Allegheny Energy Supply Company, LLC

v.

Commonwealth of Pennsylvania
Department of Environmental Protection
EHB Docket No. 2009-006-R

Expert Report of Michael C. Preston, PE

April 14, 2011

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Table of Contents

Tables

Figures

1.0 Introduction

The following report was prepared by Mr. Michael Preston, PE in collaboration with others working under his direct supervision. Mr. Preston has a Bachelor of Science degree in Chemical Engineering from the Missouri University of Science and Technology (formerly University of Missouri – Rolla). He has worked for Black & Veatch for 23 years and is currently a Project Chemical Engineer and Chemical Engineering Section Leader in Black & Veatch's Energy Business. Over his career, Mr. Preston has performed consultation, detailed design and procurement, and construction and startup support functions specifically for water and wastewater treatment related systems primarily in the power industry. A summary of his qualifications and experience is included in Attachment A.

This report contains Mr. Preston's opinions, within a reasonable degree of engineering certainty regarding the feasibility and cost of additional wastewater treatment equipment that would be required to meet NPDES discharge limits for total dissolved solids ("TDS") and sulfates established by the Pennsylvania Department of Environmental Protection (DEP) for the Hatfield's Ferry Generating Station. An application to amend the current NPDES permit was filed by Allegheny Energy (AE) in May 2007 in conjunction with the addition of three wet flue gas desulfurization (FGD) systems at the Station. Following a series of draft permit issues and review cycles, a final draft permit was issued November 22, 2008. This final draft permit included new discharge limits for TDS and sulfates not included in previous draft permit issues. Final discharge limits were established based on this draft permit in December 2008 (Amendment 1 issued December 30, 2008). In February 2009 AE filed for, and was granted, a Petition for Supersedeas to stay the Selected Scrubber Effluent Limitations identified in the Petition related to specific constituents in Outfall 006. In support of AE's comments to the final draft permit and the Petition, Black & Veatch prepared a Conceptual Wastewater Treatment Engineering and Cost Estimate for AE in December 2008. The following is an update to that report based on further and more detailed analysis of the treatment issues and associated costs at the Station.

The contents of this report are based on further detailed study and analysis of the overall Station water balance, additional Monongahela River water quality data, the resulting wastewater treatment requirements imposed by new NPDES limits for Outfall 006, and the associated costs and impacts to existing Station facilities. The constituents of primary concern, from a treatment perspective, in the final permit are TDS and sulfates. In preparing this analysis Mr. Preston and the Black & Veatch project engineers relied on their previous experience and industry knowledge pertaining to power plant water management and wastewater treatment, FGD wastewater treatment issues, various wastewater treatment systems, and cost estimating techniques. The team consulted various literature sources and also consulted with various wastewater treatment equipment suppliers to attempt to obtain the most current industry understanding for treating these particular constituents in an FGD wastewater application. The team utilized Black & Veatch's cost estimating resources along with key input from wastewater treatment suppliers to estimate the costs presented in this report.

2.0 Executive Summary

2.1 Summary Findings

The following summarizes the major findings and conclusions of this report:

- Hatfield's Ferry Power Station commissioned FGD systems for Units 1, 2, and 3 in 2009. The FGD systems create a liquid wastewater stream that must be treated prior to discharge. The wastewater stream is typical of FGD wastewaters and contains total suspended solids (TSS) and TDS.

- An FGD wastewater treatment system was commissioned in conjunction with the FGD systems and is based on a widely accepted, state-of-the-art physical/chemical process to reduce TSS and heavy metals. The process is not designed to reduce the overall TDS or sulfate levels in the wastewater stream. This treatment approach is consistent with treatment systems provided for other wet FGD wastewater treatment applications in the United States and was designed to meet initial draft NPDES permit limits issued by DEP. The treated wastewater stream is monitored in Outfall 306 and then combined with effluent from the existing Wastewater Treatment Lagoons (Outfall 206) and discharged to the Monongahela River via Outfall 006.

- The DEP issued a draft NPDES permit amendment to AE on November 22, 2008, which contained the following additional discharge limitations for Outfall 006 (not contained in previous draft permits):
  - Total Dissolved Solids:
    1. 500 mg/l (average monthly).
    2. 750 mg/l (maximum daily).
  - Sulfate
    1. 250 mg/l (maximum daily).

- The FGD wastewater treatment system is an integral part of the overall FGD system. The time at which the additional discharge limits were incorporated into the draft NPDES permit for the Station precluded AE from adequately considering and mitigating the cost impacts of meeting these discharge limits in their overall FGD implementation approach.

- Based on an engineering review, it is my opinion within a reasonable degree of engineering certainty that a combination of treatment steps which have not been traditionally employed to treat FGD discharges at existing coal fired power plants would be required to address the Outfall 006 limits for TDS and sulfates. Figure 2-1 provides a high level overview of the required new processes and how they might potentially fit into the Station's existing water management plan.

- The only potentially technically feasible means of reducing TDS and sulfate from the FGD wastewater stream at the Hatfield Station is a mechanical evaporation based process. In this process, the wastewater is evaporated and condensed, producing low TDS product water (distillate) and a relatively dry solid product (approximately 40 to 60 percent solids by weight). The distillate product from the evaporation process could be discharged to Outfall 006 (via Outfall 306). The solids are expected to be disposed of in an off site disposal facility.

- While the evaporation process has been used in power plant cooling tower blowdown applications, it has rarely been used in FGD wastewater applications. Based on our research and experience, there are less than six or seven of these treatment systems in operation in the world today, only one of which is located in the United States.

- It is necessary to continue to operate the existing physical/chemical FGD wastewater treatment process ahead of the evaporator system in order to reduce suspended solids in the evaporator feed. An additional softening system is required upstream of the evaporator to condition the evaporator feed to produce the desired solids. Space for construction of an evaporation system at Hatfield Station is very limited. The location selected for the new system for purposes of this evaluation is adjacent to the existing FGD Reagent Preparation and Dewatering Building. This location is quite constrained and a more detailed evaluation of this space is required to determine if it is feasible.

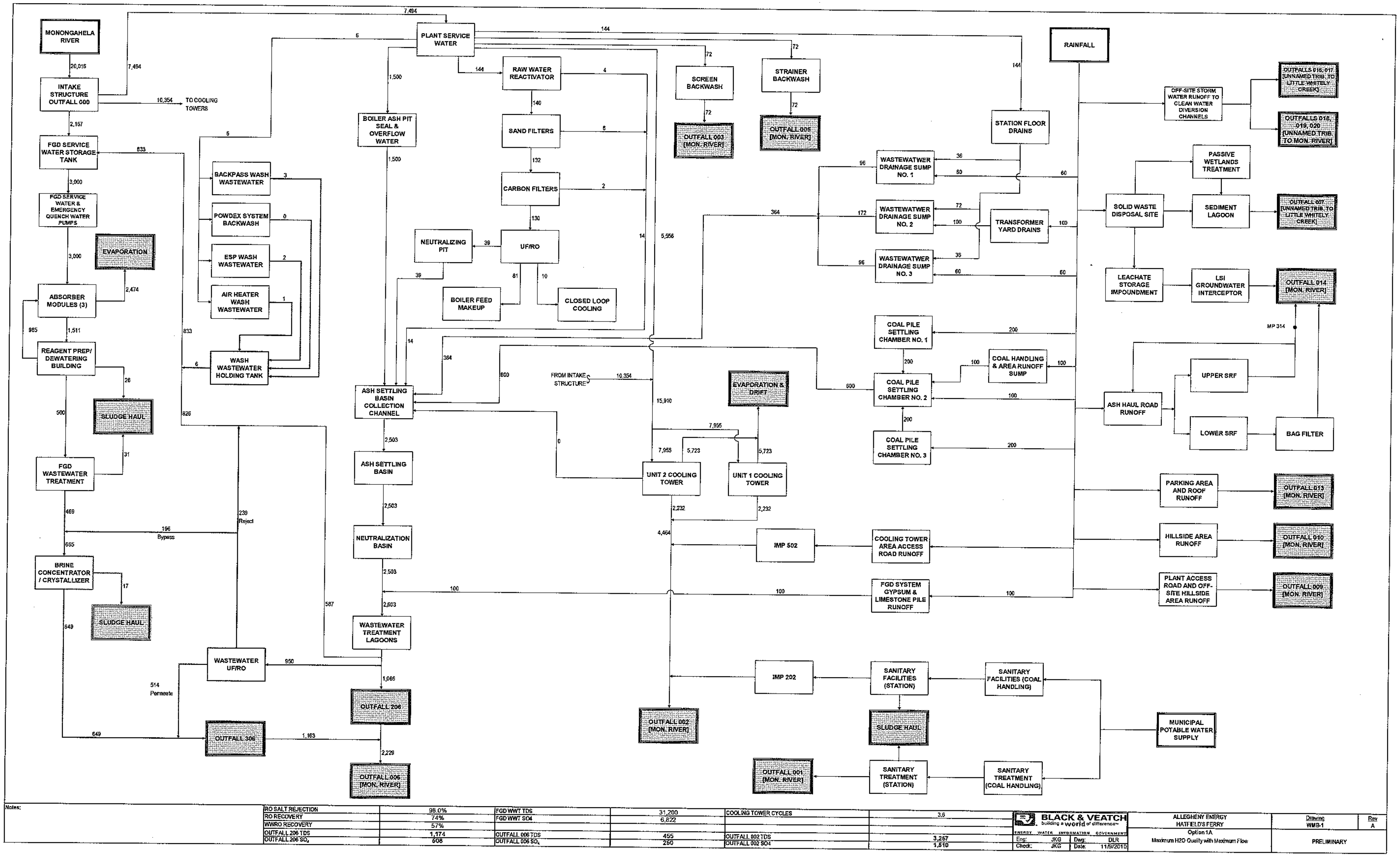
- An additional wastewater treatment system would also be required to treat a portion of the discharge from the Wastewater Treatment Lagoons. This system utilizes reverse osmosis (RO) and associated ultrafiltration (UF) pretreatment to reduce TDS and sulfates. A portion of reject water from the UF/RO process could be recycled to the FGD system as makeup with the remainder sent to the proposed FGD wastewater evaporators. The low TDS/sulfate product water from the UF/RO could be combined with distillate from the evaporators and discharged to Outfall 006 (via Outfall 306).

