Technical Background Document on the Efficiency and Effectiveness of CKD Landfill Design Elements

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1.0 INTRODUCTION

1.1 Background and Objectives

Section 3001(b)(3)(A)(iii) of the Resource Conservation and Recovery Act (RCRA) excludes cement kiln dust (CKD) from regulation under Subtitle C of RCRA, pending completion of a Report to Congress and a determination by EPA either to promulgate regulations under Subtitle C or that such regulations are unwarranted. EPA completed its Report to Congress in December 1993 (EPA 1993a) and issued its determination on cement kiln dust in February 1995 (60 FR 7366). EPA's February 1995 determination concluded that additional control of CKD is warranted to protect the public from human health risks and to prevent environmental damages resulting from current CKD disposal practices. Citing damages to ground water and health risks from inhalation of airborne CKD and ingestion via food chain pathways, EPA determined that it will use its existing authority under the Clean Air Act, Clean Water Act, and RCRA to address potential contaminant releases from CKD (EPA 1995).

As part of development of the proposed regulations for CKD, EPA recognized a need to better design and operate CKD landfills. This technical background document (TBD) presents an evaluation of the landfill design elements being considered by EPA for inclusion in the proposed rule. This TBD is organized into six sections. Section 1 identifies the objectives and methodology of this TBD; Section 2 provides a justification for using fly ash landfills as a surrogate for CKD landfills in this evaluation; Section 3 identifies the landfill design elements which are being evaluated and describes EPA's proposed standards for CKD landfill design; Section 4 discusses how the coal ash landfills were identified for further study and describes the characteristics and enviromental settings of the fly ash landfills selected for this study; Section 5 presents the results of the landfill design element analysis; and Section 6 summarizes the findings and conclusions. A list of references cited is provided at the end of the report.

1.2 Approach/Methodology

EPA is proposing CKD landfill design and operating criteria to include fugitive dust controls, surface water controls, and ground-water controls (e.g., bottom liners, final covers, and ground-water monitoring). These criteria were established after considering the results of risk analyses, damage cases, engineering evaluations, modeling, and regulatory analyses (EPA 1997). To supplement previous analyses, EPA initiated a study to assess the efficiency and effectiveness of the proposed CKD landfill design elements used at actual facilities

There are no CKD landfills have been identified with sufficient data for evaluation of the actual performance of the proposed landfill design standards. However, there are many utility coal ash landfills which have been designed to standards similar those under consideration by EPA. As discussed in Section 2, coal fly ash has many physical and chemical similarities to CKD, including an abundance of fine grained particles, relatively low permeability, and elevated levels of toxic metals (e.g., barium, chromium, nickel, and selenium). Therefore, EPA selected to study several coal ash landfills which had incoporated one or more of the landfill design elements considered in the proposed CKD rule. It is noted that other coal utility wastes are often landfilled with the fly ash including coarser grained coal bottom ash, flue gas desulfurization (FGD) scrubber sludge (which contains high concentrations of calcium sulfate, calcium sulfite and fly ash), and heavy minerals (referred to as pyrites) recovered from washing of crushed coal prior to burning.

Five coal ash landfills associated with four power plants in Pennsylvania were selected to be studied by EPA in this TBD. Data on the characteristics and performance of the designs used at these landfills were collected during regulatory file reviews and conversations with regulators familiar with these sites. EPA then evaluated these data with respect to the proposed standards being considered for CKD waste sites to determine the expected performance of the proposed CKD landfill standards.

2.0 BASIS FOR COMPARING FLY ASH LANDFILLS TO PROPOSED CKD LANDFILL DESIGN ELEMENTS

This chapter addresses how coal ash is generated and managed, compares the physical and chemical properties of coal ash to CKD, and establishes a basis for comparing coal ash landfills to CKD landfill design elements under consideration by EPA for CKD landfills.

Coal-fired utility power plants produce a number of waste by-products in large quantities during the combustion process. These by-products include fly ash, bottom ash, boiler slag, flue gas desulfurization (FGD) sludge, and several low volume waste streams formed during maintenance and water purification processes. Fly ash refers to the small ash particles carried out of a plant boiler with flue (exhaust) gases. Unmelted, larger ash particles that settle to the bottom of the boiler are termed bottom ash. Bottom slag forms when ash particles melt, and FGD sludge is generated by the removal of sulfur dioxide from boiler flue gases. The information in this section is summarized from EPA’s (1988) Report to Congress - Wastes from the Combustion of Coal by Electric Utility Power Plants (except as otherwise noted).

2.1 Coal Ash Waste Generation

The type of coal used and the boiler furnace design determine the characteristics of the ash that is generated. Most power plants use pulverizers because this allows burning of a wide variety of coal. Dry-bottom and wet-bottom pulverisers reduce the coal to a fine grained consistency before burning. The resulting small grain sizes are easily removed by flue gases producing relatively large proportions of fly ash and some bottom slag. Cyclone-fired boilers burn larger-grained coal particles which yield primarily bottom slag and small quantities of fly ash. Relatively low proportions of fly ash and bottom ash are also generated by older and smaller power plants utilizing stoker-type boilers.

2.2 Coal Ash Waste Management

Coal combustion wastes may be managed in impoundments, landfills, mines and quarries or other facilities. As shown in Table 2-1, approximately 45% of all the coal ash disposal units in the United States are landfills.

Surface impoundments or wet ponds allow the solids contained in coal ash slurries and sludges to settle and accumulate at the bottom of the ponds. One pond or a series of sedimentation ponds may be used to treat the wastes. Each pond may cover up to several hundred acres and initial depths may range from 10 to 100 feet. The accumulated solids are often dredged and taken to alternative disposal sites such as landfills.

Table 2-1 Estimated Coal Ash Disposal Unit Types by U.S. Census Region

Census Region	Surface Impoundments	Landfills	Minefills	Waste Pile	Total
New England	1	7	0	0	8
Mid Atlantic	15	34	2	0	51
South Atlantic	76	35	2	0	113
East North Central	93	73	2	0	168
East South Central	44	14	0	0	58
West North Central	59	45	8	0	112
West South Central	16	24	2	0	42
Mountain	17	40	5	0	62
Pacific	0	1	1	2	4
Total	321	273	22	2	618

Source: ICF 1993

Fly ash, bottom ash and FGD sludge collected directly from power plants or dredged from surface impoundments currently are often disposed of in non-hazardous waste landfills. If a landfill is large, it may be divided into cells that may be up to several hundred square feet in size. Waste is deposited in 1 to 10 foot deep layers and covered with six inches to several feet of soil. When cells are full, access roads between them are usually converted to containment walls. Several layers of cells, known as lifts, may be vertically stacked until the site is filled. Potential dust problems are mitigated by sprinkling water on waste and soils during disposal operations.

Abandoned mines and quarries are sometimes used as disposal sites for ash and FGD sludge. Wastes may be dumped into mine shafts or carefully placed to backfill excavated areas in the mine. At strip-mined areas, landfill placement techniques may be applied. Utility wastes, especially those with low pH values, have occasionally been disposed of in quarries. Limestone quarries are preferred for their buffering capacity, but use of such sites requires individual evaluation.

Old utility ash landfills and surface impoundments are generally simple, unlined systems. After 1975, over 40% of all generating units managed their wastes in lined facilities using one or more layers of low permeability clays or synthetic liners, or a combination of both. Fly ash has been incorporated in some clay liners since it is cohesive and fairly impermeable when properly compacted. However, variabilities in its chemical composition and changes in its permeability and sheer strength over time limit its use.

Besides the use of liners, waste management facilities may install leachate collection and ground-water monitoring systems, pre-treat wastes before disposal, and dewater the sludge to improve ease of handling and obtain the consistency suitable for landfill disposal.

2.3 Physical Characteristics of Ash and CKD

Representative ranges of values for the physical characteristics of coal combustion wastes (fly ash, and bottom ash/boiler slag), and waste CKD are presented in Table 2-2. A comparison of these two types of wastes indicates that their geotechnical properties are generally similar. Particle size distributions are dependant on waste generation processes. However, most fly ash particles range from 0.001 to 0.1 mm in diameter, and for CKD, about 55 per cent measures less than 0.03 mm (EPA 1993a). Pebble and smaller sized, uncalcined rock fragments of the raw materials used to make cement form a minor component of CKD. Data from tests performed on CKD samples used to design a final landfill cover (Dames & Moore 1996) indicate that CKD compressibility and dry density values are lower than the overall ranges for ash and boiler slag wastes. Although the ranges in permeability values for ash and CKD reflect the differences in grain sizes from site to site, CKD permeabilities appear to be very similar to that of fly ash. Slope stability parameters used to evaluate final CKD landfill covers (Dames & Moore 1996) also fall within the representative range for fly ash. It is noted that wet FGD scrubber sludge consists primarily of 0.001 to 0.05 mm sized particles, has a permeability of 10^{-6} to 10^{-4} cm/s, and an unconfined compressive strength ranging from 0 (wet) to 1600 (dry) psi.

2.4 Chemical Characteristics of Ash and CKD

The chemical composition of coal ash is related to the type of coal burned, pre-combustion coal preparation and boiler operating conditions. The composition of CKD is also dependant on how it is generated, but significant variability is possible even between kilns with relatively minor processing differences (EPA 1993a).

Bulk constituents found in both coal ash and CKD (that is, constituents that exceed 0.05 per cent by weight in the sampled material) are similar and include aluminum, calcium, iron, magnesium, potassium, silicon, sodium, and titanium. In addition, CKD bulk constituents include manganese, sulfur, and chloride (EPA 1993a). At individual ash disposal landfills, environmentally significant sulfur concentrations may be derived from co-disposal of pyrites (i.e., iron sulfide) with coal ash (EPA 1993b).

Table 2-2 Physical Characteristics of Fly Ash, Bottom Ash/Boiler Slag and CKD

Physical Characteristics	Fly Ash [a]	Bottom Ash/ Boiler Slag [a]	CKD
Particle Size (mm)	0.001-0.1	0.1 - 10	0.001 - >0.05[b]
Compaction Behavior:			
Compressibility (%)	1.8	1.4	0.25 - 0.4 [c]
Dry Density (lbs/ft^3)	80 - 90	80 - 90	35 - 65 [c]
Permeability (cm/s)	10^{-6} - 10^{-4}	10^{-3} - 10^{-1}	10^{-6} - 1.5 x 10^{-3} [b]
Slope Stability Parameters			
Cohesion (psi)	0 - 170	0	3 - 28 [c]
Angle of Internal Friction (°)	25 - 45	25 - 45	25 [c]

[a] From EPA 1988

[b] From EPA 1993a

[c] From Dames & Moore 1996. Note: CKD angle of internal friction was assumed to be 25° for closure design of a CKD landfill. All other values were laboratory measurements based upon ASTM procedures.

Representative ranges and median trace element concentrations for coal ash from three regions of the United States and for CKD are presented in Table 2-3. The data reveal that median concentrations of arsenic, barium, chromium, nickel and vanadium are lower in CKD than in coal ash, but medians generally lie within the range of concentrations found in coal ash. Cadmium, lead, selenium, and silver median concentrations are higher for CKD than for coal ash. Median concentrations of mercury and thallium in CKD are within the median ranges for coal ash, but the maximum values for mercury and thallium found in CKD exceed the coal ash maximum values.

EPA's review of leachablity tests on CKD, coal fly ash, coal bottom ash, and FGD sludge found few instances where the leachate from these wastes exceeded characteristic criteria for hazardous waste (40 CFR 261.24). EPA's review of results from Toxicity Characteristic Leaching Procedure (TCLP) analyses on CKD samples concluded that trace metal constituents rarely exceed RCRA toxicity limits (EPA 1995). TCLP analysis of 12 fly ash, 13 bottom ash, and 13 FDG sludge samples found no results above the RCRA toxicity limits. Extraction Procedure (EP) analyses found that 2 out of 78 fly ash samples exceeded the RCRA toxicity limits for arsenic or chromium (by a factor of 3.3 or 1.7, respectively) and 1 out of 25 FGD sludge samples exceeded the RCRA toxicity limit for cadmium (by a factor of 1.5) (EPA 1993b).

CKD and coal combustion wastes are generally alkaline and have very low concentrations of organic compounds. pH values for CKD leachate range from 6.11 to 12.98 standard units (EPA 1993a), and a study of ash derived from bituminous, sub-bituminous, and lignite coals reports pH values of 8.2, 10.8 and 9.2 standard units, respectively (Adriano et al. 1980). Pyrites from coal washing is sometimes co-managed with coal ash and can generate significant quantities of acid if pyrite is stored in a wet oxidizing environment. Pyrite oxidation is a major source of acid mine drainage often encountered near old coal mines. Thus landfill leachate associated with pyrite co-disposal may be acidic.

Table 2-3. Trace Metal Concentrations In Ash From Three Geographic Sources Compared to Generated CKD

Element	Eastern Coal Ash[a]		Midwestern Coal Ash[a]		Western Coal Ash [a]		CKD [b]	
	Range	Median	Range	Median	Range	Median	Range	Median
Antimony	-	-	-	-	-	-	1.77-27.2	6.2
Arsenic	2-279	75	0.5-179	54	1.3-129	18	2.1-20.3	4.9
Barium	52-2200	892	300-4300	905	300-5789	2700	11-779	103
Beryllium	-	-	-	-	-	-	0.158-1.6	0.59
Boron	10-580	121	10-1300	870	41.9-1040	311	-	-
Cadmium	0.1-8.24	1.59	0.5-18	2.6	0.1-14.3	1.01	0.89-80.7	4.6
Chromium	34-437	165	70-395	172	3.4-265	45	11.5-81.7	18.1
Cobalt	6.22-79	40.6	19-70	35.7	4.9-69	13	-	-
Copper	3.7-349	136	20-330	125	29-340	74.8	-	-
Fluorine	0.4-89	8.8	3.2-300	75	0.4-320	50.1	-	-
Lead	1.3-222	18	3-252	149	0.4-250	26.1	5.1-1490	287
Manganese	79-430	190	194-700	410	56.7-769	194	-	-
Mercury	0.02-4.2	0.192	0.005-0.3	0.044	0.005-2.5	0.067	0.005-14.4	0.11
Molybdenum	0.84-51	15	7-70	43	1.4-100	12	-	-
Nickel	6.6-258	78	26-253	121	1.8-229	38	6.9-39	15.9
Selenium	0.36-19	8.05	0.08-19	7	0.13-19	4.1	2.5-109	11.3
Silver	0.25-8	0.695	0.1-1.2	0.39	0.04-6	0.26	1.1-22.6	3.7
Strontium	59-2901	801	30-2240	423	931-3855	2300	-	-
Thallium	7-28	25	2-42	16	0.1-3.5	1.06	0.99-108	3.5
Vanadium	110-551	269	100-570	270	11.9-340	94	6.6-204	25.9
Zinc	16-1420	163	20-2300	600	4-854	71	-	-

All values are in milligrams/kilogram. Coal ash concentrations include both fly and bottom ash.

[a] From EPA 1988

[b] From EPA 1993a

"-" indicates concentration not reported.

3.0 PROPOSED OPERATING CRITERIA AND DEFAULT TECHNICAL STANDARDS FOR CKD LANDFILL DESIGN

This chapter summarizes the default technical standards for CKD landfills currently under consideration by EPA for inclusion in the proposed rule.

