple PRBs	• Ash remains in place • Geology dependent • Requires deep trenching along ~7,500 LF length • Complete source containment, but not removal • Requires heat of reaction control, dust control; reaction may produce odors • May require additional measures for downgradient plume • Monitoring/sampling required • Pump testing required to design extraction well network • Bench scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems – duration unknown, ongoing O&M/treatment costs • Extraction network and treatment system periodically evaluated for effectiveness, would require periodic changes in and/or regeneration of filtration/treatment media • Requires an approximately 20-foot-wide corridor for installation	• Ash remains in place • Monitoring/sampling required • Requires installation of 250 extraction wells and subsurface piping network to centralized groundwater treatment system housed in a building • Pump testing required to design extraction well network • Bench scale and pilot testing required to properly design treatment train • Long-term O&M of extraction and treatment systems – duration unknown, ongoing O&M/treatment costs • Extraction network and treatment system periodically evaluated for effectiveness, would require periodic changes in and/or regeneration of filtration/treatment media	• Ash remains in place • Monitoring/sampling required • Routinely evaluate for changing conditions

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Figures

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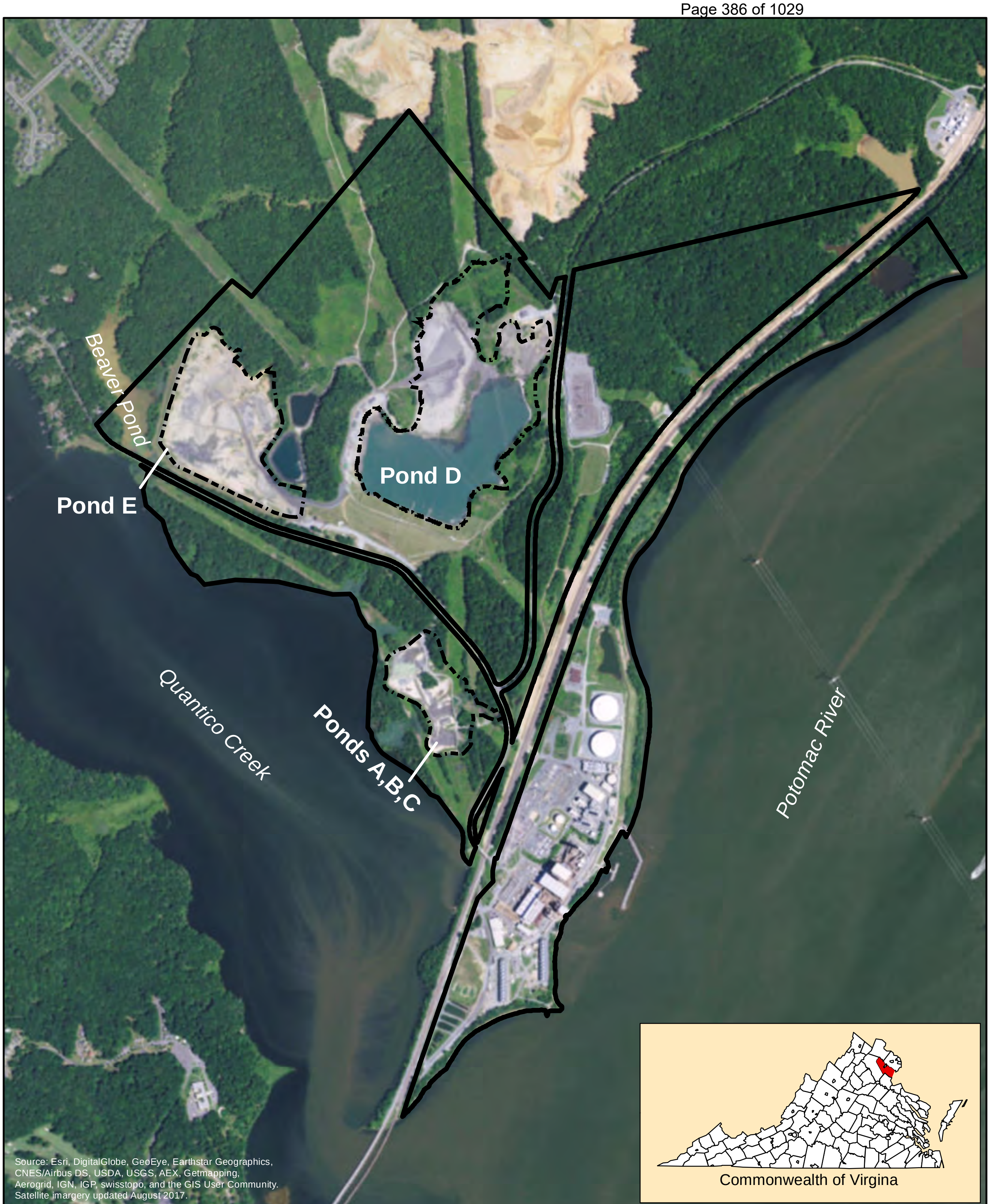

LEGEND

Approximate Property Boundary

Approximate Pond Boundary

N

0 750 1,500 3,000
Feet

AECOM

Figure 21
Site Location

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
RIP	CKS	DFM	REV. 0

Possum Point Power Station

DATE:	DEPT:
10/3/2017	Environment

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Rd
OPEN AREA
NORTH END
ASH POND E
METALS
POND B
METALS
POND A
ASH POND D
COCKPIT POINT RD
POSSUM POINT RD
10' PROPOSED CONTOURS
POND BOUNDARIES
N
0 100 200 400
AECOM
Figure 22
New On-site Landfill Potential Location
DRAWN BY: MWB
REVIEWED BY: JAB
APPROVED BY: DOS
REVISION NUMBER: REV. 0
Possum Point Power Station
DATE: 10/26/2017
DEPT:

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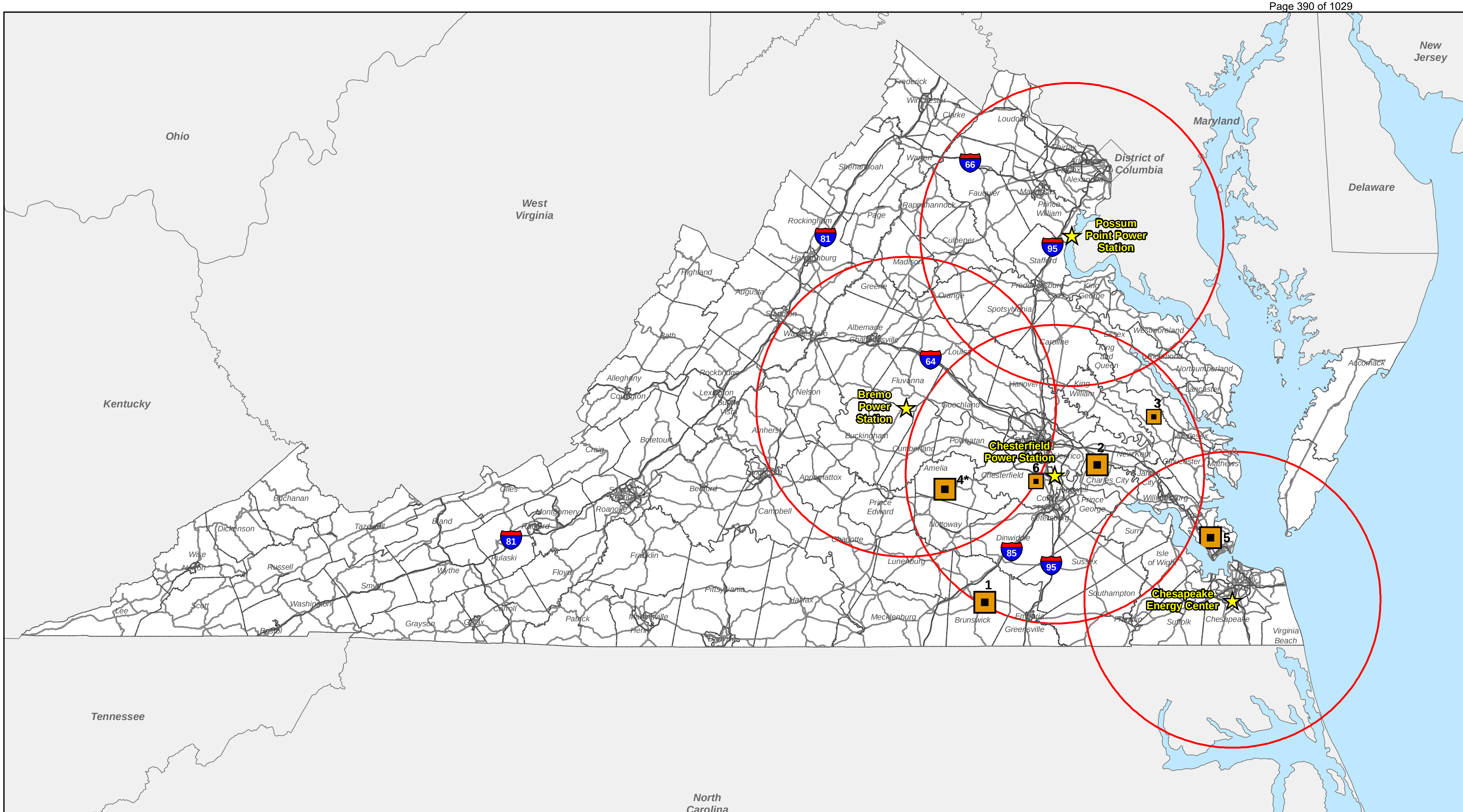

LEGEND

Limited Access Highway	
High Occupancy Vehicle (HOV) Lane	
US Primary Highway	
50 Mile Radius	
Virginia County	

Landfill Location (remaining life)

- 10 - 25 yrs.
- 25 - 50 yrs.
- > 50 yrs.
- Dominion Plant Location

N

0 12.5 25 50
Miles

AECOM

Figure 23
Off-site Commercial Landfill Locations

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MPS	JAB	DOS	REV. 0

Possum Power Point Station

DATE:	DEPT:
11/14/2017	Environment

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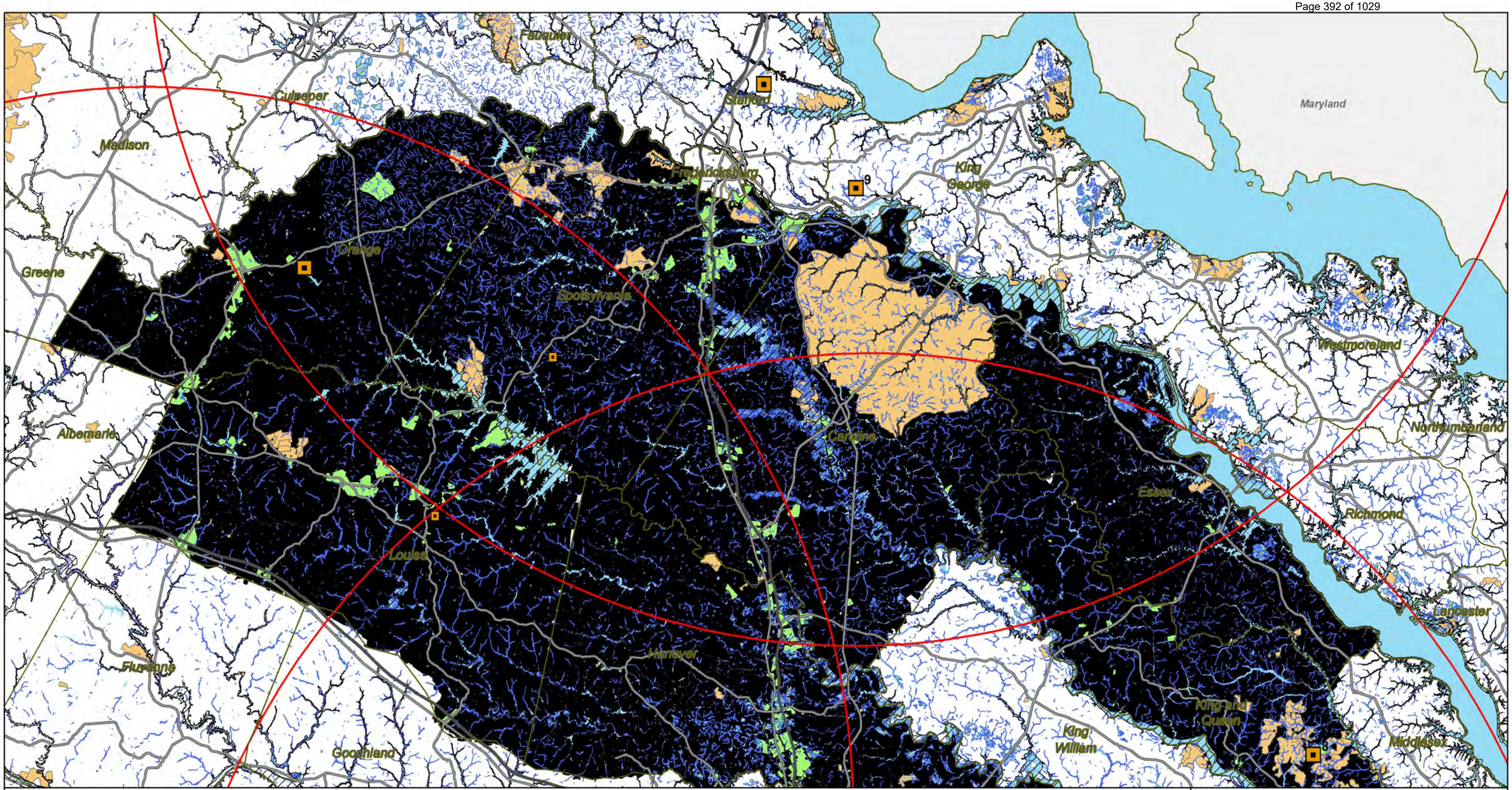

LEGEND

- Railroad
- Limited Access Highway
- High Occupancy Vehicle (HOV) Lane
- US Primary Highway
- 50 Mile Radius
- 100 yr. Flood Zone
- Wetland
- National Park Land
- US Forest Service Land
- Federal/State/Local Owned Land
- Virginia County

Zoning

- Non-Residential
- Residential and Agricultural

N

0 8 16
Miles

AECOM

Figure 24
Potential New Off-site Landfill General Location

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
MARK P. SMITH	JOHN BOVE		

Possum Point Power Station

DATE:	DEPT:
9/12/2017	Environment

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N

0 600 1,200 2,400
Feet

AECOM

Figure 25
Closure by Removal
Trucking Plan

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LAD	DOS	DOS	REV. 0

Possum Point Power Station

DATE: 10/05/2017 DEPT: Environment

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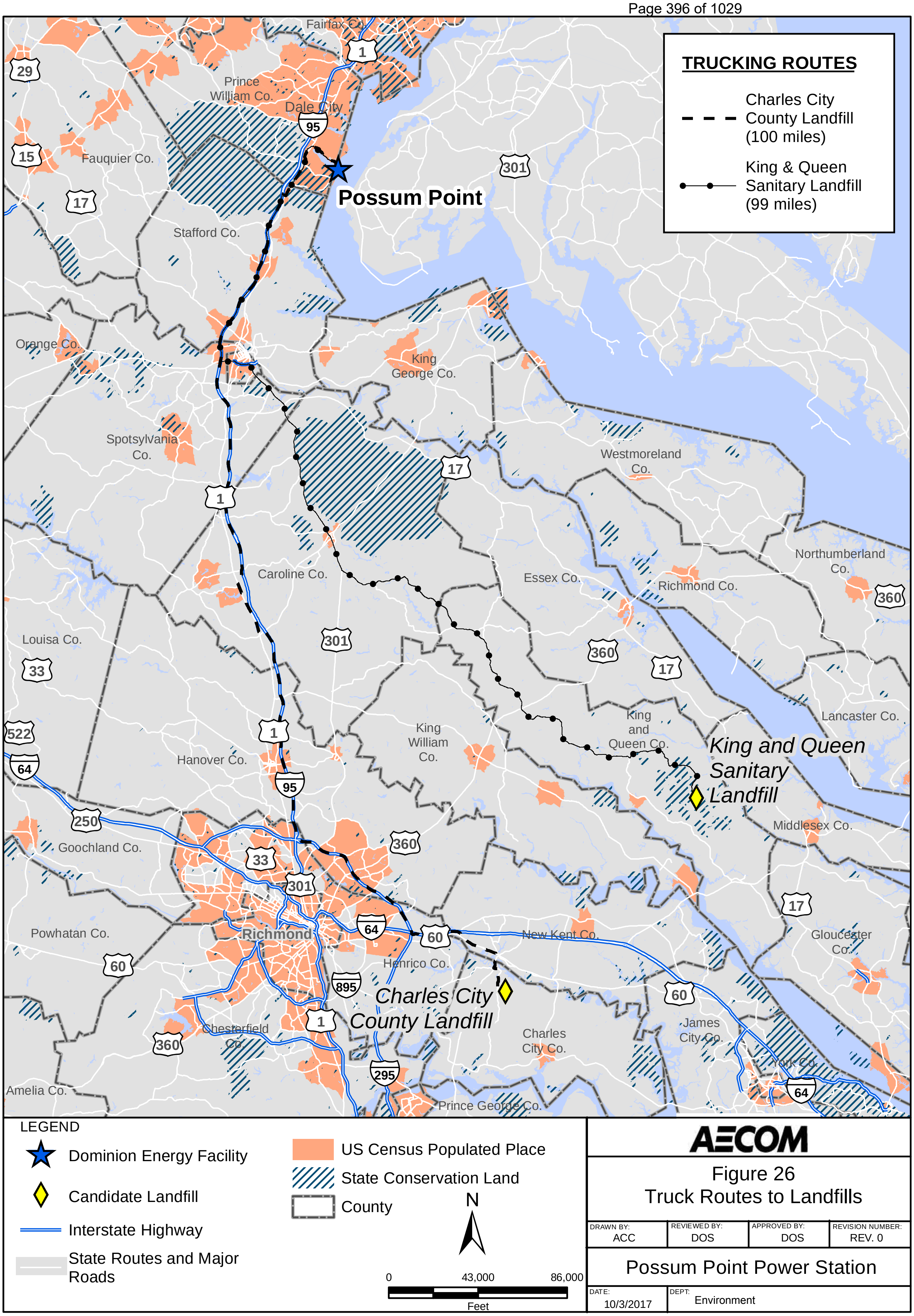

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Figure 26
Truck Routes to Landfills

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ACC	DOS	DOS	REV. 0

Possum Point Power Station

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Figure 27
Closure by Removal
Rail Plan

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Possum Point Power Station

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10/06/2017	Environment

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N

0 600 1,200 2,400
Feet

AECOM

Figure 28
Closure by Removal
Container by Barge Plan

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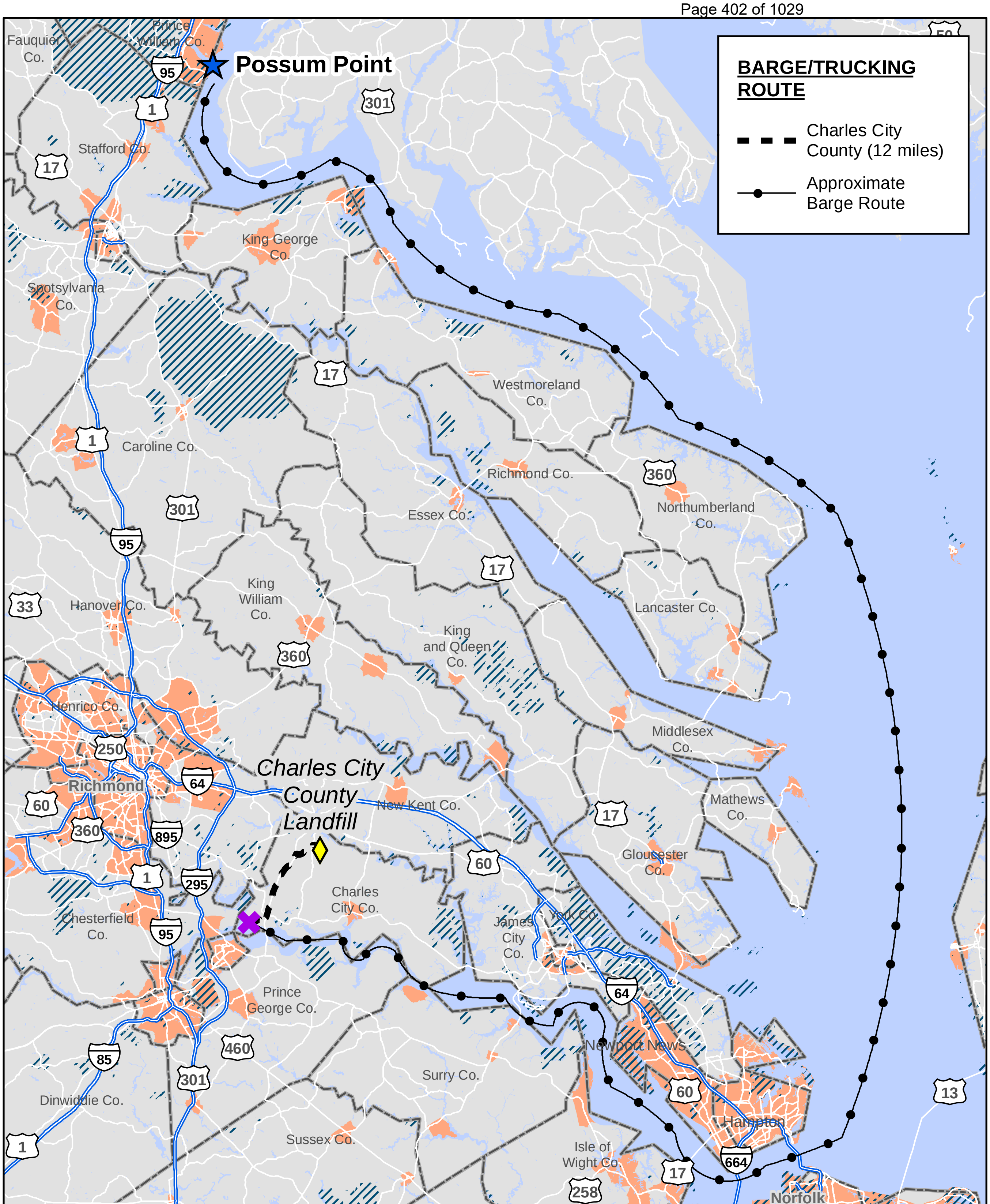

LEGEND

- Dominion Energy Facility
- Candidate Landfill
- Interstate Highway
- State Routes and Major Roads
- Port of Weanack
- US Census Populated Place
- State Conservation Land
- County

N

0 49,000 98,000
Feet

AECOM

Figure 29
Closure by Removal Barge Route

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Possum Point Power Station

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. Satellite imargery updated August 2017.

