AmerenUE

UTILITY WASTE LANDFILL FEASIBILITY STUDY

Revised June 8, 2004

Prepared by:

REITZ & JENS, INC.
CONSULTING ENGINEERS

1055 Corporate Square Drive
St. Louis, MO 63132
(314)-993-4132

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OVERVIEW

Union Electric Company's Labadie, Rush Island, Meramec and Sioux Power Plants are projected to annually produce approximately 1,325,000 tons of coal combustion ash over the next 20 years. This ash includes flyash, scrubber sludge, and bottom ash at the rates indicated in Table A. For the purpose of this study the ash was assumed to have an average dry density of 60 lbs/cubic-foot when placed in a conventional manner.

Reitz & Jens, Inc. was engaged by AmerenUE, under Task #49 of our open-ended Engineering Services Agreement Contract, to evaluate the feasibility of developing utility waste landfills (UWL) for disposal of this ash. This study briefly discusses some of the criteria that must be considered in siting, permitting, building, operating and closing UWLs, but concentrates on budgetary costs for landfilling the ash in separate landfills for each power plant, as well as a single UWL to accept wastes from all four power plants.

REGULATIONS

Utility Waste Landfills (UWL) are regulated by the Missouri Department of Natural Resources (MDNR) under rules promulgated in 10 CSR 80, Chapter 11. A copy of these rules is included in Appendix B.

The rules establish many requirements for siting, design, operation, and closure of UWLs. Some of the rules that will impact new AmerenUE landfills include:

General

- Sluicing waste into a landfill may be allowed provided the hydraulic head on top of liner is less than 1 foot;
- Access to a UWL must be controlled, on access roads only, and only when operating personnel are on duty;
- The waste must be compacted to smallest practicable volume;
- The maximum groundwater elevation must be determined, and a separation from lowest point of lowest cell must be shown on plans;
- Plans must include an effective dust control program;

Siting Restrictions

- A UWL in 100-year floodplain shall not restrict the floodplain conveyance or storage;
- A UWL shall not be located in wetland without proper Corps of Engineers permits;
- A UWL shall not be located within 200 feet of a Holocene fault in a seismic impact zone;
- A stability analysis proving that the UWL is stable, must be performed for UWLs proposed for unstable areas;

Liner Construction

- If base of the UWL liner is in contact with groundwater, the applicant must demonstrate that groundwater will not adversely impact liner;
- The detailed Site Investigation will determine if as secondary liner (a geomembrane and/or leachate collection system) is mandatory;
- A composite or clay bottom liner is required. The clay liner must include at least 2 feet of compacted clay with a permeability of less than $1x10^{-7}$ cm/sec. The composite liner must include at least 2 feet of compacted clay with a permeability less than $1x10^{-5}$ cm/sec and a 60 mil HDPE liner;

Leachate Collection

- A leachate collection system is required unless demonstrated to MDNR by the results of the detailed Site Investigation that it is not necessary;
- The leachate collection system design shall maintain less than 1-foot of leachate over the bottom liner;
- The leachate collection system shall be operated for the 20-year post closure period, or as long as MDNR determines is necessary;

Interim/Final Cover

- Wastes that are easily moved by wind (i.e. flyash) shall be covered as necessary to prevent becoming airborne;
- Mining in the landfill to remove wastes for beneficial reuse is allowed;
- Cover shall be applied to minimize infiltration of precipitation, airborne waste, and provide a pleasing appearance;
- Final side slopes shall not exceed 25% (4:1) without a detailed slope stability and erosion analysis;
- A 1-foot thick compacted soil cover shall be applied on fill areas that are idle for more than 60 days and on final side slopes at the end of each filling sequence;
- Active and intermediate slopes shall not exceed 33% (3:1);
- Final cover shall include 1-foot of $1x10^{-5}$ clay (CH,CL,ML,SC or MH) over 1-foot of soil capable of sustaining vegetative growth (topsoil);

