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# Figures

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| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | REV | DESCRIPTION | DATE | APPROVED |
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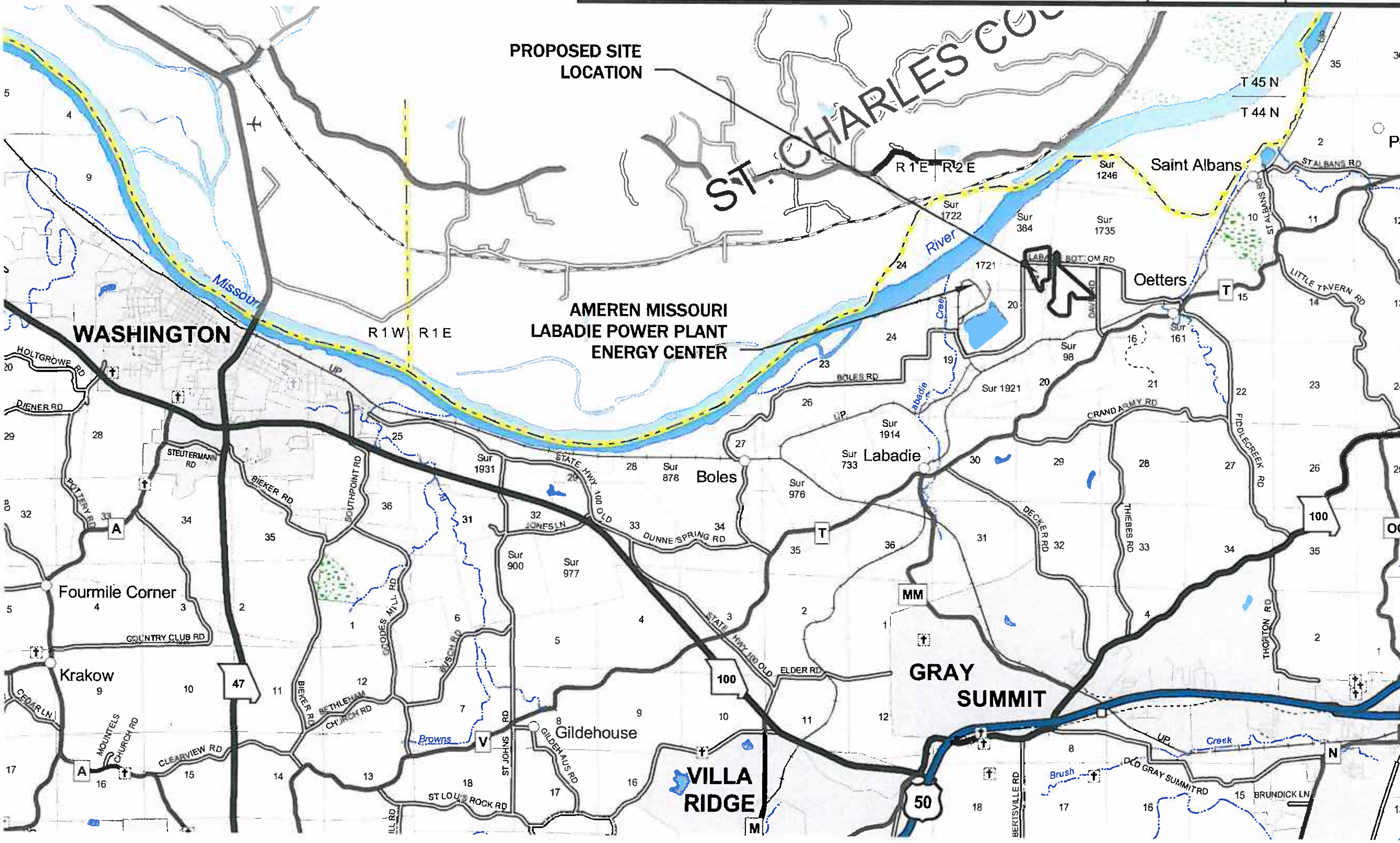


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GREDELL Engineering Resources, Inc.
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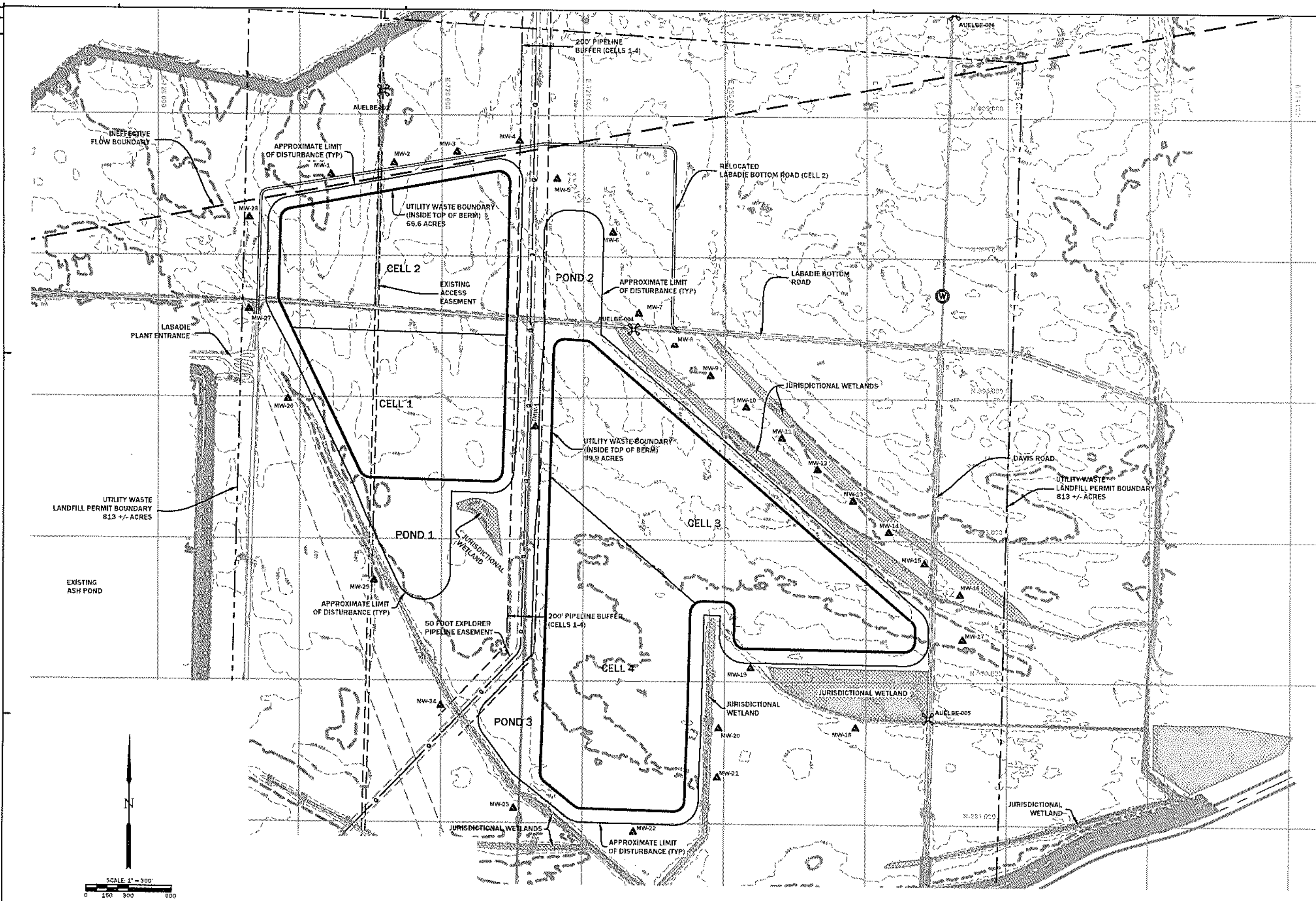
LAND AIR WATER


PREPARED FOR Ameren MISSOURI

| | |
|---|---|
| DRAWN W.J.A. (G.E.R.) | FIGURE 1, APPENDIX Q |
| CHKD. R.L.R. (G.E.R.) | LABADIE ENERGY CENTER |
| SUPV. T.R.G. (G.E.R.) | PROPOSED UTILITY WASTE LANDFILL SITE LOCATION MAP |
| APPD. T.R.G. (G.E.R.) | LOCATION 001009 — LABADIE ENERGY CENTER — CLASS 02010 |

Ameren MISSOURI ST. LOUIS, MISSOURI

REV.




## SURVEY MONUMENTS

| MONUMENT ID | NORTHING | EASTING | ELEVATION |
|---|---|---|---|
| AUELBE-001 | 990484.82 | 726569.81 | 467.19 |
| AUELBE-002 | 996166.50 | 727588.30 | 470.70 |
| AUELBE-003 | 989921.39 | 728508.32 | 467.59 |
| AUELBE-004 | 994487.78 | 729353.29 | 467.02 |
| AUELBE-005 | 991746.97 | 731438.29 | 462.78 |
| AUELBE-006 | 996729.00 | 731621.70 | 467.67 |

Missouri State Plane Coordinate System Datum-
Horizontal Datum NAD 1983,
Vertical Datum NAVD 1988

NOTES TO THE CONTRACTOR:

UNDERGROUND FACILITIES, STRUCTURES, AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE SURVEYS AND RECORDS AND THEREFORE, THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHERS, THE EXISTENCE OF WHICH IS AT PRESENT NOT KNOWN. VERIFICATION OF THE LOCATIONS OF UNDERGROUND UTILITIES, SHOWN OR NOT SHOWN, WILL BE THE RESPONSIBILITY OF THE CONSTRUCTION CONTRACTOR.

THE CONTRACTOR SHALL MAKE SUITABLE AND TIMELY REQUESTS TO ALL UTILITY OWNERS, PIPELINE OWNERS, OR OTHER PARTIES AFFECTED TO HAVE ALL NECESSARY ADJUSTMENTS OF PUBLIC OR PRIVATE UTILITIES, PIPE LINES, OR OTHER APPURTENANCES WITHIN, OR ADJACENT TO THE LIMITS OF CONSTRUCTION, AS SOON AS PRACTICAL OR POSSIBLE.

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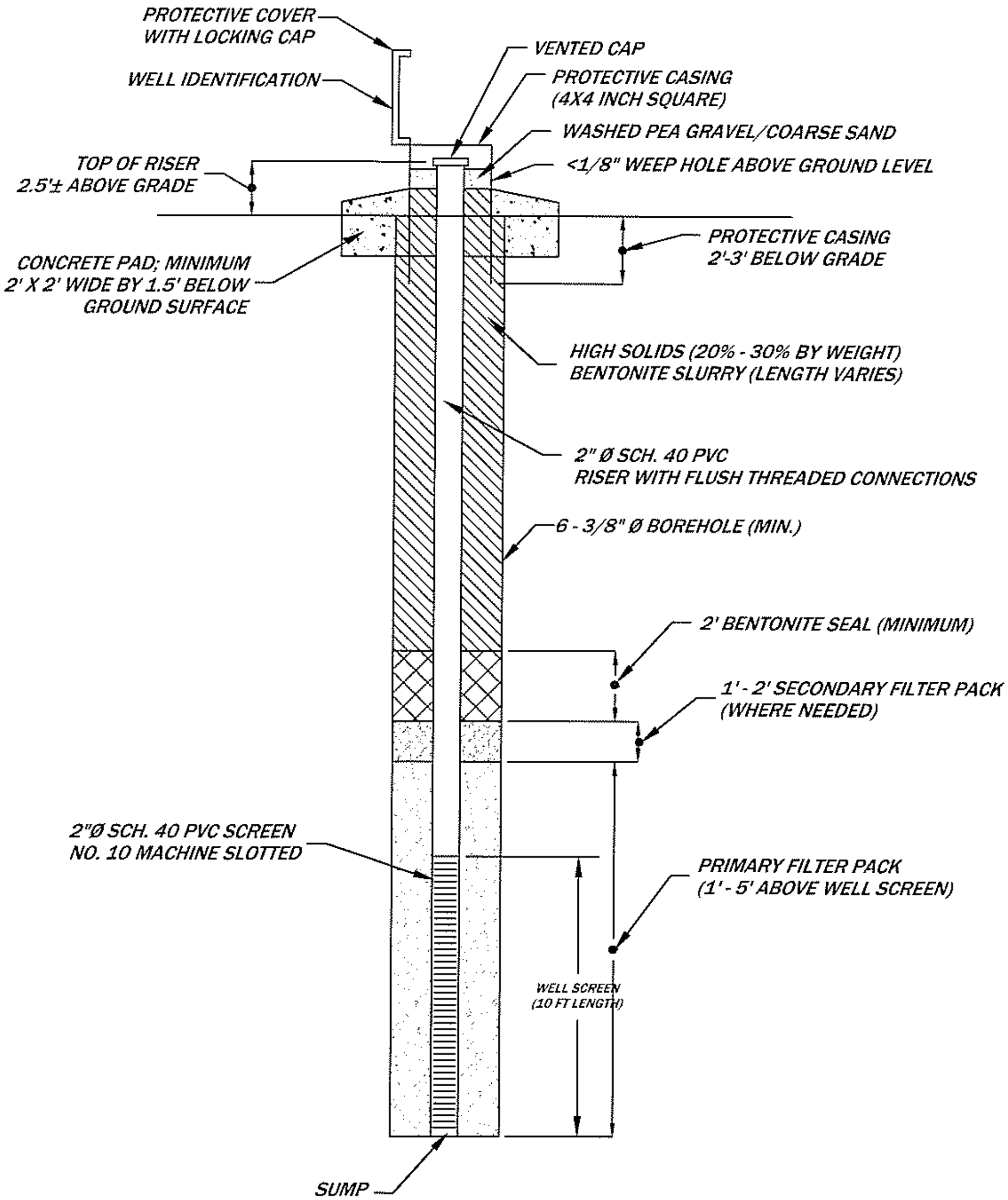
| | |
|---|---|
| DRAWN W.J.A. (G.E.R.) | FIGURE 2, APPENDIX Q<br>PROPOSED UTILITY WASTE LANDFILL<br>MONITORING WELL LOCATION MAP |
| CHKD. R.L.R. (G.E.R.) | |
| SUPV. T.R.G. (G.E.R.) | |
| APPD. T.R.G. (G.E.R.) | LOCATION 001009 — LABADIE ENERGY CENTER — CLASS 02010 |
| Ameren MISSOURI — ST. LOUIS, MISSOURI | DECEMBER 18, 2012 — REV 0 |

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| | |
|---|---|
| DRAWN A.J.K. (G.E.R.) | FIGURE 3, APPENDIX Q<br>PROPOSED UTILITY WASTE LANDFILL<br>TYPICAL GROUNDWATER MONITORING<br>WELL CONSTRUCTION DETAIL |
| CHKD. M.C.C. (G.E.R.) | |
| SUPV. M.C.C. (G.E.R.) | |
| APPD. T.R.G. (G.E.R.) | LOCATION 001009 — LABADIE ENERGY CENTER — CLASS 02010 |
| Ameren MISSOURI — ST. LOUIS, MISSOURI | DECEMBER 18, 2012 — REV. |

# Tables

# Construction Permit Application
# Proposed Utility Waste Landill
# Ameren Missouri Labadie Energy Center
# Franklin County, Missouri

## Groundwater Sampling and Analysis Plan
## Groundwater Monitoring Well Summary
## Table 1

| Monitoring Well Designation | Upgradient or Downgradient | Northing | Easting | Ground Surface Elevation (approx.) | Well Depth (feet, bgs) | Screen Length (feet) | Top of Screen Interval Elevation (approx.) |
|---|---|---|---|---|---|---|---|
| MW-1 | DG | 995574 | 727216 | 470 | 25 | 10 | 455 |
| MW-2 | DG | 995656 | 727662 | 469 | 23 | 10 | 456 |
| MW-3 | DG | 995738 | 728106 | 468 | 22 | 10 | 456 |
| MW-4 | DG | 995819 | 728547 | 468 | 21 | 10 | 457 |
| MW-5 | DG | 995548 | 728812 | 468 | 21 | 10 | 457 |
| MW-6 | DG | 995171 | 729206 | 467 | 20 | 10 | 457 |
| MW-7 | DG | 994600 | 729389 | 467 | 19 | 10 | 458 |
| MW-8 | DG | 994380 | 729642 | 466 | 18 | 10 | 458 |
| MW-9 | DG | 994160 | 729895 | 465 | 17 | 10 | 458 |
| MW-10 | DG | 993940 | 730147 | 466 | 18 | 10 | 458 |
| MW-11 | DG | 993720 | 730400 | 466 | 18 | 10 | 458 |
| MW-12 | DG | 993500 | 730653 | 465 | 17 | 10 | 458 |
| MW-13 | DG | 993280 | 730905 | 465 | 17 | 10 | 458 |
| MW-14 | DG | 993060 | 731158 | 464 | 16 | 10 | 458 |
| MW-15 | DG | 992840 | 731410 | 464 | 15 | 10 | 459 |
| MW-16 | DG | 992620 | 731663 | 464 | 15 | 10 | 459 |
| MW-17 | DG | 992302 | 731681 | 465 | 16 | 10 | 459 |
| MW-18 | DG | 991674 | 730925 | 462 | 13 | 10 | 459 |
| MW-19 | DG | 992096 | 730184 | 463 | 15 | 10 | 458 |
| MW-20 | DG | 991668 | 729958 | 463 | 14 | 10 | 459 |
| MW-21 | DG | 991332 | 729953 | 463 | 14 | 10 | 459 |
| MW-22 | UG | 990940 | 729361 | 464 | 15 | 10 | 459 |
| MW-23 | UG | 991102 | 728514 | 465 | 17 | 10 | 458 |
| MW-24 | UG | 991822 | 727995 | 465 | 17 | 10 | 458 |
| MW-25 | UG | 992708 | 727524 | 466 | 18 | 10 | 458 |
| MW-26 | UG | 993986 | 726913 | 467 | 20 | 10 | 457 |
| MW-27 | UG | 994619 | 726637 | 468 | 22 | 10 | 456 |
| MW-28 | UG | 995267 | 726640 | 469 | 24 | 10 | 455 |
| TMW-1 | DG | 993795 | 728659 | 467 | 19 | 10 | 458 |

**NOTES:**

1. Refer to Figure 2 for proposed monitoring well locations.
2. TMW-1 is a temporary ("sentry") well located immediately east of initial cell construction area (Cell 1).
3. Basis for permanent well locations described in "Documentation of Groundwater Monitoring Well Design"; see Appendix X of Construction Permit Application.
4. Refer to Figure 3 for typical well construction details.
5. MW-1 through MW-21, and TMW-1, denote generally downgradient well positions. MW-22 through MW-28 denote generally upgradient well positions.

# Construction Permit Application
# Proposed Utility Waste Landfill
# Ameren Missouri Labadie Energy Center
# Franklin County, Missouri

### Groundwater Sampling and Analysis Plan
### Groundwater Monitoring Schedule
### Table 2

| Time | Item to Be Completed | Reports to MDNR |
|---|---|---|
| 27 or 28 months before initial UWL operation | Install and develop groundwater monitoring wells. | Monitoring well installation records to Wellhead Protection Program |
| 26 months before initial UWL operation | Initial sampling event | Initial groundwater field sampling and laboratory data to Solid Waste Management Program (SWMP) |
| 23 months before initial UWL operation | Second sampling event | Groundwater field sampling and laboratory data to SWMP |
| 20 months before initial UWL operation | Third sampling event | Groundwater field sampling and laboratory data to SWMP |
| 17 months before initial UWL operation | Fourth sampling event | Groundwater field sampling and laboratory data to SWMP |
| 14 months before initial UWL operation | Fifth round of sampling | Groundwater field sampling and laboratory data to SWMP |
| 11 months before initial UWL operation | Sixth round of sampling | Groundwater field sampling and laboratory data to SWMP |
| 8 months before initial UWL operation | Seventh round of sampling | Groundwater field sampling and laboratory data to SWMP |
| 5 months before initial UWL operation | Eighth round of sampling | Report on field sampling and analytical data distributions and choice of intra-well or inter-well statistics to SWMP. Includes groundwater sampling data. |
| 2 months before initial UWL operation | Submit Request for Operating Permit to MDNR | MDNR-SWMP has 60 days to review the submittal and make a decision on the Operating Permit. |
| Initial UWL operations begin. | N/A | N/A |
| Continue monitoring once per six months during May and November | Semi-annual sampling for routine detection monitoring | Groundwater field sampling, laboratory data and statistical report within 90 days of each subsequent sampling event to SWMP |

# Appendices

# Appendix 1

## Driller's Logs and Monitoring Well Construction Details

This Appendix Intentionally Left Blank.
Information to be included following installation of groundwater monitoring wells.

# Appendix 2

Missouri Solid Waste Management Rule
Constituents for Detection Monitoring
(10 CSR 80-11.010, Appendix I)

## Ameren Missouri Labadie Energy Center
## Groundwater Sampling and Analysis Plan

### Constituents for Detection Monitoring
### 10 CSR 80-11.010 (Appendix I)

| Chemical Constituent | Units | Method[1] | PQL[2] |
|---|---|---|---|
| Aluminum (Al) | ug/l | 6010B | 50 |
| Antimony (Sb) | ug/l | 7041 | 5 |
| Arsenic (As) | ug/l | 7060A | 3 |
| Barium (Ba) | ug/l | 6010B | 5 |
| Beryllium (Be) | ug/l | 6010B | 1 |
| Boron (B) | ug/l | 6010B | 20 |
| Cadmium (Cd) | ug/l | 6010B | 2 |
| Calcium (Ca) | mg/l | 6010B | 0.05 |
| Chemical Oxygen Demand (COD) | mg/l | 410.4 | 10 |
| Chloride | mg/l | 9251 | 1 |
| Chromium (Cr) | ug/l | 6010B | 10 |
| Cobalt (Co) | ug/l | 6010B | 10 |
| Copper (Cu) | ug/l | 6010B | 10 |
| Fluoride | mg/l | 9214 | 0.10 |
| Hardness | mg/l | 2340C | NA |
| Iron (Fe) | mg/l | 6010B | 20 |
| Lead (Pb) | ug/l | 7421 | 2 |
| Magnesium (Mg) | mg/l | 6010B | 0.010 |
| Manganese (Mn) | ug/l | 6010B | 5 |
| Mercury (Hg) | ug/l | 7470A | 0.2 |
| Nickel (Ni) | mg/l | 6010B | 10 |
| pH | S.U. | 9040B | NA |
| Selenium (Se) | ug/l | 6010B | 50 |
| Silver (Ag) | ug/l | 6010B | 10 |
| Sodium (Na) | mg/l | 6010B | 0.05 |
| Specific Conductance | umhos/cm | 9050A | NA |
| Sulfate | mg/l | 9036 | 50 |
| Thallium (Tl) | ug/l | 7841 | 2 |
| Total Dissolved Solids (TDS) | mg/l | 2540C | 20 |
| Total Organic Carbon (TOC) | mg/l | 9060 | 1 |
| Total Organic Halogens (TOX) | ug/l | 9020B | 20 |
| Zinc (Zn) | ug/l | 6010B | 10 |
| Ground Water Elevation | feet | NA | NA |

1. Suggested Methods refer to analytical procedure numbers used in EPA Report SW-846 "Test Methods for Evaluating Solid Waste", third edition, November 1986, as revised, December 1987, or applicable updates.
2. Practical Quantitation Limits as established by the contract laboratory.

# Appendix 3

## Field Equipment Calibration Forms and Procedures

# Field Instrumentation Calibration Log

Calibrated by: ______________________________

Field Instrument ________ ________

S/N # ________ ________ ________ ________

| | Date | Time | pH Standards | | pH Measurements | Specific Conductivity Standard (µs/cm) | | Specific Conductivity Measurement (µs/cm) | Oxidation Reduction Potential Standard (mV) | | | | Oxidation Reduction Potential Measurement (mV) | Turbidity Standards (NTU) | | Turbidity Measurements (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beginning of Day Calibration | | | 4.00 | = | | 1413 | = | | Temperature (°C) | = | | = | | 0.02 | = | |
| | | | 7.00 | = | | | | | Standard (mV) | = | | | | 10.0 | = | |
| | | | 10.00 | = | | | | | | | | | | 1000 | = | |
| End of Day Check | | | 4.00 | = | | 1413 | = | | Temperature (°C) | = | | = | | 0.02 | = | |
| | | | 7.00 | = | | | | | Standard (mV) | = | | | | 10.0 | = | |
| | | | 10.00 | = | | | | | | | | | | 1000 | = | |

Notes: ______________________________

I certify that the aforementioned meters were calibrated within the manufactures specifications.

Date: ________ By: ______________________________

Prepared by GREDELL Engineering Resources, Inc.

## ORP Interpolation Reference Table

| Temperture °C | ORP mV | Temperture °C | ORP mV | Temperture °C | ORP mV | Temperture °C | ORP mV | Temperture °C | ORP mV | Temperture °C | ORP mV | Temperture °C | ORP mV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 237.0 | 6.6 | 231.4 | 13.2 | 228.1 | 19.7 | 223.2 | 26.3 | 219.0 | 32.7 | 214.4 | 39.3 | 209.6 |
| 0.1 | 236.9 | 6.7 | 231.3 | 13.3 | 228.0 | 19.8 | 223.2 | 26.4 | 218.9 | 32.8 | 214.3 | 39.4 | 209.5 |
| 0.2 | 236.8 | 6.8 | 231.3 | 13.4 | 228.0 | 19.9 | 223.1 | 26.5 | 218.8 | 32.9 | 214.3 | 39.5 | 209.4 |
| 0.3 | 236.7 | 6.9 | 231.2 | 13.4 | 228.0 | 20.0 | 223.0 | 26.6 | 218.7 | 33.0 | 214.2 | 39.6 | 209.3 |
| 0.4 | 236.6 | 7.0 | 231.2 | 13.5 | 227.9 | 20.1 | 222.9 | 26.7 | 218.6 | 33.1 | 214.1 | 39.7 | 209.2 |
| 0.5 | 236.5 | 7.1 | 231.2 | 13.6 | 227.8 | 20.2 | 222.9 | 26.8 | 218.6 | 33.2 | 214.1 | 39.8 | 209.2 |
| 0.6 | 236.4 | 7.2 | 231.1 | 13.7 | 227.8 | 20.3 | 222.8 | 26.9 | 218.5 | 33.3 | 214.0 | 39.9 | 209.1 |
| 0.7 | 236.3 | 7.3 | 231.1 | 13.8 | 227.7 | 20.4 | 222.8 | 27.0 | 218.4 | 33.4 | 214.0 | 40.0 | 209.0 |
| 0.8 | 236.2 | 7.4 | 231.0 | 13.9 | 227.7 | 20.5 | 222.7 | 27.1 | 218.3 | 33.5 | 213.9 | 40.1 | 208.9 |
| 0.9 | 236.1 | 7.5 | 231.0 | 14.0 | 227.6 | 20.6 | 222.6 | 27.2 | 218.2 | 33.6 | 213.8 | 40.2 | 208.8 |
| 1.0 | 236.0 | 7.6 | 231.0 | 14.1 | 227.5 | 20.7 | 222.6 | 27.3 | 218.2 | 33.7 | 213.8 | 40.3 | 208.8 |
| 1.1 | 235.9 | 7.7 | 230.9 | 14.2 | 227.5 | 20.8 | 222.5 | 27.4 | 218.1 | 33.8 | 213.7 | 40.4 | 208.7 |
| 1.2 | 235.8 | 7.8 | 230.9 | 14.3 | 227.4 | 20.9 | 222.5 | 27.5 | 218.0 | 33.9 | 213.7 | 40.5 | 208.6 |
| 1.3 | 235.7 | 7.9 | 230.8 | 14.4 | 227.4 | 21.0 | 222.4 | 27.6 | 217.9 | 34.0 | 213.6 | 40.6 | 208.5 |
| 1.4 | 235.6 | 8.0 | 230.8 | 14.5 | 227.3 | 21.1 | 222.3 | 27.7 | 217.8 | 34.1 | 213.5 | 40.7 | 208.4 |
| 1.5 | 235.5 | 8.1 | 230.8 | 14.6 | 227.2 | 21.2 | 222.3 | 27.8 | 217.8 | 34.2 | 213.5 | 40.8 | 208.4 |
| 1.6 | 235.4 | 8.2 | 230.7 | 14.7 | 227.2 | 21.3 | 222.2 | 27.9 | 217.7 | 34.3 | 213.4 | 40.9 | 208.3 |
| 1.7 | 235.3 | 8.3 | 230.7 | 14.8 | 227.1 | 21.4 | 222.2 | 28.0 | 217.6 | 34.4 | 213.4 | 41.0 | 208.2 |
| 1.8 | 235.2 | 8.4 | 230.6 | 14.9 | 227.1 | 21.5 | 222.1 | 28.1 | 217.5 | 34.5 | 213.3 | 41.1 | 208.1 |
| 1.9 | 235.1 | 8.5 | 230.6 | 15.0 | 227.0 | 21.6 | 222.0 | 28.2 | 217.4 | 34.6 | 213.2 | 41.2 | 208.0 |
| 2.0 | 235.0 | 8.6 | 230.6 | 15.1 | 226.9 | 21.7 | 222.0 | 28.3 | 217.4 | 34.7 | 213.2 | 41.3 | 208.0 |
| 2.1 | 234.9 | 8.7 | 230.5 | 15.2 | 226.8 | 21.8 | 221.9 | 28.4 | 217.3 | 34.8 | 213.1 | 41.4 | 207.9 |
| 2.2 | 234.8 | 8.8 | 230.5 | 15.3 | 226.8 | 21.9 | 221.9 | 28.5 | 217.2 | 34.9 | 213.1 | 41.5 | 207.8 |
| 2.3 | 234.7 | 8.9 | 230.4 | 15.4 | 226.7 | 22.0 | 221.8 | 28.6 | 217.1 | 35.0 | 213.0 | 41.6 | 207.7 |
| 2.4 | 234.6 | 9.0 | 230.4 | 15.5 | 226.6 | 22.1 | 221.7 | 28.7 | 217.0 | 35.1 | 212.9 | 41.7 | 207.6 |
| 2.5 | 234.5 | 9.1 | 230.4 | 15.6 | 226.5 | 22.2 | 221.7 | 28.8 | 217.0 | 35.2 | 212.8 | 41.8 | 207.6 |
| 2.6 | 234.4 | 9.2 | 230.3 | 15.7 | 226.4 | 22.3 | 221.6 | 28.9 | 216.9 | 35.3 | 212.8 | 41.9 | 207.5 |
| 2.7 | 234.3 | 9.3 | 230.3 | 15.8 | 226.4 | 22.4 | 221.6 | 29.0 | 216.8 | 35.4 | 212.7 | 42.0 | 207.4 |
| 2.8 | 234.2 | 9.4 | 230.2 | 15.9 | 226.3 | 22.5 | 221.5 | 29.1 | 216.7 | 35.5 | 212.6 | 42.1 | 207.3 |
| 2.9 | 234.1 | 9.5 | 230.2 | 16.0 | 226.2 | 22.6 | 221.4 | 29.2 | 216.6 | 35.6 | 212.5 | 42.2 | 207.2 |
| 3.0 | 234.0 | 9.6 | 230.2 | 16.1 | 226.1 | 22.7 | 221.4 | 29.3 | 216.6 | 35.7 | 212.4 | 42.3 | 207.2 |
| 3.1 | 233.9 | 9.7 | 230.1 | 16.2 | 226.0 | 22.8 | 221.3 | 29.4 | 216.5 | 35.8 | 212.4 | 42.4 | 207.1 |
| 3.2 | 233.8 | 9.8 | 230.1 | 16.3 | 226.0 | 22.9 | 221.3 | 29.3 | 216.6 | 35.9 | 212.3 | 42.5 | 207.0 |
| 3.3 | 233.7 | 9.9 | 230.0 | 16.4 | 225.9 | 23.0 | 221.2 | 29.4 | 216.5 | 36.0 | 212.2 | 42.6 | 206.9 |
| 3.4 | 233.6 | 10.0 | 230.0 | 16.5 | 225.8 | 23.1 | 221.1 | 29.5 | 216.4 | 36.1 | 212.1 | 42.7 | 206.8 |
| 3.5 | 233.5 | 10.1 | 229.9 | 16.6 | 225.7 | 23.2 | 221.1 | 29.6 | 216.3 | 36.2 | 212.0 | 42.8 | 206.8 |
| 3.6 | 233.4 | 10.2 | 229.9 | 16.7 | 225.6 | 23.3 | 221.0 | 29.7 | 216.2 | 36.3 | 212.0 | 42.9 | 206.7 |
| 3.7 | 233.3 | 10.3 | 229.8 | 16.8 | 225.6 | 23.4 | 221.0 | 29.8 | 216.2 | 36.4 | 211.9 | 43.0 | 206.6 |
| 3.8 | 233.2 | 10.4 | 229.8 | 16.9 | 225.5 | 23.5 | 220.9 | 29.9 | 216.1 | 36.5 | 211.8 | 43.1 | 206.5 |
| 3.9 | 233.1 | 10.5 | 229.7 | 17.0 | 225.4 | 23.6 | 220.8 | 30.0 | 216.0 | 36.6 | 211.7 | 43.2 | 206.4 |
| 4.0 | 233.0 | 10.6 | 229.6 | 17.1 | 225.3 | 23.7 | 220.8 | 30.1 | 215.9 | 36.7 | 211.6 | 43.3 | 206.4 |
| 4.1 | 232.9 | 10.7 | 229.6 | 17.2 | 225.2 | 23.8 | 220.7 | 30.2 | 215.9 | 36.8 | 211.6 | 43.4 | 206.3 |
| 4.2 | 232.8 | 10.8 | 229.5 | 17.3 | 225.2 | 23.9 | 220.7 | 30.3 | 215.8 | 36.9 | 211.5 | 43.5 | 206.2 |
| 4.3 | 232.7 | 10.9 | 229.5 | 17.4 | 225.1 | 24.0 | 220.6 | 30.4 | 215.8 | 37.0 | 211.4 | 43.6 | 206.1 |
| 4.4 | 232.6 | 11.0 | 229.4 | 17.5 | 225.0 | 24.1 | 220.5 | 30.5 | 215.7 | 37.1 | 211.3 | 43.7 | 206.0 |
| 4.5 | 232.5 | 11.1 | 229.3 | 17.6 | 224.9 | 24.2 | 220.5 | 30.6 | 215.6 | 37.2 | 211.2 | 43.8 | 206.0 |
| 4.6 | 232.4 | 11.2 | 229.3 | 17.7 | 224.8 | 24.3 | 220.4 | 30.7 | 215.6 | 37.3 | 211.2 | 43.9 | 205.9 |
| 4.7 | 232.3 | 11.3 | 229.2 | 17.8 | 224.8 | 24.4 | 220.4 | 30.8 | 215.5 | 37.4 | 211.1 | 44.0 | 205.8 |
| 4.8 | 232.2 | 11.4 | 229.2 | 17.9 | 224.7 | 24.5 | 220.3 | 30.9 | 215.5 | 37.5 | 211.0 | 44.1 | 205.7 |
| 4.9 | 232.1 | 11.5 | 229.1 | 18.0 | 224.6 | 24.6 | 220.2 | 31.0 | 215.4 | 37.6 | 210.9 | 44.2 | 205.6 |
| 5.0 | 232.0 | 11.6 | 229.0 | 18.1 | 224.5 | 24.7 | 220.2 | 31.1 | 215.3 | 37.7 | 210.8 | 44.3 | 205.6 |
| 5.1 | 232.0 | 11.7 | 229.0 | 18.2 | 224.4 | 24.8 | 220.1 | 31.2 | 215.3 | 37.8 | 210.8 | 44.4 | 205.5 |
| 5.2 | 231.9 | 11.8 | 228.9 | 18.3 | 224.4 | 24.9 | 220.1 | 31.3 | 215.2 | 37.9 | 210.7 | 44.5 | 205.4 |
| 5.3 | 231.9 | 11.9 | 228.9 | 18.4 | 224.3 | 25.0 | 220.0 | 31.4 | 215.2 | 38.0 | 210.6 | 44.6 | 205.3 |
| 5.4 | 231.8 | 12.0 | 228.8 | 18.5 | 224.2 | 25.1 | 219.9 | 31.5 | 215.1 | 38.1 | 210.5 | 44.7 | 205.2 |
| 5.5 | 231.8 | 12.1 | 228.7 | 18.6 | 224.1 | 25.2 | 219.8 | 31.6 | 215.0 | 38.2 | 210.4 | 44.8 | 205.2 |
| 5.6 | 231.8 | 12.2 | 228.7 | 18.7 | 224.0 | 25.3 | 219.8 | 31.7 | 215.0 | 38.3 | 210.4 | 44.9 | 205.1 |
| 5.7 | 231.7 | 12.3 | 228.6 | 18.8 | 224.0 | 25.4 | 219.7 | 31.8 | 214.9 | 38.4 | 210.3 | 45.0 | 205.0 |
| 5.8 | 231.7 | 12.4 | 228.6 | 18.9 | 223.9 | 25.5 | 219.6 | 31.9 | 214.9 | 38.5 | 210.2 | | |
| 5.9 | 231.6 | 12.5 | 228.5 | 19.0 | 223.8 | 25.6 | 219.5 | 32.0 | 214.8 | 38.6 | 210.1 | | |
| 6.0 | 231.6 | 12.6 | 228.4 | 19.1 | 223.7 | 25.7 | 219.4 | 32.1 | 214.7 | 38.7 | 210.0 | | |
| 6.1 | 231.6 | 12.7 | 228.4 | 19.2 | 223.6 | 25.8 | 219.4 | 32.2 | 214.7 | 38.8 | 210.0 | | |
| 6.2 | 231.5 | 12.8 | 228.3 | 19.3 | 223.6 | 25.9 | 219.3 | 32.3 | 214.6 | 38.9 | 209.9 | | |
| 6.3 | 231.5 | 12.9 | 228.3 | 19.4 | 223.5 | 26.0 | 219.2 | 32.4 | 214.6 | 39.0 | 209.8 | | |
| 6.4 | 231.4 | 13.0 | 228.2 | 19.5 | 223.4 | 26.1 | 219.1 | 32.5 | 214.5 | 39.1 | 209.7 | | |
| 6.5 | 231.4 | 13.1 | 228.1 | 19.6 | 223.3 | 26.2 | 219.0 | 32.6 | 214.4 | 39.2 | 209.6 | | |

Note: Standard ORP measurements 0, 5, 10, 15, 20, 25, 30, 35, and 40 were provided by Geotech Environmental Equipment, Inc.
The rest of the standard ORP measurements were interpolated from Geotech Standard ORP measurements.

# FIELD EQUIPMENT CALIBRATION PROCEDURES

## Multi-meter pH, Temperature, Conductivity, Oxidation Reduction Potential (ORP)

### pH Calibration/Operation Procedures

(Reference EPA Method 9040)

The field pH meter will be calibrated each day water samples are collected. Calibration results will be recorded on the Field Instrumentation Calibration Log in Appendix 3 of the Sampling and Analysis Plan.

**pH Three-Buffer Calibration**

This procedure is recommended for precise measurements.

1. Select three buffers which bracket the expected sample pH. The first should be near the electrode isopotential point (pH 7) and the second and third should bracket the expected sample pH (e.g. pH 4 and pH 10).
2. Rinse electrode first with distilled water and then with pH 7 buffer. Place the electrode in pH 7 buffer.
3. Wait for stable display. Set the meter to the pH value of the buffer at its measured temperature. (ATC @ 25°C = 7.00).
4. Rinse electrode first with distilled water and then with the second buffer. Place the electrode in the second buffer.
5. When the display is table, set the meter to the actual pH value of the buffer as described in the meter instruction manual.
6. Rinse electrode first with distilled water and then with the third buffer. Place the electrode in the third buffer.
7. When the display is table, set the meter to the actual pH value of the buffer as described in the meter instruction manual.
8. If all steps are performed correctly, and the slope is between 92 and 102%, proceed to pH Measurement.

For detailed calibration and temperature compensation procedures, consult meter instruction manual.

**pH Measurement**

1. Obtain a neat sample from collection device and place electrode directly into sample.
2. Allow reading to stabilize.
3. Record pH reading directly from meter and record on the Field Sampling Log.
4. Probes are to be decontaminated by multiple rinses with distilled water.

If the above procedures do not work, refer to Troubleshooting section of instrument instruction manual.

## Measuring Hints

1. Always use fresh buffers for calibration. Choose buffers that are no more than 3 pH units apart.
2. Check electrode slope daily by performing a three-buffer calibration. Slope should be 92 to 102%.
3. Between measurements, rinse electrodes with distilled water and then with the next solution to be measured.
4. Stir all buffers and samples.
5. Avoid rubbing or wiping electrode bulb, to reduce chance of error due to polarization.

## Interferences

Oil samples and salty samples may leave residues on the electrodes. The probe has to be rinsed thoroughly between all measurements using distilled water to remove salt residues. If oily residues need to be removed, rinse with acetone then distilled water. The electrodes need to be kept wet to ensure proper response.

## FIELD EQUIPMENT CALIBRATION PROCEDURES

### Conductivity/Temperature Calibration/ Operation Procedures

(Reference EPA Method 9050)

**Calibration Procedures**

Conductivity will be checked at a minimum of once per day using commercial traceable standards in the 1000 and 10,000 mmhos/cm range and recorded on the Field Instrumentation Calibration Log. Calibration checks outside of a ± 10% range are not acceptable and will require the sensor replacement and/or re-check of the standards. If calibration check standards are still outside ± 10% range, use alternate meter. Do not proceed with sample collection without acceptable calibration checks.

Temperature measurement is factory calibrated. Temperature will be checked for calibration by comparison with a laboratory thermometer within a ± 10% range prior to the sample event.

**Temperature Measurement**

Report all values on the Field Sampling Log in degrees Celsius (°C).

1. Immerse the temperature/conductivity sensor into the sample.
2. Record temperature reading directly from meter and record on the Field Sampling Log.

**Conductivity Measurement**

Report all values on the Field Sampling Log in umhos/cm (uS/cm).

1. Immerse the temperature/conductivity sensor into the sample.
2. Record conductivity reading directly from meter and record on the Field Sampling Log.
3. Sensors are to be decontaminated by multiple rinses with distilled water.

Most meters have a fixed temperature coefficient (TC) of 2.1% per °C and a fixed reference temperature of 25°C. These parameters are sufficient for the majority of "natural water" samples.

## FIELD EQUIPMENT CALIBRATION PROCEDURES

**Oxidation Reduction Potential (ORP) Calibration/ Operation Procedures**

(Reference YSI Environmental)

### ORP Calibration

Report all values on the Field Instrumentation Calibration Log in millivolts (mV).

1. Select ORP.
2. Immerse the sensor into the calibration solution.
3. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature (Refer to the Appendix 3 ORP Interpolation Reference Table in the Sampling and Analysis Plan).
4. Record ORP reading directly from meter and record on the Field Instrumentation Calibration Log.
5. Sensors are to be decontaminated by multiple rinses with distilled water.

### ORP Measurement

Report all values on the Field Sampling Log in millivolts (mV).

1. Select ORP.
2. Immerse the sensor into the sample.
3. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature (Refer to the Appendix 3 ORP Interpolation Reference Table in the Sampling and Analysis Plan).
4. Record ORP reading directly from meter and record on the Field Sampling Log.
5. Sensors are to be decontaminated by multiple rinses with distilled water.

### Low-Flow cell calibration

The manufacturer's recommended procedures shall be followed for low-flow cell calibration. A copy of these procedures is to be made a part of this sampling and analysis plan.

## FIELD EQUIPMENT CALIBRATION PROCEDURES

### Turbidimeter Calibration/ Operation Procedures

(Reference HF Scientific)

The Turbidimeter allows for the measurement of turbidity in the field. The instrument measures and reports the turbidity of a sample in nephelometric turbidity units (NTU's).

**Turbidimeter Calibration**

The instrument was calibrated and tested prior to leaving the factory. The instrument requires three (3) standards to be calibrated.

1. Select the calibration function of the instrument by pressing the CAL button once. The "CAL" block will be illuminated on the display with "1" indicating the standard required for this step of the calibration. This is the first standard that should be used in a full calibration.
2. Insert the 1000 NTU standard (CAL 1 in the figure above) into the sample well and press down until the cuvette snaps fully into the instrument. Align the indexing ring with the arrow on the instrument.
3. Wait for the reading to stabilize. Once the reading has stabilized press the enter button to indicate to the instrument that it should calibrate on this point.
4. When the instrument has completed calibration on this point, it prompts you to insert the next calibration standard into the sample well (CAL 2).
5. Repeat steps 2-4 for each calibration standard. When you calibrate on CAL 3 (turbidity free water), the instrument will automatically exit out of calibration returning back to the normal operating mode.

**Turbidimeter Measurement**

Turn on the instrument by pressing the ON/OFF button continuously for 1 second. Allow 75-second warm-up period while preparing for the turbidity measurement as described in the following steps:

1. Sample approximately 100 ml of your process, as you would normally do for turbidity measurement.
2. Obtain a clean and dry sample cuvette.
3. Rinse the cuvette with approximately 10 ml of the sample water (2/3 of cuvette volume), capping the cuvette with the black light shield (cuvette top) and inverting several times. Discard the used sample and repeat the rinsing procedure two more times.
4. Completely fill the rinsed cuvette (from step 3) with the remaining portion (approximately 15 ml) of the grab sample and then cap the cuvette with the supplied cap. Ensure that the outside of the cuvette is dry, clean and free from smudges.

5. Place the cuvette into the instrument and press it down until it snaps fully into the sample well. Index the cuvette by pressing and holding down the enter button while rotating the cuvette to identify the lowest reading (the displayed turbidity is continuously updated on the display). Once the cuvette is indexed, release the enter button to display the measured turbidity.

# Appendix 4

## Sample Container and Preservation Guidelines and Groundwater Sampling Bottle Inventory Form

## Ameren Missouri LABADIE ENERGY CENTER
## Groundwater Sampling and Analysis Plan

# Sample Container and Preservation Guidelines

| Measurement | Volume Req., (ml) | Container[a] | Preservative | Max. Holding Times | Reference |
|---|---|---|---|---|---|
| Specific Cond. (Field) | 100 | P, G | None | Det. on Site | 1 |
| pH (Field) | 50 | P, G | None | Det. on Site | 1, 2 |
| Temperature (Field) | 1000 | P,G | None | Det. on Site | 1 |
| Oxidation Reduction Potential | 1000 | P,G | None | Det. on Site | |
| Turbidity | 1000 | P,G | None | Det. on Site | |
| **Inorganics, Non-Metallics** | | | | | |
| Fluoride | 300 | P, G | $HNO_3$ to pH <2 | 28 | 1, 2 |
| Total Organic Carbon | 100 | $G_b$ | Cool, 4°C; HCl or $H_2SO_4$ to pH <2 | 28 | 1 |
| Total Dissolved Solids | 500 | P, G | Cool, 4°C | 7 Days | 1,4 |
| Chloride | 500 | P, G | Cool,4°C | 28 Days | 1, 2 |
| Sulfate | 200 | P, G | Cool, 4°C | 28 Days | 1, 2,4 |
| Total Organic Halides (TOX) | 2000 | G | Cool, 4°C; HCl or $H_2SO_4$ to pH <2 | 7 Days | 4 |
| COD | 50 | P, G | $H_2SO_4$ to pH <2 | 28 Days | 1 |
| **Metals** | | | | | |
| Total Recoverable | 500 | P, G | $HNO_3$ to pH <2 | 6 Mos | 1, 2 |
| Mercury | 500 | P, G | $HNO_3$ to pH <2 | 28 Days | 1, 2 |

**NOTES:**

a. Plastic (P) or Glass (G). For metals, polyethylene with an all polypropylene cap is preferred.
b. Use Teflon© lined cap.
c. Silver requires an amber bottle

**REFERENCES:**


1. Methods for Chemical Analysis of Water and Wastes, March, 1983, USEPA, 600/4-79-020 and additions thereto.
2. Test Methods for Evaluating Solid Waste, Physical/Chemical Method, November, 1986, Third Edition, USEPA, SW-846 and additions thereto.
3. Guidelines Establishing Test Procedures for the Analysis of Pollutant Under the Clean Water Act", Environmental Protection Agency, Code of Federal Regulations (CFR), Title 40, Part 136.
4. MDNR-FSS-001, Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations, Randy Crawford, Trish Rielly, Water Quality Monitoring Section, MDNR ESP September 17, 2003

## Groundwater Sampling Bottle Inventory

| Well ID | Date Received | Bottles Received | | | | | |
|---|---|---|---|---|---|---|---|
| | | Chloride, Sulfate, Fluoride, Hardness, and TDS 1,000 mL - 1 Total (pl - none) | Metals 500 mL (pl - $HNO_3$) | TOX 500 mL (gl - $H_2SO_4$) | TOC 125 mL Amber (gl - $H_2SO_4$) | COD 125 mL (pl - $H_2SO_4$) | Broken or Damaged Bottles |
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| Extra # 1 | | | | | | | |
| Extra # 2 | | | | | | | |
| Duplicate # 1 | | | | | | | |
| Duplicate # 2 | | | | | | | |
| Field Blank | | | | | | | |
| Trip Blank | | | | | | | |

Bottles delivered by: ______________________________

$H_2SO_4$ = Sulfuric Acid

$HNO_3$ = Nitric Acid

# Appendix 5

## Monitoring Well Field Inspection Form

## Monitoring Well Field Inspection

Facility: Ameren Missouri Labadie Energy Center Utility Waste Landfill
Monitoring Well ID: ____________________

Name (Field Sampler): ____________________________

Date: ____________

Access:
Accessibility: Good ____ Fair ____ Poor_____

Well clear of weeds and/or debris?: Yes ____ No ______

Well identification clearly visible?: Yes ____ No ______

Remarks:

Concrete Pad:
Condition of Concrete Pad: Good ____ Inadequate _____

Depressions or standing water around well?: Yes ____ No_____

Remarks:

Protective Outer Casing: Material =

Condition of Protective Casing: Good ____ Damaged_____

Condition of Locking Cap: Good ____ Damaged_____

Condition of Lock: Good ____ Damaged_____

Condition of Weep Hole: Good ____ Damaged_____

Remarks:

Well Riser: Material =

Condition of Riser: Good ____ Damaged_____

Condition of Riser Cap: Good ____ Damaged_____

Measurement Reference Point: Yes ____ No_____

Remarks:

Dedicated Purging/Sampling Device: Type -

Condition: Good ____ Damaged ____ Missing_____

Remarks:

**Field Certification**

Signed Title Date

# Appendix 6

## Field Sampling Log and Volume Tracking Log Forms

# Field Sampling Log

Facility: Ameren Missouri Labadie Energy Center UWL

Date: ______________________ Monitoring Well ID: ______________________

Name (Field Sampler): ______________________

Gas Detected Y / N

PURGE INFORMATION:

Method of Well Purge: ______________________ Dedicated? Y / N

Date/Time Initiated: ______________________ One (1) Well Volume (ml): ______________________

Initial Water Level (feet): ______________________ Total Volume Purged (ml): ______________________

GroundWater Elevation (NGVD): ______________________ Well Purged To Dryness? Y / N

Well Total Depth (feet): ______________________ Water Level after Purge (feet): ______________________

Casing Diameter (feet): ______________________ Date/Time Completed: ______________________

PURGE DATA:

| Time | Purge Rate (ml/min) | Cumulative Volume (ml) | Temp (°C) | pH | Specific Conductivity (µS) | Oxidation Reduction Potential (mV) | Dissolved Oxygen (mg/L) | Turbidity (NTU) | Water Level | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
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# Field Sampling Log

**Sampling Information:** Date: ____________ Monitoring Well ID: ____________

Method of Sampling: low flow, peristaltic pump Dedicated: Y / N

Water Level @ Sampling, Feet: ____________

Monitoring Event: Annual ( ) Semi-Annual ( ) Quarterly (x) Monthly ( ) Other ( )

Sampling Data:

| Date/Time | Sample Rate ml/min | Temp (°C) | pH | Specific Conductivity (µS) | Oxidation Reduction Potential (mV) | Dissolved Oxygen (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

**Instrument Check Data:**

pH Meter Serial #: 1* 4.0 std. = 1* 7.0 std. = 1* 10.0 std. 1*

Conduct. Meter Serial #: 1* standard = 1* µS reading = 1* µS

Turbidity Meter Serial #: 1* standard = 1* NTU reading = 1* NTU

* See instrument calibration log for daily calibration data.

**General Information:**

Weather Conditions @ time of sampling: ____________

Sample Characteristics: ____________

Sample Collection Order: Per SOP

Comments and Observations:

I certify that sampling procedures were in accordance with applicable EPA and State protocols.

Date: ____________ By: ____________ Title: ____________

Prepared by GREDELL
Engineering Resources, Inc.

# Volume Tracking Log

**Facility Name: Ameren Missouri Labadie Energy Center UWL**

| Well ID | Tally notes | Total Volume (mL) |
|---|---|---|
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Note: Each Tick mark is equal to 1000 mL or 1L.
Total volume based on a 1L graduated cylinder.

# Appendix 7

## Example Chain-of-Custody Field Record Form

# Chain of Custody Record

Date: ____________ Page: _____ of _____

| | | |
|---|---|---|
| Plant Manager | 314-992-8201 | 314-992-8204 |
| Contact Name | Phone Number | Fax Number |
| Ameren Missouri Labadie Energy Center UWL | | |
| Company Name | | |
| Labadie Bottom Road | | |
| Street Address | | |
| Labadie, MO 63055 | | |
| City, State, Zip | | |
| Labadie Power Plant | Utility Waste Landfill | |
| Project Name | Site Location | |

Analysis Request

| Preservation Code |
|---|
| 1 = 4°C |
| 2 = $HNO_3$ |
| 3 = HCl |
| 4 = $H_2SO_4$ |
| 5 = NaOH |
| 6 = Other |

| Sample ID | Date Collected | Time | Matrix | Lab ID | Preservation Code | Number of Containers | Rush | Container Size | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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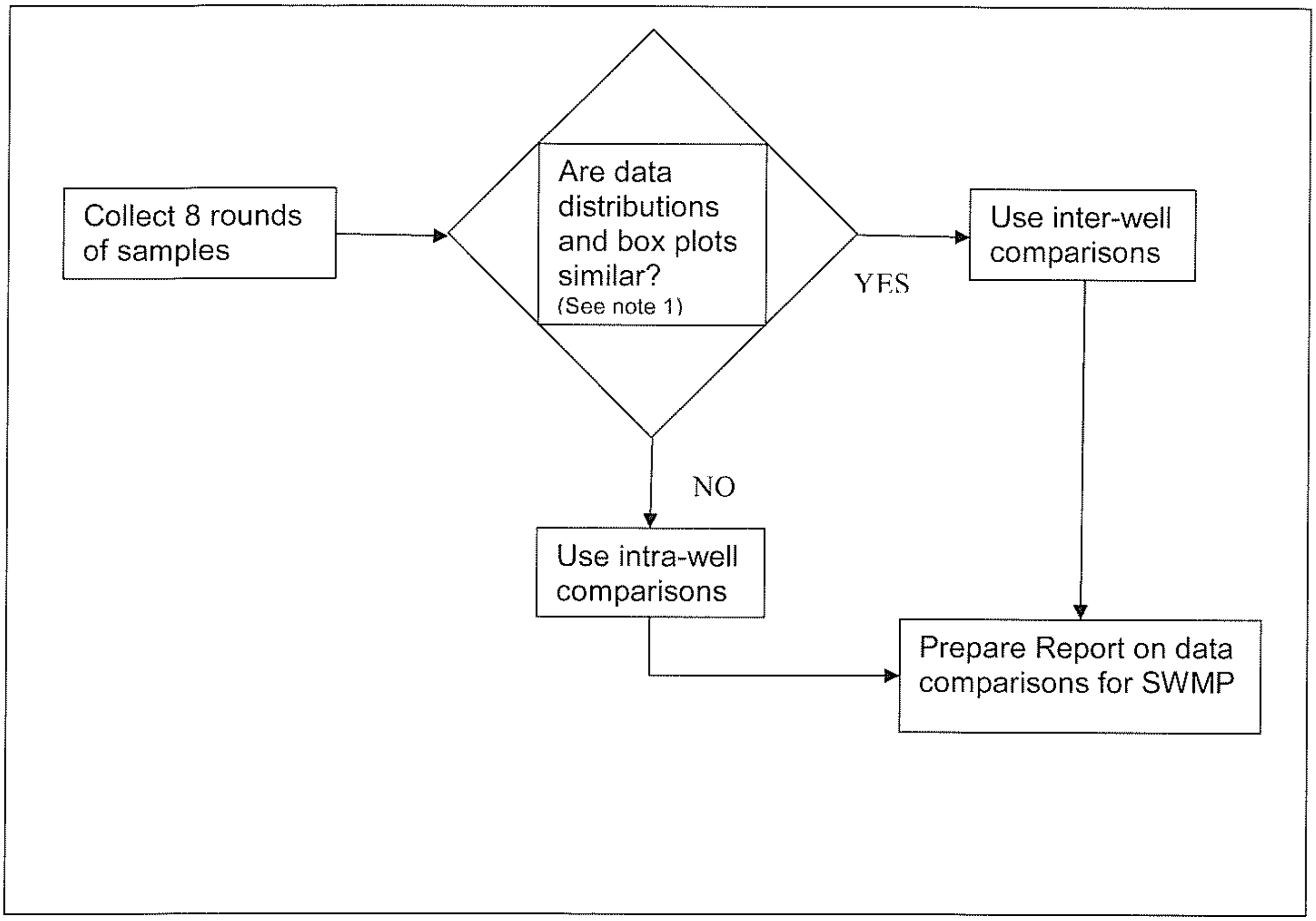
| Special Instructions / Comments | (1) Relinquished By | (2) Relinquished By | Sampler Initials: |
|---|---|---|---|
| | (1) Date / Time | (2) Date / Time | Method of Shipment |
| | (1) Company | (2) Company | HAND CARRY USPS FEDX UPS |
| | (1) Received By | (2) Received By | CoC |
| Route Results Through: Circle: Fax Email | (1) Date / Time | (2) Date / Time | Seal Intact? |
| Email address: | (1) Company | (2) Company | Yes No |

# Appendix 8

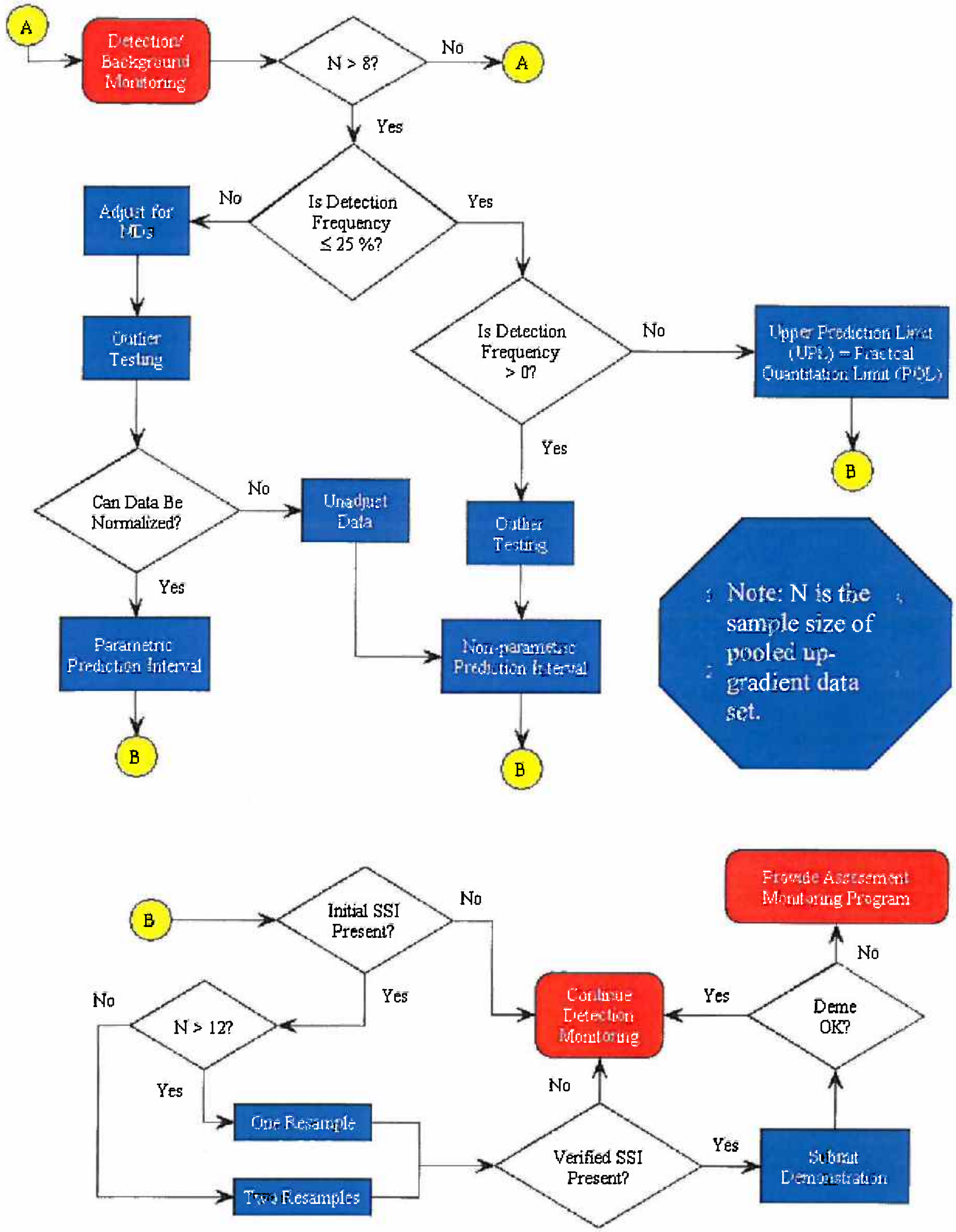
## Decision Flow Charts

# Selection of Statistical Procedure Based on Groundwater Background Data



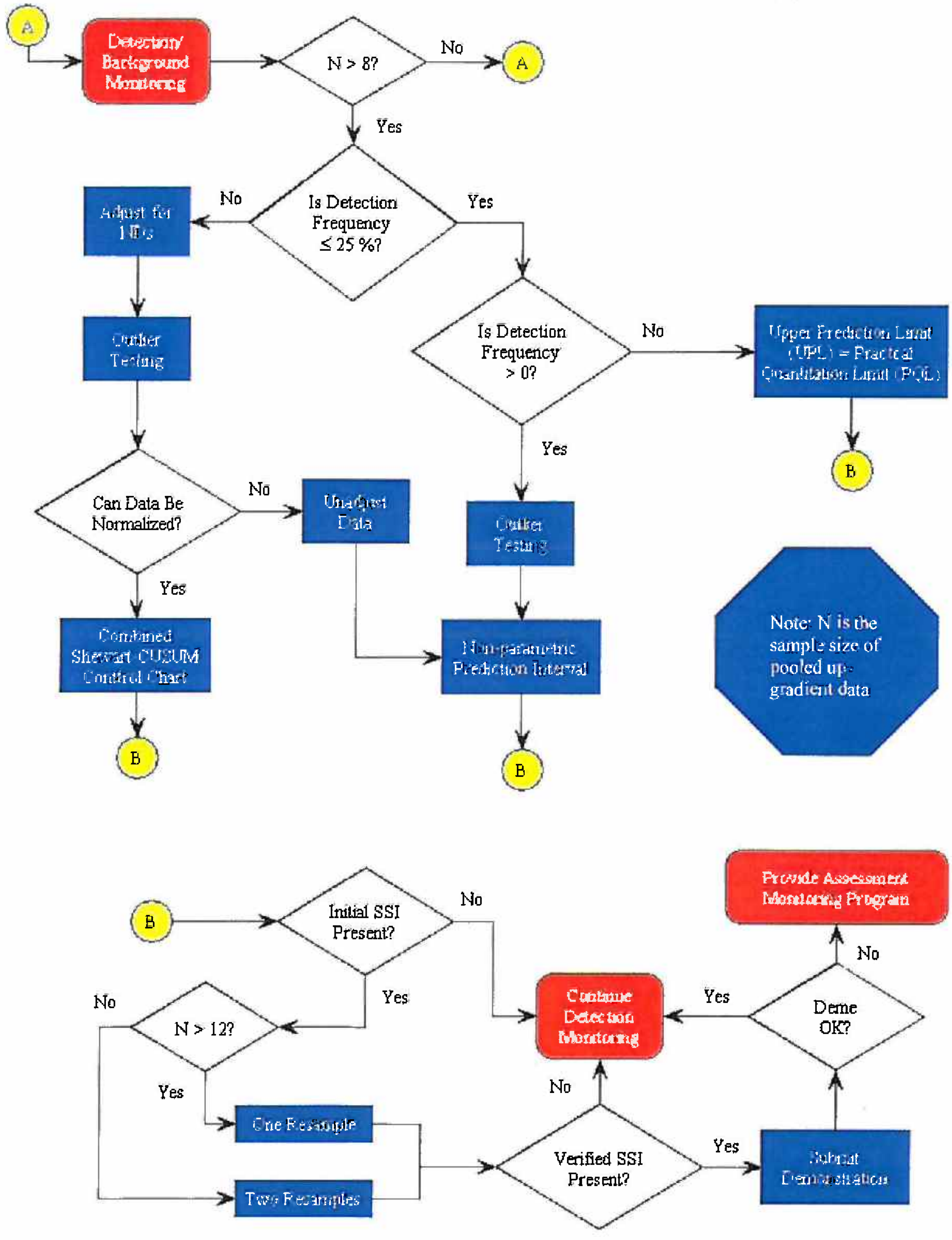

Note 1: This logic step is complex and will consist of various other steps. Exact steps are to be determined after data is available.