The proposed operating criteria include:

- Fugitive dust controls,
- Temporary cap or daily cover,
- Ground water monitoring and corrective action,
- Storm water run-on/run-off controls surface water requirements, and
- Landfill closure and post-closure requirements.

Standards for ground-water protection include:

- For units overlying karst aquifers, CKD landfills must have a composite bottom liner with a leachate collection system.
- For units in non-karst areas, the design must meet the performance standard. The performance standard will be no exceedance of ground-water protection standards (e.g., Maximum Contaminant Levels (MCLs) or other health based numbers (HBNs)) at the point of compliance.

In addition, CKD must not be disposed below the natural water table. The proposed standards are described in greater detail in the following sections.

3.1 Fugitive Dust Control

Uncontrolled fugitive dust emissions are known to be problematic at many CKD disposal sites due to the fine grained nature of CKD. In EPA's "Regulatory Determination on Cement Kiln Dust" (EPA 1995a), a total of 36 cases involving documented damage to air from CKD waste were identified. EPA is considering two standards for controlling fugitive dust at CKD waste units based on RCRA Subtitle C regulations:

> (1) Subpart N -- Landfills state that the facility owner must cover or otherwise manage the landfill to control wind dispersal (40 CFR 264.301(j)).
>
> (2) Subpart DD -- Containment Buildings state that the owner/operator must "take measures to control fugitive dust such that any openings exhibit no visible emissions" (40 CFR 264.1101(c)(1)(iv)).

In addition good waste management practices should be used during collection of the waste at the cement plant and during transportation of the waste to the disposal site. Such practices may include collecting the CKD in silos or hoppers, conditioning the waste (e.g., with water or pressing into pellets) before loading into trucks, covering the waste with tarps during transportation to the disposal site and implementing measures to minimize the potential for CKD waste spillage. It is expected that RCRA Subtitle C, Subpart J -- Tank Systems standards (40 CFR 264.190-199) for negative pressure environments, leak detection and containment controls would not be appropriate for interim storage of CKD waste. Instead, the site operator would be required to implement an effective dust control program tailored to site conditions in order to cost-effectively prevent fugitive dust emissions. At some locations, it may be found that conditioning the CKD with water, compacting the CKD during disposal, and spraying the loading area, haul roads and disposal area with water, on an as-needed basis, could effectively control fugitive dust emissions. Covering inactive areas of the landfill with soil or a dust suppressant may be appropriate if longer term fugitive dust control methods are warranted.

3.2 Temporary Cap/Cover Material Requirements

A temporary or interim cover can protect buried CKD waste from erosion due to storm water run-off, mitigate infiltration of storm water into the CKD pile, and help control fugitive dust emissions. EPA is proposing that if the CKD waste is not conditioned (pelletized, wetted, slurried, solidified, etc.) prior to disposal, a daily cover will be required for but 60 meters (200 feet) of the active face of the landfill. This is similar to RCRA Subtitle D standards which state that the operator must cover the waste with at least 6 inches of earthen materials unless demonstrated that an alternative material or alternative thickness can control fugitive dust emissions with out presenting a threat to human health or the environment (40 CFR 258.21). It is recognized that many of the reasons for requiring a soil cover at municipal landfills do not apply to CKD landfills (e.g., control of scavenging, disease vectors, fires, and odors).

3.3 Run-On/Run-Off Controls and Surface Water Requirements

To prevent off-site migration of CKD constituents during storm events, the CKD disposal unit must be designed to collect and treat storm water run-off which is generated from the active portions of the landfill. In addition, the unit must be protected from flooding due to storm water run-on from upgradient areas. As stated in EPA’s Regulatory Determination on CKD (EPA 1995), existing authorities under the Clean Water Act are considered to be adequate to protect surface waters. It is assumed that CKD rule-making standards will be similiar to the RCRA Subtitle D standards for landfill run-on/run-off controls and surface water requirements (See 40 CFR 258.26 and 258.27). These regulations require that Subtitle D landfills must be designed to accommodate storm water run-off associated with the 24-hour storm which occurs with a frequency of once every 25 years (i.e., 25-year storm). These landfills must be designed to prevent landfill slope failures or failure of the storm water run-off collection and treatment system due to the 25-year storm. Surface water run-off from active areas of a CKD landfill is likely to contain heavy loads of suspended particles, a high pH, and CKD waste constituents. Storm water run-off treatment systems at CKD disposal sites would be required to obtain and operate under a National Pollutant Discharge Elimination System (NPDES) permit if this water is expected to be discharged to off-site surface waters (40 CFR 258.27 (a)). In addition, EPA is proposing that Subtitle C location restrictions for 100-year flood plains (40 CFR 264.18 (b)) should be applied to CKD waste management units.

3.4 Bottom Liner Requirements for New or Laterally Expanding CKD Landfills

EPA's proposed bottom liner standards for design and operation of new or laterally expanding CKD landfills include a performance standard and a technical design standard for CKD landfills located over karst aquifers. Because of the high potential for CKD landfill leakage to cause ground-water degradation in karst aquifers, EPA considers the Subtitle D default technical design standard to be appropriate for CKD landfills in karstic areas. In non-karstic areas, where risk to ground-water resources are less, a performance-based landfill design is considered appropriate.

3.4.1 Default Technical Standard for Units in Karst Areas (Composite Liner and Leachate Collection System)

After evaluating the performance of a range of landfill design configurations, EPA concluded that the Subtitle D default design would be adequate to control releases to ground water from CKD landfills located in karstic areas where there is a possibility of CKD leachate entering the aquifer in a relatively undiluted form. The default technical standards for RCRA Subtitle D landfills (i.e., 40 CFR 258.40(a)(2)) specifies the installation of a composite bottom liner (i.e., 0.6 meters (2 feet) of soil with less than 10^{-7} cm/s permeability overlain by a flexible membrane liner) and a leachate collection system (designed so that less than 30 cm (1 foot) of leachate covers the liner). By minimizing net infiltration by means of a Subtitle D default landfill design, there will be a corresponding low potential for ground-water contamination. EPA's modeling of the Subtitle D default technical design predicted a leakage rate of 3×10^{-6} inches/year or less at eight different climate regions in the United States (EPA 1997).

3.4.2 Performance-Based Design for Units in Non-Karstic Areas

The Agency considered a range of options for performance standards for CKD landfills. These options included (1) the "no significant release" performance standards (based on the industry proposal and the performance-based design standards for MSWLFs under Subtitle D) and (2) a "no release" performance standards based on the approach used under Subtitle C for hazardous waste landfills. After evaluating a range of possible performance standards and considering the need for a tailored and flexible approach for the protection of ground water, the Agency is proposing a performance-based design standard that is based on the RCRA Subtitle D performance standard found in 40 CFR 258.40(a)(1):

> The design of a cement kiln dust landfill must ensure that there will be no exceedence of EPA's maximum contaminant levels (MCLs) for drinking water and/or other health based numbers (HBNs) for arsenic, antimony, barium, beryllium, cadmium, chromium, lead, mercury, nickel, selenium, silver, and thallium in the uppermost aquifer at the relevant point of compliance (POC).
>
> The relevant POC shall be no more than 150 meters (500 feet) from the waste management unit boundary and shall be located on land owned by the owner of the cement kiln dust landfill.

The performance standard will be protective of human health and the environment because it ensures that constituents of concern in ground water will be below MCLs/HBNs, and will be sufficient to prevent releases beyond the facility boundary. Selection of the "no significant release" performance standard is consistent with EPA's intent to develop tailored standards for CKD landfills that are protective of human health and the environment and will ensure flexibility for implementation by States, tribes, and municipalities. EPA's evaluation of potential landfills designs found that site-specific climate conditions are a critical factor in designing to this proposed performance standard. Based on the results of EPA's modeling of landfill designs, the most engineering controls (i.e., the Subtitle D technical default standard) are expected to be required in cold climates with more than 1 meter (40 inches) of precipitation per year. Landfill designs with fewer engineering controls (i.e., a compacted CKD bottom and top layers, vegetated cover, and no leachate collection) are expected to achieve the performance standard at non-karstic sites with about 25 cm (10 inches) or less of precipitation per year (EPA 1997).

3.5 Ground Water Monitoring and Corrective Action

EPA's proposed ground-water monitoring regulations for CKD landfills use the same approach as the RCRA Subtitle D landfill design performance standard (i.e., no exceedence of ground-water protection standards at the points of compliance (40 CFR 258.40(a)(1)) and Subtitle D ground-water monitoring regulations (40 CFR 258.50-258.55). Points of compliance used to enforce these standards are typically monitoring wells at the unit's property boundary or up to a point 150 meters (500 feet) from the landfill. EPA is proposing that ground-water detection monitoring would include analysis of pH, conductivity, total dissolved solids (TDS), potassium, chloride, sodium, and sulfate and assessment monitoring would only include toxic metals (i.e., no organic compounds). Statistical techniques for identification of potential releases to ground water will be based on methods specified in 40 CFR 258.53(g) and 40 CFR 264.97. Ground-water monitoring requirements may be suspended if the owner can prove that there is no potential for migration of hazardous constituents into the uppermost aquifer. The corrective action program for CKD landfills will be based on the RCRA Subtitle D approach found at 40 CFR 258.56-58.

EPA is proposing that new, detailed site characterization standards should be used for CKD landfills in karst areas including:

- Characterization of site hydrology (i.e., identification of: site hydraulic and geologic features; subsurface strata; recharge and discharge conditions; variability in flow directions and rates; variability in flow system due to seasonal, tidal, and nearby human influences; and those additional conditions that render the location hydraulically complex).

- Identification of the uppermost aquifer and aquifer hydraulically interconnected beneath and contiguous to the facility property, and evaluation of the potential for contaminant migration into the aquifers.

- Use of a ground-water flow net (or equivalent hydrogeological model), constructed from data collected on a local scale, that identifies the rate and direction of ground-water flow within the aquifers.

- Use of the ground-water flow net to identify the placement and position of ground-water monitoring wells to ensure compliance with the RCRA Subtitle D ground-water monitoring requirements.

3.6 Closure and Post-Closure Requirements

EPA's proposed standards for landfill closure and post-closure requirements use the same approach as the RCRA Subtitle D standards (40 CFR 258.60-61). These regulations require that, in order to close a landfill, the owner must install a final cover system that is designed to minimize infiltration and erosion. The cover must have a permeability less than or equal to the bottom liner or natural subsoils or have a permeability no greater than 10^{-5} cm/sec, whichever is less. The cover must minimize infiltration by using an infiltration layer that contains at least 18 inches of earthen material. The cover must minimize erosion by using an erosion layer that contains at least 6 inches of earthen material that is capable of sustaining native plant growth. An alternative landfill final cover design may be approved as long as it provides an equivalent degree of infiltration and erosion protection. A 30-year post-closure monitoring period would be required.

4.0 COAL ASH LANDFILLS SELECTED FOR STUDY

4.1 Ash Landfill Identification and Screening Methodology

This section discusses how utility coal ash landfills were identified and screened for study in this TBD. In a preparatory report for this TBD entitled "Identification of Candidate Landfills for Further Study", ten landfills were identified as having several of the landfill design/operation elements identified in Section 3 (SAIC 1997). Information was collected from the Utility Data Institute's (UDI) power statistic database for the year 1994 on utility coal ash generation rates and disposal practices and from telephone conversations with state regulators in Pennsylvania, Texas and Colorado on the availability of landfill engineering designs and performance data for landfills listed in the UDI database. A total of 32 utility fly ash landfills were identified in Pennsylvania, Texas and Colorado from the UDI database. In addition, documented environmental damages from coal ash landfills, as presented in EPA's "Supplemental Analysis on Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste" (EPA 1993b), were used to screen candidate landfills for further study. From this information, ten candidate landfills were recommended for consideration for further study including seven landfills in Pennsylvania, two landfills in Texas, and one facility in Maryland.

4.2 Candidate Landfills Selected for Further Study

Of the ten candidate sites recommended for consideration in Section 4.1, EPA selected four of the Pennsylvania facilities and the ash disposal site in Maryland for study. The Maryland site was subsequently dropped from this study. It was found that since the 1980's, the State of Maryland has exempted pozzolanic waste disposal (including coal ash) from regulatory oversight. As a result, the State does not have any information on the waste disposal practices or landfill design for this site.

Regulatory files on waste disposal, landfill leachate/run-off treatment, and air emissions for the four selected Pennsylvania facilities were reviewed in PDEP regional offices in April 1997. Table 4-1 presents a summary of the proposed CKD landfill design elements found at the four facilities studied in this TBD. Two ash landfills (i.e., Ash Storage Area 2 and Ash Storage Area 3) have been permitted at the Montour Steam Electric Station. At the other three Pennsylvania facilities (i.e., Conemaugh, Shawville, and Titus power plants), the ash landfills have been expanded in phases and have been issued several major and minor Solid Waste Permit Modifications over time.

Table 4-1 Landfills Selected for Study with Summary of CKD Landfill Design Elements.

Coal Utility Plant Name, State	1994 Waste Ash Disposed (1000 tons)	Landfill Design Elements Present at Landfills					
		Bottom Liner	Fugitive Dust Controls	Surface Water Controls(1)	Ground-Water Monitoring	Leachate Collection	Final Cap
Conemaugh, PA	437.9 fly ash/ 98.5 Bottom ash	Stage I - compacted subbase; Stage II composite - liner	No interim cover required/ spray water as needed/ ash mixed with FGD waste	Yes	Yes	Yes	6 inches of borrow soil mixed with 6 inches of fly ash on top/2 ft soil on sides
Area 2 Montour, PA	0 - Area 2 closed in 1989	Compacted clay or PVC liner	Ash conditioned /spray water as needed	Yes	Yes	Yes	1 ft clay soil
Area 3 Montour, PA	126.8 fly ash (most ash is sold)	PVC liner	Ash conditioned /spray water as needed	Yes	Yes	Yes	None installed yet (2 ft clay soil cap in permit)
Shawville, PA	165.7 fly ash/ 29.5 bottom ash	Pre-1992 - unlined; Stage I/II composite liner	Cover if area not used within one week/ spray water as needed/ ash conditioned	Yes	Yes	Yes	Soil cover applied over inactive areas
Titus, PA	57.6 fly ash/ 8 bottom ash (some sold)	1978-91 - clay lined; post-1991 - PVC liner	Ash conditioned /spray water as needed/ wind screen	Yes	Yes	Yes, after 1982	Currently use one ft clay cap

(1) Surface water control criteria are based on designing for a 25-year, 24-hour storm event.

4.3 Environmental Setting and Engineering Characteristics of Selected Landfills

The locations of the four selected landfill study sites are shown in Figure 1 (see Appendix A). The climate of Pennsylvania is considered to be of a humid, continental type. Average annual precipitation from 1960-1990 at the four study sites ranges from about 40 inches at Montour, Shawville, and Titus to about 45 inches for Conemaugh. Precipitation is fairly evenly distributed throughout the year. The greatest amounts of precipitation occur in the spring and summer months, while February is the driest month with about 2 inches less than the wettest months (Sterner 1994). All four facilities are located in the Ridge and Valley Province at the northern end of the Appalachian Mountain system with Mesozoic- or Paleozoic-aged bedrock formations present at shallow depths. The engineering characteristics of the selected study sites are summarized in the following subsections.