Groundwater Monitoring

- The owner/operator of a UWL must implement a groundwater monitoring program capable of determining the landfill’s impact on the quality of groundwater underlying the UWL;
- Groundwater monitoring requirements will be based on groundwater elevation, quantity and flow, geology, adjacent land use, nearby wells, etc.;
- Minimum number of wells shall be 1-upgradient, and 3-downgradient of UWL;
- A minimum of 4 quarterly samples per well shall be used to develop a baseline/background groundwater quality;

- Minimum annual detection monitoring shall analyze samples from each well in May and November;
- Analysis shall be for 32 parameters outlined in Appendix I;

Gas Monitoring

- Gas monitoring is not required;

Closure/Financial Assurance

- The leachate collection system shall be operated for the 20-year post closure period;
- Closure and post closure care shall be in accordance with 10CSR80-2.030(4)(A);
- Each UWL application shall include a closure plan and 20-year post-closure plan;

SITING ALTERNATIVES

The location of a new UWL must be approved both by the MDNR and the local entity have jurisdiction over land use.

MDNR primarily considers whether a proposed UWL site is suitable for use as a landfill based on the site's geology, topography, and the potential impacts of the landfill on the geology and water resources of surrounding areas. The MDNR follows the methodologies prescribed in 10 CSR 80 to determine whether to approve a UWL on a specific site.

City and/or County Planning Departments are usually responsible for approving the land use aspects of UWLs. In areas with formal zoning regulations, landfills are rarely a permitted use, and must be approved by the Conditional Use Permitting (CUP) process. The CUP process includes at least one public hearing, as well as formal approval by both local Planning & Zoning Boards, and City Councils.

Given the amount of public evaluation and input required in approving a new UWL, it is extremely important to anticipate the public's reaction when siting the landfill. With the exception of sites in karst areas, fault zones, or floodplains, engineering solutions can usually be developed to address the issues raised by MDNR. Land use issues are more problematic to resolve.

Recent history in the St. Louis region has shown an increased awareness and willingness to fight those land uses that are considered to be a public nuisance. Unfortunately, a Utility Waste Landfill, while necessary, is perceived by most as a public nuisance.

Often, the best location to site a new public nuisance is next to an existing nuisance. In the case of a UWL, the best siting location is probably adjacent to the power plant that is generating the waste (ash) that will be disposed of in the landfill. Siting the UWLs near the plants will also minimize transportation costs which is typically the single most expensive aspect of ash disposal.

If suitable UWL sites are not available near the plant, the next best alternative is siting the UWL near another public nuisance such as another landfill, heavy industrialized areas, or abandoned quarries. Abandoned quarries are also desirable because their geometry allows for efficient disposal of the ash.

A third alternative, although one that is becoming increasingly difficult, is to site the UWL as far away from developed areas as possible. Locating the UWL in an undeveloped area should minimize the public nuisance aspects, but may create other environmental impacts, and will increase transportation costs.

Potential UWL sites must be evaluated individually to weigh the pros and cons of each site. Land use considerations, and CUP possibilities are best evaluated by a Real-estate professional. Site specific design criteria are best evaluated by Professional Engineers and Geologists experienced in landfill design.

LANDFILL CONSTRUCTION

The construction alternatives for a utility waste landfill falls into one of three categories based on the geology and topography of the available sites. Generally, a landfill can be developed by:

1) Filling an abandoned pit quarry or other large excavation,
2) Mounding wastes above natural grades, and
3) Filling a valley or other natural feature

Typically, creating a landfill in an abandoned pit quarry will be the most cost effective because a quarry's near vertical walled geometry creates the highest ratio of air space to landfill liner. Mounding wastes is the next most efficient since the regulations require side slopes on all above grade fills to be 4:1. The geometry of a typical valley in eastern Missouri creates a relatively low air space to liner ratio, making this the most costly alternative per CY of utility waste disposed. In this study we estimated the preliminary costs of pit quarry and above ground UWLs only.

Landfills are usually constructed in cells. The cell construction allows for the landfill to be phased so that only a portion of the overall landfill site is active at any one time. Depending on the site geometry, UWLs can usually be permitted so that individual cells can be permanently closed as filling in that cell is completed. This allows the Post Closure period of the cell to begin well before the entire landfill site is closed.