- The evaporation process, UF/RO treatment, and auxiliary support facilities require at least 36 to 40 months to design, procure, construct, and commission without considering permitting delays and construction challenges. The actual time from design to commissioning could approximate four years.

- Tables 2-1 and 2-2 provide a summary of conceptual capital and operating costs for the proposed treatment systems that would be necessary to meet the proposed TDS and sulfate limits at Outfall 006. The following is a brief summary of operational impacts:

- Power Requirement 6.5 megawatts
  (Taken from the Station's available generation)
- Solids Production 55 tons per day
  (Requiring off-site disposal)
- Lime 630 lbs per hour

- Estimated capital costs are in excess of $155 million and estimated operating costs are expected to exceed $2.5 million per year not including the Station's lost net revenue for the power dedicated to operate the system or the cost to transport and dispose of solids generated by the treatment process.


MONONGAHELA RIVER
INTAKE STRUCTURE OUTFALL 000
TO COOLING TOWERS
FGD SERVICE WATER STORAGE TANK
FGD SERVICE WATER & EMERGENCY QUENCH WATER PUMPS
EVAPORATION
ABSORBER MODULES (3)
REAGENT PREP/ DEWATERING BUILDING
SLUDGE HAUL
FGD WASTEWATER TREATMENT
Bypass
Reject
BRINE CONCENTRATOR / CRYSTALLIZER
SLUDGE HAUL
WASTEWATER UF/RO
Permeate
OUTFALL 306
PLANT SERVICE WATER
BOILER ASH PIT SEAL & OVERFLOW WATER
BACKPASS WASH WASTEWATER
POWDEX SYSTEM BACKWASH
ESP WASH WASTEWATER
AIR HEATER WASH WASTEWATER
WASH WASTEWATER HOLDING TANK
RAW WATER REACTIVATOR
SAND FILTERS
CARBON FILTERS
UF/RO
NEUTRALIZING PIT
BOILER FEED MAKEUP
CLOSED LOOP COOLING
ASH SETTLING BASIN COLLECTION CHANNEL
ASH SETTLING BASIN
NEUTRALIZATION BASIN
WASTEWATER TREATMENT LAGOONS
OUTFALL 206
OUTFALL 006 [MON. RIVER]
FROM INTAKE STRUCTURE
SCREEN BACKWASH
OUTFALL 003 [MON. RIVER]
STRAINER BACKWASH
OUTFALL 005 [MON. RIVER]
EVAPORATION & DRIFT
UNIT 2 COOLING TOWER
UNIT 1 COOLING TOWER
IMP 502
IMP 202
OUTFALL 002 [MON. RIVER]
OUTFALL 001 [MON. RIVER]
STATION FLOOR DRAINS
WASTEWATER DRAINAGE SUMP NO. 1
WASTEWATER DRAINAGE SUMP NO. 2
WASTEWATER DRAINAGE SUMP NO. 3
TRANSFORMER YARD DRAINS
COAL PILE SETTLING CHAMBER NO. 1
COAL PILE SETTLING CHAMBER NO. 2
COAL PILE SETTLING CHAMBER NO. 3
COAL HANDLING & AREA RUNOFF SUMP
COOLING TOWER AREA ACCESS ROAD RUNOFF
FGD SYSTEM GYPSUM & LIMESTONE PILE RUNOFF
SANITARY FACILITIES (STATION)
SANITARY FACILITIES (COAL HANDLING)
SLUDGE HAUL
SANITARY TREATMENT (STATION)
SANITARY TREATMENT (COAL HANDLING)
MUNICIPAL POTABLE WATER SUPPLY
RAINFALL
OFF-SITE STORM WATER RUNOFF TO CLEAN WATER DIVERSION CHANNELS
OUTFALLS 016, 017 [UNNAMED TRIB. TO LITTLE WHITELY CREEK]
OUTFALLS 018, 019, 020 [UNNAMED TRIB. TO MON. RIVER]
PASSIVE WETLANDS TREATMENT
SOLID WASTE DISPOSAL SITE
SEDIMENT LAGOON
OUTFALL 007 [UNNAMED TRIB. TO LITTLE WHITELY CREEK]
LEACHATE STORAGE IMPOUNDMENT
LSI GROUNDWATER INTERCEPTOR
OUTFALL 014 [MON. RIVER]
MP 314
ASH HAUL ROAD RUNOFF
UPPER SRF
LOWER SRF
BAG FILTER
PARKING AREA AND ROOF RUNOFF
OUTFALL 013 [MON. RIVER]
HILLSIDE AREA RUNOFF
OUTFALL 010 [MON. RIVER]
PLANT ACCESS ROAD AND OFF-SITE HILLSIDE AREA RUNOFF
OUTFALL 009 [MON. RIVER]
Notes:
RO SALT REJECTION 98.0%
RO RECOVERY 74%
WWRO RECOVERY 57%
OUTFALL 206 TDS 1,174
OUTFALL 206 SO4 608
FGD WWT TDS 31,200
FGD WWT SO4 6,822
OUTFALL 006 TDS 455
OUTFALL 006 SO4 250
COOLING TOWER CYCLES 3.6
OUTFALL 002 TDS 3,257
OUTFALL 002 SO4 1,510
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ENERGY WATER INFORMATION GOVERNMENT
Eng: JKG Dwg: DLR
Check: JKG Date: 11/9/2010
ALLEGHENY ENERGY
HATFIELD'S FERRY
Option 1A
Maximum H2O Quality with Maximum Flow
Drawing WWB-1
Rev A
PRELIMINARY

Figure 2-1

Table 2-1
Wastewater Treatment Conceptual Estimate Capital Costs

Description	Capital Cost (2010$)
UF/RO Equipment	2,000,000
Softener Equipment	6,000,000
BC/CRY Equipment	24,000,000
Miscellaneous Equipment	3,565,000
Equipment Construction	24,657,000
BOP Construction	35,103,000
Total Indirect[1]	62,074,000
Total Installed Cost	157,399,000

Notes:
1. Indirect costs do not include owner costs.

Table 2-2
Wastewater Treatment Annual Operating Costs

Description	Annual Cost ($)
General Maintenance	320,000
BC Cleaning	25,000
Chemicals / Membrane Replacement	1,143,000
Steam/Cooling Water	430,000
Power	755,000
Subtotal Annual Cost	2,673,000
Sludge Haul and Disposal Cost	TBD
Labor - FTE	4

2.2 Conclusions

In order to meet proposed discharge limitations at Outfall 006 for TDS and sulfate, the FGD wastewater and a portion of the Wastewater Treatment Lagoon effluent must be treated. The FGD wastewater will require treatment using softening and evaporation processes to reduce the TDS and sulfate concentrations and ultimately convert them to dry solids for disposal. A low TDS product water stream will be created in this process. A portion of the Wastewater Treatment Lagoon effluent will require treatment using an UF/RO process to reduce TDS and sulfate concentrations. The concentrated wastewater from the UF/RO process will be recycled to the FGD wastewater evaporator. Low TDS UF/RO product water will be combined with the low TDS evaporator product water and discharged via Outfall 006.

While the treatment of the FGD wastewater and Wastewater Treatment Lagoon effluent to comply with the proposed TDS and sulfate discharge limits at Outfall 006 may be technically possible, it will be technically and logistically challenging given space constraints, and the relatively new application of this system in the power industry with very few operational examples. It also comes with significant costs. Estimated capital costs are in excess of $155 million, and estimated operating costs are expected to exceed $2.5 million per year.