LEGEND

Approximate Property Boundary

Approximate Pond Boundary

Potentiometric Contours

Compliance Program

CCR Network Well

CCR Network Background Well

AECOM

Figure 30
Potentiometric Surface
Uppermost Aquifer, April 2017

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RIP	CKS	DFM	REV. 0

Possum Point Power Station

DATE:	DEPT:
10/3/2017	Environment

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11. Abbreviations

AACE	Association for the Advancement of Cost Engineering International
ASTM	ASTM International
CAP	Corrective Action Plan
CCR	coal combustion residuals
CFR	Code of Federal Regulations
cm/sec	centimeters per second
CUP	Conditional Use Permit
CY	cubic yard(s)
DCR	(Virginia) Department of Conservation and Recreation
DEQ	(Virginia) Department of Environmental Quality
EAP	emergency action plan
FFCP	Fossil Fuel Combustion Products
GPS	Groundwater Protection Standards
ISS	in situ stabilization/solidification
LF	linear foot (feet)
LOI	Losses on Ignition
MCL	Maximum Contaminant Levels
MNA	monitored natural attenuation
msl	mean sea level
MSW	municipal solid waste
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
PMF	Probable Maximum Flood
PMI	PMI Ash Technologies, LLC
PRB	permeable reactive barrier
SB 1398	Senate Bill 1398
SSI	Statistically Significant Increase
STAR	Staged Turbulent Air Reactor
ST	Separation Technologies LLC
USEPA	U.S. Environmental Protection Agency
VAC	Virginia Administrative Code
VEB	Vertical engineered barrier
VPDES	Virginia Pollutant Discharge Elimination System
VSWMR	(Virginia) Solid Waste Management Regulations

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Senate Bill 1398 Response

Coal Combustion Residuals Ash Pond Closure Assessment

TECHNICAL MEMORANDUM 1

Beneficial Use and Ash Market Study

November 2017

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Technical Memorandum 1: Beneficial Use and Ash Market Study

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1. Introduction and Objective

Virginia Senate Bill 1398 (SB 1398) requires "that every owner or operator of a coal combustion residuals (CCR) surface impoundment that is located within the Chesapeake Bay watershed … conduct an assessment of each such CCR surface impoundment (CCR unit) regarding the closure of any such unit." The assessment must include describing groundwater and surface water conditions surrounding the surface impoundments (ash ponds) and evaluating corrective measures to restore water quality (if needed), evaluating the clean closure (closure by removal) of the CCR unit by recycling/reusing the ash or moving it to a landfill and demonstrating the long-term safety of the CCR unit if it is closed in place.

SB 1398 is applicable to eleven CCR surface impoundments (ash ponds) at four Dominion Energy (Dominion) power stations. On behalf of Dominion and in compliance with SB 1398, AECOM conducted an evaluation of the groundwater and surface water on all eleven ponds and an assessment of closure options on the five ponds that have been slated for closure. Ash has been removed or is in the process of being removed from the other six ponds; therefore, these ponds are being closed by removal. Table TM1-1 provides information on the Dominion power stations and ash ponds that were included in the study.

Table TM1-1: Ash Ponds included in the Study

Power Station	CCR Units	Remaining CCR Volume (CY)(1)	Operating Status	Area (acres)
Bremo Power Station	North Ash Pond(2)	4,800,000	Slated for closure	68
	East Ash Pond	1,400,000	Ash being actively removed and transported to North Ash Pond	27
	West Ash Pond	0	Ash removed	22
Chesapeake Energy Center(3)	Bottom Ash Pond(2)	60,000	Committed to closure by removal	5
Chesterfield Power Station	Lower Ash Pond(2)	3,600,000	Slated for closure	101
	Upper Ash Pond(2)	11,300,000	Slated for closure	112
Possum Point Power Station	Ash Pond A Ash Pond B Ash Pond C	40,000	Residual ash to be removed from Ash Ponds A, B, and C and transported to Ash Pond D	18
	Ash Pond D(2)	4,009,250	Slated for closure	70
	Ash Pond E	2,250	Residual ash to be removed and transported to Ash Pond D	38
	Total Volume	**25,211,500**		

(1) CCR volumes are based on Dominion estimates as of July 10, 2017

(2) Assessed for closure options

(3) While not subject to the assessment required by SB 1398, the CCR landfill at the Chesapeake Energy Center is slated for closure in accordance with VSWMR. Virginia DEQ issued a draft solid waste permit in June 2016 for closure of the landfill, which process was later suspended at Dominion's request. The draft permit required Dominion to evaluate and propose alternative corrective measures to address groundwater impacts. In addition, in connection with a July 31, 2017, court order, Dominion will submit a revised solid waste permit application to DEQ by March 31, 2018, to include proposed additional corrective measures to address site-wide groundwater impacts.

CCR = coal combustion residuals; CY = cubic yards; DEQ = Department of Environmental Quality; VSWMR = Virginia Solid Waste Management Regulations

1.1 Study Objective

The objective of the study was to comply with the following SB 1398 requirements to ensure the long-term safety of the ash ponds, protecting public health and the environment:

- Evaluate closure by removal with recycling or reuse (beneficial use) of the CCR material
- Evaluate closure by removal with placement of CCR material in a permitted landfill
- Evaluate closure-in-place addressing long-term safety, structural, and extreme weather event resiliency
- Describe groundwater and surface water quality surrounding each ash pond, and evaluate corrective measures if needed

AECOM was tasked with critically reviewing existing information, identifying additional studies that may be needed, performing the studies, and preparing a report that addresses the requirements of SB 1398 for each of the eleven Dominion ash ponds listed in Table TM1-1.

The objective of the SB 1398 requirements is to provide members of the legislature, environmental regulators, local government officials, and the local communities with an assessment of ash pond closure options as set forth in the legislation. Specifically, the report describes how the various options could meet the objectives of safe closure, compliance with applicable federal and state rules, and protection of public health and the environment. This report is not intended, and must not be construed, to provide recommendations or conclusions regarding the selection of the options detailed herein.

AECOM developed a series of Technical Memoranda that provide a detailed analysis of the primary technical information needed to comply with SB 1398 requirements. The Technical Memoranda provide an assessment of closure by removal options including recycling/beneficial use and landfilling; ash sampling results to supplement the beneficial use study; and evaluations of closure-in-place, groundwater and surface water conditions, and potential groundwater corrective measures. The memoranda are included as attachments to the report and are referenced as appropriate.

1.2 Technical Memorandum 1 Objective

The objective of Technical Memorandum 1 is to meet the SB 1398 requirement to evaluate the clean closure (closure by removal) of the ash ponds through excavation and responsible recycling or beneficial reuse of coal ash residuals by incorporating them into concrete or other products in a manner that prevents the release into the environment of the constituents contained within the coal ash residuals. This technical memorandum assesses the current market supply and demand of coal ash for beneficial use, along with assessing the feasibility of constructing an on-site beneficiation processing facility at individual power stations or a regional facility at a centralized power station.

As referenced in this technical memorandum, beneficial use is defined as the process of substituting CCR materials for virgin, raw materials in a natural or commercial product. Beneficiation describes the processing of fly ash to make it more suitable for a specific use, such as a substitution for Portland cement used in the production of concrete. Processing can be performed by constructing a beneficiation system on the power station site or at a regional facility.

An encapsulated beneficial use binds the CCR into a solid matrix that minimizes its mobilization into the surrounding environment (e.g., concrete, wallboard). Encapsulation is the most protective form of recycling because the constituents in the ash are permanently bound. Other beneficial uses (e.g., structural fill, flowable fill) are classified as unencapsulated and require further assessment of potential releases to the environment, as required by federal and state rules, and are therefore not included in this study.

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2. Approach to Study and Summary of Findings

To address SB 1398 requirements, AECOM performed a beneficial use and ash market study that consisted of an evaluation of the demand for fly ash for use in concrete production in a 50-mile radius of each power station and an evaluation of the regional market in Virginia, Maryland, North Carolina, and the District of Columbia, as shown on Figure TM1-1.

2.1 Approach to Study

As discussed above and consistent with the SB 1398 requirement for processing CCR, beneficiation applications were limited to those that would result in encapsulating CCR. The encapsulated uses that were considered were cement replacement, bricks, blocks, and pavers.

An evaluation of encapsulated beneficial use of ponded CCR requires considerations of the feasibility of excavating, processing, and marketing of the CCR, including the following:

- Characterization of ponded CCR
- Market need, demand, and pricing of CCR
- Market supply and identification of a market shortage or surplus
- Closure by removal process
- Processing and transporting of the CCR from the pond to a local/regional processing facility
- CCR beneficiation technology cost and production rates

The above considerations were addressed by:

- Reviewing and incorporating information provided in AECOM Technical Memoranda 2 and 3 on CCR sampling and closure by removal
- Reviewing publicly available information
- Reviewing studies conducted by organizations including the Portland Cement Association (PCA), North Carolina State University (NCSU), and Electric Power Research Institute (EPRI)
- Conducting benchmarking surveys of regional ash users including concrete producers, cement kilns, and CCR marketers
- Conducting benchmarking surveys of regional ash suppliers (utilities)
- Conducting benchmarking surveys of state department of transportation agencies on allowable fly ash substitution rates
- Reviewing information provided by ash beneficiation technology vendors

2.2 Summary of Findings

AECOM's beneficial use and ash market study evaluated the market-wide demand for fly ash based on cement consumption and found that regional (Virginia, Maryland, North Carolina, and the District of Columbia) fly ash supply is projected to exceed demand starting by 2019, without accounting for the more than 25 million CY of ponded ash stored at the four Dominion stations. Regional supply is projected to be at least 2.3 million tons per year starting in 2019, while projected 2019 fly ash usage (demand) is estimated as 1.2 to 1.9 million tons, increasing to 1.6 to 2.3 million tons in 2035, as shown in Exhibit TM1-1.

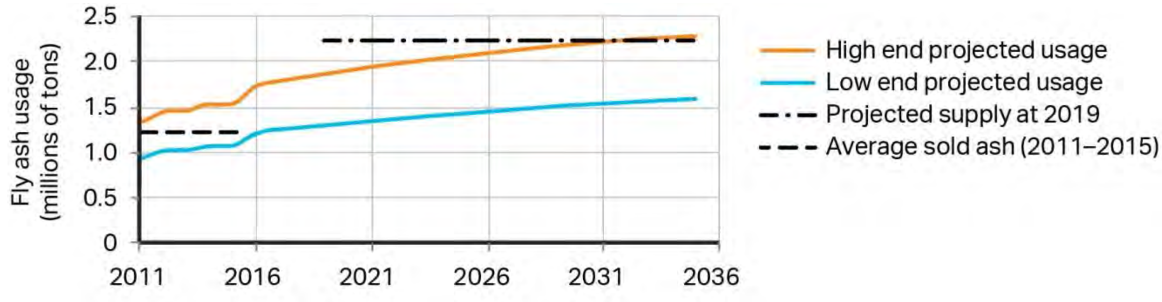

Exhibit TM1-1: Comparison of Projected Fly Ash Usage and Supply

As part of the study, AECOM performed a market review and contacted both regional and non-regional ready mix, concrete, cement kiln facilities, utilities selling fly ash, and other CCR marketers. Some regional and non-regional fly ash consumers indicated that they could use additional beneficiated fly ash beyond their current supply. Desired quantities of processed fly ash from individual end users are highly variable, ranging from approximately 1,300 to 18,000 tons per year and for one concrete company, up to 375,000 tons per year of unprocessed ash. Additionally, a fly ash marketing firm indicated the potential to sell up to 800,000 tons per year into the regional market. The demand is highly variable, depending on the end user and quality of the ash. Competitive purchase price for fly ash meeting ASTM C618 standards typically ranges from $30 to $60 per ton with added transportation costs of $7 to $33 per ton (total $37 to $93 per ton), and fly ash was reported to be transported between 60 and 200 miles.

AECOM also contacted potential beneficial use technology vendors to assess the feasibility of processing ponded ash at one centrally located Dominion station or at multiple stations. Numerous technologies were evaluated, and although this market is rapidly evolving, many of them are still in the research stage or are unproven for large-scale coal ash beneficiation. Potentially viable technologies include Staged Turbulent Air Reactor (SEFA Group); Triboelectric Separation Technologies (Separation Technologies [ST]) combined with Carbon Burnout (PMI Ash Technologies); Nu-Rock Technology (Nu-Rock); and Fly Ash Brick Plant (Belden-Eco Products). Costs varied significantly, from $96 to $285 per ton excluding transportation (see Exhibit TM1-2). For most of the technologies, the estimated costs for beneficiation are approximately 1.5 to 4.8 times greater than the current regional market price for the ash.

In addition, processing rates varied from 300,000 to 840,000 tons per year. Depending on the technology and ability of the market to use the quantity of fly ash, beneficiation would be expected to take between 11 and 24 years at Bremo, 21 to 53 years at Chesterfield, and 8 to 17 years at Possum Point. Exhibit TM 1-3 demonstrates the range of timelines for each station (not in aggregate). Chesapeake Energy Center was not evaluated due to the small quantity of ash (60,000 cubic yards) and current market interest for unprocessed ponded ash from that station.

As noted above, projections for fly ash supply and demand indicate a surplus of fly ash in the market starting in 2019 (see Exhibit TM1-1). Although the fly ash consumers that were surveyed indicate the demand and desire to use regionally processed fly ash, the potential usage amounts are variable and a reasonable estimate cannot be made without developing contractual agreements with potential users.

Exhibit TM1-2: Comparison of Beneficiation Technology Cost and Fly Ash Purchase Price

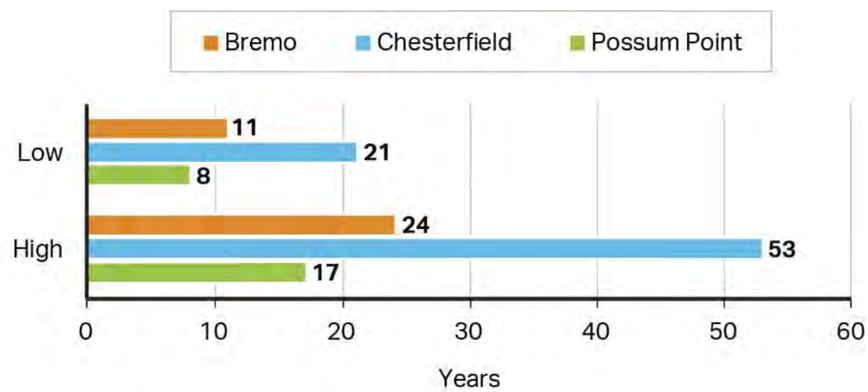

Exhibit TM1-3: Comparison of Beneficiation Technology Timelines

AECOM performed limited ash sampling and characterization at the Bremo, Chesterfield, and Possum Point Power Station ash ponds. None of the samples collected at the four ash ponds met all of the ASTM C618 criteria (ASTM, 2015). The most common issues were excessive carbon content (as measured by loss on ignition [LOI]), high moisture content, insufficient material fineness, excessive water demand, and an insufficient rate of pozzolanic reactivity (as measured by the strength activity index [SAI]). These issues could potentially be addressed via processing to reduce moisture and increase fineness of the materials, as well as using beneficiation technologies to reduce the carbon content. In addition, the presence of visible debris and refusal conditions indicates that screening of ash will likely be required to remove materials that are unsuitable for recycling prior to processing. Unsuitable materials may need to be placed in a landfill.

As described in Technical Memorandum 2, initial testing of ponded fly ash indicates that the ash may be suitable for beneficiation with the technology vendors. However, there are test data currently outside the vendor-specified moisture and LOI limits. If the decision were made to proceed with beneficiation, the following steps would be required to select the appropriate technology:

- More detailed market discussions with specific regional fly ash users to determine the actual quantity and market price they would commit to in order to supplant their current source

- More extensive sampling and characterization to meet technology-specific requirements and to determine which technologies would be most effective
- Following completion of the detailed characterization, conduct detailed cost and marketability discussions with the technology vendors to obtain firm commitments on the processing rates and costs provided in their initial estimates

The fly ash supply in the market is highly variable as a result of factors such as the development of local sources similar to the ponded ash processing facilities under development by Duke Energy, loss in supply if existing coal plants sourcing fly ash in the region close or convert to natural gas, and loss of out-of-state sources if local sources offer a consistent quality, quantity, and cost-competitive alternative.

3. Assessment and Characterization of Ponded CCR

Fly ash is commonly used as a substitution for Portland cement used in the production of concrete. Ponded fly ash can potentially be processed by beneficiation technologies to meet concrete specifications. The first step in the beneficiation process is to assess and characterize the CCR materials in the existing ash ponds. As discussed above, eleven CCR ash ponds at four Dominion stations are applicable to SB 1398. At six of the ponds, ash has been removed or is in the process of being removed, and these ponds were therefore not included in evaluation of the closure and beneficiation alternatives. In addition, vendors have indicated the ability to beneficially use the ash from the Chesapeake Energy Center Bottom Ash Pond without additional processing, so it was not included in the study. Table TM1-1 shows the CCR surface impoundments, volumes, and acreage based on information provided by Dominion.

3.1 Fly Ash Requirements

ASTM is a national standards organization in the United States for engineering-related materials and testing. ASTM C618 is widely used because it covers the use of fly ash as a pozzolan or mineral admixture in concrete. The three classes of pozzolans are Class N, Class F, and Class C. Class N is raw or calcined natural pozzolan such as some diatomaceous earths, opaline cherts, and shales; tuffs, volcanic ashes, and pumicites; and calcined clays and shales. Class F is pozzolanic fly ash normally produced from burning anthracite or bituminous coal. Class C is pozzolanic and cementitious fly ash having relatively high calcium content, normally produced from burning lignite or subbituminous coal. In the United States, Class C fly ash is usually produced by burning the Powder River Basin (western) coal, and Class F is typically used in the Southeast region. The chemical and physical requirements of ASTM C618 are listed in Table TM1-2.

Table TM1-2: ASTM C618 Chemical Requirements for Fly Ash Classes

Ash Classification	$SiO_2 + Al_2O_3 + Fe_2O_3$ (min wt%)	SO_3 (max wt%)	Moisture (max wt%)	LOI (max wt%)
C Ash	50	5	5	6
F Ash	70	5	3	6

Al_2O_3 = aluminum oxide; Fe_2O_3 = ferric oxide; LOI = loss on ignition; SiO_2 = silicon dioxide; SO_3 = sulfur trioxide; wt% = weight percent

Although some state transportation departments specify a maximum LOI value that does not exceed 3 or 4%, the ASTM criterion for Class F ash is a maximum LOI of 6%. Carbon content of the fly ash, reflected by LOI greater than 3 to 4%, may have an adverse effect on air entrainment and ultimately the strength of the resulting concrete.

Ready mixed concrete companies typically request an LOI less than 4% because they are concerned about product quality and the control of air-entraining admixtures. Equally as important to the low LOI values is the consistency in the LOI, because ready mixed concrete producers are most concerned with inconsistent batching results due to wide variations in LOI.

The ASTM C618 standard also specifies a maximum allowable moisture content of 3% for Class F ash and 5% for Class C ash. Some other properties of fly ash-concrete mixes that are of particular interest include mix workability, time of setting, bleeding, pumpability, strength development, heat of hydration, permeability, resistance to freeze-thaw, sulfate resistance, and alkali-silica reactivity.

3.2 Ash Sampling Data

AECOM performed preliminary ash sampling and characterization using a direct-push technology (DPT) drill rig at Possum Point and a Terra Sonic Compact Crawler drilling rig at Bremo and Chesterfield. All samples were collected from dry, accessible areas of the four ponds. The results of the ash sampling are summarized in Table TM1-3.

Table TM1-3: Summary of Ash Depth by Station and Ash Pond

Station / Pond	Boring ID	Boring Depth (ft bgs)	Ash Depth (ft bgs)	Reason for Termination
Bremo Power Station / North Ash Pond	BRN-B01	70.0	63.5	Native materials
	BRN-B02	85.0	79.0	Native materials
	BRN-B03	70.0	66.0	Native materials
	BRN-B04	60.0	34.0	Native materials
Chesterfield Power Station / Lower Ash Pond	LAPPB-1	40.0	32.1	Native materials
	LAPPB-2	50.0	39.5	Native materials
	LAPPB-3	50.0	34.2	Native materials
	LAPPB-4	50.0	38.3	Native materials
Chesterfield Power Station / Upper Ash Pond	UAPPB-1	70.0	69.0	Native materials
	UAPPB-2	110.0	99.3	Native materials
	UAPPB-3	90.0	79.9	Native materials
	UAPPB-4	90.0	80.3	Native materials
	UAPPB-5	90.0	84.9	Native materials
Possum Point Power Station / Ash Pond D	PPD-B01	15.0	Unknown	DPT refusal
	PPD-B02	19.5	Unknown	DPT refusal
	PPD-B03	18.8	Unknown	DPT refusal
	PPD-B04	16.6	Unknown	DPT refusal
	PPD-B05	13.6	Unknown	DPT refusal

DPT= direct push technology; ft bgs = feet below ground surface; ID = identifier

More detailed results from the study are presented in Technical Memorandum 2. The depth of ash was not determined at Possum Point Ash Pond D as a result of refusal conditions encountered at shallow depths.

3.3 Ash Characterization Data

Composite CCR samples were collected and tested in the laboratory for the parameters shown in Table TM1-4. Table TM1-5 and Table TM1-6 provide a summary of the sample analysis results for each site with respect to the various ASTM C618 method-specified acceptance criteria (ASTM, 2015). For each parameter with a specific acceptance criteria, the percentage of samples that did not meet the criteria are noted. The total number of samples analyzed at each site, as well as the number of borings, are provided in Table TM1-5.

Table TM1-4: Test Methods and Evaluated Parameters

Method	Parameter	Description
ASTM C618-15, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete Methods to be used for ASTM C618 tests are specified in ASTM C311, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland Cement Concrete	$SiO_2 + Al_2O_3 + Fe_2O_3$	Silicon, aluminum, and iron content of the ash expressed as the sum of the elemental oxides on a weight percent basis. The ash must contain a minimum amount of these species to exhibit the necessary pozzolanic properties and be a suitable replacement for Portland cement in concrete. Pozzolanic activity refers to the ability of the silica and alumina components of fly ash to react with available calcium and/or magnesium from the hydration products of Portland cement.
	SO_3	Sulfate content of the ash, expressed as sulfur trioxide on a weight percent basis. Sulfates present in the ash or concrete can impact the optimum amount of fly ash needed for maximum strength development. Excess sulfate remaining in the hardened concrete can result in detrimental sulfate attack.
	Moisture	Water content of the ash expressed as weight percent. Moisture limits are necessary to ensure proper handling characteristics of the concrete.
	LOI	Percent loss on ignition is a measure of the unburned carbon content in the ash. Carbon can react with air entrainment admixtures making it difficult to maintain proper air entrainment in concrete. Excessive carbon content can also increase the water requirement.
	% retained at 325 mesh	A measure of the fineness of the ash, expressed as the weight percent of material retained on a 325 mesh screen (45 um) using a wet sieve method. Fineness impacts the pozzolanic reactivity of the ash as well as the water required. Coarse ash particles do not react as rapidly in concrete.
	Water required	The amount of water added to the sample as part of the strength activity index test (SAI) relative to the control mixture to obtain the same flow characteristics as the control mixture. Calculated as the ratio of the water required in the test mixture to that of the control mixture, expressed as a percentage. The control mixture used for SAI tests is prepared by combining specified amounts of Portland cement, sand and water. The sample test mixture is prepared by replacing 20% by weight of the cement with the ash material to be tested, and adding water to obtain the same flow characteristics as the control sample.
	7- and 28-day SAI	Strength activity index provides an indication of the rate of pozzolanic activity. SAI is calculated as the ratio of the compressive strength of the test mixture to that of the control mixture, expressed as a percentage. Compressive strength is measured on both the control and the sample at 7 days. If the test mixture fails the criterion on the 7-day test, the test is repeated at 28 days and if it meets the criterion, the material is considered compliant with the specification.
	Soundness	A measure of the expansion/contraction of the test material when placed in an autoclave at a specified temperature and for a specified duration. The test measures the delayed detrimental expansion/contraction that can occur if high concentrations certain constituents such as magnesium oxide are present.
ASTM C40-16, Standard Test Methods for Organic Impurities in Fine Aggregates for Concrete	Organic impurities color test	Final color of a solution prepared from the material is compared to standardized color plates and if darkness exceeds plate #3, the material may contain injurious organic impurities. Thus, the method states that it is advisable to perform additional tests using ASTM C87 (Standard Test Method for Organic Impurities in Fine Aggregate on Strength of Mortar) before approving the fine aggregate for use in concrete. ASTM C87 compares the strength of mortar made with washed and unwashed fine aggregate.