The regulations state that at least 1 foot of compacted soil is placed on all areas of the UWL that are idle for more than 60 days. The purpose of this interim cover is to minimize infiltration of precipitation, and airborne wastes, and to provide a pleasing appearance. Interim cover also increases the amount of landfill airspace needed and the required quantity of suitable cover materials. Given the cementitious nature of the ash wastes, it is our opinion that MDNR can be convinced that interim cover will not be needed for UWLs taking only coal combustion ash wastes. Interim cover requirements were not included in our UWL cost estimates.

Each landfill site will have unique geologic and topographic features that will determine the final required geometry and scope of landfill improvements. For the purposes of this study, idealized landfill geometries were used to develop the landfill development cost estimates.

ABANDONED PIT QUARRY

Abandoned pit quarries provide the most efficient geometry for a landfill since the near vertical walls will provide the most amount of air space (landfill volume) per square foot of landfill bottom liner. The negatives of a pit quarry UWL development include an increase in the sidewall liner thickness, the limited amount of adequate soil for use in the landfill construction and operation, potential increases in the groundwater/leachate control requirements, and the limited number of available sites, as well as the fixed geometry of these existing sites.

For this study, we assumed that the pit quarry UWL would have a square footprint and that the ash would be landfilled to a depth of 150 feet. Furthermore, we assumed that the landfill bottom liner would include a 2 feet of compacted clay beneath a 1 foot thick drainage blanket, a 10 foot thick sidewall liner on all four sides, and a soil cap consisting of 1 foot of compacted clay beneath 1 foot of soil suitable for maintaining vegetation. The base cost estimate assumed that all soils were available from the landfill site, and that synthetic (HDPE) bottom and side liners would not be needed. Potential cost additions include the need to import (truck) soils into the site, and the addition of a synthetic bottom liner.

ABOVE GRADE

The primary advantage of and Above Grade landfill is that it can be sited virtually anywhere a relatively flat site is available. The second advantage is that excavation during development of this type of landfill can often generate the soils needed during landfill operations and closing, provided the landfill is sited in an area with a predominantly clay soil mantle. In most cases, construction of an above grade landfill will generate excess cut that is a resource that can be used to fill off-site locations. The geometry of above grade UWLs are less efficient than pit quarries because the regulations require these landfills to be constructed with 4:1 side slopes above grade. Steeper side slopes may be approved by MDNR but only after extensive slope stability analysis. Above grade UWLs will generally require more than twice the land of a pit quarry landfill with the same capacity.

For this study, we assumed that the above grade UWL would have a square footprint and that the ash would be landfilled to 100 feet above surrounding grades. The landfill would be constructed by excavating 10 feet below grade, installing the 2 foot thick compacted clay bottom liner and1-foot thick drainage blanket and then placing the landfill material. The below grade slopes in the excavated portion of the landfill would be 3:1, while the fill slopes above grade would be 4:1. As landfill cells are completed, the area will be capped with 1 foot of compacted clay beneath 1 foot of soil suitable for maintaining vegetation. The base cost estimate assumed that all soils were available from the landfill site, and that a synthetic (HDPE) bottom liner would not be needed. The primary potential cost addition considered in our analysis was the addition of a synthetic bottom liner.

COST ESTIMATES

The costs associated with disposal of ash in a Utility Waste Landfill fall into four main categories: transportation costs, landfill development costs, landfill operation costs and landfill closure costs.

Transportation Cost

Four possible modes of transportation are available for transporting ash from the power plants to a UWL: conveyor, truck, rail and barge. Conveyor transport is only feasible if the UWL is located adjacent to the power plant. Truck transport is generally the least costly alternative for short hauls, while rail and truck may be viable for longer hauls provided the UWLs are located near existing rail lines or major rivers. Substantial infrastructure costs are needed to handle the materials at both the power plant and UWL if the conveyor, rail or barge options are chosen. While trucking will create higher per mile costs, little to no material handling infrastructure is needed for this option.