3.0 Wastewater Treatment Approach

FGD system wastewater streams typically contain levels of suspended solids (TSS) (2 to 4 percent), dissolved solids (TDS) (2 to 4 percent) and certain trace metals that carry over from the combustion process and are removed from the flue gas in the FGD process. FGD wastewater treatment is typically focused on the reduction of suspended solids and certain heavy metals present in the wastewater stream. This type of treatment approach was the basis for the current physical/chemical treatment system in operation at Hatfield's Ferry Generating Station.

In May 2007, an application to amend the current Station NPDES permit was submitted to DEP in conjunction with the FGD addition. Over the ensuing 16 months, several draft permit amendments were issued and reviewed. During this time, the FGD system was being designed and constructed. The existing FGD wastewater treatment system (Existing Treatment System) was an integral component in this effort. It is my understanding that over the course of discussions with the DEP from the time the NPDES application amendment was filed until the final draft permit was issued, the details of the Existing Treatment System and its expected performance were discussed with the DEP.

The Existing Treatment System was furnished by Siemens and consists of a series of tanks, clarifiers, filters, chemical feed skids, and solids dewatering equipment designed to reduce the TSS and heavy metals in the FGD wastewater stream. The primary mode of treatment, termed physical/chemical, is based on the precipitation and settling of solids and dewatering of settled solids for disposal.

The Existing Treatment System is designed to meet TSS and heavy metal discharge limitations at Outfall 006. This treatment approach is typical of the current treatment technologies provided recently at power generating stations to treat FGD discharges. However, it is not designed to reduce TDS or sulfate levels. In our experience, these constituents have not typically been regulated through NPDES permit limits in power plant discharges.

On November 22, 2008, DEP issued a final Draft Permit Amendment for the Station which included the FGD wastewater treatment system. The Draft Permit Amendment proposed the following proposed discharge limitations for Outfall 006 that had not been included in previous draft permit issues:

- Total Dissolved Solids:
  - 500 mg/l (average monthly).
  - 750 mg/l (maximum daily).
- Sulfate
  - 250 mg/l (maximum daily).

These limits, along with others, were established in the final NPDES permit issued on December 30, 2008. Achieving these proposed discharge limits requires treatment of the FGD wastewater beyond the capabilities of the Existing Treatment System.

These TDS and sulfate limits also create additional treatment requirements for the effluent from the Station's Wastewater Treatment Lagoon. A portion of this effluent must also be treated to achieve the permitted limits for TDS and sulfates at Outfall 006.

The following Section provides an overview of wastewater treatment technologies currently being implemented, treatment alternatives for meeting the proposed TDS and sulfate discharge limitations, and the new treatment system that would be required for the reduction of TDS and sulfate at Outfall 006.

3.1 FGD Wastewater Treatment Approaches

As noted above, wet FGD wastewater contains concentrations of TSS and TDS. The typical FGD wastewater treatment approach is to reduce the TSS and certain components of TDS, primarily heavy metals, prior to discharge. A physical/chemical treatment process has been used in the majority of these applications to accomplish this. The physical/chemical process relies on solids settling equipment and chemical processes to reduce the TSS and heavy metals concentrations, producing a non-hazardous solid waste and a treated liquid stream for discharge. This is basis of the Existing Treatment System at the Station.

Other treatment systems and approaches have been utilized in specific applications. These include disposal of FGD wastewater in existing ash ponds, further biological treatment of wastewater to target specific constituents, engineered wetlands and mechanical evaporators.

There are examples where various levels of treated FGD wastewater has been proposed for reuse in the power station. The treated wastewater has been reused for ash conditioning and even cooling tower makeup in some situations. However, reuse opportunities in existing facilities, like Hatfield, are constrained by the existing equipment designs and typically this is not practical.

3.2 FGD Integrated Planning

Extensive planning and evaluation are required for the successful implementation of a FGD system, particularly in an operating station like Hatfield. Most of these efforts focus on the operational impacts to the plant performance and existing facilities, and the cost considerations for such large capital efforts. However, the cost and complexity of wet FGD wastewater treatment can play a significant role in the overall FGD implementation at an existing station, particularly where wastewater discharge regulations require more extensive FGD wastewater treatment than the industry norm. This consideration could be to the extent that it can impact critical decisions regarding the FGD chemistry (level of chlorides allowed), FGD materials of construction, the ultimate disposal of gypsum product from the FGD, and the FGD technology itself. This is especially true when thermal (evaporative) treatment of the FGD wastewater is essentially mandated by the discharge limits established for the facility. In this case it is critical to identify these constraints very early in the FGD planning stages to allow for the full consideration of all options and economical design decisions to be made.

3.3 TDS and Sulfate Treatment Approaches

In order to meet the proposed discharge limitations for TDS and sulfate, the effluent from the Existing Treatment System and the Wastewater Treatment Lagoons requires additional treatment. The only potentially available options for treatment of this effluent include deep well injection, membrane-based treatment, and evaporation systems.

3.3.1 Deep Well Injection

Deep well injection of nonhazardous wastewater requires a Class I injection well. Class I injection wells inject hazardous and non-hazardous wastes below the lowermost underground source of drinking water (USDW). Class I injection occurs into deep geologic units isolated from the USDW by layers of impermeable clay and rock.

Additional treatment of the FGD bleed stream would be required to reduce the scaling tendency of this effluent to ensure dependable operation of the wells. In my opinion, this associated treatment and deep well injection of the FGD wastewater stream is not practical or feasible at Hatfield due to infrequent use in the vicinity of the Hatfield's Ferry Generating Station, anticipated regulatory hurdles and uncertainty surrounding the applicability of this method of disposal.

3.3.2 Membrane Treatment

Nanofiltration (NF), reverse osmosis (RO) and electrodialysis are membrane processes that can be used to reduce TDS, including sulfate. These processes create a higher purity product stream and a more concentrated brine stream that must ultimately be treated by evaporation if it cannot be discharged or disposed on-site.

In the NF and RO process, influent water is put under sufficient pressure to overcome the osmotic pressure of the water against a very thin porous, synthetic membrane. The membrane allows passage of relatively pure water while resisting passage of dissolved impurities. Thus, the membrane functions as a type of "molecular filter." Figure 3-1 is a representation of the basic concept.

In my opinion, NF and RO treatment of FGD bleed stream wastewater is not practical when compared to evaporative methods of volume reduction for two reasons. First, due to the level of TDS in FGD wastewater, the osmotic pressure of FGD wastewater is quite high. This high osmotic pressure limits the RO recovery (recovery = feed/product) to approximately 50 percent or less and increases its capital and operating cost. The resulting increased concentrate flow from the RO system would require a very large evaporator system resulting in a significant additional capital cost incurred by AE; the RO system and RO pretreatment system would have a combined capital cost on the same order of magnitude as a brine concentrator. Second, the FGD wastewater TDS, TSS, and high levels of organic constituents present severe scaling and fouling issues that make operation of an RO in this service difficult and unreliable. NF treatment has similar fouling concerns.

In the electrodialysis (ED) process, influent water flows parallel to a series of flat synthetic ion exchange membranes while a dc current electric field is applied perpendicular to the direction of water flow. Each membrane is alternately permeable to either positive ions (cations) or negative ions (anions). Each ion migrates towards the electrode of opposite charge until it is stopped by its nearest non-permeable membrane. This creates alternate passages of pure and impure water which are collected and directed to service waste, respectively.

In my opinion, ED treatment is not a proven process in FGD bleed stream treatment and therefore is neither practical nor feasible at Hatfield.

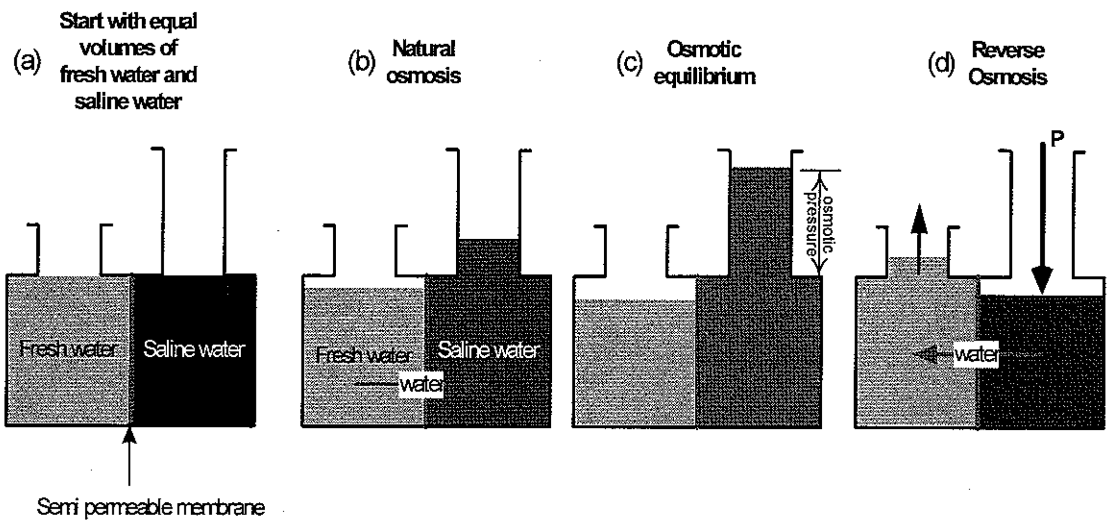

Figure 3-1
Reverse Osmosis

3.3.3 *Evaporation*

Evaporative treatment can be in the form of natural evaporation or mechanical evaporation. Natural evaporation is only applicable in arid or semi arid climates where ambient conditions heavily favor evaporation. This is not the case at the Station so evaporation ponds are not a viable alternative.