4.3.1 Conemaugh Ash Disposal Site

The Conemaugh Station is a steam electric generating station located on the Conemaugh River in West Wheatfield Township, Indiana County, Pennsylvania. It first started operations in 1970 and currently has an electric generating capacity of 1700 megawatts (MW). It is owned by the Conemaugh Owners Group which consists of nine utility corporations. Pennsylvania Electric Company (Penelec) was considered to be the plant operator until it was purchased in 1996 by General Public Utilities (GPU) Genco. The ash landfill for the Conemaugh Plant has been permitted since 1974, is currently permitted to use 506 acres (including 72 acres for logistical support) in a relatively small valley about 2 miles north of the plant and has a total permitted disposal capacity of 82,000,000 cubic yards (including future Stage III) (see Figure 2). The landfill has been projected to have to capacity until 2023. The oldest portion of the landfill (Stage I) is located in an former strip mine and is unlined except for a compacted soil subbase. Since 1988, the Stage II portions of the landfill have been lined with a 50-mil PVC bottom liner (GAI 1996).

The landfill accepts mining refuse from nearby deep coal mines, which support the Conemaugh Station; coal ash from Conemaugh Station and Stewart Station, located about 20 miles away; and other nonhazardous, noncombustible wastes generated at the Conemaugh station. The facility’s 1988 Solid Waste Disposal Permit requires deployment of dust controls (e.g., application of water or covering with soil) on an as-needed basis, if fugitive dust is observed to be generated. However no daily/interim cover is used until the final grade is achieved at a final cover is constructed. The 1988 permit requires a two-foot thick soil cover on the final sides of the landfill and specifies that the top two feet of waste consist of fly ash. A permit variance was given for the top cover of the landfill to allow mixing 6 inches of soil with 6 inches of fly ash.

A leachate collection system has been installed through out the disposal site. Acid mine drainage, landfill leachate and storm water run-off are routed to an on-site treatment system for neutralization and removal of iron before discharge to an unnamed tributary of the Conemaugh

River. The landfill waste water treatment system was originally designed to treat up to 1000 gallons/minute of leachate and storm water run-off. However, in the 1980's, this was found to be insufficient. Upgrades to the treatment system were required in the late 1980's due to flow rates above the treatment system design, inadequate pond sludge removal, and exceedences of NPDES discharge limits (Penelec and PaDER 1982 and 1984). Since then, this waste water has been routed to the Conemaugh Station for treatment along with other waste water including flue gas desulfurization (FGD) wastes. Quarterly ground-water monitoring is performed, as a permit condition, at the landfill.

4.3.2 Montour Ash Storage Areas 2 and 3

The Montour Steam Electric Station is located on the Chillisquaque Creek in Derry Township, Montour County, Pennsylvania. It first started producing electricity in 1972, currently has an electric generating capacity of 1500 MW, and is owned by the Pennsylvania Power & Light Company (PP&LC). Operations in Ash Storage Area 2 began in 1982 and lasted until 1989 when ash disposal activities began in Ash Storage Area 3 (see Figure 3). In 1982, fly ash waste management practices changed from sluicing to Ash Basin 1 to pneumatically transporting fly ash to silos for temporary storage. The fly ash is then conditioned with water and either sold off-site for beneficial uses or disposed of on-site. Montour is able to sell most of the fly and bottom ash that is generated, primarily as light weight construction fill. Ash Storage Area 2 is permitted to cover 34 acres and is lined either with 20-mil PVC (where depth to ground water is less than 2 feet) or with two feet of clay soil with a maximum permeability of 10^{-7} cm/s. Ash Storage Area 3 is permitted to cover 64 acres and is underlain by a 30-mil PVC bottom liner.

The conditioned fly ash is compacted to a minimum of 90 percent of Standard Proctor (ASTM D698) maximum density with a smooth wheel vibratory roller during disposal. Fly ash surfaces that are completed but not at final grade are sprayed with water or a dust control agent or covered with bottom ash if the ash surface begins to dust (PP&LC 1981). Permit conditions require a one-foot thick final clay cover for Ash Storage Area 2 and a two-foot thick final clay cover for Ash Storage Area 3. Storm water run-off and landfill leachate is collected in surge ponds adjacent to the landfills, routed to the plant’s Miscellaneous Plant Waste Basin for treatment with other plant waste waters and discharged under a NPDES permit. Ground-water monitoring has identified some evidence of downgradient contamination, although background concentrations of these constituents exceed drinking water standards (EPA 1993b).

4.3.3 Shawville Ash Disposal Site

The Shawville Station is a steam electric generating station located on the West Branch of the Susquehanna River in Bradford Township, Clearfield County, Pennsylvania. It began producing energy in 1954, has a generating capacity of 625 MW, and was owned and operated by Penelec until purchased in 1996 by GPU Genco. The ash disposal site is located about 0.75 mile from the Shawville Station and has been used since the 1960's (see Figure 4). The initial solid waste disposal permit application for this site was rejected in the 1970's due to the presence of acid mine drainage upgradient of the site and the presence of acidic springs underneath the landfill. Under a Consent Order and Agreement, a closure plan for the disposal site was submitted in 1984 with revisions in 1988, 1989, and 1992. Unsuccessful attempts were made to identify and permit an alternative ash disposal site until the late 1980's, when PDEP agreed to construction of a lined landfill over the old landfill. The newer portion of the landfill (Phase I) was issued a Solid Waste Permit in June 1992 and was allowed to built over the old unlined disposal site, provided that the site collects and treats the landfill leachate and acid mine drainage generated at the site. A major permit modification was issued in June 1993 to allow expansion of Phase II under the Phase I permit. Phase III and IV were scheduled to be constructed beginning in 1997 and will use a Class I liner system based on two liners (i.e., a high density polyethylene (HDPE) liner will be installed below the leachate detection system -- not low permeability soil as was used for the Phase I/II design) (GAI 1995).

The permitted disposal area consists of 120 acres including 15 acres for the closed disposal area, 50 acres for the active disposal area, and 55 acres for support activities. The permitted landfill will add an addition 90 feet of ash to the old landfill over an 18-year design life and will provide about 3.39 million cubic yards of disposal capacity. Approximately 217,000 tons of waste per year is disposed at the site and is comprised of fly ash (74%), bottom ash (18%), pyrites (8%) and minor quantities of miscellaneous, noncombustible solid waste. The bottom liner designs of Phase I and later portions of the landfill are based upon using 50 mil HPDE liners with both leachate collection and detection systems. Ash is delivered to the site in a wet state, compacted during disposal and covered with soil on a weekly basis. The landfill has been designed to accommodate run-on/run-off from the 25 year storm. Storm water run-off and leachate is routed to a treatment lagoon and discharged under a NPDES permit (LR Kimball 1992). Quarterly ground-water monitoring is performed, as a permit condition, at the landfill.

4.3.4 Beagle Club Ash Disposal Site/Titus Generating Station

The Titus Generating Station is a steam electric generating plant located on the Schuylkill River in Cumru Township, Berks County, Pennsylvania. It began producing energy in 1951, has a generating capacity of 240 MW, and is operated by Metropolitan Edison Company (Met-Ed)/ GPU Genco. The Beagle Club Ash Disposal Site is located about 1 mile south of the City of Reading, adjacent to Highway 422, and immediately across the Schuylkill River from the Titus Generating Station (see Figure 5). Disposal operations at the Beagle Club Ash Disposal Site began when it was permitted as a new ash disposal site in 1978. Major permit modifications were issued to the facility in 1984 to construct a leachate collection system under new portions of the facility and to install leachate/run-off treatment ponds and in 1991 to install a 50-mil PVC bottom liner under new portions of the facility. Because the 1984 permit prohibited new ash disposal over the old ash fill with out leachate collection, the pre-1984 ash landfill was excavated, stockpiled and then reburied. A leachate collection system was installed under the entire landfill. A minimum 2-foot-thick native clay layer is present under 9 acres of the landfill associated with pre-1991 ash disposal. Since 1991, a 50-mil-thick PVC bottom liner has been used for the remaining 10.7 acres of this landfill. An additional 18 acres has been permitted to provide support for the disposal area including leachate/run-off pond system, soil stockpiles and access roads (CEC 1992).

The Titus Generating Station produces about 44,000 tons per year of fly ash (77%), bottom ash (18%) and sedimentation pond ash (5%) (Gilbert/Commonwealth 1989). Some of the fly and bottom ash is used off-site for beneficial purposes however, most of the ash is disposed of at the Beagle Club Ash Disposal Site. As of January 1994, approximately 452 acre-feet of storage capacity was calculated to be available, which was expected to provide sufficient capacity until the year 2008.

The fly ash generated at the station is collected in hoppers, conditioned with water, trucked to the disposal site, spread in one foot lifts and compacted. Sludge from an ash sedimentation pond associated with the fly ash loading area and bottom ash is periodically removed and disposed at the disposal facility. Fly ash surfaces that are completed but not at final grade are sprayed with water or covered with bottom ash if the ash surface begins to dust. Spraying with dust control agents may be used when ash would be exposed for extended periods (e.g. for station outages). Because of the concern for dusting due to the nearby Highway 422, wind screens were constructed after 1991 to mitigate this hazard. Portions of the landfill, which have been built up to the final grade, have been capped with a one-foot-thick clay layer (maximum permeability is 10^{-7} cm/s) (Gilbert/Commonwealth 1994). Landfill leachate and dirty storm run-off are collected in ponds adjacent to the landfill and discharged under a NPDES permit to the Schuylkill River. Based on analytical results to date, no treatment has been required for this water. Ground-water monitoring has identified evidence of leakage from the landfill including total dissolved solids (TDS) and sulfate in exceedence of secondary drinking water standards.

5.0 EVALUATION OF PROPOSED LANDFILL DESIGN ELEMENTS

Data on the four utility ash sites selected by EPA for study in this TBD were collected from review of regulatory files, conversations with PDEP officials, and from publicly available documents. Note that information was gathered on both of the landfills (Ash Storage Areas 2 and 3) present at the Montour Steam Electric Station. The expected performance of the proposed CKD landfill designs described in Section 3 are evaluated in this section using data on landfill designs and operations as implemented at the four coal utility plants. The following subsections evaluate the performance of fugitive dust controls (Section 5.1), temporary covers (Section 5.2), ground-water monitoring programs (Section 5.3), storm water run-on/run-off controls (Section 5.4), composite bottom liner designs (Section 5.5), alternative bottom liner designs (Section 5.6), and closure and post-closure measures (Section 5.7) used at the fly ash landfills.

5.1 Fugitive Dust Controls

5.1.1 Fugitive Dust Control Technologies Applied At Fly Ash Landfills

The solid waste permits for each of the coal ash landfill sites require that the site control fugitive dust emissions. Fugitive dust control technologies being used at these sites range from spraying disposal area and roads with water on an as needed basis (e.g., at the Conemaugh landfill) to spraying with water as needed, compacting ash conditioned with water during disposal, and installing wind screens (e.g., at the Titus/Beagle Club landfill). There are no ash compaction/placement requirements for the Conemaugh site except for the application/mixing of FGD waste uniformly through out the landfill in layers less than 2 feet thick. The Montour and Shawville ash disposal sites compact ash conditioned with water and spray water on unpaved haul roads and exposed ash surfaces as needed. At the Montour site, a vacuum truck is present on-site to clean up loose ash from paved portion’s of Montour’s haul road. At the Shawville site, a street sweeper is used to clean up the yard around the ash loading area. Operations at these landfills typically focus on disposing ash in one foot lifts in a limited active area of the landfill until a bench is completed and a new bench is started. Landfill benches typically have a top about 3 m (10 feet) wide that slopes slightly (e.g., 3-5°) towards the landfill and are separated from each other by a vertical distance of about 6 m (20 feet).

5.1.2 Effectiveness in Controlling Fugitive Dust Emissions

The effectiveness of the fugitive dust control programs described in Section 5.1.1 for the five landfills are summarized in Table 5-1. The fugitive dust control programs at the Conemaugh, Montour and Shawville sites appear to be effective in mitigating fugitive dust emissions (pers. com. John Hamilton, PDEP 1997 and Mick Planinsek, PDEP 1997). However, during public review of a permit modification to expand the Montour Ash Storage Area 2, the Derry Township

Planning Commission filed a legal complaint against Montour alleging damage to farmland and water resources and cars covered with soot. This complaint was settled with minimal PDEP involvement (Montour County et al., 1986) and it is possible that the source of soot was from the main plant.

Table 5-1 Evaluation of Ash Landfill Fugitive Dust Controls

Ash Landfill	Design	Fugitive Dust Controls Evaluation
Conemaugh	Disposal area sprayed with water as needed and FGD wastes uniformly distributed over ash pile since early 1990's	<u>Generally effective</u> - PDEP inspector reported that dust control program is working well for the most part and that the protected location in a valley and use of better quality ash (i.e., not as prone to dusting compared to other sites) mitigates dust problems which can be a significant issue for ash landfills in the area (pers. com. M. Planinsek, PDEP 1997) - Relatively remote location to populations minimizes concern - A fine of $128 was paid for a fugitive dust summons in 10/87
Montour (Area 2)	Site closed in 1989/same design as Area 3 in 1981-89	<u>Generally effective</u> - Site closed in 1989 and is now well vegetated - A Consent Agreement with the Derry Township was executed in 1986 which included collection of particulate samples to settle a 1984 legal complaint due to soot settling on cars and to farmland damages
Montour (Area 3)	Conditioned ash compacted at disposal site and disposal area sprayed with water	<u>Effective</u> - Inspection reports indicate disposal area was kept moist and no fugitive dust emissions were observed - A truck mounted hydroseeder is required to be on-site at all times as part of the site's operating plan - Relatively remote location to populations minimizes concern (pers. com. John Hamilton, PDEP 1997)

Ash Landfill	Design	Fugitive Dust Controls Evaluation
Shawville	Conditioned ash compacted at disposal site and disposal area sprayed with water	<u>Effective</u> - Inspection reports indicate disposal area is kept moist and no fugitive dust emissions were observed - Relatively remote location to populations minimizes concern (pers. com. John Hamilton, PDEP 1997)
Titus/Beagle Club, pre-1991	Conditioned ash compacted at disposal site and disposal area sprayed with water	<u>Problems with pre-1991 design</u> - A 9/4/91 citation was issued for "excess fugitive dust emissions from ash site roadway" - In response to this citation, the site proposed and installed wind screens along every other bench after 1991 and no fine was assessed
Titus/Beagle Club, post-1991	Conditioned ash compacted at disposal site, disposal area sprayed with water, and wind screens installed	<u>Minor problems with post-1991 design</u> - An 8/16/94 PDEP site inspection found that the water truck broke for one day, however rain occurred to mitigate dusting - A 10/11/96 PDEP site inspection found that the stone access road was "covered with fly ash and needs to be maintained to prevent the migration of ash from lined areas"

There has been some PDEP concern on the effectiveness of dust control at the Titus/Beagle Club site. This issue was raised during PDEP's review of the site's solid waste permit application in 1990 and 1991. The presence of Highway 422 adjacent to the disposal site and the City of Reading within one mile of the site justifies a higher standard for controlling dust emissions than at the other sites. The site proposed and adopted a practice after 1991 of installing wind screens consisting of fabric stretched between telephone poles. The wind screens are about 30 feet high and are constructed on the top of every other bench or terrace. Since 1991, PDEP site inspection have found two instances for concern at the Titus/Beagle Club site when (1) the haul road was covered with fly ash and (2) a review of the operating log indicated that the water truck was broken down for an entire day. These inspections indicate that the site's fugitive dust control program generally has been effective however, the ash and disposal areas must be kept moist. It was noted that ash sometimes piled up against the wind screens at the Titus/Beagle Club site and needed to be covered with soil and/or regrade to prevent ponding. The use of these wind screens appears to have been helpful in controlling fugitive dust emissions (pers. com. Mike Maioli, PDEP 1997).