## *Attachment 1: Prediction Interval Test Strategy*




Source: Missouri Department of Natural Resources Solid Waste Management Program DRAFT Technical Bulletin:"Statistical Analysis Plan Guidance", 4/26/01.

***Attachment 2: Control Chart &***
***Non-Parametric Prediction Interval Test Strategy***




Source: Missouri Department of Natural Resources Solid Waste Management Program DRAFT Technical Bulletin:"Statistical Analysis Plan Guidance", 4/26/01.

# Appendix R

Closure and Post-Closure Plan

# Ameren Missouri Labadie Energy Center

## Closure and Post-Closure Plan for a Proposed Utility Waste Landfill Franklin County, Missouri

Ameren Missouri
Power Operation Services
3700 South Lindbergh Blvd.
St. Louis, Missouri 63127

December 2012

GREDELL Engineering Resources, Inc.
1505 East High Street
Jefferson City, Missouri 65101
Phone: (573) 659-9078
Fax: (573) 659-9079

# Ameren Missouri Labadie Energy Center
# Closure and Post-Closure Plan
# Proposed Utility Waste Landfill
# Franklin County, Missouri

## December 2012

## Table of Contents



## List of Appendices

# 1.0 Introduction

This Closure and Post-Closure Plan provides the criteria necessary to properly close and maintain the Ameren Missouri Labadie Utility Waste Landfill (UWL), owned and operated by Ameren Missouri. This plan includes the methods and schedule anticipated to properly close the entire landfill during or at the end of its operating life. Following closure of any portion of the landfill, 20-year post-closure maintenance requirements will be initiated. Estimated costs for completing closure and post-closure activities described herein are included to provide a basis for assuring that sufficient funds are available to complete the necessary activities. According to 10 CSR 80-2.030 (4)(B)2.D, utility waste landfills are not required to provide a post-closure financial assurance instrument (FAI).

The following Missouri Department of Natural Resources (MDNR) Technical Bulletins were utilized to prepare the Closure and Post-Closure Plan and are included as Appendices 1 and 2:

- Landfill Closure Guidance, 6/2006
- Preparing Solid Waste Disposal Area Closure and Post-Closure Plans, 6/2006

# 2.0 Closure Plan

## 2.1 Closure Plan Sequencing

The Missouri Department of Natural Resources and Franklin County will be notified in writing at least 180 days prior to the anticipated last receipt of waste in a phase of the landfill. The owner will make provisions to begin closure within 30 days of receiving final waste and will complete closure within 180 days of beginning closure on the landfill. Table 1 details the construction sequence for the landfill, which will be completed in 4 phases.

**TABLE 1**

| Phase Number | Cell Number | Disposal Acreage | Planned Use |
|---|---|---|---|
| Phase 1 | Cell 1 | 31.4 ac | Utility Waste Disposal |
| Phase 2 | Cell 2 | 35.2 ac | Utility Waste Disposal |
| Phase 3 | Cell 3 | 57.1 ac | Utility Waste Disposal |
| Phase 4 | Cell 4 | 42.8 ac | Utility Waste Disposal |
| **Total** | | **166.5 ac** | |

Prior to requesting authorization to operate, Ameren Missouri will execute an easement with MDNR that grants MDNR, its agents, or its contractors access to the permitted area to complete work specified in the closure plan, to monitor or maintain the utility waste disposal area, and/or to take remedial action during the post-closure period [10 CSR 80-2.020(2)(B)2.A]. Ameren Missouri will also submit evidence to MDNR that a notice and covenant running with the land has been recorded with the recorder of deeds in Franklin County. The notice and covenant will specify all items outlined in 10 CSR 80-2.020(2)(B)2.B(I)&(II). A copy of the Draft Agreements for Easement, Notice and Covenant Running with Land are provided in Appendix 3.

Following completion of closure activities, a letter and supporting documentation will be submitted to MDNR and Franklin County by an independent professional engineer registered in the State, verifying that closure activities have been completed in accordance with the closure plan and applicable laws and regulations. After MDNR and Franklin County approve closure of the landfill and the final survey plat, the survey plat identifying the boundaries and existence of the landfill will be recorded within 30 days with the Franklin County Recorder of Deeds. Two copies of the recorded plat will also be submitted to MDNR within 30 days of the filing with the Franklin County Recorder of Deeds.

## 2.2 Closure Activities

The required closure activities will consist of construction of the final cover, and construction of storm water control structures. Each of these closure activities will be completed according to the approved permit documents, including the Construction Permit Application and associated Plan Sheets and the Construction Quality Assurance Plan. The closure activities are discussed and detailed in the following sections of the Construction Permit Application and/or Plan Sheets:

| | |
|---|---|
| 1.) Landfill Final Cover | Section 3.12, Landfill Final Cover |
| | Section 4.9, Final Cover Material |
| | Plan Sheets 10, 11, 12, 13, 14 and 15 |
| 2.) Stormwater Runoff Controls | Section 3.7, Stormwater Management System |
| | Section 4.5.1, Stormwater Management |
| | Plan Sheets 16 and 21 |
| | Appendix N |

Ameren Missouri has the required quantity of soil suitable for construction of the final cap on their property. At closure, all soil will be obtained from on-site stockpiles or other areas within the permit boundary. The right of MDNR to utilize such soil for construction of the final cap and closure of the landfill will be provided through a binding, legal agreement between MDNR and Ameren Missouri, prior to issuance of the operating permit. The estimated average round trip distance from the soil borrow source to the landfill is less than 0.5 miles. A seed mixture compliant with MDNR's "Landfill Closure Guidance" (Appendix 1) will be used for vegetation on the final cover system.

### 2.3 Closure Cost Estimate

The purpose of closure cost assurance for landfills is to assure that sufficient funds are available to properly construct the final cover, establish vegetation, provide for erosion and drainage control and provide a pleasing appearance during the operating life of the landfill. The estimated costs for completing closure activities have been derived from the Closure and Post-Closure Cost Worksheet obtained from the MDNR Solid Waste Management Program website (http://www.dnr.mo.gov/forms/index.html). As indicated on the worksheet, the cost estimates or unit costs utilized in the calculations are in 2004 dollars. Costs are adjusted to third quarter 2012 dollars using the latest Implicit Price Deflators for Gross Domestic Product as determined by the U.S. Bureau of Economic Analysis.

Franklin County does not currently have closure and post-closure requirements for a UWL. For this reason, the requirements of 260.226 and 260.227 RSMo were used for the development of the plans and associated cost estimates.

The worksheets used to estimate the closure costs are included in Appendix 4. The closure cost estimate contained in Appendix 4A represents the maximum amount of closure financial assurance needed for the entire landfill. The cost of closing the entire 166.5-acre landfill is estimated to be $14,370,758. This cost represents the maximum amount of closure assurance needed if all cells of the landfill are open when the last volume of utility waste is deposited in the landfill.

Appendices 4B through 4E present the individual closure cost estimates for Phases 1, 2, 3, and 4. The individual phase cost estimates may be used to initially decrease the FAI and then incrementally increase the amount of the closure FAI throughout the operating life of the utility waste landfill.

## 3.0 Post-Closure Plan

### 3.1 Post-Closure Timeframe

This Post-Closure Plan includes the maintenance and monitoring activities to be performed at the landfill after closure. The post-closure maintenance period begins when MDNR agrees that the landfill, or a Phase of the landfill, has been properly closed. Post-closure maintenance will continue for 20 years from the date of final closure of the Phase or the landfill.

### 3.2 Post-Closure Activities

Post-closure care will include performance of the following activities:

1.) Maintenance of cover integrity, vegetative growth to protect the cover material, and the surface water control system

2.) Maintenance, sampling, testing and statistical analysis of the groundwater monitoring wells

Each of these post-closure activities will be completed according to the conditions of the permits and the approved permit documents. The post-closure activities are discussed and detailed in the following sections of the Construction Permit Application:

1.) Landfill Final Cover, Section 3.12 and Section 4.9, Final Cover Material
2.) Stormwater Management System, Section 3.7 and Section 4.5.1, Stormwater Management
3.) Groundwater Monitoring, Section 3.10 and Section 4.5.3, Groundwater Sampling and Analysis Plan

## 3.3 Post-Closure Cost Estimate

Per 10 CSR 80-2.030(4)(B)2.D, post-closure financial assurance is not required for utility waste landfills. However, Ameren Missouri has voluntarily agreed to provide a 20-year post-closure FAI for continued groundwater monitoring and evaluation during post-closure.

The purpose of the post-closure cost assurance for the Ameren Missouri Labadie Utility Waste Landfill is to assure that sufficient funds are available to maintain and test the groundwater monitoring system. The estimated cost for completing this post-closure care has been derived from the Closure and Post-Closure Cost Worksheet contained in the MDNR Solid Waste Management Program Technical Bulletin entitled "Preparing Solid Waste Disposal Area Closure and Post-Closure Plans", dated June 2006. The cost estimate or unit costs utilized in the calculations are in year 2004 dollars and adjusted to 2012 dollars.

Franklin County currently does not have a closure and post-closure requirements for a UWL. For this reason, the requirements of 260.226 and 260.227 RSMo were used for the development of the plans and associated cost estimate.

The worksheets used to estimate the closure and post-closure costs are included in Appendix 4. The post-closure cost estimate represents the maximum amount of post-closure financial assurance needed for the entire landfill. The cost of post-closure care for the entire 166.5-acre landfill is estimated to be $1,650,217.20. This cost represents the maximum amount of post-closure assurance needed for 20 years if all cells of the landfill are closed.

Appendix 4 also presents the individual closure and post-closure cost estimates for Phases 1, 2, 3, and 4. However, the cost for post-closure groundwater monitoring and evaluation are inseparable annual costs that will be fully funded prior to the operation of Phase 1.

### 3.4 Record Keeping

During the post-closure period, please contact Ameren Missouri, 1901 Chouteau Avenue, P.O. Box 66149, St. Louis, Missouri, 63166, (314) 554-2388, regarding any questions or issues with the landfill. Also during this period, all landfill records will be maintained by Ameren Missouri at the same address.

## 4.0 Remedial Action

If Ameren Missouri is required to develop a corrective action plan for the landfill during the life of the landfill or during the post-closure period, associated cost estimates will be prepared and a corresponding FAI will be secured.

## 5.0 Financial Assurance Instrument

Ameren Missouri may choose to provide financial assurance incrementally for closure and post-closure based on the closure and post-closure costs for each landfill construction phase as outlined below:

**Closure:**

| | |
|---|---|
| Phase 1 (31.4 acres): | $2,710,161 |
| Phase 2 (35.2 acres): | $3,038,142 |
| Phase 3 (57.1 acres): | $4,928,350 |
| Phase 4 (42.8 acres): | $3,694,105 |
| Total Closure (166.5 acres): | $14,370,758 |

**Post-Closure:**

Total Post-Closure (166.5 acres for 20 years): $1,650,217 *

*Ameren Missouri has voluntarily agreed to provide a 20-year post-closure FAI for continued groundwater monitoring and evaluation during post-closure.

**TOTAL Closure and Post-Closure:**

**Total Closure and Post-Closure (166.5 acres): FAI = $16,020,975**

The closure and post-closure cost estimates presented above are adjusted to third quarter 2012 values, as calculated in Appendix 4. The cost estimate will be reviewed every year to adjust the estimate based on the previous year's inflation rate. The results of the annual review will be submitted to the MDNR along with any recommendation for revising the amount required for closure and post-closure financial assurance funding. If changes in the design or operation of the landfill are made at a future date, the closure and post-closure plan and cost estimate will be reviewed at that time. If modifications to the plan are necessary, the revised closure and/or post-closure plan will be submitted to the MDNR along with the revised FAI.

In accordance with Utility Waste Regulation 10 CSR 80-2.030(4)(D), a FAI for closure and post-closure care may be satisfied by one of the following alternatives: trust fund or escrow account, financial guarantee bond or performance bond, irrevocable letter of credit, insurance policy, or corporate guarantee. Ameren Missouri will provide a suitable FAI prior to obtaining the initial construction permit. The FAI will be adjusted annually for inflation.

# APPENDICES

# Appendix 1

## MDNR "Landfill Closure Guidance" Technical Bulletin, dated 6/2006

Missouri Department of Natural Resources

# Landfill Closure Guidance

Solid Waste Management Program technical bulletin 6/2006

The Missouri Department of Natural Resources' Solid Waste Management Program (SWMP) has developed this technical bulletin to provide assistance to landfill owners, operators and engineers in obtaining closure approval from the department. This bulletin was prepared to provide guidance for closure under Missouri Solid Waste Management law and rules.

All owners or operators applying for closure approval must have a department approved closure/ post-closure plan. For further information regarding the preparation of closure/post-closure plans, see SWMP's technical bulletin entitled *Guidance For Preparing Solid Waste Disposal Area Closure and Post-Closure Plans* or contact SWMP at (573) 751-5401.

## 1. Closure Schedule

A. Notify the SWMP in writing of intentions to cease taking waste 180 days prior to anticipated closing date.
B. Implementation of closure must begin within 30 days of last receipt of waste.
C. Closure must be completed within 180 days of the initiation of closure activities. Time extensions may be granted by SWMP. To request an extension the owner or operator must submit a written request to SWMP within at least 30 days of the closure deadline and include a proposed schedule for completing closure. Extensions will only be granted on a case-by-case basis. However, the owner or operator must have made considerable efforts in previously closing the landfill.

## 2. Final Closure Guidance

As each phase of the landfill is completed, final cover must be applied. A good final cover will help minimize surface water infiltration and subsequent leachate production as well as minimize gas migration produced by decomposing waste. Following are descriptions of the various components of a final cover.

A. Landfills Without Composite Liners
   1. Two feet of compacted soil classified as CH, CL, ML, SC or MH as per ASTM method D-2487.
   2. One foot of vegetative soil.

B. Landfills With Composite Liners
   1. One foot of compacted soil classified as CH, CL, ML, SC or MH as per ASTM method D-2487.
   2. Geomembrane, equal to that of liner, at least 30 mil thick or 60 mil for HDPE liners.
   3. Lateral drainage layer must be constructed between the vegetative soil and the underlying geomembrane.
   4. Two feet of vegetative soil.

*Note: All borrow area soil used for cover construction must be tested by a professional engineer or their agent to ensure the soil meets the approved standards as per 10 CSR 80-3.010.*

## 3. Construction and Grading

When constructing the final cover a strict Quality Assurance/ Quality Control (QA/QC) plan must be followed to ensure the cover is not damaged in any way.

A. Final contours of the closed landfill shall not exceed the originally approved permitted final contours unless approval is granted by the department.
B. The compacted soil layer shall be constructed in 6 inch to 8 inch lifts until the desired thickness is achieved. The compacted soil must be covered so as to prevent damage from drying and cracking.
C. Side slopes shall not exceed permitted grade or 3:1 (horizontal: vertical), whichever is less. Those areas that require the placement of a geomembrane as a component of final cover must not be allowed to erode or cause slope failure. It is recommended in these cases that the slope be decreased.
D. Terracing and letdown structures shall be constructed to prevent erosion and to control stormwater, as called for in a department approved closure plan.

## 4. Vegetation

Once the cover has been applied, the top surface of the landfill must be vegetated. This is important for several reasons. A good healthy stand of vegetation helps control erosion of the topsoil from surface water runoff and wind as well as helps minimize the infiltration of stormwater into the landfill and subsequent leachate production. Following are some guidelines for establishing a good stand of vegetation.

A. Methods to establish vegetation:

1. The department recommends a hardy grass or legume mixture be used such as fescue (75 pounds/acre) and clover.
2. Soil testing of the vegetative layer for proper application of lime, fertilizer and other soil conditioning.
3. The application of mulch must be utilized during the time vegetation is to be established. Mulch is used to help prevent slope erosion, conserve soil moisture, prevent seed from being washed or blown away as well as prevent weed growth. Acceptable mulching materials include, but are not limited to, straw, hay or fiber. However, sawdust or chipped wood is not a suitable material for use as mulch.

B. The department considers that a good stand of healthy vegetation is one that controls and prevents erosion and provides vegetative cover of at least 80 percent of any square foot evaluated by department personnel. The department reserves the right to determine whether or not vegetation has been adequately established before closure is approved.

## 5. Submittals for Closure Approval

Before closure can be approved, three copies of the following documentation must be submitted.

A. Certification by a professional engineer registered in Missouri that closure has been completed in accordance with an approved closure plan. The certification must include

1. As-built drawings of the landfill. These drawings must include final contours of the landfill, vertical and horizontal limits of waste placement and any environmen tal control systems at the landfill. (The survey plat referenced below may be included on the as-built drawings, eliminating the need for two separate draw ings.)
2. Evidence that final cover components have been verified for depth and types of cover soils on 100 foot centers and identified on the as-built drawings.
3. Evidence that a dense stand of hardy vegetation has been established as per SWMP requirements, section 4. B. of this document.

B. A survey plat prepared by a licensed surveyor registered in Missouri must be submitted upon completion of closure. The plat must contain the following information at a minimum:

1. The name of the property owner as it appears on the property deed.
2. A survey and detailed legal description of the waste limits, the permitted area and the property boundary.
3. The general types, locations and depths of wastes within the property.
4. The location of any environmental control systems in place at the landfill and the length of time these systems and the landfill are to be maintained.
5. The location of all boundary markers and benchmarks located at the site.

*Note: Filing of Survey Plat:*

1. Within 30 days of department approval of the plat, the owner or operator shall file the plat with the county recorder of deeds.
2. Two copies of the recorded plat shall be submitted to the department within 30 days of the filing.

C. Owners or operators of solid waste disposal areas permitted prior to Jan. 1, 1987 and which close after Jan. 1, 1989 as part of closure must

1. Execute an easement with the department or its agents to enter the site to monitor, maintain, or take remedial action during the 30 year post-closure period.
2. Submit evidence to the department that a notice and covenant running with land has been filed with the county recorder of deeds. The notice and covenant shall specify the following:

    A. The property has been permitted as a sanitary landfill.
    B. That use of the land which interferes with the closure/post-closure plan is prohibited.

SWMP has created a standard form entitled *Agreement for Easement, Notice and Covenant Running With Land*, which must be submitted upon completion of closure. This form should be completed concurrently with the survey plat.

## 6. Closure Approval/Denial

Upon completion of the above closure activities, the permittee must request from the SWMP approval for final closure of the landfill and that closure funds be released.

A. SWMP will conduct a final closure inspection to verify that all the requirements for closure have been met.
B. SWMP will either approve or deny the request for closure approval. If the request is approved, closure funds will be released. If the request is denied, a letter will be sent to the permittee outlining the deficiencies for closure and time frames for compliance.

## 7. Recommended Guidance

A. Missouri Department of Natural Resources technical bulletin *Guidance For Preparing Solid Waste Disposal Area Closure and Post-Closure Plans.*
B. U.S. Environmental Protection Agency report *Standard Procedures For Planting Vegeta tion On Completed Sanitary Landfills.*
C. University of Missouri Extension Services document *How to Get A Good Soil Sample.*
D. University of Missouri Extension Services document *Using Your Soil Test Results.*

## For more information call or write:

Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176
Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-5401 office
(573) 526-3902 fax
www.dnr.mo.gov/env/swmp Program Home Page

# Appendix 2

## MDNR "Preparing Solid Waste Disposal Area Closure and Post-Closure Plans" Technical Bulletin, dated 6/2006

Missouri Department of Natural Resources

# Preparing Solid Waste Disposal Area Closure and Post-Closure Plans

Solid Waste Management Program Technical bulletin 6/2006

## Introduction

The Missouri Department of Natural Resource's Solid Waste Management Program has developed this technical bulletin to help landfill owners prepare closure and post-closure plans. Closure and post-closure plans are intended to describe how a facility will be closed and maintained, and more importantly to provide a basis for calculating the amount of financial assurance required for the facility. Closure and post-closure plans must be prepared or approved by a Professional Engineer (P.E.) registered in the State of Missouri, and must be approved by the Solid Waste Management Program.

The Missouri Solid Waste Management Regulations contain the following requirements in regard to closure and post-closure plans:

- Owners of active sanitary landfills are required to provide closure plans and thirty-year post-closure plans.
- Owners of active demolition landfills, utility waste landfills and special waste landfills are required to provide closure plans.
- Owners of demolition landfills permitted after July 30, 1997, are also required to provide thirty-year post-closure plans.
- Owners of utility and special waste landfills permitted after July 30, 1997, are required to provide twenty-year post-closure plans.
- Owners of inactive landfills are required to provide closure and post-closure plans in accordance with the regulations in place at the time the facility ceased accepting waste.

This technical bulletin addresses two aspects of closure and post-closure plans: the text of the plan itself and the closure and post-closure cost estimates. These aspects apply to the following facilities:

### Text of the plan

- Applies to facilities permitted after the date of this technical bulletin.
- Currently active facilities and permitted facilities that are not yet constructed will only be required to revise the text of their closure and post-closure plans to follow this new format when updating their closure and post-closure plans for any reason.
- Does not apply to inactive facilities (those that have ceased accepting waste).

### Cost estimates

- Applies to facilities permitted after the date of this technical bulletin.
- Currently active facilities, and facilities that are permitted but not yet constructed will be required to revise their cost estimates with the next annual financial assurance update.
- Does not apply to inactive facilities.

The Solid Waste Management Program recommends that the closure and post-closure plans be a separate document rather than a section, or appendix, of the overall engineering report for the facility. It is important to make a distinction between the closure and post-closure plans and other aspects of the engineering design. The regulatory requirements are specific for final cover systems, gas control systems, surface water control systems, and environmental monitoring systems. The detailed aspects of design should be addressed in the appropriate section of the engineering report. The closure and post-closure plans address more general requirements.

Where possible, the closure and post-closure plans should refer to the approved design and the approved monitoring plans, but should not reiterate them in detail. Nor should changes to the closure and post-closure plans be submitted to modify the design of the final cover system, the surface water control system, the gas collection system, the gas-monitoring plan, or the ground-water monitoring plan. The closure and post-closure plan should focus on implementation of the design, the monitoring plans, and the maintenance activities.

Not only will eliminating redundancy decrease the chances for contradictions between the engineering design documents and the closure and post-closure plans, but in many cases it will allow the owner to modify some aspect of the design, or perhaps a monitoring plan, without having to make changes to the closure or post-closure plans.

This technical bulletin has been written to address the most detailed aspects of closure and post-closure. Many of the design features discussed here, such as geosynthetic caps and active gas collection systems, may not apply to demolition landfills, utility waste landfills, special waste landfills, or older areas of sanitary landfills. Only those portions applicable to the design and operation of your facility must be addressed.

## Closure Plan

According to the regulations, closure plans must include a description of the methods and time schedules for closure of the permitted area. The plans may have distinctly different contents for older facilities as opposed to newer ones.

### Methods

The engineering design should already address in detail the construction methods to be used for the final cap system and other systems that will be built during closure, such as the gas control system and the surface water control system. There is no need to repeat these construction methods in detail in the closure plan. However, the quality assurance/quality control (QA/QC) methods for these systems may not be clearly specified in the approved engineering design. QA/QC is an important part of closure since it forms the basis for the engineering certification that the facility was properly closed. It includes things such as laboratory and field testing of soils and membranes as well as survey control. It is essential to address this aspect of construction in one way or another. While more modern facilities usually have separate QA/QC plans, older facilities may not. If not, this aspect of closure must be addressed in the closure plan.

### Schedule

Since the closure schedule depends on unpredictable factors, particularly waste flow, it would be futile to present a detailed closure schedule in the closure plan. This aspect of closure would more appropriately be termed a closure sequence. Again, for older facilities as opposed to newer ones, the closure plan may have a different focus in this regard.

Newer facilities are typically designed in phases. Current regulations require landfill owners to submit phase development drawings to show how the site will be developed. These drawings should be detailed enough to show the various stages of development of the landfill, from liner construction in new phases through closure of older phases, including construction of gas and surface water control systems. In other words, the closure sequence should already be laid out in sufficient detail in these phase development drawings. However, for older facilities, phase development drawings more than likely do not exist and should be included in the closure post-closure plan.

The closure plan must address the following:

- The plan must indicate the closure status of all areas within the permitted boundary that have received waste, regardless of when they were filled.
- The plan must indicate whether the facility will close in phases or all at one time.
- The plan must indicate the total size of the entire landfill footprint.
- For phased closure, the plan must also indicate the size of each phase.
- The plan must indicate that Missouri Department of Natural Resources will be notified in writing at least 180 days before the anticipated last receipt of waste in the landfill; or, for phased development, in any particular phase.
- The plan must indicate that closure will begin within 30 days of the last receipt of waste in the landfill or phase and will be completed within 180 days of beginning closure. The regulations allow the department to grant extensions to these time frames in certain situations, but any proposed deviations must be clearly indicated in the closure plan.
- The plan must indicate all the major steps necessary to close the landfill based on the approved engineering design and the conditions of the permit.
- For phased facilities with approved phase development drawings, the closure sequence should be summarized in the closure plan in enough detail to allow the department to determine when various landfill components will be constructed.
- For phased facilities without approved phase development drawings, the closure plan should include drawings clearly showing the planned closure sequence for the facility. The drawings should be correlated with the text of the plan to clearly indicate when various landfill components will be constructed.
- If you have an approved QA/QC plan for your facility that addresses the current regulatory requirements and construction verification procedures for the final cover system and other components to be installed or constructed as a part of closure, a simple reference to the QA/QC plan in the closure plan is sufficient.
- If you do not have an approved QA/QC plan, the closure plan must include a QA/QC plan for the final cover system and any component that will be installed as a part of closure. The QA/QC plan must address all field and laboratory procedures that will be used to verify the material properties and the construction methods for each component. The QA/QC plan must also address survey control.
- The plan must indicate that, upon completion of closure activities, a P.E. registered in the state of Missouri will certify that the facility or phase was properly closed.

## Post-closure plans

According to the regulations, post-closure plans must address the maintenance and monitoring activities required during the post-closure period. However, most of the monitoring activities are performed in accordance with approved surface water, groundwater, and gas monitoring plans. There is no need to reiterate these monitoring plans in great detail in the post-closure plan. A simple reference is adequate. The plan should focus mostly on maintenance activities.

The post-closure plan must address the following:

- The plan must show that groundwater monitoring and gas monitoring will be done in accordance with the approved monitoring plans and the terms and conditions of the permit.
- The plan must show that surface water monitoring, if applicable, will be conducted in accordance with the terms and conditions of any permit(s) issued by the Missouri Clean Water Commission.
- The plan must show the activities necessary to maintain the integrity of the final cover system, the leachate collection system, the gas control system, the gas monitoring system, the surface water control system, the groundwater monitoring system, and any other system specified in the approved engineering design.
- The plan must show the location where landfill records will be kept during the post-closure period. A copy of these records must be made available to the appropriate department staff upon request.

### Financial assurance and cost estimates

Current regulations require owners of sanitary, demolition, and utility waste landfills to provide a closure Financial Assurance Instrument (FAI). Sanitary landfill owners are also required to provide a post-closure FAI. FAIs are necessary to ensure that the department has sufficient funds to properly close and maintain the facility in the event the owner is unable to do so. The closure FAI may be returned if final closure has been approved in writing by the department. A portion of the post-closure FAI may be returned annually starting on the sixth anniversary of the beginning of the post-closure period, and the remainder may be refunded after completion of the post-closure period.

### New facilities

The solid waste disposal area permitting process is separated into several distinct steps. In addition to the preliminary and detailed site investigation requirements, owners of new facilities, those applying for a construction permit after July 30, 1997, are now required to obtain a construction permit to build a landfill and an operating permit to begin receiving waste. For owners of new facilities, a closure FAI is due prior to obtaining the initial construction permit, and a post-closure FAI is due prior to obtaining the initial operating permit.

If the operations are phased, the initial closure FAI only needs to include the amount necessary to close the first phase of the landfill, while the initial post-closure FAI must include the separable post-closure costs for the first phase, plus the inseparable post-closure costs for the entire landfill. Separable costs are those which are common only to a particular phase, such as cover maintenance. Inseparable costs are those which are common to the entire landfill, such as annual inspections, gas monitoring, and groundwater monitoring. These inseparable activities will be required for the entire landfill for the duration of the post-closure period whether or not subsequent phases are developed. For subsequent phases of new facilities, both the closure FAI and separable post-closure FAIs are due when operation of the phase is requested.

### Existing facilities

Owners of existing facilities must have a closure and post-closure FAI in place for any area of the landfill in which waste was placed after Jan. 1, 1987. For newly developed phases of existing facilities, as with new facilities, both the closure FAI and separable post-closure FAIs are due when operation of the phase is requested.

### Worksheet

In order to determine the amount of funding required for financial assurance, it is necessary to do a cost estimate. The purpose of the closure cost estimate is to determine the funding required for the department to complete landfill closure. The purpose of the post-closure cost estimate is to determine the funding required for the department to maintain and monitor the facility for the duration of the post-closure period.

To simplify the cost estimation process, the department has developed the attached worksheet to be used in calculating the amount of financial assurance required for closure and post-closure. To understand the need for a simplified worksheet, you must first understand the scenario under which the department will be required to perform closure and post-closure activities. In this situation, there will either be no responsible party, or the responsible party will be unwilling or unable to perform closure or post-closure activities. There is no other reason for the department to assume these responsibilities. In this scenario, it is quite likely that the facility has been poorly managed, either operationally, financially, or both.

In a premature closure scenario, it is unlikely that the landfill will resemble what was depicted in the approved final contour drawings. Some areas of the landfill may be at the permitted final elevation while others may be significantly lower, or higher if the landfill was poorly managed. It is likely that extensive regrading will be required for cover construction; surface water may have to be routed differently than indicated in the approved design and some portions of the gas system may be installed while others are not. The department will likely hire a consultant to determine the most cost-effective method of closure. No one can anticipate all possible scenarios, nor is the FAI intended to provide funds for all possible scenarios. It is also difficult to accurately estimate the costs for complicated systems such as landfill gas collection systems even under ideal circumstances, much less during a premature closure scenario.

For this reason, the cost estimates are not intended to be extremely detailed or complicated. They are intended as a simple method of providing a reasonable amount of money to allow the department to evaluate the condition of the landfill and close it in accordance with the minimum requirements of the regulations and any special requirements imposed by the design engineer. The most important thing is that estimates be reasonably accurate and include costs for all major aspects of landfill closure and post-closure.

The attached worksheet must be completed in order to determine the closure and post-closure costs. Any critical feature(s) included in the design for which there is no line item on the worksheet must be accounted for as well. For these features, the department will allow the use of third party quotes or professional judgement on the part of the design engineer in preparing cost estimates. These estimates should be attached to the worksheet.

Please note that this worksheet only applies to facilities with Subtitle D (composite) caps or standard soil caps (two feet of compacted clay overlain with one foot of vegetative soil). Some demolition landfills, utility waste landfills, and special waste landfills are designed with other types of caps. The department will work with the owners of these facilities on a case by case basis to determine the amount of financial assurance required, using the principles and unit costs developed in this technical bulletin.

Due to variations in design, more than one worksheet may be necessary for your facility. For example, some older landfills have both Subtitle D areas and areas with soil caps. Some portions of the landfill may be required to have an active gas extraction system while others are not. In some cases, for example where a Subtitle D permit has superceded a previous permit, one worksheet can be completed to account for all areas within a permitted landfill. However, we suggest that you complete a separate worksheet for each distinct area. The worksheet is simple enough that this should not be difficult. In no case should areas with different permit numbers be combined on the same worksheet. The text of the plan should address each distinct area and explain the variations in design from one area to the next.

For a facility where all areas or phases are designed the same, such as a complete Subtitle D facility, as subsequent phases are opened you should submit a new worksheet that accounts for all phases of the landfill. For example, if you are submitting a request to open the fifth of ten phases, you should replace previously submitted worksheets with a new one that accounts for the total acreage for phases one through five.

The worksheet is based on unit closure costs for the following standardized aspects of design:

- Compacted clay cap
- Gas collection or venting system
- 40 mil low density polyethylene membrane
- Geocomposite drainage net, if applicable
- Vegetative soil
- Surface water controls
- Vegetation
- Borrow area reclamation
- Professional services

Owners of Subtitle D facilities must provide an FAI for either an active gas extraction system or a passive venting system. You must provide an FAI for an active system only if you are:

1. required to install the system by the department to control off-site gas migration,
2. required to install the system under the Federal New Source Performance Standards (NSPS), or,
3. required to install the system by some other regulatory agency.

If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide an FAI for a passive venting system. Owners of non-Subtitle D facilities (with soil caps) are not required to provide an FAI for a gas control system at all unless they meet at least one of the above conditions.

For simplicity, the worksheet costs are the same for active extraction wells and passive vents. Costs for wells or vents must be included in the cost estimate for the phase in which they will be physically located. However, costs for other components such as connecting piping, blowers, and flares, if required, only need to be included in the cost estimate at the point they are determined to be necessary by the design engineer. Again, this will depend entirely on the phase development and closure sequence discussed previously.

For example, assume that your landfill is large enough that you will eventually be required to install a gas extraction system under NSPS. The design engineer determines that the emissions will exceed the threshold limit when the fifth of ten phases are in place. In other words, if the landfill closes prematurely after only four phases are in place, the facility will be below the threshold limit and only a passive venting system will be required. The costs for the gas vents for each of the first four phases must be included in the FAI cost estimates for those phases because they will be required regardless of whether the fifth phase is ever constructed. You must at least vent Subtitle D landfills. You must use Form B, the Worksheet for Passive Gas System, through the first four phases. However, when you request to operate the fifth phase, since this will cause you to reach the threshold limit, you must now convert the passive vents to active extraction wells, install connecting piping, and the blower/flare station. To calculate your closure cost for this system, you must complete Form A, the Worksheet for Active Gas Systems.

The worksheet is based on unit post-closure costs for the following standardized maintenance and monitoring activities:

- Site inspections
- Erosion repair and revegetation of final cap
- Groundwater sampling and analysis
- Gas monitoring
- Leachate disposal
- Groundwater monitoring system maintenance and repair
- Gas monitoring system maintenance and repair
- Gas control system maintenance and repair (if applicable)
- Leachate management system maintenance and repair
- Professional services

Owners of facilities that voluntarily design and install an active gas system will be required to provide post-closure maintenance costs for the system once it is constructed. This is simply because, once the system has been built, the department will have to maintain it.

### Worksheet unit costs

In the event the department is required to close a landfill, labor rates for the project will be in accordance with the prevailing wage rates in the county in which the landfill is located. Therefore, the unit costs in the worksheet are based primarily on R.S. Means publications because they reflect average national wage rates. A detailed analysis of the unit costs is available upon request.

You will note that the costs vary significantly depending on the round trip haul distance from the borrow area, and whether or not the landfill owner has granted an easement to the department for use of the borrow soils for closure. The higher costs due to increased haul distance should be apparent. Costs are also tied to the easement because, if the department is required to complete closure of a landfill or perform cover maintenance during the post-closure period, the costs will be much higher if we have to purchase the soil from an outside source. Therefore, unless you have executed an easement with the department that allows the use of borrow soil for closure and post-closure, we must make an assumption as to the availability of borrow soil. This assumption is that we will be able to locate and purchase the required quantity of suitable soils within five miles of the site. Therefore, for the purposes of cost estimating, we will assume a round trip haul distance of 10 miles.

### Updating the cost estimate and FAI

One of the advantages of the simplified worksheet is that it minimizes the changes required to the cost estimate and the FAI. In order to understand this, you must understand the distinction between changes to the cost estimate and changes to the FAI.

The cost estimate is based on the major aspects of landfill design such as total acreage permitted for waste disposal (landfill footprint), the type of cover (subtitle D or non-subtitle D), the type of gas system (active or passive), and the number of groundwater monitoring wells. Once your cost estimate has been revised to match the figures in this technical bulletin, it must be updated only if some design aspect changes.

The FAI is a document ensuring that a reasonable amount of money is guaranteed to the department to complete closure and post-closure activities. It is based on the cost estimate. The amount of money must be updated annually for inflation, or if the cost estimate changes.

To illustrate this, we will use the following example:

Assume that, once your cost estimate is revised to match the figures in the technical bulletin, your closure cost estimate is $2 million and your post-closure cost estimate is $3 million. If you operate for twenty years and never modify any aspect of design, you will never need to change that cost estimate. You only need to increase the FAI annually for inflation, as outlined below. However, assume that at some point you are required by the department to install an-active gas system to control a gas migration, or add two groundwater-monitoring wells. You must submit a new worksheet accounting for the increased closure or post-closure cost for the modification. Once the modifications and new cost estimate are approved by the Solid Waste Management Program, you will be required at that time to update your FAI to match the new cost estimate. From that point on, the FAI must be increased annually for inflation, but no changes to the cost estimate will be necessary unless further design changes are approved.

It is important to note that using the worksheet to update a cost estimate will always result in an estimate in year 2000 dollars. This figure must then be updated for inflation to the current year.

### Annual adjustments for inflation

Annual adjustments for inflation are determined by increasing the original dollar value using a multiplier. The multiplier is the latest percent change in the Implicit Price Deflator (IPD) for the Gross Domestic Product as determined by the U.S. Department of Commerce. The IPDs change every quarter depending on the current rate of inflation. You must always use the most recent IPD when updating a cost estimate or FAI. The most recent IPD can be obtained from the Solid Waste Management Program.

### Forms Available Online

*Closure and Post-Closure Cost Worksheet*

www.dnr.mo.gov/forms/780-1882.pdf

*Form A - Active Gas System Worksheet*

www.dnr.mo.gov/forms/780-1881.pdf

*Form B - Passive Gas System Worksheet*

www.dnr.mo.gov/forms/780-1880.pdf

*Table 1 - Cover Systems Construction and Repair Costs*

www.dnr.mo.gov/forms/780-1879.pdf

### For more information call or write:

Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176
Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-5401 office
(573) 526-3902 fax
www.dnr.mo.gov/env/swmp Program Home Page

# Appendix 3

## Agreement for Easement, Notice and Covenant Running with Land – Franklin County

**Missouri Department of Natural Resources**
**Solid Waste Management Program**

**AGREEMENT FOR EASEMENT,**
**NOTICE AND COVENANT RUNNING WITH LAND**
(Standard Form 4-11-96)

This Agreement made this DRAFT day of ______, 20___, between the Missouri Department of Natural Resources, hereinafter called Department and Ameren Missouri, hereinafter called Owner, to satisfy the requirements of the Missouri Solid Waste Management Law.

WITNESSETH.

Owner wishes to execute an Agreement for Easement, Notice and Covenant Running with Land for a solid waste disposal area (hereinafter called landfill) on property owned by owner in Franklin County, Missouri, and more fully described as follows:

PART OF SECTIONS 8 AND 17 AND PART OF U.S. SURVEY 98 IN TOWNSHIP 44 NORTH, RANGE 2 EAST OF THE FIFTH PRINCIPAL MERIDIAN, FRANKLIN COUNTY, MISSOURI, DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORDS, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREES 28 MINUTES 18 SECONDS EAST, 80.58 FEET TO THE POINT OF BEGINNING OF THE TRACT HEREIN DESCRIBED; THENCE DEPARTING SAID WESTERLY LINE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 53.86 FEET; THENCE SOUTH 61 DEGREES 52 MINUTES 36 SECONDS WEST, 208.05 FEET; THENCE SOUTH 60 DEGREES 39 MINUTES 30 SECONDS WEST, 331.03 FEET; THENCE SOUTH 69 DEGREES 57 MINUTES 40 SECONDS WEST, 377.65 FEET; THENCE SOUTH 77 DEGREES 17 MINUTES 21 SECONDS WEST, 250.40 FEET; THENCE NORTH 86 DEGREES 14 MINUTES 27 SECONDS WEST, 273.79 FEET; THENCE 89 DEGREES 40 MINUTES 33 SECONDS WEST, 235.30 FEET; THENCE NORTH 83 DEGREES 46 MINUTES 07 SECONDS WEST, 191.63 FEET; THENCE NORTH 87 DEGREES 02 MINUTES 14 SECONDS WEST, 216.88 FEET; THENCE SOUTH 84 DEGREES 28 MINUTES 52 SECONDS WEST, 166.48 FEET; THENCE SOUTH 71 DEGREES 37 MINUTES 58 SECONDS WEST, 120.83 FEET; THENCE SOUTH 71 DEGREES 28 MINUTES 48 SECONDS WEST, 164.93 FEET; THENCE SOUTH 55 DEGREES 47 MINUTES 10 SECONDS WEST, 343.76 FEET; THENCE SOUTH 55 DEGREES 28 MINUTES 54 SECONDS WEST, 805.68 FEET; THENCE NORTH 01 DEGREES 23 MINUTES 57 SECONDS EAST, 7597.67 FEET; THENCE SOUTH 86 DEGREES 27 MINUTES 31 SECONDS EAST, 5469.88 FEET; THENCE SOUTH 02 DEGREES 02 MINUTES 11 SECONDS WEST, 2991.70 FEET; THENCE SOUTH 01 DEGREES 17 MINUTES 10 SECONDS WEST, 1070.22 FEET; THENCE SOUTH 01 DEGREES 09 MINUTES 17 SECONDS WEST, 1239.51 FEET; THENCE SOUTH 01 DEGREES 42 MINUTES 10 SECONDS WEST, 492.33 FEET; THENCE SOUTH 81

DEGREES 39 MINUTES 02 SECONDS WEST, 663.60 FEET; THENCE SOUTH 83 DEGREES 24 MINUTES 58 SECONDS WEST, 688.43 FEET; THENCE SOUTH 84 DEGREES 50 MINUTES 23 SECONDS WEST, 306.70 FEET; THENCE SOUTH 80 DEGREES 32 MINUTES 21 SECONDS WEST, 241.96 FEET; THENCE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 176.34 FEET TO THE POINT OF BEGINNING.

SAID TRACT BEING SITUATED IN FRANKLIN COUNTY, MISSOURI AND CONTAINING 35,422,418 SQUARE FEET OR 813.187 ACRES, MORE OR LESS.

Owner has access to the above described landfill as follows:

PART OF SECTIONS 8 AND 17 AND PART OF U.S. SURVEY 98 IN TOWNSHIP 44 NORTH, RANGE 2 EAST OF THE FIFTH PRINCIPAL MERIDIAN, FRANKLIN COUNTY, MISSOURI, DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORDS, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREES 28 MINUTES 18 SECONDS EAST, 80.58 FEET TO THE POINT OF BEGINNING OF THE TRACT HEREIN DESCRIBED; THENCE DEPARTING SAID WESTERLY LINE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 53.86 FEET; THENCE SOUTH 61 DEGREES 52 MINUTES 36 SECONDS WEST, 208.05 FEET; THENCE SOUTH 60 DEGREES 39 MINUTES 30 SECONDS WEST, 331.03 FEET; THENCE SOUTH 69 DEGREES 57 MINUTES 40 SECONDS WEST, 377.65 FEET; THENCE SOUTH 77 DEGREES 17 MINUTES 21 SECONDS WEST, 250.40 FEET; THENCE NORTH 86 DEGREES 14 MINUTES 27 SECONDS WEST, 273.79 FEET; THENCE 89 DEGREES 40 MINUTES 33 SECONDS WEST, 235.30 FEET; THENCE NORTH 83 DEGREES 46 MINUTES 07 SECONDS WEST, 191.63 FEET; THENCE NORTH 87 DEGREES 02 MINUTES 14 SECONDS WEST, 216.88 FEET; THENCE SOUTH 84 DEGREES 28 MINUTES 52 SECONDS WEST, 166.48 FEET; THENCE SOUTH 71 DEGREES 37 MINUTES 58 SECONDS WEST, 120.83 FEET; THENCE SOUTH 71 DEGREES 28 MINUTES 48 SECONDS WEST, 164.93 FEET; THENCE SOUTH 55 DEGREES 47 MINUTES 10 SECONDS WEST, 343.76 FEET; THENCE SOUTH 55 DEGREES 28 MINUTES 54 SECONDS WEST, 805.68 FEET; THENCE NORTH 01 DEGREES 23 MINUTES 57 SECONDS EAST, 7597.67 FEET; THENCE SOUTH 86 DEGREES 27 MINUTES 31 SECONDS EAST, 5469.88 FEET; THENCE SOUTH 02 DEGREES 02 MINUTES 11 SECONDS WEST, 2991.70 FEET; THENCE SOUTH 01 DEGREES 17 MINUTES 10 SECONDS WEST, 1070.22 FEET; THENCE SOUTH 01 DEGREES 09 MINUTES 17 SECONDS WEST, 1239.51 FEET; THENCE SOUTH 01 DEGREES 42 MINUTES 10 SECONDS WEST, 492.33 FEET; THENCE SOUTH 81 DEGREES 39 MINUTES 02 SECONDS WEST, 663.60 FEET; THENCE SOUTH 83 DEGREES 24 MINUTES 58 SECONDS WEST, 688.43 FEET; THENCE SOUTH 84 DEGREES 50 MINUTES 23 SECONDS WEST, 306.70 FEET; THENCE SOUTH 80 DEGREES 32 MINUTES 21 SECONDS WEST, 241.96 FEET; THENCE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 176.34 FEET TO THE POINT OF BEGINNING.

SAID TRACT BEING SITUATED IN FRANKLIN COUNTY, MISSOURI AND CONTAINING 35,422,418 SQUARE FEET OR 813.187 ACRES, MORE OR LESS.

NOW, THEREFORE, in consideration of the mutual covenants of the parties and other valuable consideration, receipt of which is hereby acknowledged, the Department and Owner agree as follows:

1. The Department has issued Solid Waste Disposal Area Operating Permit No. ___ to Ameren Missouri, dated ______________, 20___, for the operation of a landfill by Owner in compliance with the provisions pursuant to the Missouri Solid Waste Management Law.

2. The owner hereby grants, bargains, sells and conveys to the Department, its agents, contractors, successors and assigns an easement in the landfill described above, together with an easement in the access property owned by landowner as described above, to enter the landfill as necessary to complete work specified in the closure plan, or to monitor or maintain the site if specified in a post-closure plan, or to take remedial action during the post-closure period. "Closure plan", "post-closure plan", and "post-closure period" are defined pursuant to the Missouri Solid Waste Management Law and for the purpose of this agreement are described in permit number __________DRAFT______. If the landfill is accessible only through property not owned by landowner, the owner/operator should obtain a separate easement from the access property's owner(s) in favor of the Department for appropriate access. The Department will provide assistance if this is necessary.

3. This agreement, when filed by the Owner with the Recorder of Deeds for Franklin County, Missouri, shall serve as notice that the property described herein has been permitted as a solid waste disposal area and, that use of the property in any manner which interferes with the closure and, where appropriate, post-closure plans filed with the Department is prohibited.

4. The owner, heirs, successors in title, personal representatives and assigns shall not use the herein described property in any manner which interferes with any closure and/or post-closure plans which are filed with the Department. Further, the use of the herein described property is subject to the Missouri Solid Waste Management Law and the rules promulgated thereunder.

5. Any restriction in this agreement on the use of the herein described property is a covenant running with the land.

IN WITNESS WHEREOF, the parties have hereunto set their hands the day and year first above written.

| OWNER: | DEPARTMENT: |
|---|---|
| ______________________________ | ______________________________ |
| Ameren Missouri | Missouri Department of Natural Resources |
| Name: ______________________________ | Name: DRAFT |
| Title: ______________________________ | Title: Director |

Notary for Owner:

STATE OF MISSOURI )
) ss
COUNTY OF )

On this ___________ day of ______, 20___, before me personally appeared (name), to me know to be the person described in and who executed the foregoing instrument, and acknowledged that they executed the same as their free act and deed.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal in the County and State aforesaid, the day and year first above written.

DRAFT ______________________________
Notary Public

Commission in _________________ County.

My Commission Expires: _______________.

Notary for Missouri Department of Natural Resources

STATE OF MISSOURI )
) ss
COUNTY OF COLE )

On this ______ day of ______ in the year 20___ before me, DRAFT , a Notary Public in and for the said state, personally appeared ____________ DRAFT ____________, ______________________________, Missouri Department of Natural Resources, known to me to be the person who executed the within document in behalf of the Department and acknowledged to me that he executed the same for the purposes therein stated.

DRAFT ______________________________
Notary Public

Commissioned in _______________ County.

My Commission Expires: _______________.

# Appendix 4

## Closure and Post-Closure Cost Worksheets

# Appendix 4A

## Closure and Post-Closure Cost Worksheet
## Total, All Four (4) Phases: 166.5 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

# CLOSURE AND POST-CLOSURE COST WORKSHEET

TOTAL ACREAGE-ALL PHASES

**THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.**

| DATE | | NAME OF FACILITY | | PERMIT NUMBER | |
|---|---|---|---|---|---|
| 1/10/13 | | Ameren Missouri Labadie Utility Waste Landfill | | | |
| **TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS)** | | **TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS)** | | **TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL** | |
| SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D |
| 166.5 | 0 | 0 | 0 | 0 | 0 |

1. How many acres is this financial assurance instrument intended for?

   acres for closure 166.5 acres for post-closure 0

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (TOTAL ACREAGE)

3. What is the approved final cover system design?

☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.
(If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

☐ Active extraction system ☐ Passive venting system ☒ No gas control system
If you have an active extraction system, check the appropriate box.
☐a. Required to control gas migration
☐b. Required under NSPS
☐c. Required by other agency (city, county, etc.)
☐d. Specified only by design engineer
If you check box "d", is any part of the active gas system constructed at this time?
☐Yes ☐No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
28 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.00 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
0 (gal/acre/day) ☐ HELP model ☐ Other (please explain.)

## OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.
Area consisting of acres received official closure , years post-closure.
Area consisting of acres received official closure , years post-closure.
Area consisting of acres received official closure , years post-closure.
Area consisting of acres received official closure , years post-closure.
Area consisting of acres received official closure , years post-closure.

TOTAL ACREAGE-ALL PHASES

**CLOSURE COSTS**

**Final Cover System**

Subtitle D (Composite cover) 166.5 acres x $ 72,910 per acre = (From Table One) $ 12,139,515.00

Non – Subtitle D (soil cover) acres x $ per acre = (From Table One) $ 0.00

**Gas Control System**

Active extraction system (Complete Form A and write the amount in the right column.) $ 0.00

Passive gas venting system (Complete Form B and write the amount in the right column.) $ 0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

**Other Critical Design Features**

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Closure Cost (sum of all lines) (2004 Dollars)** **$** 12,139,515.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 12,139,515.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 14,370,757.86

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860
(115.860 - 97.874) / 97.874 = 17.9860 / 97.874 = 0.1838
CURRENT IPD = 1.1838

**POST-CLOSURE COSTS**

**Inseparable Annual Costs**

| | | | |
|---|---|---|---|
| Annual landfill inspection and reporting | | | $ ~~1,000~~ |
| Gas monitoring and reporting | | | $ ~~4,450~~ |
| Annual groundwater sampling and analysis cost. | | 28 wells x 2,000 = | $ 56,000.00 |
| Annual groundwater monitoring system maintenance and statistics cost. | | | $ 13,700 |
| ☐ Leachate system maintenance (Check if applicable and write this amount in the space provided.) | $3,100 | | $ 0.00 |
| ☐ Leachate testing (Check if applicable and write this amount in the space provided.) | $2,250 | | $ 0.00 |
| ☐ Active gas extraction system maintenance and utilities (Check if applicable and write this amount in the space provided.) | $17,600 | | $ 0.00 |
| ☐ Passive gas system maintenance (Check if applicable and write this amount in the space provided.) | $1,600 | | $ 0.00 |

**Separable Annual Costs**

| | | | |
|---|---|---|---|
| Cap repair and maintenance | | 0 acres x 0 (From Table One) = | $ 0.00 |
| ☐ Leachate treatment (check if applicable) | 0 acres x 0 (Gal/Acre/Year) | x (Cost per gallon) 0.00 = | $ 0.00 |
| ☐ Leachate hauling (check if applicable) | | 0 acres x 0 (Gal/Acre/Year) x $0.05 = | $ 0.00 |

**Annual Costs for Other Critical Design Features**

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Annual Post- Closure Cost (2004 Dollars)** $69,700.00

**Adjust for Inflation**
Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 82,510.86
(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

**Total Post-Closure Cost**
Annual post-closure costs x ~~30~~ years 20 $ 1,650,217.20

# Appendix 4B

## Closure and Post-Closure Cost Worksheet
## Phase 1: 31.4 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

# CLOSURE AND POST-CLOSURE COST WORKSHEET

Phase 1

**THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.**

| DATE | NAME OF FACILITY | PERMIT NUMBER |
|---|---|---|
| 1/10/13 | Ameren Missouri Labadie Utility Waste Landfill | |

| TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS) | | TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS) | | TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL | |
|---|---|---|---|---|---|
| SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D |
| 166.5 | 0 | 0 | 0 | 0 | 0 |

1. How many acres is this financial assurance instrument intended for?

   acres for closure 31.4 acres for post-closure 0

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (PHASE 1)

3. What is the approved final cover system design?

☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.
(If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

☐ Active extraction system ☐ Passive venting system ☒ No gas control system
If you have an active extraction system, check the appropriate box.
☐a. Required to control gas migration
☐b. Required under NSPS
☐c. Required by other agency (city, county, etc.)
☐d. Specified only by design engineer
If you check box "d", is any part of the active gas system constructed at this time?
☐Yes ☐No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
28 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.0 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
(gal/acre/day) ☐ HELP model ☐ Other (please explain.)

## OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.
Area consisting of acres received official closure , years post-closure.
Area consisting of acres received official closure , years post-closure.
Area consisting of acres received official closure , years post-closure.
Area consisting of acres received official closure , years post-closure.
Area consisting of acres received official closure , years post-closure.

Phase 1

## CLOSURE COSTS

**Final Cover System**

Subtitle D (Composite cover) 31.4 acres x $ 72,910 per acre = $ 2,289,374.00
(From Table One)

Non – Subtitle D (soil cover) acres x $ per acre = $ 0.00
(From Table One)

**Gas Control System**

Active extraction system (Complete Form A and write the amount in the right column.) $ 0.00

Passive gas venting system (Complete Form B and write the amount in the right column.) $ 0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

**Other Critical Design Features**

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Closure Cost (sum of all lines) (2004 Dollars)** **$** 2,289,374.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 2,289,374.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 2,710,160.94

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860
(115.860 - 97.874) / 97.874 = 17.9860 / 97.874 = 0.1838
CURRENT IPD = 1.1838

## POST-CLOSURE COSTS

**Inseparable Annual Costs**

| | | | |
|---|---|---|---|
| Annual landfill inspection and reporting | | | $ ~~1,000~~ |
| Gas monitoring and reporting | | | $ ~~4,450~~ |
| Annual groundwater sampling and analysis cost. | | 28 wells x 2,000 = | $ 56,000.00 |
| Annual groundwater monitoring system maintenance and statistics cost. | | | $ 13,700 |
| ☐ Leachate system maintenance (Check if applicable and write this amount in the space provided.) | $3,100 | | $ 0.00 |
| ☐ Leachate testing (Check if applicable and write this amount in the space provided.) | $2,250 | | $ 0.00 |
| ☐ Active gas extraction system maintenance and utilities (Check if applicable and write this amount in the space provided.) | $17,600 | | $ 0.00 |
| ☐ Passive gas system maintenance (Check if applicable and write this amount in the space provided.) | $1,600 | | $ 0.00 |

**Separable Annual Costs**

| | | | |
|---|---|---|---|
| Cap repair and maintenance | | 0 acres x 0 (From Table One) = | $ 0.00 |
| ☐ Leachate treatment (check if applicable) | 0 acres x 0 (Gal/Acre/Year) | x (Cost per gallon) 0.00 = | $ 0.00 |
| ☐ Leachate hauling (check if applicable) | 0 | acres x 0 (Gal/Acre/Year) x $0.05 = | $ 0.00 |

**Annual Costs for Other Critical Design Features**

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Annual Post- Closure Cost (2004 Dollars)** $69,700

**Adjust for Inflation**
Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 82,510.86
(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

**Total Post-Closure Cost**
Annual post-closure costs x ~~30~~ xx years 20 $ 1,650,217.20

# Appendix 4C

## Closure and Post-Closure Cost Worksheet
## Phase 2: 35.2 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

# CLOSURE AND POST-CLOSURE COST WORKSHEET

PHASE 2

**THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.**

| DATE | NAME OF FACILITY | PERMIT NUMBER |
|---|---|---|
| 1/10/13 | Ameren Missouri Labadie Utility Waste Landfill | |

| TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS) | | TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS) | | TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL | |
|---|---|---|---|---|---|
| SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D |
| 166.5 | 0 | 0 | 0 | 0 | 0 |

1. How many acres is this financial assurance instrument intended for?

   acres for closure 35.2    acres for post-closure 0

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (PHASE 2)

3. What is the approved final cover system design?

- ☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
- ☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.

(If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

   ☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

   ☐ Active extraction system ☐ Passive venting system ☒ No gas control system

If you have an active extraction system, check the appropriate box.

- ☐ a. Required to control gas migration
- ☐ b. Required under NSPS
- ☐ c. Required by other agency (city, county, etc.)
- ☐ d. Specified only by design engineer

If you check box "d", is any part of the active gas system constructed at this time?

☐ Yes ☐ No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

PHASE 2

8. How many ground water monitoring wells do you have?
0 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.00 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
0 (gal/acre/day) ☐ HELP model ☐ Other (please explain.)

