# Appendix N

## Stormwater Calculations

# Ameren Missouri Labadie Energy Center
# Proposed Utility Waste Landfill
# December 2012

## Appendix N

## STORMWATER DRAINAGE STRUCTURE SUMMARY

10 CSR 80-11.010 (8)(B)1.F.II of the Missouri Solid Waste Management Regulations requires that "On-site drainage structures and channels shall be designed to prevent flow onto the active portion of the utility waste landfill during peak discharge from at least a twenty-five (25)-year storm...." 10 CSR 80-11.010 (8)(B)1.F.III of the Missouri Solid Waste Management Regulations requires that "On-site drainage structures and channels shall be designed to collect and control at least the water volume resulting from a twenty-four (24)-hour, twenty-five (25)-year storm." In this document, the capacities of the stormwater drainage structures are calculated and compared to expected storm flows using the Rational Method equation. Channel design calculations utilized a 1-hour, 25-year storm intensity as the basis for estimating runoff and peak discharge. The 1-hour intensity storm results in a larger peak flow than the 24-hour intensity storm. Pond storage capacity calculations utilized the 24-hour, 25-year storm intensity for the peak design volume.

### Drainage Areas and Flows

To determine the spacing of letdown structure, limits on the grade within the side benches were set. The flow line of the benches were set at a grade of 200H:1V (0.5%), and were limited to a depth of 1.5 feet difference in elevation along the length of the bench. Using those limits, the letdown structures were spaced approximately 600 feet apart, with benches rising away in both directions from each letdown structure. Figure N-1 shows the locations of letdown structures. The first letdown ditch is expected to be built in line with the eastern side of Pond 1 in Cell 1. From this location, letdown structures are numbered proceeding clockwise around the footprint of the landfill. Ponds are located on Figure 1 and are numbered in the order they are expected to be constructed.

Table N-1 is a summary of the letdown structures and is set up to indicate which pond will serve each letdown structure. The letdown structure flows are directed to the nearest pond. Table N-1 lists:

- a location at a letdown structure or pond,
- the distance along the perimeter of the side-slope crest,
- the side slope area below the top of slope which is conservatively assumed to collect in the perimeter ditch at the letdown ditch,
- the side slope area below the top of slope is also assumed to flow into the perimeter ditch through the letdown structure,
- the sum of the total drainage area flowing in the letdown structure,
- the sum of all areas served by the perimeter ditch at and above the letdown structure,
- the flow contributed to the perimeter ditch at each letdown structure, and;
- the cumulative flow in the perimeter ditch at the location of each letdown structure.

The table is set up to allow convenient coordination with the tables estimating the water profiles in the perimeter ditch.

## Capacity

The Rational Method was used to estimate the landfill's runoff. The rational method equation is:

$$Q = CIA$$

Where: Q is the flow rate (cfs)
C is the runoff coefficient (unitless)
I is the rainfall intensity (in/hr)
A is the drainage area (acres)

A runoff coefficient of C=0.4 is used and is considered representative for low to moderate permeability soils with emergent ground cover on steep slopes.

Areas served by side benches and letdowns are expected to be less than 11 acres each. For a 25-yr, 1-hr storm, the expected rainfall is 2.63 in/hr and the anticipated runoff from 11 acres is:

$$Q = 0.4 \text{ X } 2.63 \text{ in/hr X } 11 \text{ ac X } 43{,}560 \text{ ft}^2\text{/ac X } 1 \text{ ft/12 in X } 1 \text{ hr/3,600 s} = 11.67 \text{ cfs}$$

The 25-yr, 1-hr storm intensity (2.63 in/hr) is used as more conservative than the 25-yr, 24-hr storm intensity of 5.6 in. The 24-hr storm intensity would require the flow to be adjusted by dividing by 24 hours; 5.6 in/24 hr. = 0.233 in/hr. The storm intensity table is found in Rainfall Frequency Atlas of the Midwest by Floyd A. Huff and James R. Angel, Table 7 (http://www.sws.uiuc.edu/pubdoc/B/ ISWSB-71.pdf). Capacity for flow was evaluated for top of slope diversion berms, intermediate bench diversion berms (side benches) and letdown structures. The largest flow of 11.67 cfs is also used in Appendix M to test the stability of these structures for erosion during peak flow.

Manning's equation was used to calculate the flow capacity of the three types of drainage features: top of slope diversion berms; intermediate bench diversion berm; and letdown structures. Manning's equation is:

$$Q = (1.49/n)(A)(rH)^{2/3}(s)^{1/2}$$

Where: Q is the flow rate (cfs)
n is Manning's coefficient of roughness (unitless)
A is the drainage area ($ft^2$)
$r_H$ is the hydraulic radius (ft), which equals $A/P_w$, where $P_w$ is the wetted perimeter, and
s is the slope (ft/ft).

Manning's equation is also used to define the water profile in the perimeter ditch.

## Top of Slope Diversion Berms

The purpose of the top of slope diversion berms is to inhibit rill erosion on the upper part of the landfill cap and at the top of the 3:1 slope. Diversion berms are placed on the cap to direct run-off to the letdown structures. The diversion berms are simple mounds of soil constructed as a V-notch channel. The berms are modeled with Manning's equation using a triangular cross-section with side slopes of 3:1 and 50:1 (2%). The following calculation shows the capacity of a berm carrying 0.5 ft. of water with a flow line of one-half percent (0.5%), using a typical n value of .020 for the coefficient of roughness, and an area of 6.63 sq. ft.

$$Q = (1.49/0.020)(6.63)(0.25)^{2/3}(0.005)^{1/2} = 13.9 \text{ cfs} > 11.67 \text{ cfs}$$

This capacity exceeds the flow anticipated at each individual letdown structure shown on Table N-1.

**Intermediate Bench Diversion Berm (Side Benches)**

The intermediate benches are 1.5 ft deep and have a flowline of one-half percent (0.5%). They have a triangular cross-section with side slopes of 10H:1V and 3H:1V. When full, they have a cross-sectional area of 14.625 sq. ft., a wetted perimeter of 19.8 ft and a hydraulic radius of 0.74 ft. The coefficient of roughness is 0.025.

$$Q = (1.49/0.025)(14.625)(0.74)^{2/3}(0.005)^{1/2} = 50.4 \text{ cfs} > 11.67 \text{ cfs}$$

This capacity exceeds the flow anticipated at each individual letdown structure shown on Table N-1.

**Letdown Structure**

The letdowns are 1.5 ft deep and have a maximum flowline slope of 33% (3:1). They have a trapezoidal cross-section with and 8 ft bottom and 3:1 side slopes. When full, they have a cross-sectional area of 18.8 sq. ft., a wetted perimeter of 17.5 ft and a hydraulic radius of 1.1 ft. The typical coefficient of roughness equal to 0.035 was used.

$$Q = (1.49/0.035)(18.8)(1.1)^{2/3}(0.33)^{1/2} = 492 \text{ cfs} > 11.67 \text{ cfs}$$

Table N-1 and Figure N-1 (see attached) show the estimated areas served and the estimated flows from each berm and letdown structure.

**Perimeter Ditch**

Because the perimeter ditch is long and flat and it is expected to flow at a "subcritical" level. Therefore, Manning's equation used alone does not model its capacity well. A combination of Manning's equation and Bernoulli's equation were used to describe the flow in the perimeter ditch. Bernoulli's equation is

$$H = P/\delta + v^2/2g + Z$$

Where: H is the energy measured as depth of water (ft.)
P is the pressure on the water, taken as zero for open systems
$\delta$ is gamma, the unit weight of water (lb/ft$^3$)
v is the velocity of water (fps)
g is the gravity constant (32 fps$^2$)
Z is the elevation of the fluid element (ft.)