5.2 Temporary Cap or Daily Cover

5.2.1 Summary of Temporary Cap or Daily Cover Technologies Used At Fly Ash Landfills

As a permit condition, the Shawville site is required to install a temporary cover (i.e., soil or bottom ash) on ash surfaces that are expected to be inactive for a week more. None of the other sites are required to install temporary covers unless unprotected ash surfaces are exposed for six months or more (Section 288.233 of Pennsylvania Residual Waste Regulations). However, they may elect to install a temporary cover as an alternative to spraying with water as needed. As a permit condition, the Montour Ash Storage Area 3 and Shawville landfills are required to inspect the landfill cover and erosion and sediment control structures on a weekly basis and/or after storm events. At each of the sites, the ash waste is typically accumulated in benches until the final grade is achieved and then a final cover is installed soon thereafter. At the Titus/Beagle Club site, the 1989 permit application indicates that bottom ash or dust control agents may be applied when the ash would be exposed for extended periods (e.g. during generating station outages). Very little ash is currently being disposed of at the Montour plant; Ash Storage Area 2 has been closed with a one-foot thick clay cap and no final cover has been installed at Ash Storage Area 3. The maximum final landfill slopes will be 2 horizontal to 1 vertical (2:1) at the Conemaugh and Shawville sites, 2.5:1 at the Titus/Beagle Club site, and 3:1 at the two Montour sites. At each of these sites, the top of the benches are slightly sloped back towards the landfill (e.g., 3-5%) to collect surface water run-off.

5.2.2 Effectiveness of Covers Installed Prior to Site Closure

This Section describes the effectiveness of the covers installed during operation of the five landfills. The main criterion for evaluating these covers is the coverage of waste materials over time for protection against surface water erosion, reduced rainfall infiltration into the landfill, and control of fugitive dust emissions. The effectiveness of these landfill covers are summarized in Table 5-2.

Table 5-2 Evaluation of Ash Landfill Covers

Ash Landfill	Design	Landfill Cover Evaluation
Conemaugh	Final cover over inactive areas	<u>Generally effective</u> - Inspection reports indicate occasional erosion gullies over nine inches deep in disposal area
Montour (Area 2)	Final cover	<u>Generally effective</u> - Except for one corner, landfill is mostly well vegetated (see Section 5.7)

Ash Landfill	Design	Landfill Cover Evaluation
Montour (Area 3)	Fix erosion gullies on an as needed basis	Generally effective - No cover installed because only very small quantities of ash are being disposed of - Inspection reports indicate occasional erosion gullies over nine inches deep in disposal area
Shawville	Final cover over inactive areas and fix erosion gullies on an as needed basis	Generally effective - Inspection reports indicate occasional erosion gullies over nine inches deep in disposal area
Titus	Final cover over inactive areas and fix erosion gullies on an as needed basis	Generally effective - Inspection reports indicate occasional erosion gullies over nine inches deep in disposal area

As discussed in Section 5.2.1, temporary or interim landfill covers appear to be rarely used at the coal ash landfills studied in this TBD. Instead, a final cover is typically installed soon after the waste has accumulated to the final grade and disposal activities have shifted to new area of the landfill.

Gully erosion at the landfill or along the haul road appears to be a perennial issue at all of the study sites. Until final covers become vegetated they appear to be susceptible to erosion. PDEP site inspections at all of these facilities have noted some gullies deeper than 9 inches which is out of compliance with state residual waste regulations (Chapter 288.242 (a)(c)). At the Titus/Beagle Club site, it was noted that gullies (as deep as 2 feet deep) were backfilled with gravel, but new gullies often formed adjacent to the old gullies which have been repaired by backfilling with gravel. In addition, ash and soil which accumulated near the wind screen occasionally caused water to pond on top of the landfill and required periodic repair to restore proper drainage. Until the final slopes are densely vegetated, these coal ash landfills appear to be at risk from erosion. The soil covers installed at the coal ash landfills require continued monitoring and maintenance particularly after large storm events.

There appears to be a trade off between steep landfill side slopes which are prone to some erosion and landfills which cover a large area. In the long run it may be better to repair erosion gullies on landfill slopes until it becomes vegetated than to design landfills which cover and impact a larger area. Therefore, the cover designs were deemed to be effective provided ongoing monitoring and maintenance is performed until the cover is densely vegetated and protected from erosion hazards.

5.3 Ground-Water Monitoring

5.3.1 Summary of Ground-Water Monitoring Practices at Fly Ash Landfills

All of the studied coal ash landfill sites have implemented quarterly ground-water programs in compliance with their landfill permit requirements. At each facility a number of monitoring wells are located both upgradient and downgradient of the permitted landfill. At the Montour, Shawville and Titus/Beagle Club disposal sites, all of the downgradient monitoring wells are located within 140 meters (450 feet) of the downgradient edge of the landfill disposal area. However, at Conemaugh the downgradient wells were placed at a location projected to be near the edge of the landfill in the year 2028, which is over 610 meters (2000 feet) from the current disposal area.

The ground-water systems beneath the Conemaugh and Shawville landfills have been impacted by pre-existing acid mine drainage, complicating interpretation of the ground water monitoring information. The Stage I area of the Conemaugh landfill is located over a former coal strip mine. A coal strip mine is located upgradient of the Shawville landfill and the run and springs downgradient of the landfill were known to be impacted by acidic ground water since 1957 (GAI 1995). Poor-quality ground water, greatly exceeding drinking water standards for TDS and sulfate, is encountered at the Montour site due to oxidation of naturally occurring pyrite in the shale bedrock (PP&LC 1987).

Both the Conemaugh and Shawville sites are currently implementing a detection monitoring program. The Montour landfills have implemented ground-water investigations due to elevated concentrations of waste constituent parameters in the downgradient wells relative to the upgradient wells. The Titus/Beagle Club facility has not changed its ground water monitoring program since 1985 (when the monitoring program was improved to use 4-inch diameter wells and a well which was screen in coal refuse was plugged) even though some ground-water degradation from landfill operations were documented as early as 1989.

The detection monitoring program for the Conemaugh and Shawville sites compare ground-water monitoring results with calculated potential degradation indication levels (PDIL) to evaluate if a landfill release has occurred (GAI 1995 and 1996). PDILs were calculated using the following formula:

$$PDIL = M + (S * K) \qquad \text{(Equation 1)}$$

where:
M = the background mean concentration,
S = standard deviation for the background wells, and
K = statistical number depending on the number of samples collected, range of sampling dates, and percentage of censored values (K was noted to be always over 5) (GAI 1996).

For example, the background data for pH in Conemaugh's well MW-12 consisted of 8 dissolved iron measurements with a mean of 4226.3 ug/L, a standard deviation of 2379.3 and a K multiplier of 5.811. The resulting PDIL is calculated to be 18,052.41 ug/L. No indication of potential ground water contamination was found in the dissolved iron data according to this method unless a downgradient dissolved iron measurement is greater than 18,052.41 ug/L. No PDIL exceedences were noted for any monitored constituents or parameters in the recent Conemaugh and Shawville ground water assessment reports (GAI 1995 and 1996).

PDEP was notified of potential ground-water degradation at the two Montour disposal areas when trend analysis of the monitoring well data indicated rising downgradient concentrations of sulfate, calcium and other constituents in downgradient wells relative to background wells. Elevated downgradient constituents included lab conductivity for the Montour Area 3 and iron, magnesium, manganese, nickel and zinc for the Montour Area 2. The site's criteria for identifying a potential release based on the degree of concentration increases were not specified in the ground-water compliance reports (PP&LC 1987 and 1997). In 1989, PDEP began to be concerned about potential ground water quality degradation near the Titus Beagle Club site, when it was observed that from 1985 to 1988, the concentrations of specific conductance and sulfates rose 300 umhos/cm and 20-200 mg/L, respectively, in downgradient wells relative that of the background well (PaDER 1989).

5.3.2 Effectiveness of Ground Water Monitoring Systems in Detecting Releases From Fly Ash Landfills

In general, the effectiveness of a ground-water monitoring system can be judged considering the following three components: (1) its design (considering the site-specific hydrogeologic setting and the waste characteristics), (2) the constituents being monitored, and (3) statistical techniques used to evaluate the data generated by the system. Evaluation of the monitoring system design includes assessment of the well placement, the length and position of the screened interval, well construction materials, and sources of contamination. Evaluation of the statistical methodology needs to consider the regulatory objectives, the regulatory requirements, and current guidance on methods for the statistical analysis of ground-water monitoring data. The effectiveness of the ground-water monitoring systems described in Section 5.3.1 for the five landfills are summarized in Table 5-3.

Table 5-3 Evaluation of Ash Landfill Ground-Water Monitoring Programs

Ash Landfill	Design	Ground-Water Monitoring Evaluation
Conemaugh	Quarterly ground water monitoring/ data evaluated by Tolerance Interval approach	<u>Ineffective placement of monitoring wells</u> - Downgradient monitoring wells placed about 2000 ft downgradient (south) of active disposal area - No wells were located southeast or southwest of the active disposal area to identify if contaminants could migrate through bedrock into adjacent valleys to the east or west <u>Method used to calculate tolerance interval is not consistent with current EPA guidance</u> - May not indicate a release when a release has occurred
Montour (Area 2)	Quarterly ground water monitoring/ trend analysis and waste trace element comparison	<u>Effective</u> - Elevated concentrations of sulfate, and several metals in downgradient wells triggered a ground water investigation - Evaluation of trace elements in waste constituents and ground water indicate that the landfill did not leak
Montour (Area 3)	Quarterly ground water monitoring/ trend analysis	<u>Effective</u> - Increased concentrations of calcium, sulfate and conductivity were detected in downgradient wells during construction of the landfill and in 1996 following repair of surge pond spillway
Shawville	Quarterly ground water monitoring/ data evaluated by Tolerance Interval approach	<u>Effective placement of monitoring wells</u> - Given preexisting acid mine drainage underneath site - Upgradient wells include a shallow screened well and a deep screened well <u>Method used to calculate tolerance interval is not consistent with current EPA guidance</u> - May not indicate a release when a release has occurred

Ash Landfill	Design	Ground-Water Monitoring Evaluation
Titus	Quarterly ground water monitoring/ Students "t" test (99% confidence)	<u>Effective</u> - Ground water monitoring indicated leakage from landfill - Health based mandatory abatement levels were proposed by the facility because downgradient drinking water level exceedences are based on taste and odor criteria, not health based

In EPA's "Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance" (EPA 1992), recommends a similar approach to evaluating releases from RCRA facilities as that done for the Conemaugh and Shawville sites. However the K multiplier in Equation 1 is much smaller than that used in the Conemaugh and Shawville ground-water assessment report. EPA recommends the K value in Equation 1 be calculated using the following formula:

$$K = t_{(n-1,1-b)}(1 + 1/n)^{½} \qquad \text{(Equation 2)}$$

Where $t_{(n-1,1-b)}$ = (1-b) upper percentile of the t-distribution with (n-1) degrees of freedom (note the t value can be obtained form a Students t distribution table)

1- b = tolerance interval

n = number of samples.

Using this approach, the ground-water detection program implemented for the Conemaugh and Shawville sites appears to be much less protective of ground-water resources than EPA's guidance. For example, the tolerance interval with 95% coverage and a tolerance coefficient of 95% can be calculated using Equations 1 and 2 and the dissolved iron data cited in section 5.3.1 as:

$$K = t_{(n-1,1-b)}(1 + 1/n)^{½} = t_{(7,95\%)}(1 + 1/8)^{½} = 1.895(1.061) = 2.01$$

95% coverage tolerance interval = M + (S * K) = 4226.3 + (2379.3 * 2.01) = 9,009 ug/L

Therefore, using EPA's guidance for RCRA facilities, a release would be suspected and confirmatory resampling of the monitoring well would be recommended, if the downgradient dissolved iron concentration was greater than 9,009 ug/L. The use of a higher K multiplier may have been deemed appropriate for the Conemaugh and Shawville sites due to the known impact on the ground-water system resulting from coal strip mines at these sites. The potential for contaminant migration in bedrock and the 2000-foot distance between active portions of the

Conemaugh landfill and the nearest downgradient monitoring wells have been raised as points of concern by the PDEP (PDEP 1996). It is noted than the proposed CKD standard for locating monitoring is within 150 meters (500 feet) from the landfill.

Potential ground-water degradation downgradient of the Montour Ash Storage Area 2 was identified within one year following commencement of ash disposal activities in 1981. Trace element analysis of the elevated constituents indicated that the elevated concentrations in the downgradient wells was due to oxidation of pyrite in the native bedrock materials and not from waste leachate. Earthwork activities during construction of the landfill reportedly increase the rate of pyrite oxidation in native materials resulting in increased concentrations of sulfate and TDS. Elevated concentrations of indicator trace elements such as lithium, selenium, chromium and boron associated with the fly ash waste were not detected in the ground-water monitoring wells (PP&LC 1987). PDEP is currently evaluating the Montour Ash Disposal Area 3 ground-water monitoring results as part of the site's permit renewal effort. It is unclear if the circa-1996 rise in sulfate and other constituents in downgradient wells is due to landfill leakage or recent leachate/run-off pond repair work as suspected by the site operator (pers. com. John Hamilton, PDEP 1997).

As discussed in the previous section, PDEP noted evidence of landfill leakage at the Titus/Beagle Club Ash Disposal Area during the review of the Fall 1988 quarterly ground water monitoring results. PDEP has raised the issue of remediating contaminated ground water if necessary during the 1989-1991 and 1995-1997 review of the site's solid waste permit modification applications. The site has proposed their own "mandatory abatement trigger levels" (MATL), because only TDS and sulfate have been observed above EPA's Secondary Drinking Water Standards and these standards are based on taste and odor criteria and not health criteria. The site's proposed MATLs are based on EPA's Primary Drinking Water Standards, Pennsylvania Land Recycling Program Technical Guidance Manual (TDS <= 2,500 mg/L), and Human Health Standards listed in the Pennsylvania Code Title 25, whichever is greater (PDEP and GPU-Genco 1996). PDEP has not formally responded to the proposed MATLs and the site has continued to implement the quarterly ground water program required since the 1985 solid waste permit modification (including annual testing of filtered samples for 16 dissolved metals). In a 1992 ground water assessment report for the Titus/Beagle Club Ash Disposal site, alkalinity, bicarbonate, sulfate, and nitrate-nitrogen were identified at increased concentrations in most downgradient wells, relative to background data and using a confidence level of 99% (CEC 1992). The close location of the downgradient monitoring wells to the disposal area has provided an early warning capability for detecting releases to ground water from the disposal area.