**OFFICIALLY CLOSED AREAS**

11. If any areas of the landfill have been officially closed, list the following information.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

PHASE 2

**CLOSURE COSTS**

**Final Cover System**

Subtitle D (Composite cover) 35.2 acres x $ 72910 per acre = $ 2,566,432.00
(From Table One)

Non – Subtitle D (soil cover) acres x $ per acre = $ 0.00
(From Table One)

**Gas Control System**

Active extraction system (Complete Form A and write the amount in the right column.) $ 0.00

Passive gas venting system (Complete Form B and write the amount in the right column.) $ 0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

**Other Critical Design Features**

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Closure Cost (sum of all lines) (2004 Dollars) $** 2,566,432.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 2,566,432.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 3,038,142.20

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860

(115.860 - 97.874) divided by 97.874 = 17.9860 divided by 97.874 = 0.1838 (Current IPD = 1.1838)

PHASE 2

## POST-CLOSURE COSTS

**Inseparable Annual Costs**

| | |
|---|---|
| Annual landfill inspection and reporting | $ ~~1,000~~ |
| Gas monitoring and reporting | $ ~~4,450~~ |
| Annual groundwater sampling and analysis cost. 0 wells x 2,000 = | $ 0.00 |
| Annual groundwater monitoring system maintenance and statistics cost. | $ ~~13,700~~ |
| ☐ Leachate system maintenance $3,100 (Check if applicable and write this amount in the space provided.) | $ 0.00 |
| ☐ Leachate testing $2,250 (Check if applicable and write this amount in the space provided.) | $ 0.00 |
| ☐ Active gas extraction system maintenance and utilities $17,600 (Check if applicable and write this amount in the space provided.) | $ 0.00 |
| ☐ Passive gas system maintenance $1,600 (Check if applicable and write this amount in the space provided.) | $ 0.00 |

**Separable Annual Costs**

| | |
|---|---|
| Cap repair and maintenance 0 acres x 0 (From Table One) = | $ 0.00 |
| ☐ Leachate treatment (check if applicable) 0 acres x 0 (Gal/Acre/Year) x (Cost per gallon) 0.00 = | $ 0.00 |
| ☐ Leachate hauling (check if applicable) 0 acres x 0 (Gal/Acre/Year) x $0.05 = | $ 0.00 |

**Annual Costs for Other Critical Design Features**

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Annual Post- Closure Cost (2004 Dollars)** $0.00

**Adjust for Inflation**

Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 0.00

(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

**Total Post-Closure Cost**

Annual post-closure costs x ~~30~~ years 20 $ 0.00

# Appendix 4D

## Closure and Post-Closure Cost Worksheet
## Phase 3: 57.1 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

# CLOSURE AND POST-CLOSURE COST WORKSHEET

PHASE 3

**THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.**

| DATE | NAME OF FACILITY | PERMIT NUMBER |
|---|---|---|
| 1/10/13 | Ameren Missouri Labadie Utility Waste Landfill | |

| **TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS)** | | **TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS)** | | **TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL** | |
|---|---|---|---|---|---|
| SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D |
| 166.5 | 0 | 0 | 0 | 0 | 0 |

1. How many acres is this financial assurance instrument intended for?

   acres for closure 57.1 acres for post-closure 0

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (PHASE 3)

3. What is the approved final cover system design?

   ☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
   ☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.
   (If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

   ☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

   ☐ Active extraction system ☐ Passive venting system ☒ No gas control system

   If you have an active extraction system, check the appropriate box.
   ☐a. Required to control gas migration
   ☐b. Required under NSPS
   ☐c. Required by other agency (city, county, etc.)
   ☐d. Specified only by design engineer

   If you check box "d", is any part of the active gas system constructed at this time?
   ☐Yes ☐No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
0 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.00 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
0 (gal/acre/day) ☐ HELP model ☐ Other (please explain.)

## OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

PHASE 3

## CLOSURE COSTS

**Final Cover System**

Subtitle D (Composite cover) 57.1 acres x $ 72910. per acre = $ 4,163,161.00
(From Table One)

Non – Subtitle D (soil cover) acres x $ per acre = $ 0.00
(From Table One)

**Gas Control System**

Active extraction system (Complete Form A and write the amount in the right column.) $ 0.00

Passive gas venting system (Complete Form B and write the amount in the right column.) $ 0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

**Other Critical Design Features**

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Closure Cost (sum of all lines) (2004 Dollars)** **$** 4,163,161.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 4,163,161.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 4,928,349.99

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860
(115.860 - 97.874) / 97.874 = 17.9860 divided by 97.874 = 0.1838
(CURRENT IPD = 1.1838)

## POST-CLOSURE COSTS

**Inseparable Annual Costs**

| | | | |
|---|---|---|---|
| Annual landfill inspection and reporting | | | $ ~~1,000~~ |
| Gas monitoring and reporting | | | $ ~~4,450~~ |
| Annual groundwater sampling and analysis cost. | | 0 wells x 2,000 = | $ 0.00 |
| Annual groundwater monitoring system maintenance and statistics cost. | | | $ ~~13,700~~ |
| ☐ Leachate system maintenance<br>(Check if applicable and write this amount in the space provided.) | $3,100 | | $ 0.00 |
| ☐ Leachate testing<br>(Check if applicable and write this amount in the space provided.) | $2,250 | | $ 0.00 |
| ☐Active gas extraction system maintenance and utilities<br>(Check if applicable and write this amount in the space provided.) | $17,600 | | $ 0.00 |
| ☐ Passive gas system maintenance<br>(Check if applicable and write this amount in the space provided.) | $1,600 | | $ 0.00 |

**Separable Annual Costs**

| | | | |
|---|---|---|---|
| Cap repair and maintenance | | 0 acres x 0 (From Table One) = | $ 0.00 |
| ☐ Leachate treatment (check if applicable) | 0 acres x 0 (Gal/Acre/Year) | x (Cost per gallon) 0.00 = | $ 0.00 |
| ☐ Leachate hauling (check if applicable) | | 0 acres x 0 (Gal/Acre/Year) x $0.05 = | $ 0.00 |

**Annual Costs for Other Critical Design Features**

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Annual Post- Closure Cost (2004 Dollars)** $0.00

**Adjust for Inflation**

Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 0.00

(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

**Total Post-Closure Cost**

Annual post-closure costs x ~~30~~ years 20 $ 0.00

# Appendix 4E

## Closure and Post-Closure Cost Worksheet
## Phase 4: 42.8 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

# CLOSURE AND POST-CLOSURE COST WORKSHEET

PHASE 4

**THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.**

| DATE | NAME OF FACILITY | PERMIT NUMBER |
|---|---|---|
| 1/10/13 | Ameren Missouri Labadie Utility Waste Landfill | |

| TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS) | | TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS) | | TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL | |
|---|---|---|---|---|---|
| SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D | SUBTITLE D | NON-SUBTITLE D |
| 166.5 | 0 | 0 | 0 | 0 | 0 |

1. How many acres is this financial assurance instrument intended for?

   acres for closure 42.8 acres for post-closure o

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (PHASE 4)

3. What is the approved final cover system design?

☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.
(If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

☐ Active extraction system ☐ Passive venting system ☒ No gas control system

If you have an active extraction system, check the appropriate box.
☐a. Required to control gas migration
☐b. Required under NSPS
☐c. Required by other agency (city, county, etc.)
☐d. Specified only by design engineer

If you check box "d", is any part of the active gas system constructed at this time?
☐Yes ☐No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
0 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.01 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
0 (gal/acre/day) ☐ HELP model ☐ Other (please explain.)

## OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

PHASE 4

| CLOSURE COSTS | | |
|---|---|---|
| **Final Cover System** | | |
| Subtitle D (Composite cover) 42.8 acres x $ 72,910. per acre = (From Table One) | | $ 3,120,548.00 |
| Non – Subtitle D (soil cover) acres x $ per acre = (From Table One) | | $ 0.00 |
| **Gas Control System** | | |
| Active extraction system (Complete Form A and write the amount in the right column.) | $ | 0.00 |
| Passive gas venting system (Complete Form B and write the amount in the right column.) | $ | 0.00 |

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

| | | |
|---|---|---|
| **Other Critical Design Features** | | |
| Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. | $ | 0.00 |
| **Total Closure Cost (sum of all lines) (2004 Dollars)** | **$** | 3,120,548.00 |

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 3,120,548.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 3,694,104.72

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860
(115.860 - 97.874) / 97.874 = 17.9860 divided by 97.874 = 0.1838
CURRENT IPD = 1.1838

PHASE 4

## POST-CLOSURE COSTS

**Inseparable Annual Costs**

| | | |
|---|---|---|
| Annual landfill inspection and reporting | | $ ~~1,000~~ |
| Gas monitoring and reporting | | $ ~~4,450~~ |
| Annual groundwater sampling and analysis cost. | 0 wells x 2,000 = | $ |
| Annual groundwater monitoring system maintenance and statistics cost. | | $ ~~13,700~~ |
| ☐ Leachate system maintenance $3,100<br>(Check if applicable and write this amount in the space provided.) | | $ 0.00 |
| ☐ Leachate testing $2,250<br>(Check if applicable and write this amount in the space provided.) | | $ 0.00 |
| ☐ Active gas extraction system maintenance and utilities $17,600<br>(Check if applicable and write this amount in the space provided.) | | $ 0.00 |
| ☐ Passive gas system maintenance $1,600<br>(Check if applicable and write this amount in the space provided.) | | $ 0.00 |

**Separable Annual Costs**

| | | |
|---|---|---|
| Cap repair and maintenance | 0 acres x 0 (From Table One) = | $ 0.00 |
| ☐ Leachate treatment (check if applicable) | 0 acres x 0 (Gal/Acre/Year) x (Cost per gallon) 0.00 = | $ 0.00 |
| ☐ Leachate hauling (check if applicable) | 0 acres x 0 (Gal/Acre/Year) x $0.05 = | $ 0.00 |

**Annual Costs for Other Critical Design Features**

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

**Total Annual Post- Closure Cost (2004 Dollars)** $0.00

**Adjust for Inflation**
Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 0.00
(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

**Total Post-Closure Cost**
Annual post-closure costs x ~~30~~ years 20 $ 0.00

# Appendix 4F

## MDNR "Table 1 – Cover Systems Construction And Repair Costs," dated 11/2010

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

# TABLE 1 – COVER SYSTEMS CONSTRUCTION AND REPAIR COSTS

| HAUL DISTANCE (Miles) | SUBTITLE D COVER | | STANDARD SOIL COVER | | CAP REPAIR/ MAINTENANCE | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| | Easement | No Easement | Easement | No Easement | Easement | No easement |
| 1/2 | $72,910 | | $38,300 | | $256 | |
| 1 | $74,910 | | $40,300 | | $265 | |
| 1.5 | $76.000 | | $41,390 | | $269 | |
| 2 | $78,200 | | $43,590 | | $278 | |
| 2.5 | $79,100 | | $44,480 | | $281 | |
| 3 | $81,140 | | $46,530 | | $290 | |
| 3.5 | $82,190 | | $47,570 | | $294 | |
| 4 | $83,730 | | $49,120 | | $300 | |
| 4.5 | $87,720 | | $53,110 | | $316 | |
| 5 | $91,710 | | $57,100 | | $332 | |
| 6 | $93,550 | | $58,940 | | $340 | |
| 7 | $95,400 | | $60,780 | | $347 | |
| 8 | $97,240 | | $62,630 | | $355 | |
| 9 | $99,090 | | $64,470 | | $362 | |
| 10 | $100,930 | $136,290 | $66,320 | $93,460 | $370 | $525 |
| 11 | $102,580 | | $67,960 | | $376 | |
| 12 | $104,170 | | $69,560 | | $383 | |
| 13 | $105,820 | | $71,200 | | $390 | |
| 14 | $107,410 | | $72,800 | | $396 | |
| 15 | $109,010 | | $74,390 | | $402 | |
| 16 | $110,650 | | $76,040 | | $409 | |
| 17 | $112,300 | | $77,680 | | $416 | |
| 18 | $113,890 | | $79,280 | | $422 | |
| 19 | $115,540 | | $80,920 | | $429 | |
| 20 | $117,130 | | $82,520 | | $435 | |

All costs are per acre costs.

Round trip distances should be to the nearest ½ mile when less than five miles. For distances greater than five miles, round trip distances should be to the nearest mile.

If an easement has been granted to the department for the borrow area, use the per acre cost from the "Easement" column corresponding to the haul distance. If no easement has been granted to the department, the round trip haul distance is assumed to be 10 miles. Enter the correct figure in the Closure Post-Closure Cost Worksheet.

# Appendix S

## Utility Waste Landfill Emergency Contacts

# Ameren Missouri Labadie Energy Center

## Utility Waste Landfill and Emergency Contacts

## December 2012

**Utility Waste Landfill Contact Persons:**

Tom C See
Safety Supervisor
Ameren Missouri Labadie Energy Center
226 Labadie Power Plant Rd
Labadie, MO 63055
(314) 992-8246
(314) 540-3289 cell

David Strubberg
Plant Manager
Ameren Missouri Labadie Energy Center
226 Labadie Power Plant Rd
Labadie, MO 63055
(314) 992-8201
(314) 853-7584 cell

Paul R. Pike
Environmental Science Executive
Ameren Services
One Ameren Plaza
1901 Chouteau Avenue
P.O. Box 66149, MC 602
St. Louis, MO 63166-6149
314-554-2388
314-604-6905 cell
314-554-4182 fax

**Emergency Contact Phone Numbers:**

| | |
|---|---|
| Labadie Utility Waste Landfill, after hours: | Operating Supervisor<br>Ameren Missouri Labadie Energy Center<br>226 Labadie Power Plant Rd<br>Labadie, MO 63055<br>314-992-8233 |
| Highway Patrol/Troop C – (emergency) | 9-1-1 |
| (non-emergency) | (314) 340-4000 |
| Hospital | 9-1-1 |
| Hospital Emergency Room (Ambulance Service) | 9-1-1 |
| St. Johns Mercy Hospital (non-emergency)<br>901 East 5th St., Washington, Missouri | (636) 239-8000 |
| Labadie Fire Department – (emergency) | 9-1-1 |
| (non-emergency) | (636) 742-2515 |
| Franklin County Sheriff's Department – (emergency) | 9-1-1 |
| (non-emergency) | (636) 583-2560 |
| Franklin County Department of Health | (636) 583-7300 |

# Appendix T

## Recordkeeping and Reporting Forms

**Ameren Missouri Labadie Energy Center Utility Waste Landfill**
**Utility Waste Landfill Operating Permit # ____________________**
**Franklin County, Missouri**

## DAILY REPORT- General Operations

**Date:** ____________________

**Weather Information:** ____________________

**Site Visitors:** ____________________

## DAILY REPORT- Utility Waste Landfill Operations

| **Coal Combustion Products Received:** | | **Circle Appliable Units** | | **Disposal Location:** | |
|---|---|---|---|---|---|
| Fly Ash: | ______ | TPD * | CY** | Cell 1: | ☐ |
| Bottom Ash: | ______ | TPD | CY | Cell 2: | ☐ |
| FGD Material: | ______ | TPD | CY | Cell 3: | ☐ |
| Total CCP: | ______ | TPD | CY | Cell 4: | ☐ |

* TPD = Tons Per Day **CY = Cubic Yards

**Major Operational Problems, Complaints, or Difficulties:**

**Corrective Measures or Corrective Actions:**

**Dust Control Efforts:** ____________________

**Comments:**

Landfill Manager or Designated Staff ____________________
(signature)

# Monthly
# Monitoring Well Field Inspection

Well ID: ____________ Date:

**Access:**

Accessibility: Good ___ Fair ___ Poor_____

Well clear of weeds and/or debris?: Yes ___ No ______

Well identification clearly visible?: Yes ___ No ______

Remarks:

**Concrete Pad:**

Condition of Concrete Pad: Good ___ Inadequate _____

Depressions or standing water around well?: Yes ___ No_____

Remarks:

**Protective Outer Casing:** Material =

Condition of Protective Casing: Good ___ Damaged_____

Condition of Locking Cap: Good ___ Damaged_____

Condition of Lock: Good ___ Damaged_____

Condition of Weep Hole: Good ___ Damaged_____

Remarks:

**Well Riser:** Material =

Condition of Riser: Good ___ Damaged_____

Condition of Riser Cap: Good ___ Damaged_____

Measurement Reference Point: Yes ___ No_____

Remarks:

**Dedicated Purging/Sampling Device:** Type -

Condition: Good ___ Damaged ___ Missing_____

Remarks:

**Field Certification:** ________________________________________

Signed Title Date

# Appendix U

Draft FAI

March 29, 2013

**LETTER FROM CHIEF FINANCIAL OFFICER**

CERTIFIED MAIL: 7002 3150 0001 2354 9891

DIRECTOR
Missouri Department of Natural Resources
P. O. Box 176
Jefferson City, Missouri 65102

Dear Sir or Madam:

I am the chief financial officer of Union Electric Company, One Ameren Plaza, 1901 Chouteau Avenue, P. O. Box 66149, St. Louis, Missouri, 63166-6149. This letter is in support of the use of the financial test to demonstrate financial assurance, as specified in 10 CSR 80-2.030(4)(D)6. of the Missouri Solid Waste Management Rules ("SWMR") .

Solid Waste Operating Permit Number: 2005-121-LS
Sioux Power Plant Utility Waste Landfill
Sioux Plant, Union Electric Company
8501 N. State Route 94, P.O. Box 98
West Alton, MO 63386

Closure Cost Estimate: 2012 dollars $ 13,040,071
Post-Closure Care: 2012 dollars $ 951,910

Solid Waste Operating Permit Number: pending
Labadie Energy Center Utility Waste Landfill
Labadie Energy Center, Union Electric Company
226 Labadie Power Plant Rd., Labadie, MO 63055

Closure Cost Estimate: 2012 dollars $ 2,710,161
Post-Closure Care: 2012 dollars $ 1,650,217

1. This firm is the owner/operator of the following solid waste disposal areas for which financial assurance for closure care, post-closure care, or both, is demonstrated to the state of Missouri through the financial test pursuant to that specified in 10 CSR 80-2.030 (4)(D)6. of the SWMR. The current closure cost estimate, post-closure cost estimate, or both, covered by the test are shown for each disposal area:

   Sioux Power Plant Utility Waste Landfill
   Sioux Plant, Union Electric Company
   8501 N. State Route 94, P.O. Box 98
   West Alton, MO 63386

   Closure Cost Estimate: 2012 dollars $13,040,071
   Post-Closure Care: 2012 dollars $ 951,910

   Labadie Energy Center Utility Waste Landfill
   Labadie Energy Center, Union Electric Company
   226 Labadie Power Plant Rd., Labadie, MO 63055

   Closure Cost Estimate: 2012 dollars $ 2,710,161
   Post-Closure Care: 2012 dollars $ 1,650,217

2. This firm guarantees, through a corporate guarantee pursuant to that specified in 10 CSR 80-2.030(4)(D)6. of the SWMR, the closure care, post-closure care of the following solid waste disposal area(s) located in the state of Missouri owned or operated by subsidiaries of this firm. The current cost estimate for the closure care and/or post-closure care so guaranteed are shown for each disposal area(s): **NONE**

3. This firm is the owner/operator or guarantor of the following solid waste disposal areas for which financial assurance for closure and/or post-closure care is demonstrated through a financial test similar to that specified in 10 CSR 80-2.030(4)(D)6. of the SWMR. The current cost estimates for the closure and/or post-closure care covered by the test are shown for each disposal area: **NONE**

4. This firm is the owner/operator of the following solid waste disposal areas for which financial assurance for closure and/or post-closure care is demonstrated to a state through a financial test or other financial assurance instruments distinct from those specified in 10 CSR 80-2.030(4)(D)6. of the SWMR. The current closure and/or post-closure care cost estimates covered by such financial assurance are shown for each disposal area: **NONE**

   This firm is required to file a Form 10K with the Securities and Exchange Commission (SEC) for the latest fiscal year.

   The fiscal year of this firm ends on December 31. The figures for the following items marked with an asterisk are derived from this firm's independently audited, year-end financial statements for the latest completed fiscal year ended December 31, 2011 (in millions).

ALTERNATIVE II

1. Sum of current closure and post-closure cost estimates (total of all cost estimates shown in the four paragraphs above) $18.4
2. Current bond rating of most recent issuance of this firm and name of rating service: Moody's – A3 S&P – BBB+
3. Date of issuance of bond: March 20, 2009
4. Date of maturity of bond: March 15, 2039

*5. Tangible net worth: $ 4,030.

*6. Total assets in U.S. (required only if less than 90% of firm's assets are located in the U.S.): Not applicable

ANSWER YES OR NO:

7. Is line 5 at least 2 times line 1? Yes

*8. Are at least 90% of firm's assets located in the U.S.? Yes
If not, complete line 9.

9. Is line 6 at least 2 times line 1? Not applicable

"CERTIFICATION I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete.

I also hereby certify that the wording of this letter is identical to that specified in 10 CSR 80-2.030(4)(D)6.as such rules were constituted on the date shown immediately below."

Sincerely,

________________________________________

Signature

Martin J. Lyons, Jr.
Senior Vice President and
Chief Financial Officer
Date Signed: ________________

# Appendix V

Survey Plat
Revised August 2013

**Documents Included:**

Explorer Pipeline Letter

Explorer Pipeline Email Correspondence

Survey Plat

P. O. Box 2650
Tulsa, Oklahoma 74101
918-493-5172
Fax 918-493-5148
mailto:pnwakoby@expl.com

**Patrick A. Nwakoby**
Project Engineer

January 28, 2013

Ms. Barbara S. Skitt
Managing Supervisor, Real Estate
Ameren Services
PO Box 66149, MC 700
St. Louis, MO 63166-6149

**Re: Proposed Waste Landfill; Explorer Pipeline Glenpool to Wood River 24" Line; Dwg. No. 421-AA-1199; Near MP 348, Tract #67 Franklin County, Missouri.**

Dear Ms. Skitt,

Thank you for contacting Explorer Pipeline regarding the referenced project. It is our understanding that your company is working on the construction of several cells for waste landfill near your facility in Labadie, Missouri. The purpose of this letter is to express Explorer's interest in this project since it will traverse our 24-inch refined products pipeline easement.

From telephone conversations with you and others at Ameren, Explorer understands the impact on the pipeline will be minimal as follows:

The toe of the berms of the cells will be 100 feet from the centerline of the pipeline. Two gravel roads will be installed for use by Ameren traffic only to maneuver around the landfill area. These two roads will have no impact on the pipeline and shall be removed in the event of the need to access the pipeline. Ameren will install culverts to mitigate the potential of ponding water over the pipeline.

Explorer appreciates the early notification on this project and we look forward to assisting with this project to ensure its safe completion. If I can be of further assistance, please call me at (918) 493-5172.

Sincerely,

Patrick Nwakoby

**From:** Skitt, Barbara S
**Sent:** Thursday, November 15, 2012 5:39 PM
**To:** pnwakoby@expl.com
**Cc:** Reynolds, Renee M; Gerhardt, Kevin J
**Subject:** Ameren's Labadie Plant UWL Layout

Hi Patrick,

Thank you so much for your time again yesterday. Please find attached the revised layout of the Labadie UWL landfill. As we discussed the proposed landfill will no longer require a relocation of the pipe line. The new layout has the toe of the berms set back 100' off the centerline of the pipeline. The first 2 phases of the landfill will be west of the pipeline with no impact to the pipeline and phases 3 and 4 are east of the pipeline. Once phases 3 and 4 are constructed, 2 roads will be installed perpendicularly over the pipeline. These roads are for Ameren traffic only and are planned to only be gravel at a height of around 15'. These roads will be constructed in a way as not to impact the pipeline. These road will be able to be removed in short order if Explorer has a need to access their pipeline. Phases 1 and 2 have a life expectancy of 10-15 years after they go in service in 2015. Construction on phase 1 is scheduled for 2014. If you have any question feel free to call and discuss. **Please treat this email and attachment as confidential.**

Have a good evening.

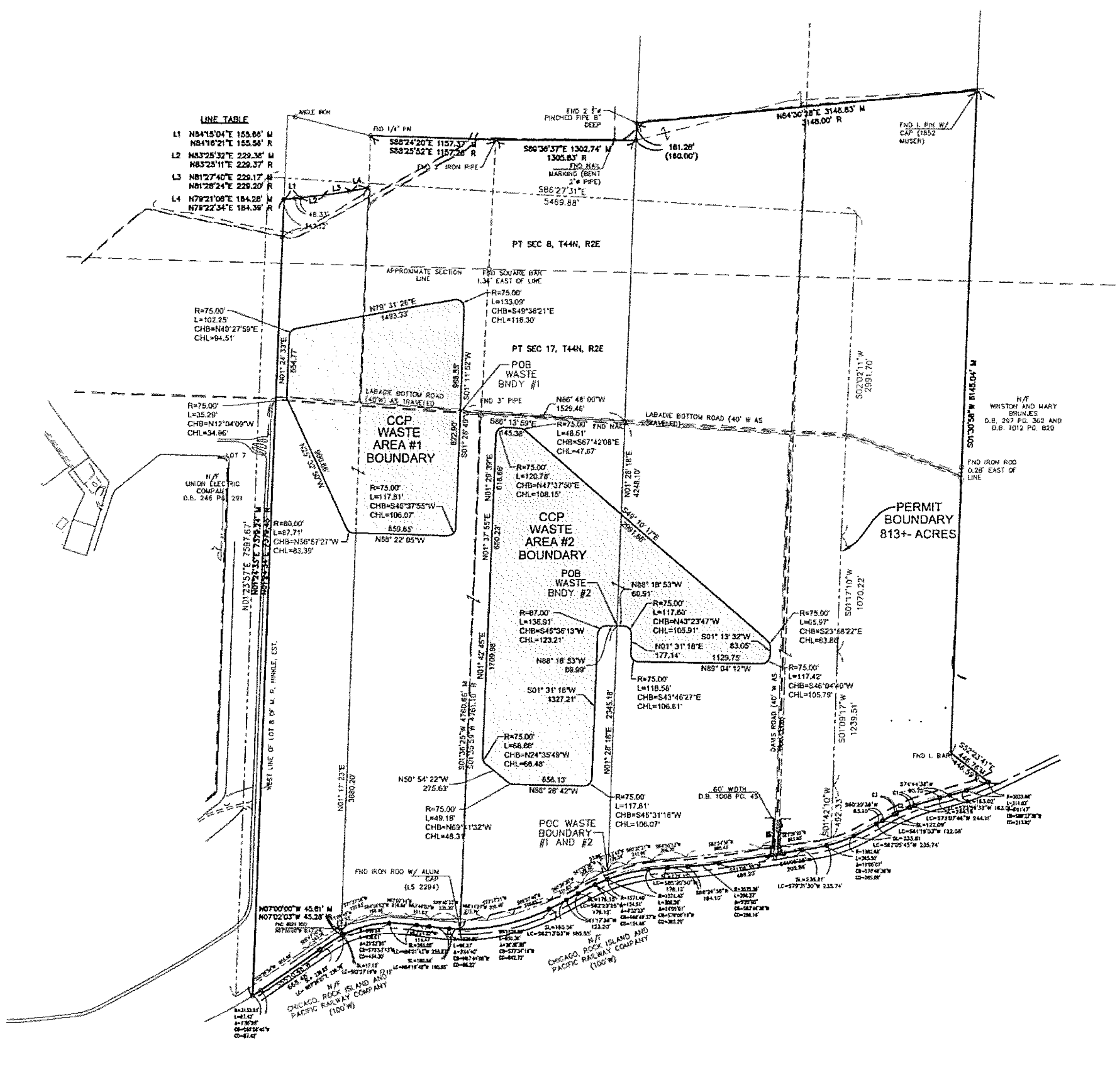
:::::::::::::::::::::::::::::

**BARBARA S. SKITT**
Managing Supervisor
Real Estate Department
T 314.554.2249
C 314.401.8674
F 314.554.2570
E bskitt@ameren.com
.............................

**Ameren Services**
1901 Chouteau Avenue
PO Box 66149, MC 700
St. Louis, MO 63166-6149
Ameren.com

# CCP WASTE BOUNDARY AND PERMIT BOUNDARY EXHIBIT

TRACTS OF LAND IN PART OF SECTION 8 AND 17,
TOWNSHIP 44 NORTH, RANGE 2 EAST
OF THE FIFTH PRINCIPAL MERIDIAN
FRANKLIN COUNTY, MISSOURI




STATE OF MISSOURI
LS-2491
MICHAEL SAM HUBER
PROFESSIONAL LAND SURVEYOR

Michael S Huber 1-24-13

TRACTS OF LAND IN PART OF SECTION 8 AND 17,
TOWNSHIP 44 NORTH, RANGE 2 EAST
OF THE FIFTH PRINCIPAL MERIDIAN
FRANKLIN COUNTY, MISSOURI

CLIENT:
REITZ & JENS, INC.
1055 CORPORATE SQUARE DRIVE
ST. LOUIS, MO 63132
PHONE: (314) 993-4132


KdG
Kuhlmann design Group, Inc.
15 East Washington Street
Belleville, Illinois 62220-2149
Tel: 618.234.8898 Fax: 618.234.8959
St. Louis, MO • Belleville, IL


DISCLAIMER OF RESPONSIBILITY

MISSOURI ARCHITECTURAL CORPORATION CERTIFICATE LIC. NO.: 000216
MISSOURI PROFESSIONAL ENGINEERING CORPORATION CERTIFICATE LIC. NO.: 000255
MISSOURI PROFESSIONAL LAND SURVEY CORPORATION CERTIFICATE LIC. NO.: 000078

| NO. | DATE | |
|---|---|---|
| | | |

| | |
|---|---|
| PROJECT NO. 120040 | CONTRACT NO. 0002 |
| DRAWN JPB | CHECKED MSH |
| DATE: 11-9-12 | |

S-1

SHEET 1 OF 1

**PROPERTY DESCRIPTION**
**Ameren Labadie Site**
**Permit Boundary**

PART OF SECTIONS 8 AND 17 AND PART OF U.S. SURVEY 98 IN TOWNSHIP 44 NORTH, RANGE 2 EAST OF THE FIFTH PRINCIPAL MERIDIAN, FRANKLIN COUNTY, MISSOURI, DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORDS, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREES 28 MINUTES 18 SECONDS EAST, 80.58 FEET TO THE POINT OF BEGINNING OF THE TRACT HEREIN DESCRIBED; THENCE DEPARTING SAID WESTERLY LINE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 53.86 FEET; THENCE SOUTH 61 DEGREES 52 MINUTES 36 SECONDS WEST, 208.05 FEET; THENCE SOUTH 60 DEGREES 39 MINUTES 30 SECONDS WEST, 331.03 FEET; THENCE SOUTH 69 DEGREES 57 MINUTES 40 SECONDS WEST, 377.65 FEET; THENCE SOUTH 77 DEGREES 17 MINUTES 21 SECONDS WEST, 250.40 FEET; THENCE NORTH 86 DEGREES 14 MINUTES 27 SECONDS WEST, 273.79 FEET; THENCE 89 DEGREES 40 MINUTES 33 SECONDS WEST, 235.30 FEET; THENCE NORTH 83 DEGREES 46 MINUTES 07 SECONDS WEST, 191.63 FEET; THENCE NORTH 87 DEGREES 02 MINUTES 14 SECONDS WEST, 216.88 FEET; THENCE SOUTH 84 DEGREES 28 MINUTES 52 SECONDS WEST, 166.48 FEET; THENCE SOUTH 71 DEGREES 37 MINUTES 58 SECONDS WEST, 120.83 FEET; THENCE SOUTH 71 DEGREES 28 MINUTES 48 SECONDS WEST, 164.93 FEET; THENCE SOUTH 55 DEGREES 47 MINUTES 10 SECONDS WEST, 343.76 FEET; THENCE SOUTH 55 DEGREES 28 MINUTES 54 SECONDS WEST, 805.68 FEET; THENCE NORTH 01 DEGREES 23 MINUTES 57 SECONDS EAST, 7597.67 FEET; THENCE SOUTH 86 DEGREES 27 MINUTES 31 SECONDS EAST, 5469.88 FEET; THENCE SOUTH 02 DEGREES 02 MINUTES 11 SECONDS WEST, 2991.70 FEET; THENCE SOUTH 01 DEGREES 17 MINUTES 10 SECONDS WEST, 1070.22 FEET; THENCE SOUTH 01 DEGREES 09 MINUTES 17 SECONDS WEST, 1239.51 FEET; THENCE SOUTH 01 DEGREES 42 MINUTES 10 SECONDS WEST, 492.33 FEET; THENCE SOUTH 81 DEGREES 39 MINUTES 02 SECONDS WEST, 663.60 FEET; THENCE SOUTH 83 DEGREES 24 MINUTES 58 SECONDS WEST, 688.43 FEET; THENCE SOUTH 84 DEGREES 50 MINUTES 23 SECONDS WEST, 306.70 FEET; THENCE SOUTH 80 DEGREES 32 MINUTES 21 SECONDS WEST, 241.96 FEET; THENCE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 176.34 FEET TO THE POINT OF BEGINNING.

SAID TRACT BEING SITUATED IN FRANKLIN COUNTY, MISSOURI AND CONTAINING 35,422,418 SQUARE FEET OR 813.187 ACRES, MORE OR LESS.

STATE OF MISSOURI
LS-2491
MICHAEL SAM
HUBER
PROFESSIONAL LAND SURVEYOR

Michael Huber 1·24·13

**PROPERTY DESCRIPTION**
**Ameren Labadie Site**
**Waste Boundary**

PART OF SECTIONS 8 AND 17 AND PART OF U.S. SURVEY 98 IN TOWNSHIP 44 NORTH, RANGE 2 EAST OF THE FIFTH PRINCIPAL MERIDIAN, FRANKLIN COUNTY, MISSOURI, DESCRIBED AS FOLLOWS:

CCP WASTE BOUNDARY AREA #1

COMMENCING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORD'S OFFICE, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREE 28 MINUTES 18 SECONDS EAST, 4,248.10 FEET TO THE CENTERLINE OF LABADIE ROAD; THENCE ALONG THE CENTER LINE OF LABADIE ROAD, NORTH 86 DEGREES 48 MINUTES 00 SECONDS WEST, 1,529.46 FEET TO THE POINT OF BEGINNING OF THE TRACT OF LAND HEREIN DESCRIBED; THENCE LEAVING SAID CENTERLINE, SOUTH 01 DEGREE 28 MINUTES 49 SECONDS WEST, 822.90 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 117.81 FEET, THE CHORD OF WHICH BEARS SOUTH 46 DEGREES 37 MINUTES 55 SECONDS WEST, A CHORD DISTANCE OF 106.07 FEET; THENCE NORTH 88 DEGREES 22 MINUTES 05 SECONDS WEST, 859.65 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 80.00 FEET, AN ARC DISTANCE OF 87.71 FEET, THE CHORD OF WHICH BEARS NORTH 56 DEGREES 57 MINUTES 27 SECONDS WEST, A CHORD DITANCE OF 83.39 FEET; THENCE NORTH 25 DEGREES 32 MINUTES 50 SECONDS WEST, 990.66 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 35.29 FEET, THE CHORD OF WHICH BEARS NORTH 12 DEGREES 04 MINUTES 09 SECONDS WEST, A CHORD DISTANCE OF 34.96 FEET; THENCE NORTH 01 DEGREE 24 MINUTES 33 SECONDS EAST, 554.77 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 102.25 FEET, THE CHORD OF WHICH BEARS NORTH 40 DEGREES 27 MINUTES 59 SECONDS EAST, A CHORD DISTANCE OF 94.51 FEET; THENCE NORTH 79 DEGREES 31 MINUTES 26 SECONDS EAST, 1,493.33 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 133.09 FEET, THE CHORD OF WHICH BEARS SOUTH 49 DEGREES 38 MINUTES 21 SECONDS EAST, A CHORD DISTANCE OF 116.30 FEET; THENCE SOUTH 01 DEGREE 11 MINUTES 52 SECONDS WEST, 968.55 FEET TO THE POINT OF BEGINNING.

Michael Huber
1-24-13

STATE OF MISSOURI
LS-2491
MICHAEL SAM
HUBER
PROFESSIONAL LAND SURVEYOR

SAID TRACT (AREA #1) OF LAND BEING SITUATED IN FRANKLIN COUNTY MISSOURI AND CONTAINING 2,900,779 SQUARE FEET OR 66.593 ACRES MORE OR LESS.

CCP WASTE BOUNDARY AREA #2

COMMENCING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORD'S OFFICE, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREE 28 MINUTES 18 SECONDS EAST, 2,345.18 FEET TO THE POINT OF BEGINNING OF THE TRACT OF LAND HEREIN DESCRIBED; THENCE DEPARTING SAID WESTERLY LINE NORTH 88 DEGREES 18 MINUTES 53 SECONDS WEST, 89.99 FEET; THENCE ALONG A CURVE TO THE LEFT, HAVING A RADIUS OF 87.00 FEET, AN ARC DISTANC OF 136.91 FEET, THE CHORD OF WHICH BEARS SOUTH 46 DEGREES 36 MINUTES 13 SECONDS WEST, A CHORD DISTANCE OF 123.21 FEET; THENCE SOUTH 01 DEGREE 31 MINUTES 18 SECONDS WEST 1,327.21 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE 117.81 FEET, THE CHORD OF WHICH BEARS SOUTH 46 DEGREES 31 MINUTES 18 SECONDS WEST, A CHORD DISTANCE OF 106.07 FEET; THENCE NORTH 88 DEGREES 28 MINUTES 42 SECONDS WEST, 656.13 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 49.18 FEET, THE CHORD OF WHICH BEARS NORTH 69 DEGREES 41 MINUTES 32 SECONDS WEST, A CHORD DISTANCE OF 48.31 FEET; THENCE NORTH 50 DEGREES 54 MINUTES 22 SECONDS WEST, 275.63 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75 .00 FEET, AN ARC DISTANCE 68.88 FEET, THE CHORD OF WHICH BEARS NORTH 24 DEGREES 35 MINUTES 49 SECONDS WEST, A CHORD DISTANCE OF 66.48 FEET; THENCE NORTH 01 DEGREE 42 MINUTES 45 SECONDS EAST, 1,709.98 FEET; THENCE NORTH 01 DEGREES 37 MINUTES 55 SECONDS EAST, 660.23 FEET; THENCE NORTH 01 DEGREES 29 MINUTES 39 SECONDS EAST, 618.66 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 120.78 FEET, THE CHORD OF WHICH BEARS NORTH 47 DEGREES 37 MINUTES 50 SECONDS EAST, A CHORD DISTANCE OF 108.15 FEET; THENCE SOUTH 86 DEGREES 13 MINUTES 59 SECONDS EAST, 145.38 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 48.51 FEET, THE CHORD OF WHICH BEARS SOUTH 67 DEGREES 42 MINUTES 08 SECONDS EAST, A CHORD DISTANCE OF 47.67 FEET; THENCE SOUTH 49 DEGREES 10 MINUTES 17 SECONDS EAST, 2991.68 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 65.97

Michael S Huber
1.24.13

STATE OF MISSOURI
LS-2491
MICHAEL SAM
HUBER
PROFESSIONAL LAND SURVEYOR

FEET, THE CHORD OF WHICH BEARS SOUTH 23 DEGREES 58 MINUTES 22 SECONDS EAST, A CHORD DISTANCE OF 63.86 FEET; THENCE SOUTH 01 DEGREE 13 MINUTES 32 SECONDS WEST, 83.05 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 117.42 FEET, THE CHORD OF WHICH BEARS SOUTH 46 DEGREES 04 MINUTES 40 SECONDS WEST, A CHORD DISTANCE OF 105.79 FEET; THENCE NORTH 89 DEGREES 04 MINUTES 12 SECONDS WEST, 1,129.75 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS 75.00 OF FEET, AN ARC DISTANCE OF 118.58 FEET, THE CHORD OF WHICH BEARS NORTH 43 DEGREES 46 MINUTES 27 SECONDS EAST, A CHORD DISTANCE OF 106.61 FEET; THENCE NORTH 01 DEGREE 31 MINUTES 18 SECONDS EAST, 177.14 FEET; THENCE ALONG A CURVE TO THE LEFT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 117.60 FEET, THE CHORD OF WHICH BEARS NORTH 43 DEGREES 23 MINUTES 47 SECONDS WEST, A CHORD DISTANCE OF 105.91 FEET; THENCE NORTH 88 DEGREES 18 MINUTES 53 SECONDS WEST, 60.91 FEET TO THE POINT OF BEGINNING.

SAID TRACT (AREA #2) OF LAND BEING SITUATION BEING SITUATED IN FRANKLIN COUNTY MISSOURI AND CONTAINING 4,351,083 SQUARE FEET OR 99.887 ACRES MORE OR LESS.

Michael S Huber
1-24-13

STATE OF MISSOURI
LS-2491
MICHAEL SAM
HUBER
PROFESSIONAL LAND SURVEYOR

# Appendix W

Groundwater Hydraulic Data

# Ameren Missouri Labadie Energy Center
# Proposed Utility Waste Landfill
# Franklin County, Missouri

# Appendix W
# Groundwater Hydraulic Data Summary

## December 2012

## INTRODUCTION

Appendix W contains a summary description and graphical representations of surface water and groundwater data acquired from the Ameren Missouri Labadie Energy Center proposed Utility Waste Landfill site during completion of the Detailed Site Investigation (DSI) in 2009-2010. The surface water and groundwater data have been evaluated to identify and describe the factors that influence the direction and flow rate of the uppermost aquifer beneath the proposed Utility Waste Landfill. Additional details on the data used for this evaluation can be found in the DSI report for this site on file with the Missouri Department of Natural Resources, Division of Geology and Land Survey in Rolla, Missouri and referenced at the end of this report.

The Ameren Missouri Labadie Energy Center is located near Missouri River Mile 57. Missouri River elevations obtained from the Labadie Energy Center gauging station, which is at the same approximate river mile, are provided for comparison to the groundwater data due to the significant influence river levels have on the groundwater potentiometric surface across the site.

## DISCUSSION OF DATA

Groundwater elevation readings were taken on a monthly basis for twelve consecutive months from all one hundred (100) piezometers installed at the site for the DSI. These readings were taken from December 2009 through November 2010. Seven additional sets of readings from select piezometers were obtained between late April and June 2010 to better evaluate what short term impacts rising Missouri River elevations have on the groundwater elevations and gradients beneath the proposed site. The DSI report also investigated what impact precipitation has on groundwater elevations. Following approval of the DSI report, 90 of the piezometers were properly plugged and abandoned in April 2011. The remaining 10 piezometers were properly plugged and abandoned in early September 2011.

During the year-long DSI monitoring period, it was determined that the direction of groundwater flow varied in response to Missouri River elevation. During periods of relatively low river elevations (November-February) the prevailing direction of groundwater flow was north-northwest toward the river. During periods of relatively high river elevations (March-October) the prevailing direction of groundwater flow shifted eastward. These changes in flow direction can be quite rapid. For example, from the "routine" monthly measurements made on May 11, 2010 to the supplemental measurements made on May 18, 2010, as the Missouri River rose 12 feet, groundwater flow shifted approximately 90 degrees from a northeasterly to a southeasterly direction. This shift was accompanied by site-wide increases in groundwater levels of between 1.5 and 7.25 feet and a corresponding increase in hydraulic gradient.

The behavior of groundwater elevations in response to changes in Missouri River stage as described in the DSI report indicated that at the beginning of the monitoring period (December 2009), river elevation was below the water table surface. It remained more or less below the local water table throughout the succeeding three months (January to March 2010) except for relatively short-term periods (4 to 9 days). Average water table elevation remained slightly above 459 feet during this period and overall groundwater flow direction was northward, toward the Missouri River. However, beginning in mid-March 2010, river level surged above 460 feet and generally remained above that elevation through late August 2010. During that same time period, average water table elevation also rose above 460 feet, where it remained throughout the five-month time span. Water table maps for this time period (March-August 2010) show overall groundwater flow direction with a strong easterly component. Northeasterly trends for the months of March and May 2010 coincided with relatively "low" average water table elevations (460.41 to 461.98 feet) and a southeasterly trend during July 2010 coincided with a relatively high and sustained water table exceeding 463 feet. By November 2010, as both the water table and river levels dropped below 460 feet, overall groundwater flow direction "reverted" to the northwest, essentially mirroring groundwater behavior observed during the first three months of monitoring.

Comparison of groundwater levels in the southeastern part of the site (farthest from the river) to groundwater levels in the northwestern part of the site (closest to the river) suggests that the reversal in groundwater flow occurs when the Missouri River level attains a more or less sustained elevation of between 461 and 463 feet.

As recorded in the DSI report, calculated groundwater velocities range from extremes of 0.1 to 584 feet per year (ft/yr). This wide range is chiefly attributable to both calculated hydraulic gradient and effective porosity values. Hydraulic conductivity values are relatively uniform across the site due to the homogeneous nature of the sandy soils comprising the alluvial aquifer. The DSI report indicated that the lower ranges in hydraulic gradient were believed more representative of prevailing groundwater movement at the site, which results in velocities ranging from 0.1 to 10 ft/yr. However, the report also noted the possibility of higher groundwater velocity values in the northwestern part of the site, where hydraulic gradient increases in response to changes in Missouri River elevation.

Figure 1 is a graphical representation of the relationship between groundwater and river elevations at the Ameren Missouri Labadie Energy Center proposed landfill site from the period December 2009 to November 2010. It is based on Figure 31 of the DSI Report. In addition, Figure 2 provides a summary of groundwater movement for the twelve-month monitoring period

(December 2009 to November 2010) during the DSI investigation. The figure is based on Figures 18-29 of the DSI Report.

## SUMMARY AND CONCLUSIONS

The variable direction of groundwater movement at the Ameren Missouri Labadie Energy Center proposed landfill site appears intrinsically related to Missouri River elevation. When river elevations are relatively high, it acts as a recharge source to the alluvial aquifer and groundwater movement is generally toward the east and southeast. Conversely, when river elevations are relatively low, the local water table appears to "unwater" toward the river and groundwater movement is generally toward the north and northwest. Based on the data presented in the DSI report, this change in flow direction occurs when the Missouri River reaches an elevation of between 461 and 463 feet. Comparison of the river gauge data acquired during the 12-month monitoring period to gauge data for the preceding ten years suggests that river levels were unseasonably high in 2010, relative to the years 2000-2009. Thus, "unwatering" of the local water table toward the Missouri River may be more prevalent than what was suggested by the DSI data. Regardless, groundwater movement throughout much of the site is along a shallow hydraulic gradient. Calculated groundwater velocities believed to be representative of this shallow gradient range from 0.1 to 10 ft/yr, but could be as high as 584 ft/yr. Higher velocities to the northwest are suggested, where hydraulic gradient increases.

## REFERENCES

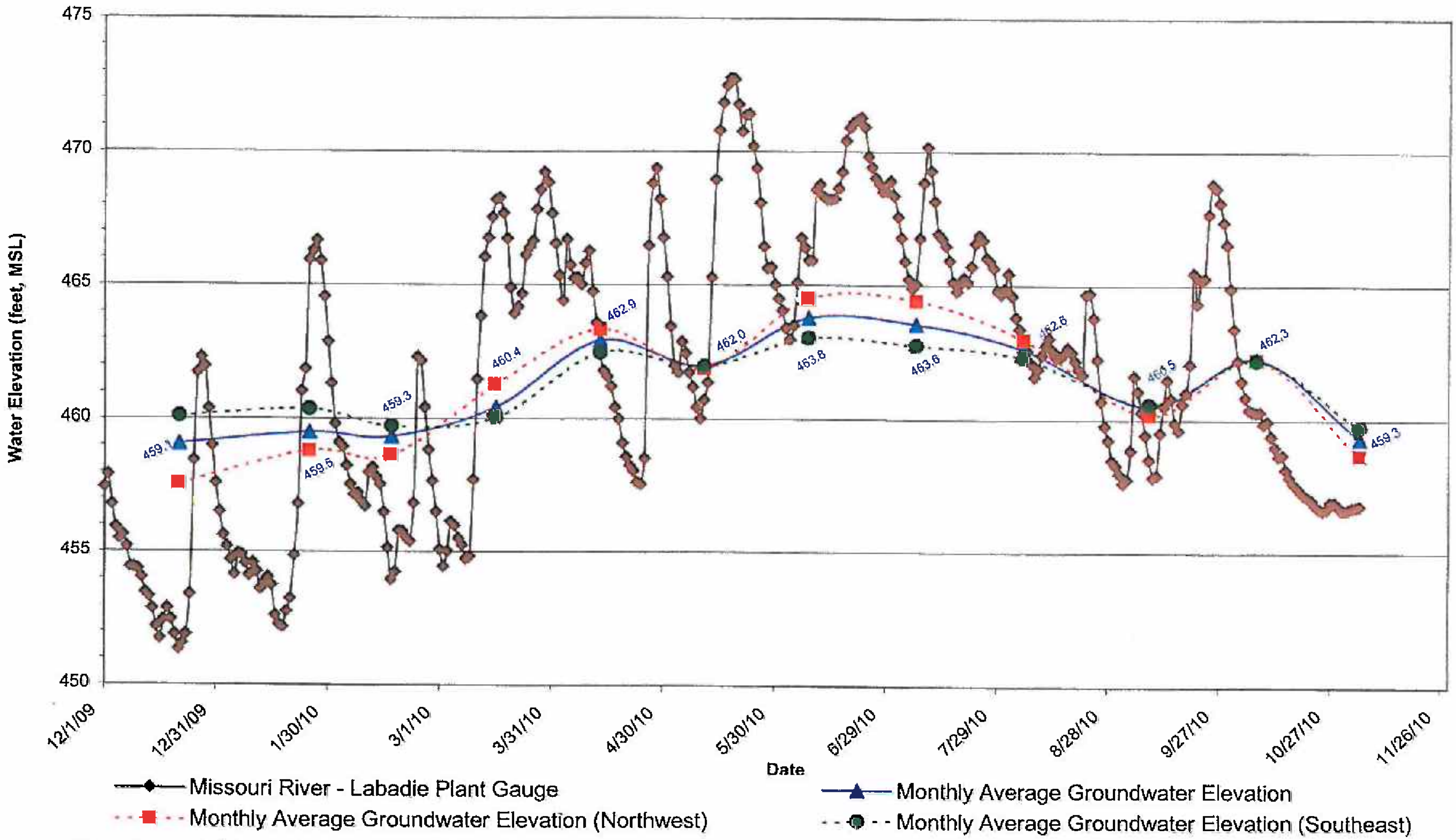

1. *Detailed Site Investigation Report For Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri*, dated February 4, 2011, revised March 30, 2011 by GREDELL Engineering Resources, Inc. and Reitz & Jens, Inc.

# FIGURES

**AMEREN MISSOURI LABADIE POWER PLANT**
**GROUNDWATER HYDRAULIC DATA SUMMARY**
**APPENDIX W**

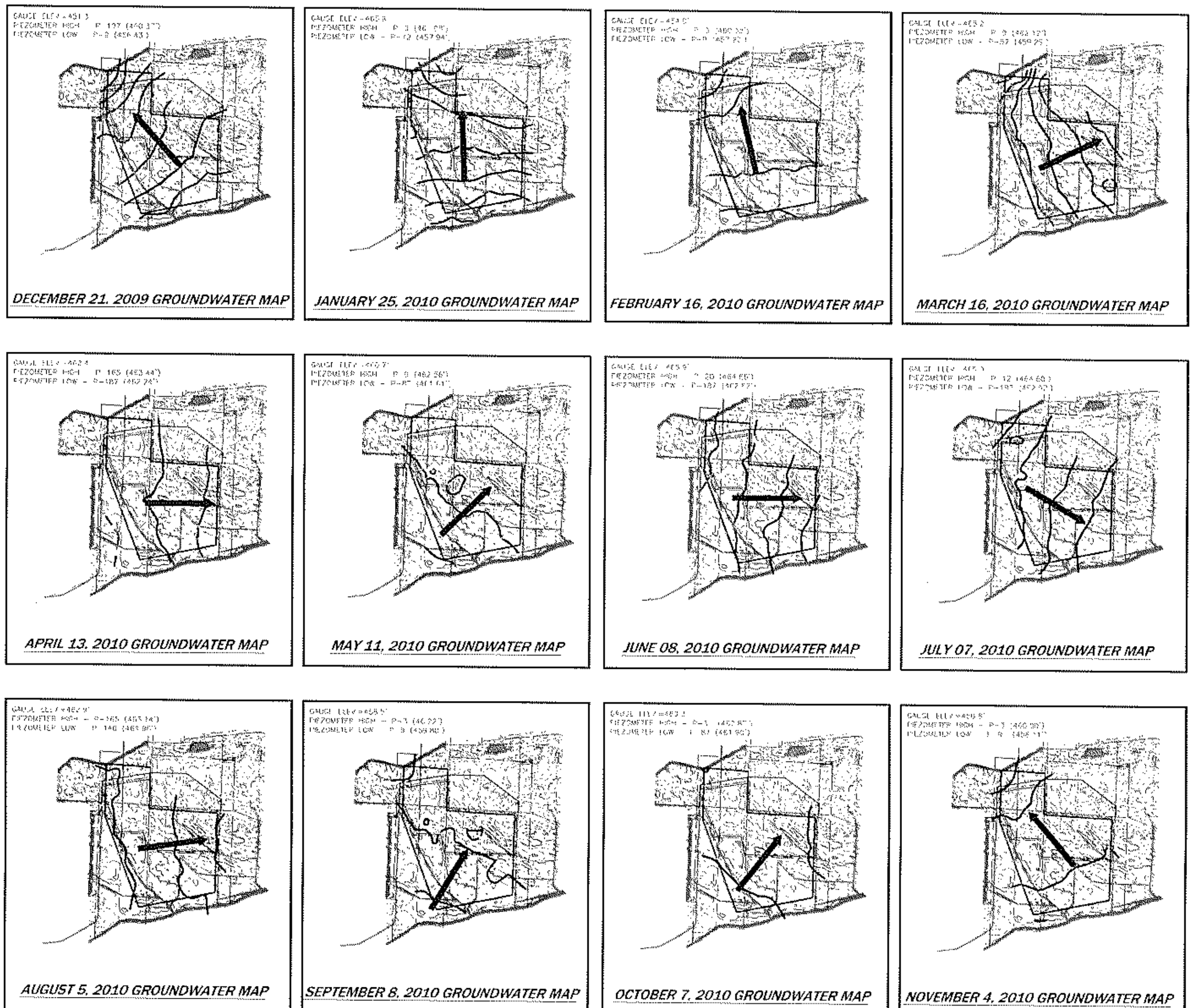
**Monthly Average Water Table Elevation vs Missouri River Elevation**

**FIGURE 1***




*From Figure 31 of the Detailed Site Investigation Report

Prepared by GREDELL Engineering Resources, Inc.



DECEMBER 21, 2009 GROUNDWATER MAP

JANUARY 25, 2010 GROUNDWATER MAP

FEBRUARY 16, 2010 GROUNDWATER MAP

MARCH 16, 2010 GROUNDWATER MAP

APRIL 13, 2010 GROUNDWATER MAP

MAY 11, 2010 GROUNDWATER MAP

JUNE 08, 2010 GROUNDWATER MAP

JULY 07, 2010 GROUNDWATER MAP

AUGUST 5, 2010 GROUNDWATER MAP

SEPTEMBER 8, 2010 GROUNDWATER MAP

OCTOBER 7, 2010 GROUNDWATER MAP

NOVEMBER 4, 2010 GROUNDWATER MAP


LEGEND

GROUNDWATER FLOW DIRECTION

GROUNDWATER CONTOUR
NOTE: CONTOUR INTERVAL

DETAILED SITE INVESTIGATION AREA

NOTES:

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| | |
|---|---|
| DRAWN W.J.A. (GER) | FIGURE 2<br>APPENDIX W<br>GENERALIZED GROUNDWATER SUMMARY<br>DECEMBER 2009 THROUGH NOVEMBER 2010 |
| CHKD M.C.C. (GER) | |
| SUPV M.C.C. (GER) | |
| APPD M.C.C. (GER) | LOCATION 001004 · LABADIE PLANT · CLASS 02010 |

Ameren ST. LOUIS, MISSOURI

# Appendix X

## Documentation of Groundwater Monitoring System Design

# Ameren Missouri Labadie Energy Center
# Proposed Utility Waste Landfill
# Franklin County, Missouri

## Appendix X
## Documentation of Groundwater Monitoring System Design

## December 2012

### INTRODUCTION

This document provides the methodology used to determine the number, location, spacing, and overall design of the proposed groundwater monitoring system for the proposed Ameren Missouri Labadie Utility Waste Landfill (UWL) at the Labadie Energy Center in Franklin County, Missouri. It is provided in support of the Solid Waste Disposal Area Construction Permit application submitted to MDNR-SWMP.

This evaluation is based on the results of the Detailed Site Investigation (DSI) undertaken in 2009-2010 and detailed in a report entitled, *Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri,* dated February 4, 2011 and revised March 30, 2011. Data from that report were utilized as baseline parameters for the development of a dispersion model that provided insight into the spacing of wells needed to provide a system of downgradient monitoring wells that would detect potential leakage from the UWL. The results of this analysis have been used to propose the number and location of the permanent groundwater monitoring wells for inclusion in the Solid Waste Disposal Area Construction Permit Application. Screen interval depths necessary to ensure full immersion during seasonal groundwater fluctuations were also assessed using the data from the DSI report. They are described at the end of this report.

### BASELINE HYDROLOGIC DATA

Review of the hydrologic data contained in the DSI Report indicate that a notable feature concerning groundwater movement is the large temporal fluctuation in overall flow direction in response to the rise and fall of Missouri River elevation (refer also to Appendix W). Examination of the monthly groundwater maps contained in that report (December 2009 through November 2010) demonstrate that the prevailing direction of flow describes a wide arc approaching 180° as it moves roughly from north-northwest during periods of low river stage to east-southeast during periods of high river stage. These temporal changes can be quite rapid. For example, between May 11, 2010 and May 18, 2010, during which period of time the Missouri River rose 12 feet, the prevailing direction of groundwater movement shifted approximately 90 degrees from northeast to southeast. This shift was accompanied by site-wide increases in groundwater levels of between 1.5 and 7.25 feet and a corresponding increase in hydraulic gradient. As a result, much of the proposed disposal area perimeter exhibits both hydraulically upgradient and downgradient conditions with respect to waste disposal limits dependent on river stage. Further, areas of the proposed UWL closer to the Missouri River appear to exhibit a more vigorous response to changing river elevations than those areas more remote from the river proper.

For those reasons, it was determined that baseline hydrologic data used should be specific with respect to proposed landfill development nearest the river relative to proposed landfill development farther from the river. Consequently, for the proposed Cell 1 and Cell 2 construction areas, hydrologic data pertaining to piezometers installed during the DSI in the western and northwestern parts of the site were considered (reference Sheet 3 of Construction Permit Application Plans for site layout). Similarly, those data pertaining to the southern and southeastern parts of the site were considered for the Cell 3 and Cell 4 construction areas. This approach allows for the recognition of variations in hydrologic conditions across the site and accounts for them in the development of a model for long-term detection monitoring at the site.

The baseline data used for the proposed cell construction areas included an assessment of principal flow direction during each of the twelve successive months of water level monitoring, calculated hydraulic gradients, and hydraulic conductivity data as presented in the DSI report. These data are provided for review as Attachment 1 to this appendix. For both the Cell 1-2 and Cell 3-4 areas, average values for hydraulic gradient and hydraulic conductivity were obtained and those values were then used to calculate a range in groundwater velocity, as summarized in Table 1. Examination of Table 1 shows that subtle variations exist in the hydrologic data for each of these areas.

These baseline data were then input into the groundwater model to determine the direction and extent of plume dispersion over a given period of time in order to develop spacing criteria and the total number of long-term groundwater monitoring wells believed required along the perimeter of proposed waste disposal boundaries.

## GROUNDWATER MODEL DESCRIPTION

The two-dimensional model chosen for use is called PLUME and is available in the Monitoring Network Design Package, MAP, authored by Golder Associates, Inc. (1992) and available through the International Ground Water Modeling Center at the Colorado School of Mines. This model was chosen because it provides a reasonable and readily available model for estimating groundwater plume dispersion independent of linear flow direction.

Mathematically stated it is:

$$C(x,y,t) = (C_o/4)\, e[(xv/2D_x)[1-(1+4kD_x/v^2)^{1/2}]]\ \mathrm{erfc}[[x-vt(1+4kD_x/v^2)^{1/2}]/2(D_x t)^{1/2}]$$
$$[\mathrm{erf}[(y+Y/2)/2(D_Y x/v)^{1/2}]-\mathrm{erf}[(y-Y/2)/2(D_Y x/v)^{1/2}]]$$

Where,

- $C(x,y,t)$ = target downgradient contaminant concentration. The value used was set at one-one thousandth (0.001) of the concentration at the point of release.

- $C_o$ = the concentration of the contaminant at the point of release. This value is 1000x the downgradient contaminant concentration. For example, if an initial chloride concentration of 3,000 mg/l is used, then the target downgradient concentration is equal to 3 mg/l, which is within generally accepted laboratory PQLs.
- k = the first-order radioactive decay constant. A conservative value of zero was used in the analysis because no diminution of the source is assumed.
- erfc = complimentary error function
- x = distance downgradient from the release. This value is generated by the software to determine the shape and dimensions of the plume.
- v = average contaminant velocity. The contaminant velocity is calculated as the groundwater velocity divided by the retardation factor (R). Generally, mobile tracers like chloride will flow at the same rate as groundwater and will not be retarded. Therefore, a conservative value of one (1) was used for R and average contaminant velocity equals groundwater velocity. The averaged annual groundwater velocity is taken as the sum of the twelve monthly displacements, which then defines the major components of the resultant vector used to determine the dispersion coefficients. For Cells 1 and 2, an average yearly velocity of 14.54 feet (1.21 feet per month) was determined (Table 2a). For Cells 3 and 4, an average yearly velocity of 12.16 feet (1.0 foot per month) was determined (Table 2b).
- $D_x$ = longitudinal dispersion coefficient. This is a constant used to model spreading of the wave front in the direction of flow. It is derived by using a coefficient times the average monthly velocity in the principal direction of flow for each of the twelve months of data collection. By projecting each monthly change in velocity and principal flow direction as a resultant vector, an estimate of the longitudinal dispersion is determined using one standard deviation divided by the average monthly velocity along the primary direction of flow. Tables 2a and 2b summarizes these calculations for both the Cell 1-2 and Cell 3-4 areas.
- t = time (in months) of continuous leakage from the defect. A value of 528 months or 44 years was used. This time period is roughly equivalent to the life expectancy of the UWL plus a 20-year closure-post closure time period.
- erf = error function
- y = transverse distance from the defect. This value is generated by the software to determine the shape and dimensions of the plume.
- Y = the width of the source. A value of one hundred feet was used because it anticipates a seam failure in the geomembrane liner.
- $D_y$ = transverse dispersion coefficient. This is the constant used to model spreading of the wave front at right angles to the direction of flow for this two dimensional model. The model uses a coefficient times the average velocity in the primary direction of flow to provide a variation in the velocity. By projecting each monthly vector as the velocity at right angles to the resultant vector for the twelve months of data collection, an estimate of the transverse dispersion factor is calculated as the standard deviation of those twelve projections divided by

the average monthly velocity at right angles the direction of flow. Tables 2a and 2b summarizes these calculations for both the Cell 1-2 and Cell 3-4 areas.