Bernoulli's equations were used to estimate the energy at each letdown structure leading to a specific stormwater pond. Manning's equation was used to estimate the slope of the energy line between the letdown structures. The perimeter ditch was broken into sections between letdowns (see Figure N-1). The depth of flow at the structure was adjusted to estimate the slope of the energy line necessary to match the distances between letdown structures or a letdown structure and the center of the entrance into a stormwater pond. The combination of these equations is used to evaluate the length of the perimeter ditch and the assumption of non-uniform flow.

The flow for the landfill, calculated using the rational method as described above, was proportionally divided between each section and is shown as a cumulative value approaching each pond.

An energy balance was applied to each section to determine the head loss and rise in depth. Bernoulli's and Manning's equations were used to calculate the depth of flow and elevation of the water level in the perimeter ditch. The attached tables summarize these calculations and show the estimated water elevations in each section (see Tables N-2 to N-7). Since these ponds are built at different times during the life of the landfill, consideration was given to the stormwater volumes to those ponds as each cell is constructed. The ponds generally serve the following cells:

| | | |
|---|---|---|
| • Pond 1 | Cells 1 and 2 | Tables N-2 and N-3 |
| • Pond 2 | Cells 3 and 4 | Tables N-4 and N-5 |
| • Pond 3 | Cells 3 and 4 | Tables N-6 and N-7 |

Ponds are placed around the Ameren Labadie Energy Center utility waste landfill where space allowed and to minimize the length of flow in the perimeter ditch. The ditch is modeled with a flat bottom width of 9 feet. At a 3:1 slope, two feet (2 ft.) of cover requires 6 feet of the perimeter ditch space. The difference is the placement of soil cover on the initial phases allows for subsequent development of cells without having the amount of infiltration on the caps. The maximum water elevation in the perimeter ditch for all modeled conditions is 485 ft., which is less than the perimeter berm top elevation of 488 ft.

**Stormwater Inlet Crests**

Runoff flow enters the ponds over stormwater inlet crests constructed in the top of the perimeter berm. These inlets were modeled as broad-crested weirs. Vennard suggests estimating the flow over a broad-crested weir by calculating the flow over the unit length of the weir using the following equation:

$$q = (2/3)^{3/2} X\ g^{1/2} X\ E^{3/2}$$

Where: q is the flow per unit width of a broad-crested weir (cfs/ft.)
g is the gravity constant (32 fps2)
E is the height of the energy line calculated for the entrance to the pond (ft.)

Since the constraints are dependent with not only the flow rate going into the stormwater ponds, but also the weir length of the pond, both elements must be considered. The stormwater collection ponds have the following minimum weir lengths at elevation 483 feet:

| | |
|---|---|
| Pond 1: | 217 ft. |
| Pond 2: | 65 ft. |
| Pond 3: | 300 ft. |

The lowest estimated energy grade line coming into any single pond is 0.511 ft. at the influent to Pond 1. Pond 1 has a weir length of 217 ft (see Table N-3). Pond 1 also has the largest design flow at a combined, estimated 69.77 cfs (see Pond 1, Table N-1). Using the equation above, the capacity of the influent structure to Pond 1 is calculated as:

$$Q = (2/3)^{3/2}(32)^{1/2}(0.646)^{3/2} = 1.59 \text{ cfs/ft.}$$

$$1.59 \text{ cfs/ft} * 217 \text{ ft} = 345 \text{ cfs} > 69.77 \text{ cfs}$$

Therefore, the influent structure to Pond 1 has sufficient capacity for the anticipated design flow.

Pond 2 has the shortest weir length, with a weir length of 65 ft. Pond 2 has an estimated energy grade line of 1.064 ft. (see Pond 2, Table N-5). The combined, estimated design flow into Pond 2 is estimated at 50.37 cfs.

$$Q = (2/3)^{3/2}(32)^{1/2}(0.836)^{3/2} = 2.35 \text{ cfs/ft.}$$

$$2.35 \text{ cfs/ft} * 65 \text{ ft} = 152.75 \text{ cfs} > 50.37 \text{ cfs}$$

Therefore, the influent structure to Pond 2 has sufficient capacity for the anticipated design flow.

It is concluded that the influent structures for the stormwater collection ponds have adequate flow capacity based on their respective weir length and the estimated height of energy grade line entering the ponds.

**Stormwater Ponds**

Three stormwater ponds will be placed around the landfill for stormwater runoff storage and management. They are identified as Pond 1, collecting runoff from Cells 1 and 2; Pond 2, collecting runoff from Cells 3 and 4; and Pond 3, collecting runoff from Cells 3 and 4. Tables N-8 through N-10 provide stage-storage data for Ponds 1 through 3, respectively. Run-off volumes were calculated using Rational Method theory (i.e., run-off Volume=CIA, where I = rainfall in total inches). A runoff coefficient of C= 0.4 is considered representative of low to moderate permeability soils with emergent ground cover on steep slopes.

A runoff coefficient of C= 1 is used for the stormwater ponds to reflect that any direct rainfall to the pond surface will accumulate completely to the pond's stored volume.

The following table compiles the estimated, maximum runoff volumes to each pond during the 25-year, 24-hour design storm event of 5.6 inches. These pond volumes were checked to see if this volume is available at each respective pond to contain the design storm:

| | | | | |
|---|---|---|---|---|
| Pond 1 | 5.7 acres | 5.6 in.= 0.47 ft. | c=1 | 2.7 acre-feet |
| Cells 1 and 2 | 66.6 acres | 5.6 in.= 0.47 ft. | c=0.4 | 12.4 acre-feet |
| | | | **Total=** | **15.1 acre-feet** |
| Pond 2 | 4.4 acres | 5.6 in.= 0.47 ft. | c=1 | 2.1 acre-feet |
| Cells 3 and 4 | 47.8 acres | 5.6 in.= 0.47 ft. | c=0.4 | 9.0 acre-feet |
| | | | **Total=** | **11.1 acre-feet** |
| Pond 3 | 3.4 acres | 5.6 in.= 0.47 ft. | c=1 | 1.6 acre-feet |
| Cells 3 and 4 | 52.1 acres | 5.6 in.= 0.47 ft. | c=0.4 | 9.8 acre-feet |
| | | | **Total=** | **11.4 acre-feet** |

The ponds have been designed with an inlet spillway elevation of 483 feet, and are to be maintained at a minimum 3 foot depth (water surface elevation of approximately 471 feet) to inhibit aquatic vegetation. Based on the stage-storage data found in Tables N-8, N-9 and N-10, the following initial maximum water surface elevations have been determined for each pond that represents the 25-year, 24-hour storm runoff volume. All maximum water elevations are well below a water surface elevation of 483 feet, which is the elevation of the bottom of the perimeter ditch. Therefore, if properly managed, the ponds have excess capacity for the anticipated 25-year, 24-hour storm runoff volume.

| Respective Pond | Min Elevation (ft.) | Max Elevation (ft.) | Corresponding Table |
|---|---|---|---|
| Pond 1 | 471 | 478 | N-8 |
| Pond 2 | 471 | 480 | N-9 |
| Pond 3 | 471 | 477 | N-10 |

**Temporary Perimeter Ditch Crossings**

As phased construction proceeds, the UWL operator may elect to retain interior berms and their top-of-berm roads during subsequent UWL phases. If interior berms are retained, it will be necessary to provide culverts through the intermediate berms at their intersection with the perimeter ditches. Preliminary culvert sizes have been estimates based on the arrangement of letdown ditches and ponds described by the previous discussion. For the purposes of these preliminary size estimates, we have assumed inlet control and one foot of headwater at the culvert inlets. These culvert sizes were estimated using standard hydraulic charts and equations, and the 25-year, 1-hour design storm event (2.63 in/hr).

| Culvert System | Letdown(s) | Accumulative Max. Flow (cfs) | Recommended Culvert Diameter (in.) |
|---|---|---|---|
| East Culvert-Cells 1 and 2 | 4,5,6,7 | 22.01 | 30 |
| West Culvert-Cells 1 and 2 | 7,8,9,10 | 26.22 | 36 |
| East Culvert-Cells 3 and 4 | 17 | 6.69 | 15 |
| West Culvert-Cells 3 and 4 | 25,26 | 14.62 | 24 |