Table TM1-4 (cont.): Test Methods and Evaluated Parameters

Method	Parameter	Description
ASTM D6913-17, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis – Test Method B	Particle size distribution	Defines the dry sieve test method procedures to determine the particle size distribution of soil-type material in size ranges from 3/8 inch (9,510 µm) to 200 mesh (74 µm) diameter.
ASTM D1921-12, Standard Test Methods for Particle Size (Sieve Analysis) of Plastic Materials – Test Method A (Modified)	Particle size distribution	Defines the dry sieve test method procedures to determine the particle size distribution of material in size ranges from 230 mesh (63 µm) to 635 mesh (22 µm) diameter.

Al_2O_3 = aluminum oxide; Fe_2O_3 = ferric oxide; LOI = loss on ignition; SAI = strength activity index; SiO_2 = silicon dioxide; SO_3 = sulfur trioxide; wt% = weight percent

Table TM1-5: Number of Boring Locations, Number of Samples Analyzed, and Ash Classification

Station	Ash Pond	No. of Boring Locations	No. of Samples Analyzed	Ash Classification
Bremo	North Ash Pond	4	17	Class F[(1)]
Chesterfield	Lower Ash Pond	4	10	Class F[(1)]
Chesterfield	Upper Ash Pond	5	37	Class F[(1)]
Possum Point	Ash Pond D	5	8	Class F[(1)]

(1) Ash with low calcium oxide content

Table TM1-6: Summary of Ash Characteristics Relative to ASTM C618 or ASTM C40 Criteria for Class F Ash

Parameter	Subparameter	ASTM C618 or ASTM C40 Criteria for Class F Ash	% of Samples Failing Criteria per Ash Pond			
			Bremo North Ash Pond	Chesterfield Lower Ash Pond	Chesterfield Upper Ash Pond	Possum Point Ash Pond D
Chemical	Sum SiO_2, Al_2O_3, Fe_2O_3, wt%	Min 70%	0%	0%	0%	0%
	CaO, wt%	Max 10%	0%	0%	0%	0%
	SO_3, wt%	Max 5%	0%	0%	0%	0%
	Moisture, wt% as received	Max 3%	100%	100%	100%	100%
	Moisture, wt% further processing	Max 30%[(1)]	59%	60%	35%	0%
	Moisture, wt% dried	Max 3%	0%	0%	0%	0%
	LOI, wt%	Max 6%	94%	80%	100%	100%
Physical	Soundness	Max ±0.8%	0%	0%	0%	0%
	% retained on #325 mesh	Max 34%	47%	70%	51%	88%
	Water required, % of control	Max 105%	53%	60%	62%	100%
	7-day SAI, % of control[(2)]	Min 75%	35%	80%	62%	50%
	28-day SAI, % of control[(2)]	Min 75%	29%	60%	32%	13%
	Organic Impurities (color plate #)	Max #3	12%	0%	0%	38%

(1) The upper moisture limit of CCR feed for selected LOI beneficiation technologies is 20 to 30%.

(2) Passing either the 7-day criterion or the 28-day SAI% criterion indicates compliance with the ASTM C618 specification.

ASTM = ASTM International; CCR = coal combustion residuals; ID = identifier; LOI = loss on ignition; SAI = strength activity index; wt% = weight percent

The calcium oxide (CaO) content of the material from all of the ponds was quite low; thus, all ash material would be considered Class F, and all data were compared to the ASTM C618 criteria for Class F ash. With respect to the chemical parameter requirements for Class F ash, the limits for moisture content and LOI content were consistently exceeded at each pond, indicating that most material at these sites will likely require beneficiation to remove unburned carbon from the ash and lower the LOI. The moisture content of the samples as received by the laboratory typically ranged from 20 to 50%, with the higher moisture content samples generally associated with greater boring depths within the ponds. Acceptable LOI and moisture content limits for selected technologies are shown in Table TM1-7.

Table TM1-7: CCR Feed Limits for Selected Beneficiation Technologies

Technology (Company)	CCR Feed LOI, %	CCR Feed Moisture, wt%
STAR (SEFA Group)	8 to 19	30
Carbon Burnout (PMI)	6 to 20	20
Nu-Rock Technology (Nu-Rock)	24	10
Fly Ash Brick Plant (Belden-Eco Products)	NR	NR

CCR = coal combustion residuals; NR = no response from vendor; PMI = PMI Ash Technologies; STAR = Staged Turbulent Air Reactor; wt% = weight percent

For Possum Point Ash Pond D, the as-received moisture content for all samples was below 30%, and only two samples exceeded 20%; however, these results are likely due to shallow boring depth. For Bremo North Ash Pond, Chesterfield Upper Ash Pond, and Chesterfield Lower Ash Pond, 35 to 60% of the samples exceeded 30% moisture by weight, suggesting that drying of material from some regions within the ponds may be needed to meet the feed specifications for the beneficiation technologies.

While the LOI values exceeded the ASTM C618 criterion at all sites, the values were generally within the range of acceptable LOI for CCR feed to one or more of the beneficiation technologies. Many concrete manufacturers require LOI values below the ASTM C618 criterion of 6%, with values of 2 to 4% often specified. An AECOM survey of ready mixed concrete producers in the study area indicated a preferred LOI content of <1% to 4%. The average LOI for samples collected at each site were 9% for Bremo North Ash Pond and 15% for Chesterfield Upper Ash Pond, well above the 6% criterion. LOI values as high as 22 and 24% were observed for some locations at Bremo North Ash Pond and Chesterfield Upper Ash Pond, respectively.

A significant portion of samples at all sites exceeded the following physical property parameters: percent retained on #325 mesh (45 micrometers, µm), water required, and strength activity index. The percent retained on #325 is a measure of the fineness of the sample, with lower numbers indicating finer particles. ASTM C618 requires 34% or less retention on #325 mesh. For any individual site, 41 to 88% of the samples analyzed failed the particle size criterion; therefore, most of the ash will likely require some type of processing (e.g., mechanical screening, hydraulic classification, or air classification separation) to remove larger particles and increase the percentage of smaller particles in the material to make it suitable for use in concrete applications. Possum Point Ash Pond D and Chesterfield Lower Ash Pond exhibited the highest percentage of samples failing the ASTM C618 #325 mesh criterion (88% and 70%, respectively), while 47% of the Bremo North Ash Pond and 51% of Chesterfield Upper Ash Pond samples failed the criterion.

An ASTM C618 SAI test is conducted by preparing a control and test mixture containing the fly ash to be tested, allowing the mixture to cure for 7 days, and then subjecting the mixture to compressive strength testing. If the test mixture fails the SAI criterion on the 7-day test, the test is repeated at 28 days, and if it meets the criterion, the material is considered compliant with the specification. The percentage of samples failing the 28-day SAI criterion ranged from 13% at Possum Point Ash Pond D to 60% at Chesterfield Lower Ash Pond. Reducing the fineness of the ash increases the reactivity and pozzolanic activity of the ash, so additional processing of the materials at these sites to meet ASTM C618 #325 mesh criterion would be expected to increase the probability that the material would meet the ASTM C618 SAI criterion.

The data indicate that 50% or more of the samples at any given site exceeded the water required criterion of 105% of the control, indicating that excessive amounts of water were required to obtain the desired flow characteristics when the ash was used as a replacement for a portion of the Portland cement in the SAI tests. In general, coarse fly ash material or ash containing high levels of carbon can increase water demand (PCA, 2016).

Thirty-eight percent (38%) of the samples at Possum Point Ash Pond D exceeded the ASTM C40-16 method color criterion (ASTM, 2016), indicating that material from some areas of the impoundment may require further evaluation to determine whether beneficiation of the material to remove organic impurities is required. Material that failed the criterion was typically associated with the 0- to 10-foot boring depths at Possum Point Ash Pond D. High clay content was noted in the boring logs for many samples collected at Possum Point Ash Pond D. Organic matter associated with the clay or minerals in the clay could be responsible for the color exceedances. Only 12% of the samples exceeded the color criterion at Bremo North Ash Pond, and none of the samples at Chesterfield Upper or Lower Ash Ponds exceeded the criterion.

3.4 Summary of Findings

The results of the samples that were evaluated in this study provide an initial indication of the CCR material characteristics in each ash pond and can be used to draw general conclusions regarding whether the unprocessed CCR material may meet ASTM C618 criteria for use in concrete or whether additional beneficiation may be warranted. None of the samples that were evaluated met all of the ASTM C618 criteria. The most common issues were excessive carbon content (as measured by LOI), high moisture content, insufficient material fineness, excessive water demand, and an insufficient rate of pozzolanic reactivity (as measured by the SAI test). These issues could potentially be addressed by processing to reduce moisture and increase fineness of the materials and by using beneficiation technologies to reduce the carbon content. Material unsuitable for beneficiation may need to be placed in a landfill.

The ash characterization results are based on the samples collected. If the decision were made to proceed with beneficiation, additional steps would be required to select the appropriate technology as discussed in Section 2.2.

4. Market Need and Demand for CCR

In assessing the market need and demand for CCR, AECOM considered the following key factors and criteria:

- The regional market including Virginia, North Carolina, Maryland, and the District of Columbia
- Fly ash consumption based on Portland cement and ready mix usage in the region and current and projected need from published sources
- Determination of need based on benchmarking surveys of regional ready mix, concrete, cement kiln, CCR marketers, and department of transportation (DOT) agencies within a 50-mile radius of Dominion stations

4.1 Fly Ash Consumption Based on Cement Usage

Depending on availability, quality, economics, and state DOT requirements, fly ash that meets ASTM C618 standards may be used as a substitute for Portland cement (PC). Therefore, the market for fly ash can be linked to the demand for PC. The forecasts for PC as presented in this section can be used as an indicator of the future demand for concrete in the construction industry. As the demand for concrete rises, the market for fly ash meeting ASTM C618 standards will also increase since fly ash can typically replace 15 to 30% of the PC used in concrete mixes.

The study also included benchmark surveys of ready mixed concrete companies, cement kilns, and other concrete production companies in the regional study area. It should also be noted that ponded ash without beneficiation can be used in certain applications but typically at lower quantities.

4.1.1 Fly Ash Usage from PCA Projections

PCA provides its members with long-term assessments regarding cement consumption and sourcing for use in planning and capital investments. According to the PCA report (PCA, 2016), long-term total cement consumption estimates are driven by two key factors: population growth and cement consumption per capita. PCA explores both the United States Bureau of Census and Moody's population projections (PCA, 2016). The PCA also relies heavily on population and per capita cement consumption as estimates for its long-term cement consumption projections. According to the PCA, population growth accounted for approximately 85% of total volume growth. However, the U.S. cement market is currently in recovery mode and a greater proportion of the 2015 to 2040 cement consumption estimates will be determined more by growth in cement consumption per capita than from population. AECOM relied on the per capita cement usage data from the PCA in its analysis.

The PCA report projects almost no growth in the kiln capacity market. Even with plant retirements, there are limited expansions due to foreign sources and multi-national ownership of the competing facilities. The PCA report also expects growth in the use of slag or fly ash as U.S. specifications allow for increased percentages to be added to concrete to offset the use of PC, increasing the domestic supply. The import supply is expected to be influenced by world economic growth conditions, trade embargos, international capacity and consumption, and conditions impacting the dry bulk shipping industry.

The PCA report presents the total cement consumption, PC, and masonry in each state by thousands of metric tons through 2015 with projections through 2040. The amount of PC consumed is expected to increase in the three states and the District of Columbia. The PCA forecasts that from 2016 to 2040, total regional cement consumption will increase from approximately 6 million tons of total cement consumption in 2016 to 10 million tons of total cement consumption in 2040.

To compute the estimated fly ash usage per state, low end (20%) and high end (30%) replacement rates were multiplied by the cement usage for each year from 2016 to 2035 from the long-term cement consumption projections from the PCA. As shown in Exhibit TM1-4, the regional study area is projected to have a fly ash usage in 2016 of 1.2 to 1.7 million tons per year. By 2035, the fly ash usage is projected to be 1.6 million to 2.3 million tons per year, depending on the fly ash replacement rate that is achieved.

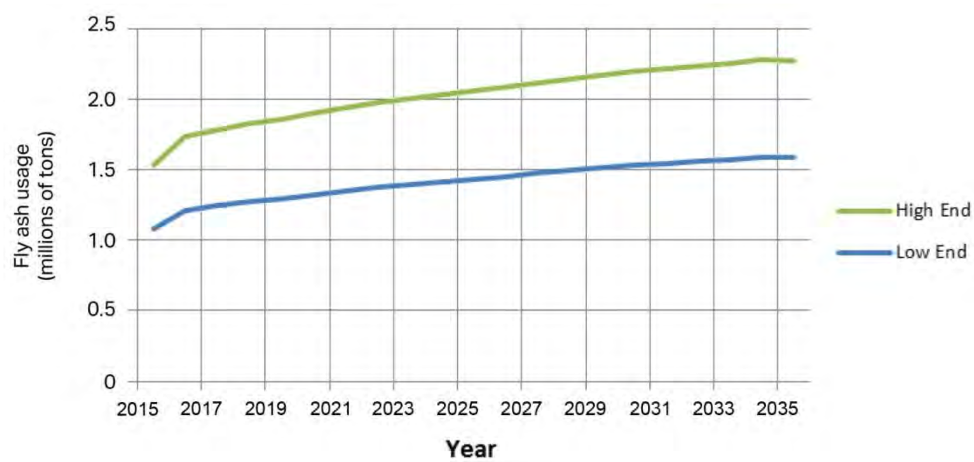

Exhibit TM1-4: PCA Projected Fly Ash Use in Region (NC, VA, MD, and DC)

4.1.2 Fly Ash Usage from Ready Mixed Concrete Production

Another indicator of fly ash usage is the production of ready mixed concrete, which is made in batch plants to project specifications and shipped to contractors at construction sites. The ready mixed concrete industry consumes approximately 75% of the cement shipped in the United States (NRMCA, 2017).

Based on member survey results, the National Ready Mixed Concrete Association (NRMCA) estimates that 83 pounds of fly ash are used per cubic yard of ready mixed concrete. Table TM1-8 presents the 2016 production quantities and estimated fly ash consumed using this conversion factor. The estimates in Table TM1-8 are significantly lower than the PCA 2016 estimates of 1.2 to 1.7 million tons per year.

Table TM1-8: 2016 Ready Mixed Concrete Production and Fly Ash Consumption

Area	2016 Ready Mixed Concrete Production (CY)	Estimated Fly Ash Consumption in Tons
District of Columbia	835,000	34,653
Maryland	4,408,000	182,932
North Carolina	9,139,000	379,269
Virginia	6,734,000	279,461
Total	**21,116,000**	**876,315**

CY = cubic yards

4.1.3 North Carolina State University Regional Fly Ash Forecast

In 2015, Michael Leming of NCSU developed a model to estimate the amount of fly ash needed in North Carolina, South Carolina, and Virginia (Leming, 2017). His estimates were based on U.S. Census Bureau projections and fly ash use from 2014 provided by the NRMCA (NRMCA, 2017). Leming's report is based on an average 35% PC substitution. Leming calculated projections through the year 2030 as shown in Table TM1-9. Leming updated the report in 2017 and found that his analysis for fly ash demand for 2015 and 2016 was consistent with the earlier report and the model he developed. The average annual fly ash demand for the three states was 2.2 million tons from 2015 to 2019, increasing to an average of 3.5 million tons from 2025 to 2030.

Table TM1-9: Leming Projected Fly Ash Demand in North Carolina, South Carolina, and Virginia, 2015 to 2030

State	2015–2019 (tons)	2020–2024 (tons)	2025–2030 (tons)	Total 2015–2030 (tons)
North Carolina	4,985,000	6,680,000	10,161,000	21,826,000
South Carolina	2,125,000	2,675,000	3,831,000	8,631,000
Virginia	4,028,000	4,943,000	7,044,000	16,015,000
Total	**11,138,000**	**14,298,000**	**21,036,000**	**46,472,000**
Annual Averages of Totals				
	2,227,600	2,859,600	3,506,000 (1)	**2,904,500** (2)

Data from Leming (2017)

(1) Calculated by dividing the total by 6 years rather than the 5 years used in Leming report

(2) Calculated by dividing the total by 16 years rather than the 15 years used in Leming report

A comparison of the results of Leming (2017) and the PCA projections in North Carolina and Virginia is shown in Table TM1-10. The significant growth in fly ash demand from 2024 to 2030 projected in the Leming report is heavily influenced by anticipated population growth, not significant increases in cement usage. Fly ash is a replacement for PC in concrete mixes, and growth in cement usage directly correlates with growth in fly ash usage. The results also indicate that Leming's fly ash projections (at a 35% fly ash replacement, using a different replacement methodology) are higher than the PCA projections (20 to 30% fly ash replacement) accepted by state DOTs for similar states of North Carolina and Virginia. The Leming report also overestimates the projected fly ash demand from 2024 to 2030, using a 5-year time frame instead of the actual 6-year time frame, without providing the annual fly ash demand. Because of these factors, the Leming report shows significant differences from the PCA projections and therefore was not used in assessing the market need for fly ash.

Table TM1-10: Projected Annual Fly Ash Usage Comparing PCA (2016) and Leming (2017) Data

State	Reference	Annual Average 2015–2019 (tons)	Annual Average 2020–2024 (tons)	Annual Average 2025–2030 (tons)
North Carolina	Leming	997,000	1,336,000	1,693,500
	PCA High End	813,367	905,905	956,335
	PCA Low End	542,244	603,937	637,557
Virginia	Leming	805,600	988,600	1,174,000
	PCA High End	576,377	673,786	744,866
	PCA Low End	384,252	449,191	496,577

Sources: PCA (2016); Leming (2017)
PCA = Portland Cement Association

4.2 Fly Ash Demand from Benchmarking Surveys with Ready Mix, Concrete, Cement Kiln, CCR Marketers, and DOT Agencies

The purpose of this section is to provide information gathered on ready mixed concrete companies, cement kiln companies, ready mixed concrete trade associations, fly ash marketers, concrete producers, and state transportation agencies in a 50-mile radius of the Dominion stations (facilities shown on Figure TM1-2). The benchmarking surveys document experiences using both unprocessed and processed fly ash generated by coal-fired power plants. The information provides a snapshot of current and future trends on the demand for fly ash in the regional study area, the allowed substitution percentages of fly ash in standard concrete production mixes, and trends in fly ash transportation distances and pricing.

The locations of the gypsum and lime companies, ready mixed concrete, precast concrete companies, and cement kilns contacted by AECOM can be seen on Figure TM1-3, with label details on Figures TM1-3A and TM1-3B. Out of the 174 locations of potential end users of ponded ash identified, AECOM received at least some survey information from 105 locations, including ready mixed concrete companies (many with multiple locations), state DOT agencies, and beneficiation vendors. Table TM1-11 is a high-level summary of potential regional end users that responded to the benchmarking survey, providing data from the 11 individual concrete companies (each representing multiple locations), 1 cement kiln, and 2 CCR marketers that responded to the survey. Responses are also discussed in the following sections.

4.2.1 Ready Mixed Concrete Companies in the Region

Ready mixed concrete plants within the region were located through internet searches and from lists of companies accredited by the NRMCA website. These companies may use fly ash in their concrete mixes if the material meets their quality specifications, is readily available and economically viable. The plant name, city, state, and zip code were compiled in an Access database and the plant locations were plotted using ArcGIS software. Plant locations are shown in Figure TM1-3. AECOM attempted to contact 41 ready mixed concrete companies (many with multiple locations) to determine the extent that fly ash is used in the ready mixed concrete industry and 17 provided responses to the survey. A summary of the survey results is presented in Table TM1-11.

Table TM1-11: Benchmarking Survey Summary of End User Responses

Market	Name of Entity	Fly Ash Usage in Mix (%)	Current Annual Fly Ash Usage (tons)	Fly Ash Price ($/ton)	Average Transportation Distance (mile)	Transportation Cost ($/ton)	Is There Enough Supply?	Max Acceptable Transportation Distance (mile)
Ready Mix and Concrete Companies (processed fly ash)	Titan America Campostella	25	18,000	NR	150–200	NR	Yes[1]	NR
	W.F. Wright Ready Mix	20	NR	25	150	25	No	150
	S.B. Cox	20–25	15,000	NR	100	NR	No	100
	GreenRock Materials	20	NR	30–55	100	NR	No	150
	Essex Concrete	15–20	6,500	35–40	200	10	NR	200
	Capital Concrete	15–20	4,000-5,000	55–60	150–200	32.5	No	200
	Commercial Ready Mix Products	25–30	NR	30	75	15	No	75
	Oldcastle Precast Inc.	20	NR	NR	100	NR	No	100
	Faddis Concrete Products	25	1,300	80–100	<150	6.5	NR	150
	Vulcan Materials Company Culpeper	15–30	6,000	10–12	100	NR	No	100
	Patriot Ready Mix Concrete	20	10,000	30–50	100–150	NR	No	150
	Branscome Inc. Hampton	10–20	5,100	40–45	150	15	No	NR
	Summary	**Avg = 21**	**Sum = 65,900**	**Avg = 40**	**Avg = 133**	**Avg = 17**	**No**	**<200**
Cement Kilns	Lehigh Cement–Union Bridge Plant	—	375,000 (unprocessed)	2-5	NR	NR	No	200
Marketers of CCR	Boral Materials Technologies (headquartered in San Antonio, TX)[2] [3]	—	1,000,000	35–40	NR	NR	No	350
	Charah (headquartered in Louisville, KY)[3]	—	800,000 (unprocessed) and 150,000 (processed)	20–80	<1,000	$0.18/mile	No	200

[1] Plant expects to start importing ash from outside Virginia in 3 to 5 years
[2] Does not pay for transportation
[3] Not currently in regional market
CCR = coal combustion residuals; NR = no response from vendor to AECOM's survey request

4.2.2 Concrete Companies in the Region

AECOM contacted several precast concrete companies within the region to determine the potential use of fly ash in the non-ready mixed concrete industry. The concrete companies contacted were selected from the list of members of the National Precast Concrete Association and the Precast Concrete Association of Virginia. Five manufacturers were contacted, including Rinker Materials, Contractors Precast Corp., Faddis Concrete Products, Oldcastle Precast Inc., and Superior Tank Inc. All of these companies are located in Northern Virginia or Maryland, within 50 miles of the Possum Point Power Station as shown in Figure TM1-3.