The illustration provided below is intended as an aide to envision how leakages will fan out (disperse) from a discrete failure point. As the contaminants move with the groundwater downgradient (X-axis), the concentration at the leading edge of the plume gets broader (Y-axis).

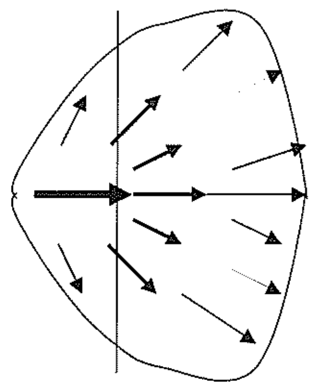


Illustration: Visualization of leak dispersion as it moves downgradient with groundwater flow.

Further documentation for the Plume model can be found in a paper authored by Wilson et al. (ref. Design of Ground-Water Monitoring Networks Using the Monitoring Efficiency Model (MEMO); GROUNDWATER, v.30, No. 6, Nov.-Dec. 1992). This reference provides a specific equation for modeling the longitudinal and transverse dispersion of a nonreactive constituent in a homogeneous medium. A copy of the reference is provided for review as Attachment 2 to this appendix.

## CRITERIA FOR MODEL

As applied to the Labadie UWL, the model assumptions used were:

- Leakage from the UWL is through an imperfection in the geomembrane liner with a length of 100 feet.
- The liner failure allows leakage to move vertically until the contaminant encounters the top of the groundwater table.
- Each release is modeled as a set of particles that move within groundwater and the particles essentially serve as mathematical markers for estimating the extent of the plume.
- The contaminants stay suspended in the water column without creating density gradients, which could influence the direction of contaminant transport.

- Contaminants move by advective and dispersive components of flow, but will not diffuse due to chemical gradients.

- The vertical component of dispersion is not considered as significant as the horizontal component because contaminant concentrations are assumed to be preferentially moving parallel with groundwater flow direction. Moreover, the intended function of the well system is as a detection monitoring network and therefore the wells will be screened in the upper portion of the alluvial aquifer to ensure early detection in the event of a contaminant release, as described at the end of this report.

- The detection limit for the contaminant is sensitive enough to be reported as it moves near a given well point. This limit is set at one-one thousandth (0.001) of the actual concentration at the point of release.

- The prevailing direction of groundwater movement is equivalent to the average of the twelve monthly directional vectors noted for each area in Attachment 1.

- The model uses no loss or gain of the solute mass due to geochemical reactions following a release, including organic reactions. Therefore, both the first order decay constant and the chemical diffusion constant were set at zero.

- The modeling uses a period of diffusion of 528 months (44 years). This time period is roughly equivalent to the life expectancy of the UWL plus a 20-year closure-post closure time period.

## MODEL APPLICATION AND WELL SPACING

The application of the PLUME model to determine an appropriate spacing for the groundwater monitoring network required input values for velocity, transverse dispersivity, longitudinal dispersivity, and time (Tables 2a and 2b). The PLUME software then uses these data to generate a scaled, 2-dimensional plot for each of the four phases showing three contours representing concentrations of one-tenth (0.1), one-hundredth (0.01), and one-one thousandth (0.001) of the concentration at the point of entry into the groundwater (Attachment 3). The innermost contour around the source represents the highest concentration (10 percent of source concentration), the middle contour represents one percent of the source concentration, and the outermost contour represents one-tenth of a percent of the source concentration.

Once the plots were developed, a series of overlays were made and superimposed on a map of the site and oriented along the primary axis of flow as determined from the average of the monthly longitudinal flow vectors presented in Tables 2a and 2b. The origin of the plots (i.e. release point) was established as close to the edge of proposed waste boundaries as practicable. The overlays were then manipulated so that points of intersection were attained at the 0.001 contour interval. Those points of intersection along the downgradient sides of the proposed UWL were then considered the minimum spacing whereupon early detection of a release could be determined. The modeling effort resulted in the identification of 21 downgradient well locations (Figure 2). Beginning at the northwestern corner of the site, well spacing along the northern edge of Cell 2 is approximately

450 feet (well ID #'s MW-1 through MW-4). Well spacing between MW-5 and MW-7 is wider since these wells are farther from the waste disposal limits of Cell 2 due to the location of Pond 2. Well spacing along the eastern perimeter of Cell 3 is approximately 330 feet (well ID #'s MW-7 through MW-17). The spacing was increased along the southern edge of Cell 3 to avoid well placement impacting jurisdictional areas (well ID # MW-18). Well spacing along the eastern perimeter of Cell 4 is between approximately 330 and 500 feet (well ID #'s MW-19 through MW-21). Table 3 summarizes location information for the proposed downgradient wells. The table also describes a temporary monitoring well (TMW-1) that will serve as a "sentry" for the initial operations within Cell 1. It will be located immediately east (downgradient) of Cell 1 within the utility pipeline corridor (Figure 2) and used to supplement water quality data derived from the permanent downgradient wells located along the eastern perimeter of Cell 3. TMW-1 will be removed as soon as Cell 3 becomes operational.

For those areas considered hydraulically upgradient of proposed waste boundaries, which includes the western and southwestern perimeter of the site, seven additional wells are proposed to complete the groundwater monitoring network. These wells are identified as MW-22 through MW-28 on Figure 2. Spacing is greater for these wells than it is for the downgradient wells. It is widest along the west-central perimeter of the site (1,400 feet) but systematically decreases to less than 1,000 feet toward the northwestern and southeastern parts of the site (i.e. where downgradient conditions begin). Table 3 summarizes location information for the proposed upgradient wells.

## WELL SCREEN PLACEMENT

A determination of well screen placement is primarily dependent upon two inter-related factors. One, the well screen should be placed at a level that ensures to the extent practicable that the entire screen interval remains fully saturated, even during periods of low river stage of the Missouri River. Two, the top of the well screen should be placed at a depth as shallow as practicable to provide early detection of contaminants that may disperse within the upper part of the water table. Lithologic composition and monitoring well construction constraints also have to be considered in the positioning of well screen depth.

As documented in the DSI Report for this facility, the chief control on water table elevations is the Missouri River. As the Missouri River stage increases, it is accompanied by a corresponding, progressive rise in groundwater levels in a northwest to southeast direction. Conversely, as the Missouri River stage decreases, it is accompanied by a progressive drop in groundwater levels that, if sustained, eventually reverses the overall direction of groundwater movement back to the northwest. While these fluctuations were apparent throughout the site, they become more pronounced to the northwest, as the Missouri River is approached. Piezometric data from that area document fluctuations in excess of eight feet whereas fluctuations in the southeastern part of the site are between three and four feet. In light of these data, a single elevation for the placement of well screens cannot be used. Rather, well screen elevations vary and become progressively deeper in a northwesterly direction.

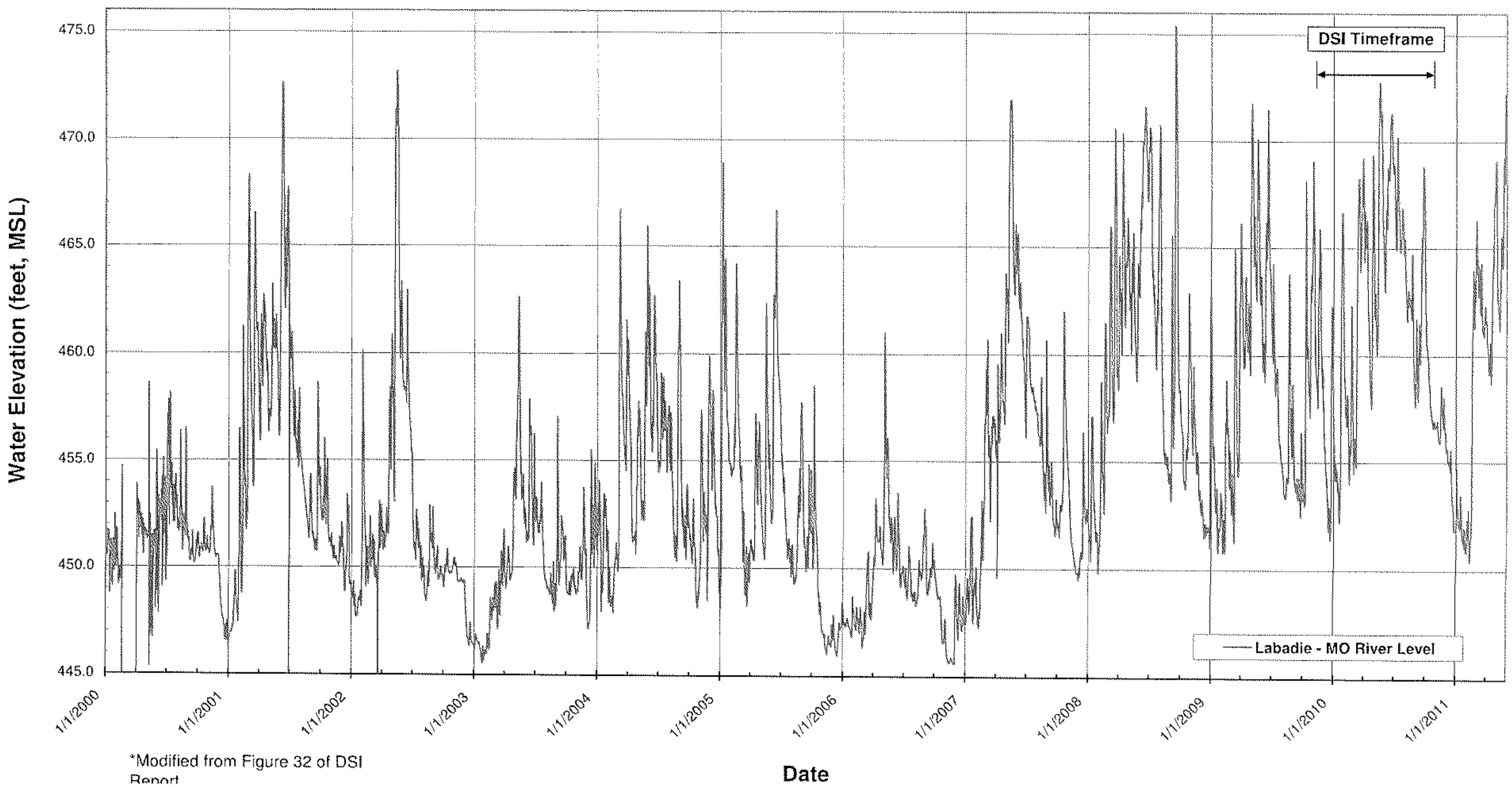
Review of the Missouri River data presented in the DSI report suggests that the 12-month timeframe during which piezometric monitoring was in effect at the site (December 2009 to November 2010) coincided with a period of relatively high Missouri River elevations (between 451 and 473 feet). Consequently, it was necessary to examine the historical data presented in that report to determine a low river elevation. Inspection of that data, which is included here for reference (Figure 1), indicates that 445 feet approximates the lowest recorded river elevation during the preceding ten-year timeframe.

Using this documented low river elevation as a point of intersection, linear regression plots were made showing the projected height of the water table surface at select points centered along the primary northwest-southeast axis of flow beneath the proposed UWL facility. Monthly water level data from a total of 14 piezometers installed during the DSI were used in the analysis (Attachment 4). The results show that the water table surface would be expected to drop to 454.5 feet in the extreme northwestern part of the facility near the location of former piezometer P-9 (Figure 2). Thus, a monitoring well in that area would need to have its well screen set at an elevation no higher than approximately 454 feet to ensure full saturation during low river stage. As the primary axis of flow is traced southeastward, the projected point of intersection of the water table surface with low river stage (445 feet) gradually increases and lines drawn perpendicular to the primary axis of flow in one-foot increments define the maximum well screen elevation throughout the remainder of the facility. Note that these incremental boundaries define regions where projected water table elevations remain approximately 0.5 feet above the maximum well screen height. Based on this analysis, anticipated well depths (assuming 10-ft well screens) for the proposed groundwater monitoring well system layout are summarized in Table 3.

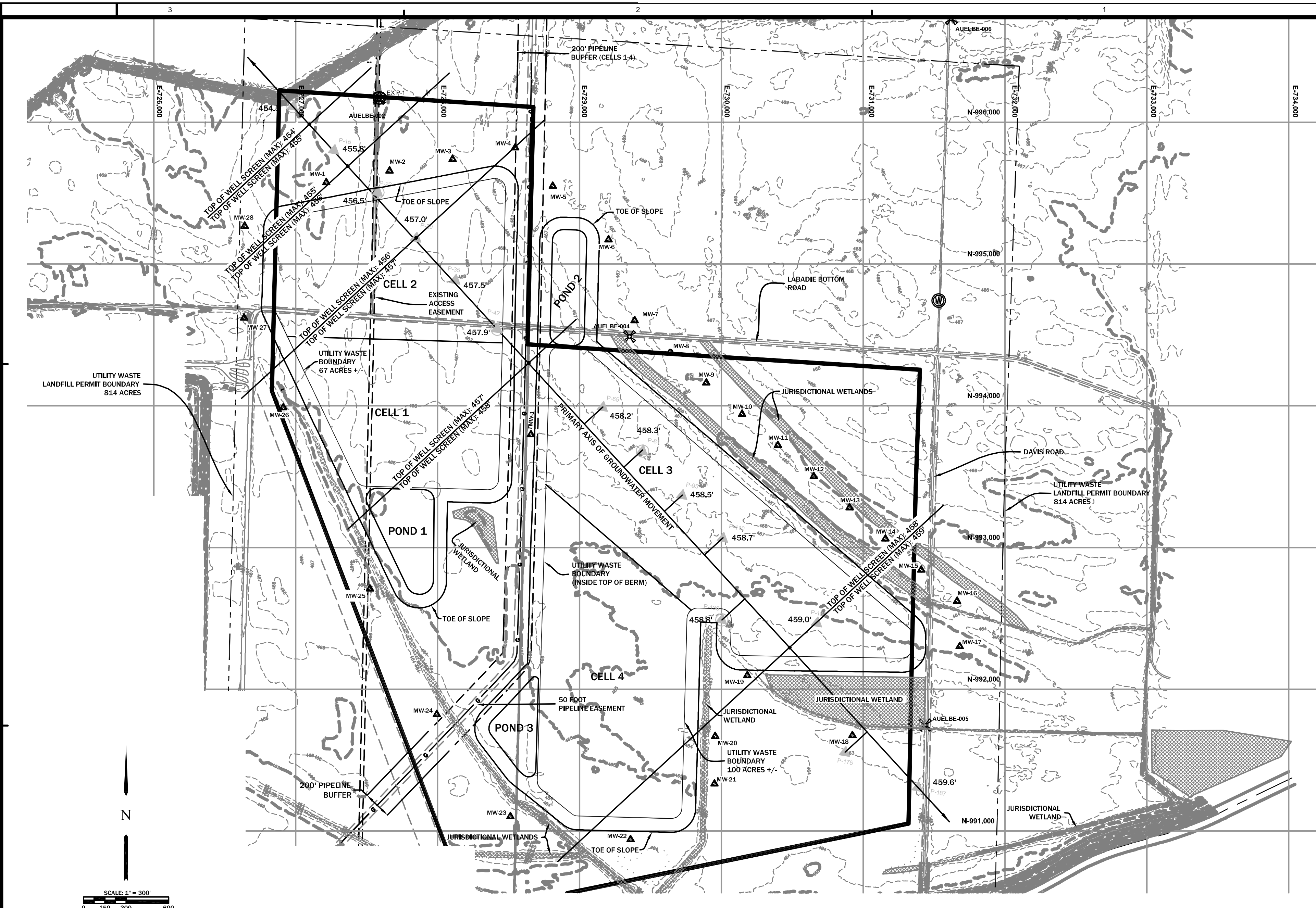
# Figures

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Construction Permit Application

Missouri River Historical Data (2000-2011)
Figure 1*




*Modified from Figure 32 of DSI Report




## SURVEY MONUMENTS

| MONUMENT ID | NORTHING | EASTING | ELEVATION |
|---|---|---|---|
| AUELBE-001 | 990484.82 | 726569.81 | 467.19 |
| AUELBE-002 | 996166.50 | 727588.30 | 470.70 |
| AUELBE-003 | 989921.39 | 728508.32 | 467.59 |
| AUELBE-004 | 994487.78 | 729353.29 | 467.02 |
| AUELBE-005 | 991746.97 | 731438.29 | 462.78 |
| AUELBE-006 | 996729.00 | 731621.70 | 467.67 |

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

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CHKD. R.L.R. (G.E.R.)
SUPV. T.R.G. (G.E.R.)
APPD. T.R.G. (G.E.R.)

FIGURE 2, APPENDIX X
PROPOSED UTILITY LANDFILL
WELL SCREEN ELEVATION SUMMARY

LOCATION 001009

LABADIE ENERGY CENTER

CLASS 02010

Ameren MISSOURI ST. LOUIS, MISSOURI

DECEMBER 18, 2012

REV.

# Tables

# Construction Permit Application
# Proposed Utility Waste Landfill
# Ameren Missouri Labadie Energy Center
# Franklin County, Missouri

## Calculated Groundwater Velocities by Month
## Table 1

| Cells 1 and 2 | | | |
|---|---|---|---|
| December 21, 2009 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0007 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 61 | 53 | 46 |
| January 25, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0008 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 70 | 60 | 53 |
| February 16, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0003 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 26 | 23 | 20 |
| March 16, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0008 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 70 | 60 | 53 |
| April 13, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0002 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 18 | 15 | 13 |
| May 11, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0001 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 9 | 8 | 7 |
| June 8, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0004 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 35 | 30 | 26 |
| July 7, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0004 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 35 | 30 | 26 |
| August 5, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0002 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 18 | 15 | 13 |
| September 8, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0001 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 9 | 8 | 7 |
| October 7, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0001 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 9 | 8 | 7 |
| November 4, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 1 & 2 Site $K_{avg}$ = 5.002 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0003 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 26 | 23 | 20 |

| Cells 3 and 4 | | | |
|---|---|---|---|
| December 21, 2009 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0003 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 41 | 35 | 31 |
| January 25, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0004 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 54 | 47 | 41 |
| February 16, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0001 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 14 | 12 | 10 |
| March 16, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0005 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 68 | 58 | 51 |
| April 13, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0003 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 41 | 35 | 31 |
| May 11, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0002 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 27 | 23 | 20 |
| June 8, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0004 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 54 | 47 | 41 |
| July 7, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0004 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 54 | 47 | 41 |
| August 5, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0003 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 41 | 35 | 31 |
| September 8, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0001 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 14 | 12 | 10 |
| October 7, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0002 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 27 | 23 | 20 |
| November 4, 2010 | | | |
| Hydraulic Conductivity (K) | Cells 3 & 4 Site $K_{avg}$ = 5.567 x $10^{-2}$ ft/min | | |
| Hydraulic Gradient (*i*) | i = 0.0001 ft/ft | | |
| Effective Porosity (n) | 0.30 | 0.35 | 0.40 |
| Velocity (=Ki/n) (ft/yr) | 14 | 12 | 10 |

**Notes**

1. Hydraulic gradient values derived using 3-point methods for 12 month monitoring period 12/09-11/10.

## Construction Permit Application
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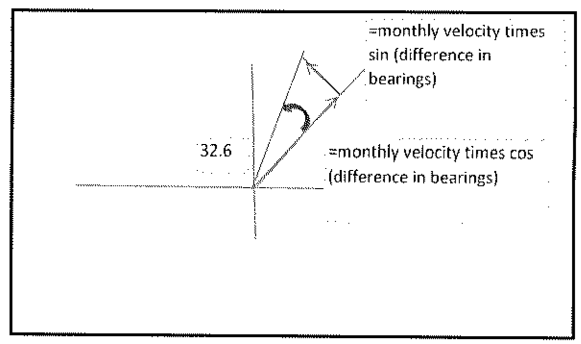
## Franklin County, Missouri

### Plume Definition for Cells 1 and 2
### Table 2a

| Cells 1 & 2 | Month/Year | Azimuth | Hydraulic Gradient | Velocity (ft/yr) | Velocity (ft/month) | East Component =x | North Component= y | Resultant East Vector | Resultant North Vector | | Hydraulic Conductivity, *.01 ft/yr | | delta angle | Cos (delta angle) | Sin (delta angle) | Monthly Velocity *Cos(delta angle) | Monthly Velocity *Sin(delta angle) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dec-09 | -74 | 0.0007 | 53 | 4.38 | -4.21 | 1.21 | -4.21 | 1.21 | | 4.642 | | -106.65 | -0.286 | -0.958 | -1.255 | -4.198 |
| | January-10 | 20 | 0.0008 | 60 | 5.01 | 1.71 | 4.71 | -2.50 | 5.91 | | 6.324 | | -12.65 | 0.976 | -0.219 | 4.886 | -1.097 |
| | February-10 | -51 | 0.0003 | 23 | 1.88 | -1.46 | 1.18 | -3.96 | 7.10 | | 4.482 | | -83.65 | 0.111 | -0.994 | 0.208 | -1.866 |
| | March-10 | 63 | 0.0008 | 60 | 5.01 | 4.46 | 2.27 | 0.50 | 9.37 | | 4.561 | | 30.35 | 0.863 | 0.505 | 4.322 | 2.531 |
| | April-10 | 94 | 0.0002 | 15 | 1.25 | 1.25 | -0.09 | 1.75 | 9.28 | | 5.00225 | Average | 61.35 | 0.479 | 0.878 | 0.600 | 1.099 |
| | May-10 | 17 | 0.0001 | 8 | 0.63 | 0.18 | 0.60 | 1.94 | 9.88 | | Effective | | -15.65 | 0.963 | -0.270 | 0.603 | -0.169 |
| | June-10 | 102 | 0.0004 | 30 | 2.50 | 2.45 | -0.52 | 4.38 | 9.36 | | Porosity (n) = | 0.35 | 69.35 | 0.353 | 0.936 | 0.883 | 2.343 |
| | July-10 | 115 | 0.0004 | 30 | 2.50 | 2.27 | -1.06 | 6.65 | 8.30 | | | | 82.35 | 0.133 | 0.991 | 0.333 | 2.482 |
| | August-10 | 94 | 0.0002 | 15 | 1.25 | 1.25 | -0.09 | 7.90 | 8.21 | | | | 61.35 | 0.479 | 0.878 | 0.600 | 1.099 |
| | September-10 | -22 | 0.0001 | 8 | 0.63 | -0.23 | 0.58 | 7.67 | 8.79 | | | | -54.65 | 0.579 | -0.816 | 0.362 | -0.511 |
| | October-10 | 48 | 0.0001 | 8 | 0.63 | 0.47 | 0.42 | 8.13 | 9.21 | | | | 15.35 | 0.964 | 0.265 | 0.604 | 0.166 |
| | November-10 | -57 | 0.0003 | 23 | 1.88 | -1.58 | 1.02 | 6.56 | 10.24 | | | | -89.65 | 0.006 | -1.000 | 0.012 | -1.878 |
| | | | | | | Average velocity, ft/yr = | | 12.16 | 57.35 | | | | | | | | |
| | Average | 38.5 | 0.00037 | | | Bearing, Northeast= | | | 32.65 | | | | | | Average monthly velocity | 1.013 | 0.000 |
| | Standard Deviation | 61.9 | 0.00026 | | | | | | | | | | | | Standard Deviation in monthly velocity | 1.767 | 2.059 |
| | Error in Mean | 17.9 | 0.00008 | 0.1572432 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | Average yearly velocity | 12.157 | 0.000 |
| | | | | | | | | | | | | | | | Alpha | 1.744 | 2.032 |
| | | | | | | | | | | | | | | | | Longitudinal | Transverse |



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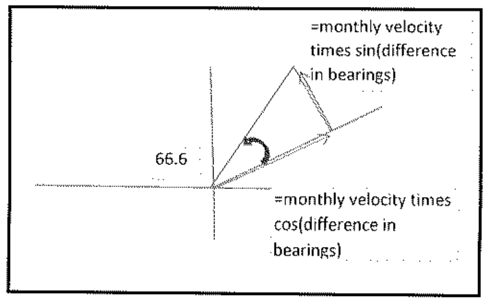
## Plume Definition for Cells 3 and 4
## Table 2b

| Cells 3 & 4 | Month/Year | Azimuth | Hydaulic Gradient | Velocity (ft/yr) | Velocity (ft/month) | East Component= x | North Component= y | Resultant East Vector | Resultant North Vector | | Hydraulic Conductivity, *.01 ft/yr | | delta angle | Cos (delta angle) | Sin (della angle) | Monthly Velocity *Cos(delta angle) | Monthly Velocity *Sin(delta angle) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dec-09 | -70 | 0.0003 | 25 | 2.08 | -1.96 | 0.71 | -1.96 | 0.71 | | 4.642 | | -136.58 | -0.726 | -0.687 | -1.513 | -1.432 |
| | January-10 | 3 | 0.0004 | 33 | 2.75 | 0.14 | 2.75 | -1.81 | 3.46 | | 6.324 | | -63.58 | 0.445 | -0 896 | 1.224 | -2.463 |
| | February-10 | -11 | 0.0001 | 8 | 0.67 | -0.13 | 0.65 | -1.94 | 4.11 | | 4.482 | | -77.58 | 0.215 | -0 977 | 0.143 | -0.651 |
| | March-10 | 63 | 0.0005 | 42 | 3.50 | 3.12 | 1.59 | 1.18 | 5.70 | | 4.561 | | -3.58 | 0.998 | -0.062 | 3.493 | -0.219 |
| | April-10 | 84 | 0.0003 | 25 | 2.08 | 2.07 | 0.22 | 3.25 | 5.92 | | 5.00225 | Average | 17.42 | 0.954 | 0.299 | 1.988 | 0.624 |
| | May-10 | 70 | 0.0002 | 17 | 1.42 | 1.33 | 0.48 | 4.58 | 6.40 | | | | 3.42 | 0.998 | 0.060 | 1.414 | 0.084 |
| | June-10 | 105 | 0.0004 | 33 | 2.75 | 2.66 | -0.71 | 7.24 | 5.69 | | Effective | | 38.42 | 0.784 | 0.621 | 2.155 | 1.709 |
| | July-10 | 109 | 0.0004 | 33 | 2.75 | 2.60 | -0.90 | 9.84 | 4.80 | | Porosity (n)= | 0.35 | 42.42 | 0.738 | 0.675 | 2.030 | 1.855 |
| | August-10 | 95 | 0.0003 | 25 | 2.08 | 2.08 | -0.18 | 11.91 | 4.62 | | | | 28.42 | 0.880 | 0.476 | 1.832 | 0.991 |
| | September-10 | 47 | 0.0001 | 8 | 0.67 | 0.49 | 0.45 | 12.40 | 5.07 | | | | -19.58 | 0.942 | -0.335 | 0.628 | -0.223 |
| | October-10 | 81 | 0.0002 | 17 | 1.42 | 1.40 | 0.22 | 13.80 | 5.29 | | | | 14.42 | 0.969 | 0.249 | 1.372 | 0.353 |
| | November-10 | -43 | 0.0001 | 8 | 0.67 | -0.45 | 0.49 | 13.34 | 5.78 | | | | -109.58 | -0.335 | -0.942 | -0.223 | -0.628 |
| | | | | | | Average velocity, ft/yr = | | 14.54 | 23.42 | | | | | | | | |
| | Average | 54.8 | 0.00028 | | | Bearing, Northeast= | | 66.58 | | | | | | | | | |
| | Standard Deviation | 50 5 | 0.00014 | | | | | | | | | | | | | | |
| | Error in Mean | 14.6 | 0.00004 | 0.1280281 | | | | | | | | | | | | | |

| | | |
|---|---|---|
| Average monthly velocity | 1.212 | 0.000 |
| Standard Deviation in monthly velocity | 1.307 | 1.239 |
| Average yearly velocity | 14.543 | 0.000 |
| Alpha | 1.078 | 1.023 |
| | Longitudinal | Transverse |



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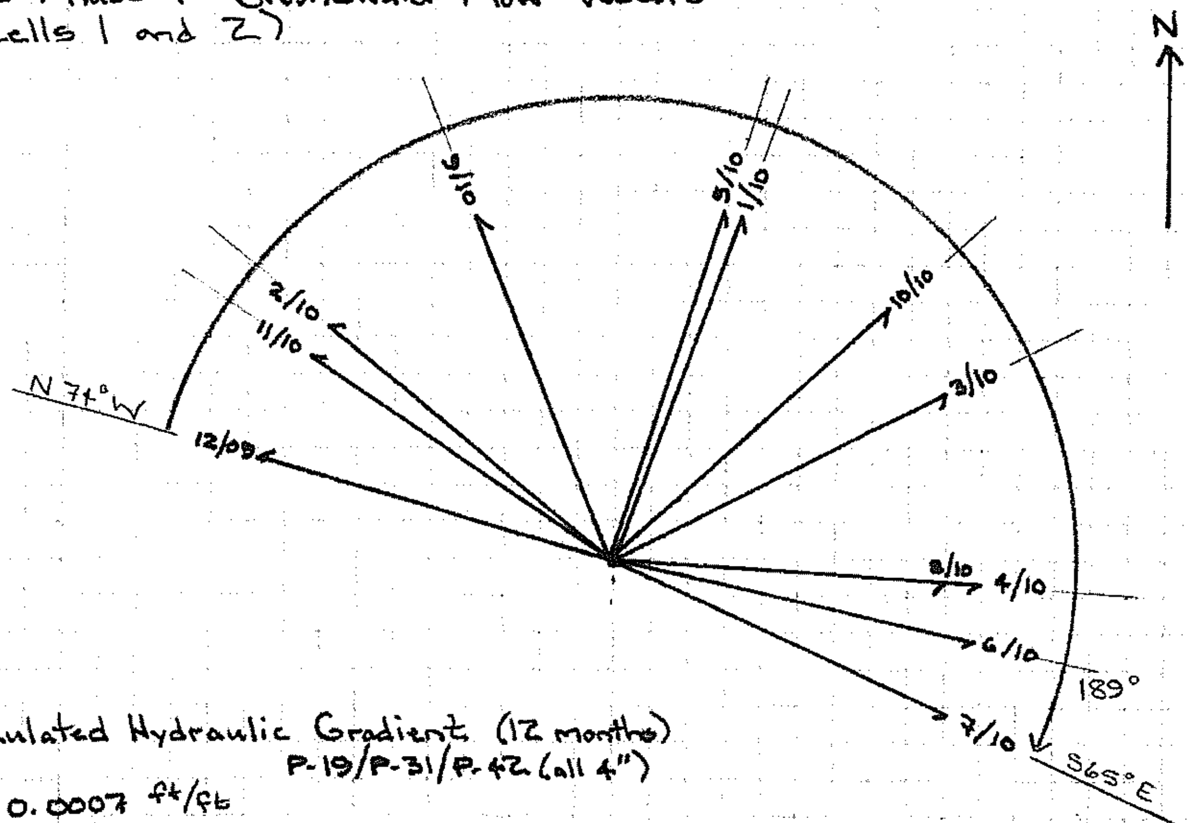
## Groundwater Monitoring Well Summary
## Table 3

| Monitoring Well Designation | Upgradient or Downgradient | Northing | Easting | Ground Surface Elevation (approx.) | Well Depth (feet, bgs) | Screen Length (feet) | Top of Screen Interval Elevation (approx.) |
|---|---|---|---|---|---|---|---|
| MW-1 | DG | 995574 | 727216 | 470 | 25 | 10 | 455 |
| MW-2 | DG | 995656 | 727662 | 469 | 23 | 10 | 456 |
| MW-3 | DG | 995738 | 728106 | 468 | 22 | 10 | 456 |
| MW-4 | DG | 995819 | 728547 | 468 | 21 | 10 | 457 |
| MW-5 | DG | 995548 | 728812 | 468 | 21 | 10 | 457 |
| MW-6 | DG | 995171 | 729206 | 467 | 20 | 10 | 457 |
| MW-7 | DG | 994600 | 729389 | 467 | 19 | 10 | 458 |
| MW-8 | DG | 994380 | 729642 | 466 | 18 | 10 | 458 |
| MW-9 | DG | 994160 | 729895 | 465 | 17 | 10 | 458 |
| MW-10 | DG | 993940 | 730147 | 466 | 18 | 10 | 458 |
| MW-11 | DG | 993720 | 730400 | 466 | 18 | 10 | 458 |
| MW-12 | DG | 993500 | 730653 | 465 | 17 | 10 | 458 |
| MW-13 | DG | 993280 | 730905 | 465 | 17 | 10 | 458 |
| MW-14 | DG | 993060 | 731158 | 464 | 16 | 10 | 458 |
| MW-15 | DG | 992840 | 731410 | 464 | 15 | 10 | 459 |
| MW-16 | DG | 992620 | 731663 | 464 | 15 | 10 | 459 |
| MW-17 | DG | 992302 | 731681 | 465 | 16 | 10 | 459 |
| MW-18 | DG | 991674 | 730925 | 462 | 13 | 10 | 459 |
| MW-19 | DG | 992096 | 730184 | 463 | 15 | 10 | 458 |
| MW-20 | DG | 991668 | 729958 | 463 | 14 | 10 | 459 |
| MW-21 | DG | 991332 | 729953 | 463 | 14 | 10 | 459 |
| MW-22 | UG | 990940 | 729361 | 464 | 15 | 10 | 459 |
| MW-23 | UG | 991102 | 728514 | 465 | 17 | 10 | 458 |
| MW-24 | UG | 991822 | 727995 | 465 | 17 | 10 | 458 |
| MW-25 | UG | 992708 | 727524 | 466 | 18 | 10 | 458 |
| MW-26 | UG | 993986 | 726913 | 467 | 20 | 10 | 457 |
| MW-27 | UG | 994619 | 726637 | 468 | 22 | 10 | 456 |
| MW-28 | UG | 995267 | 726640 | 469 | 24 | 10 | 455 |
| TMW-1 | DG | 993795 | 728659 | 467 | 19 | 10 | 458 |

# Attachment 1

## Baseline Hydrologic Data Notes

1. "Old Phase 4" Groundwater Flow Vectors (Cells 1 and 2)




2. Calculated Hydraulic Gradient (12 months)
P-19/P-31/P-42 (all 4")

| | | |
|---|---|---|
| 12/09 | 1. | 0.0007 ft/ft |
| 1/10 | 2. | 0.0008 |
| 2/10 | 3. | 0.0003 |
| 3/10 | 4. | 0.0008 |
| 4/10 | 5. | 0.0002 |
| 5/10 | 6. | 0.0001 |
| 6/10 | 7. | 0.0004 |
| 7/10 | 8. | 0.0004 |
| 8/10 | 9. | 0.0002 |
| 9/10 | 10. | 0.0001 |
| 10/10 | 11. | 0.0001 |
| 11/10 | 12. | 0.0003 |

Avg: 0.00037 ft/ft

3. Calculated K values from w/in Old Phase 4 realignment area (from DSI)

1. P-19 : $4.642 \times 10^{-2}$ ft/min
2. P-22 : $6.324 \times 10^{-2}$ "
3. P-31 : $4.482 \times 10^{-2}$ "
4. P-42 : $4.561 \times 10^{-2}$ "

Avg: $5.002 \times 10^{-2}$ ft/min

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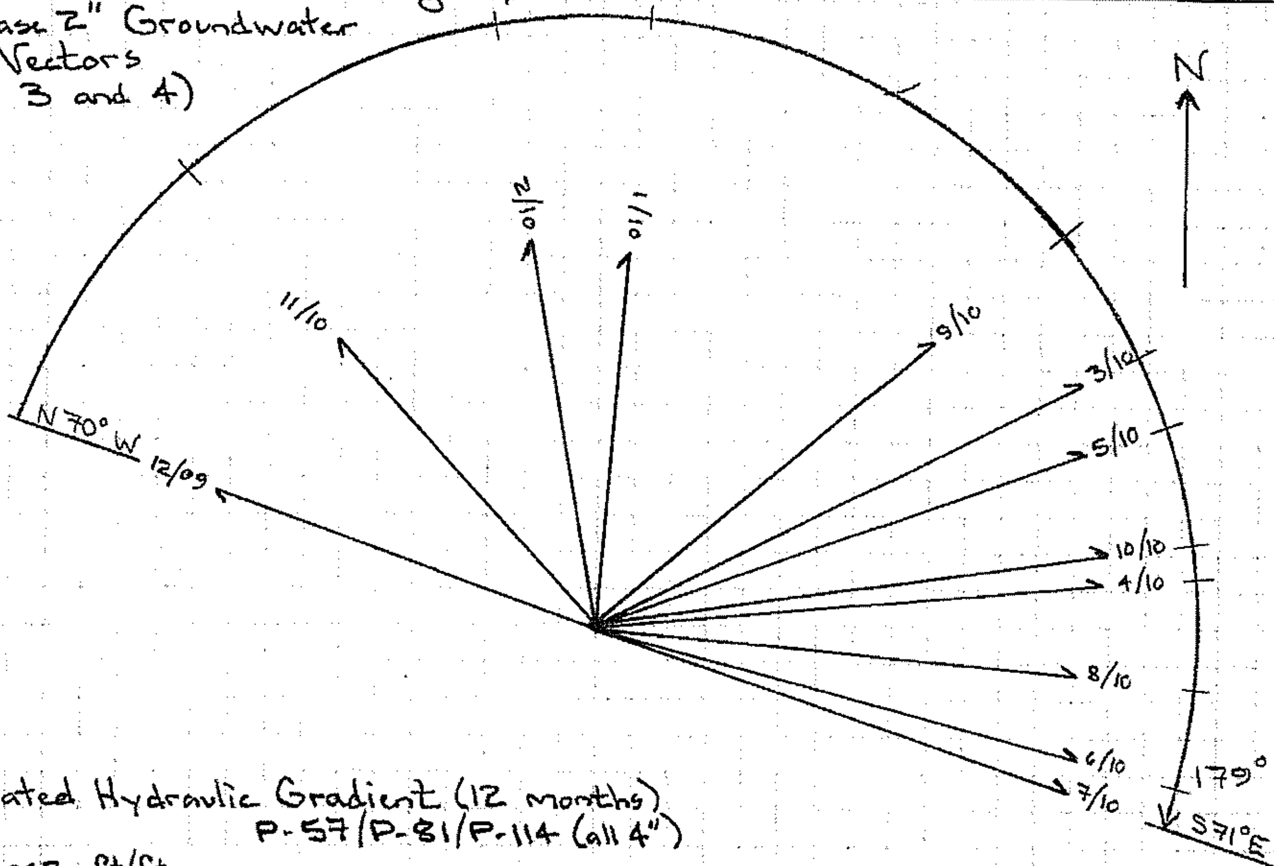
Telephone (573) 659-9078

| | | | |
|---|---|---|---|
| Date: 5-25-12 | | Page No: 1 of 1 | |
| Client: Reitz + Jens | | | |
| Prepared By: M.C. Carlson | Checked By: MCC | Project: Labadie Construction Permit | |
| Subject: Groundwater Monitoring System | | | |

1. "Old Phase 2" Groundwater Flow Vectors (Cells 3 and 4)




2. Calculated Hydraulic Gradient (12 months)
P-57/P-81/P-114 (all 4")

1. 0.0003 ft/ft
2. 0.0004
3. 0.0001
4. 0.0005
5. 0.0003
6. 0.0002
7. 0.0004
8. 0.0004
9. 0.0003
10. 0.0001
11. 0.0002
12. 0.0001

Avg: 0.00028 ft/ft

3. Calculated K values from w/in Old Phase 2 (Cells 3 and 4) Area (from DSI):
   1. P-53: $2.444 \times 10^{-2}$ ft/min
   2. P-57: $4.737 \times 10^{-2}$ ft/min
   3. P-81: $7.184 \times 10^{-2}$ ft/min
   4. P-85: $7.744 \times 10^{-2}$ ft/min
   5. P-114: $5.724 \times 10^{-2}$ ft/min

   Avg: $5.567 \times 10^{-2}$ ft/min

Printed on Recycled Paper

# Attachment 2

Wilson, C.R., Einberger, C.M., Jackson, R.L., and Mercer, R.B. (1992) "*Design of Ground-Water Monitoring Networks Using the Monitoring Efficiency Model (MEMO)*"; *GROUNDWATER*, V. 30, No. 6, Nov.-Dec.

# Design of Ground-Water Monitoring Networks Using the Monitoring Efficiency Model (MEMO)

by Charles R. Wilson[a], Carl M. Einberger[a], Ronald L. Jackson[b], and Richard B. Mercer[b]

## Abstract

**An analytical Monitoring Efficiency Model (MEMO) has been developed to assist in the design of monitoring well networks. The method simulates the migration of hypothetical contaminant plumes from a site and quantifies the efficiency of alternative well network designs in detecting the plumes. The computed detection efficiency provides a basis for optimizing the design. Maps of the site showing areas from which releases would or would not be detected by a given well network are produced, providing insight into the benefits of adding, deleting, or moving specific wells.**

## Introduction

Ground-water monitoring is generally required by regulatory agencies at hazardous waste sites, solid waste landfills, and other sites where the potential release of chemicals to the sursurface is a concern. The goals of ground-water monitoring include verifying regulatory compliance and providing early warning of a chemical release. Although the intent of such monitoring is to protect human health and the environment, a clear approach for measuring the degree of protection offered by a monitoring system has not been well established. A Monitoring Efficiency Model (MEMO) presented in this paper provides a method for quantifying the efficiency of a given monitoring well network in detecting a potential chemical release, and graphically depicting areas where releases would not be detected. The method is an extension and refinement of a physical design approach suggested by Massmann, Freeze and others (Massmann and Freeze, 1987; Freeze et al., 1990) and Meyer and Brill (1988). It provides an easily understood way to adjust and optimize the network design to site and waste conditions, and to quantify the degree of protection for public and regulatory review.

[a]Golder Associates Inc., Redmond, Washington 98052.

[b]Westinghouse Hanford Company, Richland, Washington 99352.

Received June 1991, revised March 1992, accepted April 1992.

Discussion open until May 1, 1993.

## General Approach

The technique developed in this paper quantifies the monitoring efficiency of a given monitoring well network by determining areas within a potential chemical source area where a chemical release would or would not be detected by the monitoring well network. Monitoring efficiency is defined as the ratio of the area of detection to the total area of the site. For example, a determined efficiency of 90 percent predicts that releases occurring over 90 percent of the site would be detected by the monitoring wells, and releases occurring over 10 percent of the site would not be detected.

The monitoring efficiency solution is determined in the following manner. A grid of potential chemical source points is defined within the potential source area. At each potential source point, a contaminant plume is generated using an analytical contaminant transport solution. If the plume is intersected by a monitoring well before it migrates beyond a specified boundary, the source point is considered to be detected. After checking each grid point to determine whether the plume released from that point is detected or not detected, the monitoring efficiency is calculated, and a map showing areas from which chemical releases would not be detected is produced.

An illustration of the application of MEMO is shown in Figure 1. Critical geometric elements are the potential source area(s), a grid of potential source points, the buffer zone boundary, and monitoring well locations. The buffer zone boundary is defined as the limit to which a plume can migrate before it should be detected, and serves as the plume migration limit for "early warning" detection of a contami-

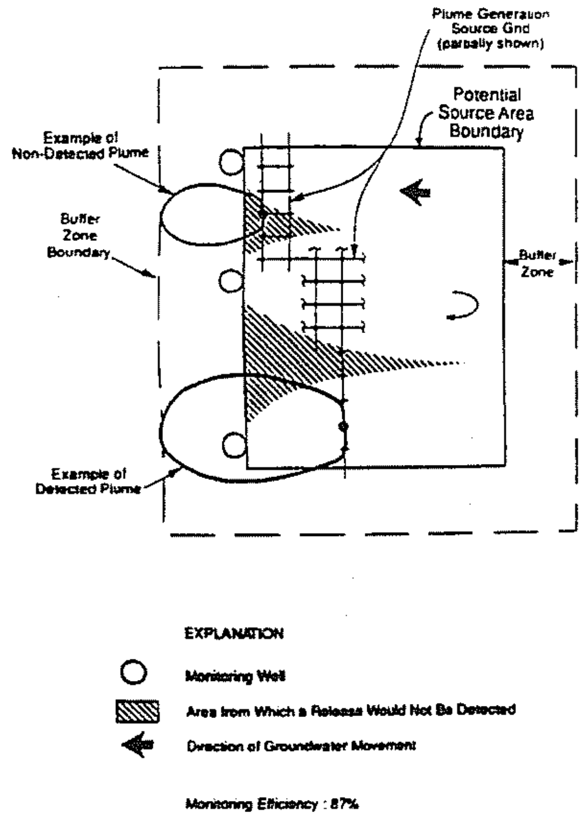



**Fig. 1. Illustration of MEMO results.**

nant release. A plume that moves beyond this limit without detection by a monitoring well is considered to be undetected. Figure 1 shows examples of detected and nondetected plumes and two distinct nondetected regions defined by source grid points from which generated plumes were not detected by monitoring wells prior to passing the buffer zone boundary.

Ground-water flow and contaminant transport parameters are required to determine the plume dimensions and configuration. Specific flow and transport input requirements will depend upon the plume generation routine used in the analysis. MEMO currently uses a two-dimensional plume generation routine based on the two-dimensional analytical solution of Domenico and Robbins (1985), but the methodology incorporated into MEMO can be applied with other analytical contaminant transport solutions.

MEMO is applied using available site-specific and/or literature-based information. Multiple simulations can be performed to analyze the sensitivity of a specific problem domain to input parameters. Because MEMO is based upon a simulation of physical processes, evaluations of the adequacy of the design are determined from the physical parameters and processes governing contaminant migration, rather than upon qualitative judgments of how many wells are enough.

## Plume Generation

MEMO uses a plume generation routine to compute the sizes and shapes of the plumes from each grid point. The plume generation routine currently incorporated into MEMO is based upon the two-dimensional analytical transport model presented in Domenico and Robbins (1985) and modified in Domenico (1987). This model assumes that solute is released along a continuous line source in a uniform aquifer, and predicts the concentrations that would be observed at points downstream of that source. The governing equation is:

$$C(x, y, t) = (C_o/4) \exp\{(xv/2D_x)[1-(1+4kD_x/v^2)^{1/2}]\}$$
$$\mathrm{erfc}\{[x - vt(1+4kD_x/v^2)^{1/2}]/2(D_xt)^{1/2}\}$$
$$\{\mathrm{erf}[(y+Y/2)/2(D_yx/v)^{1/2}] - \mathrm{erf}[(y-Y/2)/2(D_yx/v)^{1/2}]\}$$

where $C(x, y, t)$ = concentration at x, y, t; $C_o$ = source concentration; x = distance downstream from the source; y = transverse distance from the source; k = first-order radioactive decay constant; Y = width of the source in the ground water; v = average contaminant velocity; $D_x$ = longitudinal dispersion coefficient; $D_y$ = transverse dispersion coefficient; and t = time.

The average contaminant velocity is computed as:

$$v = Ki/Rn$$

where K = hydraulic conductivity; i = hydraulic gradient; R = retardation factor; and n = effective porosity.

The dispersion coefficients are functions of the contaminant velocity, the dispersivities, the retardation factor, and the diffusion coefficient for the contaminant of interest.

$$D_x = \alpha_x v + D_m/R$$
$$D_y = \alpha_y v + D_m/R$$

where $\alpha_x$ = longitudinal dispersivity; $\alpha_y$ = transverse dispersivity; and $D_m$ = effective molecular diffusion coefficient for the contaminant of interest.

MEMO is solved using a specified dilution contour, defined as:

$$C_{dil} = C_{ds}/C_o$$

where $C_{ds}$ is the detection standard selected as the limiting concentration to be detected by a monitoring well, and $C_o$, as defined above, is the source concentration.

Assumptions of the plume generation routine include negligible vertical ground-water flow and vertical chemical transport, a uniform ground-water flow field, and a continuous line source. The assumption of a uniform flow field implies constant hydrologic and transport properties and a uniform hydraulic gradient over the length of the plume.

Significant judgment is required prior to performing MEMO simulations for a site. An evaluation of the suitability of the model assumptions presented in the previous section must be performed on a case-by-case basis. For example, it should be recognized that the plume shape predicted by the model is idealized for uniform aquifer conditions, and the heterogeneities present at field sites may cause plumes to assume irregular shapes. As with any model, care must be taken that erroneous conclusions are not made based on inadequate assumptions about the problem domain.

## Required Input Parameters

The principal input parameters required for MEMO are the geometry and discretization of the problem domain, potential source width, the contaminant transport parameters, and the dilution contour to be measured in the monitoring wells. Parameters that are not known from site-specific field data must be conservatively estimated. Sensitivity analyses may be performed to identify critical parameters affecting monitoring efficiency predictions.

### *Geometry of Problem Domain*

Key geometric elements of the problem domain are the potential source area(s), monitoring wells to be investigated, and the location of the buffer zone boundary. Geometric data are input using a standard coordinate system, and a uniform source grid spacing must also be specified. The sensitivity of an efficiency analysis to the source grid spacing should be evaluated, since grid spacing can influence the accuracy of the solution.

Monitoring wells are located between the potential source area(s) and the buffer zone boundary. Plumes that are not detected by a monitoring well prior to contacting the buffer zone boundary are considered to be "not detected" in the monitoring efficiency estimate. However, it should not be inferred that plumes considered "not detected" for purposes of network design will never be detected. Plumes will continue to expand until steady state is reached, and may eventually be detected prior to reaching steady state. Identification of a buffer zone is necessary because unless the center line of a plume directly contacts a monitoring well, the leading edge of the plume will migrate beyond the monitoring well prior to plume detection.

Although a smaller buffer zone width is more conservative because it will generate a lower apparent monitoring efficiency, our sensitivity analyses have indicated that MEMO efficiency predictions are not particularly sensitive to buffer zone widths greater than several hundred feet. The appropriate width for the buffer zone will depend on site-specific and regulatory conditions. General criteria for establishing buffer zone widths include distances to property boundaries and neighboring dwellings, distances to ground-water supply wells or surface-water bodies, the velocity of ground-water movement, and the relative costs and benefits of providing early detection of a release. Buffer zone widths established for hazardous waste facilities in current regulations vary, but are on the order of hundreds to thousands of feet. We have used a conservative width of 500 feet for remote sites.

### *Potential Source Width*

Vertical migration of contaminants through the unsaturated zone to the water table is assumed to create a source of contamination in the ground water that generates the contaminant plume. The width of the source in the ground water will depend upon the dimensions of the release at the waste site and the subsequent dispersion in the unsaturated zone. The size and strength of this source may be estimated from field measurements if releases have occurred at the site, or from the size, type of contaminants, and transport mechanisms of a hypothetical release from the site.

The data needed to support a rigorous analysis of the potential source width are often lacking, requiring that this parameter be conservatively estimated. Smaller source widths are more conservative because they are more difficult to detect. The source width estimate should take into account the dimensions of the release at the waste site and the effects of migration through the unsaturated zone. The dimensions of the release at the waste site may be, for example, the dimensions of a typical waste container at an unlined site, or may be the dimensions of a potential liner leak at a lined site. Migration through the unsaturated zone is usually accompanied by lateral spreading. The source width may be increased for larger release dimensions and larger unsaturated zone thicknesses, but the estimated mass flux of contaminants entering the ground water should be held constant by adjusting the source concentration used to calculate the dilution contour.

### *Contaminant Transport Parameters*

Contaminant transport parameters required for plume generation are the direction of ground-water movement, the average contaminant velocity, and the longitudinal and transverse dispersivities. Optional contaminant transport parameters are the molecular diffusion coefficient and the first-order radioactive decay constant.

If ground-water level data are available for a site, they can be used to estimate the direction of ground-water movement. If no water-level data are available, the direction of ground-water movement may be estimated from regional hydrogeologic data or from site topography. The sensitivity of the monitoring efficiency estimate to variations in ground-water flow direction should be considered, particularly when no field data are available. The efficiency of a particular monitoring well network can be significantly changed by a change in the ground-water flow direction.

The average contaminant velocity can be approximated from estimates of the average hydraulic conductivity, hydraulic gradient, retardation factor, and effective porosity at the site. With the Domenico and Robbins plume generation routine, for a plume of a given length the shape of the generated plume is independent of the time required to develop the plume, if decay and molecular diffusion are negligible. For example, a plume that traveled 500 feet in five years would be predicted to have the same shape as one that traveled 500 feet in 50 years. Because of this independence, for cases where decay and diffusion are negligible, the monitoring efficiency solution is not dependent on the hydraulic parameters governing the average contaminant velocity, and is not sensitive to the choice of average contaminant velocity.

Site-specific dispersivities are rarely available, and must usually be estimated from available literature values for similar geologic media. Gelhar et al. (1985) provide a source for such information. Dispersivity values have been reported to increase as the length of the plume increases, although the most reliable measured values are the lower estimates. The selection of values is complicated by the fact that considerably more data are available for longitudinal than transverse dispersivities; thus the uncertainty is higher for the transverse dispersivity. If the data base for transverse dispersivity cannot support a direct estimate, it can be estimated as a fraction of the longitudinal value ($\alpha_y/\alpha_x = 0.1$ is commonly used). The width of the plume is quite sensitive to the transverse dispersivity ($\alpha_y$) and is relatively insensitive to the longitudinal dispersivity ($\alpha_x$). Longer, thinner plumes are harder to detect, and therefore larger values of longitudinal and smaller values of transverse dispersivity are more conservative. For application to a site with unconsolidated silts, sands, and gravels, the best direct estimate values for transverse and longitudinal dispersivities were 8 and 28 feet, respectively, using a scale of interest of about 1,000 feet. The relatively high transverse to longitudinal ratio of about 0.3 was supported by limited site-specific data. For conservatism, the monitoring network design was based upon a transverse dispersivity of 5 feet and a longitudinal dispersivity of 35 feet.

For most field situations, the diffusion coefficient is quite small compared to the adjective velocity and can be neglected. For sites with very low adjective velocities, the effect of molecular diffusion can be evaluated in a sensitivity analysis. Radioactive or chemical decay can be incorporated into the monitoring efficiency study by specifying a first-order decay constant.

### Dilution Contour

The dilution contour ($C_{dil}$), defined as the ratio of the detection standard ($C_{ds}$) to the concentration at the source of the plume in the ground water ($C_o$), identifies the boundary of the plume used in the monitoring efficiency determination. The monitoring efficiency is affected by the dilution contour, because plumes of a given length are slightly wider for a lower dilution contour than for a higher dilution contour. The wider plumes would be easier to detect and fewer monitoring wells would be required to achieve a target monitoring efficiency. To provide adequate early warning of a release, the design should be based upon a dilution contour for the more mobile potential contaminants at the site.

To determine an appropriate dilution contour, the source strength and detection standard must be estimated. The source strength is the contaminant concentration at the plume source within the aquifer. The potential source strength may be estimated through analysis of ground-water samples from an identified source area where a release has already occurred, through analysis of the physical conditions of the waste and the site, or through identifying a threshold source strength that would be of regulatory concern. The first of these approaches is not typically possible, because monitoring well network designs are generally prepared for sites where releases have not yet occurred or have not been established. In estimating source strength using the other approaches, release of contaminants from the potential source area(s) is considered to be continuous and governed by long-term average hydrologic conditions.

If the mass flux rate of contaminants released from the site is assumed to be constant, the strength and width of the source in the ground water become inversely related. If the width of the source increases, such as from a higher estimated dispersion in the unsaturated zone, the strength of the source must decrease, because the total mass flux of contaminant entering the ground water remains constant. Although the network design is sensitive to changes in either source strength or source width when taken independently, it becomes relatively insensitive when the inverse relationship between these parameters is considered.

Estimates of source strength based upon the physical conditions of the waste and the site may be made considering the amounts and physical states of potential contaminants in the waste, the probable mobilization and release mechanisms into the unsaturated zone, the dispersive effects occurring in the unsaturated zone, and the rate of ground-water movement in the underlying aquifer. Factors which should be considered are whether the waste is in solid or liquid form, and its potential mobility given the conditions of release or disposal. The data necessary to rigorously address the processes of release and subsequent migration to the ground water are often unavailable, and conservative estimates must be made.

Estimates of source strength may also be based upon threshold values that would be of regulatory concern. This approach is useful when the contaminant of concern has an assigned regulatory standard such as a maximum contaminant level (MCL), but its concentration at the point of release at the waste site is difficult to estimate, for example, because of a lack of solubility information. This approach has been particularly useful for metals and radionuclides. The threshold strength of concern is generally considered to be the regulatory standard, and the contaminant concentration at the source in the ground water would be set to approximately equal that standard. This would be more conservative than estimates based on solubility limits if the regulatory standard is less than the estimated source concentration. However, if the estimated source concentration is less than the regulatory standard, it is recommended that the regulatory standard be used as the source concentration to avoid an overly conservative design.

## Example Application

MEMO has been employed to design monitoring networks for eight waste management areas on the U.S. Department of Energy's Hanford Site in eastern Washington. Before applying MEMO at a location, the relevant hydrogeologic data and information on waste characteristics are assembled and reviewed to develop alternative conceptual models of the directions and stability of ground-water movement and the unsaturated zone transport conditions associated with alternative release scenarios. Uncertainties in parameter values are analyzed in MEMO sensitivity studies, and uncertainties in the validity of the assumptions used in MEMO are identified. Higher design monitoring efficiencies may be used at sites with greater parameter uncertainties.

The data base parameters for MEMO were developed

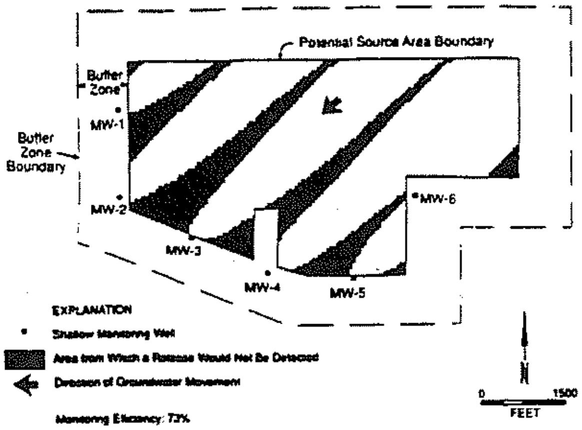



Fig. 2. Example MEMO results for a network of six wells.

by applying the logic described above. The results of example applications are shown in Figures 2 and 3 for a waste site of irregular geometry. The direction of ground-water flow was assumed to be the same throughout the site. The following data base was used in this example:

| | |
|---|---|
| Source Width | 20 feet |
| Buffer Zone Width | 500 feet |
| Longitudinal Dispersivity | 35 feet |
| Transverse Dispersivity | 5 feet |
| $C_{dil}$ | 0.001 |

Contaminant decay and molecular diffusion were considered negligible in this example.

Figure 2 shows the MEMO results for a relatively sparse downgradient network of six wells. The shaded areas on the figure indicate locations where a release is not predicted to be detected. The influence of the approximately 1,500-foot gaps between the monitoring wells can be seen in the sizes of the shaded areas. The efficiency of this network is about 73 percent, and is less the minimum target of 90 percent adopted for this example. Efficiencies may be improved by adding or adjusting locations of monitoring wells in the vicinity of the larger shaded areas.

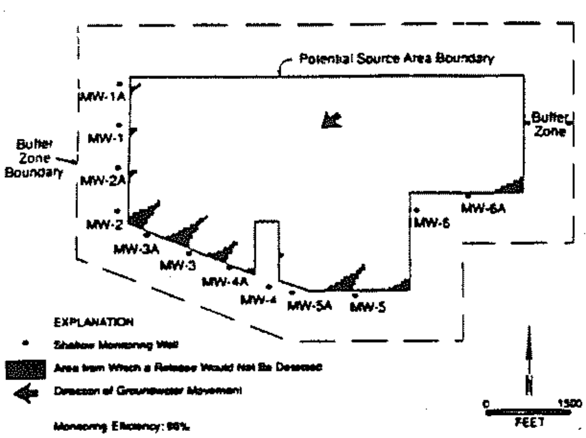



Fig. 3. Example MEMO results for a network of 12 wells.

Figure 3 shows the MEMO results for the site shown in Figure 2, but with a network of 12 wells. This network greatly reduces the shaded areas and increases the monitoring efficiency to 96 percent. This efficiency may be unnecessarily high for the site, particularly if the direction of ground-water flow is stable. Monitoring wells can be moved, added, or deleted until a satisfactory network is achieved. The sensitivity of the final network to uncertainties in ground-water flow directions or in any of the other input parameters can also be evaluated.

## Future Model Development

The monitoring efficiency concept of MEMO can be developed with other assumptions and applications. Some examples of areas for future model development are discussed in this section.