Mechanical evaporation uses energy driven evaporation processes to reduce the wastewater stream to a high purity distillate and a semi dry solid that can be disposed in a landfill.

3.3.3.1 Spray Drying. Spray drying refers to the process of evaporating an aqueous stream by spraying the stream into a hot, unsaturated gas, thereby producing a humidified gas stream and solid waste stream. The heat source can be either a high temperature gas produced by fuel gas combustion or the coal flue gas itself. In either case, the Station's existing particulate removal system can be utilized to capture salt particles small enough to be entrained in the gas stream.

In my opinion, this approach is cost prohibitive, relatively unproven in this application, and often results in a new air emissions source. Additionally, the calcium chloride salt that is created is difficult to handle and store due to its hygroscopic nature.

3.3.3.2 Brine Concentration. Brine concentration refers to the process of partially evaporating water from the waste stream, thereby concentrating the TDS and reducing the volume of wastewater. It is considered a volume reduction step and typically employed prior to a final treatment step such as crystallization or evaporation pond disposal.

The brine concentrator that may potentially work at Hatfield is a falling film, mechanical vapor compression process capable of 80 to 90 percent recovery efficiencies depending on the feedwater quality. A simplified schematic of the system is shown on Figure 3-2. A heat exchanger brings the feed temperature to near its atmospheric boiling point by recovering heat from the distillate. The non-condensable gases are then stripped from the feed in the deaerator. Concentrated slurry in the brine sump is mixed with the feed and is continuously recirculated to the top of the evaporator, where it is distributed to the inside wall of each tube as thin film. Water is evaporated from the film as it passes down the tube. This steam passes through a mist eliminator and then is compressed by the vapor compressor. The pressure increase raises the condensation temperature of the steam above the boiling point of the recirculating brine. The steam condenses on the outside of the tube giving up its heat of condensation, causing more water to be evaporated from the brine inside the tubes. Hot condensate is pumped back through the heat exchanger and exits as the brine concentrator product water/distillate.

A small bleed stream is removed from the concentrated slurry recirculation to control the dissolved solids level in the brine concentrator. This stream can be taken to disposal in a pond, used for process water (such as ash conditioning) or to a crystallizer.

An auxiliary boiler or outside steam supply is required for plant startup.

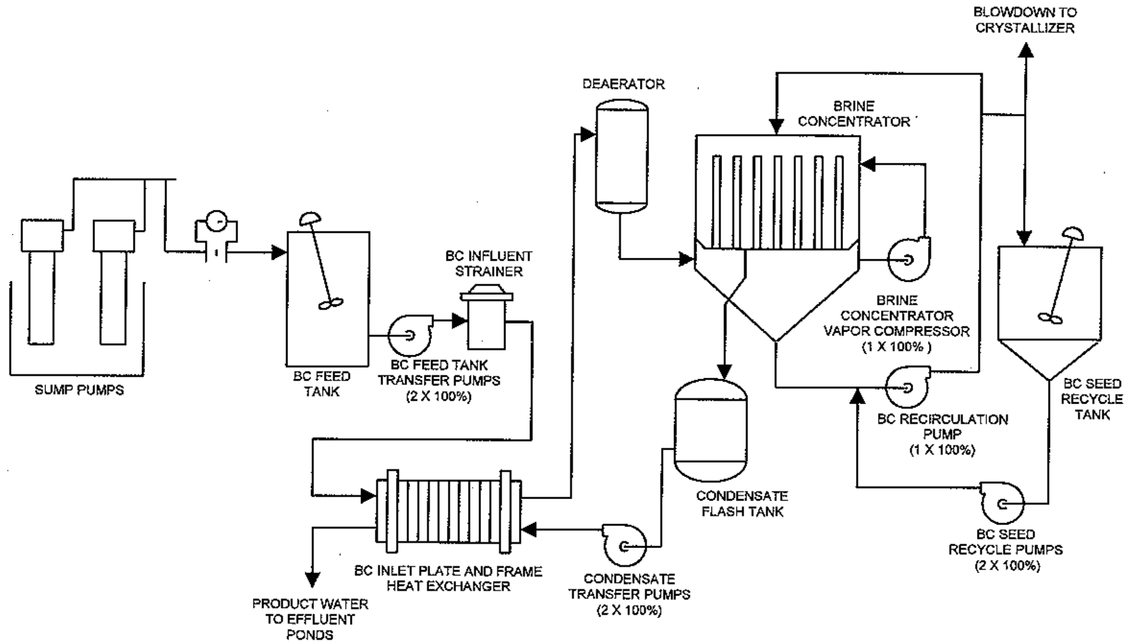

Figure 3-2
Brine Concentrator

3.3.3.3 Crystallization. The crystallization process utilizes a flash evaporator/crystallizer to concentrate the feed stream and produce a solid salt and high purity distillate product. It typically operates as a forced circulation evaporator as opposed to the falling film type brine concentrator. A simplified schematic of the system is shown on Figure 5.

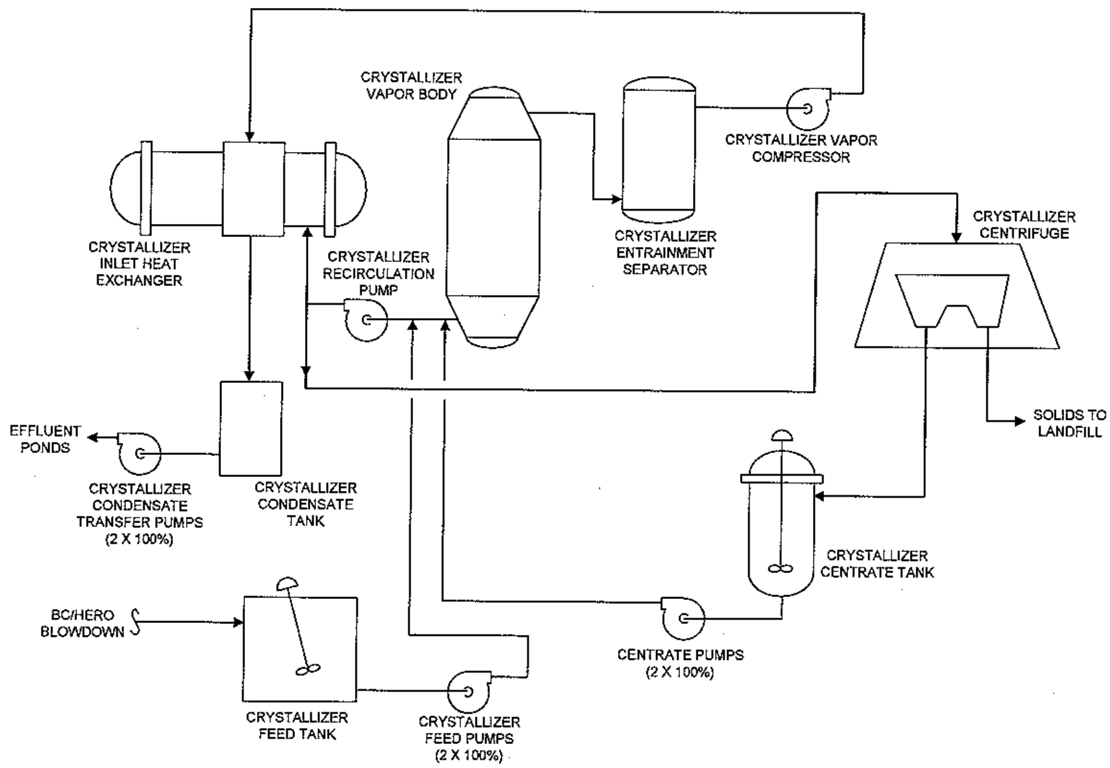

Figure 3-3
Crystallizer Flow Schematic

The feed is pumped from a crystallizer feed tank to the crystallizer at the suction of the crystallizer recirculation pump, where it is mixed with the crystallizer slurry from the crystallizer vapor body. The crystallizer slurry is continuously recirculating through the vapor body and the crystallizer heat exchanger. Antifoam is typically injected into the recirculation piping for foam control in the crystallizer process. The crystallizer slurry is heated to just below its boiling point in the heat exchanger. The slurry is discharged to the crystallizer vapor body, which is at atmospheric pressure. The depressurization of the crystallizer slurry in the vapor body causes the water in the slurry to flash (evaporate). The evaporated water (steam) exits through the top of the crystallizer vapor body and flows through the crystallizer entrainment separator to the crystallizer vapor compressor.