4.2.3 Overview of Cement Kilns in the Study Area

Fly ash can be used as cement kiln feed, potentially offsetting some of the energy to produce clinker (used as cement binder) and serving as a source of additional silica or aluminum compounds. According to an EPRI study (EPRI, 2016), up to 14% of the cement kiln feed by weight could be replaced with fly ash. These facilities would compete with Dominion to sell PC to ready mixed concrete companies for straight mixes, instead of allowing fly ash substitution, but could also obtain fly ash for use in producing the PC.

Cement kiln locations in the local study area were obtained from internet searches and from internal AECOM databases. As shown on Figure TM1-3, four cement kilns are located in the region; only Kerneos is in the local study area, within 50 miles of Chesapeake Energy Center, but it is not interested in using CCR. AECOM contacted the four vendors to determine the extent that fly ash is used in the cement kiln industry and three of these (including Kerneos) responded to the survey.

4.2.4 Overview of CCR Marketers

AECOM contacted three CCR marketers (Boral Material Technologies, Charah, and Headwaters Resources, Inc.) to determine the demand for beneficiated fly ash and two responding to the survey. Both of these companies are headquartered outside the service areas. Charah verified the projection of excess regional ash supply by 2019.

4.2.5 Other Agencies/Companies Contacted

AECOM also contacted ready mixed concrete trade associations and state DOT agencies for benchmarking their observations on the demand for fly ash, the needs of member companies, and details on replacement percentages for fly ash allowed in PC and concrete mixes. The locations and label descriptions for the offices of these associations, agencies, and cement kilns are presented in Figures TM1-4 and TM1-4A.

4.3 Summary of Findings

In summary, the results of the market need evaluation indicate that based on the PCA projections, fly ash usage in 2016 ranged from 1.2 to 1.7 million tons per year. By 2035, the fly ash usage is projected to range from 1.6 million to 2.3 million tons per year, depending on the fly ash replacement rate achieved.

Based on the benchmarking surveys, most of the companies that were contacted indicated that there is currently a shortage of fly ash and that demand exists. However, the regional quantity of fly ash that is currently in demand is highly variable, ranging from approximately 1,300 to 18,000 tons per year and for one concrete company, up to 375,000 tons per year of unprocessed ash. Additionally, a fly ash marketing firm indicated the potential to sell up to 800,000 tons per year into the regional market.

The variable demand is dependent on the end user and whether the ash is processed, as shown in Exhibit TM1-5. CCR marketers are not included in this exhibit, as they are not direct end users of the materials.

Exhibit TM1-5: Fly Ash Demand from Benchmark Surveys (NC, VA, MD, and DC)

The higher quantities of ash were typically associated with unprocessed ash. In addition, the current market price for ash is extremely variable, ranging from approximately $10 to $100 per ton (typically between $30 and $60 per ton), with transportation costs ranging from $7 to $33 per ton as reflected in Table TM1-11 and Exhibit TM1-6.

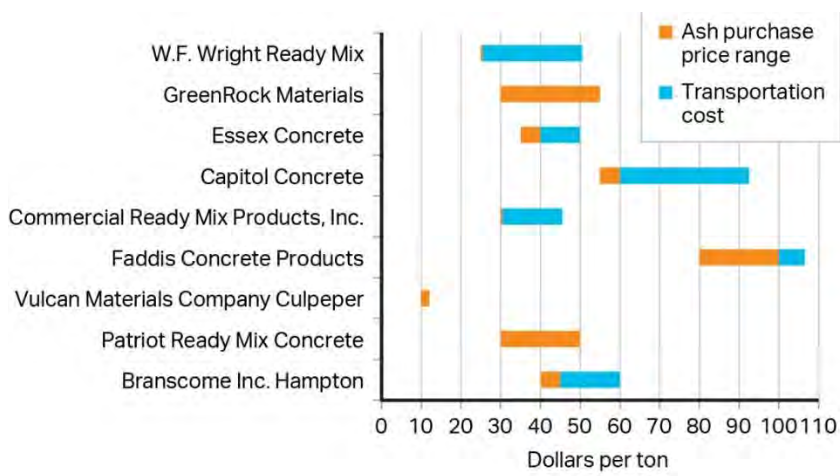

Exhibit TM1-6: Processed Fly Ash Pricing from Benchmark Surveys (NC, VA, MD, and DC)

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5. Market Supply

The purpose of this section is to identify the coal-fired power plants and other independent power producers operating in the regional study area who use coal as a fuel source. AECOM also reviewed published information for each of these power plants, related to their production and sales data for fly ash, over the period of 2011 to 2015. AECOM has relied on the data reports provided by the Energy Information Administration (EIA), related to the operating power plants and the quantities of fly ash generated, sold, and the pricing per ton reported by each utility.

5.1 Utilities Selling Fly Ash

Each year the EIA publishes a Power Plant Operations Report using data from Form EIA-923 that provides extensive information on operational power plants in the United States. AECOM collected available information from the 2016 report on the coal-fired power plants and independent power generators operating in the regional study area. These power plants are shown on Figure TM1-5. Next, AECOM gathered byproduct sales and production data for fly ash for each one of the identified power generators using each year's Plant Operations Report for the years 2011 to 2015, to include the production, sales, and revenues from fly ash for each power plant in Virginia, Maryland, and North Carolina (no power plants are currently burning coal in the District of Columbia). The yearly revenue per ton was calculated for each power generator, based on the tons of fly ash sold and the revenue earned. Additional information regarding tons of material sold was taken from the 2011 to 2015 Coal Combustion Byproducts Generator Reports, published on the Maryland Department of the Environment Coal Combustion Byproducts website.

The 2011 to 2015 fly ash generation and sales data was used to plot how much ash each power generator sold, on average, over this period. Power generators were categorized as Dominion facilities, regulated utilities, or other power generators. As presented in Figure TM1-5, all the power facilities were plotted, even if they did not sell any fly ash. Many of the power generators in the regional study area were not selling fly ash from 2011 to 2015; any power generator that sold less than an average of 10,000 tons per year was not included on Figure TM1-5. In addition, utilities producing and selling fly ash from 2011 to 2015 are summarized in Exhibit TM1-7. This exhibit does not reflect potential future ash generation and additional sales of produced fly ash in the regional market. Dominion is also evaluating the potential for sales of future produced fly ash from the Chesterfield station.

Exhibit TM1-7 indicates that fly ash production in the region declined from 5.4 million tons to 4 million tons, and sales declined from 1.7 million tons to 1 million tons. The percentage of ash sold versus ash produced by the utilities in the study region is presented in Exhibit TM1-8.

The results indicate that approximately 20 to 30% of the regional fly ash that was produced between the years of 2011 to 2015 was sold on the market. These results do not account for ponded ash in the region that is anticipated to be added to the market starting in 2019.

Between 2011 and 2015, 14 power generators reported revenues from selling fly ash. Of the 14 generators, the Duke James E. Rogers Energy Complex had the highest total reported prices at $22 per ton. Mayo and Roxboro reported sales between $13 and $14 per ton. In 2015, the Morgantown

Generating Plant had the highest reported sales price at $29 per ton. Brandon Shores and Herbert A. Wagner reported sales between $5 and $9 per ton.

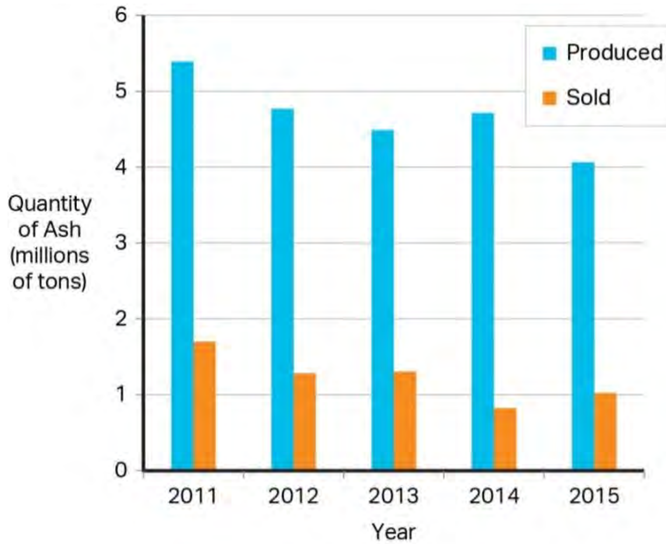

Exhibit TM1-7: Fly Ash Produced and Sold by Regional Utilities (NC, VA, and MD)

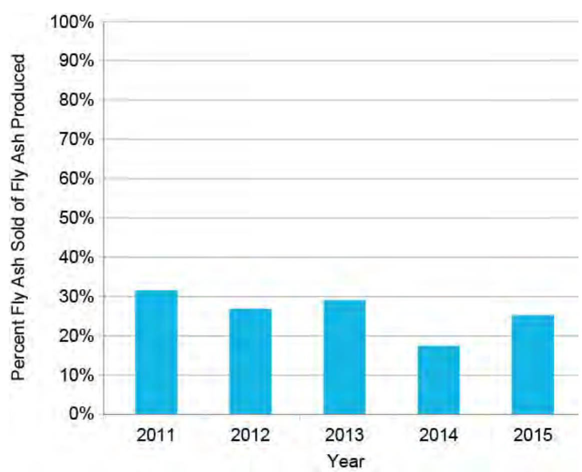

Exhibit TM1-8: Percent Fly Ash Sold of Fly Ash Produced by Regional Utilities (NC, VA, and MD)

5.2 Utilities Selling Fly Ash Contacted by AECOM

AECOM contacted beneficial reuse contacts by phone survey at five utility plants located in the regional study area to determine if they were beneficiating fly ash, including NRG's Chalk Point, Talen Energy's Herbert A. Wagner, AES's Warrior Run, Talen Energy's Brandon Shores, and Duke (several facilities) were contacted. Locations of these facilities are shown on Figure TM1-5.

5.3 North Carolina Fly Ash Sources

Duke has identified three sites for development of an ash beneficiation system as required by North Carolina state law. These facilities are the Goldsboro, Cape Fear, and Salisbury Power Plants. Each facility is required to be capable of processing 300,000 to 350,000 tons per year through 2029, potentially flooding the market with an additional 1,000,000 tons per year of fly ash meeting ASTM C-618 standards. Regulated utilities and other power generators sold an average of 1.3 million tons per year of fly ash, from 2011 to 2015, which is the most current information available. The end result is that over the next 2 years as these three plants begin beneficiation, and through 2029, the regional market may be flooded with fly ash.

5.4 Other Fly Ash Sources

Based on discussions and correspondence with SEFA, the following out-of-region sources of fly ash or slag could potentially be considered as sources for the region.

- Spartan Materials received permission from the State of North Carolina to import fly ash from India. They have a storage facility leased in Morehead City, NC, and are actively marketing the product in North Carolina. Spartan Materials has also added this fly ash source to the Virginia Department of Transportation approved materials listing.
  - AECOM spoke to a Spartan Materials company representative who confirmed the company is importing fly ash from around the world and has access to ports along the eastern seaboard but would not confirm quantities shipped or where they are marketing the fly ash. The representative stated they did not need permission from the states to market or ship their fly ash.
  - AECOM reached out to the Virginia and North Carolina DOT offices to inquire if fly ash from India is being used within each of their jurisdictions. Both agencies have approved the Spartan Materials India fly ash.
  - The company has received a 2-year lease to store and reship 150,000 tons per year of fly ash from India (Rich, 2017).
- SEFA stated that there is a new slag cement source in Virginia. Argos imports slag to its grinding facility in Tampa, FL, and barges it to its ship terminal in Chesapeake, VA. Slag cement is ground granulated blast furnace slag, a byproduct of steel making, and is a direct competing product to coal ash in the concrete industry. There are three imported slag cement marketers in Virginia.
  - AECOM contacted Argos but was unable to confirm whether Argos is importing slag cement into Virginia.
- Ash Ventures, a consortium of ST (owned by the Titan America), and Charah (KY) are bringing fly ash from Cincinnati, OH, by rail into Titan's ship terminal in Chesapeake. Virginia's demand for fly ash is being served by sources from Maryland, North Carolina, West Virginia, Pennsylvania, Georgia, Tennessee, and now Ohio.
  - AECOM contacted Charah but was unable to confirm if fly ash is being railed to Virginia for distribution.
- SEFA continues to reclaim and process over 900 tons per day from coal ash ponds in Georgetown, SC. This source is completely sold out and is on track to supply nearly 300,000 tons of high-quality fly ash per year to the construction industry.

– According to public information, the Georgetown, SC, facility began operation in early 2015, and was designed to process 300,000 tons per year of market ready fly ash (Rising Star, 2015). The quantity of beneficiated ash being placed in the construction industry is unavailable.

5.5 Summary of Findings

As discussed above, regulated utilities and other power generators sold an average of 1.3 million tons per year of fly ash from 2011 to 2015. These sales represented only 20 to 30% of the fly ash produced by the utilities. When forecasting future supply the following additional factors must be considered:

- SEFA's capability to provide 300,000 tons per year of reclaimed and processed ponded coal ash from ponds at the Georgetown, SC, STAR facility to South Carolina and other markets.
- Unquantified quantities of fly ash from sources in Maryland, North Carolina, West Virginia, Pennsylvania, Georgia, Tennessee, and Ohio.
- Unquantified alternative cementitious products such as cement slag being used in the regional study area and new sources starting operation.
- Development of SEFA Star facilities at the Goldsboro, Cape Fear, and Salisbury Duke Power Plants, with a planned processing capacity of 300,000 to 350,000 tons per year each that will beneficiate ponded coal ash from each of the generating stations. The STAR facilities will likely be online in 2019 and operate until 2029, adding up to 1,000,000 tons per year of fly ash meeting ASTM C618 standards.

The 2016 estimated forecast for fly ash usage (demand) ranges from 1.2 to 1.7 million tons per year. By 2035, the fly ash usage is projected to range from 1.6 million to 2.3 million tons per year, depending on the fly ash replacement rate achieved. From a market standpoint, when the Duke STAR facilities come on line in 2019, the fly ash supply will increase to at least 2.3 million tons per year, excluding unknown quantities of fly ash currently imported into Virginia, resulting in a projected fly ash surplus in the regional study area (see Exhibit TM1-9). This surplus is projected to exist before Dominion would enter the market to beneficially reuse ponded ash from the Bremo, Chesterfield, and Possum Point Power Stations.

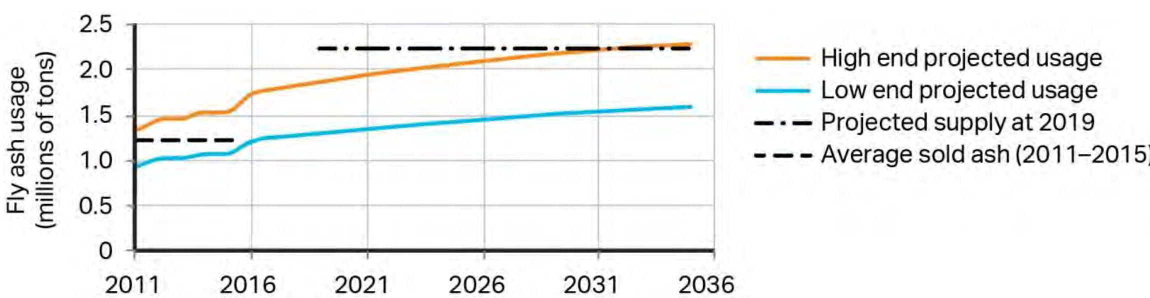

Exhibit TM1-9: Comparison of Projected Fly Ash Usage and Supply

In addition, benchmarking surveys with regional CCR Marketer Charah indicate that they expect a surplus of beneficiated fly ash in the study area region within the next 3 to 5 years when beneficiated ash from North Carolina enters the regional market. Charah anticipates that in the region comprising the states of Virginia, Maryland, North Carolina, and South Carolina the supply will be approximately 1.6 million tons per year, but the demand will be 900,000 tons per year.

6. Evaluation and Consideration of the Closure by Removal Process

Prior to beneficiation of pond fly ash, the ash will need to be excavated and handled following a traditional closure by removal process for the ash ponds. Closure by removal involves several material handling processes, including dewatering and water management, CCR excavation, on-site transportation to staging/loadout areas, drying and stockpiling to prepare for transportation, and backfilling and restoration of the former ash pond.

6.1 Site Infrastructure to Support Removal Activities

To support the logistics of closure by removal, infrastructure would need to be constructed at each power station based on specific site constraints and chosen beneficiation technology. Infrastructure improvements could include on-site road networks, CCR staging areas, truck handling areas, support areas, intersection improvements, traffic control measures, or other improvements based on site conditions.

6.2 Dewatering and Water Management

Dewatering of the CCR impoundments and water treatment will be required to implement closure by removal options. Dewatering will be necessary prior to and during excavation of CCR to remove free water (surface water) from the ash pond and interstitial (pore) water from CCR, and to control stormwater run-on/run-off and groundwater.

Dewatering will likely be implemented using a combination of deep wells to penetrate the full CCR thickness and temporary trenches and CCR grading to direct water to low points within the impoundments prior to removal. Water will be removed using a network of pumps, collection piping, temporary storage tanks, and transfer stations to gather water and pump it to a central location for treatment. Dewatering activities will likely be initiated prior to excavation work and will continue on a 24/7 basis as long as necessary to ensure workable site conditions.

Water treatment will likely consist of pre-treatment storage, chemical mixing, suspended solids removal, pH adjustment, metals precipitation, solids handling (filter press), filtration, post-treatment storage, discharge piping system, and associated automation and controls. Based on dewatering flow rates, water treatment may occur on a continuous or batch basis. The water will be treated and discharged in accordance with a facility-specific Virginia Pollutant Discharge Elimination System Permit.

Dewatering and water treatment costs are a significant portion of the closure by removal options requiring upfront capital expenditures and monthly operation and maintenance. For estimating the closure by removal options, AECOM has assumed dewatering and treatment for the duration of the excavation and site restoration activities. Due to the recurring monthly costs for water management, project duration becomes a significant cost driver.

6.3 CCR Excavation

Closure by removal will involve excavating CCR from the ponds such that no residual materials remain visible, followed by over-excavating the removal footprints by approximately 6 inches. Typically, the excavation is performed in successive benches to safely step down to the pond bottom depths. Excavation would be performed with excavators and other approved equipment as designated by a licensed contractor.

CCR excavation activities should be performed in compliance with the requirements of 29 CFR 1926.651 and 1926.652 for excavation and trench safety. CCR remains stable when the water content of the excavated material is below 25%, allowing for tracked equipment, such as excavators and bulldozers, as well as rubber-tired off-road dump trucks to perform the excavation work safely.

Access and egress to the excavation area is typically maintained through a series of ramps strategically placed to allow for continuous work.

6.4 Transportation to On-Site Staging/Loadout Areas

Once excavated, CCR would be loaded into off-road dump trucks and hauled from the excavation area on dedicated haul routes either to an on-site staging area within the current impoundment or a dedicated on-site stockpile area with proper containment, dust control, and water collection and treatment systems. On-site haul routes will likely need to be constructed or improved at each site to provide sufficient widths and turn radii for efficient and safe operation of large off-road dump trucks. Water trucks will be necessary on site full time to reduce fugitive dust for the duration of hauling.

Mobile conveyor systems may also be used to transfer CCR on site depending on available space and site limitations; if conveyors are used, additional dust control measures may be needed.

6.5 Drying and Stockpiling

In some cases, the CCR may need to be temporarily stockpiled to gravity drain and/or air dry to meet acceptable moisture content (typically between 25 and 35%), prior to loadout for off-site transportation. Drying areas may be near excavation or loadout areas, but sufficient laydown area should be planned to provide 1 week or more of drying time prior to loadout.

Wind rows, with water diversion channels, are also a standard method for drying CCR. Wind rows increase surface area exposed to the atmosphere and allow greater evaporation potential through exposure to wind and sun. Wind rows should be oriented to limit fugitive dust emissions. Wind-rowed CCR may require re-handling several times to rotate CCR for maximum drying potential and to achieve desired moisture content prior to loadout.

6.6 Backfilling and Restoration of Former Ash Ponds

Restoration of former ash ponds will depend on future site needs and conditions. Restoration activities could include reusing former ash pond areas as stormwater management facilities, backfilling pond areas for re-development, removing dikes and restoring original grades, creating wetlands, or restoring habitat. Restored former ash ponds could also be used to support ongoing power generating activities by, for example, serving as equipment or material storage areas, parking or staging areas, or maintenance areas. Post-removal use of the site should be included in the closure by removal design.

At a minimum, closure by removal activities for former ash ponds that will not serve as stormwater management units will provide for decommissioning and de-classification of the impoundment dams to remove them from regulatory oversight. Remaining soil removed from the embankments that meets regulatory criteria to allow it to remain in place can be used for a variety of purposes either during the closure by removal process or as part of the site restoration. During restoration, the embankment soil can be used to restore pre-development lines and grades and to promote efficient surface water runoff.

Restoration activities should result in a site that requires minimum long-term maintenance. Establishment of vegetation, restoration of effective surface water conveyance, and providing for erosion and sediment control are key elements of any restoration project. For the purposes of this study, AECOM assumes that ash pond embankments that will not be incorporated into future stormwater management ponds will be removed and used within the ash pond limits as part of the restoration.

6.7 Impacts

Potential impacts associated with on-site closure by removal activities include safety, environmental, community, schedule, and cost for the various on-site closures by removal options as outlined in Technical Memorandum 3 and the associated Table TM1-12.

Table TM1-12: On-Site Closure by Removal and Beneficiation Impacts

Category	Considerations
Safety	• Ash pond stays open for duration of beneficiation, increases safety risk, and results in prolonged duration for dewatering/water treatment • Safety risks from excavation and over-the-road hauling due to significant volume and multi-year duration removal project (up to 150 trucks per day each way for the duration) • Excavation/construction safety operating heavy equipment and dump trucks on and adjacent to the station
Environmental	• Ash pond stays open for the duration of beneficiation, with resulting prolonged duration for dewatering and water treatment • Noise and emissions from excavation equipment, truck traffic • Dust and odor control may be required • Greater potential for groundwater migration during CCR removal • Engineering challenges for CCR dewatering and excavation • Removes source of potential groundwater impacts
Community	• Community impacts from over-the-road hauling due to significant volume and multi-year duration removal project (up to 150 trucks per day each way for the duration) • Truck traffic may result in increased noise, emissions, traffic congestion, and vehicle accidents • Transportation by rail may decrease community impacts as compared to truck transportation, but noise, safety, and emissions would remain concerns
Schedule	• Duration to implement several evaluated technologies exceeds CCR closure requirements of 15 years • Market risks (there may be insufficient demand) • No on-site storage space is available for beneficiated ash, requiring “on demand” processing that limits production/removal to what the market would accept

CCR = coal combustion residuals

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7. Beneficiation Technologies

The purpose of this section is to identify potential proven, developing, and research-stage technologies that may be feasible to process the ponded ash at Dominion facilities. The list of potential beneficiation technology vendors is substantial. Numerous technologies were evaluated, and although this market is rapidly evolving, many technologies are still in the research stage or are unproven for large-scale coal ash beneficiation. A list of evaluated technologies is provided below; vendor locations are shown on Figure TM1-6.