MEMO currently provides a deterministic solution for the monitoring efficiency. A probabilistic model incorporating a Monte Carlo approach has been considered, with user-specified probabilistic functions for each of the field or literature-derived input parameters. Rather than producing a single monitoring efficiency, a range of values would be produced. Graphical output could present contours of the frequency of detection of each potential source point, rather than shading nondetected potential source points.

A three-dimensional analytical solution can be incorporated into MEMO to allow evaluations of nested monitoring well networks. The user would specify well locations and screen intervals for each well. Plume migration would be limited by a planar buffer zone limit. MEMO can also be developed with a two-dimensional or three-dimensional finite-difference or finite-element contaminant transport module, to allow application to sites where available data and site complexity suggest that the simplifying assumptions of the current analytical solution are inappropriate.

As an alternative to using the buffer zone concept, plumes can be limited by migration time or allowed to reach steady state, prior to checking for detection in a monitoring well. However, if this approach is used, the downgradient limit of each generated plume will vary with the geometry of the source area. At sites where ground-water contamination is of concern, early warning of contamination is typically desired to allow corrective action to be taken. The buffer zone boundary serves as the limit for plume migration before early warning should occur. For this reason, the buffer zone concept is our preferred configuration for the model.

## Conclusions

MEMO is a method for monitoring well network design that is quantitative and produces easily understood graphical output. The computed detection efficiency provides data for optimization of a monitoring network design based upon physical processes. The model requires significant judgment because of the need to obtain or estimate the input parameters. The benefits obtained from adding, deleting, or moving wells can be readily demonstrated using multiple simulations. The model has been found to be of significant value in justifying a network design to both regulatory agencies and site owners. The approach can be readily adapted or enhanced to address alternative problems. For example, the model can be modified for use with three-dimensional plume generation techniques if required for a particular site. It also can be developed on a probabilistic basis, to quantify the uncertainty in the design, as an alternative to the deterministic and conservative approach described here. The expanded use of MEMO and other similar design approaches is expected to promote reduction in the uncertainties inherent in monitoring well network design.

## Availability of Model

MEMO software and a User's Manual can be obtained from the authors.

## Acknowledgments

MEMO was developed at the request of Westinghouse Hanford Company, Richland, Washington, for the U.S. Department of Energy. The authors would like to acknowledge the support and insightful comments received on the MEMO concept from many colleagues. Particular thanks go to Ian Miller, Rick Kossik, and George Evans for their valuable insights into the basic modeling concepts, and to Scott Kindred, John Velimesis, and Scott Warner for their help in brainstorming ideas, verifying the code, polishing the text, and working through many manual applications.

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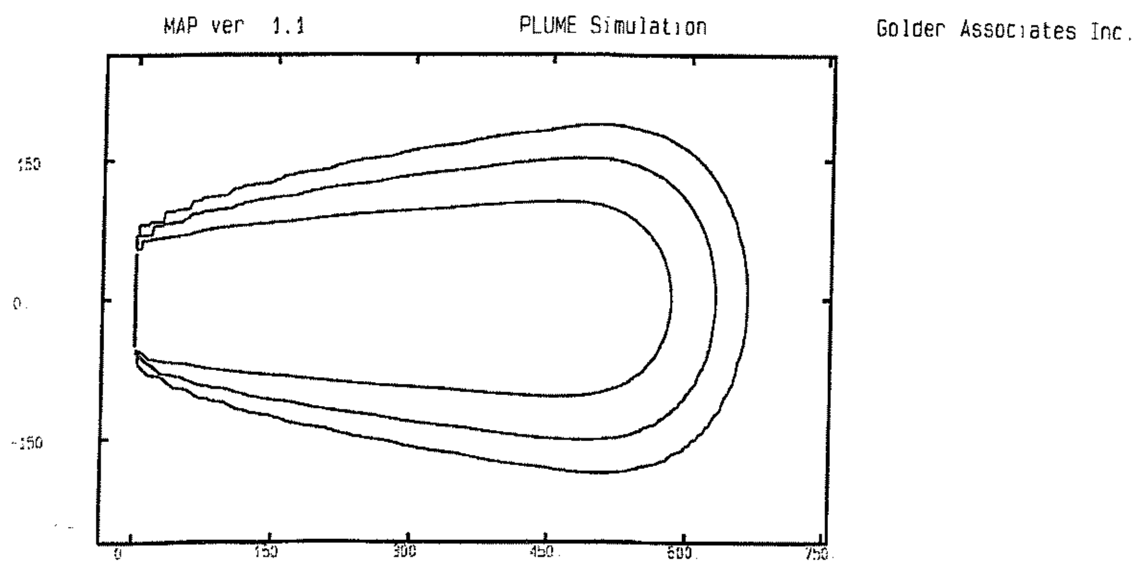
# Attachment 3

PLUME Model Outputs

Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center
Cells 1 and 2
Plume Model Output for 44 Years

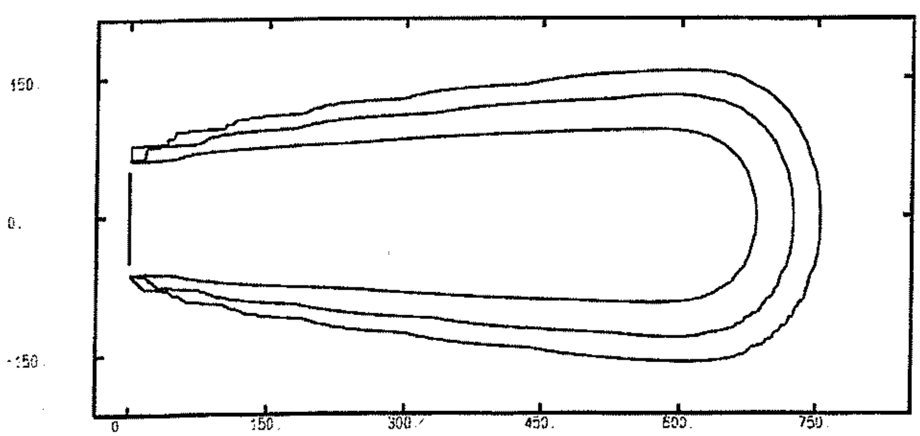



Contours at: .00100, .01000, .10000
Advection time = 528.00
Average contaminant velocity = 1.0130
Width of line source = 100.00

Longitudinal dispersivity = 1.74
Transverse dispersivity = 2.03
First-order decay constant = .000E+00
Diffusion coefficient = .000E+00

Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center
Cells 3 and 4
Plume Model Output for 44 Years

MAP ver 1.1 PLUME Simulation Golder Associates Inc.




Contours at: .00100, .01000, .10000

Advection time = 528.00

Average contaminant velocity = 1.2120

Width of line source = 100.00

Longitudinal dispersivity = 1.07

Transverse dispersivity = 1.02

First-order decay constant = .000E+00

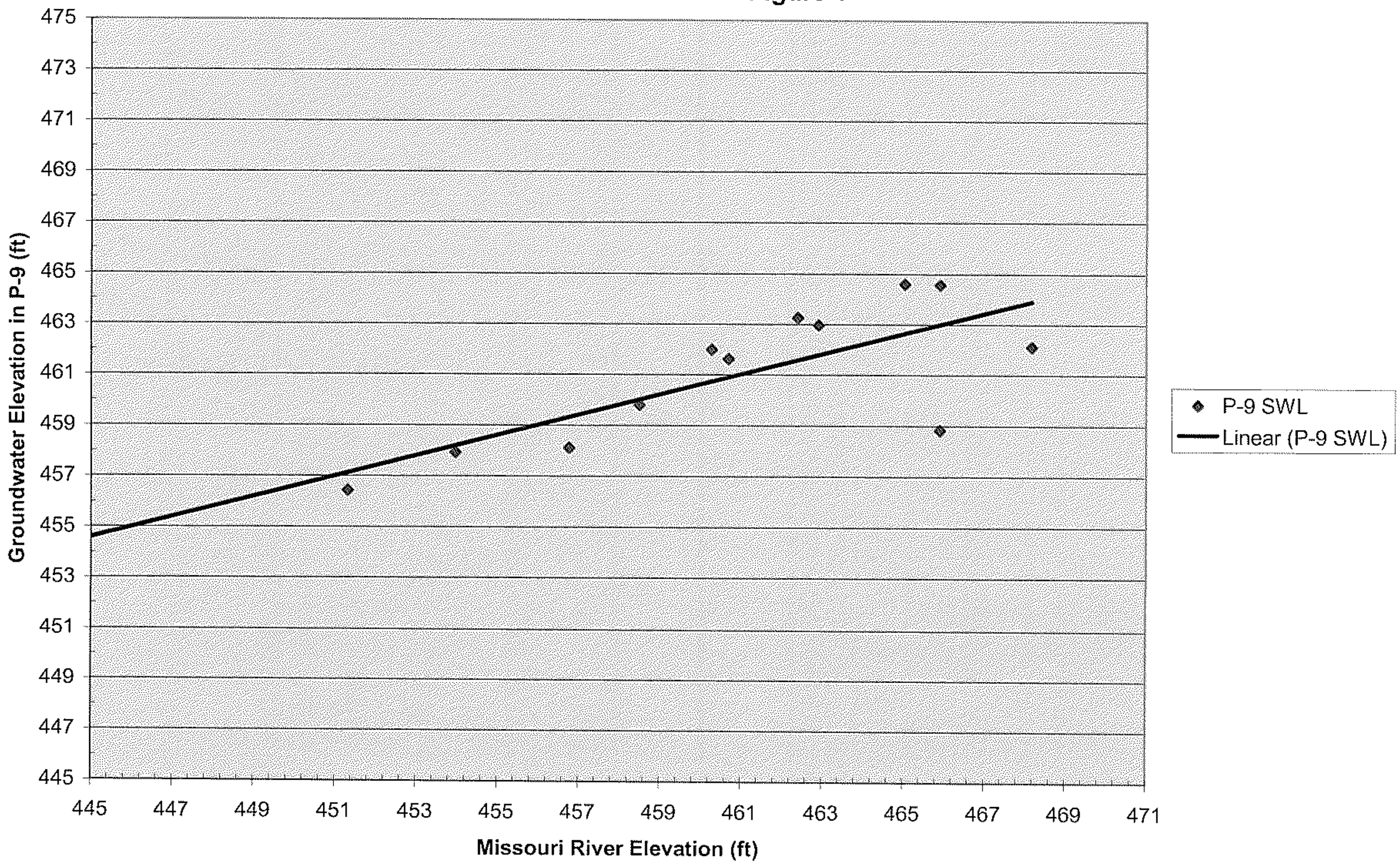
Diffusion coefficient = .000E+00

# Attachment 4

## Linear Regression Plots
## Missouri River Elevation vs
## Top of Water Table

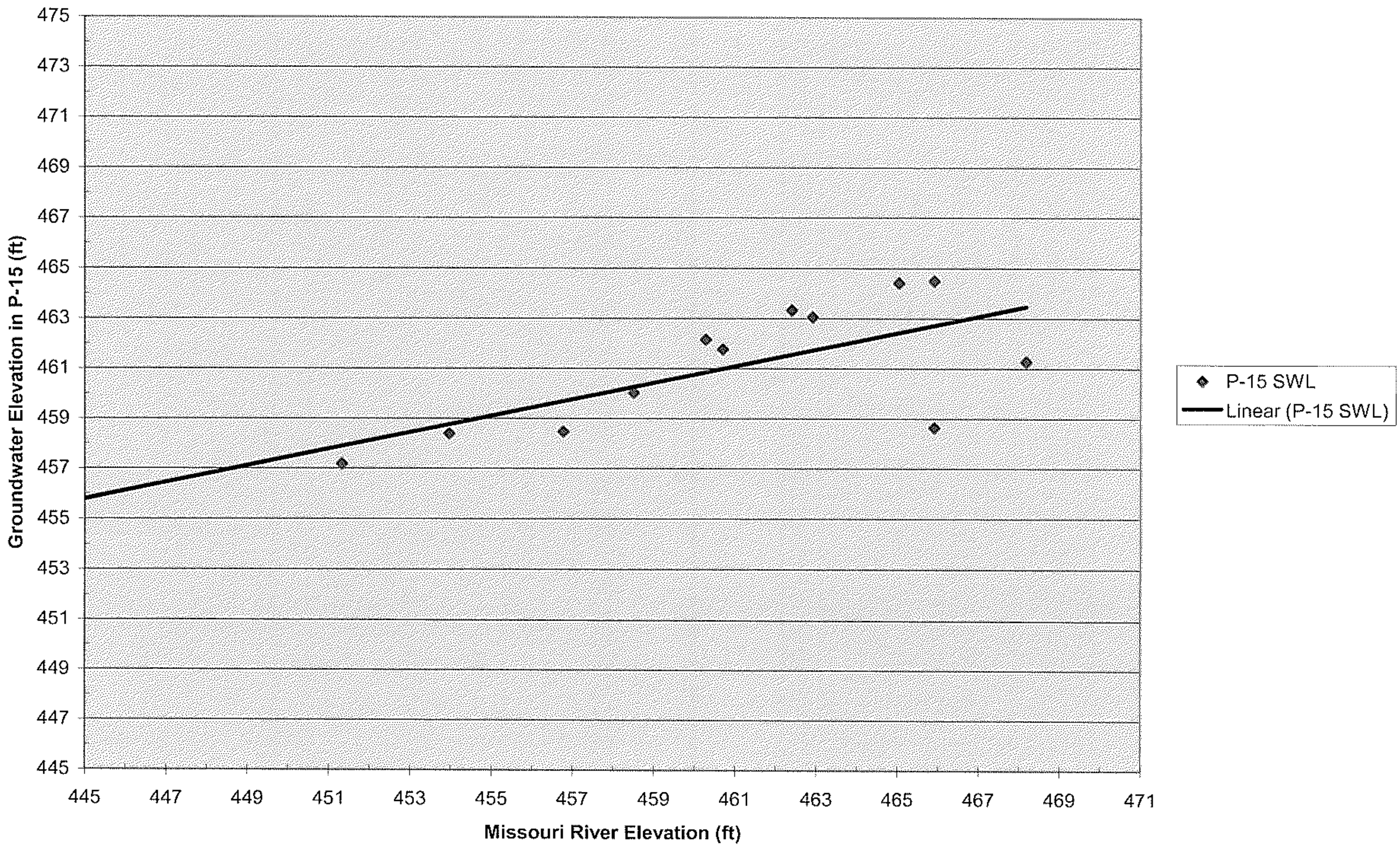
**Construction Permit Application**
**Proposed Utility Waste Landfill**
**Ameren Missouri Labadie Energy Center**

**Missouri River Elevation vs Top of Water Table (P-9)**
**Attachment 4 - Figure 1**



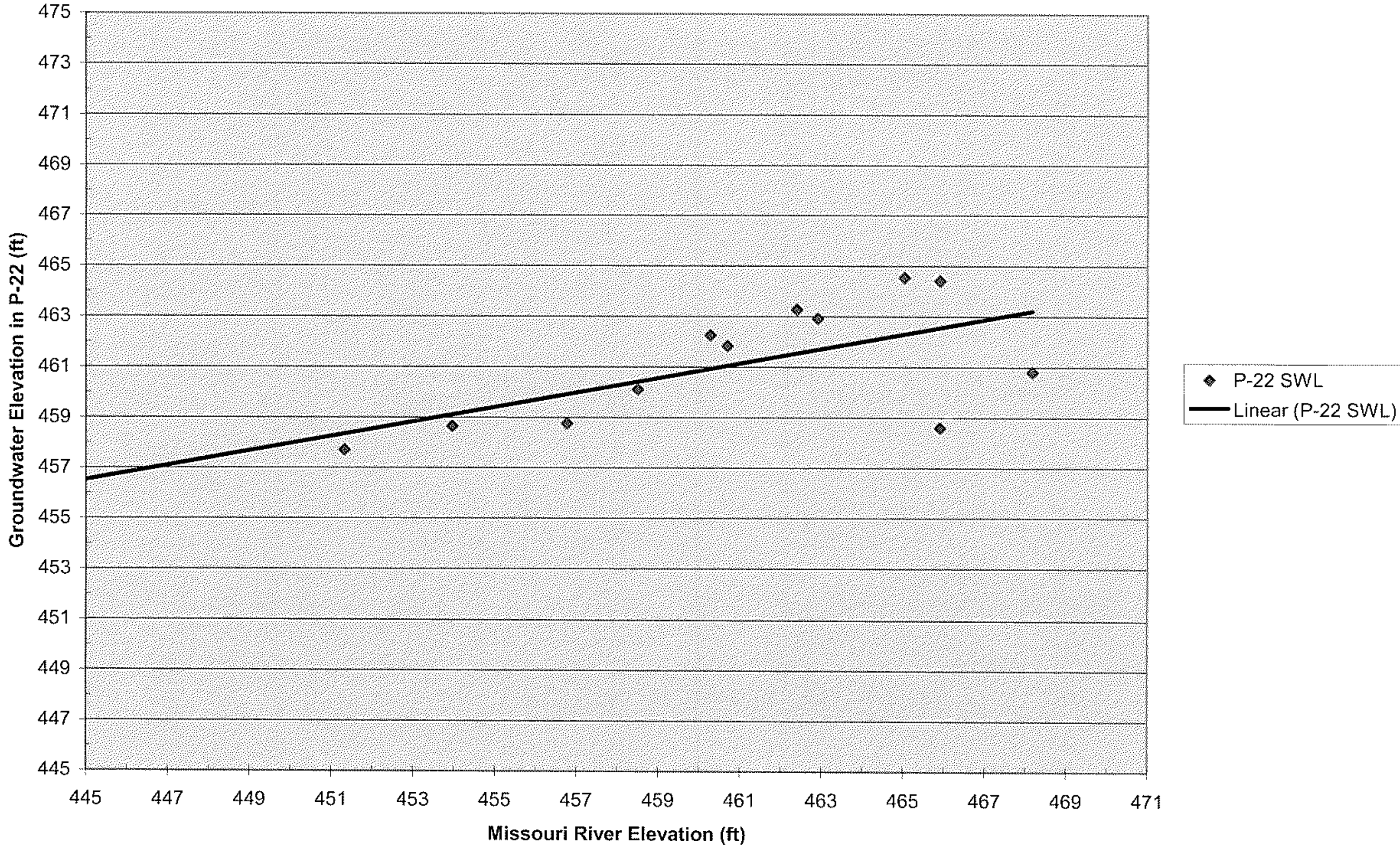
**Construction Permit Application**
**Proposed Utility Waste Landfill**
**Ameren Missouri Labadie Energy Center**

**Missouri River Elevation vs Top of Water Table (P-15)**
**Attachment 4 - Figure 2**



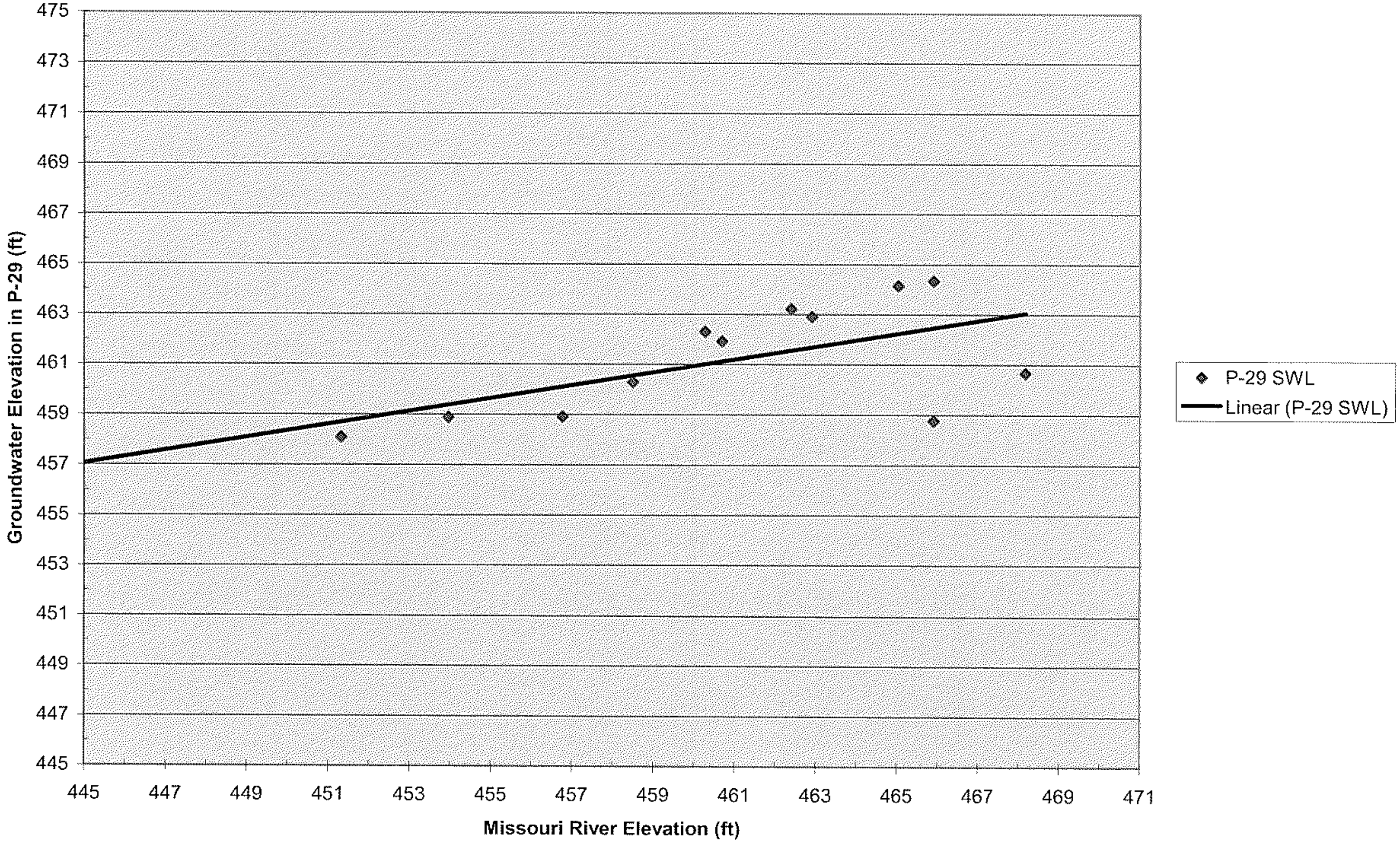
## Construction Permit Application
## Proposed Utility Waste Landfill
## Ameren Missouri Labadie Energy Center

### Missouri River Elevation vs Top of Water Table (P-22)
### Attachment 4 - Figure 3



## Construction Permit Application
## Proposed Utility Waste Landfill
## Ameren Missouri Labadie Energy Center

### Missouri River Elevation vs Top of Water Table (P-29)
### Attachment 4 - Figure 4



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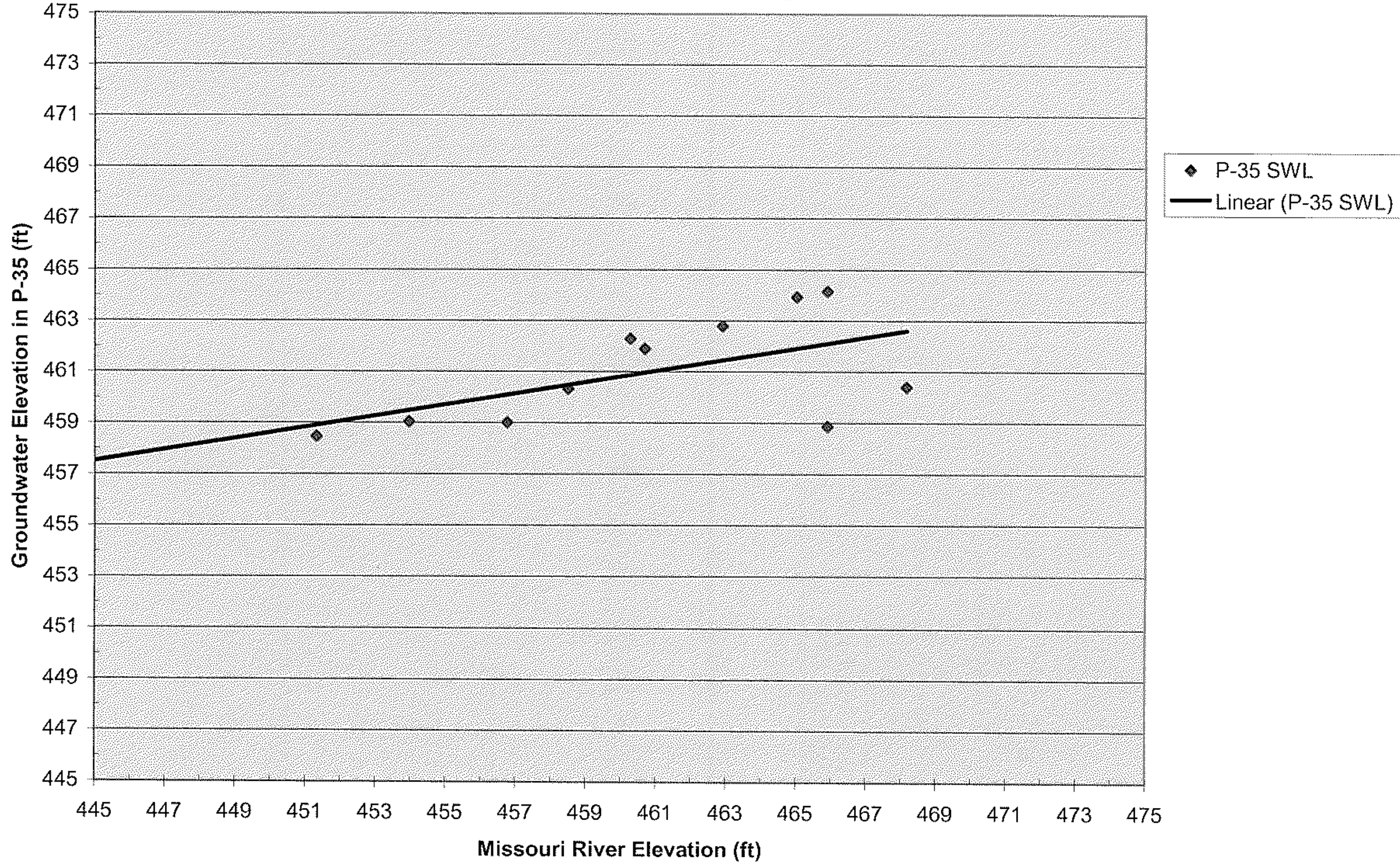
**Proposed Utility Waste Landfill**
**Ameren Missouri Labadie Energy Center**

**Missouri River Elevation vs Top of Water Table (P-35)**
**Attachment 4 - Figure 5**



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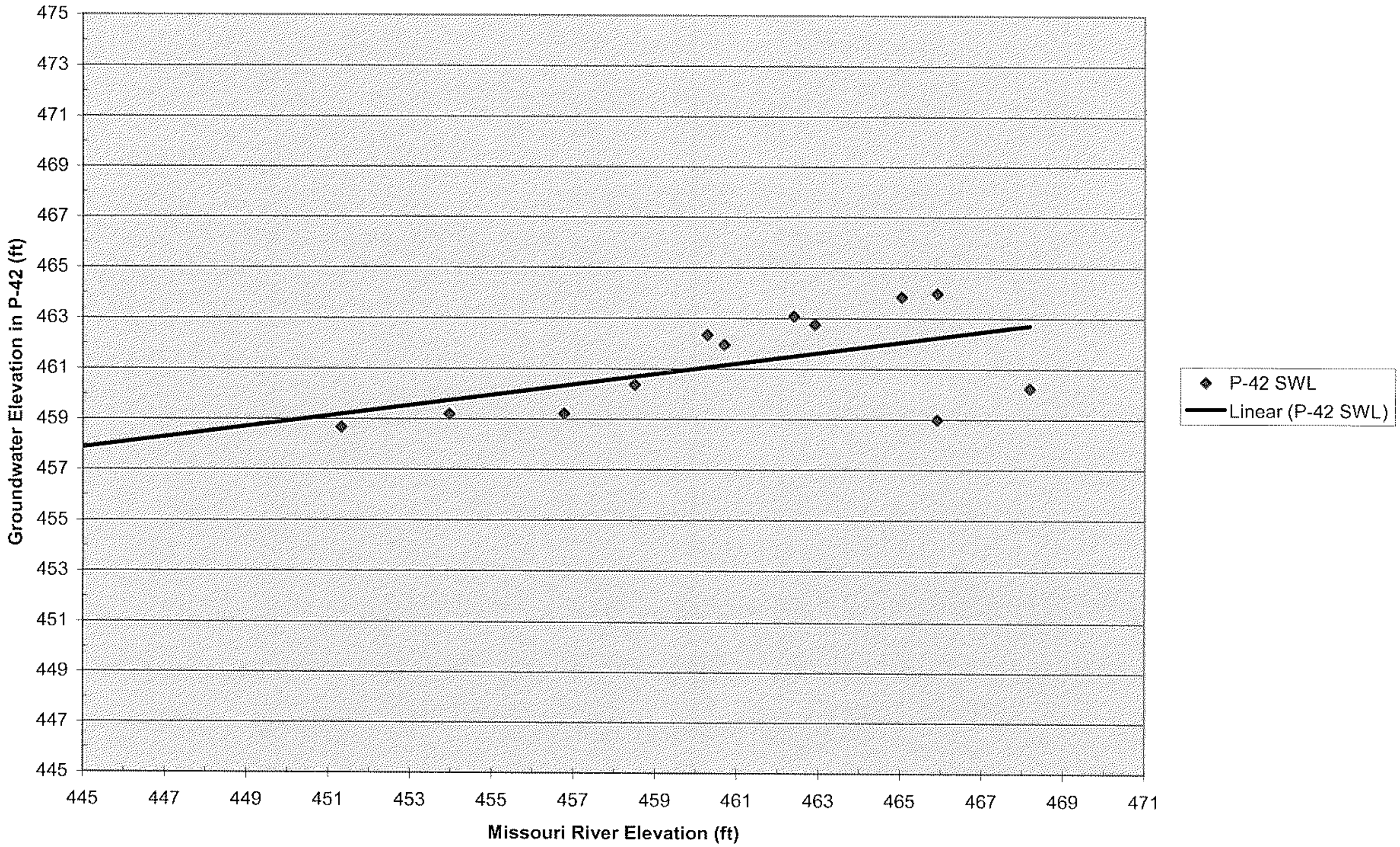
**Proposed Utility Waste Landfill**
**Ameren Missouri Labadie Energy Center**

**Missouri River Elevation vs Top of Water Table (P-42)**
**Attachment 4 - Figure 6**



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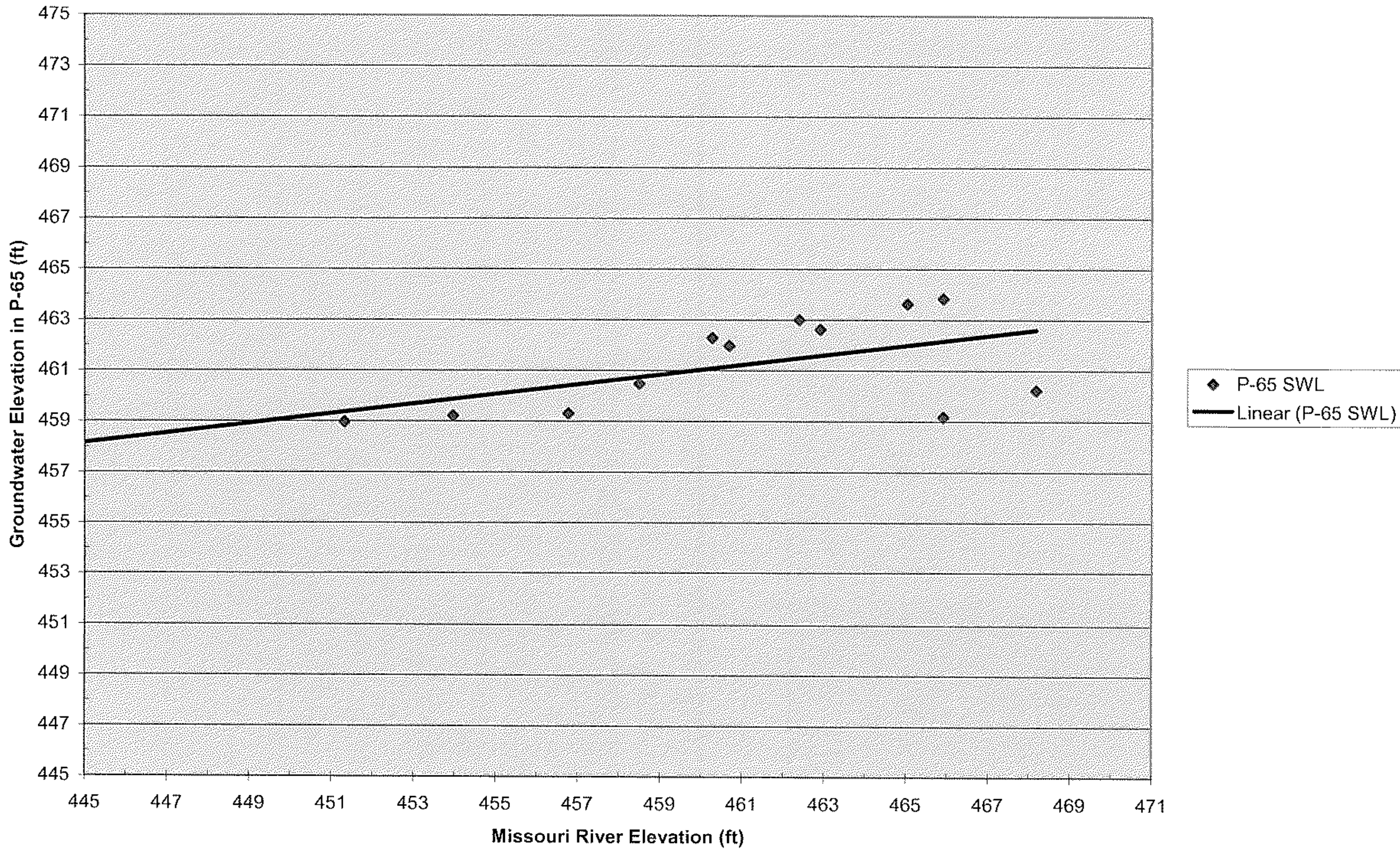
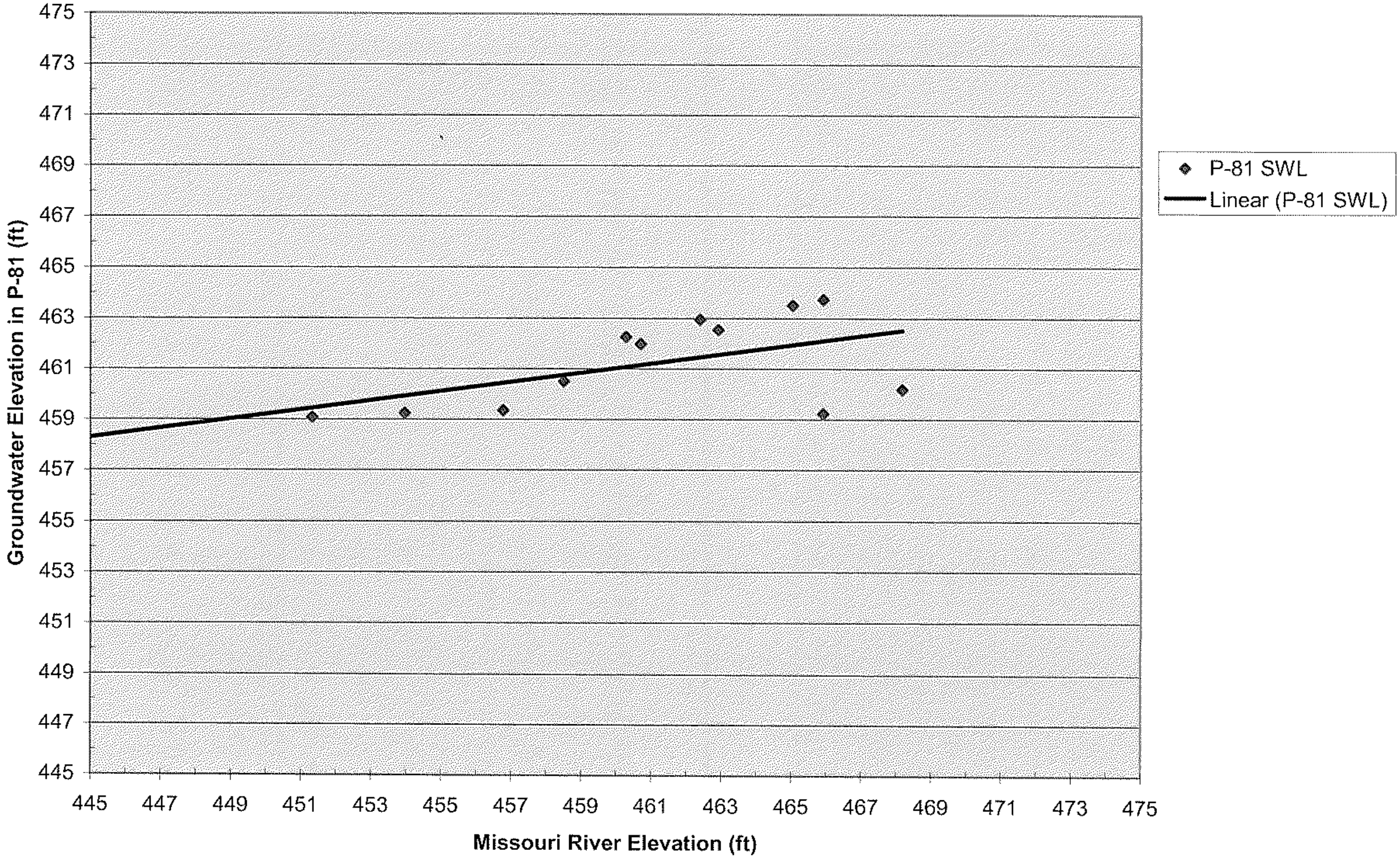
## Proposed Utility Waste Landfill
## Ameren Missouri Labadie Energy Center

### Missouri River Elevation vs Top of Water Table (P-65)
### Attachment 4 - Figure 7



**Construction Permit Application**
**Proposed Utility Waste Landfill**
**Ameren Missouri Labadie Energy Center**

**Missouri River Elevation vs Top of Water Table (P-81)**
**Attachment 4 - Figure 8**



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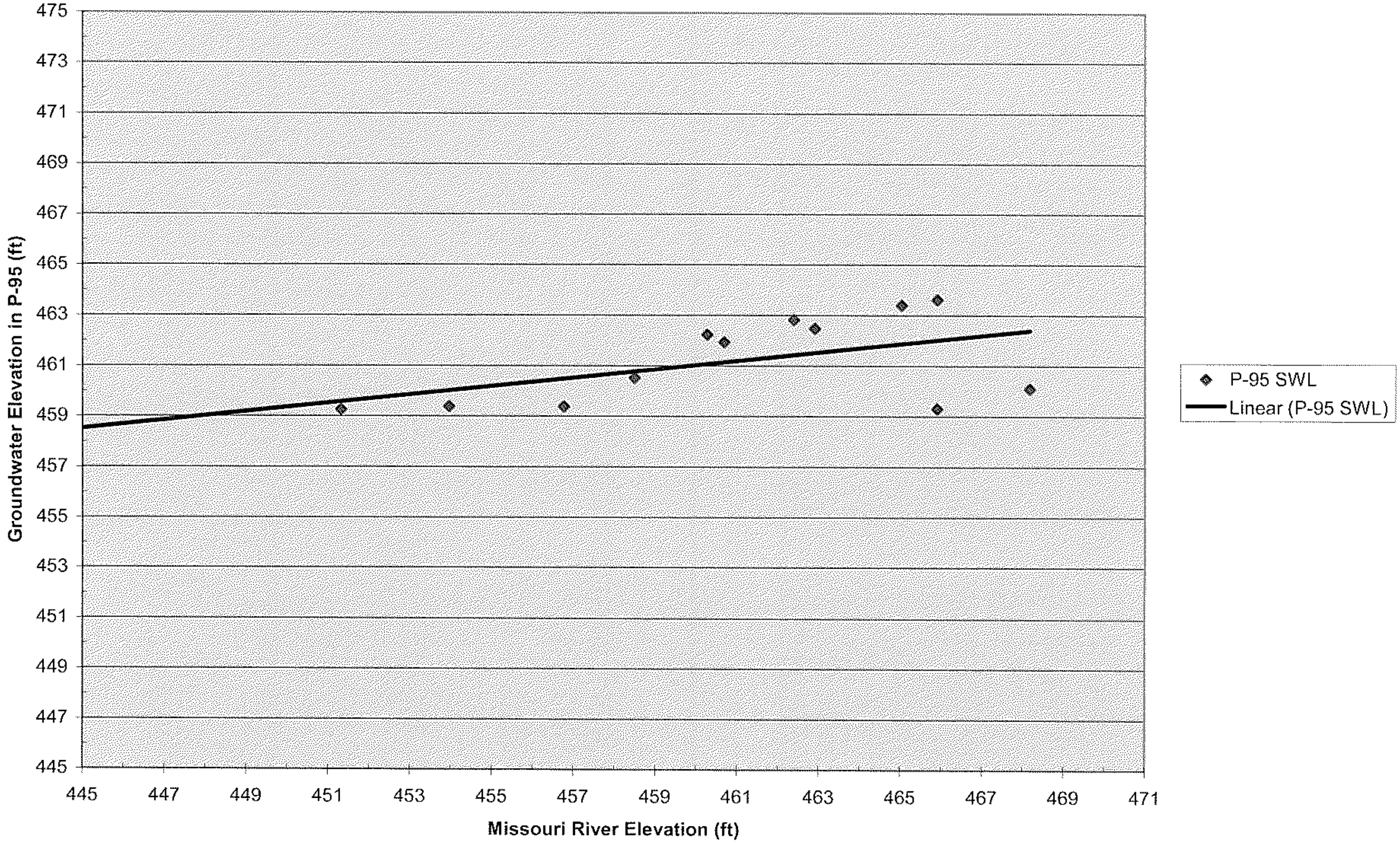
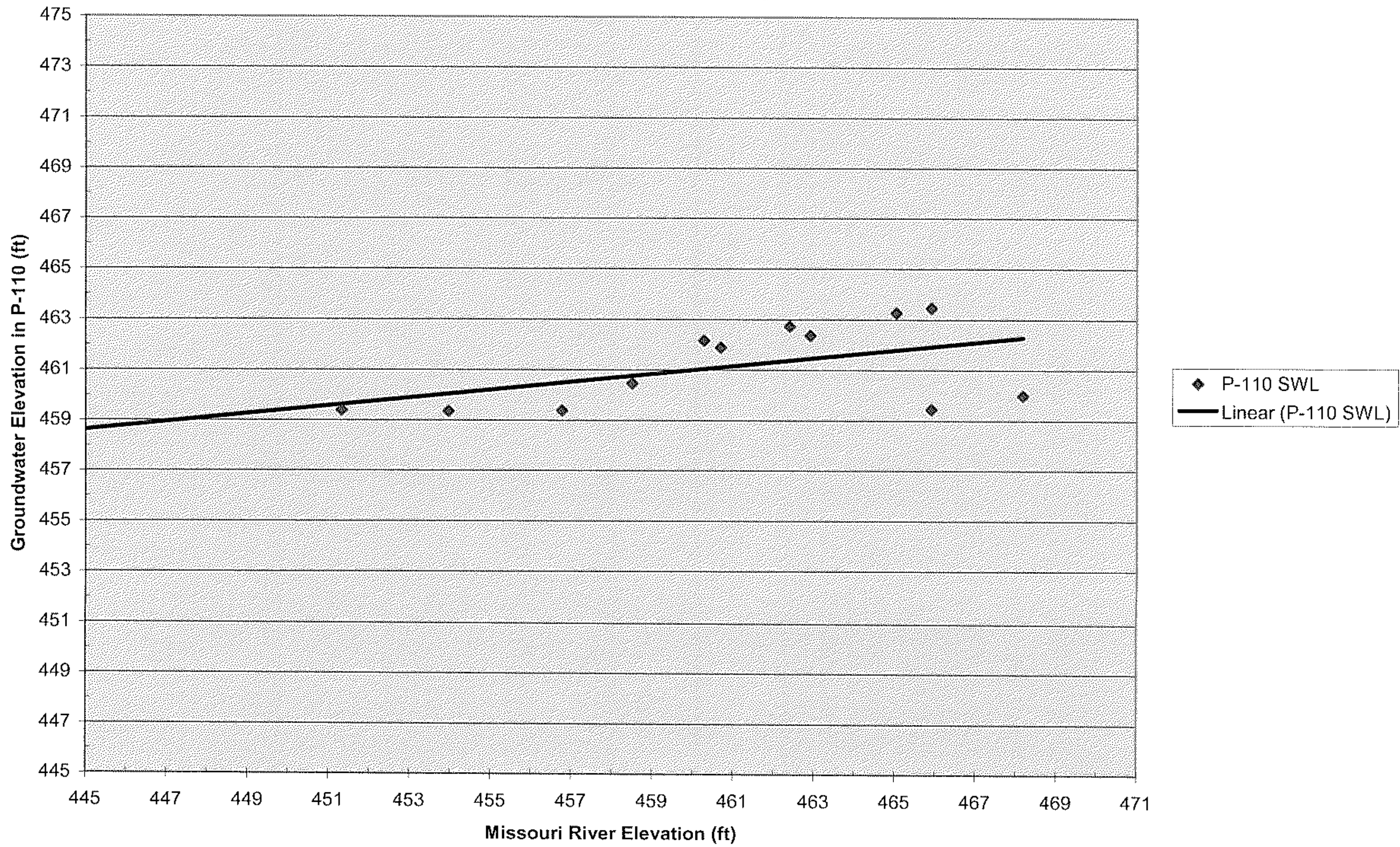
## Proposed Utility Waste Landfill
## Ameren Missouri Labadie Energy Center

### Missouri River Elevation vs Top of Water Table (P-95)
### Attachment 4 - Figure 9



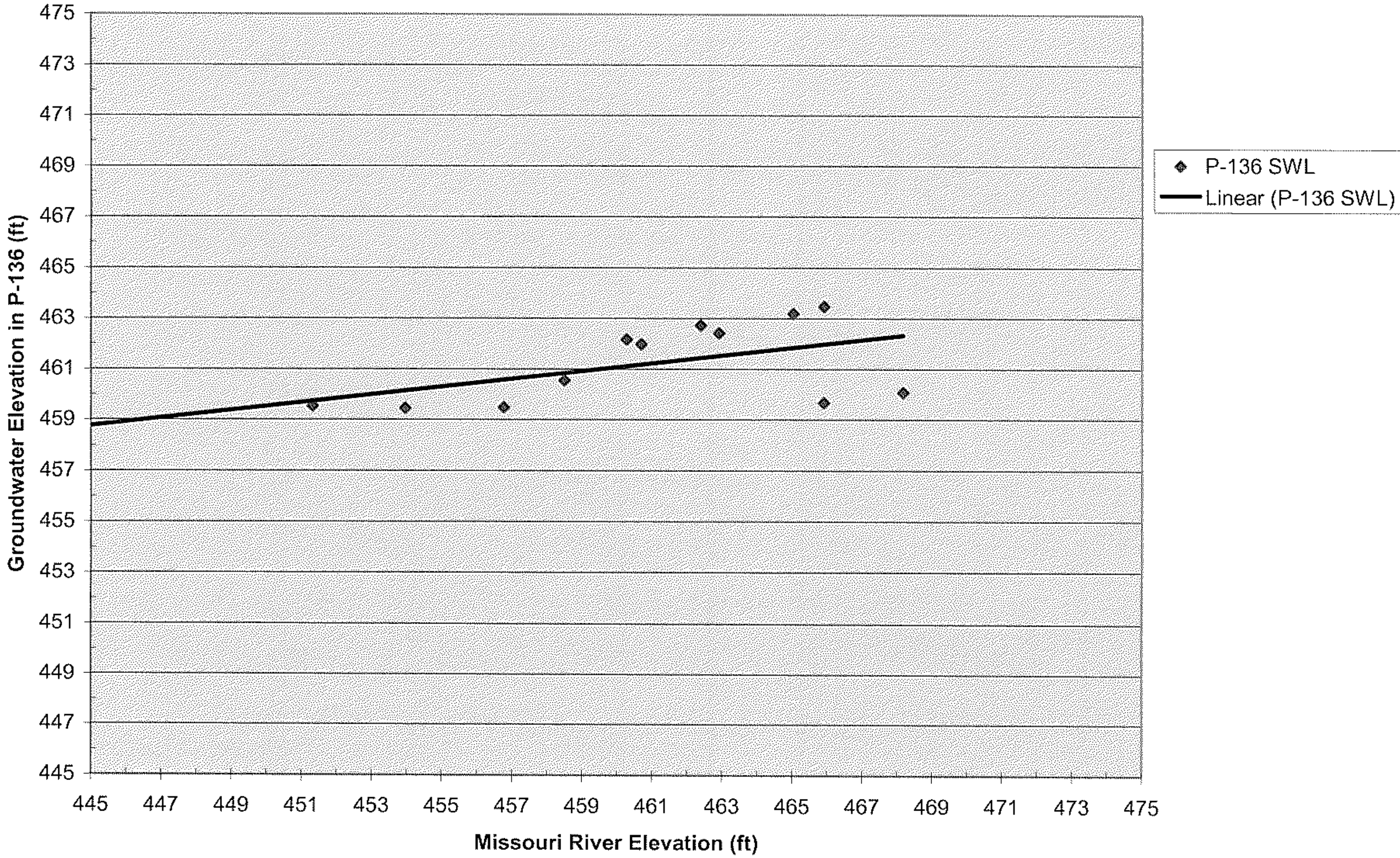
**Construction Permit Application**
**Proposed Utility Waste Landfill**
**Ameren Missouri Labadie Energy Center**

**Missouri River Elevation vs Top of Water Table (P-110)**
**Attachment 4 - Figure 10**



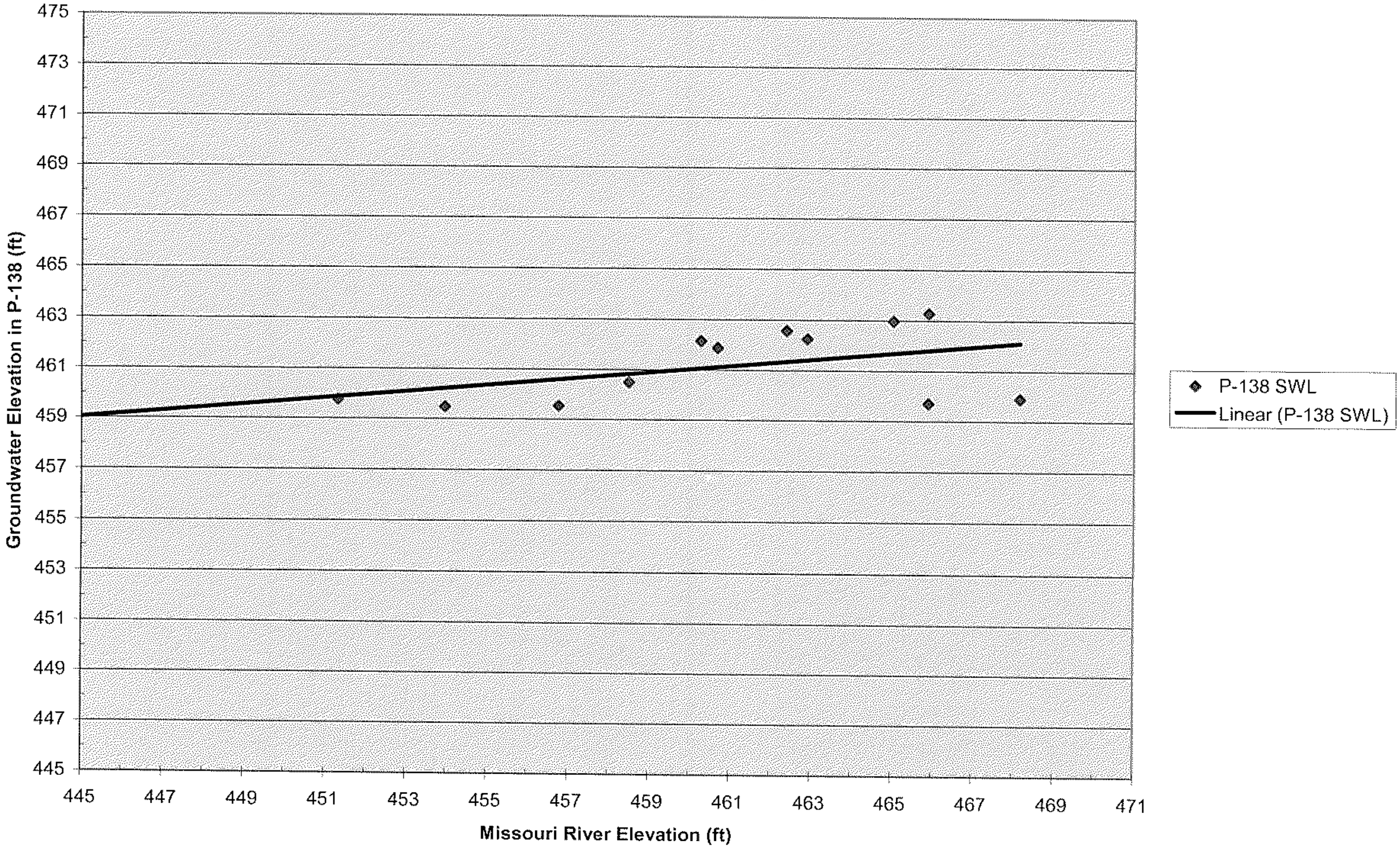
**Construction Permit Application**
**Proposed Utility Waste Landfill**
**Ameren Missouri Labadie Energy Center**

**Missouri River Elevation vs Top of Water Table (P-136)**
**Attachment 4 - Figure 11**



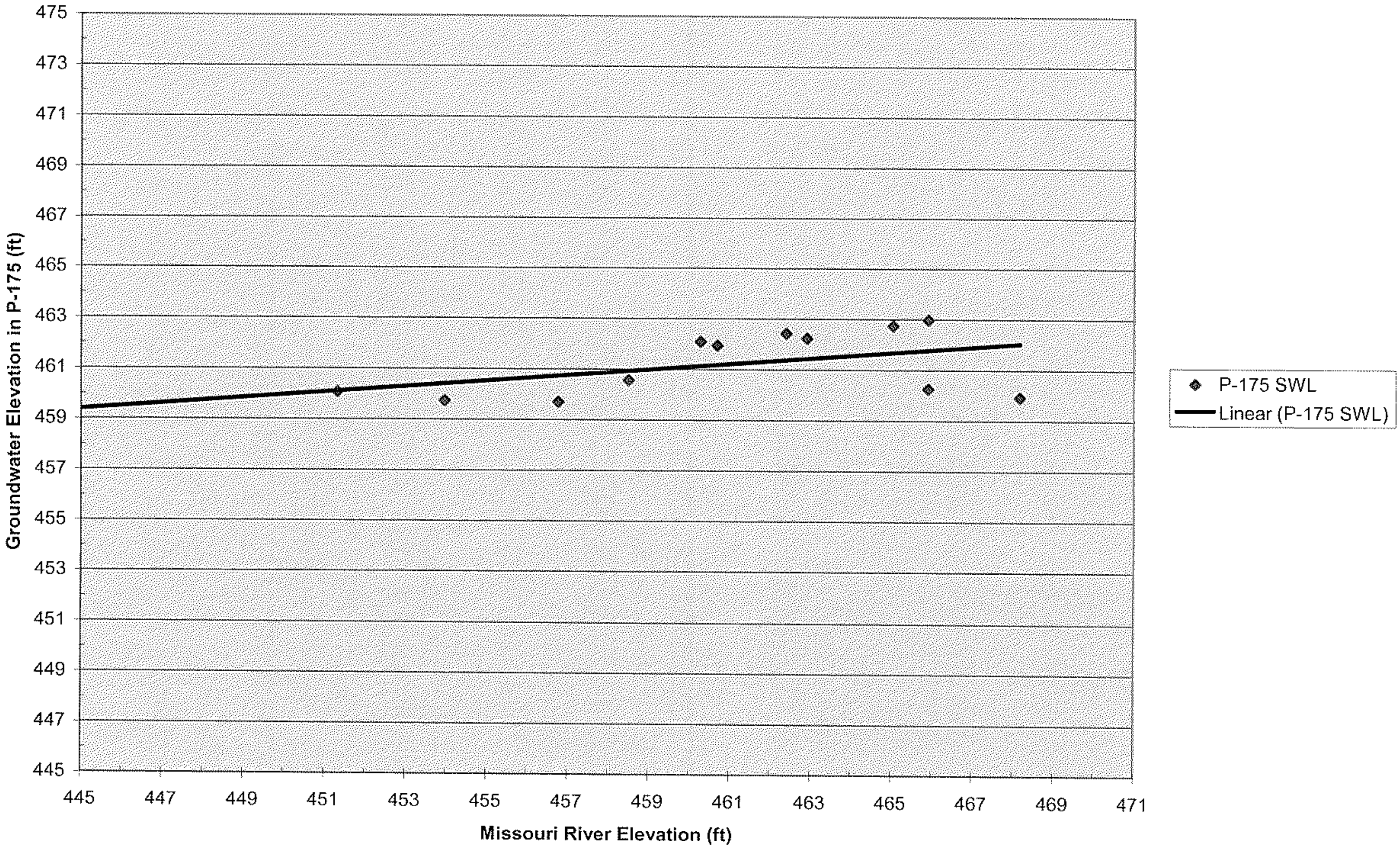
## Construction Permit Application
## Proposed Utility Waste Landfill
## Ameren Missouri Labadie Energy Center

### Missouri River Elevation vs Top of Water Table (P-138)
### Attachment 4 - Figure 12



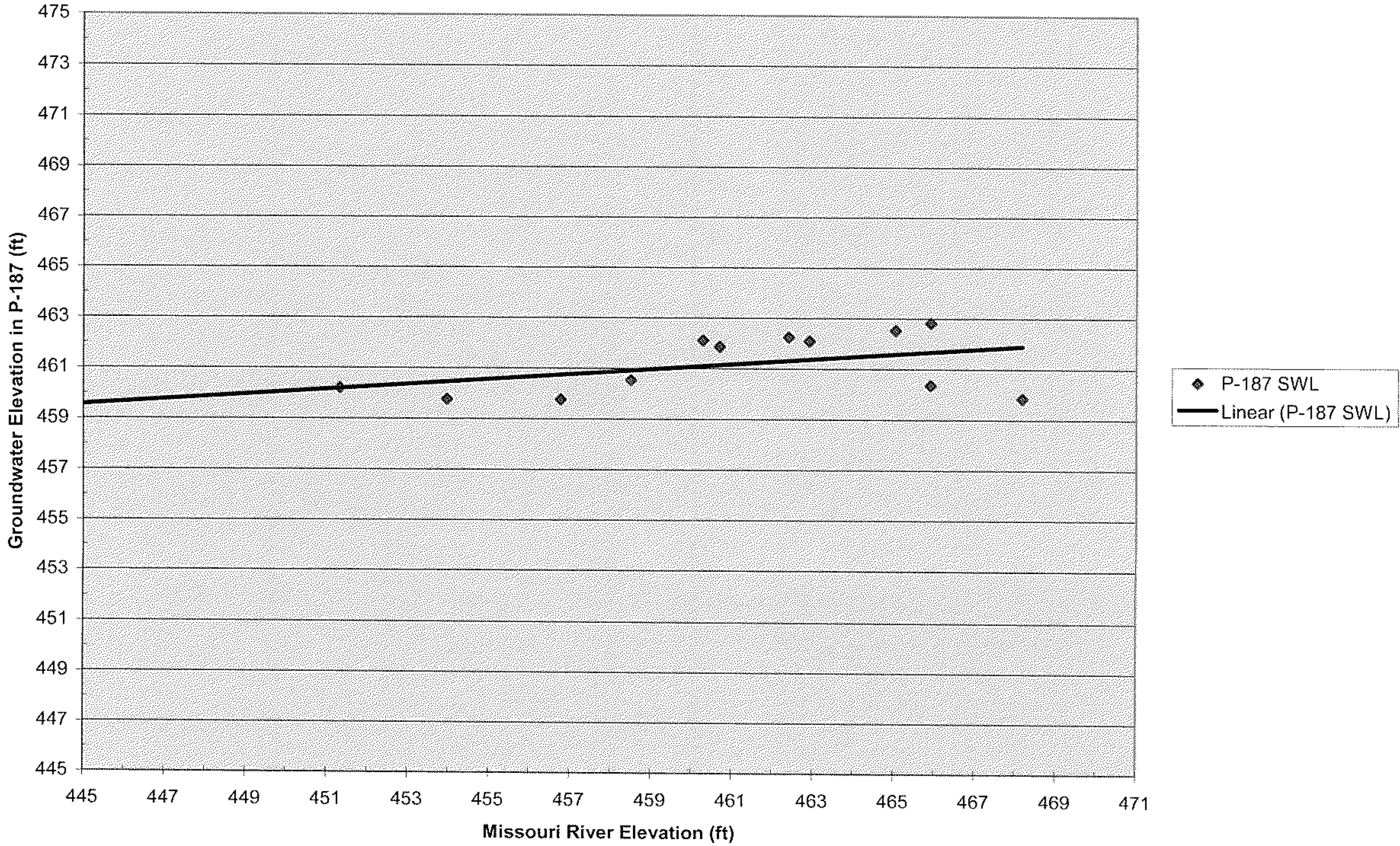
## Construction Permit Application
## Proposed Utility Waste Landfill
## Ameren Missouri Labadie Energy Center

### Missouri River Elevation vs Top of Water Table (P-175)
### Attachment 4 - Figure 13



## Construction Permit Application
## Proposed Utility Waste Landfill
## Ameren Missouri Labadie Energy Center

### Missouri River Elevation vs Top of Water Table (P-187)
### Attachment 4 - Figure 14



# Appendix Y

Miscellaneous Engineering Calculations
Revised August 2013

**Documents Included:**

Y(a) Leachate Pipe and Pump Calculations
Revised August 2013

Y(b) Estimated Maximum Settlements Leachate Collection Pipe Profile

Y(c) Water Management Calculations

Y(d) Flood Mitigation Calculations
Revised August 2013

Y(e) Geosynthetics Design Calculations

# Appendix Y(a)

Leachate Pipe and Pump Calculations

# Ameren Missouri Labadie Energy Center
# Leachate Pipe and Pump Calculations
# Proposed Utility Waste Landfill
# Franklin County, Missouri

## January 2013, Revised August 2013

## Table of Contents



## Supplemental Information for Appendix Y(a)

Leachate Pump Calculation
Calculations of Pipe Size and Pump Power for Leachate Collection
ISCO Industries: HDPE Pipe and Piping Solutions
Leachate Pumping to Holding Tanks(s) Worksheet


Prepared by GREDELL Engineering Resources, Inc.