The crystallizer vapor compressor compresses the steam to provide additional energy to drive the process. Desuperheating water is added to the steam to provide saturated steam. The saturated steam is sent to the crystallizer heat exchanger. Alternately, an auxiliary steam supply can be used in lieu of the vapor compressor.

The condensate collected in the crystallizer heat exchanger shell side flows to the crystallizer condensate flash tank. Crystallizer condensate transfer pumps are used to recycle the product/distillate to the plant.

The crystallizer recirculation pumps periodically transfer a portion of the slurry to a dewatering system. The amount of crystallizer slurry sent and the frequency at which it is sent to the dewatering system are adjusted to maintain crystallizer suspended solids at the design level. The solids from use of such a dewatering system at Hatfield would have to be disposed off-site to a landfill.

3.3.3.4 Salt Conversion. In FGD wastewater treatment applications, a salt conversion step is typically required ahead of the brine concentrator to convert the predominantly calcium and magnesium chloride bleed stream to sodium chloride. This salt conversion is necessary to provide a salt that can ultimately be crystallized and dewatered in a more stable form suitable for landfill disposal.

The chemical treatment requires a softening system to convert the calcium and magnesium salts into sodium salts. The salt conversion requires a great deal of chemical and produces more solids for disposal. In my opinion, full conversion is not practical or necessary at Hatfield and only a partial salt conversion to reduce magnesium is included.

3.4 Hatfield's Ferry Potential Treatment Approach To Address TDS and Sulfate

In reviewing the Station's water balance data, existing systems design, and NPDES discharge limitations for Outfall 006, an evaporative treatment approach was deemed the only potentially feasible system to treat the FGD wastewater to meet the proposed TDS and sulfate limits. This approach utilizes the salt conversion and mechanical evaporation processes described above. A variation of this approach is currently utilized in Italy on power stations operated by ENEL. Another variation of this approach is utilized by Kansas City Power and Light's Iatan Unit 2 recently commissioned in Weston, MO.

An ultrafilter followed by reverse osmosis (UF/RO) is a potential system to treat the effluent from the Wastewater Treatment Lagoon. This approach or some variation of this approach is commonly used in power plant wastewater treatment. The concentrated wastewater from the RO, the reject, is combined with the FGD wastewater and fed to the evaporator. This has a significant impact to the size of the potential mechanical evaporation system for the Station.

Assuming such a system could be feasibly constructed at Hatfield, the FGD wastewater from the current treatment system would have to be pumped to a storage tank ahead of the proposed evaporation system. This tank levelizes flow surges and provides storage for normal maintenance activities required in the evaporation system. The wastewater is pumped from the tank to the salt conversion step to convert the magnesium salts in the FGD wastewater to sodium salts that can be crystallized in the evaporator as described above. Precipitated solids are dewatered and disposed in the onsite landfill, or possibly reused in the FGD process as reagent.

Treated water from the salt conversion step would be forwarded to the brine concentrator/crystallizer. In order to assure reliability and deal with normal maintenance requirements associated with limited water storage, this system would require includes two

60 percent brine concentrators and one 100 percent crystallizer. An electric boiler is included for startup steam supply. The concentrated slurry stream from the crystallizer is dewatered to produce solids suitable for off-site landfill disposal.

The product water (distillate) from the evaporator system can contain less than 25 mg/l of TDS. The distillate would flow through IMP 306, combine with effluent from IMP 206 and discharge to the Monongahela River via Outfall 006.

A portion of the Wastewater Treatment Lagoon would be pumped to a UF/RO system. The UF portion provides pretreatment for the RO to reduce suspended solids and some organics. It is a pressurized UF system with associated backwashing and chemical backwashing systems. Filtered water from the UF is routed to a single pass RO to reduce TDS, including sulfate, in the water. The product water from the RO would be combined with the product water from the brine concentrator crystallizer prior to Outfall 306. The RO reject, or concentrated waste stream, is pumped to the storage tank ahead of the brine concentrator/crystallizer.

This potential treatment system was located adjacent to the existing FGD Reagent Preparation and Dewatering Building at the Station for purposes of this analysis. Figure 3-4 shows the proposed location on the site map and Figures 3-5 and 3-6 are conceptual arrangements. The storage tank, lime storage silo, brine concentrators, and crystallizer would be located outside, adjacent to the building. Other equipment would have to be located inside a new wastewater treatment building.

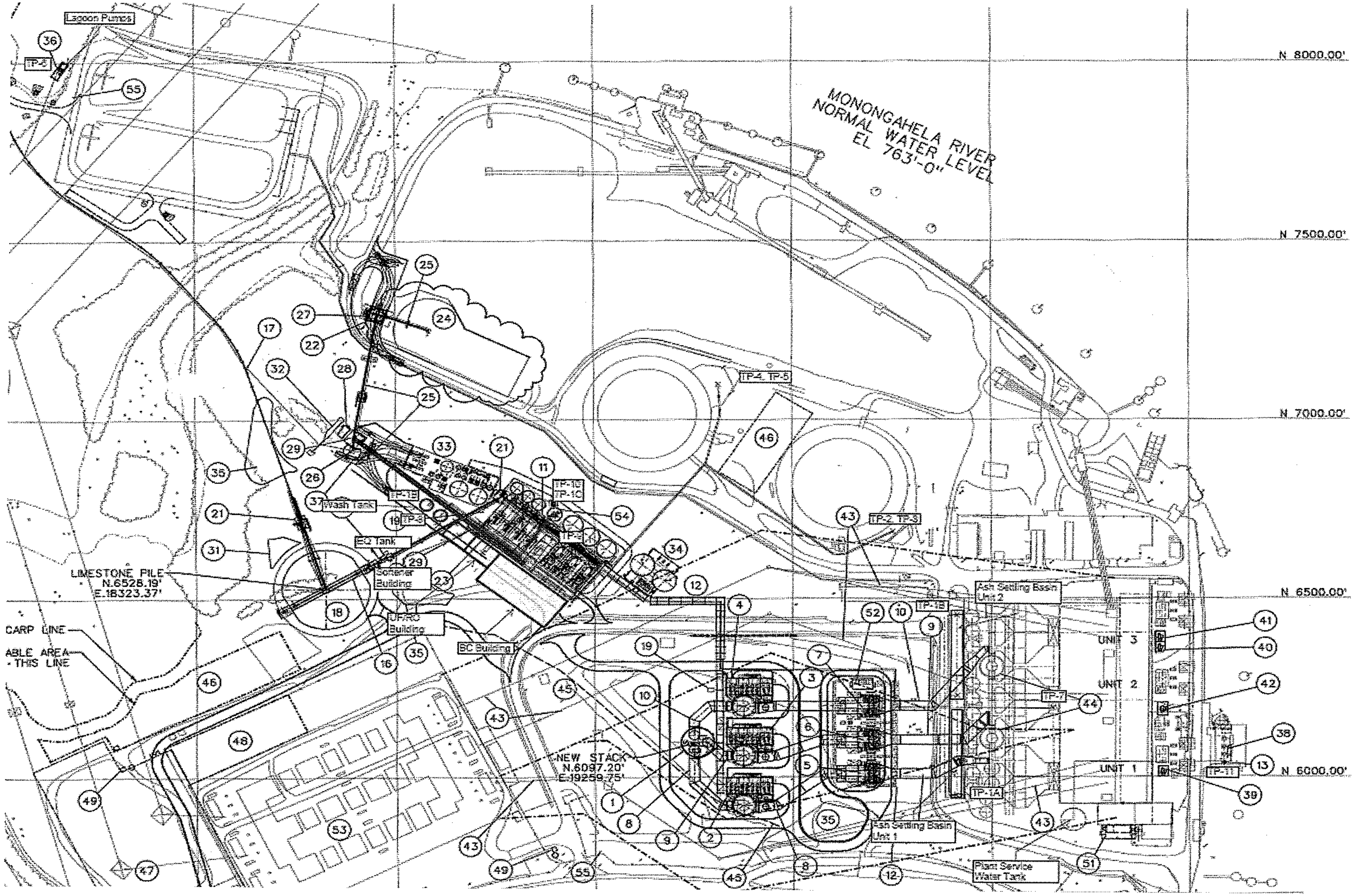
Lagoon Pumps
TP-6
MONONGAHELA RIVER
NORMAL WATER LEVEL
EL 763'-0"
N 8000.00'
N 7500.00'
N 7000.00'
N 6500.00'
N 6000.00'
TP-4, TP-5
TP-2, TP-3
TP-1B
TP-1D
TP-1C
TP-1E
TP-8
Wash Tank
EQ Tank
Softener Building
UF/RO Building
SC Building
LIMESTONE PILE
N.6528.19'
E.18323.37'
CARP LINE
ABLE AREA
THIS LINE
NEW STACK
N.6097.20'
E.19259.75'
Ash Settling Basin Unit 2
Ash Settling Basin Unit 1
UNIT 3
UNIT 2
UNIT 1
TP-7
TP-1A
TP-11
Plant Service Water Tank