# TABLES

| Ameren Labadie Energy Center Utility Waste Landfill<br>Area and Flow At Each Letdown Structure<br>25-yr, 1-hr Event<br>Table N-1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location | Distance | Side Slope Area | Top Area | Total Area | Total Area | Cumulative Area | Flow | |
| | (ft) | (ac) | (ac) | (sf) | (ac) | (ac) | in letdown, (cfs) | accumulative, (cfs) |
| LETDOWNS 1-11 (Cells 1 & 2)<br>Flow to Pond 1<br>Rotating Clockwise from East Side of Outlet Pond 1 | | | | | | | | |
| Letdown 2 | 500 | 2.17 | 1.89 | 176796 | 4.06 | 4.06 | 4.31 | 35.00 |
| Letdown 3 | 940 | 2.75 | 5.42 | 356250 | 8.18 | 12.24 | 8.68 | 30.69 |
| Letdown 4 | 1450 | 2.11 | 3.14 | 228750 | 5.25 | 17.49 | 5.57 | 22.02 |
| Letdown 5 | 1850 | 2.73 | 1.40 | 180000 | 4.13 | 21.62 | 4.38 | 16.45 |
| Letdown 6 | 2500 | 2.51 | 1.91 | 192500 | 4.42 | 26.04 | 4.69 | 12.06 |
| Letdown 7 | 3000 | 2.53 | 4.42 | 302813 | 6.95 | 32.99 | 7.37 | 7.37 |
| Flow to Pond 1 | | | | | | | | |
| Rotating Counter Clockwise from East Side of Outlet Pond 1 | | | | | | | | |
| Letdown 1 | 220 | 4.19 | 2.48 | 290400 | 6.67 | 6.67 | 7.07 | 34.77 |
| Letdown 11 | 1020 | 4.19 | 4.15 | 363281 | 8.34 | 15.01 | 8.85 | 27.70 |
| Letdown 10 | 1550 | 2.48 | 4.82 | 317813 | 7.30 | 22.30 | 7.74 | 18.85 |
| Letdown 9 | 1950 | 3.80 | 2.97 | 295000 | 6.77 | 29.07 | 7.18 | 11.11 |
| Letdown 8 | 2920 | 2.59 | 1.11 | 161250 | 3.70 | 32.78 | 3.93 | 3.93 |
| LETDOWNS 12-29 (Cells 3 & 4)<br>Flow to Pond 3<br>Rotating Clockwise from East side of Pond 3 | | | | | | | | |
| Letdown 14 | 0 | 3.24 | 2.85 | 265200 | 6.09 | 6.09 | 6.46 | 18.61 |
| Letdown 15 | 500 | 2.81 | 2.81 | 244400 | 5.61 | 11.70 | 5.95 | 12.16 |
| Letdown 16 | 950 | 2.81 | 3.04 | 254800 | 5.85 | 17.55 | 6.20 | 6.20 |
| Flow to Pond 2 | | | | | | | | |
| Rotating Counter-Clockwise from West side of Outlet Pond 2 | | | | | | | | |
| Letdown 18 | 860 | 4.82 | 2.18 | 305000 | 7.00 | 7.00 | 7.43 | 14.12 |
| Letdown 17 | 1360 | 2.81 | 3.50 | 274860 | 6.31 | 13.31 | 6.69 | 6.69 |
| Flow to Pond 2<br>Rotating Clockwise from East side of Outlet Pond 2 | | | | | | | | |
| Letdown 19 | 600 | 4.53 | 1.42 | 259200 | 5.95 | 5.95 | 6.31 | 36.25 |
| Letdown 20 | 1100 | 2.87 | 4.99 | 342300 | 7.86 | 13.81 | 8.34 | 29.94 |
| Letdown 21 | 1600 | 2.87 | 1.03 | 170000 | 3.90 | 17.71 | 4.14 | 21.60 |
| Letdown 22 | 2100 | 2.87 | 1.26 | 180000 | 4.13 | 21.84 | 4.38 | 17.46 |
| Letdown 23 | 2600 | 3.46 | 0.09 | 154800 | 3.55 | 25.40 | 3.77 | 13.08 |
| Letdown 24 | 3040 | 5.17 | 0.53 | 248000 | 5.69 | 31.09 | 6.04 | 9.31 |
| Letdown 25 | 3790 | 2.70 | 3.47 | 268600 | 6.17 | 33.82 | 6.54 | 3.27 |
| Flow to Pond 3<br>Rotating Counter-Clockwise from East-Side of Outlet Pond 3 | | | | | | | | |
| Letdown 13 | 320 | 1.32 | 0.22 | 67200 | 1.54 | 1.54 | 1.64 | 32.61 |
| Letdown 12 | 960 | 3.40 | 1.32 | 205900 | 4.73 | 6.27 | 5.01 | 30.97 |
| Letdown 29 | 1780 | 2.70 | 1.21 | 170000 | 3.90 | 10.17 | 4.14 | 25.96 |
| Letdown 28 | 2240 | 2.53 | 2.53 | 220000 | 5.05 | 15.22 | 5.36 | 21.82 |
| Letdown 27 | 2640 | 2.41 | 2.41 | 210000 | 4.82 | 20.04 | 5.11 | 16.46 |
| Letdown 26 | 3120 | 1.89 | 5.72 | 331600 | 7.61 | 27.66 | 8.08 | 11.35 |
| Letdown 25 | 3330 | 2.70 | 3.47 | 268600 | 6.17 | 33.82 | 6.54 | 3.27 |

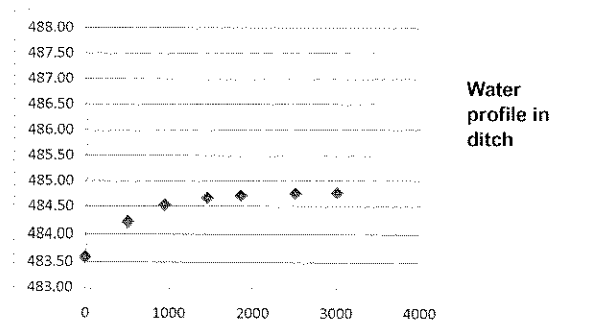
| Inputs | 25-yr, 1-hr storm | |
|---|---|---|
| Intensity | 2.63 | in |
| C Factor | 0.4 | unitless |

# Ameren Labadie Energy Center Utility Waste Landfill
## Perimeter Ditch Water Profile: 25-yr, 1-hr event
## Elevation for Stated Flow
## Clockwise from Pond 1
## Table N-2