## 1.0 Introduction

Piping proposed for use at the Ameren Missouri Labadie Utility Waste Landfill (UWL) was reviewed for capacity and resistance to crushing and buckling under various conditions. First, capacity for leachate collection piping in the cells and the leachate force mains is estimated. Second, several scenarios representing a pipe element of the leachate collection system at some phase of the UWL development was checked for resistance to crushing and buckling. Sketches of each scenario are included in Section 3.5.

## 2.0 Pipe Capacity

## 2.1 Leachate Force Main

Leachate will be pumped to storage or treatment. Leachate pump and pipe requirements are estimated in this appendix.

Assumptions:

- The worst case flow of 13.4 gpm is in the 31.4-ac Cell 1 (see Appendix O, Table O-1, Sub Appendix O-11). Prorating this over the 166.5 acres, the flow is 71 gpm.
- The longest run of pipe is anticipated to be 2500 ft (the length of the furthest Cell 3 sump in southeast corner from Pond 2).
- Leachate will be pumped to a 12-ft diameter, horizontal tank on top of the perimeter berm and a 3-ft saddle. The elevation difference will be from the bottom of the sump to 15 ft above the top of berm:

  488 elevation + 15 ft - 464.2 elevation = 38.8 ft.

The head loss is estimated using the Hazen-Williams formula

$$H_f = [(0.00208 \times L) / (D_I^{4.8655})] \times (100 \times Q / C)^{1.85}$$

Where:
$h_f$ is the head loss (ft),
L is the length (2500 ft),
$D_I$ is the inside diameter of the pipe (in),
Q is the rate of flow (71 gpm), and
C is the friction factor (150 for HDPE).

The inside diameter 4-in nominal diameter DR17 pipe is 3.939 in. The head loss is

$$H_f = 0.00208 \times 2500 / 3.939^{4.8655} \times (100 \times 71/150)^{1.85} = 8.3 \text{ ft}$$

The total head is: 8.3 ft + 38.8 ft = 47.1 ft

There are 2 sumps in Cell 1, so the typical pump would only need to handle a rate of 13.4 gpm / 2 = 6.7 gpm (the sumps in the other cells have smaller drainage areas, and, therefore, will have smaller flows per sump). A review of leachate pump manufacturer's literature revealed that leachate pump models are available that can produce 10 gpm or more of flow at 50 ft of head (e.g., EPG SERIES 8 Surepump™).

## 2.2 Leachate Collection Pipe

The leachate collection pipes in each cell are intentionally oversized. The following calculations estimate the full-flow capacity of a nominal 6-in DR 11 HDPE pipe at a 0.5 percent slope using Manning's equation.

$Q = 1.49 / n \times A \times R^{2/3} \times S^{1/2}$

Where:
Q is the flow (cfs),
n is Manning's n (0.009 for HDPE),
A is the cross-sectional area of the pipe (sq ft),
R is the wetted perimeter (ft), and
S is the slope (0.5 percent or 0.005 ft/ft).
$A = \pi \times d^2 / 4$

Where d is the inside diameter. For a nominal 6-in HOPE DR 11 pipe, the inside diameter is 5.348 in or 0.446 ft.

$A = \pi \times (0.4457 \text{ ft})^2 / 4 = 0.156$ sq ft

$P = \pi \times d = \pi \times 0.446$ ft = 1.4 ft

R = A / P = 0.156 sq ft / 1.4 ft = 0.111 ft

$Q = (1.49 / 0.009) \times 0.156 \times 0.111^{2/3} \times 0.005^{1/2} = 0.42$ cfs

0.42 cfs x 7.48 gal/cfs x 60 s/min = **190 gpm**

As previously estimated, the maximum flow in a sump is approximately 7 gpm, but the use of the lowest flow leachate pump capacity at 11.1 gpm, actual flow is significantly less than the capacity of the proposed pipe.

## 3.0 Crushing and Buckling Scenarios

The methods used to estimate resistance to crushing and buckling follow those published by the Plastics Pipe Institute (PPI) in its Handbook for PE Pipe (2nd Edition). A conservative CCP unit weight, 120 pounds per cubic foot (95% compaction of the Standard Proctor), was used for all crushing and buckling calculations. This unit weight is higher than reported in the typical cell material profile provided in Scenario 2 (below) because 95% compaction of the CCP is not anticipated. Therefore, the calculations and reported factors of safety are conservative.

## 3.1 Scenario 1

Scenario 1 represents a leachate collection pipe (DR 11) placed in a trench with rock bedding, a minimum 12 inches of aggregate protective cover, and live loads. An H20 truck, which is a 20 ton truck with properties defined by The American Association of State Highway and Transportation Officials (AASHTO), is used for modeling live loads over the pipe.

**Determine Total Vertical Load**

1. **Earth Load - Vertical prism loads**

*Earth Load* $(P_E) = w_{cover}H_{cover} + w_{bedding}H_{bedding}$ = *(120 pcf *1.0 ft) + (125 pcf *1.5 ft)*
= *308 psf*

Where:
$w_{waste}$ = Density of Aggregate Cover = 120 pcf
$H_{waste}$ = Depth of Aggregate Cover = 1.0 ft
$w_{bedding}$ = Density of Bedding = 125 pcf
$H_{bedding}$ = Depth of Bedding = 1.5 ft

2. **Live Load - Determine loading for an H20 truck using Timoshenko's Equation for a load directly above the pipe and the Boussinesq Equation for a load straddling the pipe. Use the greater load to be conservative**.

***Timoshenko's Equation***

$$\text{LIve Load } (P_L) = \frac{I_f W_w}{A_c}\left(1-\frac{H^3}{(r_\gamma^2+H^2)^{1.5}}\right) = \frac{3*16{,}000 lb}{1.39\,ft^2}\left(1-\frac{(2.5\,ft)^3}{[(0.665\,ft)^2+(2.5\,ft)^2]^{1.5}}\right)$$

= *3,366 psf*

Where:
H = Total Depth of Cover = 2.5 ft
$I_f$ = Impact Factor = 3 (Typical for unpaved surface)
$W_w$ = Wheel Load = 16,000 Ib (Typical value for H20 truck

$A_c$ = Contact Area = 1.39 ft$^2$ (Typical value for H20 truck)

$r_\gamma$ = Equivalent Radius = $\sqrt{\frac{A_c}{\pi}} = \sqrt{\frac{1.39\,ft^2}{\pi}}$ = 0.665 ft

**Boussinesq Equation**

*Live Load ($P_L$) =* $\frac{3I_f W_W H^3}{2\pi r^2} = \frac{3*3*16{,}000lb*(2.5\,ft)^3}{2\pi(5.6\,ft)^2}$ *= 65.0 psf*

The live load is 130 psf to account for two wheels.

Where:
H = Total Depth of Cover = 2.5 feet
$I_f$ = Impact Fator =3 (For an unpaved surface)
$W_w$ = Wheel Load = 16,000 Ibs (Typical value for H20 Truck)
x = Horizontal distance from wheel to center of pipe = 5 ft. (assuming truck is 10 ft wide and centered over pipe)
r = Diagonal distance from wheel to center of pipe = $\sqrt{x^2 + H^2} = \sqrt{(5\,ft)^2 + (2.5\,ft)^2}$ = 5.6 ft

### 3. Total Vertical Load

*Total Vertical Pressure ($P_{Total}$) = $P_E$ + $P_L$ = 308 psf + 3,366 psf = 3,700 psf*

## Calculate Ring Deflection

1. **Ring Deflection – Determine whether the ring deflection is less than the allowable 5% using Spangler's Modified Iowa Formula.**

*Ring Deflection =* $\left(\frac{\Delta X}{D_M}\right) = \frac{1}{144}\left(\frac{K_{BED}L_{DL}P_E + K_{BED}P_L}{\frac{2E}{3}\left(\frac{1}{DR-1}\right)^3 + 0.061F_S E'}\right)$

$= \frac{1}{144}\left(\frac{(0.1*1.5*308\,psf) + (0.1-3{,}366\,psf)}{\left(\frac{2*21{,}000}{3}\right)*\left(\frac{1}{11-1}\right)^3 + (0.061*0.85*3{,}000\,psi)}\right)$ *= 0.016 or 1.6%*

1.6 % < 5 %, therefore the ring deflection is within the acceptable range.

Where:
$K_{BED}$ = Bedding Factor = 0.1 (Typical Value)
$L_{DL}$ = Deflection Lag Factor = 1.5 (Typical Value)
$P_E$ = 308 psf (Greater Value Calculated Above)
$P_L$ = 3,366 psf (Calculated Above)
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
E' = Modulus of Soil Reaction = 3,000 psi (Assume compacted crushed rock)
$F_s$ = Soil Support Factor = 0.85 (When: $\frac{E'_N}{E'}$ = 0.2 and $\frac{B_d}{D_O}$ = 3)
DR = Dimension Ratio = 11

## Crushing and Buckling Forces

1. **Compressive Stress - Determine whether the compressive stress is less than the allowable 800 psi.**

*Compressive Stress (S)* = $\frac{P_{Total} * DR}{288} = \frac{3{,}700\,psf * 11}{288}$ = *141 psi*

141 psi < 800 psi, the compressive stress value is within the acceptable range.

Where:
$P_{Total}$ = 3,700 psf (Previously calculated)
DR = Dimension Ratio = 11

2. **Allowable Constrained Buckling Pressure - Determine if the buckling pressure is greater than $P_{TOTAL}$ (3,700 psf) using Luscher's Equation.**

*Constrained Buckling Pressure ($P_{WC}$)* = $\frac{5.65}{N}\sqrt{RB'E'*\frac{E}{12(DR-1)^3}}$

= $\frac{5.65}{2}\sqrt{0.80*0.227*3{,}000\,psi*\frac{21{,}000\,psi}{12(11-1)^3}}$ = *87.2 psi = 12,550 psf*

*12,550 psf > 3,700 psf, the buckling pressure is within the acceptable range*

Where:
N = Safety Factor = 2

R = Buoyancy Reduction Factor = 1 - 0.33 $\frac{H_{GW}}{H}$ = 1 – 0.33 $\frac{1.5\,ft}{2.5\,ft}$ = 0.80

$H_{GW}$ = Groudwater Height Above Pipe = 1.5 ft assuming a maximum 1 ft allowed on liner plus an addition 0.5 ft.
H = Cover Above Pipe = 2.5 ft

B’ = Soil Support Factor = $\frac{1}{1+4e^{-0.065H}}$ = $\frac{1}{1+4e^{-0.065*2.5}}$ = 0.227

E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
E’ = Modulus of Soil Reduction = 3,000 psi (Assuming compacted crushed rock)

## 3.2 Scenario 2

Scenario 2 represents a leachate collection pipe as in Scenario 1, except under the loading conditions of the UWL at full capacity.

**Determine Total Vertical Load**

1. **Earth load - Vertical prism loads**

*Earth Load* ($P_E$)= $w_{waste}H_{waste} + w_{soil}H_{soil} + w_{bedding}H_{bedding}$

$$= (120\,pcf * 98\,ft) + (120\,pcf * 2\,ft) + (125\,pcf * 1.5\,ft) = 12{,}188\,psf$$

Where:
$w_{waste}$ = Density of Waste = 120 pcf
$H_{waste}$ = Depth of Waste = 98 ft
$W_{soil}$ = Density of Waste = 120 pcf
$H_{soil}$ = Depth of Waste = 2.0 ft
$w_{bedding}$ = Density of Bedding = 125 pcf
$H_{bedding}$ = Depth of Bedding = 1.5 ft

2. **Live Load – No Live Load Exists**

$P_L = 0\ psf$

3. **Total Vertical Load**

*Total Vertical Pressure* ($P_T$) = $P_L + P_E$ = *0 psf + 12,188 psf = 12,188 psf*

## Calculate Ring Deflection

1. **Rigidity Factor – Use the Watkins- Gaube Method to find Rigidity Factorm Deformation Factor, and Soil Stress. From this, Ring Deflection can be found and should be less than the allowable 5%.**

   *Rigidity Factor ($R_f$)* = $\frac{12E_s(DR-1)^3}{E}$ = $\frac{12*3{,}491psi*(11-1)^3}{21{,}000\,psi}$ = *1,995*

   Where:

   $E_s$ = Secant Modulus of Soil = $M_s\frac{(1+\mu)(1-2\mu)}{(1-\mu)}$ = $4{,}700\,psi\frac{(1+0.3)(1-2*0.3)}{(1-0.3)}$

   = 3,491 psi

   Assuming, $M_s$ = 4,700 psi and $\mu$ = 0.3, based on typical values.

   DR = Dimension Ratio = 11

   E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)

2. **Deformation Factor – For Rigidity Factor of 1,995**

   Deformation Factor (DF) = 1.5

3. **Soil Strain**

   *Soil Strain ($\varepsilon_s$)* = $\frac{P_E}{144E_s}$ = $\frac{12{,}188\,psi}{144*3{,}491psi}$ = *0.024 or 2.4 %*

   Where:
   $P_E$ = 12,188 psi (previously calculated)
   $E_s$ = 3,491 psi (previously calculated)

4. **Ring Deflection – Determine whether Ring Deflection is less than the allowable 5%.**

   *Ring Deflection* $\left(\frac{\Delta X}{D_M}\right)$ = *$\varepsilon_s$(%)*DF = 2.4% * 1.5 = 3.6%*

   Since 3.6% < 9%, the ring deflection is within acceptable range.

**Calculate Hoop Stress**

1. **Hoop Thrust Stiffness Ratio –**

*Hoop Stress Stiffness Ratio ($S_A$) =* $\frac{1.43 M_S r_{cent}}{EA}$ = $\frac{1.43 * 4{,}700\,psi * 3.095 in}{21{,}000\,psi * 0.60 in}$ *= 1.65*

Where:
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
A = Pipe Thickness = 0.60 in
$M_S$ = 4,700 psi (Typical Value, From Table 3.12)
$r_{cent}$ = radius to pipe centroid = 3.095 in

2. **Vertical Arching Factor –**

*Vertical Arching Factor (VAF) =* $0.88 - 0.71\left(\frac{S_A - 1}{S_A + 2.5}\right)$ = $0.88 - 0.71\left(\frac{1.65 - 1}{1.65 + 2.5}\right)$ *= 0.769*

3. **Hoop Stress – Determine if Hoop Stress is less than the allowable 800 psi using the radial directed earth pressure ($P_{RD}$)**

*Radial Directed Earth Pressure ($P_{RD}$) =* $VAF * P_E$ = $0.769 * 12{,}188\,psf$ *= 9,373 psf*

Where:
$P_E$ = Vertical Earth Load = 11,403 psf (calculated above)

*Hoop Stress (S) =* $\frac{(P_{RD} + P_L)DR}{288}$ = $\frac{(9{,}373\,psf + 0\,psf) * 11}{288}$ *= 358 psi*

358 psi < 800 psi, therefore the hoop stress is within the acceptable range

Where:
$P_L$ = 0 psf (No live load)
DR = Dimension Ratio = 11

## 3.3 Scenario 3

Scenario 3 represents a sump riser (DR 17) on the side slope, bedded in a trench, and under a live load. Loads were treated as if they were normal to the pipe. This is a larger pipe that contains the sump and pump discharge pipe.

## Determine Total Vertical Load

### 1. Earth Load - Vertical prism loads

*Earth Load* ($P_E$)= $w_{cover}H_{cover} + w_{bedding}H_{bedding}$ = *(120 pcf *1.0 ft) + (125 pcf *1.0 ft)*
= *245 psf*

Where:
$w_{waste}$ = Density of Aggregate Protective Cover = 120 pcf
$H_{waste}$ = Depth of Aggregate Protective Cover = 1.0 ft
$w_{bedding}$ = Density of Bedding = 125 pcf
$H_{bedding}$ = Depth of Bedding = 1.0 ft

### 2. Live Load - Determine loading for a 6,000 lb (3-ton) skid steer directly above the pipe using Timoshenko's Equation. According to the PPI Handbook, the load of a wheel directly over the pipe will be greater than two wheels straddling the pipe when there is less than 4ft of cover.

***Timoshenko's Equation***

$$\text{Llve Load } (P_L) = \frac{I_f W_w}{A_c}\left(1-\frac{H^3}{(r_\gamma^2+H^2)^{1.5}}\right) = \frac{3*1{,}500\,lb}{0.89\,ft^2}\left(1-\frac{(2.0\,ft)^3}{[(0.53\,ft)^2+(2.0\,ft)^2]^{1.5}}\right)$$

= *489 psf*

Where:
H = Total Depth of Cover = 2.0 ft
$I_f$ = Impact Factor = 3 (Typical for unpaved surface)
$W_w$ = Wheel Load = 6,000 lb/ 4 tires = 1,500 Ib
$A_c$ = Contact Area = 0.66 ft * 1.33 ft = 0.89 $ft^2$
$r_\gamma$ = Equivalent Radius = $\sqrt{\frac{A_c}{\pi}} = \sqrt{\frac{0.89\,ft^2}{\pi}}$ = 0.53 ft

### 3. Total Vertical Load

*Total Vertical Pressure* ($P_T$) = $P_L + P_E$ = *489 psf + 245 psf = 734 psf*

## Calculate Ring Deflection

### 1. Ring Deflection – Determine whether the ring deflection is less than the allowable 5% using Spangler's Modified Iowa Formula.

*Ring Deflection* = $\left(\frac{\Delta X}{D_M}\right) = \frac{1}{144}\left(\frac{K_{BED}L_{DL}P_E + K_{BED}P_L}{\frac{2E}{3}\left(\frac{1}{DR-1}\right)^3 + 0.061F_S E'}\right)$

$= \frac{1}{144}\left(\frac{(0.1*1.5*245\,psf)+(0.1-489\,psf)}{\left(\frac{2*21{,}000}{3}\right)*\left(\frac{1}{17-1}\right)^3 + (0.061*0.3*3{,}000\,psi)}\right)$ *= 0.010 or 1.0%*

1.0 % < 5 %, therefore the ring deflection is within the acceptable range.

Where:
$K_{BED}$ = Bedding Factor = 0.1 (Typical Value)
$L_{DL}$ = Deflection Lag Factor = 1.5 (Typical Value)
$P_E$ = 245 psf (Calculated Above)
$P_L$ = 489 psf (Calculated Above)
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
E' = Modulus of Soil Reaction = 3,000 psi (Assume compacted crushed rock)
$F_s$ = Soil Support Factor = 0.3 (When: $\frac{E_N'}{E'}$ = 0.2 and $\frac{B_d}{D_O}$ = 1.5)
DR = Dimension Ratio = 17

## Crushing and Buckling Forces

1. **Compressive Stress - Determine whether the compressive stress is less than the allowable 800 psi.**

*Compressive Stress (S)* = $\frac{P_{Total} * DR}{288} = \frac{734\,psf * 17}{288}$ *= 43 psi*

43 psi < 800 psi, the compressive stress value is within the acceptable range.

Where:
$P_{Total}$ = 734 psf (Previously calculated)
DR = Dimension Ratio = 17

2. **Allowable Constrained Buckling Pressure - Determine if the buckling pressure is greater than $P_{TOTAL}$ (734 psf) using Luscher's Equation.**

*Constrained Buckling Pressure ($P_{WC}$) =* $\frac{5.65}{N}\sqrt{RB'E'*\frac{E}{12(DR-1)^3}}$

= $\frac{5.65}{2}\sqrt{1.0*0.222*3{,}000\,psi*\frac{21{,}000\,psi}{12(17-1)^3}}$ *= 47.7 psi = 6,869 psf*

*6,869 psf > 734 psf, the buckling pressure is within the acceptable range*

Where:
N = Safety Factor = 2
R = Buoyancy Reduction Factor = 1 - 0.33$\frac{H_{GW}}{H}$ = 1 – 0.33$\frac{0\,ft}{2.0\,ft}$ = 1.0

$H_{GW}$ = Groudwater Height Above Pipe = 0 ft because there will be no standing water on the slope
H = Cover Above Pipe = 2.0 ft

B' = Soil Support Factor = $\frac{1}{1+4e^{-0.065H}}$ = $\frac{1}{1+4e^{-0.065*2.0}}$ = 0.222
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)

E' = Modulus of Soil Reduction = 3,000 psi (Assuming compacted crushed rock)

**Calculate Allowable Live Load Pressure**

1. **Allowable Live Load Pressure – Calculate live load pressure for a shallow cover situation. The pressure calculated should be less than the live load.**

*Allowable Live Load Pressure ($P_{LA}$) =* $\frac{12w(KH)^2}{ND_o}+\frac{7387.2(I)}{ND_o{}^2C}\left(S-\frac{wD_oH}{288A}\right)$

= $\frac{12*120\,pcf\,(2.46*2\,ft)^2}{2*18in}+\frac{7387.2*0.094}{2*(18in)^2*0.53in}\left(3{,}000\,psi-\frac{120\,pcf\,*18in*2\,ft}{288*1.06in}\right)$

*= 7,006 psf*

734 psf < 7,006 psf, the allowable live load is in the acceptable range

Where:
w = Average Density of Cover Material = 120 pcf
H = Depth of Cover = 2 ft

K = Passive Earth Pressure Coefficient = $\frac{1+\sin\phi}{1-\sin\phi}$ = $\frac{1+\sin(25)}{1-\sin(25)}$ = 2.46

$\phi$ = 25° for a loose silty material

N = Safety Factor = 2

$D_o$ = Outside Diameter of Pipe = 18 in

A = Pipe Wall Thickness = 1.06 in (Based in DR of 17)

C = Outer Fiber Wall of Centroid = 0.5t = 0.5*1.06 in = 0.53 in

S = Material Yield Strength = 3,000 psi

I = Pipe Wall Moment of Inertia = $\frac{t^2}{12}$ = $\frac{(1.06in)^2}{12}$ = 0.094

## 3.4 Scenario 4

Scenario 4 represents a pipe (DR 17) in the perimeter berm for carrying leachate to a holding tank.

**Determine Total Vertical Load**

1. **Earth Load – Vertical prism loads**

   *Earth Load ($P_E$)= $w_{soil}H_{soil}$ = (120 pcf *4.0 ft) = 480 psf*

   Where:
   $w_{soil}$ = Density of Soil = 120 pcf
   $H_{soil}$ = Depth of Soil Cover = 4.0 ft

2. **Live Load - Determine loading for an H20 truck using Timoshenko's Equation for a load directly above the pipe and the Boussinesq Equation for a load straddling the pipe. Use the greater load to be conservative**.

   ***Timoshenko's Equation***

   *Llve Load ($P_L$)* = $\frac{I_f W_w}{A_c}(1-\frac{H^3}{(r_\gamma^2+H^2)^{1.5}}) = \frac{3*16{,}000lb}{1.39\,ft^2}(1-\frac{(4.0\,ft)^3}{[(0.665\,ft)^2+(4.0\,ft)^2]^{1.5}})$

   *= 1,384 psf*

   Where:
   H = Total Depth of Cover = 4.0 ft
   $I_f$ = Impact Factor = 3 (Typical for unpaved surface)
   $W_w$ = Wheel Load = 16,000 Ib (Typical value for H20 truck
   $A_c$ = Contact Area = 1.39 $ft^2$ (Typical value for H20 truck)

$r_\gamma$ = Equivalent Radius = $\sqrt{\frac{A_c}{\pi}} = \sqrt{\frac{1.39\,ft^2}{\pi}}$ = 0.665 ft

**Boussinesq Equation**

*Live Load ($P_L$)* = $\frac{3I_f W_W H^3}{2\pi r^2} = \frac{3*3*16{,}000lb*(4.0\,ft)^3}{2\pi(6.4\,ft)^2}$ *= 137.0 psf*

The live load is 274 psf to account for two wheels.

Where:
H = Total Depth of Cover = 4.0 feet
$I_f$ = Impact Fator =3 (For an unpaved surface)
$W_w$ = Wheel Load = 16,000 Ibs (Typical value for H20 Truck)
x = Horizontal distance from wheel to center of pipe = 5 ft. (assuming truck is 10 ft wide and centered over pipe)
r = Diagonal distance from wheel to center of pipe = $\sqrt{x^2 + H^2} = \sqrt{(5\,ft)^2 + (4.0\,ft)^2}$ = 6.4 ft

3. **Total Vertical Load**

*Total Vertical Pressure ($P_{Total}$) = $P_E$ + $P_L$ = 480 psf + 1,384 psf = 1,864 psf*

__**Calculate Ring Deflection**__

1. **Ring Deflection – Determine whether the ring deflection is less than the allowable 5% using Spangler's Modified Iowa Formula.**

*Ring Deflection* = $\left(\frac{\Delta X}{D_M}\right) = \frac{1}{144}\left(\frac{K_{BED}L_{DL}P_E + K_{BED}P_L}{\frac{2E}{3}\left(\frac{1}{DR-1}\right)^3 + 0.061F_S E'}\right)$

$$= \frac{1}{144}\left(\frac{(0.1*1.5*480\,psf) + (0.1-1{,}384\,psf)}{\left(\frac{2*21{,}000}{3}\right)*\left(\frac{1}{17-1}\right)^3 + (0.061*0.85*2{,}000\,psi)}\right)$$ *= 0.013 or 1.3%*

1.3 % < 5 %, therefore the ring deflection is within the acceptable range.

Where:
$K_{BED}$ = Bedding Factor = 0.1 (Typical Value)
$L_{DL}$ = Deflection Lag Factor = 1.5 (Typical Value)
$P_E$ = 480 psf (Greater Value Calculated Above)
$P_L$ = 1,384 psf (Calculated Above)
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
E' = Modulus of Soil Reaction = 2,000 psi (Assume compacted coarse grained soil)
$F_s$ = Soil Support Factor = 0.85 (When: $\frac{E_N^{'}}{E'}$ = 0.2 and $\frac{B_d}{D_O}$ = 3)
DR = Dimension Ratio = 17

## Crushing and Buckling Forces

1. **Compressive Stress - Determine whether the compressive stress is less than the allowable 800 psi.**

*Compressive Stress (S)* = $\frac{P_{Total} * DR}{288}$ = $\frac{1{,}864\,psf\ *17}{288}$ = *110 psi*

110 psi < 800 psi, the compressive stress value is within the acceptable range.

Where:
$P_{Total}$ = 1,864 psf (Previously calculated)
DR = Dimension Ratio = 17

2. **Allowable Constrained Buckling Pressure - Determine if the buckling pressure is greater than $P_{TOTAL}$ (1,864 psf) using Luscher's Equation.**

*Constrained Buckling Pressure ($P_{WC}$)* = $\frac{5.65}{N}\sqrt{RB'E'*\frac{E}{12(DR-1)^3}}$

= $\frac{5.65}{2}\sqrt{1.0*0.245*2{,}000\,psi*\frac{21{,}000\,psi}{12(17-1)^3}}$ = *40.9 psi = 5,890 psf*

*5,890 psf > 1,864 psf, the buckling pressure is within the acceptable range*

Where:
N = Safety Factor = 2
R = Buoyancy Reduction Factor = 1 - 0.33$\frac{H_{GW}}{H}$ = 1 – 0.33$\frac{0\,ft}{4.0\,ft}$ = 1.0
$H_{GW}$ = Groudwater Height Above Pipe = 0 ft because there will be no standing

water on the slope
H = Cover Above Pipe = 4.0 ft

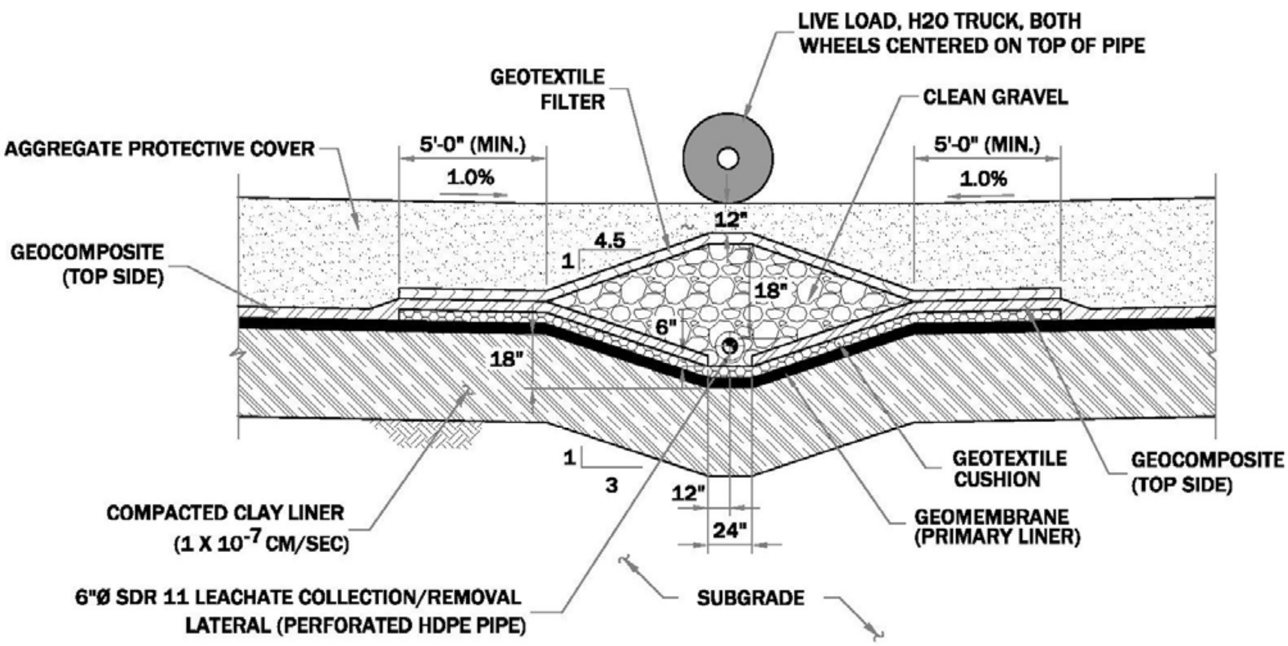
B' = Soil Support Factor = $\frac{1}{1+4e^{-0.065H}}$ = $\frac{1}{1+4e^{-0.065*4.0}}$ = 0.245

E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)

E' = Modulus of Soil Reduction = 2,000 psi (Assuming compacted coarse grained soil)

## 3.5 Scenario Sketches

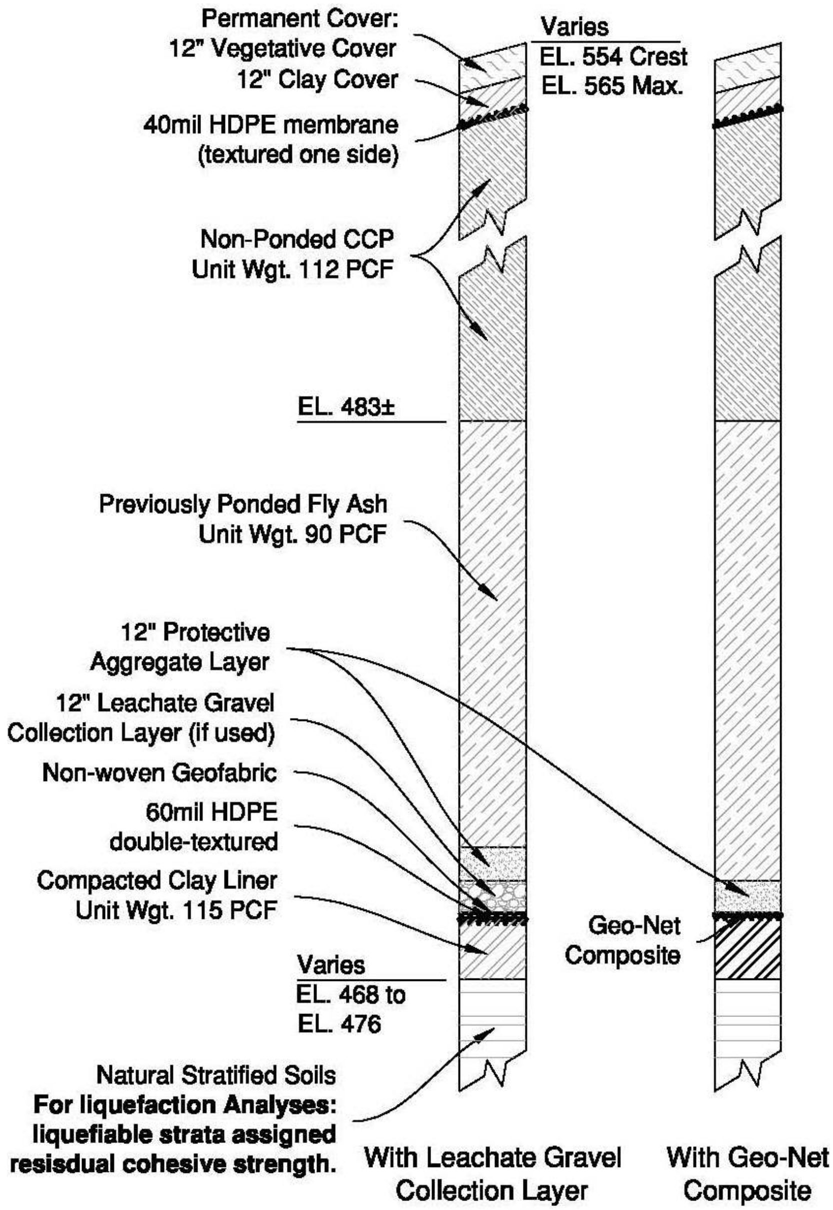
**Scenario 1**




***LEACHATE COLLECTION LATERAL TRENCH (ALTERNATE)***

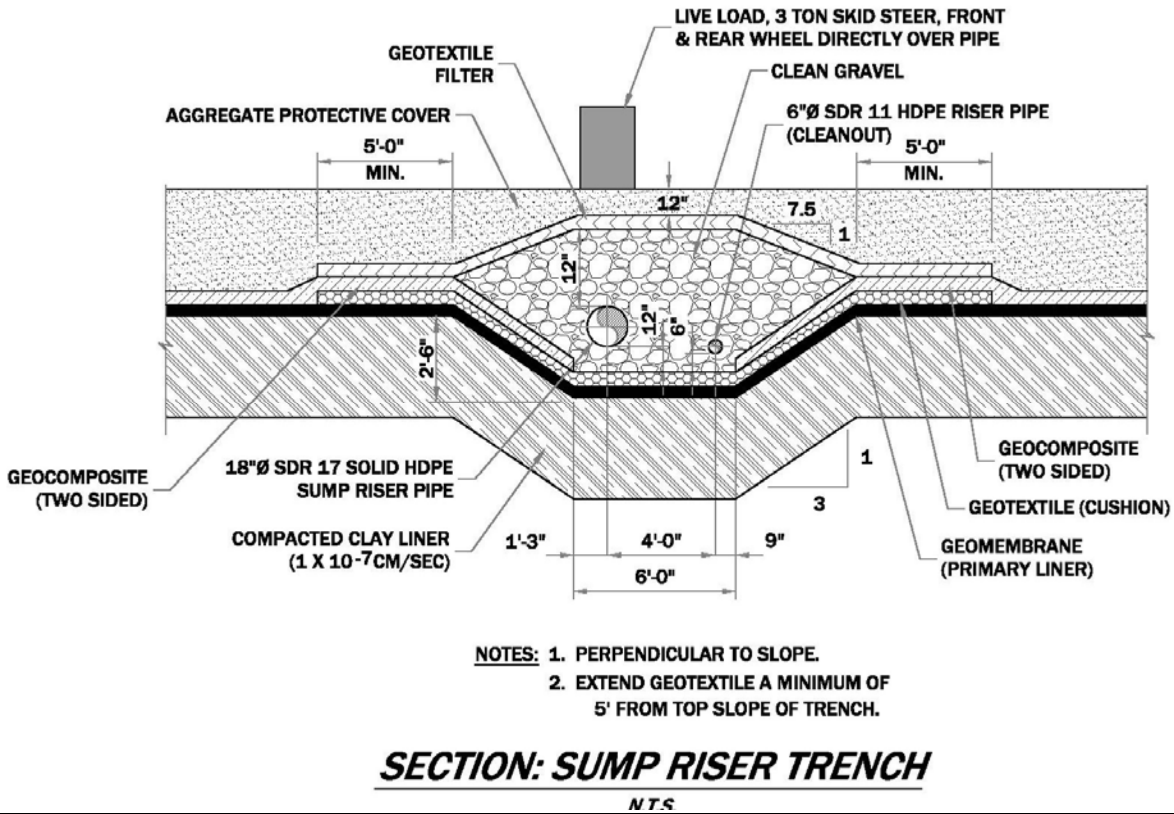
*N.T.S.*

## Scenario 2

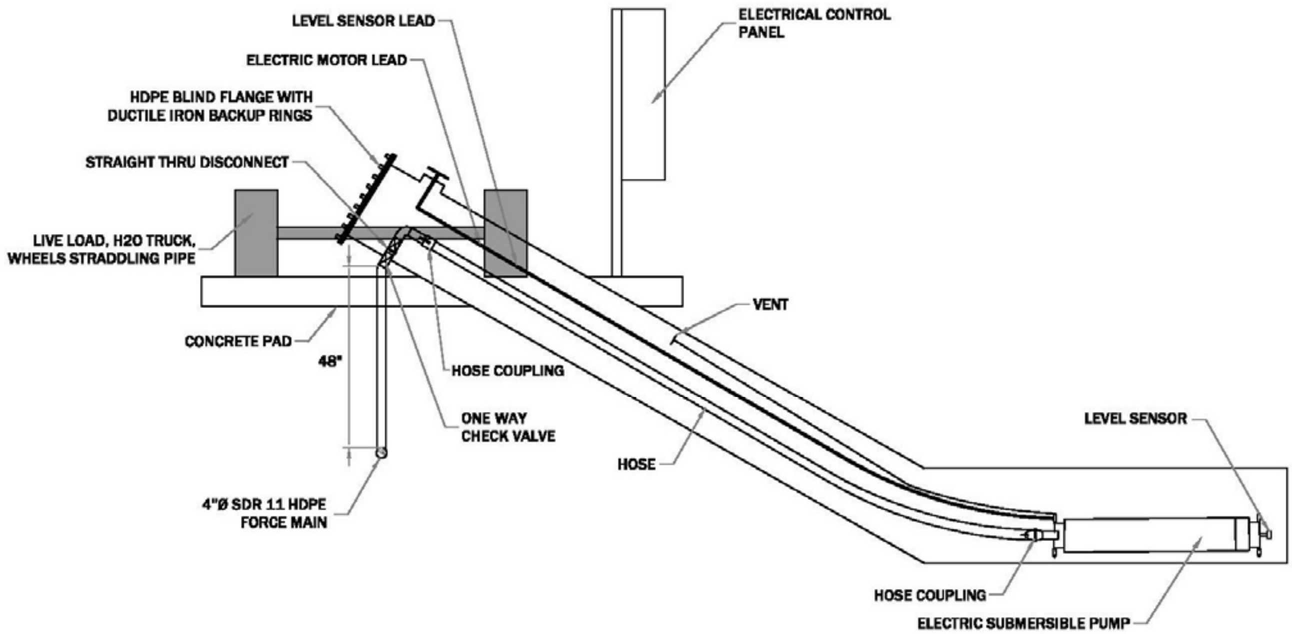



Typical Cell Material Profile
NOT TO SCALE

## Scenario 3


LIVE LOAD, 3 TON SKID STEER, FRONT & REAR WHEEL DIRECTLY OVER PIPE
GEOTEXTILE FILTER
CLEAN GRAVEL
AGGREGATE PROTECTIVE COVER
6"Ø SDR 11 HDPE RISER PIPE (CLEANOUT)
5'-0" MIN.
5'-0" MIN.
12"
7.5
1
12"
12"
6"
2'-6"
GEOCOMPOSITE (TWO SIDED)
18"Ø SDR 17 SOLID HDPE SUMP RISER PIPE
COMPACTED CLAY LINER (1 X 10-7CM/SEC)
1'-3"
4'-0"
9"
6'-0"
1
3
GEOCOMPOSITE (TWO SIDED)
GEOTEXTILE (CUSHION)
GEOMEMBRANE (PRIMARY LINER)
NOTES: 1. PERPENDICULAR TO SLOPE.
2. EXTEND GEOTEXTILE A MINIMUM OF 5' FROM TOP SLOPE OF TRENCH.
SECTION: SUMP RISER TRENCH
N.T.S.

## Scenario 4




***TYPICAL LEACHATE PUMP STATION WITH LEACHATE FORCE MAIN***

*N.T.S.*

# Supplemental Information for Appendix Y(a)

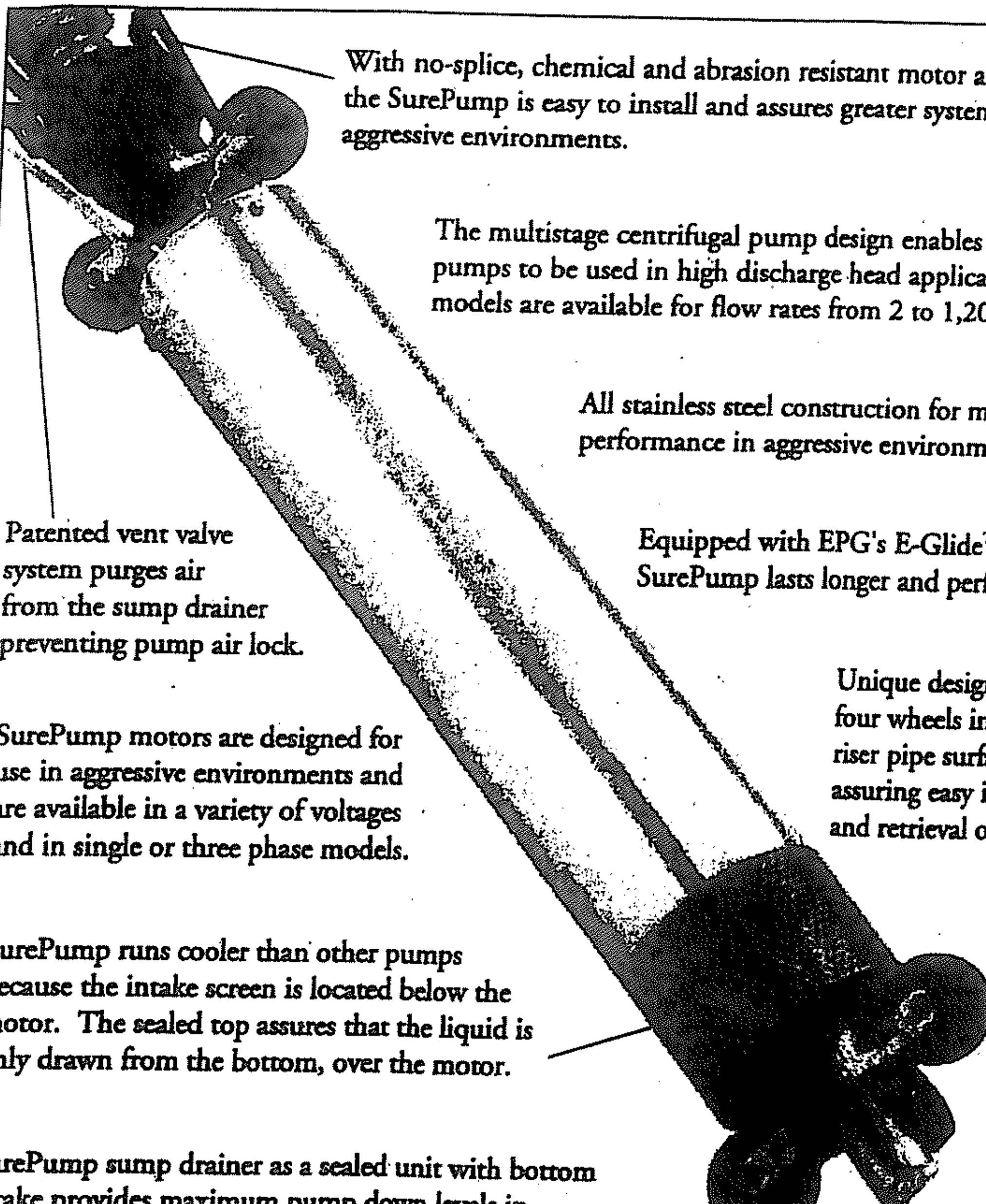
## Pipe and Pump Calculations

From Sioux Const. Permit Mod. Report Feb 2012

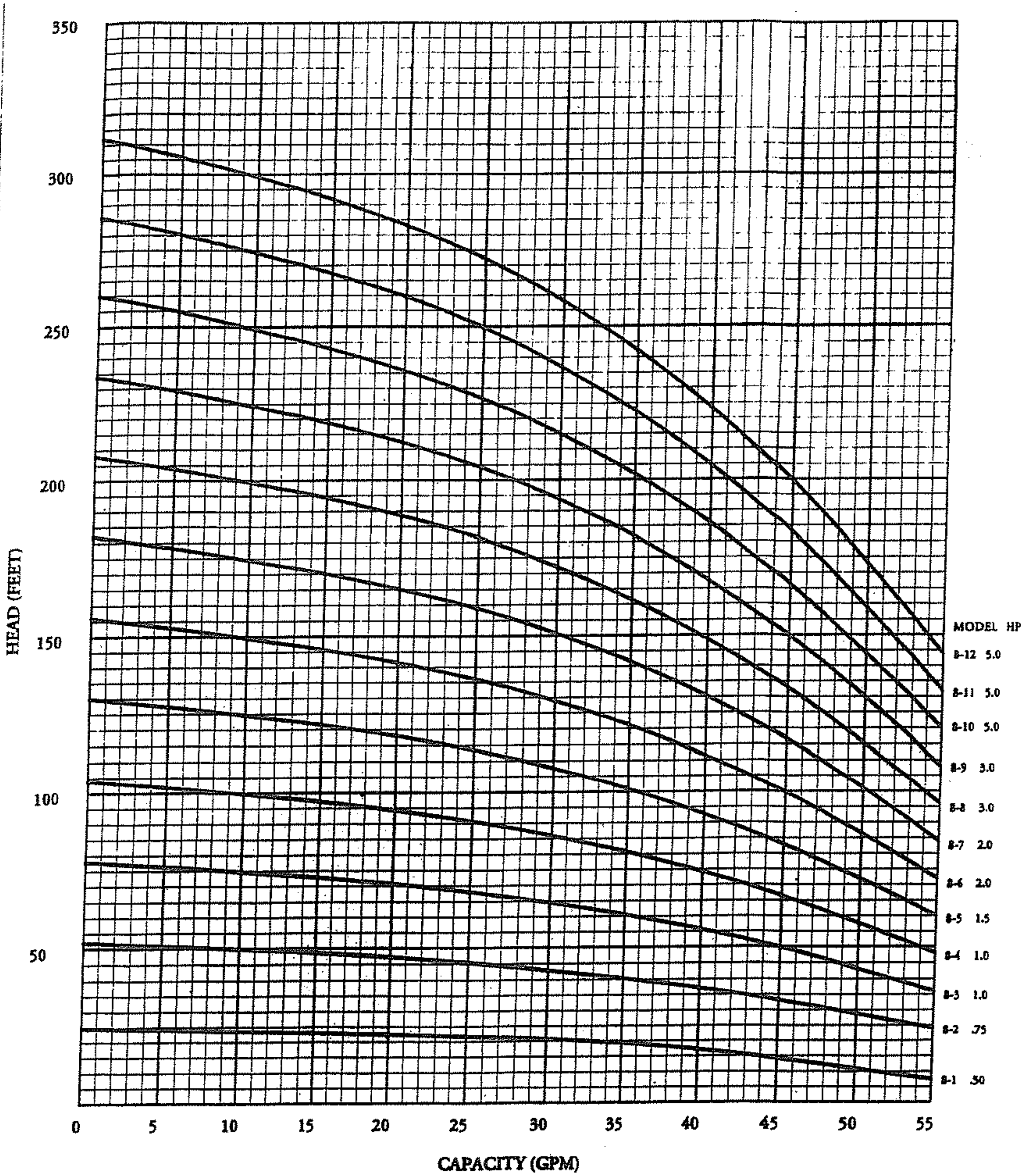


# Horizontal Wheeled Sump Drainer

More details at www.epgco.com



# SERIES 8 SurePump™
## Flow Range 20-50 GPM
## 60 Hz




DATA SUBJECT TO CHANGE WITHOUT NOTICE

# Pump Capacities

If the following curves do not meet your needs, please call us at 800-443-7426 and ask for an application specialist. Custom pumps in additional sizes, flow rates and head are available.

## SurePump™

| Curve | Model | Flow Range |
|---|---|---|
| 05714-0000 | SERIES 1 | 1 to 7 GPM |
| 05770-0000 | SERIES 1.5 | 3 to 10 GPM |
| 05771-0000 | SERIES 2 | 4 to 14 GPM |
| 05772-0000 | SERIES 3 | 10 to 20 GPM |
| 05773-0000 | SERIES 5 | 15 to [illegible] GPM |
| 05774-0000 | SERIES 8 | 20 to 50 GPM |
| 05775-0000 | SERIES 12 | 35 to 75 GPM |
| 05776-0000 | SERIES 15 | 45 to 95 GPM |

| Curve | Model | Flow Range |
|---|---|---|
| 0577[illegible] | SERIES 17 | 20 to [illegible] GPM |
| 05778-0000 | SERIES 30 | 50 to 200 GPM |
| 057[illegible] | SERIES [illegible] | 75 to [illegible] GPM |
| 05780-0000 | SERIES 60 | 50 to 400 GPM |
| 057[illegible] | SERIES 77 | 75 to [illegible] GPM |
| 05782-0000 | SERIES 95 | 95 to 680 GPM |
| 05783-0000 | SERIES 125 | 125 to [illegible] GPM |

The SurePumps are available in the following configurations:

**WSDPT:** Wheeled Sump Drainer with integral level sensor for side slope riser applications

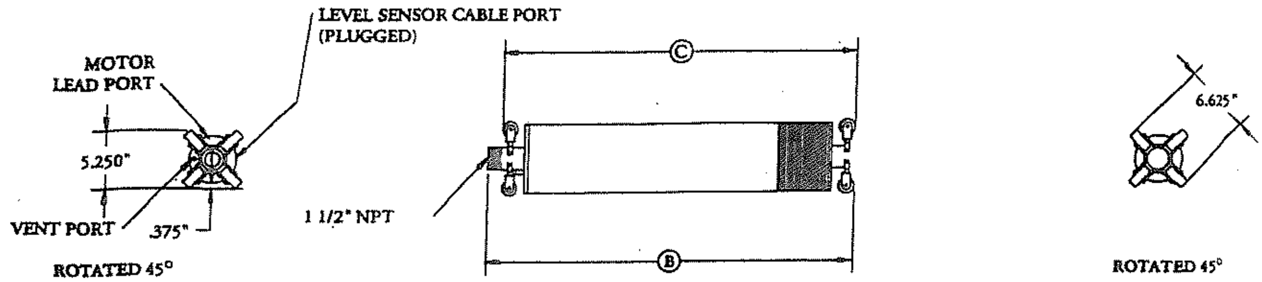
**WSD:** Wheeled Sump Drainer without integral level sensor for side slope riser applications

**VSDPT:** Vertical Sump Drainer with integral level sensor

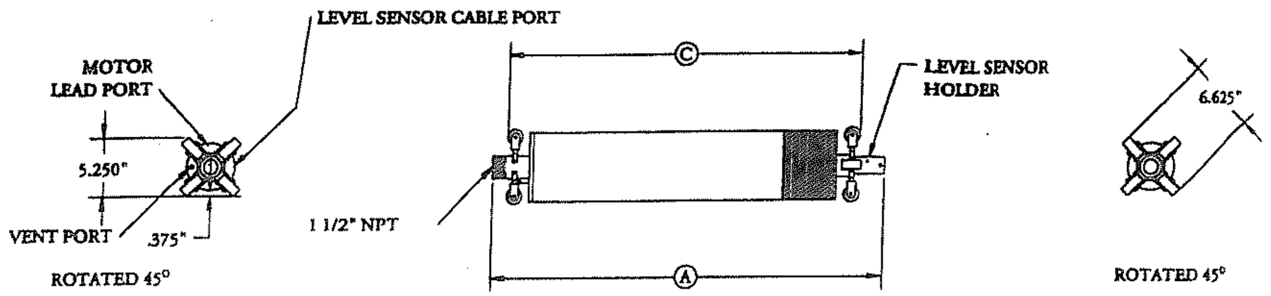
**VSD:** Vertical Sump Drainer with no level sensor

**TSP:** Submersible Pump

# SERIES 8 SIZE 4 WHEELED SUMP DRAINER




## WSD



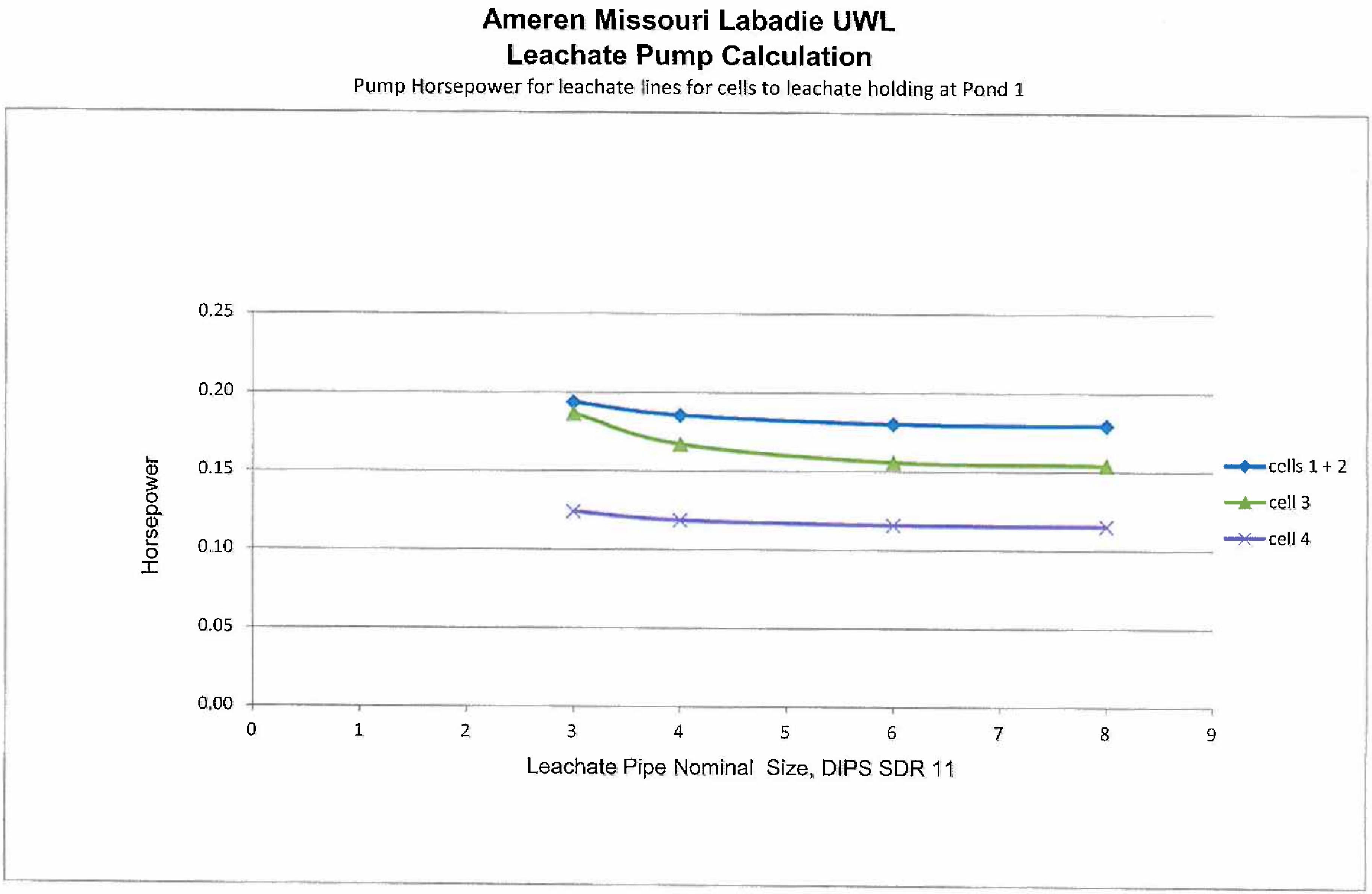

## WSDPT

| MODEL | HP | PHASE | A | B | C | *APPROX. SHIPPING WEIGHT WSD | *APPROX. SHIPPING WEIGHT WSDPT |
|---|---|---|---|---|---|---|---|
| 8-1 | 0.50 | 1 | 32.72 | 31.60 | 30.85 | 62.79 | 67.79 |
| 8-1 | 0.50 | 3 | 32.72 | 31.60 | 30.85 | 62.79 | 67.79 |
| 8-2 | 0.75 | 1 | 35.50 | 34.38 | 33.63 | 68.95 | 68.95 |
| 8-2 | 0.75 | 3 | 35.50 | 34.38 | 33.63 | 68.95 | 68.95 |
| 8-3 | 1.00 | 1 | 38.24 | 37.12 | 36.37 | 75.08 | 80.08 |
| 8-3 | 1.00 | 3 | 38.24 | 37.12 | 36.37 | 75.08 | 80.08 |
| 8-4 | 1.00 | 1 | 39.89 | 38.77 | 38.02 | 77.36 | 82.36 |
| 8-4 | 1.00 | 3 | 39.89 | 38.77 | 38.02 | 77.36 | 82.36 |
| 8-5 | 1.50 | 1 | 43.41 | 42.29 | 41.54 | 86.09 | 91.09 |
| 8-5 | 1.50 | 3 | 41.54 | 40.42 | 39.67 | 79.64 | 84.64 |
| 8-6 | 2.00 | 1 | 46.56 | 45.44 | 44.69 | 92.53 | 97.53 |
| 8-6 | 2.00 | 3 | 45.06 | 43.94 | 43.19 | 88.37 | 93.37 |

| MODEL | HP | PHASE | A | B | C | *APPROX. SHIPPING WEIGHT WSD | *APPROX. SHIPPING WEIGHT WSDPT |
|---|---|---|---|---|---|---|---|
| 8-7 | 2.00 | 1 | 48.21 | 47.09 | 46.34 | 94.81 | 99.81 |
| 8-7 | 2.00 | 3 | 46.71 | 45.59 | 44.84 | 90.65 | 95.65 |
| 8-8 | 3.00 | 1 | 58.36 | 57.24 | 56.49 | 126.69 | 131.69 |
| 8-8 | 3.00 | 3 | 55.36 | 54.24 | 53.49 | 113.36 | 118.36 |
| 8-9 | 3.00 | 1 | 60.01 | 58.89 | 58.14 | 128.97 | 133.97 |
| 8-9 | 3.00 | 3 | 57.01 | 55.89 | 55.14 | 115.64 | 120.64 |
| 8-10 | 5.00 | 1 | 67.66 | 66.54 | 65.79 | 150.91 | 155.91 |
| 8-10 | 5.00 | 3 | 61.66 | 60.54 | 59.79 | 131.25 | 136.25 |
| 8-11 | 5.00 | 1 | 69.31 | 68.19 | 67.44 | 153.19 | 158.19 |
| 8-11 | 5.00 | 3 | 63.31 | 62.19 | 61.44 | 133.53 | 138.53 |
| 8-12 | 5.00 | 1 | 70.96 | 69.84 | 69.09 | 155.47 | 160.47 |
| 8-12 | 5.00 | 3 | 64.96 | 63.84 | 63.09 | 135.81 | 140.81 |

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE, LEVEL SENSOR AND CABLE.




Prepared byGREDELL Engineering Resoruces, Inc.