Figure 3-4

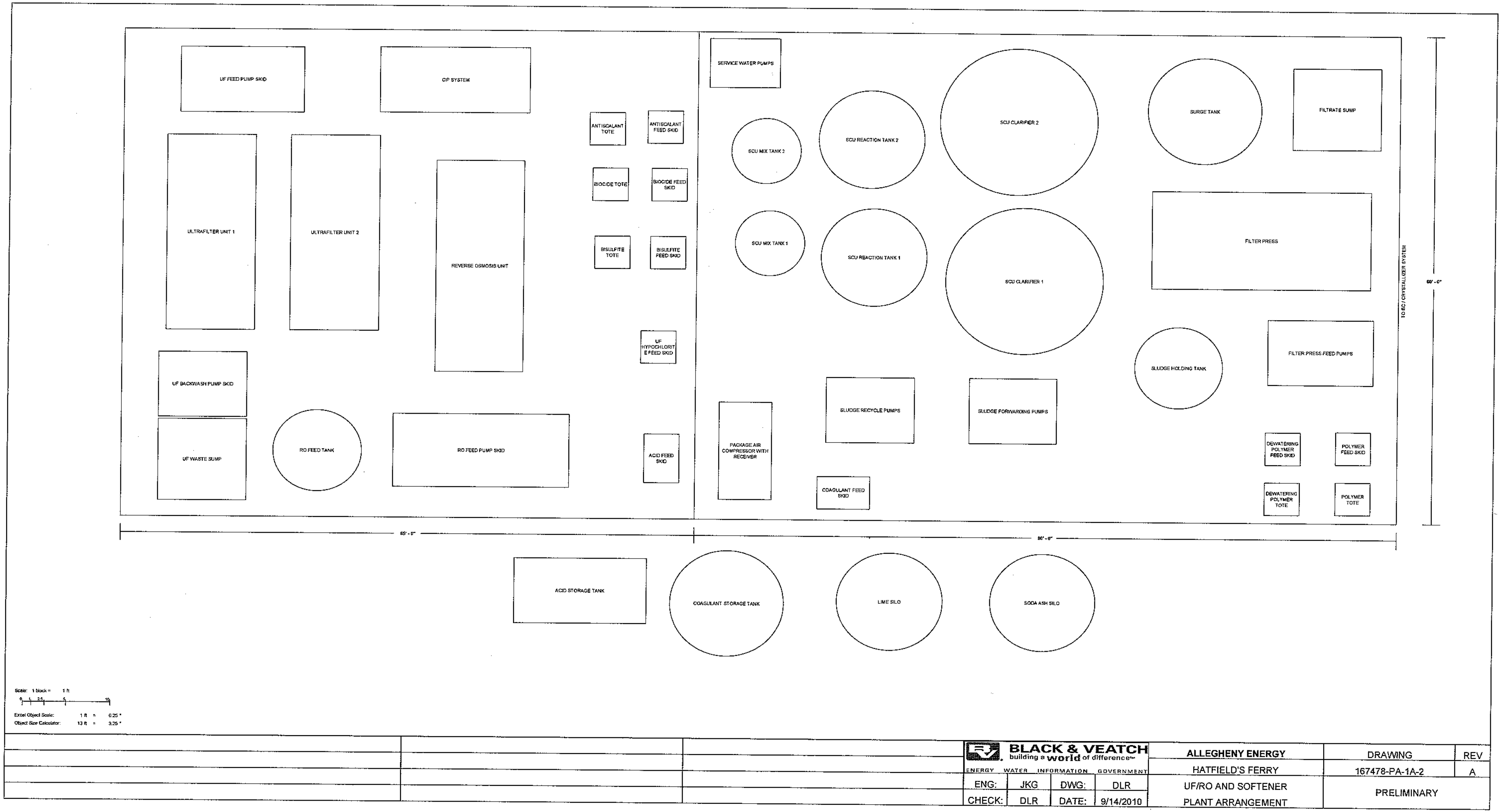
UF FEED PUMP SKID
CIP SYSTEM
ANTISCALANT TOTE
ANTISCALANT FEED SKID
BIOCIDE TOTE
BIOCIDE FEED SKID
BISULFITE TOTE
BISULFITE FEED SKID
ULTRAFILTER UNIT 1
ULTRAFILTER UNIT 2
REVERSE OSMOSIS UNIT
UF HYPOCHLORITE FEED SKID
UF BACKWASH PUMP SKID
UF WASTE SUMP
RO FEED TANK
RO FEED PUMP SKID
ACID FEED SKID
65' - 0"
SERVICE WATER PUMPS
SCU MIX TANK 2
SCU REACTION TANK 2
SCU CLARIFIER 2
SURGE TANK
FILTRATE SUMP
SCU MIX TANK 1
SCU REACTION TANK 1
SCU CLARIFIER 1
FILTER PRESS
SLUDGE HOLDING TANK
FILTER PRESS FEED PUMPS
TO BC / CRYSTALLIZER SYSTEM
60' - 0"
PACKAGE AIR COMPRESSOR WITH RECEIVER
SLUDGE RECYCLE PUMPS
SLUDGE FORWARDING PUMPS
COAGULANT FEED SKID
DEWATERING POLYMER FEED SKID
POLYMER FEED SKID
DEWATERING POLYMER TOTE
POLYMER TOTE
80' - 0"
ACID STORAGE TANK
COAGULANT STORAGE TANK
LIME SILO
SODA ASH SILO
Scale: 1 block = 1 ft
0 1 2.5 5 10
Excel Object Scale: 1 ft = 0.25 "
Object Size Calculator: 13 ft = 3.25 "
BLACK & VEATCH
building a world of difference
ENERGY WATER INFORMATION GOVERNMENT
ENG: JKG
DWG: DLR
CHECK: DLR
DATE: 9/14/2010
ALLEGHENY ENERGY
HATFIELD'S FERRY
UF/RO AND SOFTENER
PLANT ARRANGEMENT
DRAWING
167478-PA-1A-2
REV
A
PRELIMINARY