In performing this study, AECOM used responses to Dominion's request for information for the beneficial use of coal combustion products from Dominion's facilities in Virginia as set forth in Dominion's November 23, 2016, Request for Information,[1] and the Duke Energy Coal Combustion Product Management Study, herein referred to as the Electric Power Research Institute (EPRI, 2016), to supplement information gathered through AECOM's benchmark surveys. In addition, surveys were conducted to obtain additional information from companies discussed in both reports, and other vendors that contacted Dominion directly. Technology vendors that do not have operating facilities in the United States, were in early research stages, or had no experience applying their technology to ponded ash were not contacted as part of the AECOM survey.

7.1 Developing Technologies

The following vendors contacted Dominion regarding their interest in managing some or all of the ponded ash from Bremo, Chesterfield, Chesapeake, and Possum Point Power Stations.

- Progressive Industries, Inc. was founded in 1978 in Sylacauga, AL, as a manufacturer for air classifiers and grinders. Progressive air classifiers are cyclones which separate particles based on size. The air classifiers are available in 11 sizes. The fly ash leaving the classifier has an LOI of less than 2%.
- RSG, Inc. is located in Sylacauga, AL, and is a manufacturer of air classifiers and grinding mills. Feed ash must be placed in a dryer before being placed in the air classifier if the ash is not already dry. Processing rates range from 5 tons per hour to 100 tons per hour.
- Sturtevant, Inc. was founded in 1883 in Hanover, MA, as a manufacturer of air classifiers and other material processing equipment. They have sold more than 5,000 air classifiers throughout the United States and internationally, but few air classifiers have been installed in the United States in the past few years.
- CeraTech began commercial operations in 2002 in Alexandria, VA. Their products include ekkomaxx, a concrete alternative; KemROK, a chemical-resistant concrete; and FireROK, a heat-resistant concrete. CeraTech produces alternative cement using 95% Class C fly ash and 5% proprietary activators. This technology is not appropriate for Class F fly ash.

[1] Dominion Energy, "Request for Information #2016-1123, Processing/Marketing of Ponded Ash, November 23, 2016: Chesterfield Power Station; Possum Point Power Station; and Bremo Power Station; Processing & Marketing of Ponded Ash" (November 23, 2016).

- NAES Corporation/Circumix Technology is headquartered in Issaquah, WA, and developed the Circumix Dense Slurry Technology. In the Circumix process, wastewater is mixed with fly ash and other combustion residuals. The produced slurry sets in 24 to 72 hours with a cured strength of 600 to 2,000 psi. The slurry is then disposed of in a lined landfill with a leachate collection system where the slurry can be dried in tiers and capped or used to cap an existing landfill.
- Virginia Power Coal-Ash Pellet Oyster Reefs were started when Virginia Power began collaborating with research of the use of coal ash to build artificial oyster habitats. Two reefs were constructed using coal-ash pellets near Fisherman's Island as part of a remediation project funded by the Aquatic Reef Habitat Program, the Virginia Power Company (now known as Dominion Energy), the Virginia Oyster Repletion Program, and several government offices including the USEPA. It was determined to be non-leaching, and as effective as traditional artificial reef bases.
- Spartan Materials headquartered in Blue Ash, OH, is an international supplier of fly ash to the concrete industry. Spartan Materials has secured an agreement to obtain Class F fly ash from a large coal burning utility in India.
- Turboden was founded in Milan, Italy, in 1980 as a manufacturer of Organic Rankine Cycle (ORC) turbogenerators. ORC turbogenerators recover heat to generate electric and thermal power from renewable sources and from industrial waste heat and do not use fly ash.
- Sierra Energy was founded in Davis, CA, in 2004 and developed the FastOx gasifier. One FastOx gasifier facility is under construction at the U.S. Army Garrison Fort Hunter Liggett in Monterey, California. In The FastOx gasification process, waste is dried to below 50% moisture, which is fed into the top of the gasifier, injected with oxygen and steam, and heated to form a syngas. There are no data to suggest that fly ash would be an appropriate fuel source.
- SonoAsh began operating in 2000 as a soil remediation technology, consulting, and services firm. In 2008, SonoAsh was approached by Nalco MoboTech to evaluate the ability of sonic separation technology to reduce the carbon content in low quality ash to create a marketable product. SonoAsh has not been commercially implemented at this stage.
- RJ Smith is a construction firm in Richmond, VA. Services include erosion control, site development, excavation services, logistics planning and execution, demolition, landfill development/capping, and aggregate production. RJ Smith has developed a process to transform CCR into a beneficially re-used construction product. In the process, CCR materials go through a proprietary mixing and production process to create blocks of solid cementitious material with an anticipated 28-day cure strength of more than 4,000 psi. After curing, the blocks can be crushed and sized to meet standard crushed aggregate criteria for use in the construction materials industry.
- Boral North America acquired Headwaters, Inc., in May 2017. With the acquisition, Boral North America gained industry-leading positions in CCR processing and distribution as well as concrete block and construction materials businesses. Boral is currently considering relatively large volume beneficial use applications including the manufacture of aggregates from reclaimed ash. Aggregates can be manufactured from fly ash using PC or cement kiln dust as a binder, geopolymer chemistry, or thermal sintering. Boral has also investigated the use of foaming agents as a way to make ultra-light weight building products with high fly ash contents (Flexcrete).

All of these technologies are market limited because they depend on the market to use the ash generated by the technology.

AECOM also reviewed the ash management technology proposed by EnCAP-IT, which uses mechanically stabilized earth (MSE) berms for CCR containment that use ash instead of soil in the MSE construction. In this process, only a small portion of the material would be beneficially used; the remainder of the CCR would be removed from the ash pond and consolidated or mechanically stabilized, similar to closure-in-place. Ash ponds with more than 65 acres require the construction of multiple MSE walls to segregate the pond into multiple sections. The ash is then moved from one section to the other to facilitate installing a liner, which is not anticipated to meet CCR Rule requirements because the liner would not be a composite liner. Moving the ash would add the significant costs of handling and moving the same ash multiple times. In addition, although MSE walls have been used widely in civil construction applications, there are no examples of MSE wall construction within the footprint of previously saturated ash ponds. Constructing multiple walls to facilitate this method of closure also raises stability concerns because internal walls could be more than 80 feet tall and built on a substrate that has been an active pond for many years. The EnCAP-IT technology does not meet the intent of the study to beneficiate the ash with encapsulated uses such as cement replacement, bricks, blocks, and pavers, and was not considered further.

7.2 Technologies Further Evaluated

The following four technologies were considered further in this evaluation: Staged Turbulent Air Reactor (SEFA Group); Triboelectric Separation Technologies (ST) combined with Carbon Burnout (PMI Ash Technologies); Nu-Rock Technology (Nu-Rock); and Fly Ash Brick Plant (Belden-Eco Products).

7.2.1 SEFA Group

Founded in 1976, the SEFA Group began researching methods to refine coal ash in the mid-1990s. SEFA developed the Staged Turbulent Air Reactor (STAR) process to refine the ash into a Portland cement replacement. The first STAR plant was built at McMeekin Station in Lexington, SC. SEFA now operates three STAR beneficiation facilities at power plants, along with five facilities that use other technologies. Facilities are located in South Carolina, North Carolina, Tennessee, Maryland, and Pennsylvania.

7.2.1.1 Process Overview

In the STAR process, CCR is pneumatically fed into a reactor and ignited. The STAR process can utilize ponded ash, or freshly produced ash. The feed CCR requires an LOI ranging from 8 to 19% on a dry basis, and the process can tolerate up to 30% moisture content. The carbon in the CCR is used for a self-fueled combustion reaction. The CCR is then processed into a pozzolan, collected in a baghouse, and stored before sale and shipment. Typical STAR-processed fly ash has an LOI of less than 1%. Constructing a SEFA facility takes approximately 9 months with an additional 6 to 12 months for pre-construction activities such as permitting.

7.2.1.2 Market Position

SEFA's core market is within 180 miles of a processing facility, which could expand up to 250 miles. Ash is delivered to ready mixed concrete customers by their fleet of 175 trucks. Their distribution network consists of concrete producer customers, and local market common carriers. Ash is marketed from each operating facility by SEFA. SEFA estimates that they have the ability to process up to 1 million tons of ash per year from the facilities being constructed in North Carolina, beginning in 2019. SEFA reported they are processing a total of 700,000 tons per year from the NRG Morgantown plant in Newburg, MD, the McMeekin South Carolina Electric and Gas plant in Lexington, SC, and the Santee Cooper Winyah Generating Station in Georgetown, SC.

7.2.1.3 Considerations

Considerations for SEFA facilities include:

- Schedule delays may occur to obtain environmental permits.
- Uncertainty in the quality and moisture content of the ponded ash could cause operational delays or delays to shipping processed fly ash to end users, if the annual throughput cannot be met.
- Operational difficulties and delays may occur due to blended fly ash, bottom ash, and other materials that may be present.
- Beneficial use requires following the closure by removal process which will result in excavation noise, material handling requirements, and safety considerations as discussed in Section 6.
- Transportation of beneficiated materials to the market may require 150 trucks per day for many years, resulting in considerations associated with safety, noise, and emissions.
- Duration of beneficiation is dependent on market demand.

7.2.2 PMI Ash Technologies and Separation Technologies

For purposes of ponded ash, PMI Ash Technologies (PMI) and ST propose a combined facility that leverages the strengths of both technologies. PMI was founded in 1986 in Florida and is currently located in Raleigh, NC. PMI developed the Carbon Burnout (CBO) technology, which ESI, Inc. of Tennessee (ESI) helped design, and it was commercialized in 1999. ESI has also been involved in engineering and constructing several PMI facilities. PMI has constructed four CBO facilities; one of which formerly operated at the Chesapeake Energy Center.

According to the ST website, ST began operating in 1989 to commercialize electrostatic separation and was bought by Titan America in 2002. Ash Venture, an ash supplier, is a subsidiary of ST and a joint venture between ST and Charah. ST operates one CBO facility and 20 electrostatic separators for CCR beneficiation. Both processes produce a pozzolan, which can be used for the production of concrete products.

7.2.2.1 Processes Overview

According to PMI, during the CBO process, fly ash is distributed from storage silos to a fluid bed combustor. Feed fly ash can have moisture content up to 25% and is dried using byproduct heat from the CBO system. Air is circulated to separate the fly ash particles and heated, which allows for the particles to ignite and the carbon to burn; the carbon content in the fly ash sustains the burn. Fly ash is then collected from the flue gas and placed back into the fluid bed. The low carbon ash is placed in a heat exchanger for cooling. The ash and flue gas are separated in a cold cyclone and baghouse. Heat can be collected from the flue gas and the heated ash and used to heat the power plant’s condensate steam. Following heat collection, the fly ash is dried and distributed, and the flue gas is sent back to the power plant's unit. The resulting product has an LOI ranging from 2% to 4%.

A PMI CBO facility typically uses 7,000 square feet of space and can process 200,000 tons of fly ash per year and potentially up to 1,000,000 tons per year if multiple processing units are installed. It takes 12 months to construct a PMI facility, with an additional 3 to 6 months for engineering post-construction.

The CBO process combusts CCR to produce a low-carbon pozzolan, and is fueled by the carbon in the CCR. The feed CCR has an LOI of between 6 and 20%, with a moisture content of 20%. Heat can be recovered from this process and used at the power station.

Electrostatic separation separates ash particles using positive and negative electrodes. Feed CCR consists of the CCR dried by the CBO process, with an LOI of between 4 and 25%. The particles are separated into a positively charged carbon material with a high LOI, which can be re-burned, and a negatively charged low carbon pozzolan, which can be used in concrete.

7.2.2.2 Market Position

PMI has several plants in commercial operation but uses third-party ash marketers. ST has an existing distribution network in Virginia, West Virginia, North Carolina, Maryland, Delaware, New Jersey, Pennsylvania, and New York, utilizing the resources of ST parent company Titan America. Titan America also has internal demand for the product, through its ready mixed concrete and Portland cement manufacturing facilities. ST has six separation units online in the United States. Triboelectric Separation Technologies are currently used to process material from the following plants:

- Brunner Island Power Plant, PA (PPL Corporation)
- Brandon Shores Plant, Baltimore, MD (Raven Power)
- Roxboro Steam Plant, Semora, NC (Duke Energy)
- R.D. Morrow Plant, Hattiesburg, MS (South Mississippi Electric Power Association)
- St. John's River Power Park, Jacksonville, FL (Jackson Energy Authority)
- Big Bend Power Station, Tampa, FL (Tampa Electric)

7.2.2.3 Considerations

Considerations associated with these technologies include:

- There are no PMI/ST combined units currently in operation processing ponded ash.
- Schedule delays may occur to obtain environmental permits.
- Uncertainty in the quality and moisture content of the ponded ash, which could cause operational delays or delays to shipping processed fly ash to end users if the annual throughput cannot be met
- Operational difficulties and delays may occur due to blended fly ash, bottom ash, and other materials that may be present.
- Beneficial use requires following the closure by removal process which will result in excavation noise, material handling requirements, and safety considerations as discussed in Section 6.

- Transportation of beneficiated materials to the market may be up to 150 trucks per day for many years, resulting in several considerations associated with safety, noise, and emissions.
- Duration of beneficiation is dependent on market demand.

7.2.3 Nu-Rock

Nu-Rock was founded more than 20 years ago in Australia and is developing building products that use industrial byproducts. Nu-Rock operates a pilot production facility in Australia, a second production facility in South Africa, and a third facility is reportedly scheduled to be constructed in Baldwin, IL, for Dynegy Baldwin; however, groundbreaking was delayed in October 2017 with no rescheduled date announced.

7.2.3.1 Process Overview

Processing facilities are located on site at a coal burning power plant or former plant site. The Nu-Rock process is modular, and can be configured to process multiples of 125,000 tons of fly ash per year, up to 500,000 tons per year. Construction of a Nu-Rock facility takes 6 months, with at least 3 months up front required for permitting. Nu-Rock uses a non-hazardous binding reagent to harden CCR into a variety of products including bricks and blocks, pipe, pavers, and tiles as well as sand and aggregates. The products harden and cure at ambient temperatures without the addition of process heat. In addition to binding any type of CCR, this process binds environmental contaminants of concern, eliminating the risk of leaching. The CCR can have an LOI of up to 24%, and must be dewatered to a moisture content of 10%.

7.2.3.2 Market Position

Nu-Rock does not have an existing distribution network or production facility in the United States. However, a Nu-Rock facility is reportedly scheduled for construction at the Dynegy Midwest Generation, Inc. Baldwin Energy Complex in Baldwin, IL. Construction was expected to be completed in 2017, but groundbreaking was delayed in October 2017 with no rescheduled date announced. This technology has successfully been commercialized in Australia. Products could be delivered by truck within an economic limit of 250 to 300 miles of the processing facility.

7.2.3.3 Considerations

Considerations associated with this technology include the following:

- Nu-Rock is new to the U.S. market, and its products need to be certified by testing to demonstrate that they meet American standards.
- The first U.S. plant has not been constructed, and the company has no operating history using ponded ash.
- Commercial acceptance of the product may be an issue.
- Uncertainty in the timing to get the permits for the facility.
- Uncertainty in the quality and moisture content of the ponded ash could cause operational delays or delays to shipping processed fly ash to end users if the annual throughput cannot be met

- Operational difficulties and delays may occur due to blended fly ash, bottom ash, and other materials that may be present.
- Beneficial use requires following the closure by removal process, which would result in excavation noise, material handling requirements, and safety considerations, as discussed in Section 6.
- Transportation of beneficiated materials to the market may include up to 150 trucks per day for many years, resulting in considerations of safety, noise, and emissions.
- Duration of beneficiation depends on market demand.

7.2.4 Belden-Eco Products

Belden-Eco Products is privately owned by the Belden Brick Company and Eco-Ash. The Belden Brick Company has been operating for over 130 years, and has constructed three brick plants in the past 16 years. However, Belden-Eco Products does not have a manufacturing plant.

7.2.4.1 Process Overview

CCR is processed and fired in a kiln to render it inert. Following firing, the CCR is mixed with other materials to form ceramic bricks. The CCR replaces up to 70% of traditionally used clay and shale in ceramic bricks.

7.2.4.2 Market Position

Belden-Eco Products does not have a fly ash brick plant in operation. However, the Belden Brick Company has an extensive network of over 300 distributors and two dealerships. If the plant at Dominion were to process 500,000 tons of CCR per year, that would represent 8% of the brick market. In addition, 75% of the brick market is east of the Mississippi.

7.2.4.3 Considerations

Considerations related to this technology include the following:

- Belden-Eco Products does not have an operating CCR processing facility or recycled brick plant.
- Belden-Eco Products has not sold fly ash bricks commercially, but they have a pending patent to develop bricks from fly ash and have performed bench scale testing of bricks made from ponded ash.
- Delays in industry acceptance of the bricks could lead to delays in pond closure.
- There is uncertainty in the timing to get the permits for the facility.
- Uncertainty in the quality and moisture content of the ponded ash could cause operational delays or delays to shipping processed fly ash to end users if the annual throughput cannot be met
- Operational difficulties and delays may occur due to blended fly ash, bottom ash, and other materials that may be present.
- Beneficial use requires following the closure by removal process, which results in excavation noise, material handling requirements, and safety considerations, as discussed in Section 6.

- Transportation of beneficiated materials to the market may require up to 150 trucks per day for many years, resulting in considerations associated with safety, noise, and emissions.
- Duration of beneficiation depends on market demand.

7.3 Summary of Findings

Table TM1-13 is a summary of the technology requirements and processing capabilities.

Table TM1-13: Summary of Ash Specifications for Vendor Beneficiation Technologies

<table>
<tr><th>Technology (Company)</th><th>Acceptable LOI (%)</th><th>Dominion Wet Ash LOI (%)</th><th>Acceptable Moisture Content (%)</th><th>Dominion Wet Ash Moisture Content (%)</th><th>Fly Ash Processing Capability (tons per year)</th></tr>
<tr><td>STAR (SEFA Group)</td><td>8 to 19</td><td rowspan="4">6 to 23</td><td>30</td><td rowspan="4">15 to 51</td><td rowspan="2">430,000 to 840,000</td></tr>
<tr><td>Triboelectric Separation Technologies (ST) with Carbon Burnout (PMI Ash Technologies)</td><td>6 to 20</td><td>25</td></tr>
<tr><td>Nu-Rock Technology (Nu-Rock)</td><td>24</td><td>10</td><td rowspan="2">300,000 to 550,000</td></tr>
<tr><td>Fly Ash Brick Plant (Belden-Eco Products)</td><td>NR</td><td>NR</td></tr>
</table>

NR = no response from technology vendor to AECOM's survey request; ST = Separation Technologies LLC, STAR = Staged Turbulent Air Reactor

8. Feasibility of On-site versus Regional Ash Processing Facilities

Per SB 1398 requirements, the study has also considered the feasibility of on-site processing of ash at individual stations for cementitious purposes as well as the feasibility of creating a processing facility to service multiple facilities. The criteria to be considered include:

- Quantity of ash to be removed at each station
- Market for the materials
- Technologies to be considered
- Timing for the facility to be on line
- Costs
  - Cost for technology
  - Costs for ash characterization
  - Cost for excavating, screening, drying, and transporting, along with dewatering and water treatment
  - Operations and maintenance (O&M) costs for the technology and site operations
- Community impacts

This study also considered the development of a regional processing facility to be located at Chesterfield Power Station that would receive coal ash transported from the Bremo and Possum Point stations for processing and beneficial use. For the purpose of this study, only one unit for each processing technology evaluated was proposed to be developed at each power station.

A discussion of the site-specific processing facilities at each Dominion power station that were studied and a regional processing facility at Chesterfield follows. The cost model does not include loading or transportation costs to the end user and does not consider potential revenue from selling the ash for beneficial use or recycling.

8.1 Bremo Power Station

Approximately 6.2 million CY of ponded ash requires removal from Bremo.

8.1.1 Market

Bremo has access to and is close to central and western Virginia. The density of ready mixed and precast concrete companies within the 50-mile radius of the local study area is the smallest of the four local study areas (see Figure TM1-3). The Bremo local study area also has the smallest population out of the four local areas that were evaluated, resulting in lower cement consumption needs. The market for fly ash is directly tied to cement consumption. There are no other power plants selling fly ash in the local area as shown in Figure TM1-5.

8.1.2 Schedule and Costs

Table TM1-14 provides a summary of the potential beneficial use options at Bremo Power Station, including duration and costs. The timing for excavating the North Ash Pond may vary significantly based on beneficiation technology throughput rates and market demand. Since there is no available space on the station property to temporarily store ash either before or after processing, ash would have to be excavated from the pond and processed on an as-needed basis. Processing rates are limited to technology throughput rates, as summarized in Table TM1-14. Additionally, processing rates will need to be adjusted based on whether there is a market demand for the beneficiated product at the time it is processed.

Table TM1-14: Summary of Closure by Removal with Beneficial Use Options at Bremo

Technology	End Product	Throughput (tons/year)	Time to Excavate North Ash Pond[1] (years)	Range of Costs for Technologies
SEFA STAR	PC substitute	430,000 to 840,000	11 to 21	Technology Capital = $17M to $244M
PMI/ST	PC substitute			Technology O&M = $141M to $801M
				Materials Handling = $241M to $607M
Nu-Rock	Masonry blocks, pavers, pipes, etc.	300,000 to 550,000	14 to 24	**Total Projected = $593M to $1,345M**
Belden Eco-Products	Brick			Estimated Cost/Ton = $96 to $217

[1] Time to excavate the pond is estimated based on the throughput of the technologies; excavation and processing rates may vary based on market demand of the beneficiated product

M = million; O&M = operations and maintenance; PC = Portland cement; PMI/ST = PMI Ash Technologies / Separation Technologies; SEFA = SEFA Group; STAR = Staged Turbulent Air Reactor

The timing to develop each facility is typically 2 to 3 years, including permitting and construction. Costs include capital costs for the recycling/beneficiation equipment, O&M costs for the recycling equipment/process, and capital and O&M for materials handling. Materials handling includes excavation, drying, and transporting ponded ash to the on-site recycling facility, along with dewatering and water treatment.

8.2 Chesterfield Power Station

The ponded ash at Chesterfield station is currently stored in the Upper Ash Pond and Lower Ash Pond. Approximately 3.6 million CY require removal from the Lower Ash Pond and 11.3 million CY from the Upper Ash Pond.

8.2.1 Market

Chesterfield has access to and is close to southern Virginia and North Carolina and has a substantial number of ready mixed and precast concrete companies within the 50-mile radius of the local study area (see Figure TM1-3). The construction industry in Virginia and North Carolina is expected to show positive growth; the PCA calculated that cement consumption in North Carolina was 0 to 5% higher in April 2017 compared to April 2016. There are no competitor power plants selling fly ash in the local study area as shown in Figure TM1-5.

8.2.2 Schedule and Costs

Table TM1-15 is a summary of the potential beneficial use options at Chesterfield Power Station, including duration and costs. The timing for excavating the Lower and Upper Ash Ponds may vary significantly based on beneficiation technology throughput rates and market demand. Since there is no available space on the station property to temporarily store ash either before or after processing, ash would have to be excavated from the pond and processed on an as-needed basis. Processing rates are limited to technology throughput rates, as summarized in Table TM1-15. Additionally, the processing rates will need to be adjusted based on whether there is a market demand for the beneficiated product at the time it is processed.