| | | | $S_{s,left}$ = 3 | | $S_{s,right}$ = 3 | | Base Width (ft) = 9 | | Mannings N = 0.02 | | So (ft) = 0 | | Runoff Factor for 2.63 in/ hr rainfall= 0.017 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation | Depth | Channel Bottom Elevation | Slope of Water Surface | Adjusted Base | Adjusted Height | Area | Velocity | $v^2/2g$ | Specific Energy | Hydraulic Radius | Slope | S-So | Distance | Total Distance | True Distance | Location | Distance from Culvert | Q |
| | | | | | | | Average Velocity | | Change in Specfic Energy | Average Hydraulic Radius | | | | | | | | |
| (ft) | (ft) | (ft) | (ft/ft) | (ft) | (ft) | (sf) | (fps) | (ft) | (ft) | (ft) | (ft/ft) | (ft/ft) | (ft) | (ft) | (ft) | | (ft) | (cfs) |
| 483.59 | 0.59 | 483 | | | | 6.35 | 1.898 | 0.0560 | 0.646 | 0.499 | | | | 0 | 0 | Pond 1 | 0 | 12.06 |
| | 0.63 | | 0.0011928 | | | | 2.082 | | 0.654 | 0.712 | 1.24E-03 | 1.24E-03 | 528 | 528 | | | | |
| 484.22 | 1.22 | 483 | | 9.00 | 1.2200 | 15.45 | 2.266 | 0.0797 | 1.300 | 0.924 | | | | | 500 | Letdown 2 | 500 | 35.00 |
| | 0.31 | | 0.0007271 | | | | 1.871 | | 0.264 | 1.019 | 6.19E-04 | 6.19E-04 | 426 | 955 | | | | |
| 484.53 | 1.53 | 483 | | 9.00 | 1.5300 | 20.79 | 1.476 | 0.0338 | 1.564 | 1.113 | | | | | 940 | Letdown 3 | 940 | 30.69 |
| | 0.13 | | 0.0002606 | | | | 1.212 | | 0.110 | 1.152 | 2.21E-04 | 2.21E-04 | 499 | 1453 | | | | |
| 484.66 | 1.66 | 483 | | 9.00 | 1.6600 | 23.21 | 0.949 | 0.0140 | 1.674 | 1.190 | | | | | 1450 | Letdown 4 | 1450 | 22.02 |
| | 0.04 | | 0.0001138 | | | | 0.817 | | 0.033 | 1.202 | 9.48E-05 | 9.48E-05 | 351 | 1805 | | | | |
| 484.70 | 1.70 | 483 | | 9.00 | 1.7000 | 23.97 | 0.686 | 0.0073 | 1.707 | 1.214 | | | | | 1850 | Letdown 5 | 1850 | 16.45 |
| | 0.04 | | 5.238E-05 | | | | 0.587 | | 0.036 | 1.225 | 4.76E-05 | 4.76E-05 | 764 | 2568 | | | | |
| 484.74 | 1.74 | 483 | | 9.00 | 1.7400 | 24.74 | 0.487 | 0.0037 | 1.744 | 1.237 | | | | | 2500 | Letdown 6 | 2500 | 12.06 |
| | 0.01 | | 2.724E-05 | | | | 0.392 | | 0.008 | 1.240 | 2.09E-05 | 2.09E-05 | 367 | 2936 | | | | |
| 484.75 | 1.75 | 483 | | 9.00 | 1.7500 | 24.94 | 0.296 | 0.0014 | 1.751 | 1.243 | | | | | 3000 | Letdown 7 | 3000 | 7.37 |

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.

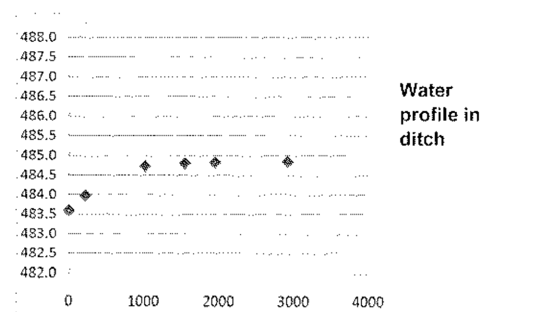


# Ameren Labadie Energy Center Utility Waste Landfill
## Perimeter Ditch Water Profile: 25-yr, 1-hr event
## Elevation for Stated Flow
## Counter Clockwise from Pond 1
## Table N-3

| | | | $S_{s,left}$ = 3 | | $S_{s,right}$ = 3 | | Base Width (ft) = | 9 | Mannings N = 0.02 | | So (ft) = 0 | | Runoff Factor for 2.63 in/ hr rainfall= | | | 0.017 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation | Depth | Channel Bottom Elevation | Slope of Water Surface | Adjusted Base | Adjusted Height | Area | Velocity | $v^2/2g$ | Specific Energy | Hydraulic Radius | Slope | S-So | Distance | Total Distance | True Distance | Location | Distance from Culvert | Q |
| | | | | | | | Average Velocity | | Change in Specfic Energy | Average Hydraulic Radius | | | | | | | | |
| (ft) | (ft) | (ft) | (ft/ft) | (ft) | (ft) | (sf) | (fps) | (ft) | (ft) | (ft) | (ft/ft) | (ft/ft) | (ft) | (ft) | (ft) | | (ft) | (cfs) |
| 483.59 | 0.59 | 483 | | | | 6.35 | 1.898 | 0 0560 | 0.646 | 0.499 | | | | 0 | 0 | Pond 1 | 0 | 12.06 |
| | 0.37 | | 0.0016659 | | | | 2.473 | | 0.458 | 0.628 | 2.06E-03 | 2.06E-03 | 222 | 222 | | | | |
| 483.96 | 0.96 | 483 | | 9.00 | 0.9600 | 11.40 | 3.049 | 0.1443 | 1.104 | 0.757 | | | | | 220 | Letdown 1 | 220 | 34.77 |
| | 0.76 | | 0.0009613 | | | | 2.093 | | 0.636 | 0.991 | 8.04E-04 | 8.04E-04 | 791 | 1013 | | | | |
| 484.72 | 1.72 | 483 | | 9.00 | 1.7200 | 24.36 | 1.137 | 0.0201 | 1.740 | 1.225 | | | | | 1020 | Letdown 11 | 1020 | 27.70 |
| | 0.07 | | 0.0001422 | | | | 0.935 | | 0.058 | 1.246 | 1.18E-04 | 1.18E-04 | 492 | 1505 | | | | |
| 484.79 | 1.79 | 483 | | 9.00 | 1.7900 | 25.72 | 0.733 | 0.0083 | 1.798 | 1.266 | | | | | 1550 | Letdown 10 | 1550 | 18.85 |
| | 0.03 | | 5.652E-05 | | | | 0.578 | | 0.019 | 1.273 | 4.40E-05 | 4.40E-05 | 442 | 1947 | | | | |
| 484.82 | 1.82 | 483 | | 9.00 | 1.8150 | 26.22 | 0.424 | 0.0028 | 1.818 | 1.280 | | | | | 1950 | Letdown 9 | 1950 | 11.11 |
| | 0.02 | | 1.269E-05 | | | | 0.286 | | 0.013 | 1.285 | 1.06E-05 | 1.06E-05 | 1182 | 3129 | | | | |
| 484.83 | 1.83 | 483 | | 9.00 | 1.8300 | 26.52 | 0.148 | 0.0003 | 1.830 | 1.289 | | | | | 2920 | Letdown 8 | 2920 | 3.93 |

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.




Prepared by Gredell
Engineering Resources, Inc.

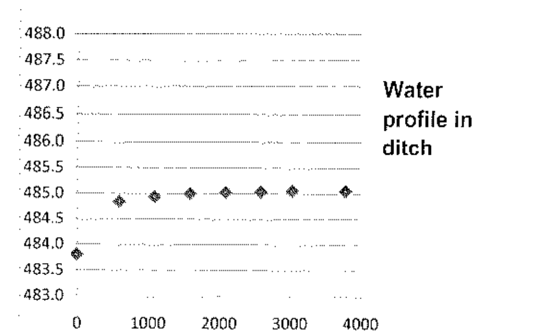
December 2012

# Ameren Labadie Energy Center Utility Waste Landfill
## Perimeter Ditch Water Profile: 25-yr, 1-hr event
## Elevation for Stated Flow
## Clockwise from Pond 2
## Table N-4