Figure 3-5

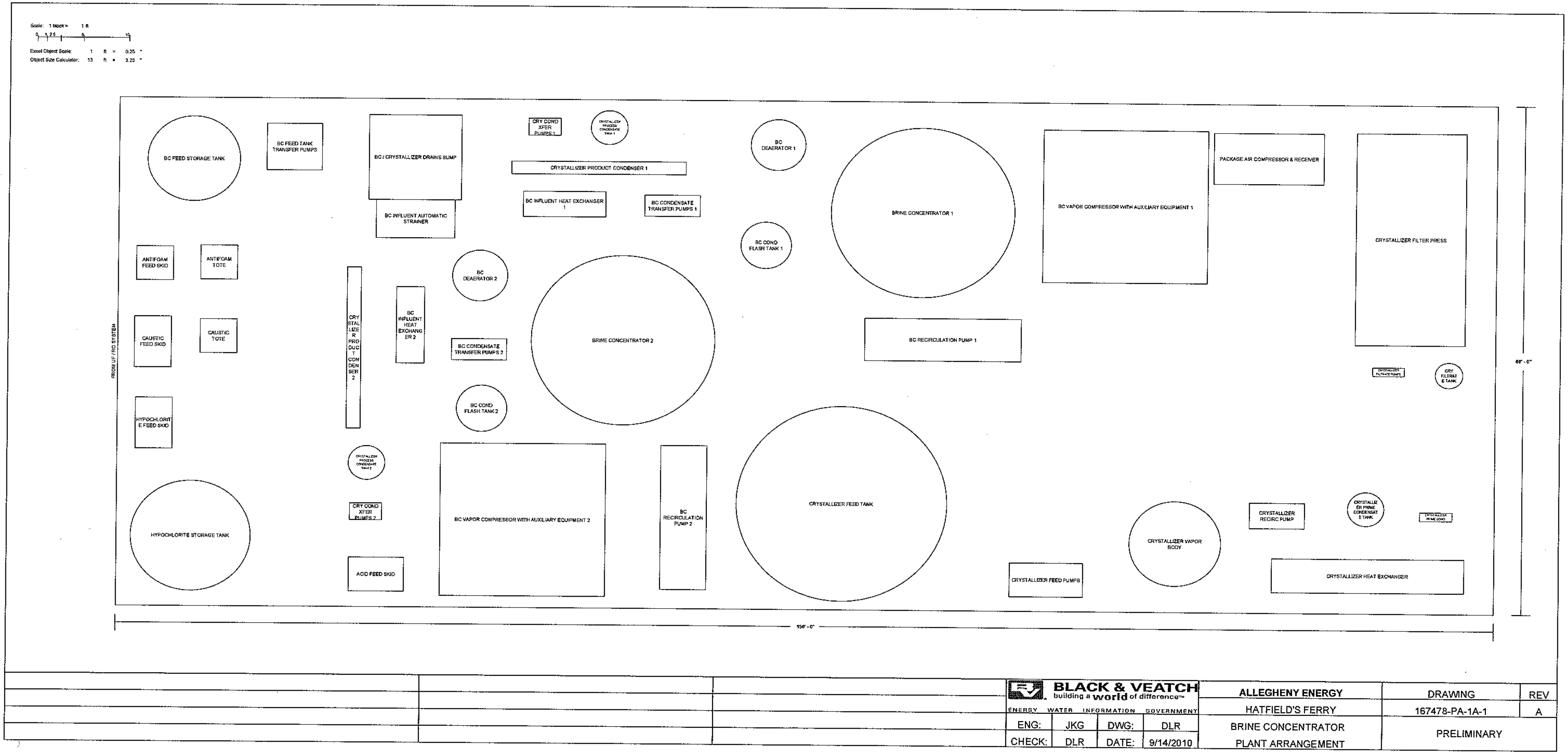

Figure 3-6
Conceptual Layout

In order to power this treatment system, new 6.9 kV feeds would have to be installed from the auxiliary power system in the main power block. Additional load studies or reviews are required to verify the adequacy of existing systems to support this approach. Secondary unit substations (SUS), motor control centers (MCC), power panels, etc. would have to be provided to condition the load and distribute power to the equipment. The new treatment system would be controlled by a programmable logic control (PLC) system located in the new water treatment building.

The new treatment system is anticipated to require at least 36 to 40 months to design, procure, construct, and commission not considering potential permitting and construction delays. Extended delivery times for materials required for the evaporator systems and labor market restrictions could further increase this time period.

A summary of the major equipment that would be required for the system is as follows:

- Wastewater Storage Tank--360,000 gallons
- Softeners—2 x 350 gpm
- Soda Ash Feed System
- Brine Concentrators (BC--2 x 50 percent)
- BC Vapor Compressor
- BC Recirc Pump
- Crystallizer Feed Tank
- Crystallizer--1 x 100 percent
- Crystallizer Recirc Pump
- Crystallizer Vapor Compressor
- Crystallizer Heater
- Dewatering Equipment--Belt Press
- Electric Startup Boiler
- Ultrafiltration System with associated backwash and chemical feed equipment
- Reverse Osmosis System
- Wastewater Treatment Building
- Secondary Unit Substations
- Motor Control Centers
- Programmable Logic Control

4.0 Evaporator System Cost Development

For this Report, conceptual project costs and yearly operating costs (+/- 30%) were determined. The project costs including the site development, the purchase of equipment and supporting facilities necessary to achieve the desired discharge concentration limits, the construction and commissioning of this equipment, and the associated indirect costs were determined based on a factored cost estimate. The operating costs including chemical costs, labor, electrical demand, and hauling solids to landfill were determined based on operation of the equipment and the associated operating cost component. The following is a brief summary of the cost estimate approach.

4.1 Project Costs

The following is a brief summary of major factors in the project cost.

- Major Equipment Cost. Cost for major equipment/systems was obtained from estimates provided by system suppliers. This includes the mechanical evaporator system..
- Miscellaneous Balance of Plant Equipment. Equipment such as tanks, pumps, the UF/RO system, electrical gear, buildings, etc required to support the major equipment operation was estimated from Black & Veatch database of pricing information.
- Construction Cost. The construction cost for the project was estimated by Black & Veatch based on local rates provided by AE and appropriate productivity factors.
- Indirect Cost. Indirect costs include engineering, construction management, insurance, fees, contingency, etc. This cost is based on a percentage of the direct equipment cost.

4.2 Annual Operating Costs

Annual operating costs are the costs which will continue to affect AE after the commissioning of the wastewater treatment system discussed herein. The operating costs are based on cost estimates for 2010. The significant operating costs considered in this study are: labor, electrical demand, hauling solids, lime, and other chemicals:

- The labor is based on and additional four full-time equivalents.
- The dewatered solids are expected to be hauled to an off-site landfill. The cost for this disposal has not been included in the current estimate.
- Lime, caustic, acid, antifoam, and antiscalant chemical feeds are required on an ongoing basis. Other chemicals such as sodium hypochlorite, EDTA, citric acid, etc are required periodically for cleaning. The annual cost for these chemicals was estimated based on B&V experience and market prices for chemicals.
- Membrane replacement includes periodic replacement of membranes in the UF and the RO.

- Utility costs for cooling water, power, etc are based on supplies from the existing systems at the Station.
- This estimate does not include the Station's lost net revenue due to the power required to operate the system that cannot be sold or the cost to transport and dispose of solids generated by the treatment process.

4.3 Cost Summary

In my opinion, within a reasonable degree of engineering certainty, this approach has the potential to achieve the proposed TDS and sulfate discharge limitations at Outfall 006. The capital and operating costs are presented in 2010 dollars. Escalation costs have not been included.

The estimate is considered an Order of Magnitude estimate or an AACE Class 5 estimate. Costs may vary by up to 30 percent.

/s/ Michael C. Preston, P.E.
Michael C. Preston, P.E.

Project Chemical Engineer / Section Leader

Industrial Water and Wastewater Treatment for Power Generation, Wastewater Reuse and Zero Liquid Discharge Facilities

Education
Bachelors, Chemical Engineering, University of Missouri – Rolla, 1988

Professional Registration
1994, Kansas, 13157
1998, Texas, 84287
2000, Arizona, 34720

Total Years Experience
23

Joined B&V
1988

Professional Associations
International Desalination Association

Language Capabilities
English

Michael C. Preston has 23 years experience in evaluating and designing water and *wastewater* treatment systems for power plants. His responsibilities have included engineering studies, environmental licensing and compliance support, water balances, conceptual design, detailed design, procurement, and material selection related to power plant industrial water and wastewater treatment systems. He has worked on treatment systems involving desalination, water softening and clarification, heavy metals reduction, filtration, ion exchange, and reverse osmosis systems for high purity steam cycle makeup. As the B&V Energy Chemical Engineering Section Leader, Mr. Preston is also responsible for training, field support, supplier relations, and developing technical standards for a Section of 16 Chemical Engineers.

Representative Project Experience

Warren County Combined Cycle, Dominion Energy, Virginia
2010 - Present
Project Engineer. Responsible for conceptual design and turnkey specifications for water and wastewater systems to support a combined cycle plant located in Virginia.

Holcomb Unit 2, Sunflower Electric Power Corporation, Kansas
2010 – Present
Project Engineer. Responsible for conceptual design and turnkey specifications for water and wastewater systems to support a 900 MW coal fired plant in Kansas.

Afton Station Wastewater Treatment Upgrades, Public Service of New Mexico, New Mexico
2010 – Present
Project Engineer. Responsible for studying and designing upgraded to existing wastewater treatment systems to enhance their functionality.

SHED IGCC Pre-Feed Study, South Heart Energy Development, North Dakota
2009 – 2010
Project Engineer. Responsible for conceptual design of water and wastewater systems to support IGCC pre-feed study and associated cost estimate. This facility was designed to be a zero liquid discharge facility.

Brine Concentrator Replacement Study, NV Energy, Las Vegas, Nevada
2009 - 2010
Project Engineer. Responsible for a study to evaluate the cost of replacing an existing wastewater brine concentrator against other treatment options. Study also considered taking plant wastewater

directly to on-site evaporation ponds for disposal based on future capacity factors for the plant.

Hatfield's Ferry Wastewater Treatment Engineering Study, Allegheny Energy Co, Pittsburgh, PA
2008-Present
Project Manager Responsible for study and cost estimate to support a new wastewater treatment system to reduce TDS and sulfate concentrations in FGD bleed stream from the plant. Study focused on using membranes and brine concentrator crystallizer to treat and reuse plant wastewater.