Table TM1-15: Summary of Closure by Removal with Beneficial Use Options at Chesterfield

Technology	End Product	Throughput (tons/year)	Time to Excavate Ash Ponds[1] (years)	Range of Costs for Technologies
SEFA STAR	PC substitute	430,000 to 840,000	21 to 46	Technology Capital = $17M to $244M
PMI/ST	PC substitute			Technology O&M = $441M to $3,012M
				Materials Handling = $820M to $1,764M
Nu-Rock	Masonry blocks, pavers, pipes, etc.	300,000 to 550,000	30 to 53	**Total Projected = $1,486 M to $4,251M**
Belden-Eco Products	Brick			Estimated Cost/Ton = $100 to $285

[1] Time to excavate the pond is estimated based on the throughput of the technologies; excavation and processing rates may vary based on market demand of the beneficiated product

M = million; O&M = operations and maintenance; PC = Portland cement; SEFA = SEFA Group; PMI/ST = PMI Ash Technologies / Separation Technologies; STAR = Staged Turbulent Air Reactor

The timing to develop each facility is typically 2 to 3 years, including permitting and construction. Costs include capital costs for the recycling/beneficiation equipment, O&M costs for the recycling equipment/ process, and capital and O&M for materials handling. Materials handling includes excavation, drying, and transporting ponded ash to the on-site recycling facility, along with dewatering and water treatment.

8.3 Possum Point Power Station

Approximately 4 million CY of ponded ash requires removal from Possum Point.

8.3.1 Market

Possum Point has access to and is close to Northern Virginia, Maryland, and the District of Columbia and has a substantial number of ready mixed and precast concrete companies within the local study area (see Figure TM1-3). However, the construction industry in Maryland and the District of Columbia is projected to show the least growth in the regional study area. In fact, the PCA calculated that cement consumption in the District of Columbia and Maryland dropped approximately 5% in April 2017 compared to April 2016. There are also several competitor power plants that are selling fly ash in the local study area as shown in Figure TM1-5 that would compete to source fly ash to concrete producers.

8.3.2 Schedule and Costs

Table TM1-16 provides a summary of the potential beneficial use options at Possum Point Power Station, including duration and costs. The timing for excavating Ash Pond D may vary significantly based on beneficiation technology throughput rates and market demand. Since there is no available space on the station property to temporarily store ash either before or after processing, ash would have to be excavated from the pond and processed on an as-needed basis. Processing rates are limited to technology throughput rates, as summarized in Table TM1-14. Additionally, the processing rates will need to be adjusted based on whether there is a market demand for the beneficiated product at the time it is processed.

Table TM1-16: Summary of Closure by Removal with Beneficial Use Options at Possum Point

Technology	End Product	Throughput (tons/year)	Time to Excavate Ash Pond D(1) (years)	Range of Costs for Technologies
SEFA STAR	PC substitute	430,000 to 840,000	8 to 15	Technology Capital = $17M to $244M Technology O&M = $74M to $507M Materials Handling = $188M to $404M
PMI/ST	PC substitute			
Nu-Rock	Masonry blocks, pavers, pipes, etc.	300,000 to 550,000	11 to 17	**Total Projected = $471M to $899M**
Belden-Eco Products	Brick			Estimated Cost/Ton = $118 to $225

(1) Time to excavate the pond is estimated based on the throughput of the technologies; excavation and processing rates may vary based on market demand of the beneficiated product

M = million; O&M = operations and maintenance; PC = Portland cement; SEFA = SEFA Group; PMI/ST = PMI Ash Technologies / Separation Technologies; STAR = Staged Turbulent Air Reactor

The timing to develop each facility is typically 2 to 3 years, including permitting and construction. Costs include capital costs for the recycling/beneficiation equipment, O&M costs for the recycling equipment/ process, and capital and O&M for materials handling. Materials handling includes excavation, drying, and transporting ponded ash to the on-site recycling facility, along with dewatering and water treatment.

8.4 Regional Beneficiation Facility

This study considered the development of a regional processing facility to be located at Chesterfield Power Station that would receive coal ash transported from the Bremo and Possum Point Power Stations for processing and beneficial use. Chesterfield is the most central of the three stations, and it also contains the majority of the ash (14.9 million of the 25.2 million CY), minimizing loading and hauling costs. In general, this is not considered a cost-effective option and would result in several of the ash ponds remaining open for at least three decades. The most expedient beneficiation technology would be able to process the ash from the Chesterfield Power Station in 26 years (3 years to design, obtain regulatory approval, and construct and 23 years to process the ash based on technology throughput). Since there is no available area on the Chesterfield station property to temporarily store ash from the other stations, ash would have to be transported on an as-needed basis. Based on throughput rates, it would take another 6 years to process the Possum Point Power Station ash and an additional 10 years for Bremo ash, for a total of 42 years for all three stations. The Chesterfield County Conditional Use Permit would also need to be amended to allow ash to be trucked to the station.

8.5 Community Impacts

Typical community impacts that would be evaluated when selecting beneficiation as a closure alternative include:

- Miles of residential and public areas passed

- Lane or load restrictions, railroad crossings
- Greenhouse gas emissions
- Noise
- Traffic increases and road capacity to handle additional truck traffic
- Road replacement costs and frequency
- Safety statistics on the roads
- Number of truck transportation trips based on the routes and miles from each Dominion studied station to the end user
- Hours of operation for the end user and delivery restrictions, if any
- Compatibility with other users of the route (e.g., schools, industrial deliveries)
- Specialty zoned districts passed in route (e.g., schools, religious organizations)

Once qualified end users are identified, specific analysis of community impacts can be addressed. The number of truck trips creates the impacts, which can be estimated based on volumes, durations, and similar issues.

8.6 Summary of Findings

The range of projected total costs for beneficial use facilities at each of the studied Dominion stations to recycle ponded ash is presented in Exhibit TM1-10. Based on the benchmarking results discussed previously, fly ash is selling on average for $30 to $60 per ton plus $7 to $33 per ton for transportation. For most of the technologies, the estimated costs for beneficiation are approximately 1.5 to 4.8 times greater than the current regional market price for the ash.

Exhibit TM1-10: Comparison of Beneficiation Technology Cost and Fly Ash Purchase Price

In addition, the processing rates varied from 300,000 to 840,000 tons per year, indicating a total duration of beneficiation of 8 to 53 years, depending on the technology and ability of the market to use the quantity of fly ash (see Exhibit TM1-11).

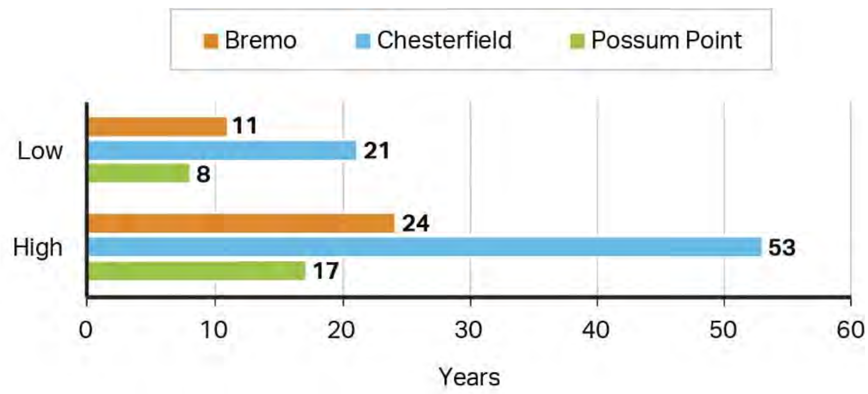

Exhibit TM1-11: Comparison of Beneficiation Technology Timelines

There is a potential to beneficially reuse fly ash from the Dominion stations on a regional and non-regional basis and within the current market pricing. However, due to the variability in the market, the actual beneficiation quantity on an annual basis cannot be estimated. Initial testing on the ponded fly ash indicates that it may be suitable for beneficiation with the technology vendors, but some test data are currently outside vendor-specified limits. If the decision were made to proceed with beneficiation, the following steps would need to be taken to select the appropriate technology:

- More detailed market discussions with specific regional fly ash users to determine the actual quantity and market price they would commit to in order to supplant their current source
- More detailed characterization of the fly ash at a frequency prescribed by the technology vendors to determine which facilities and the total quantity of ponded fly ash that could meet vendor criteria
- Following completion of the detailed characterization, detailed cost and marketability discussions with the technology vendors to obtain firm commitments on the processing rates and costs provided in their initial estimates

9. Study Assumptions and Limitations

9.1 Transportation Considerations

This is a preliminary survey of end users' potential interest in the receipt of consistent quality fly ash meeting ASTM C618 standards. Typically, after the benchmark data are collected, an end user may request a sample of the ponded ash for testing and/or request that lab data be provided. The benchmark surveys that AECOM conducted included questions on the transportation of fly ash from the sources to the user sites. Survey responses indicated that most sites typically receive fly ash that is transported up to 100 to 150 miles to their facilities and rarely up to 200 miles. The facilities indicated that this was the economic limit for transporting fly ash. Most of the respondents stated they did not have access to rail or barge at their location or did not have the storage infrastructure at their location to receive fly ash shipments by rail.

9.2 Cost Estimates

To support the assessment, AECOM developed cost estimates for various beneficiation technologies for each of the three power stations. Opinions of probable cost are estimates of possible construction costs for informational purposes. The costs are Class 5 estimates (see Table TM1-17) are limited to the conditions existing at issuance, and are not a guarantee of actual price or cost. Uncertain market conditions such as but not limited to local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions may affect the accuracy of these estimates. AECOM is not responsible for any variance from costs presented in this document or actual prices and conditions obtained.

9.3 Limitations and Obstacles to the Recycling and Beneficial Reuse of Dominion Energy's Ponded Ash

AECOM conducted benchmark surveys of cementitious end users (ready mixed concrete companies, cement kiln companies), ready mixed concrete trade associations, fly ash marketers, concrete producers, utilities selling and/or processing their fly ash, emerging technology vendors, and state transportation agencies for benchmarking of their experiences using both untreated and beneficiated fly ash generated by coal-fired power plants. AECOM also examined the EPRI report (EPRI, 2016) and additional information sent directly to Dominion by vendors. Survey information collected by AECOM was provided for select vendors that were market ready and had current or pending commercial applications with locations in or near the regional study area. Companies and products were grouped based on technology type and market readiness. A description of some of the limitations and obstacles from the benchmark studies are provided below.

9.3.1 Benchmark Studies

The results of the benchmark surveys identified the following obstacles or limitations to placing fly ash that meets ASTM C618 standards in the local and regional study areas:

- The Virginia DOT mandates the use of fly ash in concrete mixes to offset the alkali properties of the aggregate typically used in these mixes. VDOT has indicated a historic insufficient fly ash supply, and that materials are typically transported 150 to 200 miles when available.

Table TM1-17: Cost Estimate Classification Matrix

Estimate Class	Primary Characteristic	Secondary Characteristic			
	Level of Project Definition[1]	End Usage[2]	Methodology[3]	Expected Accuracy Range[4]	Preparation Effort[5]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: –20% to –50% H: +30% to +100%	1
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: –15% to –30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, authorization, or control	Semi-detailed unit costs with assembly level line items	L: –10% to –20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: –5% to –15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: –3% to –10% H: +3% to +15%	5 to 100

Source: AACE (2005)
(1) Expressed as percent of complete definition
(2) Typical purpose of estimate
(3) Typical estimating method
(4) Typical variation in low and high ranges. The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.
(5) Typical degree of effort relative to least cost index of 1. If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.
H = high; L = low

- Survey respondents stated they expect limited growth in the construction industry, between 3 and 5% per year over the next 5 years. As the market grows, some fly ash will be consumed since it can replace 15 to 30% of PC based on state DOT standards.
- Individual concrete producers are willing to accept limited quantities of fly ash, estimated between 6,000 to 18,000 tons per year; therefore, multiple end users would need to be identified and contracted as a market for beneficiated Dominion ash.
- Only encapsulated beneficial uses for fly ash were considered for this study. Encapsulation is the most protective form of recycling because the constituents in the ash are permanently bound. The CCR Rule places heavy restrictions on unencapsulated recycling, and the USEPA has concluded that the beneficial use of encapsulated fly ash in concrete is ideal because environmental impacts are comparable to or lower than those from analogous non-fly ash products.
- Market saturation of beneficiated fly ash is likely once the STAR units at Duke's Buck Steam Station, H.F. Lee, and Cape Fear power plants in North Carolina are operational. An estimated 1 million tons per year of beneficiated ash will be introduced in the Mid-Atlantic region, estimated to begin in 2019 and lasting through 2029.
- Uncertainty in the availability of fly ash with consistent quality due to plant conversions to natural gas and shuttered coal plants.

10. References

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11. Abbreviations

µm	micrometer
ASTM	ASTM International
CaO	calcium oxide
CBO	Carbon Burnout
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CY	cubic yards
DEQ	Virginia Department of Environmental Quality
DOT	Department of Transportation
EIA	Energy Information Administration
EPRI	Electric Power Research Institute
ESI	ESI, Inc. of Tennessee
ID	identifier
LOI	loss on ignition
MSE	encapsulated mechanically stabilized earth
NCSU	North Carolina State University
NR	no response
NRMCA	National Ready Mixed Concrete Association
ORC	Organic Rankine Cycle
PC	Portland cement
PCA	Portland Cement Association
PMI	PMI Ash Technologies
psi	pounds per square inch
SAI	strength activity index
SB	Senate Bill
SEFA	SEFA Group
ST	Separation Technologies
STAR	Staged Turbulent Air Reactor
VSWMR	Virginia Solid Waste Management Regulation
wt%	weight percent

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Figures

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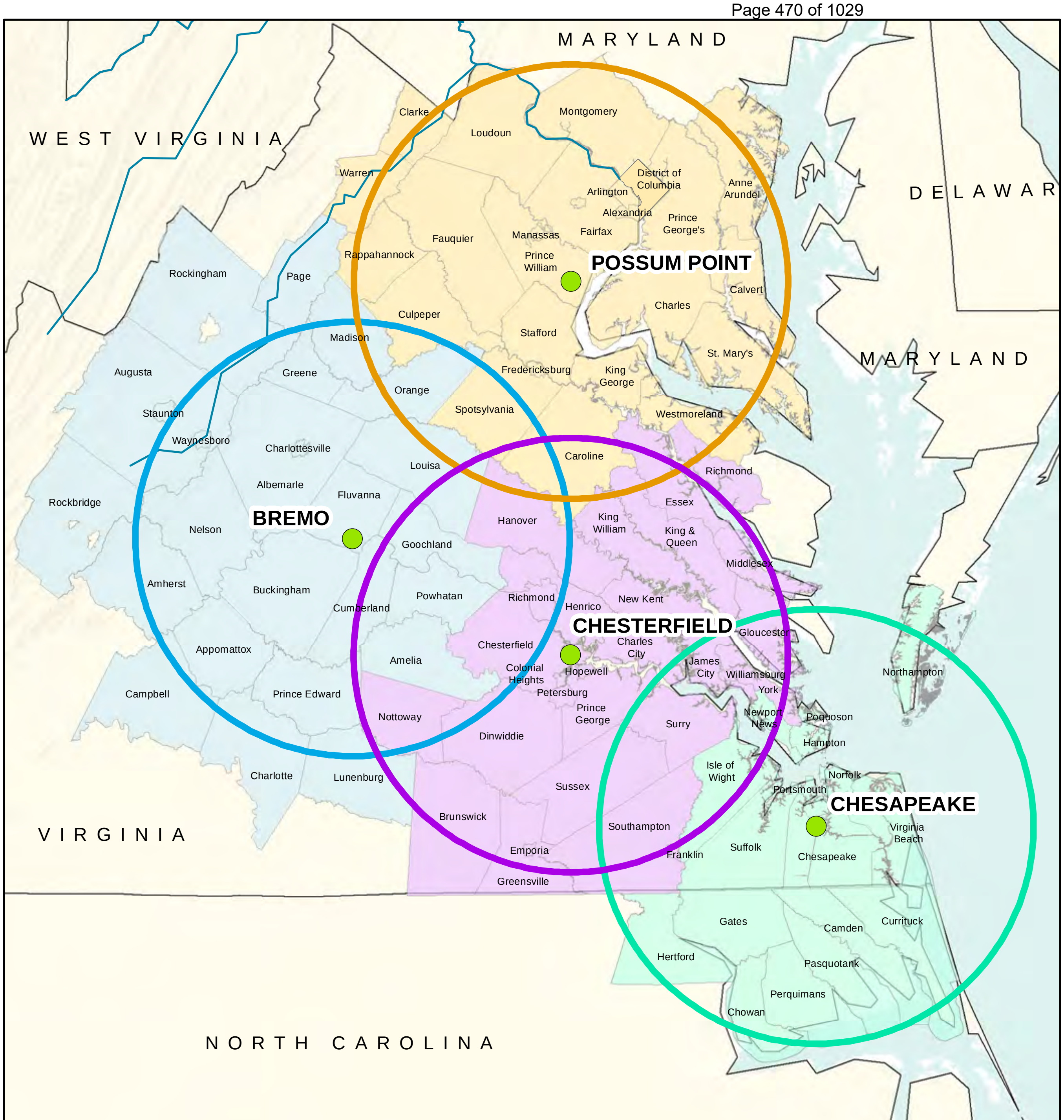

LEGEND

- Dominion Power Stations in Study
- Rivers

Chesapeake Power Station
- 50 Mile Radius
- Counties of Interest

Chesterfield Power Station
- 50 Mile Radius
- Counties of Interest

Bremo Power Station
- 50 Mile Radius
- Counties of Interest

Possum Point Power Station
- 50 Mile Radius
- Counties of Interest

N

0 20 40 80
Miles

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Figure TM1-1 Study Area Overview

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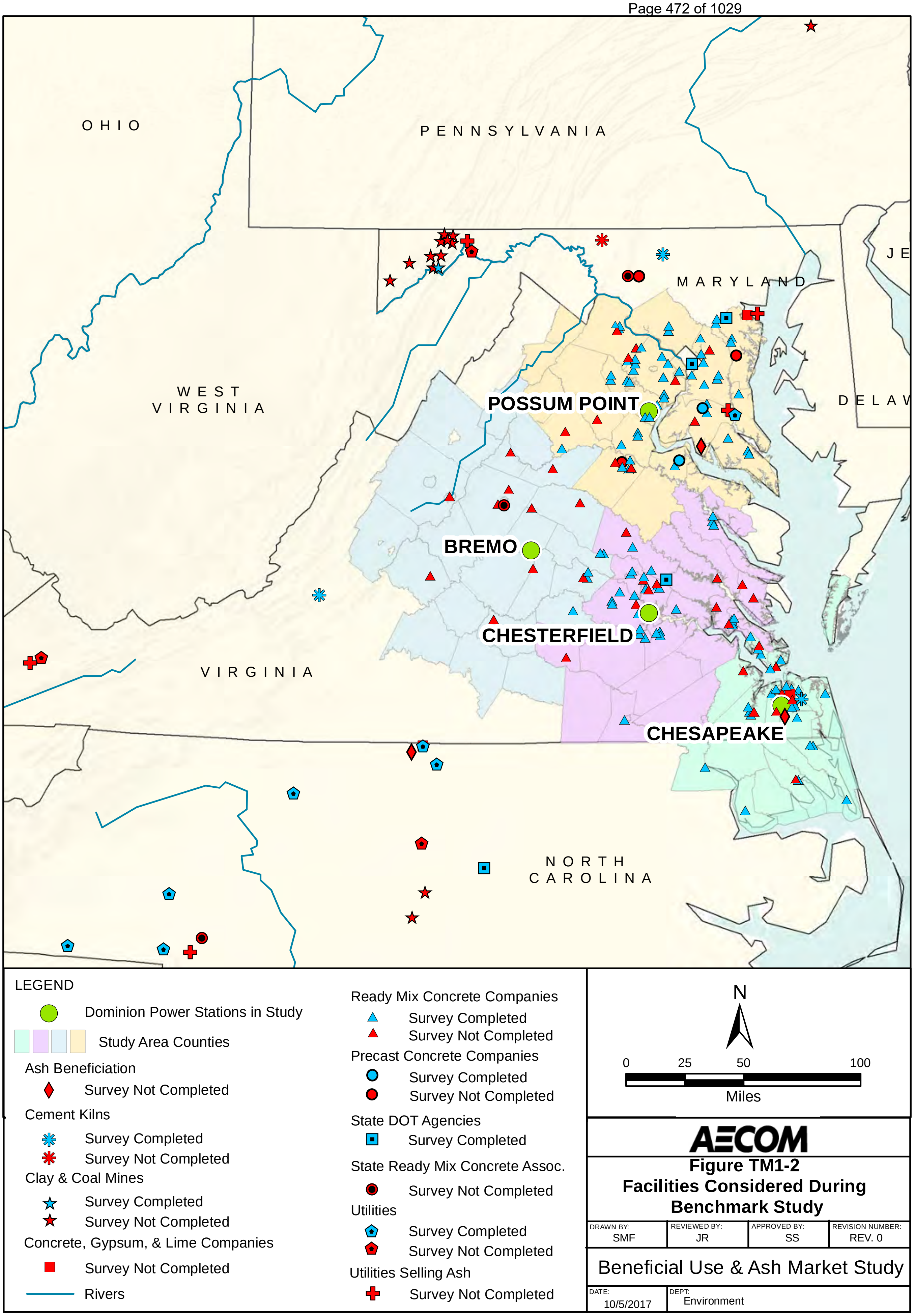

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Figure TM1-2
Facilities Considered During Benchmark Study

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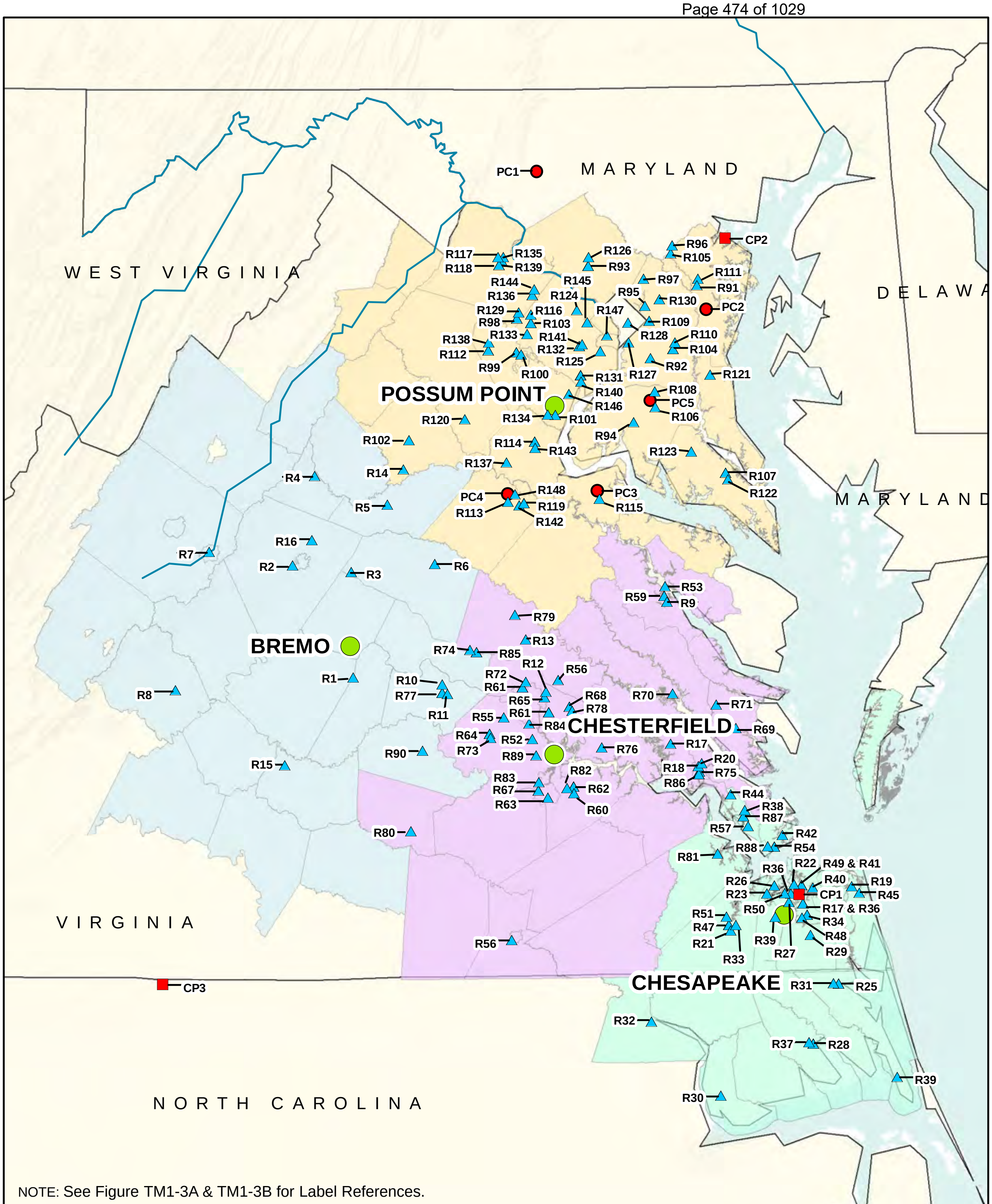

LEGEND

- Dominion Power Stations in Study
- Study Area Counties
- Ready Mix Concrete Companies
- Precast Concrete Companies
- Concrete, Gypsum, & Lime Companies
- Rivers

N

0 15 30 60
Miles

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Figure TM1-3
Cement & Concrete Companies in Study Area

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LABEL LEGEND

NOTE:
See Figure TM1-3 for Label Locations.