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $S_{s,left}$ = 3 | | $S_{s,right}$ = 3 | | Base Width (ft) = 9 | | Mannings N = 0.02 | | So (ft) = 0 | | Runoff Factor for 2.63 in/ hr rainfall= 0.017 | | | | | |
| Elevation | Depth | Channel Bottom Elevation | Slope of Water Surface | Adjusted Base | Adjusted Height | Area | Velocity | $v^2/2g$ | Specific Energy | Hydraulic Radius | Slope | S-So | Distance | Total Distance | True Distance | Location | Distance from Culvert | Q |
| | | | | | | | Average Velocity | | Change in Specfic Energy | Average Hydraulic Radius | | | | | | | | |
| (ft) | (ft) | (ft) | (ft/ft) | (ft) | (ft) | (sf) | (fps) | (ft) | (ft) | (ft) | (ft/ft) | (ft/ft) | (ft) | (ft) | (ft) | | (ft) | (cfs) |
| 483.80 | 0.80 | 483 | | | | 9.12 | 3.975 | 0.2453 | 1.045 | 0.649 | | | | 0 | 0 | Pond 2 | 0 | 36.3 |
| | 1.03 | | 0.001709 | | | | 2.671 | | 0.814 | 0.969 | 1.35E-03 | 1.35E-03 | 603 | 603 | 600 | | | |
| 484.83 | 1.83 | 483 | | 9.00 | 1.8300 | 26.52 | 1.367 | 0.0290 | 1.859 | 1.289 | | | | | | Letdown 19 | 600 | 36.3 |
| | 0.10 | | 0.000208 | | | | 1.208 | | 0.088 | 1.317 | 1.83E-04 | 1.83E-04 | 481 | 1083 | 1100 | | | |
| 484.93 | 1.93 | 483 | | 9.00 | 1.9300 | 28.54 | 1.049 | 0.0171 | 1.947 | 1.346 | | | | | | Letdown 20 | 1100 | 29.9 |
| | 0.06 | | 0.000111 | | | | 0.887 | | 0.051 | 1.363 | 9.44E-05 | 9.44E-05 | 541 | 1624 | 1600 | | | |
| 484.99 | 1.99 | 483 | | 9.00 | 1.9900 | 29.79 | 0.725 | 0.0082 | 1.998 | 1.380 | | | | | | Letdown 21 | 1600 | 21.6 |
| | 0.03 | | 5.5E-05 | | | | 0.650 | | 0.027 | 1.389 | 4.94E-05 | 4.94E-05 | 545 | 2170 | 2100 | | | |
| 485.02 | 2.02 | 483 | | 9.00 | 2.0200 | 30.42 | 0.574 | 0.0051 | 2.025 | 1.397 | | | | | | Letdown 22 | 2100 | 17.5 |
| | 0.01 | | 3.76E-05 | | | | 0.501 | | 0.008 | 1.400 | 2.90E-05 | 2.90E-05 | 266 | 2436 | 2600 | | | |
| 485.03 | 2.03 | 483 | | 9.00 | 2.0300 | 30.63 | 0.427 | 0.0028 | 2.033 | 1.403 | | | | | | Letdown 23 | 2600 | 13.1 |
| | 0.02 | | 1.68E-05 | | | | 0.364 | | 0.014 | 1.407 | 1.52E-05 | 1.52E-05 | 891 | 3327 | 3040 | | | |
| 485.05 | 2.05 | 483 | | 9.00 | 2.0450 | 30.95 | 0.301 | 0.0014 | 2.046 | 1.411 | | | | | | Letdown 24 | 3040 | 9.3 |
| | 0.00 | | 5.91E-06 | | | | 0.150 | | 0.001 | 1.412 | 2.59E-06 | 2.59E-06 | 423 | 3749 | 3790 | | | |
| 485.05 | 2.05 | 483 | | 9.00 | 2.0475 | 31.00 | 0.000 | 0.0000 | 2.048 | 1.413 | | | | | | Letdown 25 | 3790 | 3.3 |

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.




Prepared by Gredell Engineering Resources, Inc.

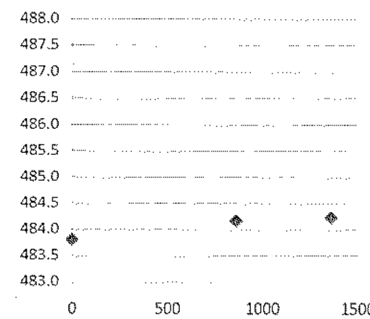
December 2012

# Ameren Labadie Energy Center Utility Waste Landfill
## Perimeter Ditch Water Profile: 25-yr, 1-hr event
## Elevation for Stated Flow
## Counter Clockwise from Pond 2
## Table N-5

| | | | $S_{s,left}$ = 3 | | $S_{s,right}$ = 3 | | Base Width (ft) = 9 | | Mannings N = 0.02 | | So (ft) = 0 | | Runoff Factor for 2.63 in/ hr rainfall= 0.017 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation | Depth | Channel Bottom Elevation | Slope of Water Surface | Adjusted Base | Adjusted Height | Area | Velocity | $v^2/2g$ | Specific Energy | Hydraulic Radius | Slope | S-So | Distance | Total Distance | True Distance | Location | Distance from Culvert | Q |
| | | | | | | | Average Velocity | | Change in Specfic Energy | Average Hydraulic Radius | | | | | | | | |
| (ft) | (ft) | (ft) | (ft/ft) | (ft) | (ft) | (sf) | (fps) | (ft) | (ft) | (ft) | (ft/ft) | (ft/ft) | (ft) | (ft) | (ft) | | (ft) | (cfs) |
| 483.80 | 0.80 | 483 | | | | 9.12 | 1.530 | 0.0363 | 0.836 | 0.649 | | | | 0 | 0 | Pond 2 | 0 | 14 |
| | 0.36 | | 0.000431 | | | | 1.253 | | 0.338 | 0.767 | 4.05E-04 | 4.05E-04 | 836 | 836 | 860 | | | |
| 484.16 | 1.16 | 483 | | 9.00 | 1.1600 | 14.48 | 0.975 | 0.0148 | 1.175 | 0.886 | | | | | | Letdown 18 | 860 | 14 |
| | 0.06 | | 0.000128 | | | | 0.704 | | 0.048 | 0.905 | 1.03E-04 | 1.03E-04 | 468 | 1304 | 1360 | | | |
| 484.22 | 1.22 | 483 | | 9.00 | 1.2200 | 15.45 | 0.433 | 0.0029 | 1.223 | 0.924 | | | | | | Letdown 17 | 1360 | 7 |

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.



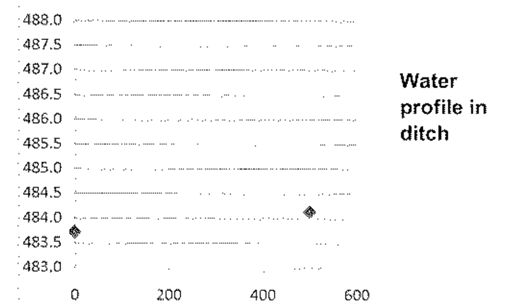

Water profile in ditch

# Ameren Labadie Energy Center Utility Waste Landfill
## Perimeter Ditch Water Profile: 25-yr, 1-hr event
## Elevation for Stated Flow
## Clockwise from Pond 3
## Table N-6

| | | | $S_{s,left}$ = 3 | | $S_{s,right}$ = 3 | | Base Width (ft) = 9 | | Mannings N = 0.02 | | So (ft) = 0 | | Runoff Factor for 2.63 in/ hr rainfall= 0.017 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation | Depth | Channel Bottom Elevation | Slope of Water Surface | Adjusted Base | Adjusted Height | Area | Velocity | $v^2/2g$ | Specific Energy | Hydraulic Radius | Slope | S-So | Distance | Total Distance | True Distance | Location | Distance from Culvert | Q |
| | | | | | | | Average Velocity | | Change in Specfic Energy | Average Hydraulic Radius | | | | | | | | |
| (ft) | (ft) | (ft) | (ft/ft) | (ft) | (ft) | (sf) | (fps) | (ft) | (ft) | (ft) | (ft/ft) | (ft/ft) | (ft) | (ft) | (ft) | | (ft) | (cfs) |
| 483.72 | 0.72 | 483 | | | | 8.04 | 1.742 | 0.0471 | 0.767 | 0.593 | | | | 0 | 0 | Pond 3 | 0 | 14 |
| | 0.00 | | 0 | | | | 2.029 | | 0.036 | 0.593 | 1.50E-03 | 1.50E-03 | 24 | 24 | 0 | | | |
| 483.72 | 0.72 | 483 | | 9.00 | 0.7200 | 8.04 | 2.317 | 0.0833 | 0.803 | 0.593 | | | | | | Letdown 14 | 0 | 19 |
| | 0.41 | | 0.000848 | | | | 1.592 | | 0.338 | 0.730 | 7.00E-04 | 7.00E-04 | 483 | 508 | 500 | | | |
| 484.13 | 1.13 | 483 | | 9.00 | 1.1300 | 14.00 | 0.868 | 0.0117 | 1.142 | 0.867 | | | | | | Letdown 15 | 500 | 12 |