5.4 Storm Water Run-On/Run-Off Controls and Surface Water Controls

5.4.1 Storm Water Run-On/Run-Off Controls and Surface Water Controls at Employed At Fly Ash Landfills

As required by Pennsylvania's Clean Stream Law (Act 394) and Residual Waste Regulations (Sections 288.241-243), storm water run-off controls for all of the study landfills were designed to have sufficient capacity to control dirty run-off associated with the 25-year, 24-hour storm events from the unvegetated portions of the landfills. The solid waste permit applications for these facilities provide calculations on the expected 25-year storm run-off quantities and flow velocities. The landfill's erosion and sedimentation control features were designed based on these calculations. Typical engineered features designed to accommodate this run-off include installing hay bails and/or plastic silt fences at the toe of unvegetated slopes, lining diversion ditches with corrugated pipe, concrete or liner (if necessary), installing periodic small sediment trap/clean out basins, and sequenced site development.

At several of these sites, the solid waste permits require inspection of the storm water and erosion control features on a weekly basis and/or after every storm event. For the Conemaugh facility, the 1988 solid waste permit required that a narrative be submitted within 30 days of issuance of the landfill permit which included inspection schedules and maintenance procedures for the storm water management system.

Storm water run-off at theses sites are routed to lined holding/equalization ponds near the ash landfills and then either conveyed to the electric generating stations' waste water treatment systems (as is the case for the Conemaugh, Montour, and Shawville sites) or tested and discharged to surface water under a NPDES permit (as is the case for the Titus/Beagle Club site). Emergency overflow spill ways which have been installed on these ponds and are permitted to release untreated water associated with the 10-year, 24-hour storm (i.e., Conemaugh (pre-1987), Titus, and Montour sites) or storm water run-off/leachate flows exceeding 500 gpm (i.e., Shawville site). According to a 1995 NPDES permit, flow at the Shawville leachate/storm water pump station was estimated to exceed 500 gpm approximately for 8 hours, 1 day/year. In 1987, the Conemaugh waste water treatment system was upgraded under with a new leachate/run-off surge pond to handle two 10-year, 24 hour storm events separated by a 24 hour dry period (135 acre-feet storage capacity) and in approximately 1990 the leachate/run-off water was routed to the FGD thickener for treatment with the FGD wastes. Solids from FGD waste treatment system are disposed in the ash landfill and represent up to 33% of the waste disposed at the landfill.

Contaminated water collected from landfill underdrains (i.e., Conemaugh and Shawville sites) and landfill leachate (at all four sites) are co-managed with the dirty storm water run-off. At the Titus/Beagle Club site, landfill leachate is collected in one pond and then discharged to the dirty storm water pond before being released to the Schuylkill River. In case this water might not met the NPDES discharge limits (i.e., pH between 6 and 9 at all times, and maximum daily, monthly, and/or instantaneous limits for total suspended solids and oil and grease), the site has a contract in place to truck the water off site for treatment. Both ponds are usually drain concurrently for about two to five days/month.

5.4.2 Effectiveness of Storm Water Controls

The effectiveness of the storm water controls described in Section 5.4.1 for the landfill designs are summarized in Table 5-4. Compliance histories and environmental permits for the previous 10 years are required, by the Pennsylvania Residual Waste Regulations (Section 288.283), to be disclosed in the annual operation reports. From these reports, at least 15 NPDES or other permit violations occurred between 1982 and 1996 which are potentially associated with the landfill leachate/run-off treatment systems. Eleven of these instances involved the Conemaugh site and the other four are associated with the Shawville site. Over $100,000 has been paid in fines for these violations, including $60,000 in 1987, under an “Administrative Order for Conemaugh Station involving industrial waste/sewage compliance dates”.

Table 5-4 Evaluation of Ash Landfill Surface Water Run-Off Controls

Ash Landfill	Design	Storm Water Run-Off Evaluation
Conemaugh (pre 1988)	1000 gpm treatment capacity (neutralization/ precipitation of metals)	<u>Under designed leachate/run-off treatment system</u> - Several Notice of Violations due to untreated releases of leachate/run-off from overflow spillway, discharge of iron above NPDES limit, and not removing sludge from treatment ponds in a timely fashion
Conemaugh (post 1988)	Leachate/run-off routed to plant’s high density sludge treatment pond with FGD waste	<u>Better leachate/run-off treatment system</u> - Surge pond capacity greatly increased in 1987 - In 1991, system is capable of treating 1800 gpm without NPDES permit violations - Unclear if 7/94 NPDES permit violations can be attributed to landfill operations
Montour (Area 2 and 3)	Leachate/run-off routed to plant’s waste water treatment system	<u>Effective</u> - No NPDES violations associated with the leachate/run-off ponds - A rip in the leachate/run-off pond liner occurred during pond clean out due to local erosion of bottom ash and protective soil over liner - The Area 2 leachate/dirty run-off pond is located adjacent to the 100-year floodplain.

Ash Landfill	Design	Storm Water Run-Off Evaluation
Shawville	Leachate/run-off routed to plant's waste water treatment system	Unable to determine effectiveness - Four notices of violations (e.g., pH) from plant waste water treatment system (other parts of the plant besides landfill may be responsible for the NOVs) - In 1995, NPDES permit was renewed without any upgrades required
Titus	Leachate pond releases to storm water pond which releases to river (no treatment)	Effective - No NPDES violations associated with the leachate/run-off ponds - Site requests waiver for 4000 mg/L instantaneous maximum and 3000 mg/L monthly average TDS discharge limits (A 1000 mg/L TDS maximum limit was proposed to become effective in 1999) - Site has contract in place to truck waste water off site if unable to meet discharge limits

The leachate/run-off treatment system for the Conemaugh site was designed in the 1970's to treat (i.e., neutralize with lime, settle solids, and precipitate iron) 1000 gpm of acid mine drainage, landfill leachate and storm water run-off. However, in a 1982 Consent Agreement it was noted that on a number of occasions the surge pond was unable to hold the leachate and run-off generated at the landfill. This water overtopped the spillway, by-passed treatment and discharged into an unnamed tributary of the Conemaugh River. After a larger surge pond was installed and the leachate/run-off was routed to be treated with FGD wastes, the site was able to treat and discharge up to 1,800 gpm with out exceeding its NPDES discharge limits. Most of the Conemaugh and Shawville violations were associated with discharge exceeding the NPDES limits (i.e., pH too low and/or iron concentration to high). Landfill cover erosion associated with surface water run-off were evaluated in Section 5.2.2.

The storm water management systems built at the Montour and Titus/Beagle Club landfills appear to be effective and no NPDES permit violations have been noted for these landfill operations. In 1993, an average of 0.01 million gallons/day from Area 2 and 0.093 million gallons/day from Area 3 of the dirty run-off and leachate were routed through the plant's waste water treatment system, which handles a average flow of 3.9 million gallons/day (CH2M Hill 1993). At the Titus/Beagle Club facility, the landfill leachate and storm water discharges to the Schuylkill River have of sufficiently good quality to satisfy NPDES requirements.

5.5 Composite Bottom Liner with Leachate Collection

5.5.1 Use of Composite Liners and Leachate Collection at Fly Ash Landfills

Pennsylvania residual waste regulations require a double bottom liner for industrial Class I wastes which exhibit hazardous waste characteristics (e.g., pyrites). Coal is often milled and washed to remove heavy minerals including pyrite prior to being burned in the power plant. When pyrite is oxidized to ferrous iron and sulfate, acid is often generated by the oxidation of ferrous iron and precipitation of ferric hydroxide. This process is often a source of acid mine drainage and may result in pH levels below 2.5 SU. At the Conemaugh and Shawville sites, the pyrites are disposed of in the ash landfill. PDEP has granted a variance for pyrite disposal at the Shawville site, because of the leachate detection system installed below the bottom liner and because of a requirement to install a double liner system for the Phase III/IV expansions after 1997. PDEP is tentatively allowing pyrite disposal at the Conemaugh site provided that the facility demonstrates that the landfill is not leaking or impacting the underlying ground-water system. PDEP has said that this could be proved at the Conemaugh site by a ground-water assessment rather than an evaluation of liner integrity (Penelec/GPU 1994). Based on typical analytical results, coal fly ash and bottom ash are commonly classified as Class II and Class III wastes, respectively. Class II wastes must be disposed in a unit which has a single bottom liner, while Class III wastes have no bottom liner disposal requirement.

The leachate collection and bottom liner designs of the coal ash landfills studied in this TBD are summarized in Table 5-5. The use of plastic bottom liners, either polyvinyl chloride (PVC) or high density polyethylene (HDPE), has been installed throughout the Montour Ash Storage Area 3 landfill. For the Conemaugh, Shawville and Titus/Beagle Club landfills, plastic liners were installed in only the newer portions of the landfill. At the Montour Ash Storage Area 2, a plastic liner was used only where the depth to ground water was less than 2 feet below the bottom of the waste (otherwise, 2-feet of native clay compacted to a permeability less than 10^{-7} cm/s was used). No minimum permeability criteria for the soil under the plastic liners was established at any of the studied sites. The bottom liners were installed over underdrains at the Conemaugh and Montour storage areas to prevent excessive pore pressure build up below the bottom liner. In the 1992 solid waste permit for the Shawville site, a leachate detection system was required under the bottom liner, consisting of a geonet overlying fly ash subbase compacted to at least 95% of the maximum density and with a minimum bearing capacity of 1.5 tons/ft^2. None of the other sites have installed a leachate detection system below the bottom liner. All of the landfills studied have leachate collection systems installed throughout the landfill. For landfills with plastic liners, the leachate collection systems consist of perforated pipes placed no more than about 200 feet from each other in a bottom ash and/or non-calcareous gravel drainage blanket. At all of the landfills the plastic liners were placed between two geomembrane layers to protect the liner from excessive strain and a geofabic was typically installed over the leachate collection system to prevent clogging. Quality control procedures used during installation of the plastic liners include non-destructive and destructive seam testing, letters from the liner manufacturer stating the compatibility of the liner with the waste material, chemical compatibility tests (EPA Method 9090), and field inspections by an independent inspector.

Table 5-5 Summary of Bottom Liner Design Configurations

Landfill Site	Leachate Collection	Bottom Liner Design	Leachate Detection Below Bottom Liner
Conemaugh Stage I (1974-1988)	Yes	Compacted native soil	No
Conemaugh Stage II (post-1989)	Yes	50-mil PVC	No
Montour Area 2	Yes	2 ft clay (10^{-7} cm/s) or 20 mil PVC	No
Montour Area 3	Yes	30 mil PVC	No
Shawville Stage I/II	Yes	50-60 mil PVC or HDPE	Geonet over compacted fly ash
Titus (1978-1984)	No	2 ft clay (no max. permeability specified)	No
Titus (1985-1990)	Yes	2 ft clay (no max. permeability specified)	No
Titus (post 1991)	Yes	50-mil PVC	No
RCRA Subtitle D[1]	Yes	60 mil HDPE and 2 ft clay (10^{-7} cm/s)	No

[1] RCRA Subtitle D design used by EPA in evaluation of CKD landfill designs (EPA 1997).

As a 1988 permit condition, the Conemaugh site is required to measure the discharge rates of the leachate and ground water collection systems on a daily basis and is responsible for cleaning these drains if ferric hydroxide formations causes clogging of these drains. Based on PDEP's request, attempts to continuously monitor the leachate generation rate from a weir at the Titus/Beagle Club site began in 1994. Minor problems were encountered in forgetting to change the recorder paper on a timely (quarterly) basis and initially not being able to check the leachate flow results without taking the instrument apart. No discharge data from the Conemaugh systems were found during the record review for this TBD and only high level summaries of the leachate generation rate (i.e., varies between 9.75 and 33.43 gpm (PDEP 2/10/97 site inspection)) were found in PDEP inspection reports for the Titus/Beagle Club site. Therefore, it is not possible to evaluate the performance of the bottom liners designs with respect to clogging of the leachate collection system. If a steady decrease in the leachate generation rate over an extended period or excessive ferric hydroxide precipitation were observed, then clogging of the leachate collection system could be suspected.

5.5.2 Effectiveness of Plastic Bottom Liners for Controlling Releases to Ground Water

The effectiveness of the plastic bottom liner systems described in Section 5.5.1 for the three landfills are summarized in Table 5-6. The Montour Ash Storage Area 2 and the Titus/Beagle Club sites are not included in Table 5-6, because portions of these landfills are not lined with a plastic liner. The bottom liner performance at these two sites is evaluated in Section 5.6.

Table 5-6 Evaluation of Ash Landfill PVC/HDPE-Based Bottom Liner Controls

Ash Landfill	Design	Bottom Liner Integrity Evaluation
Conemaugh (Stage II)	50-mil PVC	Unknown - Nearest downgradient monitoring well located about 2000 feet from landfill
Montour (Area 3)	30-mil PVC	Unknown - Ground-water monitoring results indicate elevated concentrations in downgradient wells but PDEP is uncertain if a release has occurred or if elevated concentrations are due to pyrite oxidation in native material associated with recent repair work
Shawville (Phase I/II)	50-mil PVC/HDPE	No evidence of leakage - Site has not reported any leachate in the leachate detection system (geonet and pipes installed below the bottom liner)

No evidence of leakage has been reported from the bottom liner and leachate detection system installed in 1992 at the Shawville site. The integrity of the Montour Ash Storage Area 3 and Conemaugh Stage II liners are currently unknown. At Conemaugh the nearest downgradient wells are located about 600 meters (2000 feet) from the current disposal area, which is likely to be too far away to detect a release from past or current disposal operations. In February 1997, elevated levels of sulfate, calcium, and specific conductivity were identified in downgradient monitoring well MW-3-3 relative to previous quarters. The cause of the these increases is unknown but may be related to recent repairs made to leachate/run-off basin’s overflow spillway. It is noted that during construction of the landfill, before ash was placed in the facility, sharp increases of conductivity, sulfate, calcium, magnesium, manganese, and strontium were observed in downgradient wells (PP&LC 1997). .

5.6 Alternative Liner Designs

5.6.1 Use of Alternative Liner Designs at Fly Ash Landfills

The use of low permeability native clay has been used as a bottom liner for the Montour Ash Storage Area 2 and Titus/Beagle Club sites. It is unclear what native soils were present and compacted to form the bottom liner of the Stage I area in the Conemaugh landfill. At the Montour Ash Storage Area 2 site, a maximum permeability of 10^{-7} cm/s was required for areas not underlain by a PVC bottom liner and a ground-water underdrain system was installed to route upgradient surface run-off water and shallow ground water under the landfill. The compacted clay was required to kept moist to prevent desiccation until it was covered with bottom ash after testing confirmed that the desired permeability was achieved. No maximum clay permeability was required for the Conemaugh Stage I and Titus/Beagle Club designs, except that the clay must be at least two feet thick at the Titus/Beagle Club site. Leachate was not collected at the Titus/Beagle Club site from prior to 1984. In 1984, the previously disposed ash was excavated, stockpiled on-site during construction of a leachate collection system, and then redisposed.

5.6.2 Effectiveness in Controlling Releases to Ground Water

The effectiveness of the alternative bottom liner systems described in Section 5.6.1 for the three landfill designs are summarized in Table 5-7. Ground-water monitoring results at the Titus/Beagle Club site indicate that landfill has released waste constituents to ground water. It is likely that the release may have occurred in the 1978-84 time frame when no leachate collection was performed at the landfill. HELP computer modeling of the 9 acre portion of the landfill without the PVC liner predicted a maximum monthly leakage rates of 1.6 gpm (0.3 inches/month) in 1994 to less than 0.1 gpm (0.02 inches/month) following site closure, projected in 2008 (Gilbert-Commonweath 1994). Although elevated levels of sulfate and other parameters were identified in downgradient wells at the Montour Ash Storage Area 2 facility, no release has been confirmed because trace indicator constituents associated with the coal ash (i.e., selenium, lithium, boron and chromium) were not detected at elevated levels in the downgradient wells (PP&LC 1987). The integrity of the Conemaugh Stage I liner is currently unknown. At Conemaugh the nearest downgradient wells are located more than 2000 feet from the Stage I disposal area, which may be too far away to detect a release from the Stage I disposal operations.