Ready Mix Concrete Companies

Bremo

R1 - Allied Concrete Company - New Canton Plant
R2 - Allied Concrete Company - Charlottesville
R3 - Allied Concrete Company - Zion Crossroads
R4 - Allied Concrete Company - Ruckersville
R5 - Allied Concrete Company - Orange
R6 - Allied Concrete Company - Louisa/Mineral
R7 - Allied Concrete Company - Waynesboro Plant #9
R8 - Lynchburg Ready Mix Concrete - Amherst
R9 - Essex Concrete Corporation - Main Office
R10 - Essex Concrete Corporation - Flat Rock Plant
R11 - Powhatan Ready Mix - Flat Rock
R12 - S.B. Cox Ready Mix
R13 - Titan Virginia Ready Mix - Ashland
R14 - Vulcan Materials Company - Culpeper
R15 - W C Newman Company Inc.
R16 - Wilson Ready Mix - Charlottesville Plant

Chesapeake

R17 - Allied Concrete Company
R18 - Argos USA Lee Hall
R19 - Atlas Concrete
R20 - Branscome Inc. - Lee Hall Plant
R21 - Brothers Ready Mix Co
R22 - Capital Concrete Inc.
R23 - Capital Concrete Inc. - Chesapeake #3
R24 - Capital Concrete Inc. - Virginia Beach #2
R25 - Commercial Ready Mix
R26 - Commercial Ready Mix
R27 - Commercial Ready Mix - Portsmouth #50
R28 - Commercial Ready Mix Products - Elizabeth City #30
R29 - Commercial Ready Mix Products - Dominion Plant
R30 - Commercial Ready Mix Products - Edenton #30
R31 - Commercial Ready Mix Products - Moyock #25
R32 - Commercial Ready Mix Products Inc. - Main Office
R33 - Commercial Ready Mix Products, Inc.
R34 - Commercial Ready Mix Products, Inc. - Chesapeake #90
R35 - Green Acres Land Development - Powells Point Plant #1
R36 - Lafarge North America
R37 - Northeastern Ready Mix Inc.
R38 - Rappahannock Concrete Inc. - Newport News
R39 - Quikcrete - Chesapeake
R40 - Titan America - Corporate Headquarters
R41 - Titan America - Campostella
R42 - Titan America - Hampton

Chesapeake

R43 - Titan America - Toano
R44 - Titan Virginia Ready Mix - Lee Hall/Skiffes Creek
R45 - Titan Virginia Ready Mix - Oceana
R46 - Titan Virginia Ready Mix - Port Norfolk
R47 - Titan Virginia Ready Mix - Suffolk
R48 - Vulcan Materials Company
R49 - Vulcan Materials Company - Norfolk Yard
R50 - Vulcan Materials Company - Portsmouth Yard
R51 - Vulcan Materials Company - East Suffolk Yard

Chesterfield

R52 - Allied Concrete Products
R53 - Beasley Concrete Inc.
R54 - Branscome Concrete Inc. - Hampton Plant
R55 - Central Concrete Inc.
R56 - Commercial Ready Mix Products Inc. - Emporia Plant R57 - Concrete Dispatch
R58 - Essex Concrete Corporation - Rockville
R59 - Essex Concrete Corporation - Tappahannock
R60 - Essex Concrete Corporation - Petersburg Plant
R61 - Greenrock Materials - Downtown Plant
R62 - Greenrock Materials - Prince George Plant
R63 - Petersburg Ready Mix
R64 - Powhatan Ready Mix - Chesterfield
R65 - Powhatan Ready Mix - Airport
R66 - Powhatan Ready Mix - Bryan Park Plant #6201-1/6201-2
R67 - Powhatan Ready Mix - Dinwiddie
R68 - Powhatan Ready Mix
R69 - Rappahannock Concrete - Main Office/Plant
R70 - Rappahannock Concrete Corporation
R71 - Rappahannock Concrete Corporation
R72 - Ready Mixed Concrete Company - Bryan Park Plant #6201-1/6201-2
R73 - Ready Mixed Concrete Company - Warbro Road Plant #6200
R74 - Ready Mixed Concrete Company
R75 - Ready Mixed Concrete Company
R76 - Roxbury Ready Mix
R77 - S B Cox Ready Mix - Powhatan Plant
R78 - S B Cox Ready Mix - Airport Plant
R79 - S B Cox Ready Mix - Doswell Plant
R80 - S B Cox Ready Mix - Nottoway Plant
R81 - S B Cox Ready Mix - Smithfield Plant
R82 - Vulcan Materials Company - Petersburg
R83 - Vulcan Materials Company - Dinwiddie Ready Mix
R84 - Vulcan Materials Company - Richmond Ready Mix
R85 - Vulcan Materials Company - Mechanicsville Ready Mix
R86 - Vulcan Materials Company - Williamsburg Ready Mix
R87 - Vulcan Materials Company - Newport News Ready Mix
R88 - Vulcan Materials Company - Hampton Plant Number W03
R89 - Vulcan Materials Company - Chester Ready Mix
R90 - W F Wright Ready Mixed Inc.

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Figure TM1-3A
Cement & Concrete Companies in Study Area

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LABEL LEGEND

NOTE:
See Figure TM1-3 for Label Locations.

Ready Mix Concrete Companies

Possum Point

R91 - Aggregate Industries - Crofton Plant No. 610/611
R92 - Aggregate Industries - Clinton Plant Number 633
R93 - Aggregate Industries - Rockville Plant Number 622
R94 - Aggregate Industries - La Plata Plant Number 52
R95 - Aggregate Industries - Bladensburg Plant Number 603
R96 - Aggregate Industries - Jessup Plant Number 652
R97 - Aggregate Industries - Beltsville Plant Number 624
R98 - Aggregate Industries - Chantilly Plant Number 677
R99 - Aggregate Industries - Manassas Plant
R100 - Aggregate Industries - Manassas Plant Two
R101 - Aggregate Industries - Dumfries and Handyman Plant
R102 - Allied Concrete Company - Culpeper Plant
R103 - Atlantic Contracting
R104 - Atlantic Contracting & Material Co
R105 - Bay Ready Mix Concrete, LLC - Annapolis Junction Plant #1
R106 - Carruth & Son Inc. - Bryantown Plant #1
R107 - Chaney Enterprises - Hollywood Plant #4
R108 - Chaney Enterprises - Waldorf Plant #1
R109 - Chaney Enterprises - Seat Pleasant Plant #3
R110 - Chaney Enterprises - Upper Marlboro Plant #2
R111 - Chaney Enterprises - Gambrills Plant #12
R112 - Chaney Enterprises - Gainesville Plant
R113 - Chaney Enterprises - Spotsylvania Plant #22
R114 - Chaney Enterprises - Stafford Plant #21
R115 - Chaney Enterprises - King George Plant #20
R116 - Dubrook Concrete
R117 - Essroc Ready Mix
R118 - Hanson Ready Mix - Leesburg Plant #522
R119 - Hanson Ready Mix - Fredericksburg Plant #525
R120 - Hanson Ready Mix - Bealeton Plant #526
R121 - Howlin Concrete Inc. - Owings Plant #3
R122 - Howlin Concrete Inc. - Hollywood Plant #4
R123 - Howlin Concrete Inc. - Mechanicsville Plant #2
R124 - Miller & Long Co Inc. - McLean Plant #7
R125 - Patriot Ready Mixed Concrete
R126 - Rockville Fuel & Feed Co. Inc. - Southlawn Plant 1&2 R127 - Schuster Concrete Ready Mix LLC MGM Plant #4
R128 - Superior Concrete Materials - Washington D.C. Plant R129 - Superior Concrete Materials - Chantilly Plant #107
R130 - Superior Concrete Materials
R131 - Superior Concrete Materials - Lorton Plant #108
R132 - Titan America - Springfield Plant
R133 - Titan America - Centreville Plant #201
R134 - Titan Virginia Ready Mix - Dumfries
R135 - Titan Virginia Ready Mix - Leesburg Plant #208
R136 - Titan Virginia Ready Mix - Sterling Plant 206/207
R137 - Titan Virginia Ready Mix - Falmouth Plant #205
R138 - Vulcan Materials Company - Gainesville Plant #5
R139 - Vulcan Materials Company - Leesburg Plant #V11

Possum Point

R140 - Vulcan Materials Company - Newington Ready Mix
R141 - Vulcan Materials Company - Edsall Road Plant V03
R142 - Vulcan Materials Company - New Post Plant V19
R143 - Vulcan Materials Company - Stafford Plant L05
R144 - Vulcan Materials Company - Dulles V0 Plant #5
R145 - Vulcan Materials Company - Falls Church Plant V02
R146 - Vulcan Materials Company -Woodbridge Plant #V06
R147 - Vulcan Materials Company - Shirlington Plant V01
R148 - Vulcan Materials Company - Spotsylvania Plant L08

Precast Concrete Companies

Possum Point

PC1 - Rinker Materials
PC2 - Contractors Precast Corporation
PC3 - Faddis Concrete Products
PC4 - Oldcastle Precast Inc.
PC5 - Superior Tank Inc.

Concrete, Gypsum, & Lime Companies

Chesapeake

CP1 - US Gypsum Co. - Norfolk, VA

Out of Service Area

CP2 - US Gypsum Co. -Baltimore, MD
CP3 - Certainteed Gypsum NC Inc.

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Figure TM1-3B
Cement & Concrete Companies in Study Area

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NOTE: See Figure TM1-4A for Label references.

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Figure TM1-4
Agencies, Associations, & Facilities Contacted

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LABEL LEGEND

NOTE:
See Figure TM1-4 for Label Locations.

Cement Kilns

Bremo

C1 - Roanoke Cement - Roanake Plant

Chesapeake

C2 - Kerneos, Inc. - Norfolk Plant

Out of Service Area

C3 - Lehigh Cement - Union Bridge Plant
C4 - Holcim USE - Hagerstown Plant

State Ready Mix Concrete Associations

Bremo

SA1 - Virginia Ready Mixed Concrete Association

Out of Service Area

SA2 - Carolinas Ready Mixed Concrete Association
SA3 - Maryland Ready Mix Concrete Association

State DOT Agencies

Chesterfield

SD1 - VDOT Division of Materials

Out of Service Area

SD2 - NCDOT
SD3 - MD DOT
SD4 - DC DOT

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Figure TM1-4A
Agencies, Associations, & Facilities Contacted

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Site Location

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LEGEND

Dominion Power Plants Selling Fly Ash
- 10,000-50,000
- 50,000-100,000
- 100,000-250,000
- 250,000-400,000

Other Power Plants Selling Fly Ash
- 10,000-50,000
- 50,000-100,000
- 100,000-250,000
- 250,000-400,000

Dominion Power Stations in Study

Study Area Counties

Rivers

Power Plants Not Selling Fly Ash
- Dominion Facilities
- Other Facilities

Note 1: Data obtained from Form EIA-923, "Power Plant Operations Report" 2011-2015. U.S. Energy Information Administration.
Note 2: Data reported is the average tons per year sold, 2011 – 2015.
Note 3: Yorktown and Chesapeake Power Plants are no longer producing Fly Ash.

N

0 15 30 60 Miles

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Figure TM1-5 Power Plants Selling Fly Ash in Tons

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Ash Beneficiation Units

AB1 - SEFA - NRG Morgantown
AB2 - SEFA - Winyah Generating Station
AB3 - STI - Brandon Shores Generating Station
AB4 - STI - Roxboro Generating Station
AB5 - SEFA - Wateree Station
AB6 - SEFA - McMeekin Plant
AB7 - STI - St. Johns River Power Plant
AB8 - STI - Big Bend Generating Station
AB9 - STI - Morrow Generating Plant
AB10 - PMI/ESI - Brayton Point Station
AB11 - STI - Brunner Island Power Plant
AB12 - Fly Ash Direct - Avon Lake Generation Station
AB13 - Fly Ash Direct - Joppa Generating Station
AB14 - Fly Ash Direct - Fayette Power Project
AB15 - Fly Ash Direct - Oklaunion Generating Station
AB16 - Fly Ash Direct - Trenton Generating Station
AB17 - SEFA Buck STAR Plant
AB18 - SEFA Lee STAR Plant
AB19 - SEFA Cape Fear STAR Plant

LEGEND

Dominion Power Stations in Study
Study Area Counties
Ash Beneficiation Units
Ash Beneficiation Units Under Development

N

0 70 140 280 Miles

AECOM

Figure TM1-6
Ash Beneficiation Companies

DRAWN BY:	REVIEWED BY:	APPROVED BY:	REVISION NUMBER:
SMF	JR	SS	REV. 0

Beneficial Use & Ash Market Study

DATE:	DEPT:
10/5/2017	Environment

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US Emerging Technology Companies

E1 - ArcSec Technologies LLC
E2 - Ceratech
E3 - Physical Sciences Inc.
E4 - Applied Plasma Arc Technologies, LLC
E5 - Eco-Ash LLC/Belden Eco Products
E6 - Ash Improvement Technology, Inc.
E7 - Phoenix Solutions Co.
E8 - Ramrock Building Systems
E9 - Sphere One
E10 - Hebel USA
E11 - Sierra Energy
E12 - Ultalite/Cyco-Systems
E13 - Periodic Products, Inc.
E14 - AERCON
E15 - Quadex, LLC
E16 - VHSC Pozzoslag
E17 - Tusaar
E18 - NuForm Materials
E19 - Intelligent Composites, LLC
E20 - Pittsburgh Mineral & Environmental Technology, Inc.
E21 - RECO Cement Products, LLC

Canadian Emerging Technology Companies

E22 - Ucore Rare Metals Inc.
E23 - Mitton Cavitation
E24 - Orbite Technologies, Inc.
E25 - SonoAsh

Emerging Technology Companies Outside North America (Not Shown on Map)

EMC Cement
Carbonair Ltd.
Lytag
Delft Solids Solutions
Zeobond
Hyssil Pty Ltd.
Ecopropp Pty Ltd.
Vecor Australia Pty Ltd
Latrobe Magnesium
Nu-ROCK
Ash Resources Ltd

LEGEND

- Dominion Power Stations in Study
- Study Area Counties
- Emerging Technology Companies
- Rivers

N

0 200 400 800
Miles

AECOM

Figure TM1-7 Emergining Technologies Locations

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Senate Bill 1398 Response

Coal Combustion Residuals Ash Pond Closure Assessment

TECHNICAL MEMORANDUM 2

Evaluation of CCR Characteristics

November 2017

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Senate Bill 1398 Response:
Coal Combustion Residuals Ash Pond Closure Assessment

Technical Memorandum 2: Evaluation of CCR Characteristics

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1. Introduction and Summary of Findings

Virginia Senate Bill 1398 (SB 1398) requires "that every owner or operator of a coal combustion residuals (CCR) surface impoundment that is located within the Chesapeake Bay watershed … conduct an assessment of each such CCR surface impoundment (CCR unit) regarding the closure of any such unit." The assessment must include describing groundwater and surface water conditions surrounding the surface impoundments (ash ponds) and evaluating corrective measures to restore water quality (if needed), evaluating the clean closure (closure by removal) of the CCR unit by recycling/reusing the ash or moving it to a landfill and demonstrating the long-term safety of the CCR unit if it is closed in place.

SB 1398 is applicable to eleven CCR surface impoundments (referred to as ash ponds in this report) at four Dominion Energy (Dominion) power stations. On behalf of Dominion, AECOM conducted an evaluation of the groundwater and surface water on all eleven ponds and an assessment of closure options on the five ponds that have been slated for closure. Ash has been removed or is in the process of being removed from the other six ponds; therefore, these ponds are being closed by removal. Table TM2-1 provides information on the Dominion power stations and ash ponds that were included in the study.

Table TM2-1: Ash Ponds included in the Study

Power Station	CCR Units	Remaining CCR Volume (CY)[1]	Operating Status	Area (acres)
Bremo Power Station	North Ash Pond[2]	4,800,000	Slated for closure	68
	East Ash Pond	1,400,000	Ash being actively removed and transported to North Ash Pond	27
	West Ash Pond	0	Ash removed	22
Chesapeake Energy Center[3]	Bottom Ash Pond[2]	60,000	Committed to closure by removal	5
Chesterfield Power Station	Lower Ash Pond[2]	3,600,000	Slated for closure	101
	Upper Ash Pond[2]	11,300,000	Slated for closure	112
Possum Point Power Station	Ash Pond A Ash Pond B Ash Pond C	40,000	Residual ash to be removed from Ash Ponds A, B, and C and transported to Ash Pond D	18
	Ash Pond D[2]	4,009,250	Slated for closure	70
	Ash Pond E	2,250	Residual ash to be removed and transported to Ash Pond D	38
	Total Volume	**25,211,500**		

(1) CCR volumes are based on Dominion estimates as of July 10, 2017

(2) Assessed for closure options

(3) While not subject to the assessment required by SB 1398, the CCR landfill at the Chesapeake Energy Center is slated for closure in accordance with VSWMR. Virginia DEQ issued a draft solid waste permit in June 2016 for closure of the landfill, which process was later suspended at Dominion's request. The draft permit required Dominion to evaluate and propose alternative corrective measures to address groundwater impacts. In addition, in connection with a July 31, 2017, court order, Dominion will submit a revised solid waste permit application to DEQ by March 31, 2018, to include proposed additional corrective measures to address site-wide groundwater impacts.

CCR = coal combustion residuals; CY = cubic yards; DEQ = Department of Environmental Quality; VSWMR = Virginia Solid Waste Management Regulations

1.1 Study Objective

The objective of the study was to comply with the following SB 1398 requirements to ensure the long-term safety of the ash ponds while protecting public health and the environment:

- Evaluate closure by removal with recycling or reuse (beneficial use) of the CCR material
- Evaluate closure by removal with placement of CCR material in a permitted landfill
- Evaluate closure-in-place addressing long-term safety, structural, and extreme weather event resiliency
- Describe groundwater and surface water quality surrounding each ash pond and evaluate corrective measures if needed

AECOM was tasked with critically reviewing existing information, identifying additional studies that may be needed, performing the studies, and preparing a report that addresses the requirements of SB 1398 for each of the eleven Dominion ash ponds listed in Table TM2-1.

The objective of the SB 1398 requirements is to provide members of the legislature, environmental regulators, local government officials, and the local communities with an assessment of ash pond closure options as set forth in the legislation. Specifically, the report describes how the various options could meet the objectives of safe closure, compliance with applicable federal and state rules, and protection of public health and the environment. This report is not intended, and must not be construed, to provide recommendations or conclusions regarding the selection of the options detailed herein.

AECOM developed a series of Technical Memoranda that provide a detailed analysis of the primary technical information needed to comply with SB 1398 requirements. The Technical Memoranda provide an assessment of closure by removal options (including recycling/beneficial use and landfilling); ash sampling results to supplement the beneficial use study; and evaluations of closure-in-place, groundwater and surface water conditions, and potential groundwater corrective measures. The memoranda are included as attachments to the report and are referenced as appropriate.

1.2 Technical Memorandum 2 Objective

The objective of Technical Memorandum 2 is to provide preliminary CCR chemical and physical property information that may be used to evaluate the potential viability of beneficial use/recycling of the CCR in the ponds included in this study. Specifically, information presented in Technical Memorandum 2 is intended to help address the following SB 1398 requirement:

> Evaluate the clean closure of the CCR unit through excavation and responsible recycling or reuse of coal ash residuals by incorporating them into concrete or other products in a manner that prevents the release into the environment of the pollutants contained within the coal ash residuals. Such evaluation shall consider the feasibility of the onsite processing of a CCR unit for cementitious purposes as well as the feasibility of creating a processing facility or facilities to serve multiple CCR units (Virginia Senate Bill 1398, Chapter 817).

The purpose of the ash sampling was to determine whether the ponded ash could be used as a direct replacement for Portland cement without additional processing, and if not, to determine what properties needed to be addressed to make the ash suitable. To that end, representative samples were obtained from the Bremo Power Station North Ash Pond, Chesterfield Power Station Upper and Lower Ash Ponds, and Possum Point Power Station Ash Pond D and analyzed in accordance with ASTM International (ASTM) C618 specifications for use in concrete.

The materials from the Chesapeake Energy Center Bottom Ash Pond were previously evaluated by others for use in cement manufacturing and determined to meet reuse requirements; therefore, an evaluation of CCR materials at Chesapeake Energy Center is not included in the study. Dominion has committed to closure by removal for this pond.

1.3 Summary of Findings

The sample results evaluated in this study provide an initial indication of the CCR material characteristics within each pond and can be used to draw general conclusions regarding whether the unprocessed CCR material may meet ASTM C618 criteria for use in concrete or whether additional processing (beneficiation) may be warranted. None of the samples collected at the four ponds evaluated in this study met all of the ASTM C618 criteria. The most common issues were excessive carbon content (as measured by loss on ignition [LOI]), high moisture content, insufficient material fineness, excessive water demand, and an insufficient rate of pozzolanic reactivity (as measured by the strength activity index [SAI]), which will affect the ability to reuse the ash as described below.