Fort Martin Wastewater Treatment Engineering Study, Allegheny Energy Co, Pittsburgh, PA
2009-Present
Project Manager Responsible for study and cost estimate to support a new wastewater treatment system to reduce TDS and sulfate concentrations in FGD bleed stream from the plant. Study focused on using membranes and brine concentrator crystallizer to treat and reuse plant wastewater. Subsequently producing specifications for mechanical evaporation systems.

Meramec Station Demineralizer Replacement, AmerenUE, St. Louis, Missouri
2009-Present
Project Engineer. Responsible for the conceptual and detailed design and procurement support for a 600 gpm reverse osmosis with pretreatment and off-site regenerated mixed bed polishing to replace an aging ion exchange demineralizer. New equipment located in a new water treatment building on the existing plant site. Supported cost estimate based on conceptual design used by Client for funding request.

Enid Ammonia Plant UF/RO Addition, Koch Nitrogen Co, Enid, Kansas
2009-Present
Project Manager. Responsible for the design and procurement support for a 1000 gpm ultrafiltration (UF) unit and a 680 gpm reverse osmosis unit. These systems will replace a portion of the existing ion exchange based water treatment systems at the plant. The new system was designed based on recommendations from the Water & Wastewater Management Study performed for the Enid Plant and will reduce the total dissolved solids in the plant discharge as well as minimize chemical use for the water treatment systems.
Water & Wastewater Management Study, Koch Nitrogen Co, Wichita, Kansas
2008-2009
Project Manager. Responsible for the review of the water and wastewater management at four of Koch's ammonia production plants around the Midwest. Responsible for the preparation of the study

including recommendations and cost estimates for improving water and wastewater handling at these facilities.

Sandy Creek Power Station, Sandy Creek Power Partners, Waco, Texas
2007-Present
Project Chemical Engineer. Responsible for design, procurement, construction and startup support of the water/wastewater treatment equipment for a 900 MW ultrasupercritical coal fired power station utilizing treated municipal wastewater as raw water supply. Systems include raw water pretreatment (lime/soda softening) with associated solids handling, reverse osmosis/mixed bed demineralizer, deep bed condensate polishing, chemical dosing equipment for steam cycle and cooling tower, sampling and analysis, aqueous ammonia storage and handling, plant wastewater collection and treatment including heavy metals reduction process for coal pile runoff, on-site sanitary wastewater treatment, and potable water supply.

West Phoenix Water Balance Study, Arizona Public Service, Phoenix, Arizona
2007
Project Engineer. Responsible for the updating of the Station water balance and evaluation of need for new water treatment system. The Station water balance was developed for each individual Unit and for the overall Station water balance.

Ontario Power Generation Emissions Control Study, Ontario, Canada.
2006-2007
Project Chemical Engineer. Support study with conceptual design of a physical/chemical treatment for FGD chloride purge stream wastewater.

Big Stone Unit 2, Big Stone II Co-Owners, Millbank, South Dakota.
2006-Present
Project Chemical Engineer. Responsible for conceptual design of the water/wastewater treatment equipment for a 600 MW ultrasupercritical coal fired power station. Systems include reverse osmosis/mixed bed demineralizer, raw water pretreatment (lime/soda softening), deep bed condensate polishing, chemical dosing equipment, sampling and analysis, anhydrous ammonia storage and handling, plant wastewater collection and treatment (including brine concentrator and evaporation pond), and potable water supply.

JK Spruce 2, City Public Service of San Antonio, San Antonio, Texas.
2006-Present

Project Chemical Engineer. Responsible for design, procurement, construction and startup support for the water/wastewater treatment equipment for a 750 MW coal fired power station. Systems include ion exchange demineralizer, deep bed condensate polishing, chemical dosing equipment, sampling and analysis, aqueous ammonia storage and handling, plant wastewater collection and treatment, potable water supply and sanitary waste collection.

National Institutes of Health Water Management Study; NORESCO; Bethesda, Maryland
2005-2006
Project Chemical Engineer. Responsible for the assessment of potential water savings at the NIH central utilities plant. Reviewed the existing plant operations and water balance and devised method to recover and treat chiller plant cooling tower blowdown and reuse as makeup to existing low pressure boilers in steam plant.

Warrick Power Plant; Alcoa ; Newburgh , Indiana
2004-2005
Project Chemical Engineer. Responsible for conceptual design and cost estimate for a zero liquid discharge FGD bleed stream treatment system to support environmental upgrades at the plant.

Port Westward Generating Project; Portland General Electric; Clatskanie, Oregon
2004-2005
Project Chemical Engineer. Responsible for design, procurement, construction, and startup support for water and wastewater systems for a 400 MW combined cycle power station utilzing high efficiency combustion turbine. Systems include cycle and circulating water chemical feed, aqueous ammonia storage and handling, sampling and analysis, potable water, and wastewater systems.

Beaumont Cogeneration Project; Exxon Mobil; Beaumont, Texas
2003-2004
Project Chemical Engineer. Responsible for design, procurement, construction, and startup support for a 500 MW cogeneration power station. Systems include chemical feed, anhydrous ammonia storage and handling, sampling and analysis, potable water, and wastewater systems.

Stanton Energy Center Demineralization Addition; Orlando Utilities Commission; Orlando, Florida
2003
Chemical Engineer. Responsible for the design, procurement, installation and startup support for a 300 gpm multi-media filter – ion exchange demineralizer addition and 600 gpm brine concentrator crystallizer for wastewater treatment. The filters are utilized to filter secondary treated effluent for use as plant service

(lime / soda / magnesium sulfate softening), wastewater systems, service water, potable water, and cycle makeup and storage. Desert Basin is a zero discharge facility utilizing evaporation ponds. Makeup to the cooling tower is a blend of tertiary treated sewage treatment plant water and canal water from Central Arizona Project. Coordinated preoperational services including chemical cleaning and air blow.

Selected Publications

- *Process Selection for Power Plant ZLD Systems,* International Water Conference, Pittsburgh, Pennsylvania, 2003.
- *Zero Liquid Discharge Best Practices,* Black & Veatch Technology Conference, Overland Park, KS, 2003
- *Desalination,* Black & Veatch Technology Conference, Overland Park, KS, 2004
- *Overview of Desalination Technology,* International Water Conference, Orlando, FL, 2005

References

The following are references that have been reviewed in supporting FirstEnergy in the development of FGD wastewater treatment alternatives.

1. *Wastewater Treatment for FGD Purge Streams*, Paper #33 Presented at MEGA Symposium 2008, August 2008.
2. *Evaluation and Management of the Impact of FGDs on Wastewater,* Paper #105 presented at MEGA Symposium 2008, August 2008.
3. *Steam Electric Power Generating Point Source Category: Final Detailed Study Report,* EPA Document 821-R-09-008.
4. *Treatment Technology Summary for Critical Pollutants of Concern in Power Plant Wastewaters,* Electric Power Research Institute Technical Report Update 1012549, January 2007.
5. *Guidance for Assessing Wastewater Impacts of FGD Scrubbers,* EPRI Technical Manual 1013313, December 2006.
6. *FGD Materials of Construction Selection and Optimization of FGD and Wastewater Treatment System Design,* AIRPOL Symposium, August 2004.
7. *New Low Temperature ZLD Process,* International Water Conference Paper IWC-09-052, October 2009.
8. *ZLD Achieved for the Treatment of FGD Wastewater at Iatan Station,* International Water Conference Paper IWC-09-051, October 2009.
9. *ZLD Systems Installed for ENEL Power Plants in Italy,* International Water Conference Paper IWC-08-33, October 2008.

BCZ

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A PROFESSIONAL CORPORATION

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April 14, 2011

VIA FIRST CLASS MAIL

Bruce M. Herschlag, Esquire
James A. Meade, Esquire
Pennsylvania Department
of Environmental Protection
Southwest Region Office
400 Waterfront Drive
Pittsburgh, PA 15222-4745

VIA FEDERAL EXPRESS OVERNIGHT

Abigail Dillen, Esquire
Staff Attorney
Earthjustice
156 William Street, Suite 800
New York, NY 10038

Re: **Environmental Integrity Project and Citizens Coal Council vs. Pennsylvania Department of Environmental Protection and Allegheny Energy Supply Company, LLC, EHB Dkt. No. 2009-039-R (Consolidated with 2009-006-R)**

Dear Bruce, Jim and Abby:

Pursuant to our agreement regarding exchange of expert reports, enclosed please find the following expert reports, which are being provided on behalf of Allegheny Energy Supply Company, LLC ("Allegheny Energy"):

1. "Expert Report of Gary A. Amendola, P.E."
2. "Expert Report of Michael C. Preston, P.E."

As always, please call me if you have any questions.

Sincerely,

Mark D. Shepard

MDS/msm

Enclosures

cc: David W. Gray, Esq. (w/ encs.)
Donald C. Bluedorn, Esq. (w/o encs.)
Lisa M. Bruderly, Esq. (w/o encs.)