Table 5-7 Evaluation of Ash Landfill Alternative Bottom Liner Controls

Ash Landfill	Design	Bottom Liner Integrity Evaluation
Conemaugh (Stage I)	Compacted soil subbase	Unknown - Overlies former coal strip mine and downgradient monitoring well located over 2000 feet from landfill
Montour (Area 2)	20-mil PVC or 2 feet 10^{-7} cm/s native clay	No landfill leakage detected - Downgradient ground-water monitoring results do not indicate elevated concentrations of trace elements associated with coal ash
Titus (1978-91)	2 feet native clay soil (no permeability requirement); no leachate collection in 1978-84	Known landfill leakage - Downgradient ground-water monitoring results indicate degradation for sulfate and TDS (first observed in 1988) - HELP model results predict up to 1.6 gpm leakage in 1994 (declines to 0.1 gpm leakage during 5 years following site closure projected in 2008)

5.7 Landfill Closure and Post-Closure Measures at Fly Ash Landfills

5.7.1 Summary of Closure and Post-Closure Activities at Fly Ash Landfills

Only one of the coal ash landfill study sites has been closed. The Montour Ash Storage Area 2 was closed in about 1989 just prior to commencement of fly ash disposal activities in the Ash Storage Area 3. The design of this landfill closure includes placing of a one-foot thick native clay cover over the landfill, allowing the cover to become densely vegetated, and sampling the ground-water monitoring wells for a 30-year post-closure period. It is noted that a final cover was installed on the side slopes of this landfill during disposal as benches were completely filled with ash. As noted in Section 5.2, final vegetated covers are also installed at the other landfills as portions of the final grade is achieved. At the time of Montour Ash Storage Area 2 closure, most of the landfill sides were covered with the one-foot thick native clay cap and vegetation.

5.7.2 Effectiveness of Closure

The effectiveness of the Montour Ash Storage Area 2 closure design is summarized in Table 5-8. The closure design of the final cap with a one-foot thick native clay soil cover appears to be effective as evidence by densely vegetated landfill side slopes. However, an adequate soil cover is currently not present in one corner at the top of the landfill, resulting is a sparse vegetative cover and local erosion at one corner of the landfill. Post-closure ground-water monitoring will be performed for a period of 30 years and results to have not indicated that the landfill is leaking (pers. com. Jim Diehl and Joe Figured, PDEP 1997).

Table 5-8 Evaluation of the Montour Ash Storage Area 2 Closure Design

Ash Landfill	Design	Closure Evaluation
Montour (Area 2)	1-foot native clay cap covered with vegetation/ 30-year post-closure monitoring period	<u>Effective design, but poor execution</u> - Insufficient thickness of soil present at one corner on top of the landfill resulting in sparse vegetation and erosion in one corner of the landfill - The sides of the landfill have an excellent stand of vegetation where a soil cover was provided - Ground-water monitoring does not indicate any evidence of leakage from the landfill to ground water

6.0 CONCLUSIONS

This section summarizes the findings on the effectiveness and efficiency of the landfill design elements evaluated in Section 5 and projects how effective these design elements would function at CKD landfills. The utility coal ash landfills studied for this TBD were found to use a wide variety of designs to minimize environmental impacts from disposal operations.

6.1 Fugitive Dust Controls

All of the study sites spray unpaved haul roads and disposal areas with water for control of fugitive dust emissions. As long as the fly ash and unpaved roads were kept wet, fugitive dust emissions were controlled. Continuous application of water by water trucks was sometimes needed during extended periods of drought and there is a risk to the environment if a water truck was broken down during one of these periods.

Additional measures were taken at three power plants to condition the fly ash with water and to compact it during disposal. This appears to have provided greater control over fugitive dust emissions as well as extending the capacity of these landfills. Due to potential visibility hazards on adjacent Highway 422, 30-foot high wind screens were constructed at the Titus/Beagle Club Ash Landfill. The wind screens appear to have helped to control fugitive dust emissions, however application of water over areas prone to dusting is the primary dust control measure at this site. Hoppers or silos were used at all of the utility plants to temporarily store the fly ash as it is being generated and until it is transported to the landfill for disposal. Cleaning and covering of trucks was required at the Conemaugh site when hauling ash from off-site locations.

These dust control measures could be effectively applied at CKD disposal sites. Care must be taken to not over apply water to CKD due to the potential caustic quality of the run-off that may be generated and because this may result in failure to achieve the desired in-place density during compaction. Conditioning CKD with water and compacting it during disposal is expected to help control fugitive dust emissions. Wind screens and/or spraying of dust suppressants may be considered for deployment at CKD disposal sites near populated areas or where there is a high degree of concern over fugitive dust emissions. Additional fugitive dust control measures evaluated by EPA for potential use at CKD disposal sites include pelletization of waste CKD and application of a latex or soil cover over the waste pile (ICF 1997).

6.2 Temporary or Interim Landfill Cover

PDEP regulations require installation of vegetated temporary of interim landfill cover if an ash surface is expected to be exposed for more than six months. The interim cover is required to be temporarily vegetated and otherwise protected against erosion if neither waste nor final cover is placed within 30 days (Section 288.234 of the Residual Waste Regulations). At Shawville, a bottom ash or soil cover is required when the ash surface is exposed for more than one week. Other sites have procedures to cover unstable fly ash surfaces with soil or bottom ash, on an as-needed basis or if operations are expected to be shut down for extended periods. At most of the utility ash landfills studied in this TBD, it was found that interim or temporary soil covers were generally not used. Instead, ash is disposed of in a limited area on a near-continuous basis until the final grade is achieved. After the final grade is achieved, a final cover is constructed, and ash disposal is initiated in a new area. Gully erosion of the final cover has been noted to be an issue at several the ash disposal sites, requiring on-going inspection and maintenance.

Disposal operations at coal ash landfills suggest that it may be possible to dispose of CKD with out constructing interim covers, if compacted, conditioned CKD is disposed of on a daily basis and an inspection and abatement program is implemented to effectively control fugitive dust emissions and site erosion. Disposal operations should be concentrated in as small area as is feasible (i.e., an active disposal area of 60 m (200 ft) or less in length). In this way CKD landfills would be constructed in a phased manner, where disposal cells or benches are filled on a sequential basis and capped to minimize infiltration, erosion and fugitive dust emissions prior to final closure. A final cover should be installed to stabilize the ash as soon as possible after the final grade is achieved.

6.3 Ground-Water Monitoring

A network of upgradient and downgradient monitoring wells/points are being monitored on a quarterly basis at all of the coal ash landfills studied. At the Titus/Beagle Club site, downgradient monitoring wells, located less than 90 meters (300 feet) from the landfill, have provided timely warning that the ground-water system has been impacted from ash disposal operations. At the Conemaugh site, however, the downgradient wells are located near the projected edge of the landfill in the year 2028, which is more than 600 meters (2000 ft) from current and past disposal operations. This ground-water monitoring system is relatively ineffective as an early warning system for identifying potential landfill leakage. If the wells were located within 500 feet of the downgradient edge of the waste management unit, the system would be more effective and would be consistent with EPA’s proposed approach for monitoring ground water at CKD landfills. None of the studied coal ash landfills are located over karst aquifers. For CKD landfills at karstic sites, EPA is proposing are greater degree of site characterization and more sophisticated ground-water monitoring than those used for the studied coal ash landfills.

At the Titus/Beagle Club, Conemaugh and Shawville facilities statistical methods are used to evaluate ground-water monitoring data to determine whether the ash disposal operations have impacted ground water. At the Titus/Beagle Club site, the operator/owner used a 99% confidence level and identified several constituents in downgradient wells at concentrations exceeding background. However, at the Conemaugh and Shawville sites, the statistical methods are not consistent with current EPA guidance and would not be as effective in identifying potential releases to ground water. It is noted that pre-existing acid mine drainage has impacted the ground-water system under the Conemaugh and Shawville sites, so that identification of releases from these landfills may be difficult to identify. EPA is considering using the statistical techniques specified in 40 CFR 258.53(g) and 40 CFR 264.97 to evaluate potential landfill leakage. These regulations appear to include the approach used for the Titus/Beagle Club ground-water assessment.

6.4 Storm Water Controls

At all of the coal ash landfills, surface run-off from unvegetated ash surfaces is collected in leachate and/or storm water run-off collection ponds and treated as necessary for discharge under a NPDES permit. These storm water controls have been designed to accommodate the 25-year, 24-hour storm per Section 288.242 of the PA Residual Waste Regulations. Discharges from dirty storm water collection ponds emergency overflows are permitted at the Conemaugh, Montour Areas 2 and 3, and Titus/Beagle Club landfills for storm events equal to or greater than the 10-year, 24-hour storm. After the vegetation becomes established, the surface water collection system is modified to convey this water downslope of the landfill without collection/treatment. Except for the Montour Area 2 leachate/dirty run-off pond, all of the landfills studied were located away from of the 100-year floodplain. Gully erosion of the final cover has been noted to be an issue at several sites, requiring on-going inspection and maintenance.

At the coal ash landfills studied, at least 15 NPDES permit violations were found potentially involving landfill leachate/run-off treatment systems. At the Conemaugh and Shawville sites, preexisting acid mine drainage requires greater attention to the design of the treatment system when this waste stream is combined with the leachate and dirty surface water run-off. Routing leachate/storm water run-off waters through the utility plant’s waste water treatment system appears to provide a greater treatment capacity and to result in a lower potential for exceeding NPDES discharge limits.

Comanagement and cotreatment of landfill leachate and dirty storm water run-off may be an effective approach at CKD landfills, provided that the waste water treatment system is of sufficient capacity to handle the quantity of leachate, storm water run-off and potentially contaminated ground water for the expected life of the landfill. It may be feasible to treat this water in the cement plant’s main waste water treatment system.

6.5 Composite Bottom Liner

Only three of the studied landfills (i.e., Conemaugh Stage II, Shawville Stage I/II, and Montour

Ash Storage Area 3) were found to have used a modified composite bottom liner design where the landfill is entirely underlain by a plastic (e.g., PVC or HPDE) bottom liner. However, the requirements for the clay portion of the composite liner for these landfills was less stringent than the 2 feet of clay with a permeability less than 10^{-7} cm/s, specified in the RCRA Subtitle D regulations (40 CFR 258.40(a)(2)). At Shawville, the Stage I/II landfill was constructed over the old landfill after the fly ash was compacted to at least 95% of the maximum density and with a minimum bearing capacity of 1.5 tons/ft^2. No minimum permeability (other than that resulting from site clearing, grubbing and rolling soil flat) was required for the subbase material of the Conemaugh and Montour landfills. Underdrains were constructed at the Montour and Conemaugh landfills to drain upgradient surface water and/or shallow ground water and to prevent excessive pressure heads under the landfill. All these landfills have a leachate collection system installed throughout the landfill immediately overlying the bottom liner.

The Shawville landfill was constructed in 1992 with a leachate detection system (geonet) under the bottom liner. Because the facility has not reported any fluids from the leachate detection system, the bottom liner at the Shawville landfill appears to be working properly, with no measurable leakage. Ground-water monitoring results at the Conemaugh and Montour facilities indicate the presence of pre-existing, poor quality ground water under these landfills. This pre-existing, poor quality ground water makes it difficult to evaluate the potential for leakage through the landfill bottom liners.

EPA is considering using the RCRA Subtitle D composite liner design as the technical default standard for CKD landfills. EPA's evaluation of the Subtitle D composite liner design indicates that the expected leakage from this design is very small and would be protective of human health and ground-water resources (EPA 1997). In designing a bottom liner for CKD landfills in non-karstic areas, EPA is considering a performance-based design standard that is based on the RCRA Subtitle D performance standard found in 40 CFR 258.40(a)(1). This standard would allow the use of a modified bottom liner design, such as those found at the coal ash landfill sites, as long as there is no exceedence of EPA's maximum contaminant levels (MCLs) for drinking water and/or other health based numbers (HBNs) for arsenic, antimony, barium, beryllium, cadmium, chromium, lead, mercury, nickel, selenium, silver, and thallium in the uppermost aquifer at the relevant point of compliance (POC).

6.6 Alternative Bottom Liner Designs

Portions of the Montour Area 2 and Titus/Beagle Club landfills do not have a plastic bottom liner, but instead use compacted native clay as a bottom liner. At the Montour Area 2 facility, a plastic liner was only used in areas where the depth to water was less than 0.6 meters (2 feet), otherwise the bottom liner consisted of a 2-foot-thick native clay with a maximum permeability of 10^{-7} cm/s. A 2-foot-thick native clay with no permeability requirement was used a bottom liner for the

Titus/Beagle Club landfill prior to 1991. From 1978 to 1984, the Titus/Beagle Club landfill operated without a leachate collection system. In 1984-85 this landfill was excavated and stockpiled until redisposed on site in a landfill with a leachate collection system. After 1991, a PVC bottom liner was installed at the Titus/Beagle Club landfill.

Ground-water degradation downgradient of the Montour Area 2 and Titus/Beagle Club facilities has been identified from the ground-water monitoring data. Evaluation of trace element concentrations in downgradient ground water at the Montour Area 2 facility indicates that no leakage has been confirmed because the degradation appears to be related to oxidation of naturally-occurring pyrite in the shale bedrock rather than fly ash constituents. HELP modeling of the Titus landfill has predicted a current maximum leakage rate of 1.6 gpm (0.3 inches/month) from the 9 acre portion of the landfill with out a plastic liner. Based on these observations, it appears that alternative bottom liner designs which do not use synthetic liners may be appropriate for some CKD landfills depending upon site-specific conditions.

EPA's evaluation of CKD landfill bottom liner designs indicates that CKD landfills located in non-karstic areas with annual rainfall less than about 29 inches may not require plastic liners (i.e., "modified CKD high" design) and with annual rainfall less than about 10 inches may not require leachate collection systems (i.e., "modified CKD low" design) (EPA 1997). The leachate collection system/bottom liner of the "modified CKD high" design consists of a geotextile filter fabric over 1 foot of sand (leachate collection layer), which is underlain by a geotextile support fabric and 4 feet of compacted CKD with a permeability of 2×10^{-5} cm/s. The bottom liner of the "modified CKD low" design consists of 4 feet of compacted CKD and does not include a leachate collection system.

6.7 Landfill Closure and Post-Closure Measures

The Montour Area 2 facility was closed in 1989. Closure activities consisted of completing installation of a final 1-foot-thick clay cover over the landfill, allowing it to become vegetated, and continuing with the ground-water monitoring program during a 30-year post-closure period. PDEP granted a variance for the 1-foot-thick clay cover based on the results from demonstration plot test of a 1-foot-thick and 2-foot-thick clay covers performed at the Montour site. A recent inspection of the Montour Area 2 landfill has found that erosion has exposed waste ash in one corner of the landfill where vegetation did not become sufficiently established. PDEP attribute the poorer than expected performance of the final cover to unfavorable growing conditions (i.e., soil removed by erosion, lack of moisture, and excessive wind) at this exposed location. It is noted that the performance of vegetation growth in a relatively small test plot may not be directly extrapolated for a large landfill (per. com. Mark Stevens, PDEP 1997).