January 2013

Area of Cell 1 31.4 Ac

| Measured | Sf | Ac | | Ac Corrected |
|---|---|---|---|---|
| 680, 1370, 0.5 | 465800 | 14.98 | 31.4 / 30.38 | = 15.5 |
| 140, (1370+1300)/2 | 186900 | Sump 2 | | |
| 390, (1300+1130)/2 | 413100 | 15.4 | 31.4 / 30.38 | 15.9 |
| 520, 990, 0.5 | 257400 | Sump 1 | | |
| | | 30.38 | | 31.4 |

Flow from HELP Model OGE3 R003

Peak 612.5 gpad → 0.00095 cfs/Ac

Annual 209.8 gpad → 0.00032 cfs/Ac

| | Ac | cfs/sump | Total flow |
|---|---|---|---|
| Sump 1 | 15.9 | .0151 × 0.00095 | 0.0632 |
| Sump 2 | 15.5 | .0147 | 0.0481 |
| | Add Cell 2 | .0334 | |

4" SDR 11 DIPS Effective Diameter = 3.89" = 0.32' ISCO

$$\text{Area} = \frac{\pi d^2}{4} = 0.082 \text{ sf}$$

$$\text{Velocity} = Q/A = 0.0632/0.082 = 0.77 \text{ fps}$$

$$\text{Reynold's No} = \frac{Vd}{V_K}$$ where $V_K$ = Kinematic Viscosity = 0.00001217 ft²/sec at 60° Vennard Fluid mechanics

$$R_E = \frac{(0.77)(0.32)}{1.217 \times 10^{-5}} = 20400$$

**GREDELL** Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING LAND - AIR - WATER
Telephone (573) 659-9078

| | | | |
|---|---|---|---|
| Date: 11/6/2012 | | Page No: 2 of 2 | |
| Client: Reitz & Jens | | | |
| Prepared By: FD | Checked By: | Project: Ameren MO Labadie CCP LF | |
| Subject: Check Calculations of Pipe Size and Pump Power for Leachate Collection | | | |

Velocity and friction head

$e$ = roughness $= 7\times10^{-5}$ ft

$d = 0.32$ ft

$e/d = \frac{7\times10^{-5}}{3.2\times10^{-1}} = 2.2\times10^{-4} = 0.000202$

entering Moody's Diagram for $Re = 20{,}400$ and $e/d = 0.0002$ $f = 0.025$

$$\left(1 + f\frac{L}{d}\right)\frac{v^2}{2g} = \left(1 + \frac{0.025(140)}{0.32}\right)\frac{(0.77)^2}{2(32.2)} =$$

$g$ = gravity constant 32.2 ft/sec²

$$= (1 + 10.8)\frac{(0.59)}{64.4} = 0.11 \text{ ft}$$

$$= \left(1 + \frac{0.028(140)}{0.324}\right)\frac{(0.765)^2}{64.4}$$

$$(1 + 12.2)\frac{0.585}{64.4} = 0.12 \text{ ft}$$

Printed on Recycled Paper

| | |
|---|---|
| Pipe Type: | DIPS |
| Pipe Diameter: | 3 |
| Pipe SDR: | SDR 11 |
| Flow Rate:(GPM) | 28.3 |
| Pipe Length:(ft) | 140 |

ISCO INDUSTRIES

| | | |
|---|---|---|
| Pipe I. D.:(in) | 3.21 | |
| Wall Thickness:(in) | 0.360 | |
| Pressure Rating: | 160 | |
| Flow Velocity:(ft/sec) | 1.12 | $= (q^{0.408709}/d^2)$ |
| Head loss: (ft/100 feet) | 0.164 | $= .2083(100/C)^{1.852} x (q^{1.852}/d^{4.8655})$ |
| System Pressure loss: (psi) | 0.10 | |

Calculate Reset Print Form

Disclamier: The calculations in this program are, to the best of our knowledge, current and represent calculations normally used to size high-density polyethylene pipe. ISCO Industries, LLC does not accept responsibility for the use and/or application of these programs. Each project or applicatin has its own set of conditions and input variables. The intrepretation and use of these input

| | |
|---|---|
| Pipe Type: | DIPS |
| Pipe Diameter: | 4 |
| Pipe SDR: | SDR 11 |
| Flow Rate:(GPM) | 28.3 |
| Pipe Length:(ft) | 140 |

| | | |
|---|---|---|
| Pipe I. D.:(in) | 3.89 | |
| Wall Thickness:(in) | 0.436 | |
| Pressure Rating: | 160 | |
| Flow Velocity:(ft/sec) | 0.76 | $= (q^{0.408709}/d^2)$ |
| Head loss: (ft/100 feet) | 0.065 | $= .2083(100/C)^{1.852} x (q^{1.852}/d^{4.8655})$ |
| System Pressure loss: (psi) | 0.04 | |

Calculate Reset Print Form

Disclamier: The calculations in this program are, to the best of our knowledge, current and represent calculations normally used to size high-density polyethylene pipe. ISCO Industries, LLC does not accept responsibility for the use and/or application of these programs. Each project or applicatin has its own set of conditions and input variables. The intrepretation and use of these input

| | |
|---|---|
| Pipe Type: | DIPS |
| Pipe Diameter: | 6 |
| Pipe SDR: | SDR 11 |
| Flow Rate:(GPM) | 28.3 |
| Pipe Length:(ft) | 140 |

| | | |
|---|---|---|
| Pipe I. D.:(in) | 5.60 | |
| Wall Thickness:(in) | 0.627 | |
| Pressure Rating: | 160 | |
| Flow Velocity:(ft/sec) | 0.37 | $= (q^{0.408709}/d^2)$ |
| Head loss: (ft/100 feet) | 0.011 | $= .2083(100/C)^{1.852} x (q^{1.852}/d^{4.8655})$ |
| System Pressure loss: (psi) | 0.01 | |

Calculate Reset Print Form

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| | |
|---|---|
| Pipe Type: | DIPS |
| Pipe Diameter: | 8 |
| Pipe SDR: | SDR 11 |
| Flow Rate:(GPM) | 28.3 |
| Pipe Length:(ft) | 140 |

ISCO INDUSTRIES

| | | |
|---|---|---|
| Pipe I. D.:(in) | 7.34 | |
| Wall Thickness:(in) | 0.823 | |
| Pressure Rating: | 160 | |
| Flow Velocity:(ft/sec) | 0.21 | $= (q^{0.408709}/d^2)$ |
| Head loss: (ft/100 feet) | 0.003 | $= .2083(100/C)^{1.852} x (q^{1.852}/d^{4.8655})$ |
| System Pressure loss: (psi) | 0.00 | |

Calculate Reset Print Form

Disclamier: The calculations in this program are, to the best of our knowledge, current and represent calculations normally used to size high-density polyethylene pipe. ISCO Industries, LLC does not accept responsibility for the use and/or application of these programs. Each project or applicatin has its own set of conditions and input variables. The intrepretation and use of these input

# Ameren MO Labadie Energy Center
## Computer Worksheet
## Leachate Pumping to Holding Tank(s)

| | | | | |
|---|---|---|---|---|
| e, roughness= | 0.00007 | ft. | | Technical literature from Chevron Petroleum Company |
| Flow pre acre | 0.0009 | cfs/acre | From HELP Model for Operational Condition, run OGE3R003 | |

| | | | |
|---|---|---|---|
| Tank on saddles | 10,000 | Gallon / acre / d | 612.5 | 209.8 |
| | | cfs/acre | 0.000947743 | 0.000324631 |
| length | 30 | Flow condition | peak | average |
| height | 4 | Sample | OGE3R003 | OGE3R003 |

| | Area for sump | | Distances to tanks | | Flow of leachate | | |
|---|---|---|---|---|---|---|---|
| | Measured | Corrected | Total Distance | Incremental distance | | | |
| | Acres | | feet | | | | |
| cell 1 | 31.4 | | . | | Flow/ sump , cfs | Total flow at sump,cfs | Total flow at sump,gpm |
| 1 | 15.4 | 15.9 | 140 | 140 | 0.02 | 0.06 | 28.33 |
| 2 | 15 | 15.5 | 630 | 490 | 0.01 | 0.05 | 21.56 |
| cell 2 | 35.2 | | | | | | |
| 1 | 11.1 | 10.9 | 2300 | 1670 | 0.01 | 0.03 | 14.97 |
| 2 | 11.6 | 11.4 | 2800 | 500 | 0.01 | 0.02 | 10.32 |
| 3 | 13.1 | 12.9 | 3200 | 400 | 0.01 | 0.01 | 5.48 |
| | | 35.2 | | | | | |
| | | | | | | | |
| cell 3 | 57.1 | | | | | | |
| 1 | 8.7 | 8.9 | 2850 | 2850 | 0.01 | 0.05 | 24.29 |
| 2 | 10.3 | 10.6 | 3350 | 500 | 0.01 | 0.05 | 20.49 |
| 3 | 10.3 | 10.6 | 3840 | 490 | 0.01 | 0.04 | 15.99 |
| 4 | 10.0 | 10.2 | 4330 | 490 | 0.01 | 0.03 | 11.48 |
| 5 | 10.2 | 10.4 | 4820 | 490 | 0.01 | 0.02 | 7.15 |
| 6 | 6.3 | 6.4 | 5310 | 490 | 0.01 | 0.01 | 2.72 |
| | | 57.1 | | | | | |
| cell 4 | 42.8 | | | | | | |
| 1 | 8.8 | 8.4 | 1650 | 1650 | 0.01 | 0.04 | 18.20 |
| 2 | 9.7 | 9.3 | 2150 | 500 | 0.01 | 0.03 | 14.61 |
| 3 | 11.8 | 11.4 | 2660 | 510 | 0.01 | 0.02 | 10.64 |
| 4 | 14.2 | 13.7 | 3160 | 500 | 0.01 | 0.01 | 5.81 |

DIPS SDR 11

| | 3 | 4 | 6 | 8 | Reynolds's Number | | | |
|---|---|---|---|---|---|---|---|---|
| Diameter in inches | 3.21 | 3.89 | 5.6 | 7.34 | 3.21 | 3.89 | 5.6 | 7.34 |
| Diameter in feet | 0.27 | 0.32 | 0.47 | 0.611666667 | | | | |
| Area in square feet | 0.056 | 0.083 | 0.171 | 0.294 | | | | |
| cell 1 - 1 | 1.12 | 0.76 | 0.37 | 0.21 | 25,000 | 20,000 | 14,000 | 11,000 |
| cell 1 - 2 | 0.85 | 0.58 | 0.28 | 0.16 | 19,000 | 16,000 | 11,000 | 8,000 |
| cell 2 | | | | | - | - | - | - |
| cell 2 - 1 | 0.59 | 0.40 | 0.20 | 0.11 | 13,000 | 11,000 | 7,000 | 6,000 |
| cell 2 - 2 | 0.41 | 0.28 | 0.13 | 0.08 | 9,000 | 7,000 | 5,000 | 4,000 |
| cell 2 - 3 | 0.22 | 0.15 | 0.07 | 0.04 | 5,000 | 4,000 | 3,000 | 2,000 |
| cell 3 - 1 | 0.96 | 0.66 | 0.32 | 0.18 | 21,000 | 17,000 | 12,000 | 9,000 |
| cell 3 - 2 | 0.81 | 0.55 | 0.27 | 0.16 | 18,000 | 15,000 | 10,000 | 8,000 |
| cell 3 - 3 | 0.63 | 0.43 | 0.21 | 0.12 | 14,000 | 11,000 | 8,000 | 6,000 |
| cell 3 - 4 | 0.46 | 0.31 | 0.15 | 0.09 | 10,000 | 8,000 | 6,000 | 4,000 |
| cell 3 - 5 | 0.28 | 0.19 | 0.09 | 0.05 | 6,000 | 5,000 | 4,000 | 3,000 |
| cell 3 - 6 | 0.11 | 0.07 | 0.04 | 0.02 | 2,000 | 2,000 | 1,000 | 1,000 |
| cell 4 - 1 | 0.72 | 0.49 | 0.24 | 0.14 | 16,000 | 13,000 | 9,000 | 7,000 |
| cell 4 - 2 | 0.58 | 0.39 | 0.19 | 0.11 | 13,000 | 11,000 | 7,000 | 6,000 |
| cell 4 - 3 | 0.42 | 0.29 | 0.14 | 0.08 | 9,000 | 8,000 | 5,000 | 4,000 |
| cell 4 - 4 | 0.23 | 0.16 | 0.08 | 0.04 | 5,000 | 4,000 | 3,000 | 2,000 |

| | e/D | | | | Friction factor | | | |
|---|---|---|---|---|---|---|---|---|
| | 3.21 | 3.89 | 5.6 | 7.34 | 3.21 | 3.89 | 5.6 | 7.34 |
| cell 1 - 1 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.026 | 0.028 | 0.028 | 0.028 |
| cell 1 - 2 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.027 | 0.031 | 0.032 | 0.033 |
| cell 2 - 1 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.029 | 0.033 | 0.034 | 0.035 |
| cell 2 - 2 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.032 | 0.038 | 0.037 | 0.037 |
| cell 2 - 3 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.036 | 0.042 | 0.042 | 0.042 |
| cell 3 - 1 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.027 | 0.029 | 0.03 | 0.032 |
| cell 3 - 2 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.029 | 0.03 | 0.03 | 0.032 |
| cell 3 - 3 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.03 | 0.032 | 0.032 | 0.038 |
| cell 3 - 4 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.032 | 0.034 | 0.038 | 0.04 |
| cell 3 - 5 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.038 | 0.038 | 0.044 | 0.044 |
| cell 3 - 6 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.05 | 0.05 | 0.065 | 0.065 |
| cell 4 - 1 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.028 | 0.028 | 0.032 | 0.034 |
| cell 4 - 2 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.031 | 0.031 | 0.032 | 0.035 |
| cell 4 - 3 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.032 | 0.034 | 0.035 | 0.04 |
| cell 4 - 4 | 0.000261682 | 0.000215938 | 0.00015 | 0.00011444 | 0.038 | 0.04 | 0.065 | 0.065 |

| | Incremental head loss for velocity and friction | | | | Total head including elevation head with diameter of tank and 1 foot for tank saddle | | | | Horsepower (3) | (4) | (6) | (8) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3.21 | 3.89 | 5.6 | 7.34 | 3.21 | 3.89 | 5.6 | 7.34 | 3.21 | 3.89 | 5.6 | 7.34 |
| cell 1 - 1 | 0.29 | 0.12 | 0.02 | 0.01 | 27.05 | 25.89 | 25.15 | 25.04 | 0.19 | 0.19 | 0.18 | 0.18 |
| cell 1 - 2 | 0.57 | 0.25 | 0.04 | 0.01 | 26.77 | 25.78 | 25.13 | 25.03 | | | | |
| cell 2 - 1 | 1.00 | 0.43 | 0.07 | 0.02 | 26.19 | 25.52 | 25.09 | 25.02 | | | | |
| cell 2 - 2 | 0.16 | 0.07 | 0.01 | 0.00 | 25.20 | 25.09 | 25.01 | 25.00 | | | | |
| cell 2 - 3 | 0.04 | 0.02 | 0.00 | 0.00 | 25.04 | 25.02 | 25.00 | 25.00 | | | | |
| cell 3 - 1 | 4.16 | 1.71 | 0.29 | 0.08 | 30.37 | 27.19 | 25.37 | 25.10 | 0.19 | 0.17 | 0.16 | 0.15 |
| cell 3 - 2 | 0.57 | 0.22 | 0.04 | 0.01 | 26.21 | 25.49 | 25.08 | 25.02 | | | | |
| cell 3 - 3 | 0.35 | 0.14 | 0.02 | 0.01 | 25.65 | 25.26 | 25.05 | 25.01 | | | | |
| cell 3 - 4 | 0.19 | 0.08 | 0.01 | 0.00 | 25.30 | 25.12 | 25.02 | 25.01 | | | | |
| cell 3 - 5 | 0.09 | 0.03 | 0.01 | 0.00 | 25.10 | 25.04 | 25.01 | 25.00 | | | | |
| cell 3 - 6 | 0.02 | 0.01 | 0.00 | 0.00 | 25.02 | 25.01 | 25.00 | 25.00 | | | | |
| cell 4 - 1 | 1.41 | 0.54 | 0.10 | 0.03 | 26.94 | 25.75 | 25.14 | 25.04 | 0.12 | 0.12 | 0.12 | 0.12 |
| cell 4 - 2 | 0.31 | 0.12 | 0.02 | 0.01 | 25.54 | 25.21 | 25.04 | 25.01 | | | | |
| cell 4 - 3 | 0.17 | 0.07 | 0.01 | 0.00 | 25.23 | 25.09 | 25.02 | 25.01 | | | | |
| cell 4 - 4 | 0.06 | 0.02 | 0.01 | 0.00 | 25.06 | 25.02 | 25.01 | 25.00 | | | | |

# CIVIL ENGINEERING HANDBOOK

LEONARD CHURCH URQUHART, C.E., Editor-in-Chief

*Consulting Engineer, Porter, Urquhart, McCreary & O'Brien Newark, N.J.; Los Angeles, San Francisco, and Sacramento, Calif.*

FOURTH EDITION

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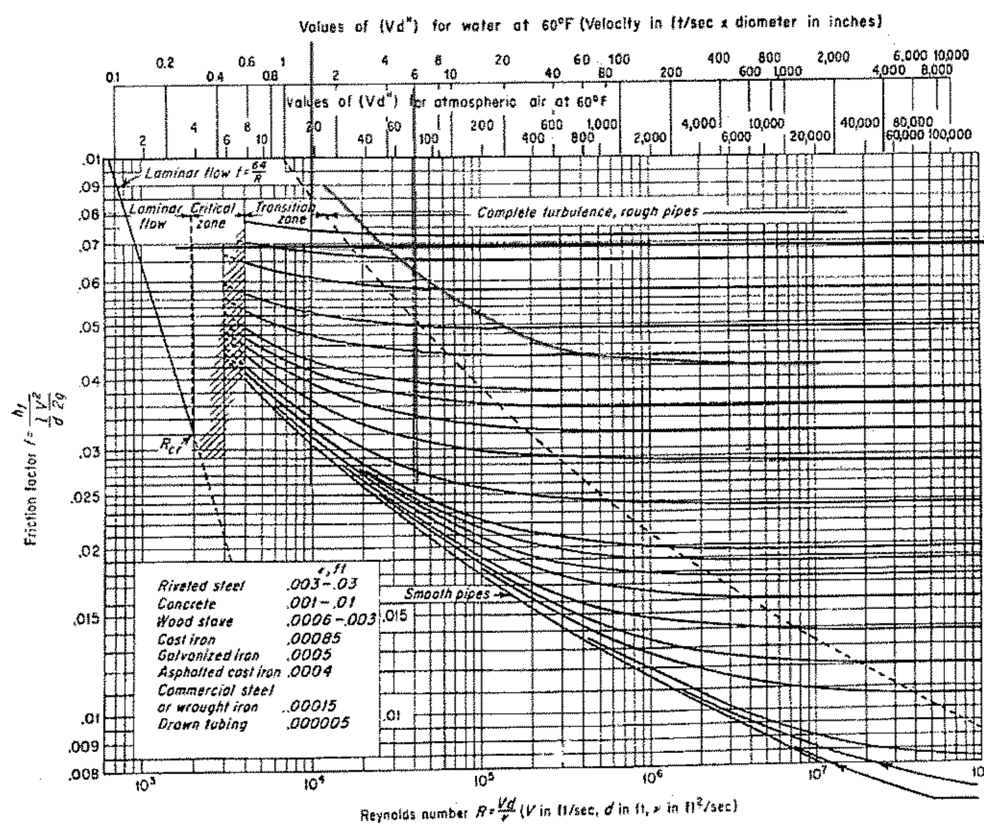


Fig. 61. Pipe friction coefficients.

Moody's chart. It is taken from the reference below. ...d to find friction factors for water in long pipes.

# Appendix Y(b)

## Estimated Maximum Settlements
## Leachate Collection Pipe Profile

**Ameren Missouri Labadie Energy Center**
**Utility Waste Landfill**
**Franklin County, MO**
**January 2013**

# Estimated Maximum Settlements for Leachate Collection Pipe Profile Appendix Y(b)

A graphical analysis of the effect of long-term settlement due to the weight of utility waste on the leachate collection pipe is shown on the following page and detail number 1 on sheet 18 of the drawings. Analysis indicated that long-term settlement would cause a negative pipe slope within the approximately 180 feet of pipe length upstream of the leachate collection sump. The negative slope occurs because the maximum long-term settlement is estimated to be approximately 2.2 feet on the interior of the landfill, while it is estimated to be approximately 0.8 feet at the leachate collection sump. If the pipe were installed with a 0.5% slope running all the way to the sump, future settlement could reduce the final pipe slope to about -0.2%.

To mitigate this risk, it is proposed to slightly steepen the design slope of the leachate collection trenches from the head of the collection pipe to the sumps in order to provide a minimum post-construction, post-settlement pipe grade of 0.5%. The proposed design trench bottom grades are elevation 465.0 at the sump low point and elevation 467.0 at an inflection point 200 feet upstream from the sump low point. Laying out the trenches and sumps for excavation to these fixed elevations will provide a maximum installed leachate collection line slope of 0.6% from the head of the line to the inflection point, and a slope of 1.0% from the inflection point to the sumps.

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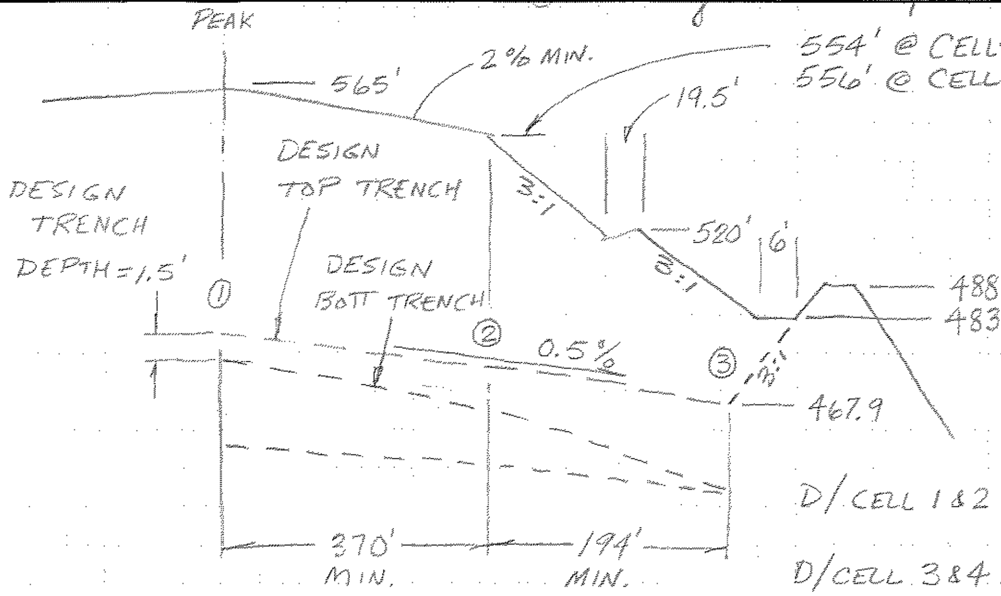
| | | | |
|---|---|---|---|
| Date: 11/15/12 | | Page No: 1 of 1 | |
| Client: Reitz & Jens | | | |
| Prepared By: BD | Checked By: | Project: Labadie UWL | |
| Subject: Leachate Trench Grading to Compensate UWL Settlement | | | |




See Appendix J for Settlement Estimates

D/CELL 1 & 2 : (554 − 483) 3 + 19.5 + 6 − (483 − 46.8) 3 = 193.5'

D/CELL 3 & 4 : (556 − 483) 3 + 19.5 + 6 − (483 − 468) 3 = 199.5'

| LOCATION → | ① | | ② | | ③ | |
|---|---|---|---|---|---|---|
| TOP TRENCH PRE-S EL. | 470.72 | | 468.87 | | 467.90 | |
| BOTT TRENCH PRE-S EL. | 469.22 | | 467.37 | | 466.40 | (BASED ON 0.5% INITIAL SLOPE ON BOTT TRENCH) |
| MAX. EST. S | 2.17 | | 2.17 | | 1.42 | |
| MIN. EST. S | 1.67 | | 1.50 | | 0.83 | |
| BOTT TRENCH MAX. POST-S EL.* | 467.55 | | 465.87 | | 465.57 | * W/O DESIGN GRADE COMPENSATION |
| SLOPE, % | | 0.45 | | 0.15 ← UNACCEPTABLE | | |
| BOTT TRENCH MIN. POST-S EL.* | 467.05 | | 465.20 | | 464.98 | * W/O DESIGN GRADE COMPENSATION |
| SLOPE, % | | 0.50 | | 0.11 ← UNACCEPTABLE | | |
| MAX ΔS PER X-SECTS | | 0.42' | | 0.83' | | |
| PROP. BOTT TRENCH PER MAX ΔS | 469.22 | 0.61% | 466.95 | 0.96% | 465.04 | |
| THEOR. POST-S EL. PER MAX ΔS | 467.05 | 0.50% | 465.20 | 0.50% | 464.21 | |

FOR DETAIL 1/18 :
SET DESIGN BOTT TR @ ② = 467.0'
" " " " @ ③ = 465.0'
REPORT SLOPE ① → ② @ 0.6% (design)
REPORT SLOPE ② → ③ @ 1.0%

# Appendix Y(c)

Water Management
Calculations

**Ameren Missouri Labadie Energy Center**
**Utility Waste Landfill**
**Franklin County, MO**
**January 2013**

# Appendix Y(c)
# Water Management Calculations

Leachate and stormwater are planned to be managed on site. The following calculations describe the capacity needed for water storage and pumping.

1. Leachate Flow

Cell 1 HELP Model results for leachate flow:

- Operational condition is worst case (Appendix O, Sub Appendix O -11).
- For the Operational condition for Cell 1:
    - Geocomposite drainage layer on the bottom and side slope:
        - Peak Daily Volume is: 13.4 gpm or 19,296 gpd.
        - Average Annual Volume is: 321,394 cu. ft./yr or 2,404,000 gallons per year.
    - Aggregate material drainage layer on the bottom and a geocomposite layer on the side slope:
        - Peak daily leachate flow is: 11.7 gpm or 16,848 gpd.
        - Average Annual Volume is: 320,708 cu. ft./yr or 2,399,000 gallons per year.

For Cell 3 at 57.1 acres; estimate the leachate volumes by pro-rating maximum peak daily flows using the ratio of the size of Cell 3 (57.1 acres) to Cell 1 (31.4 acres) or 1.819 (rounded).

- Peak daily leachate flow is: 21.3 gpm or 30,672 gpd.
- Average Annual Volume is: 584,616 cu. ft./yr or 4,367,000 gallons per year.

2. Stormwater Flow

Cell 1 HELP Model results for stormwater flow:

- Peak daily stormwater runoff is: 1,683,913 gpd

Estimating the maximum daily stormwater runoff using the ratio of Cell 3 to Cell 1:

- Peak daily stormwater runoff is: 3,063,000 gpd.

3. Estimate the Volume of Onsite Reuse of Leachate and/or Stormwater Runoff

Onsite water (leachate or stormwater runoff) usage:

- Reuse for CCP Moisture Conditioning Estimate:
  - The daily CCP generation rate for the first five years: 2,300,000 CY. The ratio of fly ash to bottom ash is 70% to 30%.
  - Therefore, the annual volume of fly ash generation is:
  - (2,300,000 CY / 5) x 0.70 = 322,000 CY/ year:
  - At 22% moisture by volume for conditioning, the water usage is 70,840 CY per year or 1,912,680 cubic feet (cf) or 14,306,846 gallons per year for CCP moisture conditioning.
  - This equates to an average daily water demand of 39,200 gpd, or an average flow rate of 27 gpm.

- Usage for Dust Control on Haul Roads:
  - Onsite water usage for dust control on onsite haul roads:
  - Assume an application rate of 0.25 inches (depth) per hour applied 6 hours per day or 1.5 inches per day.
  - Assume a road width of 12 feet and a ¼ mile of onsite haul road.
  - Volume is 12' x 1320' x0.25"/hr x 6 hr/day/(12"/1') = 1,980 cf per day
  - Volume is 1,980 cf/day x 7.48 gallons/cf = 14,810 gpd for dust control
  - Volume is 14,810 gpd x 5 days/wk x 52 weeks/yr = 3,850,600 gallons per year for dust control.
  - This equates to an average daily water demand of 10,550 gpd, or an average flow rate of 7.3 gpm.

Estimated Total Volume of Potential Onsite Reuse: 18,157,446 gallons per year or approximately 34.3 gpm.

4. Leachate Storage

The estimated required onsite leachate tank storage volume is calculated for the average annual volume from the HELP model results:

- Cell 1 Initial = 4.2 gpm x 1440 = 6,048 gpd = 2,207,520 gallons per year
- Cell 3 Initial = 6,048 x 57 ac/31 ac = 10,998 gpd = 4,014,312 gallons per year
- Cell 1 Operational = 4.6 gpm x 1440 = 6,624 gpd = 2,417,760 gallons per year
- Cell 3 Operational = 6,624 x 57 ac/ 31 ac = 12,180 gpd = 4,445,559 gallons per year

Therefore, a 10,000 gallon onsite storage tank will provide for an average of 0.8 days storage of the average annual leachate flow for Cell 3. One (1), 10,000 gallon horizontal tank would be 12 feet in diameter by 30 feet long. One or more tanks can be utilized based on the actual leachate flow and the demand for onsite reuse.

Backup leachate management will be at an off site POTW.

Backup stormwater management will be through the Labadie Energy Center's plant stormwater management system, which will be dependent on current NPDES operating permit requirements.

# Appendix Y(d)

Flood Mitigation
Calculations

# Ameren Missouri Labadie Energy Center
# Proposed Utility Waste Landfill
# Franklin County, Missouri
# January 2013, Revised August 2013

# Appendix Y(d)
# Flood Mitigation Calculations

**<u>Pumping Rates for Flood Water Protection – Cell 3</u>**

Known:

Average Area of Cell 3 between floor and 480 ft. elev. = 49 ac

Average Bottom Elevation of Cell 3 from CADD surface = 471.2 ft

100-year Flood Elevation = 484 ft

Depth of water is estimated using the method described in Figure 7 of Appendix J. The density of water is substituted for the density of CCP to estimate the water fill depth need to protect against uplift during a flood. The inside toe of the slopes where the gravel drainage layer terminates is considered the critical location in the liner system that is most sensitive to hydrostatic uplift. The end-of-construction ballast against uplift at this location is equal to 2-feet of clay liner and 1-foot of protective cover. With estimated densities of 115 pounds per cubic foot (pcf) and 125 pcf, respectively, the ballast of 355 pounds per square foot (psf) at this location is the lowest at any point on the liner. Required elevations are determined by adding “H” values plus liner and cover thickness to elevation 466 feet.

$$H_{\text{Inside Cell}} = (H_{\text{Outside Cell}} \text{ x } 62.4 \text{ pcf x } 1.1 – 355 \text{ psf}) / 62.4 \text{ pcf}$$

$$H_{\text{Outside Cell}} = 484 \text{ ft} – 466 \text{ ft (lowest bottom of liner elevation)} = 18 \text{ ft}$$

$$H_{\text{Inside Cell}} = (18 \text{ ft x } 62.4 \text{ pcf x } 1.1 – 355 \text{ psf}) / 62.4 \text{ pcf} = 14.1 \text{ ft (elev. } 483.1 \text{ ft)}$$

49 ac x 43,560 sf/ac x (483.1 - 471.2 ft) = 25,399,836 cf

25,399,836 cf x 7.48 gal/cf = 189,990,773 gal

Assume pumping will occur for 10 days, 24 hours per day:

10 days x 1,440 min/day = 14,400 min

Pumping rate = 189,990,773 gal / 14,400 min = 13,194 gpm

A pumping rate of 13,194 gpm, pumping 24 hours per day, is required to fill Cell 3 in 10 days for 100-year flood protection. High capacity pumps and power equipment necessary for pumping are readily available from equipment dealers and contractors within the St. Louis metropolitan area in the event of a major flood.

## Fill Volume for Flood Mitigation

For each cell of the UWL, when there is an impending flood event that creates floodwater levels that exceed the minimum elevation of CCPs inside the active cell, CCPs will be placed at an accelerated rate in the active cell until it reaches an elevation sufficient to counterbalance uplift pressure during a flood. Again using the method described in Figure 7 of Appendix J, the minimum elevation of CCP's is determined as follows:

$$H_{CCP} = (H_{Outside\ Cell} \text{ x } 62.4 \text{ pcf x } 1.1 - 355 \text{ psf}) / 93.0 \text{ pcf}$$

$$H_{Outside\ Cell} = 484 \text{ ft} - 466 \text{ ft (lowest bottom of liner elevation)} = 18 \text{ ft}$$

$$H_{CCP} = (18 \text{ ft x } 62.4 \text{ pcf x } 1.1 - 355 \text{ psf}) / 93.0 \text{ pcf} = 9.5 \text{ ft (elev. 478.5 ft)}$$

A fill elevation of 478.5 feet provides sufficient ballast to resist the uplift pressure on the clay liner created by 100-year flood elevation of 484 feet, with a factor-of-safety of 1.1.

Fill volumes for each cell are estimated in the attached Table. Cell 3 has the largest estimated fill volume of 578,000 CY at elevation 478.5 ft. At a rate of 10,000 CY/day, it would take 58 days to fill to elevation 478.5 ft.

## Flood Mitigation Culvert Design for Stormwater Ponds

The maximum anticipated rate of floodwater rise is estimated at 5-feet in 24-hours at the proposed site. To mitigate this flood risk, it is proposed to install pipe culverts with the capacity to intake water at a rate that will raise the pond levels at least 5-feet in 24 hours while limiting excess uplift head on the liner to less than 3-feet. The proposed pipe culverts were modeled with their flowline at elevation 472 feet, and a maximum headwater at the inlet of 2-feet.

The maximum volume in any 5-foot elevation interval in the stormwater ponds occurs in Pond 2. From elevation 478 feet to 483 feet, the volume is 19.8 acre-feet (see Table N-8, Appendix N). Based on a water elevation rise of 5 feet per day, the required inflow rate through a culvert in cubic feet per second (cfs) is:

$$(19.8 \text{ acre-feet/day})*(43{,}560 \text{ ft}^2\text{/acre})*(1 \text{ day/24 hours})*(1 \text{ hour/3600 sec}) = 10.0 \text{ cfs}$$

Based on the assumption of 2 feet of headwater on the pipe inlet at all times and an inflow discharge value of 10.0 cfs, the proposed diameter for a HDPE pipe culvert is 24 inches. Based on a pond berm design with a 12-foot top width at 488 elevation, 3:1 side slopes, and a culvert pipe at 472 elevation, the culvert pipe will be approximately 110 feet in length. A "duckbill" elastomeric valve is proposed to be installed on the culvert outlet to prevent backflow and subsequent loss of water. Additionally, a mechanical check valve is proposed to be installed in the pipe to control flow into the stormwater pond and to provide redundant backflow protection.

Solution of culvert design is by determination of flow under given headwater and tailwater conditions. The two critical conditions of flow through the proposed culvert are full pipe flow and partial pipe flow. These two conditions can be analyzed by their controlling element; inlet and/or outlet control.

Full pipe flow is a critical condition with submerged inlet and free fall outlet. This condition can be defined through a capacity equation given by:

$$q = a\sqrt{2gH} / \sqrt{1 + Ke + Kdv + KcL}$$

Where:

q=flow capacity (cfs)
a=conduit cross-sectional area ($ft^2$)
H=head causing flow (ft.) = 2' – 0.6*pipe diameter = 0.8'
Ke=entrance loss coefficient
Kc=friction loss coefficient from pipe
Kdv= duckbill valve friction loss coefficient
L=length of conduit (ft.)
g=acceleration due to gravity (32 ft/$s^2$)

$$q = \pi (1)^2 * \sqrt{2*32*.8}\ ) / \sqrt{1+.78+1.0+(0.0165*110)}\ )$$

q=10.50 cfs

Friction loss due to the mechanical check valve does exist, however the loss values are negligible. Under the conditions of full pipe flow, a 24-inch diameter design culvert is acceptable since the pipe discharge, q (10.5 cfs) is greater than the calculated minimum pond inflow requirement of 10.0 cfs.

Under submerged inlet and submerged outlet conditions, H=2 ft. and the outlet flow capacity using the above equation is 16.6 cfs, which exceeds the 10 cfs minimum pond inflow requirement.

The second critical flow condition is orifice controlled partial flow. This condition is illustrated by a submerged inlet and a free fall outlet. This condition can be defined by a capacity equation given as:

$$q = aC\sqrt{2gh}$$

Where:

q=flow capacity (cfs)
a=conduit cross-sectional area ($ft^2$)
C=coefficient for a sharp-edged orifice (0.6)
g=acceleration due to gravity (32 ft/$s^2$)
h= head to the center of the orifice (ft.)

$$q = \pi (1)^2 * 0.6 * \sqrt{2*32*1}$$

q=15.1 cfs

Under the conditions of orifice controlled partial flow, a 24-inch diameter culvert is acceptable since $q_{outflow}$ (15.1 cfs) is greater than the required $q_{inflow}$ (10.0 cfs). The value of h=1 foot is the minimum value for a 24" culvert under the specified condition. As h increases, the outflow capacity increases, which continues to satisfy the condition of outflow capacity > inflow capacity.

**Ameren Missouri Labadie Energy Center**
**Proposed Utility Waste Landfill**
**Flood Elevation vs. Fill Volumes**

**Appendix Y(d)**
**January 2013**

| Cell | 100-yr Flood Elevation (ft) | Required CCP Elevation (ft) | Mean EL. Cell Floor | Floor Area (acres) | Area at 480 EL. (acres) | Volume to Fill Cell (cy) | Time to Fill with Varying Daily Disposal Rates (days) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1,000 CY/day | 2,000 CY/day | 4,000 CY/day | 8,000 CY/day | 10,000 CY/day |
| 1 | 484 | 478.5 | 471.1 | 24.9 | 27.0 | 311,000 | 311 | 156 | 78 | 39 | 32 |
| 2 | 484 | 478.5 | 471.5 | 31.2 | 33.8 | 368,000 | 368 | 184 | 92 | 46 | 37 |
| 3 | 484 | 478.5 | 471.2 | 46.9 | 51.3 | 578,000 | 578 | 289 | 145 | 73 | 58 |
| 4 | 484 | 478.5 | 471.5 | 37.7 | 40.8 | 444,000 | 444 | 222 | 111 | 56 | 45 |

**Notes**

Volumes are estimates only, based on:

- Areas from permit drawings.
- The mean cell floor elevations were determined from CADD surfaces.
- Cell fill volumes were estimated using the average-end-area method.
- For the purposes of this table, it was estimated that the minimum CCP elevation to prevent hydrostatic uplift of the liner is 478.5 ft.
- For the purposes of this table, the cell areas at 478.5 ft and 480 ft are considered equivalent.

# Appendix Y(e)

## Geosynthetic Design Calculations

**Ameren Missouri Labadie Power Plant**
**Utility Waste Landfill**
**Franklin County, Missouri**
**January 2013**

# Appendix Y(e)
# Geosynthetics Design Calculations

The following anchor trench and slope stability design is based on three-foot horizontal to one-foot vertical slope utilizing a 60-mil HDPE textured geomembrane, a 250-mil Geocomposite with double sided 6 ounce per square yard non-woven needlepunched geotextile, and a 40-mil geomembrane. The calculations were performed through use of the equations provided in the book "Designing with Geosynthetics". Three conditions were analyzed: bottom liner slope stability, anchor trench design for the utility waste landfill's bottom liner and internal tensile stress within the bottom liner side slope layers.

Reference:


1. Koerner, R.M., Designing with Geosynthetics, 5th Edition, Prentice Hall, Upper Saddle River, New Jersey, 2005
2. Koerner, R.M., Designing with Geosynthetics, 2nd Edition, Prentice Hall, Upper Saddle River, New Jersey, 1990
3. Coduto, D.P., Geotechnical Engineering Principles and Practices, Prentice Hall, Upper Saddle River, New Jersey, 1999
4. Held, R.J., Soil Survery of Franklin County, Missouri, United States Department of Agriculture: Soil Conservation Service, 1989
5. *GSE HD Smooth Geomembrane*; Product Data Sheet; GSE Lining Technology, LLC: Houston, TX, REV 5MAR2012.
6. *GSE HD Textured Geomembrane*; Product Data Sheet; GSE Lining Technology, LLC: Houston, TX, REV 09APR2012.
7. *GSE FabriNet HF Geocomposite*; Product Data Sheet; GSE Lining Technology, LLC: Houston, TX, REV 01MAY2012.



Prepared by:
GREDELL Engineering Resources, Inc.

January 2013

## Appendix Y(e) Notes

**Slope Stability of Liner, Anchor Trench Pullout, and Liner Layer Stress Calculation**

Calculations Required:

1. Failure due to sliding of leachate collection protective cover.
2. Failure due to anchor trench pullout of geomembrane and geocomposite.
3. Failure due to tensile stress in liner layers.

1. Side Slope Cover Material Stability on 3(H):1(V) Slope

From Koerner (5th Edition) the stability of the system is achieved if all interface friction angles (δ) are greater than the slope angle (β). The Factor of Safety (F.S.) will be determined by the use of Equation 5.22 (pg. 492, 5th Ed.) where δ is the lowest numerical interface friction angle. Interface friction angles are taken from Table 5.6, Koerner, 2nd Edition, and Table 5.7, Koerner, 5th Edition.

$\beta = \tan^{-1}(\frac{1}{3}) = 18.43^{\circ}$

$$F.S. = \frac{\tan\delta}{\tan\beta}$$

$\delta_{clay\text{-}geomembrane} = 26^{\circ} > 18.43^{\circ}$

$\delta_{geomembrane\text{-}geotextile} = 32^{\circ} > 18.43^{\circ}$

$\delta_{geotextile\text{-}protectivecover} = 30^{\circ} > 18.43^{\circ}$

$$F.S. = \frac{\tan 26^{\circ}}{\tan 18.43^{\circ}} = 1.5$$

**The slope is stable with a F.S. of 1.5.**

2. Anchor Trench Depth and Runout Calculations

Check design detail to determine if proposed runout and anchor trench depth provides adequate F.S.

Koerner gives detailed equations for calculating required depth and runout on pgs. 500-506 (5th Ed.). Rearranging Eq. 5.26, one can solve for runout length ($L_{RO}$), anchor trench depth ($d_{AT}$), or allowable stress ($T_{allow}$). The allowable stress was solved for and input to a spreadsheet to expedite calculations. The equation was used as follows:

$$T_{allow} = \frac{d^{AT}[0.5 * \gamma_{AT}(K_P - K_A)] + d_{AT}[\sigma(K_P - K_A)] + L_{RO}[\sigma_n(\tan\delta_u + \tan\delta_L)]}{[\cos\beta - \sin\beta\tan\delta_L]}$$

Attached to these calculations are printouts of the inputs and results for this calculation.

In order to determine certain friction angles some assumptions were made about the material to be used for berm construction which affects the anchor trench soil as well as the cover soil on top of the liner runout. It was assumed that stock piled soil from the top 18 inches of onsite soil would be used.

Onsite soils are predominately Blake-Waldron Complex classification as determined using the cares website. USDA soil survey of Franklin County, Missouri (1989) defines Blake-Waldron as CL, CL-CH soil with plasticity indices ranging from 10-45 within the top 24", giving an average of approximately 26.0. For calculation purposes $P_I$ was chosen to be 30.0. Using Fig. 13.17 from Coduto (pg. 489), this gives an effective friction angle of approximately 27°. This soil will also have a compacted unit weight of approximately 115 $lb/ft^3$.

The interface friction angle between the geomembrane and the material directly above and below it must be taken from published data until more site specific data are known. $\delta_L$ for the geomembrane-CCL inferface will be selected from Table 5.6 from Koener 2nd Edition. Detail 5/17 on Sheet 17 shows the geometry of the designed anchor trench and runout.

To determine if the liner or geocomposite will pullout of the anchor trench the calculated $T_{allow}$ was compared to the $T_{Design}$ obtained from the manufacturer's specifications. If $T_{allow} > T_{Design}$ the liner (or composite) will yield before anchor trench pullout occurs.

For 60 mil textured HDPE Geomembrane:

$$T_{Design} = 22 \text{ kN/m}$$
$$T_{allow} = 44.88 \text{ kN/m}$$
$$T_{allow} > T_{Design}, \text{ therefore no pullout}$$

$$\text{F.S.} = \frac{T_{allow}}{T_{Design}} = 2.0$$

For 250 mil Geocomposite with 6 oz/sq yd non-woven, needle-punched Geotextile:

$$T_{Design} = 9.60 \text{ kN/m}$$
$$T_{allow} = 49.31 \text{ kN/m}$$
$$T_{allow} > T_{Design}, \text{ therefore no pullout}$$

$$\text{F.S.} = \frac{T_{allow}}{T_{Design}} = 5.1$$

3. Tensile Stress Calculations within Liner Layers

$N = W\cos(\beta)$

$W = W_C - T_C$

$$\beta = slopeangle = \tan^{-1}(1/3) = 18.43°$$

$H_C = HeightofCover = 2.0'$

$L_S = LengthofSlope = 53.8'$

$\gamma_c = 130 pcf$

$\phi = 26°$

$W_C = H_c L_s \gamma_c$

$Tc = \sigma_H \tan\phi H_C = K_0 \sigma_U (\tan\phi) H_C$

Tc = (1-sin(26))(2')(130 pcf)(2')(tan(26))= 142 lb/ft
Wc = (2')(53.8')(130 pcf) = 14,000 lb/ft

W = 14,000 – 142 = 13,858 lb/ft
N = 13,858*cos(18.43) = 13,147 lb/ft

**a.) Shear Forces in Geocomposite**

$F_{above} = N * \tan(\delta_u)$

$F_{below} = N * \tan(\delta_L)$

$F_a = (13{,}147)\tan 25 = 6130.5 lb/ft$

$F_b = (13{,}147)\tan 32 = 8215.2 lb/ft$

Therefore Geocomposite is not in tension

**b.) Shear Forces in Geomembrane**

$F_{above} = F_{belowfromcomposite} = 8215.2 lb/ft$

$F_{below} = N \tan\delta_u = (13{,}147)\tan 26 = 6412.2 lb/ft$

$F_{above} > F_{below}$

Therefore the Geomembrane is in tension

$\sigma_{n,\max} = (\gamma_{ccp})(H_{ccp}) = (134 pcf)(100') = 13{,}400 psf = 93.1 psi$

$\sigma_{all,membrane} = \frac{131 lb/in}{0.06 in} = 2138 psi$

F.S.= $\frac{\sigma_{all}}{\sigma_{\max}} = \frac{2183}{93.1} = 23.4$

Therefore the geomembrane is acceptable.

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| | |
|---|---|
| Date: JAN 2013 | Page No: 1 of 2 |
| Client: REITZ & JENS | |
| Prepared By: M | Checked By: BD |
| Project: AMEREN MISSOURI LABADIE | |
| Subject: SLOPE STABILITY OF COVER, ANCHOR TRENCH PULLOUT AND COVER STRESS | |

THESE CALCULATIONS FOR THE GEOSYNTHETICS IN THE COVER ARE SUPPLEMENTAL TO THOSE FOR THE LINER. THEY APPLY THE SAME METHODS.

① SIDE SLOPE COVER MATERIAL STABILITY

THE PREVIOUSLY CALCULATED SLOPE ANGLE IS 18.43°.

THE CCP IS ASSUMED TO BE SIMILAR TO SAND FOR THE PURPOSE OF ESTIMATING THE FRICTION ANGLE BETWEEN IT AND THE GEOMEMBRANE.

$$\delta_{GEOMEMBRANE-CCP} = 22^\circ > 18.43^\circ$$

(SAND FRICTION ANGLE ~ 30°)

$$F.S. = \frac{\tan 22^\circ}{\tan 18.43^\circ} = 1.2$$

$$\frac{\tan 30^\circ}{\tan 18.43^\circ} = 1.7$$

② ANCHOR TRENCH DEPTH AND RUNOUT

ANCHOR TRENCH AND RUNOUT CALCULATIONS WERE PREVIOUSLY CONDUCTED FOR 60-MIL HDPE. THE SAME METHODS WERE APPLIED TO THE 40-MIL GEOMEMBRANE [SEE ATTACHED PRINTOUT]

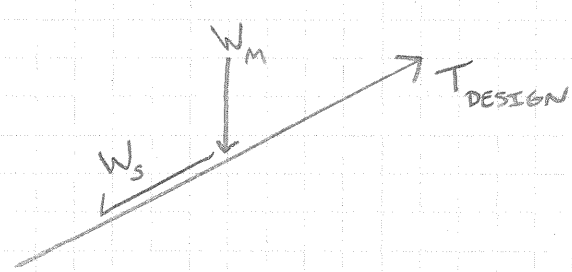
$$T_{ALLOW} = 24.72 \text{ kN/m}$$

$$T_{DESIGN} = 15 \text{ kN/m}$$

$$T_{ALLOW} > T_{DESIGN}$$

$$F.S. = \frac{24.72 \text{ kN/m}}{15 \text{ kN/m}} = 1.6$$

THE LENGTH OF THE GEOMEMBRANE MUST BE SHORT ENOUGH SO ITS WEIGHT DOES NOT PULL OUT OF THE TRENCH

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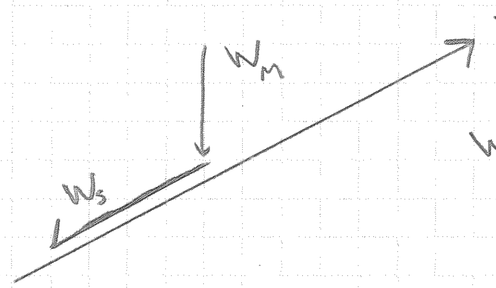


$W_S \leq T_{DESIGN}$

$$W_S = W_M \sin 18.43^\circ$$

$$W_M = \gamma t L$$

$$\approx 59 \text{ pcf} (40 \text{ mil}) \left( \frac{1 \text{ ft}}{12{,}000 \text{ mil}} \right) = (0.2 \text{ psf}) L$$

$$W_S = (0.2 \text{ psf}) L (\sin 18.43^\circ) = (0.06 \text{ psf}) L$$

$$T_{DESIGN} = 15{,}000 \text{ N/m} \left( \frac{1 \text{ lb}}{4.448222 \text{ N}} \right) \left( \frac{0.3048 \text{ m}}{\text{ft}} \right)$$

$$T_{DESIGN} = 1028 \text{ lb/ft}$$

$$(0.06 \text{ psf}) L \leq 1028 \text{ lb/ft}$$

$$\boxed{L \leq 17{,}133 \text{ ft}}$$

## Ameren Missouri
## Labadie Energy Center UWL
## Anchor Trench & Runout Calculations for 40 mil Geomembrane

| Design Data & Material Properties | |
|---|---|
| Allowable Stress in Geosynthetic (kPa), $\sigma_{ALLOW}$ | 14,763.8 |
| Thickness of Geosynthetic (m), $t_g$ | 0.0010 |
| Side Slope Ratio (V:H), 1: | 3.00 |
| Side Slope Angle (degrees), $\beta$ | 18.43 |
| Angle of Shearing Resistance between Geosynthetic & adjacent material BELOW Geosynthetic (degrees), $\delta_L$ | 22.00 |
| Angle of Shearing Resistance between Geosynthetic & adjacent material ABOVE Geosynthetic (degrees), $\delta_U$ | 0.00 |
| Unit Weight of Runout Cover Material (kN/m$^3$), $\gamma_{CM}$ | 18.07 |
| Thickness of Runout Cover Material (m), $t_{CM}$ | 0.61 |
| Applied Normal Stress from Cover Material (kPa), $\sigma_n$ | 11.02 |
| Unit Weight of Soil in Anchor Trench (kN/m$^3$), $\gamma_{AT}$ | 18.07 |
| Angle of Shearing Resistance of Fill Soil in Trench (degrees), $\Phi_A$ (Typically the same as $\Phi_P$) | 22.00 |
| Angle of Shearing Resistance of Soil in Trench Wall (degrees), $\Phi_P$ (Typically the same as $\Phi_A$) | 22.00 |
| Allowable Force in Geosynthetic (kN/m), $T_{DESIGN}$ | 15.00 |
| Active Earth Pressure from Trench Fill, $K_A$ | 0.45 |
| Passive Earth Pressure from Trench Wall, $K_P$ | 2.20 |

| Calculate Length of Runout ($L_{RO}$) for Given Depth of Anchor Trench ($d_{AT}$) | |
|---|---|
| Depth of Anchor Trench (m), $d_{AT}$ | |
| Length of Geosynthetic Runout Required (m), $L_{RO}$ | 0.00 |

| Calculate Depth of Anchor Trench ($d_{AT}$) for Given Length of Runout ($L_{RO}$) | |
|---|---|
| Length of Geosynthetic Runout (m), $L_{RO}$ | |
| Depth of Anchor Trench Required (m), $d_{AT}$ | 0.00 |

| Calculate Allowable Force in Geosynthetic and Factor of Safety | |
|---|---|
| Length of Geosynthetic Runout (m), $L_{RO}$ | 0.61 |
| Depth of Anchor Trench (m), $d_{AT}$ | 0.61 |
| Allowable Force in Geosynthetic (kN/m), $T_{ALLOW}$ | 24.72 |
| Factor of Safety, F.S. | 1.6 |

# Ameren Missouri
# Labadie Energy Center UWL
# Anchor Trench & Runout Calculations for 60 mil Geomembrane

| Design Data & Material Properties | |
|---|---|
| Allowable Stress in Geosynthetic (kPa), $\sigma_{ALLOW}$ | 15,333.3 |
| Thickness of Geosynthetic (m), $t_g$ | 0.0015 |
| Side Slope Ratio (V:H), 1: | 3.00 |
| Side Slope Angle (degrees), β | 18.43 |
| Angle of Shearing Resistance between Geosynthetic & adjacent material BELOW Geosynthetic (degrees), $\delta_L$ | 26.00 |
| Angle of Shearing Resistance between Geosynthetic & adjacent material ABOVE Geosynthetic (degrees), $\delta_U$ | 0.00 |
| Unit Weight of Runout Cover Material (kN/m$^3$), $\gamma_{CM}$ | 18.07 |
| Thickness of Runout Cover Material (m), $t_{CM}$ | 0.91 |
| Applied Normal Stress from Cover Material (kPa), $\sigma_n$ | 16.52 |
| Unit Weight of Soil in Anchor Trench (kN/m$^3$), $\gamma_{AT}$ | 18.07 |
| Angle of Shearing Resistance of Fill Soil in Trench (degrees), $\Phi_A$ (Typically the same as $\Phi_P$) | 27.00 |
| Angle of Shearing Resistance of Soil in Trench Wall (degrees), $\Phi_P$ (Typically the same as $\Phi_A$) | 27.00 |
| Allowable Force in Geosynthetic (kN/m), $T_{DESIGN}$ | 23.00 |
| Active Earth Pressure from Trench Fill, $K_A$ | 0.38 |
| Passive Earth Pressure from Trench Wall, $K_P$ | 2.66 |

| Calculate Length of Runout ($L_{RO}$) for Given Depth of Anchor Trench ($d_{AT}$) | |
|---|---|
| Depth of Anchor Trench (m), $d_{AT}$ | |
| Length of Geosynthetic Runout Required (m), $L_{RO}$ | 0.00 |

| Calculate Depth of Anchor Trench ($d_{AT}$) for Given Length of Runout ($L_{RO}$) | |
|---|---|
| Length of Geosynthetic Runout (m), $L_{RO}$ | |
| Depth of Anchor Trench Required (m), $d_{AT}$ | 0.00 |

| Calculate Allowable Force in Geosynthetic and Factor of Safety | |
|---|---|
| Length of Geosynthetic Runout (m), $L_{RO}$ | 0.61 |
| Depth of Anchor Trench (m), $d_{AT}$ | 0.61 |
| Allowable Force in Geosynthetic (kN/m), $T_{ALLOW}$ | 44.88 |
| Factor of Safety, F.S. | 2.0 |

Prepared By:
GREDELL Engineering Resources, Inc.

January 2013

## Ameren Missouri
## Labadie Energy Center UWL
## Anchor Trench & Runout Calculations for 250 mil Geocomposite

| Design Data & Material Properties | |
|---|---|
| Allowable Stress in Geosynthetic (kPa), $\sigma_{ALLOW}$ | 1,523.8 |
| Thickness of Geosynthetic (m), $t_g$ | 0.0063 |
| Side Slope Ratio (V:H), 1: | 3.00 |
| Side Slope Angle (degrees), $\beta$ | 18.43 |
| Angle of Shearing Resistance between Geosynthetic & adjacent material BELOW Geosynthetic (degrees), $\delta_L$ | 32.00 |
| Angle of Shearing Resistance between Geosynthetic & adjacent material ABOVE Geosynthetic (degrees), $\delta_U$ | 0.00 |
| Unit Weight of Runout Cover Material (kN/m$^3$), $\gamma_{CM}$ | 18.07 |
| Thickness of Runout Cover Material (m), $t_{CM}$ | 0.91 |
| Applied Normal Stress from Cover Material (kPa), $\sigma_n$ | 16.52 |
| Unit Weight of Soil in Anchor Trench (kN/m$^3$), $\gamma_{AT}$ | 18.07 |
| Angle of Shearing Resistance of Fill Soil in Trench (degrees), $\Phi_A$ (Typically the same as $\Phi_P$) | 27.00 |
| Angle of Shearing Resistance of Soil in Trench Wall (degrees), $\Phi_P$ (Typically the same as $\Phi_A$) | 27.00 |
| Allowable Force in Geosynthetic (kN/m), $T_{DESIGN}$ | 9.60 |
| Active Earth Pressure from Trench Fill, $K_A$ | 0.38 |
| Passive Earth Pressure from Trench Wall, $K_P$ | 2.66 |

| Calculate Length of Runout ($L_{RO}$) for Given Depth of Anchor Trench ($d_{AT}$) | |
|---|---|
| Depth of Anchor Trench (m), $d_{AT}$ | |
| Length of Geosynthetic Runout Required (m), $L_{RO}$ | 0.00 |

| Calculate Depth of Anchor Trench ($d_{AT}$) for Given Length of Runout ($L_{RO}$) | |
|---|---|
| Length of Geosynthetic Runout (m), $L_{RO}$ | |
| Depth of Anchor Trench Required (m), $d_{AT}$ | 0.00 |

| Calculate Allowable Force in Geosynthetic and Factor of Safety | |
|---|---|
| Length of Geosynthetic Runout (m), $L_{RO}$ | 0.61 |
| Depth of Anchor Trench (m), $d_{AT}$ | 0.61 |
| Allowable Force in Geosynthetic (kN/m), $T_{ALLOW}$ | 49.31 |
| Factor of Safety, F.S. | 5.1 |

PRODUCT DATA SHEET

# GSE HD Smooth Geomembrane

METRIC

GSE HD is a smooth high density polyethylene (HDPE) geomembrane manufactured with the highest quality resin specifically formulated for flexible geomembranes. This product is used in applications that require excellent chemical resistance and endurance properties.

[*]

**AT THE CORE:**
**An HDPE geomembrane used in applications that require excellent chemical resistance and endurance properties.**

## Product Specifications

These product specifications meet GRI GM 13

| Tested Property | Test Method | Frequency | Minimum Average Value | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0.75 mm | 1.00 mm | 1.50 mm | 2.00 mm | 2.50 mm |
| Thickness, (minimum average), mm<br>Lowest individual reading | ASTM D 5199 | every roll | 0.750<br>0.675 | 1.00<br>0.90 | 1.50<br>1.35 | 2.00<br>1.80 | 2.50<br>2.25 |
| Density, g/cm³ | ASTM D 1505 | 90,000 kg | 0.940 | 0.940 | 0.940 | 0.940 | 0.940 |
| Tensile Properties (each direction)<br>Strength at Break, N/mm<br>Strength at Yield, N/mm<br>Elongation at Break, %<br>Elongation at Yield, % | ASTM D 6693, Type IV<br>Dumbbell, 50 mm/min<br><br>G.L. 50 mm<br>G.L. 33 mm | 9,000 kg | <br>20<br>11<br>700<br>12 | <br>27<br>15<br>700<br>12 | <br>40<br>22<br>700<br>12 | <br>53<br>29<br>700<br>12 | <br>67<br>37<br>700<br>12 |
| Tear Resistance, N | ASTM D 1004 | 20,000 kg | 93 | 125 | 187 | 249 | 311 |
| Puncture Resistance, N | ASTM D 4833 | 20,000 kg | 240 | 320 | 480 | 640 | 800 |
| Carbon Black Content, % (Range) | ASTM D 1603*/4218 | 9,000 kg | 2.0 - 3.0 | 2.0 - 3.0 | 2.0 - 3.0 | 2.0 - 3.0 | 2.0 - 3.0 |
| Carbon Black Dispersion | ASTM D 5596 | 20,000 kg | Note(1) | Note(1) | Note(1) | Note(1) | Note(1) |
| Notch Constant Tensile Load, hr | ASTM D 5397, Appendix | 90,000 kg | 300 | 300 | 300 | 300 | 300 |
| Oxidative Induction Time, min | ASTM D 3895, 200°C; $O_2$, 1 atm | 90,000 kg | >100 | >100 | >100 | >100 | >100 |
| TYPICAL ROLL DIMENSIONS | | | | | | | |
| Roll Length(2), m | | | 341 | 265 | 171 | 131 | 104 |
| Roll Width(2), m | | | 6.86 | 6.86 | 6.86 | 6.86 | 6.86 |
| Roll Area, m² | | | 2,341 | 1,819 | 1,171 | 899 | 711 |

NOTES:
- (1)Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (2)Roll lengths and widths have a tolerance of ±1%.
- GSE HD Smooth is available in rolls weighing approximately 1,800 kg.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

[ DURABILITY RUNS DEEP ] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

PRODUCT DATA SHEET

# GSE HD Textured Geomembrane

## METRIC

GSE HD Textured is a co-extruded textured high density polyethylene (HDPE) geomembrane available on one or both sides. It is manufactured from the highest quality resin specifically formulated for flexible geomembranes. This product is used in applications that require increased frictional resistance, excellent chemical resistance and endurance properties.