- **Excessive Carbon Content** – Excessive carbon content interferes with air entrainment agents that concrete manufacturers add to control the amount of air in the concrete. Adequate air content is critical for proper freeze protection of concrete products. In addition, highly variable carbon content can make it difficult for concrete manufacturers to properly control air entrainment addition during the manufacturing process.

- **Insufficient Material Fineness** – Concrete components are proportioned to achieve a certain minimum strength at a specified age. When fly ash is too coarse, it does not react properly to provide the necessary strength characteristics in a sufficient amount of time, resulting in concrete with inadequate strength properties.

- **Moisture and Excessive Water Demand** – Concrete must have certain flow characteristics to be handled properly when being poured and worked in place. Flow characteristics are determined by the water content of the mix and manufacturers design around specified water-to-cement ratios in their processes. When water demand is too high or moisture content of the ash is too high, it can impact the flow and workability of the material, and create issues in operating within the design limits of the manufacturing process. Excessive carbon content can also increase the amount of water needed to obtain specified flow and workability characteristics.

- **Insufficient Rate of Pozzolanic Activity** (related to material fineness) – Concrete products are required to achieve a specified minimum strength at a specified age in order for the end product to be usable for the design purpose. When the chemical reactions are too slow, strength of the concrete is compromised.

These issues could be addressed by processing the ash to reduce moisture and increase fineness of the materials and using beneficiation technologies to reduce the carbon content. Further sampling, analyses, and feasibility studies for ash in each pond would be required before selecting specific beneficiation technologies or developing a detailed beneficiation plan for each station.

Table TM2-2 lists the number of borings that were conducted and the number of samples that were analyzed at each station.

Table TM2-2: Number of Boring Locations, Number of Samples Analyzed, and Ash Classification

Station	Ash Pond	No. of Boring Locations	No. of Samples Analyzed	Ash Classification
Bremo	North Ash Pond	4	17	Class F(1)
Chesterfield	Lower Ash Pond	4	10	Class F(1)
Chesterfield	Upper Ash Pond	5	37	Class F(1)
Possum Point	Ash Pond D	5	8	Class F(1)

(1) Ash with calcium oxide content below 10%

Table TM2-3 provides a summary of the sample analysis results for each station with respect to the ASTM C618 acceptance criteria. For each parameter, the percentage of samples that did not meet the criterion is noted. The calcium oxide (CaO) content of the material at all of the stations was below 10%; thus, all ash material from the stations would be considered Class F, and all data were compared to the ASTM C618 criteria for Class F ash.

Table TM2-3: Summary of Ash Characteristics Relative to ASTM C618 or ASTM C40 Criteria for Class F Ash

			% of Samples Failing Criteria			
Parameter	Subparameter	ASTM C618 or ASTM C40 Criteria for Class F Ash	Bremo North Ash Pond	Chesterfield Lower Ash Pond	Chesterfield Upper Ash Pond	Possum Point Ash Pond D
Chemical	Sum SiO_2, Al_2O_3, Fe_2O_3, wt%	Min 70%	0%	0%	0%	0%
	CaO, wt%	Class F Max 10%	0%	0%	0%	0%
	SO_3, wt%	Max 5%	0%	0%	0%	0%
	Moisture, wt% as received	Max 3%	100%	100%	100%	100%
	Moisture, wt% further processing	Max 30%(1)	59%	60%	35%	0%
	Moisture, wt% dried	Max 3%	0%	0%	0%	0%
	LOI, wt%	Max 6%	94%	80%	100%	100%
Physical	Soundness	Max ±0.8%	0%	0%	0%	0%
	% retained on #325 mesh	Max 34%	47%	70%	51%	88%
	Water required, % of control	Max 105%	53%	60%	62%	100%
	7-day SAI, % of control(2)	Min 75%	35%	80%	62%	50%
	28-day SAI, % of control(2)	Min 75%	29%	60%	32%	13%
	Organic impurities (color plate #)	Max #3	12%	0%	0%	38%

(1) The upper moisture limit of CCR feed for selected beneficiation technologies is 20 to 30%.

(2) Passing either the 7-day criterion or the 28-day SAI% criterion indicates compliance with the ASTM C618 specification.

ASTM = ASTM International; Al_2O_3 = aluminum oxide; CaO = calcium oxide; Fe_2O_3 = iron oxide; ID = identifier; LOI = loss on ignition; SiO2 = silicon dioxide; SAI = strength activity index; SO_3 = sulfur trioxide; wt% = weight percent

With respect to the chemical parameter requirements for Class F ash, the limits for moisture content and LOI content were consistently exceeded at each site, indicating that most material at these stations requires some type of beneficiation to remove unburned carbon from the ash and lower the LOI. Beneficiation technologies designed to reduce the carbon content of fly ash are discussed in Technical Memorandum 1. The non-electrostatic technologies (SEFA Group's [SEFA] Staged Turbulent Air Reactor [STAR] technology with PMI Ash Technologies' [PMI] Carbon Burn-out Process) can accept CCR feed with up to 20% by weight LOI and up to 20% to 30% by weight moisture, as shown in Table TM2-4. The drying of materials from all stations would be required if used as feed for Separation Technology Inc.'s (STI) triboelectric process because electrostatic processes require low moisture in the feed material.

The moisture content of the samples as received by the laboratory typically ranged from 20% to 50%, with the higher-moisture-content samples generally associated with greater boring depths within the ash ponds. For the North Ash Pond at the Bremo Power Station and the Upper Ash Pond and Lower Ash Pond at the Chesterfield Power Station, 35% to 60% of the samples exceeded 30% moisture content, suggesting that drying of material in some regions in the ash ponds may be needed to meet the CCR feed specifications for the beneficiation technologies. For Ash Pond D at the Possum Point Power Station, the as-received moisture content by weight for all samples was below 30%, and only two samples exceeded 20%; however, this is likely due to the shallow boring depth.

Although the LOI values exceeded the ASTM C618 criteria at all sites, the LOI values were generally within the range of acceptable LOI for CCR feed for one or more of the beneficiation technologies listed in Table TM2-3. As noted in Technical Memorandum 1, many concrete manufacturers may require LOI values below the ASTM C618 criterion of 6%, with values of 2% to 4% often specified.

Table TM2-4: CCR Feed Limits for Selected Beneficiation Technologies

	CCR Feed	
Technology	LOI, %	Maximum Moisture, wt%
SEFA STAR	8–19	30
PMI Carbon Burn-out	6–20	20

CCR = coal combustion residuals; LOI = loss on ignition; PMI = PMI Ash Technologies; SEFA = SEFA Group; STAR = Staged Turbulent Air Reactor; wt% = weight percent

An AECOM survey (AECOM, 2017) of ready-mix concrete manufacturers in the study area is described in Technical Memorandum 1. The results indicated that the preferred LOI content ranged from <1% to 4%. The average LOI for the samples collected at each site was above the 6% criterion (from 9% to 15%) for the North Ash Pond at the Bremo Power Station and the Upper Ash Pond at the Chesterfield Power Station, respectively). As discussed in Section 4, LOI values as high as 22% to 24% were observed for some boring locations at the North Ash Pond at the Bremo Power Station and the Upper Ash Pond at the Chesterfield Power Station, respectively.

A significant portion of the samples at all the stations exceeded the percent retained on the #325 mesh (45 μm), water required, and SAI. The percent retained on the #325 mesh is a measure of the fineness of the sample, with lower numbers indicating finer particles. ASTM C618 requires 34% or less retention on #325 mesh. At all the stations, 41% to 88% of the samples analyzed failed the particle size criterion; therefore, most of the ash would likely require some type of processing (e.g., mechanical screening, hydraulic classification, air classification separation) to remove larger particles and increase the percentage of smaller particles in the material to make it suitable for use in concrete applications. Pond D at the Possum Point Ash Power Station and the Lower Ash Pond at the Chesterfield Power Station exhibited the highest percentage of samples failing the ASTM C618 #325 mesh criterion (88% and 70%, respectively); the North Ash Pond at the Bremo Power Station and the Upper Ash Pond at the Chesterfield Power Station had 41% and 47% of the samples failing the criterion, respectively.

The strength activity test is conducted by preparing a control and test mixture containing the fly ash to be tested, then subjecting the two materials to compressive strength testing after a 7-day cure time. If the test mixture fails the criterion on the 7-day test, the test is repeated at 28-days and if it meets the criterion, the material is considered compliant with the specification. The percentage of samples failing the 28-Day SAI criterion ranged from 13% at Bremo North Ash Pond to 60% at Chesterfield Lower Ash Pond. Reducing the fineness of the ash increases the reactivity and pozzolanic activity of the ash, so one would expect that additional processing of the materials at these sites to meet ASTM C618 #325 mesh criterion would also increase the likelihood of the material meeting the ASTM C618 SAI criterion. The data indicate 50% or more of the samples at any given station exceeded the water required criterion of 105% of the control, indicating that excessive amounts of water were required to obtain the desired flow characteristics when the ash was used as a replacement for a portion of the Portland cement in the SAI tests. In general, coarse fly ash material or ash containing high levels of carbon can increase water demand (PCA, 2007).

Some 38% of the samples at Ash Pond D at the Possum Point Power Station exceeded the ASTM C40 method color criterion, indicating material from some areas of the ash pond may require further evaluation to determine if beneficiation of the material is required to remove organic impurities. Material that failed the criterion was typically associated with boring depths of 0 to 10 feet at Ash Pond D. High clay content was noted in the boring logs for many samples collected at Pond D. Organic matter associated with the clay or minerals in the clay could be responsible for the color exceedances. Only 12% of the samples exceeded the color criterion at the North Ash Pond at the Bremo Power Station, and none of the samples at the Upper Ash Pond or Lower Ash Pond at the Chesterfield Power Station exceeded the criterion. The analytical laboratory and/or the field geologist noted that the two samples that exceeded the color criterion at the North Ash Pond contained a significant amount of clay.

2. Background Information

2.1 Definitions

2.1.1 Coal Combustion Residuals Rule

The Coal Combustion Residuals Rule (CCR Rule) establishes a comprehensive definition of beneficial use of CCR to support the responsible recycling of CCR by distinguishing safe, beneficial use from disposal.

2.1.2 Beneficial Use or Recycling/Reuse

Beneficial use of CCR is the process of substituting secondary materials for some or all of the virgin, raw materials in a natural or commercial "analogous product." The CCR may be used either as generated or after additional processing. An encapsulated beneficial use binds the CCR into a solid matrix that minimizes its mobilization into the surrounding environment (e.g., as concrete or wallboard). All other beneficial uses (e.g., structural fill, flowable fill) are classified as unencapsulated and require further evaluation of potential releases to the environment (AECOM, 2016).

The CCR Rule establishes four criteria that must be met to substitute a CCR for beneficial use. If these criteria are met, the CCR Rule does not regulate the beneficial use. Table TM2-5 lists the beneficial use criteria.

Table TM2-5: Beneficial Use Conditions

Criterion	Demonstration
1	The CCR must provide a functional benefit.
2	The CCR must substitute for the use of a virgin material, conserving natural resources that would otherwise need to be obtained through practices such as extraction.
3	The use of the CCR must meet relevant product specifications, regulatory standards, or design standards when available, and when such standards are not available, the CCR is not used in excess quantities.
4	When unencapsulated use of CCR involves placement on the land of 12,400 tons or more in non-roadway applications, the user must demonstrate and keep records, and provide such documentation upon request, that environmental releases to ground water, surface water, soil, and air are comparable to or lower than those from analogous products made without CCR or that environmental releases to groundwater, surface water, soil, and air will be at or below relevant regulatory and health-based benchmarks for human and ecological receptors during use.

Source: 40 CFR § 257.53(1)–(4)   CCR = coal combustion residuals

This technical memorandum assumes that most of the potential end users for beneficially reusing or responsibly recycling the ash, with the exception of mines, are using the CCR for encapsulated purposes, and therefore the characteristics of the unprocessed ponded CCR material have been compared to the ASTM C618 criteria for use in concrete.

2.1.3 Recycling

The American Coal Ash Association (ACAA) and other utility industry associations have worked with the U.S. Environmental Protection Agency in the past to promote the benefits of reusing or recycling fly ash.

ACAA's "Beneficial Use, Simply Recycling by Another Name Fact Sheet" mentions that there are numerous environmental benefits of recycling or beneficially reusing fly ash, including reduced land disposal, reduced utilization of virgin resources, and reduced greenhouse gases. In addition, the Green Building Initiative and the U.S. Green Building Council both encourage using fly ash in concrete or products that contain recycled materials and encourage the use of "recycled content" as part of the components of many structures through Leadership in Energy and Environmental Design (LEED) certification, in which fly ash is credited as recycled content in the building. In this report, the words recycling and beneficial reuse of CCR are meant to be interchangeable phrases.

2.1.4 Beneficiation

Beneficiation is the term describing the processing of fly ash to make it more suitable for a specific use. In this study, beneficiation processes, systems, and equipment are assumed to include processes designed to lower the carbon content of the fly ash and/or alter the particle size (i.e., fineness) so it will meet ASTM C618 standards for substitution for Portland cement used in the production of concrete. Some of the engineering properties of fly ash that are of particular interest as an admixture or a cementitious addition to Portland Cement Concrete include fineness, carbon content (as indicated by LOI) chemical composition, moisture content, and pozzolanic activity. Most specifying departments of transportation refer to ASTM C618 when citing acceptance criteria for the use of fly ash in concrete. Without beneficiation, the fly ash as produced would not meet the ASTM standards and would be less likely to be recycled for use in ready mix or concrete production as discussed in Section 4 of this report.

2.2 ASTM C618 Specification

ASTM is a national and international organization based in the United States that sets standards for engineering-related materials and testing. ASTM C618 is widely used because it covers the use of fly ash as a pozzolan (mineral admixture in concrete) (ASTM, 2015). The three classes of pozzolans are Class N, Class F, and Class C. Class N is raw or calcined natural pozzolans such as some diatomaceous earths, opaline cherts, and shales; tuffs, volcanic ashes, and pumicites; and calcined clays and shales. Class F is pozzolanic fly ash normally produced from burning anthracite or bituminous coal; Class F fly ash generally has a low calcium content (CaO <10% by weight). Class C is pozzolanic and cementitious fly ash that has a relatively high calcium content; Class C fly ash is normally produced from burning lignite or subbituminous coal. In the United States, Class C fly ash is usually produced by burning Powder River Basin (western) coal. The fly ash in the ponds evaluated in this study comes from stations that burned bituminous fuel, with CaO content consistent with Class F ash. Therefore, all comparisons in this study were conducted using Class F criteria. The chemical and physical requirements listed in the ASTM C618 specification that are typically of most interest are listed in Tables TM2-6 and TM2-7, respectively (Yeboah, 2014).

Table TM2-6: ASTM C618 Chemical Requirements for Fly Ash Classes

Ash Classification	$SiO_2 + Al_2O_3 + Fe_2O_3$ (Min. wt %)	SO_3 (Max. wt %)	Moisture (Max. wt %)	LOI (Max. wt %)
C	50	5	5	6
F	70	5	3	6

Al2O3 = aluminum oxide; CaO = calcium oxide; Fe_2O_3 = iron oxide; LOI = loss on ignition; SiO2 = silicon dioxide; SO_3 = sulfur trioxide; wt% = weight percent

Table TM2-7: ASTM C618 Physical Requirements for Fly Ash Classes

Ash Classification	Retained #325 Mesh (Maximum wt %)	Water Required (Maximum % of Control)	7- and 28-Day Strength Activity Index (Minimum % of Control)	Soundness Autoclave Expansion/Contraction (Maximum %)
C	34	105	75	±0.8
F	34	105	75	±0.8

wt% = weight percent

Although the ASTM criterion for Class F ash is a maximum LOI of 6%, some state transportation departments specify a maximum LOI value that does not exceed 3 or 4% (US DOT, 2016). If the carbon content of the fly ash, reflected by LOI, is greater than 3% to 4%, this feature may have an adverse effect on air entrainment and ultimately the strength of the resulting concrete. Ready-mix companies typically request an LOI of less than 4% because they are concerned about product quality and the control of air-entraining admixtures. Equally important to the low LOI values is the consistency in the LOI, because ready-mix concrete producers are most concerned with inconsistent batching results due to wide variations in LOI.

The ASTM C618 standard also specifies a maximum allowable moisture content of 3%. Some other properties of fly-ash-concrete mixes that are of particular interest include mix workability, time of setting, bleeding, pumpability, strength development, heat of hydration, permeability, resistance to freeze-thaw, sulfate resistance, and alkali-silica reactivity (US DOT, 2016).

Additional definitions of and details for the method parameters used to assess the ash data in this study are provided Table TM2-8. In addition to ASTM C618 parameters, the samples were also analyzed for injurious organic impurities according to ASTM C40-16 and more comprehensive particle size distribution (PSD) using the dry-sieve methods specified in ASTM D6913 and ASTM D1921.

Table TM2-8: Test Methods and Evaluated Parameters

Method	Parameter	Description
ASTM C618-15, Standard Specification For Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete Methods to be used for ASTM C618 tests are specified in **ASTM C311**, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland Cement Concrete	SiO_2 + Al_2O_3+ Fe_2O_3	Silicon, aluminum, and iron content of the ash expressed as the sum of the elemental oxides on a weight percent basis. The ash must contain a minimum amount of these species to exhibit the necessary pozzolanic properties and be a suitable replacement for Portland cement in concrete. Pozzolanic activity refers to the ability of the silica and alumina components of fly ash to react with available calcium and/or magnesium from the hydration products of Portland cement.
	SO_3	Sulfate content of the ash, expressed as sulfur trioxide on a weight percent basis. Sulfates present in the ash or concrete can impact the optimum amount of fly ash needed for maximum strength development. Excess sulfate remaining in the hardened concrete can result in detrimental sulfate attack.
	Moisture	Water content of the ash expressed as weight percent. Moisture limits are necessary to ensure proper handling characteristics of the concrete.
	LOI	Percent loss on ignition is a measure of the unburned carbon content in the ash. Carbon can react with air entrainment admixtures (AEAs) making it difficult to maintain proper air entrainment in concrete. Excessive carbon content can also increase the water requirement.

Table TM2-8 (cont.): Test Methods and Evaluated Parameters

Method	Parameter	Description
	% retained at 325 mesh	A measure of the fineness of the ash, expressed as the weight percent of material retained on a 325 mesh screen (45-um) using a wet sieve method. Fineness impacts the pozzolanic reactivity of the ash as well as the water required. Coarse ash particles do not react as rapidly in concrete.
	Water required	The amount of water added to the sample as part of the strength activity index test (SAI) relative to the control mixture to obtain the same flow characteristics as the control mixture. Calculated as the ratio of the water required in the test mixture to that of the control mixture, expressed as a percentage. The control mixture used for SAI tests is prepared by combining specified amounts of Portland cement, sand and water. The sample test mixture is prepared by replacing 20% by weight of the cement with the ash material to be tested, and adding water to obtain the same flow characteristics as the control sample.
	7- and 28-day SAI	Strength activity index provides an indication of the rate of pozzolanic activity. SAI is calculated as the ratio of the compressive strength of the test mixture to that of the control mixture, expressed as a percentage. Compressive strength is measured on both the control and the sample at 7-days. If the test mixture fails the criterion on the 7-day test, the test is repeated at 28-days and if it meets the criterion, the material is considered compliant with the specification.
	Soundness	A measure of the expansion/contraction of the test material when placed in an autoclave at a specified temperature and for a specified duration. The test measures the delayed detrimental expansion/contraction that can occur if high concentrations certain constituents such as magnesium oxide (MgO) are present.
ASTM C40-16, Standard Test Methods for Organic Impurities in Fine Aggregates for Concrete	Organic impurities color rest	Final color of a solution prepared from the material is compared to standardized color plates and if darkness exceeds plate #3, the material may contain injurious organic impurities. Thus, the method states that it is advisable to perform additional tests using ASTM C87 (Standard Test Method for Organic Impurities in Fine Aggregate on Strength of Mortar) before approving the fine aggregate for use in concrete. ASTM C87 compares the strength of mortar made with washed and unwashed fine aggregate.
ASTM D6913-17, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis – Test Method B	Particle size distribution	Defines the dry sieve test method procedures to determine the particle size distribution of soil-type material in size ranges from 3/8 inch (9510-µm) to 200 mesh (74-µm) diameter.
ASTM D1921-12, Standard Test Methods for Particle Size (Sieve Analysis) of Plastic Materials – Test Method A (Modified)	Particle size distribution	Defines the dry sieve test method procedures to determine the particle size distribution of material in size ranges from 230 mesh (63-µm) to 635 mesh (22-µm) diameter.

Al_2O_3 = aluminum oxide; Fe_2O_3 = ferric oxide; LOI = loss on ignition; SAI = strength activity index; SiO_2 = silicon dioxide; SO_3 = sulfur trioxide; wt% = weight percent

2.3 Overview of Dominion Power Stations

2.3.1 Bremo Power Station

The 68-acre North Ash Pond was built at the Bremo Power Station in 1983 by constructing an ash pond in a steep drainage feature in the rising natural hillside. Dominion is currently relocating approximately 1.4 million CY of material from the East Ash Pond to the North Ash Pond. Once the relocation of ash is completed, it is anticipated that the North Ash Pond will contain 6.2 million CY of CCR materials. Historical information indicates that the CCR materials may be up to 75 feet thick.

2.3.2 Chesapeake Energy Center

The 5-acre Bottom Ash Pond is a combined incised/diked earthen embankment structure. It was designed as two separate ponds, but it was ultimately constructed in 1984 as a single ash pond. From late 2001 to early 2002, two berms were constructed of reclaimed bottom ash in the eastern part of the pond to facilitate the settling of solids in that area of the pond. The ash pond is surrounded by water on three of its four sides. The maximum height of the embankments is approximately 17 feet. The pond is inactive and stopped receiving bottom ash in October 2015. Approximately 60,000 CY of bottom ash are being removed from this pond.

2.3.3 Chesterfield Power Station

The Lower Ash Pond at the Chesterfield Power Station covers an area of approximately 100 acres. It was constructed in 1964 and was expanded five feet vertically in 1967/1968. The CCR materials contained in the Lower Ash Pond include fly ash, bottom ash, boiler slag, coal mill rejects (pyrites), coal fines, coal pile runoff, boiler cleaning wastewater, and water from the station master sump. Current volume estimates indicate that the Lower Ash Pond contains approximately 3.6 million CY of CCR materials.

The 112-acre Upper Ash Pond was constructed in 1983 to store CCR and other materials consisting of fly ash, bottom ash, boiler slag, flue gas emission control residuals, coal mill rejects, coal fines, and general dredge spoil materials. The CCR stored in the Lower Ash Pond was periodically dredged and hydraulically transferred to the Upper Ash Pond for final storage. Current volume estimates indicate that the Upper Ash Pond contains approximately 11.3 million CY of CCR materials.

2.3.4 Possum Point Power Station

The 64-acre Ash Pond D was constructed at the Possum Point Power Station across a valley in 1988 to replace a pre-existing ash pond in the same location. Ash Pond D was used as an ash pond for the settling and long-term storage of CCR and other materials; it was also used as a disposal site for the dried filtered material from the river water clarification process, and the U.S. Army Corps of Engineers occasionally disposes of dredged river materials at this site. Dominion has relocated CCR materials from Ash Ponds A, B, C, and E into Ash Pond D. Current volume estimates indicate that Ash Pond D contains approximately 4.0 million CY of CCR materials.

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