EPA is considering standards for landfill closure and post-closure requirements based on the

RCRA Subtitle D regulations (40 CFR 258.60-61). The cover must have a permeability less than or equal to the bottom liner or natural subsoils or have a permeability no greater than 10^{-5} cm/sec, whichever is less. The cover must minimize infiltration by using an infiltration layer that contains at least 18 inches of earthen material. The cover must minimize erosion by using an erosion layer that contains at least 6 inches of earthen material that is capable of sustaining native plant growth. Similar to the PDEP approach (Section 288.234 of the Residual Waste Regulations), an alternative landfill final cover design may be approved as long as it provides an equivalent degree of infiltration and erosion protection.

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APPENDIX A - FIGURES

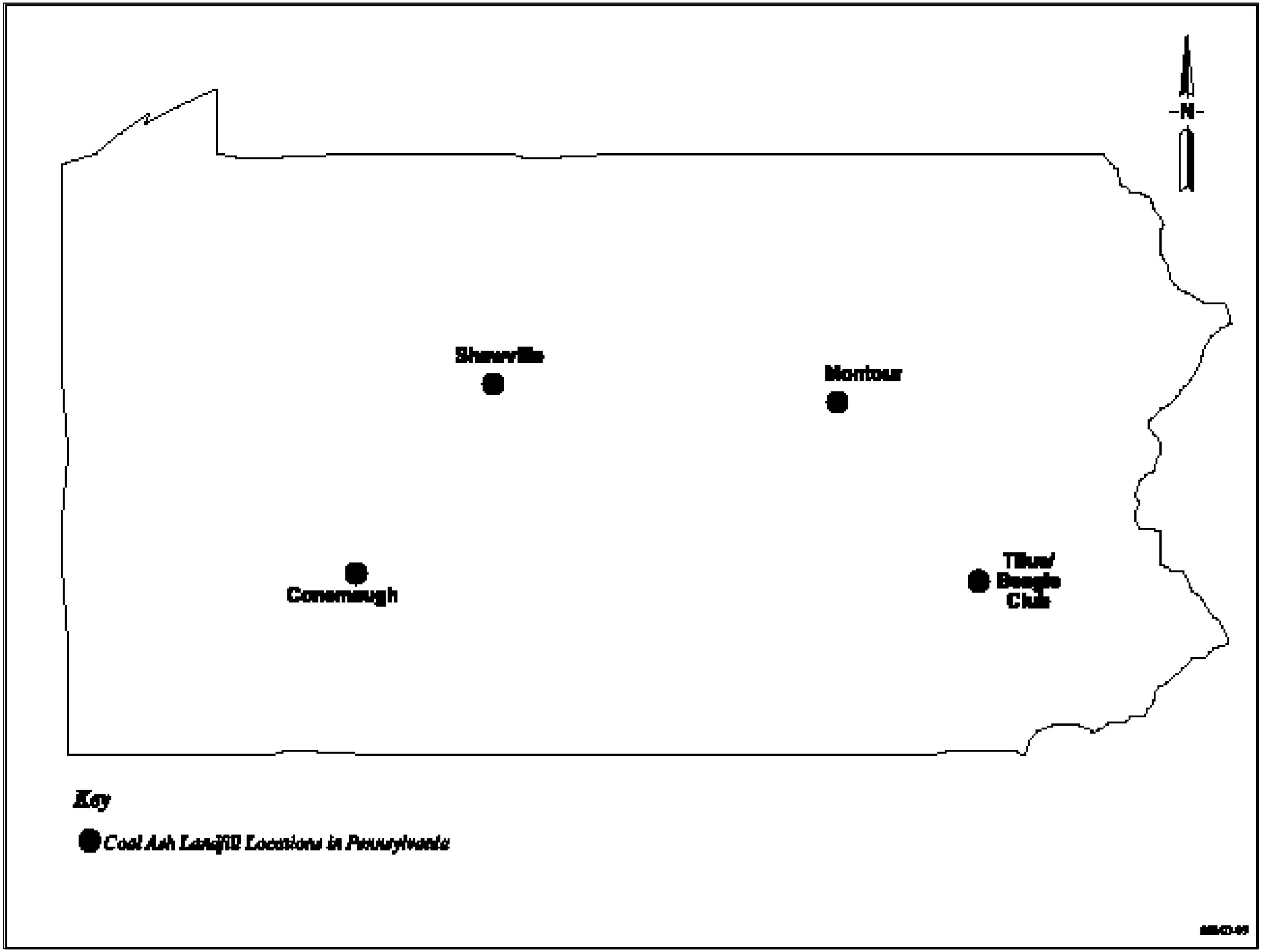

Figure 1 Utility coal ash landfill study sites in Pennsylvania

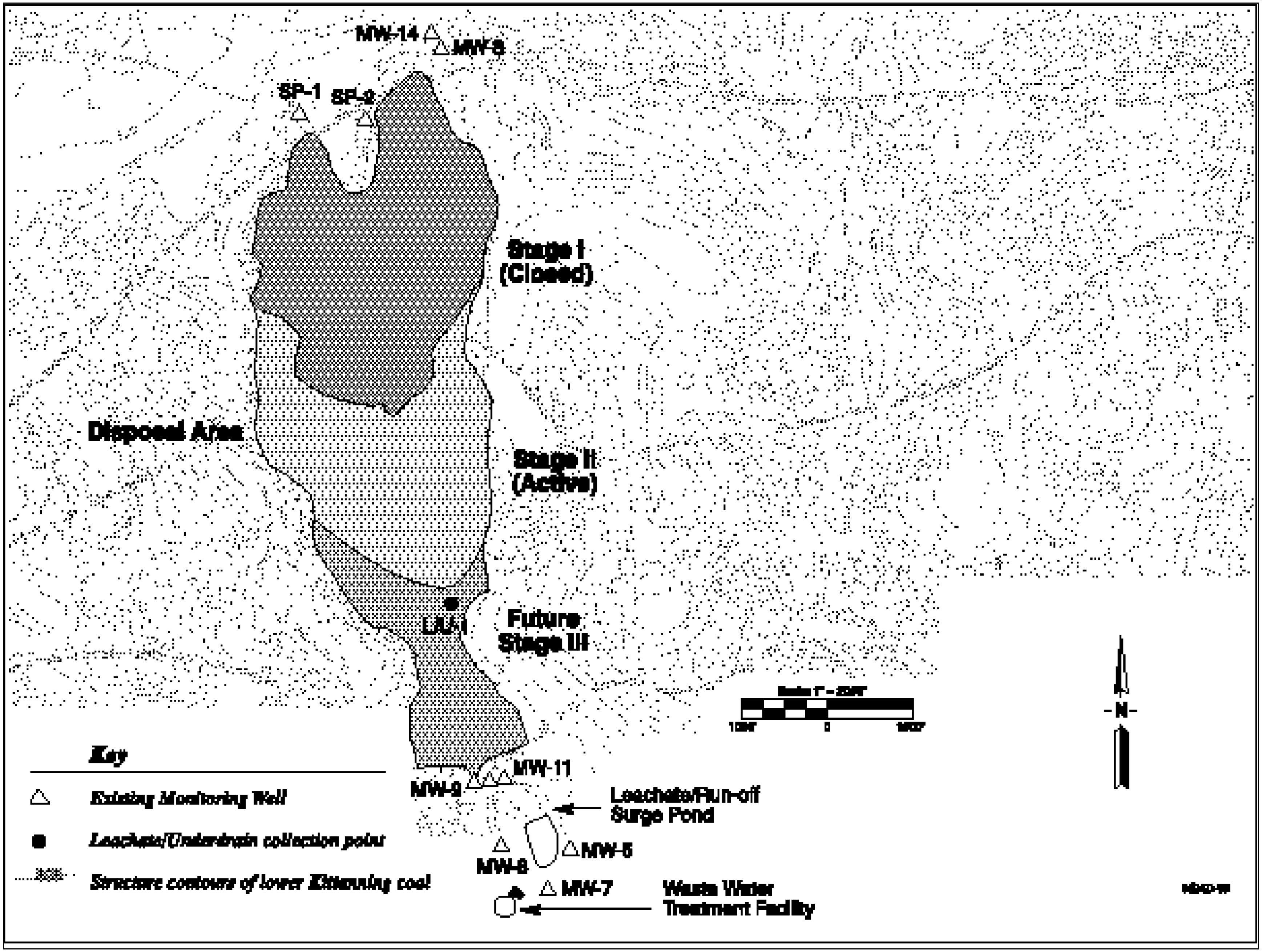

Figure 2 Plan of the Conemaugh Ash Disposal Site, Indiana County, Pennsylvania

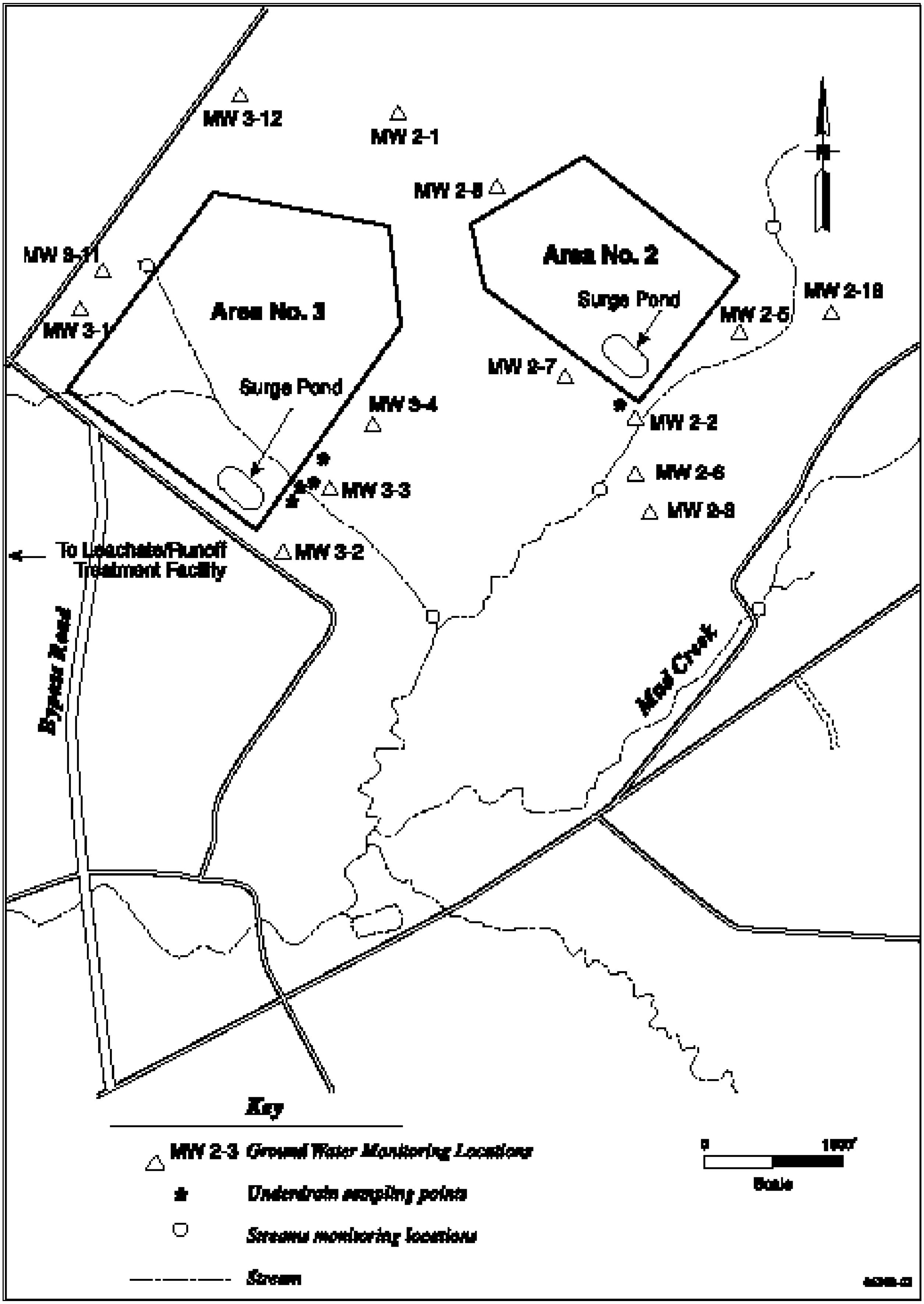

Figure 3 Montour Ash Storage Areas 2 and 3 Site Map, Montour County, Pennsylvania

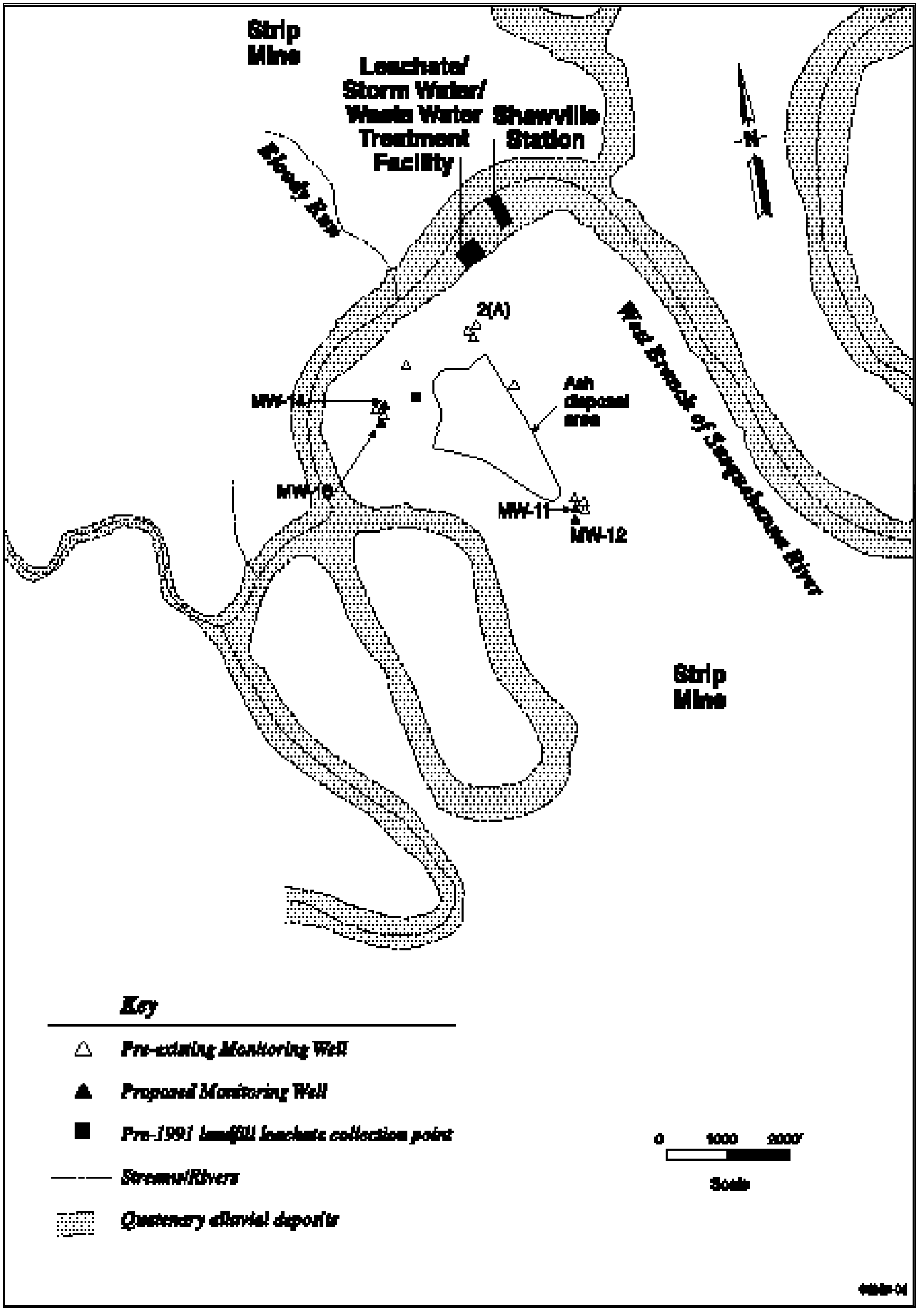

Figure 4 Plan of the Shawville Ash Disposal Site, Clearfield County, Pennsylvania