Notes:

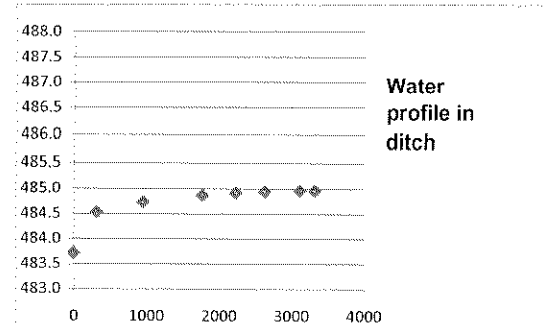
1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.



# Ameren Labadie Energy Center Utility Waste Landfill
## Perimeter Ditch Water Profile: 25-yr, 1-hr event
## Elevation for Stated Flow
## Counter Clockwise from Pond 3
## Table N-7

| | | | $S_{s,left}$ = 3 | | $S_{s,right}$ = 3 | | Base Width (ft) = | 9 | Mannings N = 0.02 | | So (ft) = 0 | | Runoff Factor for 2.63 in/ hr rainfall= | | 0.017 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation | Depth | Channel Bottom Elevation | Slope of Water Surface | Adjusted Base | Adjusted Height | Area | Velocity | $v^2/2g$ | Specific Energy | Hydraulic Radius | Slope | S-So | Distance | Total Distance | True Distance | Location | Distance from Culvert | Q |
| | | | | | | | Average Velocity | | Change in Specific Energy | Average Hydraulic Radius | | | | | | | | |
| (ft) | (ft) | (ft) | (ft/ft) | (ft) | (ft) | (sf) | (fps) | (ft) | (ft) | (ft) | (ft/ft) | (ft/ft) | (ft) | (ft) | (ft) | | (ft) | (cfs) |
| 483.72 | 0.72 | 483 | | | | 8.04 | 4.058 | 0.2557 | 0.976 | 0.593 | | | | 0 | 0 | Pond 3 | 0 | 32.61 |
| | 0.81 | | 0.0024 | | | | 2.813 | | 0.592 | 0.853 | 1.77E-03 | 1.77E-03 | 334 | 334 | 320 | | | |
| 484.53 | 1.53 | 483 | | 9.00 | 1.5300 | 20.79 | 1.568 | 0.0382 | 1.568 | 1.113 | | | | | | Letdown 13 | 320 | 32.61 |
| | 0.20 | | 0.0003 | | | | 1.415 | | 0.187 | 1.172 | 2.94E-04 | 2.94E-04 | 635 | 969 | 960 | | | |
| 484.73 | 1.73 | 483 | | 9.00 | 1.7300 | 24.55 | 1.262 | 0.0247 | 1.755 | 1.231 | | | | | | Letdown 12 | 960 | 30.97 |
| | 0.14 | | 0.0002 | | | | 1.106 | | 0.129 | 1.271 | 1.61E-04 | 1.61E-04 | 803 | 1772 | 1780 | | | |
| 484.87 | 1.87 | 483 | | 9.00 | 1.8700 | 27.32 | 0.950 | 0.0140 | 1.884 | 1.312 | | | | | | Letdown 29 | 1780 | 25.96 |
| | 0.05 | | 0.0001 | | | | 0.860 | | 0.045 | 1.326 | 9.21E-05 | 9.21E-05 | 491 | 2262 | 2240 | | | |
| 484.92 | 1.92 | 483 | | 9.00 | 1.9200 | 28.34 | 0.770 | 0.0092 | 1.929 | 1.340 | | | | | | Letdown 28 | 2240 | 21.82 |
| | 0.03 | | 7E-05 | | | | 0.670 | | 0.021 | 1.347 | 5.47E-05 | 5.47E-05 | 381 | 2643 | 2640 | | | |
| 484.95 | 1.95 | 483 | | 9.00 | 1.9450 | 28.85 | 0.570 | 0.0051 | 1.950 | 1.355 | | | | | | Letdown 27 | 2640 | 16.46 |
| | 0.02 | | 3E-05 | | | | 0.480 | | 0.013 | 1.359 | 2.77E-05 | 2.77E-05 | 480 | 3123 | 3120 | | | |
| 484.96 | 1.96 | 483 | | 9.00 | 1.9610 | 29.19 | 0.389 | 0.0023 | 1.963 | 1.364 | | | | | | Letdown 26 | 3120 | 11.35 |
| | 0.00 | | 2E-05 | | | | 0.250 | | 0.002 | 1.365 | 7.50E-06 | 7.50E-06 | 246 | 3369 | 3330 | | | |
| 484.97 | 1.97 | 483 | | 9.00 | 1.9650 | 29.27 | 0.112 | 0.0002 | 1.965 | 1.366 | | | | | | Letdown 25 | 3330 | 3.27 |

Notes:
1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.



## Ameren Labadie Energy Center Utility Waste Landfill
## Stormwater Management Pond 1
## Pond Volume Calculations
## Table N-8

| | |
|---|---|
| Base Width of Pond in feet | 373 |
| Base Length of Pond in feet | 573 |
| Rise of Slope in feet | 1 |
| Run of Slope in feet | 3 |

| WIDTH (FT) | LENGTH | WATER LEVEL (FT) | AVERAGE AREA (SQ FT) | VOLUME PER INCREMENT (VOL/FT) | TOTAL VOLUME OF POND (CU FT) | TOTAL VOLUME OF POND (ACRE FEET) | CAPACITY IN USE (ACRE FEET | REMAINING CAPACITY (ACRE FEET) | Elevation (FEET) |
|---|---|---|---|---|---|---|---|---|---|
| 373 | 573 | | | | | | | | 468 |
| 379 | 579 | 1 | 108,293 | 108,293 | 108,293 | 2.5 | ----- | ----- | 469 |
| 385 | 585 | 2 | 111,167 | 111,167 | 219,459 | 5.0 | ----- | ----- | 470 |
| 391 | 591 | 3 | 114,077 | 114,077 | 333,536 | 7.7 | ----- | ----- | 471 |
| 397 | 597 | 4 | 117,023 | 117,023 | 450,558 | 10.3 | 0.0 | 34.3 | 472 |
| 403 | 603 | 5 | 120,005 | 120,005 | 570,563 | 13.1 | 2.8 | 31.5 | 473 |
| 409 | 609 | 6 | 123,023 | 123,023 | 693,585 | 15.9 | 5.6 | 28.7 | 474 |
| 415 | 615 | 7 | 126,077 | 126,077 | 819,662 | 18.8 | 8.5 | 25.8 | 475 |
| 421 | 621 | 8 | 129,167 | 129,167 | 948,828 | 21.8 | 11.4 | 22.8 | 476 |
| 427 | 627 | 9 | 132,293 | 132,293 | 1,081,121 | 24.8 | 14.5 | 19.8 | 477 |
| 433 | 633 | 10 | 135,455 | 135,455 | 1,216,575 | 27.9 | 17.6 | 16.7 | 478 |
| 439 | 639 | 11 | 138,653 | 138,653 | 1,355,228 | 31.1 | 20.8 | 13.5 | 479 |
| 445 | 645 | 12 | 141,887 | 141,887 | 1,497,114 | 34.4 | 24.0 | 10.2 | 480 |
| 451 | 651 | 13 | 145,157 | 145,157 | 1,642,271 | 37.7 | 27.4 | 6.9 | 481 |
| 457 | 657 | 14 | 148,463 | 148,463 | 1,790,733 | 41.1 | 30.8 | 3.5 | 482 |
| 463 | 663 | 15 | 151,805 | 151,805 | 1,942,538 | 44.6 | 34.3 | 0.0 | 483 |
| 469 | 669 | 16 | 155,183 | 155,183 | 2,097,720 | 48.2 | 37.8 | | 484 |

NOTES:

1. The table is valid for a triangular pond with a uniform interior side slope.
2. The table utilizes the 'end area method' of volume estimation utilizing the area of each one foot increment of pond depth, beginning at the bottom.
3. The volume due to the bottom slope below the 468 feet elevation was not considered in the capacity volume calculations. A minimum depth of three feet in the pond bottom is planned at all times.
4. The upper three feet of the pond are not counted in the capacity volume calculations due to the need to maintain a minimum freeboard to prevent wave damage above the maximum water level at all times.