AmerenUE estimates that it will cost approximately $3 per ton to collect and transport the ash to an off-site landfill location for disposal, provided the landfill site is within 10 miles of the power plant. They estimate that these transportation costs will increase to $4.50 per ton for a landfill between 10 and 20 miles from the generation source. Similar increases can be expected as the landfill sites are moved further away from the ash generation site (power plant). Higher transportation unit prices should also be expected in highly developed, congested areas.

UWL Development Costs

The costs to develop a landfill site include the property purchase cost, landfill development cost, and professional services costs to design and permit the UWL. While a landfill is typically developed in cells over a period of years, our estimate assumes that the entire landfill footprint is developed simultaneously.

The estimated costs to develop both UWL types at each of the four power plants, as well as the cost to develop both types in a single location to accept ash from all four power plants are included in Appendix A. These estimates are based on unit rates in current 2004 dollars. The estimates include the costs to purchase the minimum amount of property needed for the landfill, and are based on unit price estimates provided by AmerenUE's Real-estate Department.

UWL Operating Costs

The costs to operate a UWL site include the costs to unload, place, and compact the ash materials within the landfill; costs to manage and dispose of leachate from the landfill, as well as the costs to monitor groundwater quality outside the landfill as required by the MDNR regulations. These estimated costs assume that the landfill will be open daily and use a unit rate for each cubic yard of ash disposed. If the landfill is managed to be open only periodically when large waste shipments arrive, operating costs should be somewhat reduced.

The annual estimated UWL operating costs are based on unit rates in current 2004 dollars. Inflation costs are not included in the future operating costs. The "Cost per Ton" shown in Table B includes the present value of the annual operating costs over a period 20 years, assuming an annual interest rate of 5%.

<u>UWL Closure Costs</u>

The costs to close a UWL site include the costs to cap and close each site at the end of its 20 year operational life, as well as the costs to monitor and maintain the site during the 20 year post-closure period mandated by MDNR. These closure and post-closure costs are based on unit rates in current 2004 dollars. Inflation costs are not included in the closure costs. The "Cost per Ton" shown in Table B includes the present value of the post closure costs 20 years in the future, plus the closure costs, all discounted to a present cost assuming a 5% annual interest rate over the next 40 years.

<u>Potential Cost Additions</u>

The primary potential cost additions are the costs to import suitable clay soils for landfill liners if not available on-site, and the costs to install a synthetic bottom liner if required by MDNR. Both of these unit costs are based on 2004 dollars without inflation. The "Cost per Ton with Contingencies" in Table B includes the added cost to import soils and install a synthetic liner during original UWL development, plus the additional costs to import soils at closure, discounted to a present cost assuming a 5% annual interest rate.

<u>Summary</u>

The present value costs to permit, construct, operate, and close Utility Waste Landfills for each of the Ameren UE power plants are summarized in Table B. Unit costs per ton of material landfilled have been developed for both pit quarry and above grade UWLs.

While several scenarios were evaluated we would suggest four separate unit prices are used when planning a Utility Waste Landfill:

	Unit cost per ton of material landfilled	
Landfill Type	Meramec	Labadie, Rush Island & Sioux
Pit Quarry UWL using on-site soils	$3.60	$2.40-2.60
Pit Quarry UWL using imported soils	$4.50	$2.90-3.50
Above Grade UWL using on-site soils	$5.60	$2.80-3.10
Above Grade UWL using imported soils	$5.70	$2.80-3.20
Transportation to UWL within 10 miles	$3.00+	$3.00
Transportation to UWL from 10 to 20 miles	$4.50+	$4.50

The total disposal cost (trucking plus landfill cost) to dispose of the ash in a new UWL will range from $6.60 to $10.20 at the Meramec Plant, and $5.40 to $8.00 at all other plants. These costs should be used for planning purposes only, as the quantities and rates used to establish the unit prices were estimates based on 2004 dollars, and the final costs for the UWL are heavily determined by site specific conditions. The higher unit costs for the Meramec Plant were primarily due to the higher land costs and congestion in the vicinity of the plant.

Any questions regrading the content of this report should be directed to Paul H. Reitz, P.E. at Reitz & Jens, Inc.