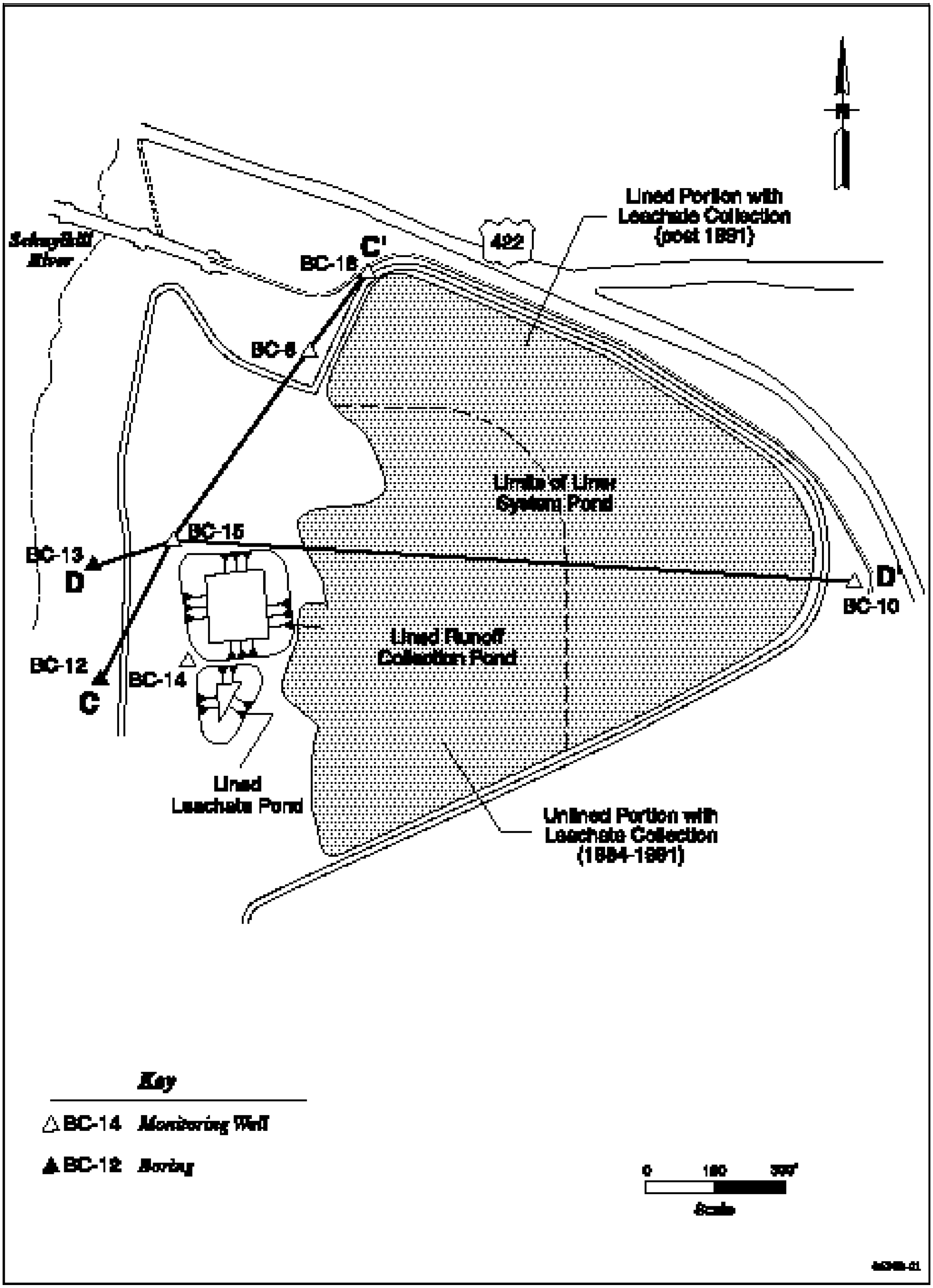

Figure 5 Plan of the Titus/Beagle Club Ash Disposal Site, Berks County, Pennsylvania

APPENDIX B - TELEPHONE CONVERSATION SUMMARIES

Telephone Conversation Summary

Date: June 24 and 27, 1997

From: Ken Toney

To: Jim Diehl (Hydrogeologist) (717) 327-3757 and
Joe Figured, PDEP, (717) 327-3730

Subject: Post-Closure Performance of Montour Ash Storage Area 2

On June 24, Jim Diehl provided me with the status of post-closure ground-water monitoring, but deferred to Joe Figured for performance of the final cover at the site. Jim said the a 30 year post-closure ground-water monitoring period is expected for this site which closed in about 1989. The site has been forwarding the ground-water monitoring results from this site on PDEP's standard Form 14R. Results to date do not indicate any evidence of leakage from this landfill, although oxidation of pyrite in the shale bedrock has elevated the concentrations of certain constituents in downgradient monitoring wells. This phenomenon was explained in the 1987 ground-water assessment for the site. He mentioned as a point of background information, that the neighbor adjacent to the east side of the landfill has complained about contaminants "bubbling into her field" and that she has been trying to sell the land to the Montour. PDEP's position on this neighbor's allegation of off-site migration of contaminated ground water is that it is not confirmed by the ground-water monitoring data.

Jim Diehl provided me with information on the final cover as told to him by a PDEP inspector for the site. The sides of the landfill have an excellent stand of vegetation. However no soil was place on top of the landfill resulting in scarce vegetation on the top of the landfill. One corner of the landfill is having a problem with erosion due to scarce vegetation. This corner was noted to be located in the most recently active portion of the landfill.

Telephone Conversation Summary

Date: March 19, 1997 (same date as telephone conversation)

From: Ken Toney, SAIC

To: John Hamilton, Facilities Manager, Northcentral Region, Bureau of Land Recycling & Waste Management, Pennsylvania Dept. Of Environmental Protection (717) 327-3653

Subject: Utility Ash Landfills in the Pennsylvania Northcentral Region

I identified twelve utility fly ash landfills Work Assignment 219 listed in Pennsylvania. He was familiar with the Shawville and two Montour facilities. Engineering reports on these facilities are available in his office. He provided me with the following information.

<u>Montour Ash Disposal Area 2.</u> Disposal Area 2 was permitted in the early 1980s (1981?) and closed in 1989. The oldest half has a bottom clay liner and the newer half has a PVC liner.

<u>Montour Ash Disposal Area 3.</u> Disposal Area 3 is not currently used because all of the new ash is able to be marketed. It is considered to be filled to about half of its design capacity. At the power plant, dry fly ash is stored in a silo, it is then conditioned with water and loaded into a truck for delivery to the disposal site. Disposal Area 3 has a HDPE bottom liner.

<u>Montour Ash Disposal Areas 2 and 3</u>. Both landfills generate leachate which is treated at an on-site water treatment facility which discharges water under a NPDES permit. The landfills have been designed to accommodate run-on/run-off associated with a 25 year storm. The site does not have a storm water permit, but surface water run off from the landfill is collected and tested; if “dirty” it is routed to the treatment plant, if “clean”it is discharged without treatment. PDEP is attempting to get a bond from Montour to ensure that the landfills will eventually be capped properly. Montour was one of the first residual waste sites to have lined landfills in the Northcentral Region. EPRI has conducted a number of studies at the site particularly on the potential for the ash to generate leachate. A study cell was constructed and lysimeters were installed to collect vadose water samples. The combined area of disposal areas 2 and 3 is 30 acres.

<u>Shawville.</u> In 1996, the site was sold to GPU (no longer PA Electric). The landfill covers approximately 40.5 acres. It began operation in the 1950s and was permitted in January 1991. A new area of the landfill has an HDPE single liner, but the old area is unlined. There is no daily cover requirement, but an intermediate cover is required for ash that is exposed for more than about one week. The landfill has been designed for the 25-year storm. Storm water and landfill leachate is routed to a treatment lagoon and ultimately discharged under a NPDES permit. A final cap has not been design, but PDEP is attempting to get a bond from Shawville to ensure that the landfill will eventually be capped properly. PDEP is asking Shawville to commit to a cap in the future even though a final cap is not currently required.

Telephone Conversation Summary

Date: June 11, 1997

To: John Hamilton, Facilities Manager, Northcentral Region, Bureau of Land Recycling & Waste Management, Pennsylvania Department of Environmental Protection (717) 327-3653

From: Ken Toney, SAIC

Subject: Montour and Shawville Coal Ash Landfills

Following a records review of these two sites, I asked John for clarification on the following questions:

Montour

What are the results from the airborne particulate monitoring that was done as part of the 1986 Consent Agreement for Site 2 in 1986? The Consent Agreement was between the Township and Montour, these monitoring results were not forwarded to PDEP. From his experience with regulating the site, Montour's fugitive dust control practices are "working fine". The site compacts moist ash, is in a fairly remote location, and there are no outstanding air complaints related with the landfill.

What are the Module 8 parameters in the 1987 Site 3 permit? These parameters consist of 14 organic compounds and 12 toxic metals.

Why is a two foot final cover required for Site 3 but only a one foot cover for Site 2? Does this requirement have anything to do with the vegetation tests plots that were done at Site 2? A 2 foot final cover is a requirement of Pennsylvania regulations. Montour could request a permit modification if they show that a thinner cover would provide an equivalent degree of protection. The previous vegetation test plots results were not considered, because Montour has not requested a permit modification.

What is the current evaluation of releases from Site 3 to the ground water system? PDEP is currently reviewing the permit renewal application for Site 3. They are uncertain if releases from the landfill are affecting downgradient ground water quality or if it is as Montour claims due to oxidation of pyrite in native soil and bedrock.

Shawville

What are the results of leachate detection monitoring of the landfill to date? The site has not reported any leachate in the leachate detection monitoring system.

How are the fugitive dust control practices working? There are no fugitive dust control issues with Shawville because it is in a location even more remote from populations than is Montour and they compact the moist ash as it is disposed of.

Any problems with the 1995 ground water assessment? The site is affected by previous strip mining activity, therefore comparing downgradient to upgradient ground water monitoring results is not appropriate. The ground water assessment was sufficient given the conditions at the landfill.

Telephone Conversation Summary

Date: June 19, 1997

To: Mike Maiole, PDEP - Reading, PA; (610) 916-0100

From: Ken Toney, SAIC

Subject: Titus/Beagle Club Ash Landfill

Mike gave me the following information on the Beagle Club Ash Landfill:

- The wind screens are about 30 feet high and consist of telephone poles with fabric stretched between them.

- His opinion was that the wind screens helped to control dusting but keeping the ash moist was required to effectively control fugitive dust emissions. Overall the site's dust control program has been effective.

- He stated that the site is still performing quarterly ground-water monitoring of the same parameters in their 1991 permit. No ground water clean up has been required yet. However, PDEP has not formally accepted the site's proposal to have less stringent mandatory abatement levels for sulfate and TDS.

Telephone Conversation Summary

Date: June 17, 1997

To: Mick Planinsek, PDEP-Greensburg, (412) 725-5431

From: Ken Toney, SAIC

Subject: Fugitive Dust Controls at Conemaugh Ash Disposal Site

Mick is responsible for performing routine Pennsylvania Department of Environmental Protection (PDEP) inspections at the Conemaugh Ash Disposal Site. I reviewed with him that Conemaugh is required to implement fugitive dust controls (spraying with water or other measures) on an as needed basis and that the waste disposal permit leaves the choice of dust control methods up to the site as long as it works. He said for the most part Conemaugh's fugitive dust control program was working well. However, they may have problems controlling dust in August, when it gets hot for several days in a row. In these situations, the water trucks must continuously make the rounds watering the roads and the disposal area. He agreed with my conclusion that implementing effective dust controls requires ongoing monitoring and maintenance

He mentioned that PennElec (one of the owners at Conemaugh) is required to implement fugitive dust controls on an as needed basis at their Homer City and Keystone plants, which are in the same general region as Conemaugh. Homer City has been issued a NOV for fugitive dust controls. Contributing factors to fugitive dust at Homer City include being in a more exposed location (Conemaugh is nestled in a valley) and has poorer quality ash (Conemaugh's ash is less susceptible to dusting because either coarser grained and/or is mixed FGD waste). At Homer City, an approved dust suppressant (Syntex - a product of Penzoil) was applied to the site in May and appeared to be working a month later. He remarked that the Syntex appeared to go on like a coat of paint when it was applied, in terms of thickness and consistency. Syntex was only applied to inactive areas and is not expected to work if disturbed by vehicles.

Mick mentioned that Conemaugh was currently transporting most of their ash to the coal cleaning plant which is supporting PennElec's three plants, in order to stabilize coal refuse sludge resulting from coal milling and washing.

Telephone Conversation Summary

Date: June 30, 1997

From: Ken Toney

To: Mark Stevens (geologist) (717) 327-3653 and
Jason Fellon (soil scientist), PDEP, (717) 327-3730

Subject: Post-Closure Performance of Montour Ash Storage Area 2

Mark Stevens returned my call regarding closure of the Montour Ash Storage Area 2. He is currently reviewing a permit application for continued operation at Montour. He provided some additional information to that provided by Joe Figured and Jim Deal last week. He said that the landfill is in a exposed position with low-lying surrounding countryside. The cover of the landfill is exposed to wind and surface run-off erosion and has a hard time holding moisture. These are not ideal conditions for growing vegetation. I mentioned that the permit required a test plot using a one foot soil cover and that the results appeared to be acceptable even though it took a little longer than the two-foot soil plot to become established. He said that what is seen in a small scale test may not always be extrapolated to an entire landfill. He transferred me to Jason Fellon who could explain more about PDEP's landfill cover requirements.

Jason said that PA residual regulations require a 2-foot final soil cover, unless an equivalent cover that meets the performance standards is provided. He faxed me the PA regulations for final cover requirements. Some important points for landfill covers include removal of large rocks greater than 6 inches, having a high percentage of fines (to hold water), and ensuring that the soil has a proper balance of nutrients (fertility testing). He mentioned that fertility testing is often over looked in the design of landfill covers (not considered in computer models). He mentioned that there is a balance in the amount of organic matter that is needed in the landfill cover. Too much organic matter could make the cover combustible.