Elevation:

| | | |
|---|---|---|
| 468 | Pond Bottom | |
| 471 | Minimum working depth | Three feet of water to prevent growth of objectionable vegetation. |
| 483 | Reserve for storm | 25 year, 24 hour storm event. |
| 484 | Maximum high water | Three feet below emergency spillway. |
| 487 | Flood protection elevation | Height of emergency spillway. |

[1] Rainfall intensities are from RAINFALL FREQUENCY ATLAS OF THE MIDWEST by Floyd A. Huff and James R. Angel, Midwestern Climate Center, 1992, http://www.sws.uiuc.edu/pubdoc/B/ISWSB-71.pdf

## Ameren Labadie Energy Center Utility Waste Landfill
## Stormwater Management Pond 2
## Pond Volume Calculations
## Table N-9

| | |
|---|---|
| Base Width of Pond in feet | 144 |
| Base Length of Pond in feet | 714 |
| Rise of Slope in feet | 1 |
| Run of Slope in feet | 3 |

| WIDTH (FT) | LENGTH | WATER LEVEL (FT) | AVERAGE AREA (SQ FT) | VOLUME PER INCREMENT (VOL/FT) | TOTAL VOLUME OF POND (CU FT) | TOTAL VOLUME OF POND (ACRE FEET) | CAPACITY IN USE (ACRE FEET | REMAINING CAPACITY (ACRE FEET) | Elevation (FEET) |
|---|---|---|---|---|---|---|---|---|---|
| 144 | 714 | | | | | | | | 468 |
| 150 | 720 | 1 | 105,408 | 105,408 | 105,408 | 2.4 | ----- | ----- | 469 |
| 156 | 726 | 2 | 110,628 | 110,628 | 216,036 | 5.0 | ----- | ----- | 470 |
| 162 | 732 | 3 | 115,920 | 115,920 | 331,956 | 7.6 | 0.0 | 42.0 | 471 |
| 168 | 738 | 4 | 121,284 | 121,284 | 453,240 | 10.4 | 2.8 | 39.2 | 472 |
| 174 | 744 | 5 | 126,720 | 126,720 | 579,960 | 13.3 | 5.7 | 36.3 | 473 |
| 180 | 750 | 6 | 132,228 | 132,228 | 712,188 | 16.3 | 8.7 | 33.3 | 474 |
| 186 | 756 | 7 | 137,808 | 137,808 | 849,996 | 19.5 | 11.9 | 30.1 | 475 |
| 192 | 762 | 8 | 143,460 | 143,460 | 993,456 | 22.8 | 15.2 | 26.8 | 476 |
| 198 | 768 | 9 | 149,184 | 149,184 | 1,142,640 | 26.2 | 18.6 | 23.4 | 477 |
| 204 | 774 | 10 | 154,980 | 154,980 | 1,297,620 | 29.8 | 22.2 | 19.8 | 478 |
| 210 | 780 | 11 | 160,848 | 160,848 | 1,458,468 | 33.5 | 25.9 | 16.2 | 479 |
| 216 | 786 | 12 | 166,788 | 166,788 | 1,625,256 | 37.3 | 29.7 | 12.3 | 480 |
| 222 | 792 | 13 | 172,800 | 172,800 | 1,798,056 | 41.3 | 33.7 | 8.4 | 481 |
| 228 | 798 | 14 | 178,884 | 178,884 | 1,976,940 | 45.4 | 37.8 | 4.2 | 482 |
| 234 | 804 | 15 | 185,040 | 185,040 | 2,161,980 | 49.6 | 42.0 | 0.0 | 483 |
| 240 | 810 | 16 | 191,268 | 191,268 | 2,353,248 | 54.0 | 46.4 | | 484 |

NOTES.
1. The table is valid for a rectangular pond with a uniform interior side slope.
2. The table utilizes the 'end area method' of volume estimation utilizing the area of each one foot increment of pond depth, beginning at the bottom.
3. The volume due to the bottom slope below the 468 feet elevation was not considered in the capacity volume calculations. A minimum depth of three feet in the pond bottom is planned at all times.
4. The upper three feet of the pond are not counted in the capacity volume calculations due to the need to maintain a minimum freeboard to prevent wave damage above the maximum water level at all times.

Elevation:

| | | |
|---|---|---|
| 468 | Pond Bottom | |
| 471 | Minimum working depth | Three feet of water to prevent growth of objectionable vegetation. |
| 483 | Reserve for storm | 25 year, 24 hour storm event. |
| 484 | Maximum high water | Three feet below emergency spillway. |
| 487 | Flood protection elevation | Height of emergency spillway. |

[1] Rainfall intensities are from RAINFALL FREQUENCY ATLAS OF THE MIDWEST by Floyd A. Huff and James R. Angel, Midwestern Climate Center, 1992, http://www.sws.uiuc.edu/pubdoc/B/ISWSB-71.pdf

## Ameren Labadie Energy Center Utility Waste Landfill
## Stormwater Management Pond 3
## Pond Volume Calculations
## Table N-10

| | |
|---|---|
| **Base Width of Pond in feet** | 233 |
| **Base Length of Pond in feet** | 598 |
| **Rise of Slope in feet** | 1 |
| **Run of Slope in feet** | 3 |

| **WIDTH** (FT) | **LENGTH** | **WATER LEVEL** (FT) | **AVERAGE AREA** (SQ FT) | **VOLUME PER INCREMENT** (VOL/FT) | **TOTAL VOLUME OF POND** (CU FT) | **TOTAL VOLUME OF POND** (ACRE FEET) | **CAPACITY IN USE** (ACRE FEET) | **REMAINING CAPACITY** (ACRE FEET) | **Elevation** (FEET) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| 233 | 598 | | | | | | | | 468 |
| 239 | 604 | 1 | 70,923 | 70,923 | 70,923 | 1.6 | ----- | ----- | 469 |
| 245 | 610 | 2 | 73,452 | 73,452 | 144,374 | 3.3 | ----- | ----- | 470 |
| 251 | 616 | 3 | 76,017 | 76,017 | 220,391 | 5.1 | ----- | ----- | 471 |
| 257 | 622 | 4 | 78,618 | 78,618 | 299,008 | 6.9 | 0.0 | 24.0 | 472 |
| 263 | 628 | 5 | 81,255 | 81,255 | 380,263 | 8.7 | 1.9 | 22.2 | 473 |
| 269 | 634 | 6 | 83,928 | 83,928 | 464,190 | 10.7 | 3.8 | 20.2 | 474 |
| 275 | 640 | 7 | 86,637 | 86,637 | 550,827 | 12.6 | 5.8 | 18.2 | 475 |
| 281 | 646 | 8 | 89,382 | 89,382 | 640,208 | 14.7 | 7.8 | 16.2 | 476 |
| 287 | 652 | 9 | 92,163 | 92,163 | 732,371 | 16.8 | 9.9 | 14.1 | 477 |
| 293 | 658 | 10 | 94,980 | 94,980 | 827,350 | 19.0 | 12.1 | 11.9 | 478 |
| 299 | 664 | 11 | 97,833 | 97,833 | 925,183 | 21.2 | 14.4 | 9.7 | 479 |
| 305 | 670 | 12 | 100,722 | 100,722 | 1,025,904 | 23.6 | 16.7 | 7.3 | 480 |
| 311 | 676 | 13 | 103,647 | 103,647 | 1,129,551 | 25.9 | 19.1 | 5.0 | 481 |
| 317 | 682 | 14 | 106,608 | 106,608 | 1,236,158 | 28.4 | 21.5 | 2.5 | 482 |
| 323 | 688 | 15 | 109,605 | 109,605 | 1,345,763 | 30.9 | 24.0 | 0.0 | 483 |
| 329 | 694 | 16 | 112,638 | 112,638 | 1,458,400 | 33.5 | 26.6 | | 484 |

NOTES.
1. The table is valid for a triangular pond with a uniform interior side slope.
2. The table utilizes the 'end area method' of volume estimation utilizing the area of each one foot increment of pond depth, beginning at the bottom.
3. The volume due to the bottom slope below the 468 feet elevation was not considered in the capacity volume calculations. A minimum depth of three feet in the pond bottom is planned at all times.
4. The upper three feet of the pond are not counted in the capacity volume calculations due to the need to maintain a minimum freeboard to prevent wave damage above the maximum water level at all times.

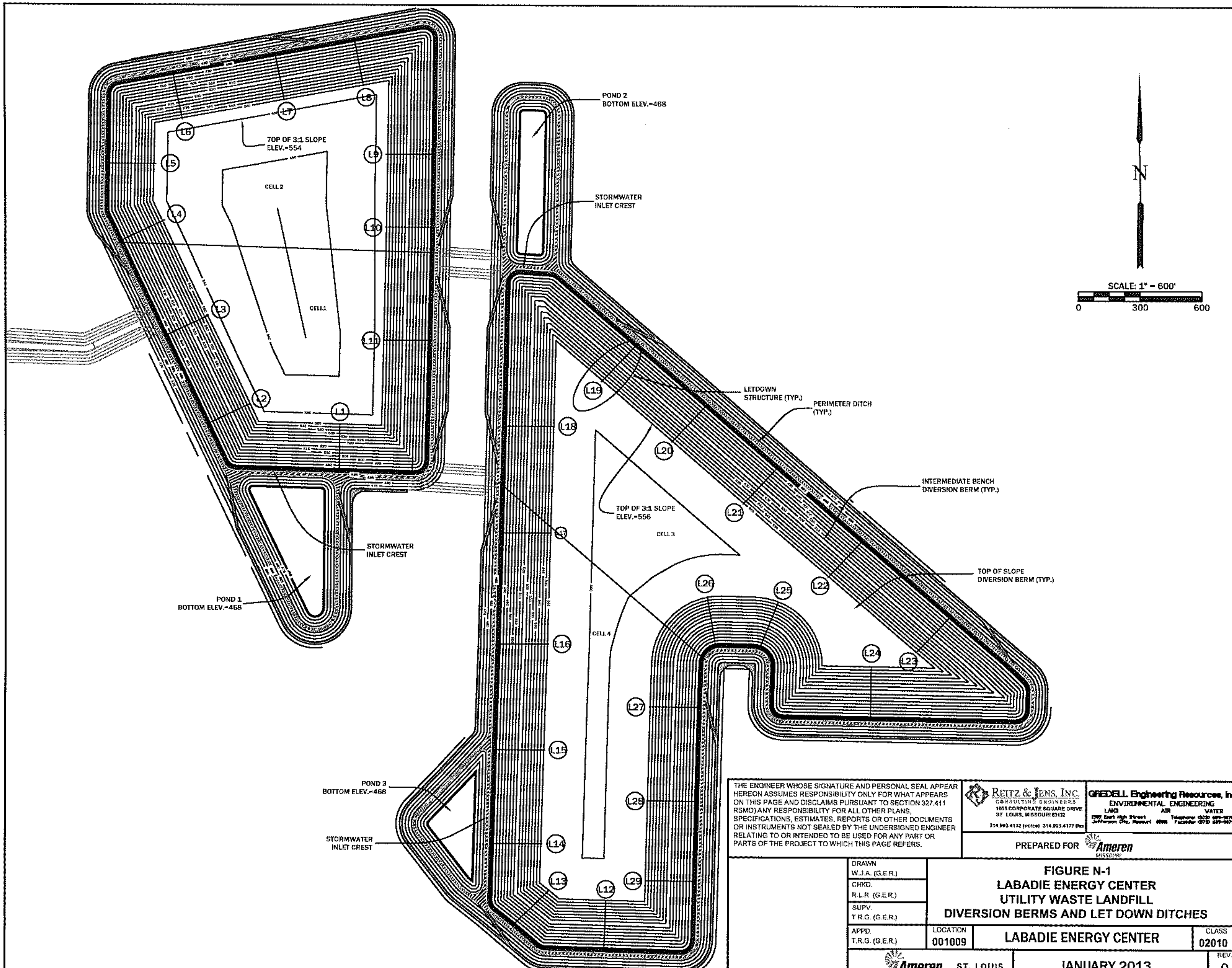
Elevation:

| | | |
|---|---|---|
| 468 | Pond Bottom | |
| 471 | Minimum working depth | Three feet of water to prevent growth of objectionable vegetation. |
| 483 | Reserve for storm | 25 year, 24 hour storm event. |
| 484 | Maximum high water | Three feet below emergency spillway. |
| 487 | Flood protection elevation | Height of emergency spillway. |

[1] Rainfall intensities are from RAINFALL FREQUENCY ATLAS OF THE MIDWEST by Floyd A. Huff and James R. Angel, Midwestern Climate Center, 1992, http://www.sws.uiuc.edu/pubdoc/B/ISWSB-71.pdf

# FIGURES

M:\Share\CADDFiles\AMEREN-UE\LABADIE\CONSTRUCTION PERMIT\2012 DRAWINGS\CPA DRAFT OCT 2012\FIG N-1 APPENDIX 11-1-12.dwg, Cover Sheet, 1/22/2013 9:30:43 AM




THE ENGINEER WHOSE SIGNATURE AND PERSONAL SEAL APPEAR HEREON ASSUMES RESPONSIBILITY ONLY FOR WHAT APPEARS ON THIS PAGE AND DISCLAIMS PURSUANT TO SECTION 327.411 RSMO) ANY RESPONSIBILITY FOR ALL OTHER PLANS, SPECIFICATIONS, ESTIMATES, REPORTS OR OTHER DOCUMENTS OR INSTRUMENTS NOT SEALED BY THE UNDERSIGNED ENGINEER RELATING TO OR INTENDED TO BE USED FOR ANY PART OR PARTS OF THE PROJECT TO WHICH THIS PAGE REFERS.

REITZ & JENS, INC.
CONSULTING ENGINEERS
1055 CORPORATE SQUARE DRIVE
ST. LOUIS, MISSOURI 63132
314.993.4132 (voice) 314.993.4177 (fax)

GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING
LAND AIR WATER

PREPARED FOR Ameren MISSOURI

| | |
|---|---|
| DRAWN | W.J.A. (G.E.R.) |
| CHKD. | R.L.R. (G.E.R.) |
| SUPV. | T.R.G. (G.E.R.) |
| APPD. | T.R.G. (G.E.R.) |

**FIGURE N-1**
**LABADIE ENERGY CENTER**
**UTILITY WASTE LANDFILL**
**DIVERSION BERMS AND LET DOWN DITCHES**

| LOCATION | | CLASS |
|---|---|---|
| 001009 | LABADIE ENERGY CENTER | 02010 |

Ameren MISSOURI — ST. LOUIS, MISSOURI — JANUARY 2013 — REV. 0