[*]

**AT THE CORE:**
**An HDPE geomembrane used in applications that require increased frictional resistance, excellent chemical resistance and endurance properties.**

### Product Specifications

These product specifications meet GRI GM13

| Tested Property | Test Method | Frequency | Minimum Average Value | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0.75 mm | 1.00 mm | 1.50 mm | 2.00 mm | 2.50 mm |
| Thickness, (minimum average), mm<br>Lowest individual reading | ASTM D 5994 | every roll | 0.750<br>0.675 | 1.00<br>0.90 | 1.50<br>1.35 | 2.00<br>1.80 | 2.50<br>2.25 |
| Density, g/cm³ , (min.) | ASTM D 1505 | 90,000 kg | 0.940 | 0.940 | 0.940 | 0.940 | 0.940 |
| Tensile Properties (each direction)<br>Strength at Break, N/mm<br>Strength at Yield, N/mm<br>Elongation at Break, %<br>Elongation at Yield, % | ASTM D 6693, Type IV<br>Dumbbell, 50 mm/min<br><br>G.L. 50 mm<br>G.L. 33 mm | 9,000 kg | <br>8<br>11<br>100<br>12 | <br>10<br>15<br>100<br>12 | <br>16<br>22<br>100<br>12 | <br>21<br>29<br>100<br>12 | <br>26<br>37<br>100<br>12 |
| Tear Resistance, N | ASTM D 1004 | 20,000 kg | 93 | 125 | 187 | 249 | 311 |
| Puncture Resistance, N | ASTM D 4833 | 20,000 kg | 200 | 267 | 400 | 534 | 667 |
| Carbon Black Content, % (Range) | ASTM D 1603*/4218 | 9,000 kg | 2.0 - 3.0 | 2.0 - 3.0 | 2.0 - 3.0 | 2.0 - 3.0 | 2.0 - 3.0 |
| Carbon Black Dispersion | ASTM D 5596 | 20,000 kg | Note(1) | Note(1) | Note(1) | Note(1) | Note(1) |
| Asperity Height, mm | ASTM D 7466 | second roll | 0.40 | 0.45 | 0.45 | 0.45 | 0.45 |
| Notch Constant Tensile Load(2), hr | ASTM D 5397, Appendix | 90,000 kg | 300 | 300 | 300 | 300 | 300 |
| Oxidative Induction Time, min | ASTM D 3895, 200°C; $O_2$, 1 atm | 90,000 kg | >100 | >100 | >100 | >100 | >100 |
| TYPICAL ROLL DIMENSIONS | | | | | | | |
| Roll Length(3), m | Double-Sided Textured<br>Single-Sided Textured | | 253<br>308 | 213<br>238 | 158<br>165 | 122<br>125 | 101<br>101 |
| Roll Width(3), m | | | 6.86 | 6.86 | 6.86 | 6.86 | 6.86 |
| Roll Area, m² | Double-Sided Textured<br>Single-Sided Textured | | 1,736<br>2,113 | 1,461<br>1,633 | 1,084<br>1,132 | 837<br>858 | 693<br>693 |

NOTES:
- (1)Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (2)NCTL for GSE HD Textured is conducted on representative smooth geomembrane samples.
- (3)Roll lengths and widths have a tolerance of ±1%.
- GSE HD Textured is available in rolls weighing approximately 1,800 kg.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

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[ DURABILITY RUNS DEEP ] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

PRODUCT DATA SHEET

# GSE FabriNet HF Geocomposite

METRIC

GSE FabriNet HF geocomposite consists of a 6.3 mm thick GSE HyperNet HF geonet heat-laminated on one or both sides with a GSE nonwoven needle-punched geotextile. The geotextile is available in mass per unit area range of 200 g/m² to 540 g/m². The geocomposite is designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions.

[*]

**AT THE CORE:**
**A 6.3 mm thick GSE HyperNet HF geonet heat-laminated on one or both sides with a nonwoven needle-punched geotextile.**

## Product Specifications

| Tested Property | Test Method | Frequency | Minimum Average Roll Value | | |
|---|---|---|---|---|---|
| **Geocomposite** | | | 200 g/m² | 270 g/m² | 335 g/m² |
| Transmissivity(2), m²/sec<br>Double-Sided Composite<br>Single-Sided Composite | ASTM D 4716 | 1/50,000 m² | <br>$5 \times 10^{-4}$<br>$1.5 \times 10^{-3}$ | <br>$5 \times 10^{-4}$<br>$1.5 \times 10^{-3}$ | <br>$3 \times 10^{-4}$<br>$1 \times 10^{-3}$ |
| Ply Adhesion, g/cm | ASTM D 7005 | 1/4,600 m² | 178 | 178 | 178 |
| **Geonet Core(3) – GSE HyperNet HF** | | | | | |
| Transmissivity(2), m²/sec | ASTM D 4716 | | $3 \times 10^{-3}$ | $3 \times 10^{-3}$ | $3 \times 10^{-3}$ |
| Density, g/cm³ | ASTM D 1505 | 1/4,600 m² | 0.94 | 0.94 | 0.94 |
| Tensile Strength (MD), N/mm | ASTM D 5035/7179 | 1/4,600 m² | 9.6 | 9.6 | 9.6 |
| Carbon Black Content, % | ASTM D 1603(6)/4218 | 1/4,600 m² | 2.0 | 2.0 | 2.0 |
| **Geotextile(3,4)** | | | | | |
| Mass per Unit Area, g/m² | ASTM D 5261 | 1/8,300 m² | 200 | 270 | 335 |
| Grab Tensile, N | ASTM D 4632 | 1/8,300 m² | 710 | 975 | 1,155 |
| Puncture Strength, N | ASTM D 4833 | 1/8,300 m² | 395 | 525 | 725 |
| AOS, US sieve(1) (mm) | ASTM D 4751 | 1/50,000 m² | 0.212 | 0.180 | 0.150 |
| Permittivity, (sec⁻¹) | ASTM D 4491 | 1/50,000 m² | 1.5 | 1.3 | 1.0 |
| Flow Rate, lpm/m² | ASTM D 4491 | 1/50,000 m² | 4,480 | 3,865 | 3,050 |
| UV Resistance, % retained | ASTM D 4355<br>(after 500 hours) | once per<br>formulation | 70 | 70 | 70 |
| NOMINAL ROLL DIMENSIONS | | | | | |
| Geonet Core Thickness, mm | ASTM D 5199 | 1/4,600 m² | 6.3 | 6.3 | 6.3 |
| Roll Width(5), m | | | 4.5 | 4.5 | 4.5 |
| Roll Length(5), m | Double-Sided Composite<br>Single-Sided Composite | | 70.1<br>79.2 | 64.0<br>79.2 | 64.0<br>76.2 |
| Roll Area, m² | Double-Sided Composite<br>Single-Sided Composite | | 321<br>362 | 293<br>362 | 293<br>348 |

**[Product specifications continued on back]**

[*]

**AT THE CORE:**
**A 250 mil thick HyperNet HF geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.**

## Product Specifications [continued]

NOTES:

- [1]AOS in mm is a maximum average roll value.
- [2]Gradient of 0.1, normal load of 10,000 psf, water at 70˚F between steel plates for 15 minutes. Contact GSE for performance transmissivity value for use in design.
- [3]Component properties prior to lamination.
- [4]Refer to geotextile product data sheet for additional specifications.
- [5]Roll widths and lengths have a tolerance of \1%.
- [6]Modified.

# Appendix Z

Groundwater Demonstration

REPORT
2008012455

# AMEREN MISSOURI LABADIE ENERGY CENTER
# UTILITY WASTE LANDFILL (UWL)
# SOLID WASTE DISPOSAL AREA
# FRANKLIN COUNTY, MISSOURI

## APPENDIX Z
## DEMONSTRATION: BASE OF UTILITY WASTE LANDFILL LINER IN INTERMITTENT CONTACT WITH GROUND WATER

Prepared for

Ameren
MISSOURI

Prepared by

REITZ & JENS, INC.
CONSULTING ENGINEERS

STATE OF MISSOURI
JEFFREY LYNN FOUSE
NUMBER E-21043
REGISTERED PROFESSIONAL ENGINEER

11/21/2012

November 2012

The Professional whose signature and personal seal appear hereon assumes responsibility only for what appears in the attached report and disclaims (pursuant to Section 327.411 RSMo) any responsibility for all other plans, estimates, specifications, reports, or other documents or instruments not sealed by the undersigned Professional relating to or intended to be used for any part or parts of the project to which this report refers.

# APPENDIX Z
# DEMONSTRATION: BASE OF UTILITY WASTE LANDFILL LINER IN INTERMITTENT CONTACT WITH GROUND WATER

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# DEMONSTRATION: BASE OF A UTILITY WASTE LANDFILL LINER IN INTERMITTENT CONTACT WITH GROUND WATER

## 1.0 INTRODUCTION

The Missouri Solid Waste Management Rules for utility waste disposal (reference Chapter 11, Utility Waste Landfill) were effective on July 30, 1997, in response to statutory changes to the Missouri Solid Waste Management Law. The statutory changes were intended to distinguish the physical and chemical characteristics of utility waste from the sanitary and demolition wastes that were the focus of the original solid waste management Rules (reference Chapter 3, Sanitary Landfill, and Chapter 4, Demolition Landfill), as well as to address other unique issues of the electric power generation industry. Chapter 11 is patterned after Chapter 3 and Chapter 4, which were originally created in 1973 in response to the new Missouri Solid Waste Management Law.

10 CSR 80-11.010(1) General Provisions, states the overall intent of the rule, stating in part:

> This rule is intended to provide for utility waste landfill operations that will have minimal impact on the environment. The rule sets forth requirements and the method of satisfactory compliance to ensure that the design, construction and operation of utility waste landfills will protect the public health, prevent nuisances and meet applicable environmental standards. *The requirement subsections contained in this rule delineate minimum levels of performance required of any utility waste landfill operation. The satisfactory compliance subsections are presented as the authorized methods by which the objectives of the requirements can be realized. The satisfactory compliance subsections are based on the practice of landfilling utility waste. If techniques other than those listed as satisfactory compliance in design or operation are used, it is the obligation of the utility waste landfill owner/operator to demonstrate to the department in advance that the techniques to be employed will satisfy the requirements.* Procedures for the techniques shall be submitted to the department in writing and approved by the department in writing prior to being employed. [*emphasis added*]

Ameren Missouri recognizes that, if they choose to "...utilize techniques other than those listed as satisfactory compliance in the design and operation..." of the utility waste landfill, they must "...demonstrate to the department in advance that the techniques to be employed will satisfy the requirements..."

The Missouri Department of Natural Resources' rules for utility waste landfills (UWL) stipulate in 10 CSR 80-11.010(4)(B)6 that:

> If the base of the landfill liner will be in contact with ground water, the applicant shall demonstrate to the department's satisfaction that the ground water will not adversely impact the liner.

In addition, 10 CSR 80-11.010(8)(B)1.C requires that the plans shall include:

> Ground water elevation and proposed separation between the lowest point of the lowest cell and the predicted maximum water table elevation;

The lowest point of the base of the clay liner for the cells will be at el. 466, which is 2 feet above the "natural water table" as defined in the following section. The bottom of the clay liner in the lowest sumps will probably be in intermittent contact with the ground water. In accordance with 10 CSR 80-11.010(1), this document has been prepared to demonstrate that the ground water intermittent contact will not adversely impact the compacted clay liner in the sumps, per 10 CSR 80-11.010(4)(B)6, based upon the interpretation that this regulation is applicable to the sumps because they are integral with the cells.

It is the objective of this report to provide the technical and regulatory basis for:

- demonstrating the impacts of an intermittent high ground water table on the composite bottom liner (specifically the bottom compacted clay liner and the HDPE membrane liner on top of the compacted clay liner) are negligible;
- evaluating the environmental impact of this site condition on the projected use of the UWL; and
- demonstrating that the characteristics of the compacted clay liner and the proper design of the UWL will continue to function as designed in compliance with the intent of the 10 CSR 80-11.010 to minimize environmental hazards and comply with applicable ground water and surface water quality standards and requirements throughout the life and post-closure of the UWL.

Section 2.0 of this report provides a summary discussion of the technical basis of the structural and hydraulic engineering properties of compacted clay liners (CCLs) and the potential impact to CCLs from intermittent contact with ground water in the protection of surface water and ground water quality. Section 3.0 provides an overview of the impact to the environmental protections provided to surface water and ground water by the utility waste landfill's CCL under intermittent contact with the unconfined ground water. Finally, Section 4.0 identifies the specific requirements of 10 CSR 80-11.010 that potentially require demonstration of satisfactory compliance with the requirements of the Utility Waste Landfill design and operational standards.

## 1.1 Brief Project Description

The Labadie UWL will be developed on property contiguous with the boundary of property upon which the Labadie Energy Center is situated, on the right descending (south) overbank area of the Missouri River between River Miles 56.88 and 57.38. The existing ground surface ranges from about el. 471 to el. 465[1] below the current footprint of the UWL. The areas of lower ground surface elevations (below about el. 464) located in the southeast region of the site have been excluded from the proposed developed area of the UWL.

The proposed UWL is located in the alluvial deposits adjacent to the Missouri River. As demonstrated in the Detailed Site Investigation (DSI) for this project[2] the ground water levels are strongly influenced by

[1] Elevations herein refer to the North American Vertical Datum of 1988 (NAVD88) which is the datum used in FEMA's new Flood Insurance Rate Maps (FIRM). NAVD88 corrects many of the problems with the earlier NGVD of 1929.
[2] *Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri*, dated February 4, 2011, revised March 30, 2011. Approved by Missouri Department of Natural Resources, Division of Geology and Land Survey on April 8, 2011.

the Missouri River (see Appendix W or page 39 of DSI Report). Because the Missouri River is an "open river," that is not controlled by a dam in the vicinity of the Labadie Energy Center, the level of the Missouri River and hence the natural water table at the site are constantly changing. Therefore, the Natural Water Table is never under static hydrologic conditions.

The UWL site is currently protected from regular Missouri River flooding by the Labadie Bottom Levee District agricultural levee with heights at or near the 100-year flood elevation. In the unlikely event that the agricultural levee is overtopped or breached, the UWL site is further protected from direct Missouri River flood currents by the Labadie Energy Center itself which is upstream and higher than the 500-year flood elevation, creating a low velocity shadow, or ineffective flow area, over the entire UWL site. The regulatory 100-year base flood elevation (BFE) of 483.98 at the upstream end of the UWL site became effective on October 18, 2011. The 500-year flood elevation at this river station is reported by FEMA to be 487.55. By comparison, the flood crest at this location in August 1993 was about el. 483.6.

The Labadie UWL will be divided into four distinct internal drainage zones or cells. The lowest point of each drainage area is designed to be el. 468 (top of composite liner), while the highest point of each cell bottom will be el. 474 to 476 (top of composite liner). The majority of the UWL bottom is designed to have a minimum 1% slope and will have a "blanket drain" as a part of the leachate collection system. In addition to the blanket drain, each cell will have a 6-inch diameter collection pipe running generally perpendicular to the outside edge of the landfill at an approximate 0.5% slope.

Each collection pipe will discharge into a small leachate sump (approximate size 15 feet by 20 feet). The bottom of the composite clay liner in the sumps is designed to be at el. 463.0. With settlement, the bottom of the clay of the composite liner in the sumps is estimated to be at el. 462.2. The 15 sumps represent less than 0.15% of the entire UWL acreage. Additionally, the sumps will be gravel filled and are expected to have one to three feet of water in them under normal operating conditions.

## 2.0 TECHNICAL BASIS

In the 1980's through the mid-1990's, compacted clay liners and composite liners were the subject of significant research and technical discussion due to increasing regulatory requirements on industrial and municipal landfills. The base of knowledge regarding compacted clay liner was established on a national level and the technical requirements were widely adopted as 'state of the art' Missouri's current utility waste landfill requirements were adopted in the mid-1990's and closely follow the prevailing technical basis for compacted clay liners. The Labadie UWL utilizes a two-foot thick composite liner system (compacted clay liner overlain by a flexible membrane liner). An intermittent high ground water table will first come in contact with the bottom of the compacted clay liner in the sumps. Therefore, the focus of the technical discussion is on the lower compacted clay liner, not the upper flexible membrane liner.

### 2.1 Requirements of Compacted Clay Liner

The compacted clay liner must have the following characteristics (10 CSR 80-11.010(6)(B)):

1) For a composite liner, includes a lower component that consists of at least a 2-foot layer of compacted soil with a hydraulic conductivity (k) of no more than $1 \times 10^{-5}$ cm/sec., and compacted to 95% of standard Proctor (ASTM D699) maximum dry unit weight ($\gamma_{d,max}$)

with the moisture content at the time of compaction between optimum moisture content ($w_{opt}$) and 4% above $w_{opt}$, or within other ranges of density and moisture such that are shown to provide for the liner to have a $k \leq 1 x 10^{-5}$ cm/sec.

2) The soils used for the compacted clay liner shall have the following minimum specifications:
   A. Be classified as low plastic clay (CL), high plastic clay (CH) or sandy clay (SC).
   B. Have more than 30% particle sizes by weight passing U.S. #200 sieve (0.075mm).
   C. Have an Atterberg liquid limit (LL) $\geq$ 20%
   D. Have an Atterberg plasticity index (PI) $\geq$ 10%.

Daniel and Koerner (1993) reported that the degree of saturation of clay liners placed with this criteria ranges from 71% to 98%, and averages 85%. That is, the voids in the soil matrix may still contain some air as well as water. The technical questions in regard to the clay liner are: 1) If the GWT is above the bottom liner for a long enough time, could the compacted clay liner become saturated; and 2) what are the potential ramifications of the compacted clay liner becoming saturated? Frank et al (2005) reported that a compacted clay liner which had been under 0.31m of water for 14 years did not become fully saturated. The report theorized that this is due to the very high capillary stresses in the matrix of the compacted clay which could not be overcome by high external hydrostatic pressure. Therefore, the internal shear strength and hydraulic properties of the compacted clay liner were not affected.

The proposed design of the cells for the Labadie UWL will use a clay liner with a maximum hydraulic conductivity of $1 x 10^{-7}$ cm/sec, which provides an additional factor of safety that the hydraulic conductivity will not exceed the required maximum even if changes to the clay liner should occur. This report will demonstrate that the initial permeability of the clay liner, even at the more stringent than required $1 x 10^{-7}$ cm/sec permeability, will not be impacted by intermittent contact with groundwater.

## 2.2 Definition of Natural Ground Water Table at Labadie UWL Site

This section was submitted to the Missouri Department of Natural Resources and Franklin County as a separate report titled "Design Basis for Ground Water Level," dated April 9, 2012, to present a rational definition of the "Natural Water Table" as it applies to this site, as a basis for the design of the Labadie UWL.

The daily average levels of the Missouri River at the Labadie Energy Center from December 3, 1999, through November 9, 2010, were used in the analyses of the hydrogeology of the site for the DSI because these are the only Missouri River readings close to the site. The 3973 readings are plotted in Figure 32 (attached) from the DSI Report. The graph of the data demonstrates the highly variable nature of the Missouri River level at the site. The highest level in the data is el. 475.4 which occurred on September 16, 2008. The lowest statistically significant level in the data with multiple occurrences is el. 445.3. Below is a table of the frequencies of the Missouri River levels in 2-foot intervals from these data:

Frequencies of Missouri River Levels at Labadie Energy Center (2000-2010)

| Range | No. | % | % Greater |
|---|---|---|---|
| 474-475.4 | 3 | 0.08% | |
| 472-473 | 12 | 0.30% | 0.38% |
| 470-471 | 52 | 1.31% | 1.69% |
| 468-469 | 75 | 1.89% | 3.57% |
| 466-467 | 77 | 1.94% | 5.51% |
| 464-465 | 132 | 3.32% | 8.83% |
| 462-463 | 187 | 4.71% | 13.54% |
| 460-461 | 225 | 5.66% | 19.20% |
| 458-459 | 263 | 6.62% | 25.82% |
| 456-457 | 348 | 8.76% | 34.58% |
| 454-455 | 365 | 9.19% | 43.77% |
| 452-453 | 518 | 13.04% | 56.81% |
| 450-451 | 801 | 20.16% | 76.97% |
| 448-449 | 577 | 14.52% | 91.49% |
| 393-448 | 338 | 8.51% | 100.00% |

The ground water levels at the site were monitored monthly for the DSI from December 2009 through November 2010. These findings are summarized in Appendix W. The data show that the alluvial aquifer discharges toward the Missouri River during periods of relatively low flow, during which time the ground water levels below the site will be 1 to 3 feet above the Missouri River level. However, when the Missouri River is above approximate el. 461 for a sustained period, the ground water flow reverses and the ground water levels approach the level of the Missouri River near the river (in the northwest portion of the site) and about 5 feet or more below the river level over the majority of the site.

This is demonstrated in the graph of the average water table elevations versus the Missouri River elevation in Figure 1 of Appendix W. From June 5, 2010, through July 5, 2010, the Missouri River elevation at the plant was above el. 465.1, and reached a maximum of el. 471.3. During this period, the average ground water table below the site rose to el. 464, with the average ground water table approaching el. 465 in the northwest portion of the site. The level of the Missouri River at the plant also was above el. 465 between May 13 and May 30, 2010, with a maximum level of el. 472.8. During this shorter duration of sustained high river levels (18 days compared to 30 days in June and July), the average ground water table beneath the site rose from el. 462.0 to el. 463.0. It can be concluded from these data that the ground water table beneath the site will rise to about el. 464 when the Missouri River at the plant is above el. 465 for about 30 days and reaches a maximum level above el. 471 during that period. The question then becomes "How often do such sustained high Missouri River levels occur at the site?"

From the above table, the Missouri River was at or above el. 465 about 9% of the days from December 1999 through November 2010, and was at or above el. 470 about 1.7% of the days. There were 12 intervals in this decade during which the Missouri River at the plant was above el. 465 for more than 5 days and peaked above el. 470. However, the Missouri River level was above el. 465 for more than 13 days during only 5 of these 12 intervals:

Periods of Sustained High Missouri River Levels at Labadie Energy Center (2000-2010)

| Period | No. Days | Maximum River Elev. |
|---|---|---|
| June 3 – July 8, 2008 | 36 | 471.6 |
| June 5 – July 5, 2010 | 30 | 471.3 |
| May 2 – May 20, 2002 | 19 | 473.2 |
| May 13 – May 30, 2010 | 18 | 472.8 |
| May 9 – May 21, 2007 | 13 | 471.9 |

As stated above, the data from the 12 months of ground water level monitoring at the site indicate that the maximum average ground water level of about el. 464 will occur when the sustained high Missouri River level at the Labadie Energy Center exceeds el. 465 for more than 18 days, and probably approaching 30 days, with a peak river level above el. 471. While the level of the Missouri River at the site has exceeded el. 470 about 1.7% of the 3973 days from December 1999 through November 2010, an interval of sustained high river levels adequate to create a high average ground water level of el. 464 has occurred only twice. **Therefore, defining el. 464 as the average "Natural Water Table" or ground water level at the site would appear to be conservative, in that it occurs for a relatively short duration only about two times in a 10-year period. This Natural Water Table elevation can also be considered the 'average high groundwater table' at the Labadie UWL site.**

## 2.3 Potential Technical Impacts of a High Ground Water Table

The potential impacts of a ground water table (GWT) that is above the bottom compacted clay liner are:

1. potential swelling of the compacted clay liner, particularly if the clay is high plastic (CH) as defined by ASTM D2487,
2. hydrostatic uplift against the bottom of the compacted clay liner,
3. potential loss of shear strength of the compacted clay liner,
4. potential decrease in the stability of exterior or interior slopes,
5. constructability of a compacted clay liner in a high ground water table, and
6. long-term performance of the composite liner system.

### 2.3.1 Potential Swelling

High plastic clay (i.e. "CH" with a LL above 50%) has a tendency to swell when the clay is at low moisture content. When relatively dry, expansive clay is exposed to free water, then the clay will swell if it is not confined by a large pressure. The weight of the CCP in the UWL (particularly in the sumps which are at the lowest elevations) confines the clay liner and therefore reduces this swell potential. Swelling would increase the void ratio of the clay and could result in a larger hydraulic conductivity. The clay for the liner will be imported to the site. Part of the laboratory testing to qualify the clay liner material will include grain size and Atterberg limits to determine the swell potential of the clay soils.

Composite samples of the clay liner material will be compacted in a qualified soil laboratory for hydraulic conductivity tests for the approval of the clay material. The first step in the hydraulic conductivity test is to saturate the sample at a low confining pressure (ASTM D5084). Thus, any swelling that may occur would do so in the test cell, and the hydraulic conductivity that is subsequently measured would already be affected by any swelling. Therefore, laboratory testing on the clay liner material will take into account any swell potential.

### 2.3.2 Hydrostatic Uplift

Water levels approaching the 100-year flood elevation around the UWL perimeter berms will create a hydrostatic uplift pressure on the base of the composite liner. Operational procedures to counteract this potential uplift concern are discussed in Section 3.3.2.2 and Appendix J of the Construction Permit Application. Dry cells will be filled with CCPs upon completion to counter any hydrostatic uplift that might occur.

### 2.3.3 Loss of Shear Strength

The shear strength of a soil has 2 components: the effective cohesion (c') and the effective internal friction angle (ø'). Unless there is some cementation in the soil matrix, the cohesive shear strength is actually very small at very low confining pressures (Terzaghi, Peck, Mesri, 1996). Saturation of a soil will reduce its shear strength, primarily due to the loss of negative pore pressures, and the impact of the increase in pore pressure during shearing. Therefore, ø' is the critical shear strength property. However, the area of a sump is very small compared to the extents of the perimeter berm, so the loss of shear strength of the clay liner in the sump, if it could occur, will have an insignificant impact on the stability of the exterior slopes of the UWL. Consolidated-undrained (C-U) triaxial compression tests with pore pressure measurements will be run on representative composite clay liner samples. The first step in the C-U test is to ensure that the sample is saturated (ASTM D4767). Thus, the impact of potential saturation is already incorporated in the measurement of ø'. Therefore, the possible impact of saturation of the compacted clay liner, if it could occur, is not an issue because the saturated properties used in the analyses for the UWL will be verified by the laboratory testing of the clay liner material before it is approved for construction.

### 2.3.4 Stability of Slopes

A ground water level that is at the ground surface results in the minimum factor of safety for the global stability of any slope because of the reduction in effective confining stress in the natural soils beneath and beyond the toe of the berm. The internal stability of the waste is not affected by the external ground water level because the waste is isolated from the ground water by the liner. Some of the cases of global stability of the waste slope and perimeter berm that were analyzed used measured long-term shear strength properties (c' and ø') and an assumed exterior water level at ground surface. So, the issue of high ground water levels, or flooding, has been considered in the stability analyses reported in the Construction Permit Application, including under seismic load and liquefaction potential.

### 2.3.5 Constructability of Clay Liner in a High Ground water Table

A high ground water table could interfere with the excavation to final subgrade of the bottom liner and with the compaction of the clay liner. If this condition occurs, the subgrade will be soft and will tend to pump and rut, making it difficult to properly compact the clay liner. Once the ground water level is about 2 or 3 feet below the subgrade, then it is possible to construct the bottom liner in accordance with the project specifications. So, a high ground-water could adversely affect the construction schedule and costs, which will be addressed at the time of construction. But the quality and performance of the properly constructed bottom liner will not be impacted for the reasons presented in the preceding sections.

### 2.3.6 Long-term Performance of Composite Liner System

The types of clays used in construction of the liner and the methods of construction will preclude potential negative impacts of infrequent high ground water levels on the long-term performance of the composite liner system. Also, the long-term properties which were used in the analyses for the UWL, and the various extreme conditions which were considered (i.e., flooding or earthquake) take into consideration extreme adverse conditions which may occur during the operating life and post closure performance. Only one potential impact of an intermittent, high GWT on the bottom liner in the sumps could not be mitigated by the design and construction of the UWL – the hydrostatic uplift pressure. Therefore, this impact will be addressed through operational requirements of the UWL.

## 3.0 ENVIRONMENTAL PROTECTION OF A UTILITY WASTE LANDFILL

As stated in 10 CSR 80-11.010 (1) General Provisions, "The rule sets forth requirements and the method of satisfactory compliance to ensure that the design, construction and operation of utility waste landfills will protect the public health, prevent nuisances and meet applicable environmental standards…". The individual subsections 10 CSR 80-11.010 imply that the Missouri Solid Waste Management Law and Rules, as they relate to utility waste, are promulgated primarily to prevent the construction and operation of solid waste disposal areas from negatively impacting the surface waters, ground water and air, in particular, typically monitored within a specific zone of impact surrounding the solid waste disposal area. The following sections discuss the environmental protections provided by the Labadie UWL design and operation. The focus of this section is on the protection of ground water quality and surface water quality, because the performance of the CCL does not have a direct impact on air quality.

### 3.1 Ground Water Quality Protection

Protection of ground water quality is a primary objective of regulatory design and operating requirements for utility waste disposal areas. Liners, leachate collection systems, and final cover systems all focus on: keeping the waste materials relatively dry; minimizing the quantity of leachate formed by the disposal area; containing the leachate within the disposal area; and collecting and removing the leachate from the disposal area for further treatment and ultimate disposal outside of the disposal area environment. With regard to ground water in intermittent contact with the utility waste landfill liner, the critical issues are: the continued structural integrity of the liner, both as the base of the landfill and as a component of the composite liner; and the hydraulic performance of the CCL component of the composite liner to serve its intended function of containing the leachate within the disposal area. The discussion of specific, potential technical impacts to the landfill design in Section 2.0 demonstrate that the structural integrity and the hydraulic performance of the CCL component are not impacted by ground water in intermittent contact with the utility waste landfill liner. Therefore, the CCL component's functions of providing a structural base for the landfill and of containing leachate within the disposal area are not diminished.

## 3.2 Surface Water Quality Protection

Regarding ground water in intermittent contact with the utility waste landfill liner, the continued structural integrity and hydraulic performance of the CCL component of the composite liner to serve its intended function of containing the leachate within the disposal area indirectly relates to the protection of surface water quality at the Labadie UWL. The design and construction of berms around the perimeter of each disposal cell to prevent inundation of the utility waste during future Missouri River flood events are the primary design protection of surface water quality at the Labadie UWL. The proposed operational plan to contain all stormwater runoff generated inside of the perimeter berms provides the primary operational protection of surface water quality. The design and operation of the primary stormwater management systems are not directly impacted by ground water in intermittent contact with the utility waste landfill liner.

# 4.0 DEMONSTRATION OF COMPLIANCE WITH 10 CSR 80-11.010

The 'dry tomb' landfill concept seeks to avoid permanent placement of waste below the natural ground water table, in part, to avoid a direct connection to ground water through a liner leak and to avoid the long-term infiltration of ground water into the landfill that would require additional post closure care in the form of increased leachate removal and disposal. The design of the Labadie UWL does not propose to permanently place waste below the ground water table. This statement is supported by the original Detailed Site Investigation for the UWL. In addition, the technical discussions in Section 2.0 of this report support Ameren Missouri's position that the intermittent contact of the CCL with ground water does not impact the ability of the CCL to satisfactorily meet the requirements of 10 CSR 80-11.010 (Chapter 11, Utility Waste Landfill). This results in Ameren Missouri proposing the use of techniques other than those listed in 10 CSR 80-11.010 as satisfactory compliance in the design and operation of the utility waste disposal area. As previously stated, this report provides a demonstration to the Missouri Department of Natural Resources Solid Waste Management Program that the site conditions at the Labadie UWL, coupled with the engineering design and operational details, are acceptable from both a technical and regulatory perspective.

The rule format for Chapter 11 generally includes one section for each specific topic, each followed by three subsections [(A) Requirement; (B) Satisfactory Compliance – Design; and (C) Satisfactory Compliance – Operations]. Section 4.1 identifies the design and/or operational methods proposed for the Labadie UWL that require demonstration that the overall requirements of Chapter 11, Utility Waste Landfill, are met for the site conditions and design of the Labadie UWL.

## 4.1 Design/Operational Considerations Relative to Unique Labadie UWL Site Conditions

The following sections of the Missouri Solid Waste Management Rules have been identified for specific summary discussion as a conclusion to the demonstration that the Labadie UWL meets the minimum requirements of the Missouri Solid Waste Management Rules. The design and/or operational issues identified are listed below, followed by the regulatory REQUIREMENT [emphasis added] as identified in the appropriate rule section or subsections and the specific design and/or operational methods specified by Chapter 11. Finally, reference is made to the specific technical issues provided in Section 2.0 that support the proposed deviation from the specified design and/or operational method. In review, the critical points of Section 2.0 are summarized below:

- Studies have shown that clay liners do not become saturated even when continuously submerged for years due to the very high internal capillary stresses. Therefore the internal properties of the clay liner are unlikely to be affected by intermittent contact with ground water;
- The compacted clay liner for the Labadie UWL is designed to have a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec, which provides an added safety factor that the maximum hydraulic conductivity of $1x10^{-5}$ cm/sec required by regulation will not be exceeded. Furthermore, the initial installed hydraulic conductivity of the CCL will not be impacted by intermittent contact with groundwater;
- The laboratory measurement of hydraulic conductivity of the clay liner allows for any potential swelling at low confining pressures;
- The remote threat of adverse hydrostatic uplift will be addressed through operational procedures of the UWL;
- The minimum internal and interface shear strength properties assumed for the compacted clay liner for the design of the UWL will be specified (see Appendix J) and verified for the offsite clay liner material; and
- The structural stability analyses of the perimeter berms and exterior slopes of the UWL considered the worst-case condition of a ground water table at the ground surface. Therefore, this condition is considered in the current design.

### 4.1.1 INTERMITTENT GROUND WATER CONTACT WITH LANDFILL LINER.

**Regulatory Citation and Requirement:**

***10 CSR 80-11.010(4) Site Selection.***
*(A) Requirement. Site selection and utilization shall include a study and evaluation of geologic and hydrologic conditions and soils at the proposed utility waste landfill and an evaluation of the environmental effect upon the projected use of the completed utility waste landfill. Applications for utility waste landfill construction permits received on or after the effective date of this rule shall document compliance with all applicable siting restriction requirements contained in paragraphs (4)(B)1. through 5. of this rule.*

**Regulatory Design and/or Operational Techniques:**

*(B)6. If the base of the landfill liner will be in contact with ground water, the applicant shall demonstrate to the department's satisfaction that the ground water will not adversely impact the liner.*

*(B)7. Owners/operators of proposed utility waste landfills shall demonstrate how adverse geologic and hydrologic conditions may be altered or compensated for via surface water drainage diversion, underdrains, sumps, and other structural components. All alterations of the site shall be detailed in the plans. Precipitation, evapotranspiration and climatological conditions shall be considered in site selection and design.*

*(B)8. The results of the detailed site investigation report will be the basis to determine if a secondary liner, such as a geomembrane, or a leachate collection system is mandatory to ensure that there is no environmental impact from the landfill. Owner/operators of proposed utility waste landfills shall make a demonstration based on the following:*

*A. An evaluation of the physical and/or chemical characteristics of the waste; and*

*B. Documentation through modeling, testing, or other research data proving that the quality of ground water underlying the proposed site will not be affected and that there is no potential for migration of fluids from the utility waste landfill.*

**Discussion of Alternative Design:**

This report provides specific discussion of technical information indirectly required by this regulation relative to the intermittent contact of the CCL component of the composite liner. As outlined in the details of Section 2.0, the design of the utility waste landfill for the Labadie Energy Center anticipates the potential for saturated clays and saturated insitu base conditions, as well as the potential impact of high ground water table conditions intermittently caused by fluctuating Missouri River levels. No additional design alternatives or changes are considered necessary, as supported by the information in the report.

**Compliance with Regulatory Requirement:**

The CPA for the Labadie UWL addresses the site selection and utilization requirements, including a study and evaluation of geologic and hydrologic conditions and soils at the proposed utility waste landfill and an evaluation of the environmental effect upon the projected use of the completed utility waste landfill. The technical discussion in Section 2.0 provides additional "demonstration" relative to the site-specific design with regard to the intermittent contact of the CCL component of the composite liner.

Based on the conclusions of this report, no additional design or operational changes are necessary to demonstrate that the geologic and hydrologic conditions referenced in 10 CSR 80-11.010(4), Site Selection, (specifically, the intermittent contact of small portions of the bottom of the landfill liner) are necessary to demonstrate that the quality of ground water underlying the proposed site will not be affected and that there is no increased potential for migration of fluids from the Labadie UWL. The liner and leachate collection requirements are further discussed in previous and subsequent portions of this report.

### 4.1.2. IMPACT OF DSI RESULTS ON LINER AND LEACHATE COLLECTION SYSTEM DESIGN.

**Regulatory Citation and Requirement:**

***10 CSR 80-11.010(5) Design***

*(A) Requirement. Plans, addendums, as-built drawings, or other documents which describe the design, construction, operation, or closure of a utility waste landfill or which request an operating permit modification for the utility waste landfill shall be prepared or approved by a professional*

*engineer. These documents shall be stamped or sealed by the professional engineer and submitted to the department for review and approval.*

**Regulatory Design Requirements:**

*(A)3. Owners/operators of utility waste landfills shall demonstrate how adverse geologic and hydrologic conditions may be altered or compensated for via surface water drainage diversion, underdrains, sumps, and other structural components. All alterations of the site shall be detailed in the plans.*

*A. Precipitation, evapotranspiration and climatological conditions shall be considered in site selection and design.*

*B. Engineering plans and specifications that have computer model attached to them shall list the limitations and assumptions of each model used in the application.*

*(A)4. Plans for stability analyses for all stages of construction shall include:*

*A. Settlement and bearing capacity analyses shall be performed on the in-place foundation material beneath the disposal area. The effect of foundation material settlement on the liner and leachate collection shall be evaluated;*

*B. Stability analyses shall be performed on all liner and leachate system components;*

*C. Leachate collection pipe material and drainage media shall be analyzed to demonstrate that these components possess structural strength to support maximum loads imposed by overlying waste materials and equipment;*

*D. Waste mass stability analyses shall be performed on the disposal area at final waste grade conditions and at intermediate slope conditions; and*

*E. Stability analyses shall be performed on all final cover system components, including an evaluation of the effect of waste settlement on the final cover system components, side slope liner system components, surface water management system components and gas migration system components.*

**Discussion of Alternative Design:**

The Detailed Site Investigation (DSI) required by 10 CSR 80-2.015 addressed the precipitation, evapotranspiration and climatological conditions considered in original site selection and design. This included ground water table elevations and the relationship of the Missouri River levels to the ground water table. This report provides additional technical discussion of this information. In addition, the models and calculations submitted with the CPA address all stages of construction and operation of the Labadie UWL.

This report provides additional technical discussion relative to the intermittent contact of the CCL component of the composite liner. As outlined in detail in Section 2.0, the proposed design and operation of the utility waste landfill for the Labadie Energy Center anticipates the potential for saturated clays and saturated insitu base conditions, as well as the potential impact of high ground water table conditions intermittently caused by fluctuating Missouri River levels. No additional design alternatives or changes are believed necessary to address 10 CSR 80-11.010 (5).

**Compliance with Regulatory Requirement:**

In compliance with 10 CSR 80-11.010 (5), Design, this demonstration report has been prepared by professional engineers, has been reviewed and approved by a professional engineer and bears the signature and seal of the principal design engineer.

## 4.1.3. LANDFILL LINER SEPARATION FROM GROUND WATER.

**Regulatory Citation and Requirement:**

***10 CSR 80-11.010(8) Water Quality.***
(A) Requirement. The location, design, construction and operation of the utility waste landfill shall minimize environmental hazards and shall conform to applicable ground and surface water quality standards and requirements. Applicable standards are federal, state or local standards and requirements that are legally enforceable.

**Regulatory Design Requirements:**

*(B)1. Plans shall include*

*C. Ground water elevation and proposed separation between the lowest point of the lowest cell and the predicted maximum water table elevation;*

**Discussion of Alternative Design:**

This report provides information relative to the proposed separation between the lowest point of the lowest cell and the predicted normal water table elevation. In addition, it further evaluates the potential impact of the intermittent contact of the CCL component of the composite liner. No additional design alternatives or changes are believed necessary to address 10 CSR 80-11.010 (8).

**Compliance with Regulatory Requirement:**

The content of this demonstration report support the conclusion that the regulatory requirement is met. The proposed design, construction and operation of the utility waste landfill shall minimize environmental hazards and shall conform to applicable ground and surface water quality standards and requirements.

## 4.1.4. DESIGN AND OPERATION OF LINER SYSTEM.

**Regulatory Citation and Requirement:**

***10 CSR 80-11.010(10) Liner Systems.***

*(A) Requirement. A liner shall be placed on all surfaces to minimize the migration of leachate from the utility waste landfill.*

**Regulatory Design Requirements:**

*(B)1. For a composite liner a lower component that consists of at least a two-foot (2') layer of compacted soil with a hydraulic conductivity of no more than 1 x $10^{-5}$ cm/sec. A compacted soil liner at a minimum shall be constructed of six to eight-inch (6-8") lifts, compacted to ninety-five percent (95%) of standard Proctor density with the moisture content between optimum moisture content and four percent (4%) above the optimum moisture content, or within other ranges of density and moisture such that are shown to provide for the liner to have a hydraulic conductivity no more than 1 x $10^{-5}$ cm/sec. For a single compacted clay liner a component that consists of at least a two-foot (2') layer of compacted soil with a hydraulic conductivity of no more than 1 x $10^{-7}$ cm/sec. A compacted soil liner at a minimum shall be constructed of six to eight-inch (6-8") lifts, compacted to ninety-five percent (95%) of standard Proctor density with the moisture content between optimum moisture content and four percent (4%) above the optimum moisture content, or within other ranges of density and moisture such that are shown to provide for the liner to have a hydraulic conductivity of no more than 1 x $10^{-7}$ cm/sec. The design shall include a detailed explanation of the construction techniques and equipment necessary to achieve ninety-five percent (95%) of the standard Proctor density under field conditions. The design also shall include QA/QC procedures to be followed during construction of the liner. The composite liner and the compacted clay liner shall be protected from the adverse effects of desiccation or freeze/thaw cycles after construction, but prior to placement of waste. Traffic shall be routed so as to minimize the detrimental impact on the constructed liner prior to placement of waste. The soils used for this purpose shall meet the following minimum specifications:*

*A. Be classified under the Unified Soil Classification Systems as CL, CH, or SC (ASTM Test D2487-85);*
*B. Allow more than thirty percent (30%) passage through a No. 200 sieve (ASTM Test D1140);*
*C. Have a liquid limit equal to or greater than twenty (20) (ASTM Test D4318-84);*
*D. Have a plasticity index equal to or greater than ten (10) (ASTM Test D4318-84); and*
*E. Have a coefficient of permeability equal to or less than 1 x $10^{-7}$ cm/sec for the compacted clay liner and 1 x $10^{-5}$ cm/sec for the composite liner when compacted to ninety-five percent (95%) of standard Proctor density with the moisture content between optimum moisture content and four percent (4%) above the optimum moisture content, when tested by using a flexible wall permeameter (ASTM D-5084) or other procedures approved by the department;*

**Alternative Design:**

The proposed utility waste disposal area will utilize a composite liner that will consist of a 60-mil HDPE geomembrane liner underlain by two feet of compacted clay liner with a hydraulic conductivity equal to or less than 1 x $10^{-7}$ cm/sec. This proposed design significantly exceeded the performance of the minimum design standards and performance of the two liner options prescribed in 10 CSR 80-11.010 (10). Ameren Missouri proactively chose this design to minimize the migration of leachate from the utility waste disposal area and to provide a UWL that will address anticipated future regulatory revisions.

**Compliance with Regulatory Requirement:**

The regulatory requirement is met and exceeded by the Labadie UWL proposed composite liner design. This report demonstrates that the intermittent contact of ground water with the CCL component of the composite liner will not impact the CCL's design, function or performance.

## 4.2 Impact on the Construction Permit Application

Following the review and acceptance of this demonstration by MDNR, this demonstration will be incorporated into the approved engineering report and plans required to be maintained throughout the operating life and post closure care as required by the Solid Waste Disposal Area Operating Permit.

## 5.0 REFERENCES

ASTM D4767, "Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils."

ASTM D5084, "Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter."

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*Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri*, dated February 4, 2011, revised March 30, 2011. Approved by Missouri Department of Natural Resources, Division of Geology and Land Survey on April 8, 2011.

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MDNR and Stark, Timothy D. (1997). Draft Technical Guidance Document on Static and Seismic Slope Stability for Solid Waste Containment Facilities. Solid Waste Management Program, Division of Environmental Quality, Missouri Department of Natural Resources, Jefferson City, MO, 96 p.

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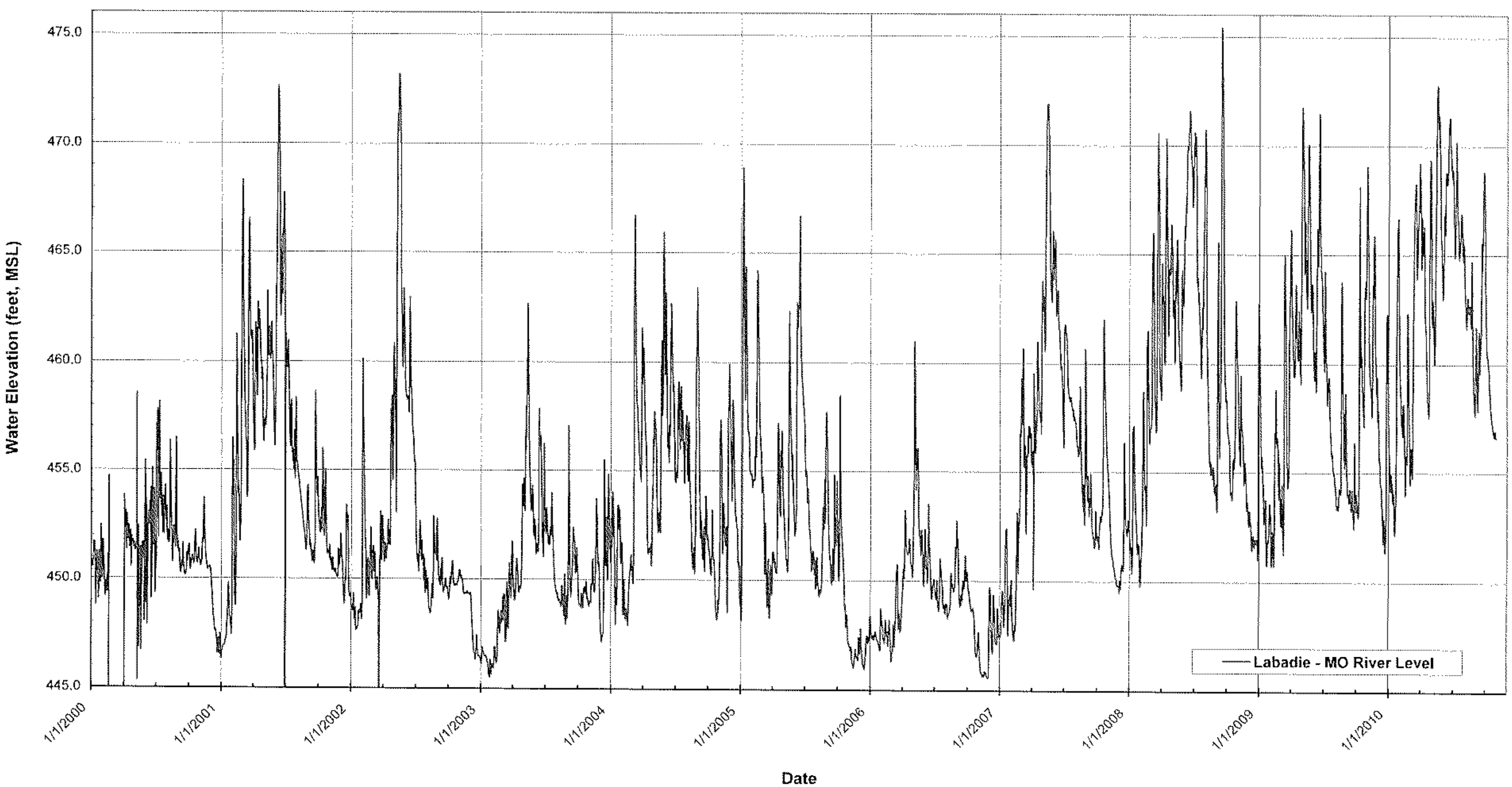
**Detailed Site Investigation**
**Proposed Utility Waste Disposal**
**Ameren Missouri Labadie Power Plant**

**Missouri River 10-Year Historical Data (2000-2010)**

**FIGURE 32**



**<u>CONFIDENTIAL BUSINESS INFORMATION</u>**

# Ameren Missouri Labadie Power Station
# Utility Waste Landfill
# <u>DESIGN BASIS FOR GROUND WATER LEVEL</u>

April 9, 2012

<u>Introduction and Purpose</u>

The County Commission amended the County's Unified Land Use Regulations on October 25, 2011 to add regulations concerning Non-Utility Waste and Utility Waste Landfills (UWL) in Franklin County, Missouri. Article 10, Section 238(C)(3) of these amended regulations requires in part that:

*c.)* *The clay or composite soil component at the base of the Utility Waste Landfill shall be at least two (2) feet above the Natural Water Table in the site area.*

Section 238(A)(11) defines "Groundwater" as "*Water below the land surface in the zone of saturation.*"

Section 238(A)(19) defines "Natural Water Table" as:

> *The level at which water stands in a fully saturated unconfined aquifer as measured by shallow piezometers or wells. The natural water table is under static hydrologic conditions and uninfluenced by groundwater pumping or other engineered activities.*

The site of the proposed UWL at Ameren Missouri's Labadie Power Station is located in the alluvial deposits adjacent to the Missouri River. As demonstrated in the Detailed Site Investigation (DSI) for this project[1] the ground water levels are strongly influenced by the Missouri River (page 39 of DSI Report). Because the Missouri River is an "open river," that is not controlled by a dam in the vicinity of the Labadie Power Station, the level of the Missouri River and hence the natural water table at the site are constantly changing. Therefore, the Natural Water Table is never "under static hydrologic conditions."

The amended County Unified Land Use Regulations allow the Independent Registered Professional Engineer to review and approve certain UWL requirements after evaluation of a specific UWL site and consultation with the UWL owner and engineer. This paper presents a rational definition of the "Natural Water Table" as it applies to the site of the proposed UWL at Ameren Missouri's Labadie Power Station, as a basis for design of the UWL. This report was prepared at the request of Ameren Missouri by Reitz & Jens, Inc., the Designer of Record for the Labadie UWL.

<u>Brief Project Description</u>

The Labadie UWL will be developed on property contiguous with the boundary of property upon which the Labadie Power Station is situated, on the right descending (south) overbank area of the

[1] *Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri*, dated February 4, 2011, revised March 30, 2011. Approved by Missouri Department of Natural Resoures, Division of Geology and Land Survey on April 8, 2011.

Missouri River between River Miles 56.71 and 57.38. The existing ground surface ranges from about el. 471 to el. 465[2] below the current design of the UWL. The areas of lower ground surface elevations (below about el. 464) located in the southeast region of the site are in potential wetlands and therefore have been excluded from the proposed developed area of the UWL.

The UWL site is currently protected from regular Missouri River flooding by the Labadie Bottom Levee District agricultural levee with heights at or near the 100-year flood elevation. In the unlikely event that the agricultural levee is overtopped or breached, the UWL site is further protected from direct Missouri River flood currents by the Labadie Power Station itself which is upstream and higher than the 500-year flood elevation, creating a low velocity shadow, or ineffective flow area, over the entire UWL site. The regulatory 100-year base flood elevation (BFE) of 483.98 at the upstream end of the UWL site became effective on October 18, 2011. The 500-year flood elevation at this river station is reported by FEMA to be 487.55. By comparison, the flood crest at this location in August 1993 was about el. 483.6. The planned top of the constructed perimeter berms of the Labadie UWL will be at el. 488.

Ground Water Levels and Missouri River Data

The daily average levels of the Missouri River at the Labadie Power Station from December 3, 1999, through November 9, 2010, were used in the analyses of the hydrogeology of the site for the DSI because these are the only Missouri River readings close to the site. The 3973 readings are plotted in Figure 32 (attached) from the DSI Report. The graph of the data demonstrates the highly variable nature of the Missouri River level at the site. The highest level in the data is el. 475.4 which occurred on September 16, 2008. The lowest level in the data is el. 393.0 which occurred on June 29, 2001. Below is a table of the frequencies of the Missouri River levels in 2-foot intervals from these data:

Frequencies of Missouri River Levels at Labadie Power Station (2000-2010)

| Range | No. | % | % Greater |
|---|---|---|---|
| 474-475.4 | 3 | 0.08% | |
| 472-473 | 12 | 0.30% | 0.38% |
| 470-471 | 52 | 1.31% | 1.69% |
| 468-469 | 75 | 1.89% | 3.57% |
| 466-467 | 77 | 1.94% | 5.51% |
| 464-465 | 132 | 3.32% | 8.83% |
| 462-463 | 187 | 4.71% | 13.54% |
| 460-461 | 225 | 5.66% | 19.20% |
| 458-459 | 263 | 6.62% | 25.82% |
| 456-457 | 348 | 8.76% | 34.58% |
| 454-455 | 365 | 9.19% | 43.77% |
| 452-453 | 518 | 13.04% | 56.81% |
| 450-451 | 801 | 20.16% | 76.97% |
| 448-449 | 577 | 14.52% | 91.49% |
| 393-448 | 338 | 8.51% | 100.00% |

[2] Elevations herein refer to the North American Vertical Datum of 1988 (NAVD88) which is the datum used in FEMA's new Flood Insurance Rate Maps (FIRM). NAVD88 corrects many of the problems with the earlier NGVD of 1929.

The ground water levels at the site were monitored monthly for the DSI from December 2009 through November 2010. The data show that the alluvial aquifer discharges toward the Missouri River during periods of relatively low flow, during which time the ground water levels below the site will be 1 to 3 feet above the Missouri River level. However, when the Missouri River is above about el. 461 for a sustained period, the ground water flow reverses and the ground water levels approach the level of the Missouri River near the river (in the northwest portion of the site) and about 5 feet or more below the river level over the majority of the site.

This is demonstrated in the graph of the average water table elevations versus the Missouri River elevation in Figure 31 from the DSI Report. From June 5, 2010, through July 5, 2010, the Missouri River elevation at the plant was above el. 465.1, and reached a maximum of el. 471.3. During this period, the average ground water table below the site rose to el. 464, with the average ground water table approaching el. 465 in the northwest portion of the site. The level of the Missouri River at the plant also was above el. 465 between May 13 and May 30, 2010, with a maximum level of el. 472.8. During this shorter duration of sustained high river levels (18 days compared to 30 days in June and July), the average ground water table beneath the site rose from el. 462.0 to el. 463.0. Therefore, it appears from these data that the ground water table beneath the site will rise to about el. 464 when the Missouri River at the plant is above el. 465 for about 30 days and reaches a maximum level above el. 471 during that period. How often do such sustained high Missouri River levels occur at the site?

From the above table, the Missouri River was at or above el. 465 about 9% of the days from December 1999 through November 2010, and was at or above el. 470 about 1.7% of the days. There were 12 intervals during this decade during which the Missouri River at the plant was above el. 465 for more than 5 days and during which time the river level exceeded el. 470. However, the Missouri River level was above el. 465 for more than 13 days during only 5 of these intervals:

Periods of Sustained High Missouri River Levels at Labadie Power Station (2000-2010)

| Period | No. Days | Maximum River Elev. |
|---|---|---|
| June 3 – July 8, 2008 | 36 | 471.6 |
| June 5 – July 5, 2010 | 30 | 471.3 |
| May 2 – May 20, 2002 | 19 | 473.2 |
| May 13 – May 30, 2010 | 18 | 472.8 |
| May 9 – May 21, 2007 | 13 | 471.9 |

As stated above, the data from the 12 months of ground water level monitoring at the site indicate that the maximum average ground water level of about el. 464 may occur when the sustained high Missouri River level at the Labadie Power Station exceeds el. 465 for more than 18 days, and probably approaching 30 days, with a peak river level above el. 471. While the level of the Missouri River at the site has exceeded el. 470 about 1.7% of the 3973 days from December 1999 through November 2010, an interval of sustained high river levels adequate to create a high average ground water level of el. 464 has occurred only twice. **Therefore, the definition of el. 464 as the average "Natural Water Table" at the site would appear to be an extreme event that occurs for a relatively short duration only about two times in a 10-year period.**

Requirements for "Beneficial Use"

The Missouri Department of Natural Resources (MDNR) has previously permitted the use of CCR as fill for "beneficial use" without a clay liner if the fill was above the normal annual high ground water level. Adoption of el. 464 at the proposed site of the Labadie UWL would satisfy this requirement.

Summary

The current Franklin County Land Use regulations for Utility Waste Landfills require that the clay or composite soil component at the base of the Utility Waste Landfill shall be at least two (2) feet above the Natural Water Table in the site area, and that the definition of "Natural Water Table" is the "static hydrologic conditions uninfluenced by groundwater pumping or other engineered activities."

The site of the proposed UWL at Ameren Missouri's Labadie Power Station is located in the alluvial deposits adjacent to the Missouri River. As demonstrated in the Detailed Site Investigation (DSI) for this project, the ground water levels are strongly influenced by the Missouri River. Because the Missouri River is an "open river," the level of the Missouri River and hence the natural water table at the site is never under truly "static hydrologic conditions." Based upon the 12 months of monitoring of ground water levels at the site and almost 11 years of daily Missouri River level readings at the Labadie Power Station, the definition of el. 464 as the average "Natural Water Table" at the site would appear to be an extreme event that occurs for a relatively short duration only about two times in a 10-year period, and therefore would satisfy the intent of the Franklin County Land Use regulations.

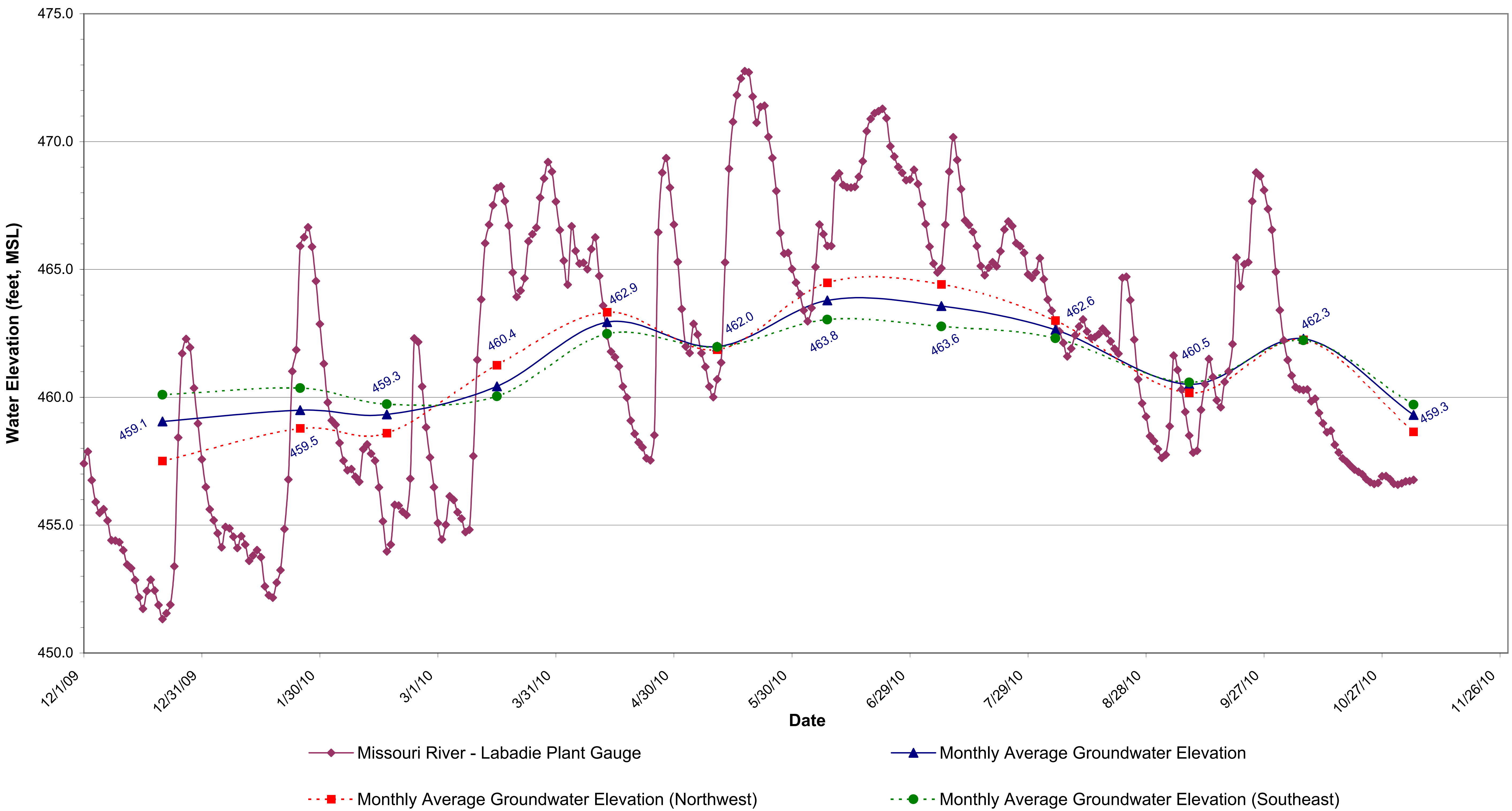
Attachments

Figure 31 from DSI Report, "Monthly Average Water Table Elevation VS Missouri River Elevation"
Figure 32 from DSI Report, "Missouri River 10-Year Historical Data (2000-2010)"

**Detailed Site Investigation**
**Proposed Utility Waste Disposal**
**Ameren Missouri Labadie Power Plant**

**Monthly Average Water Table Elevation vs Missouri River Elevation**

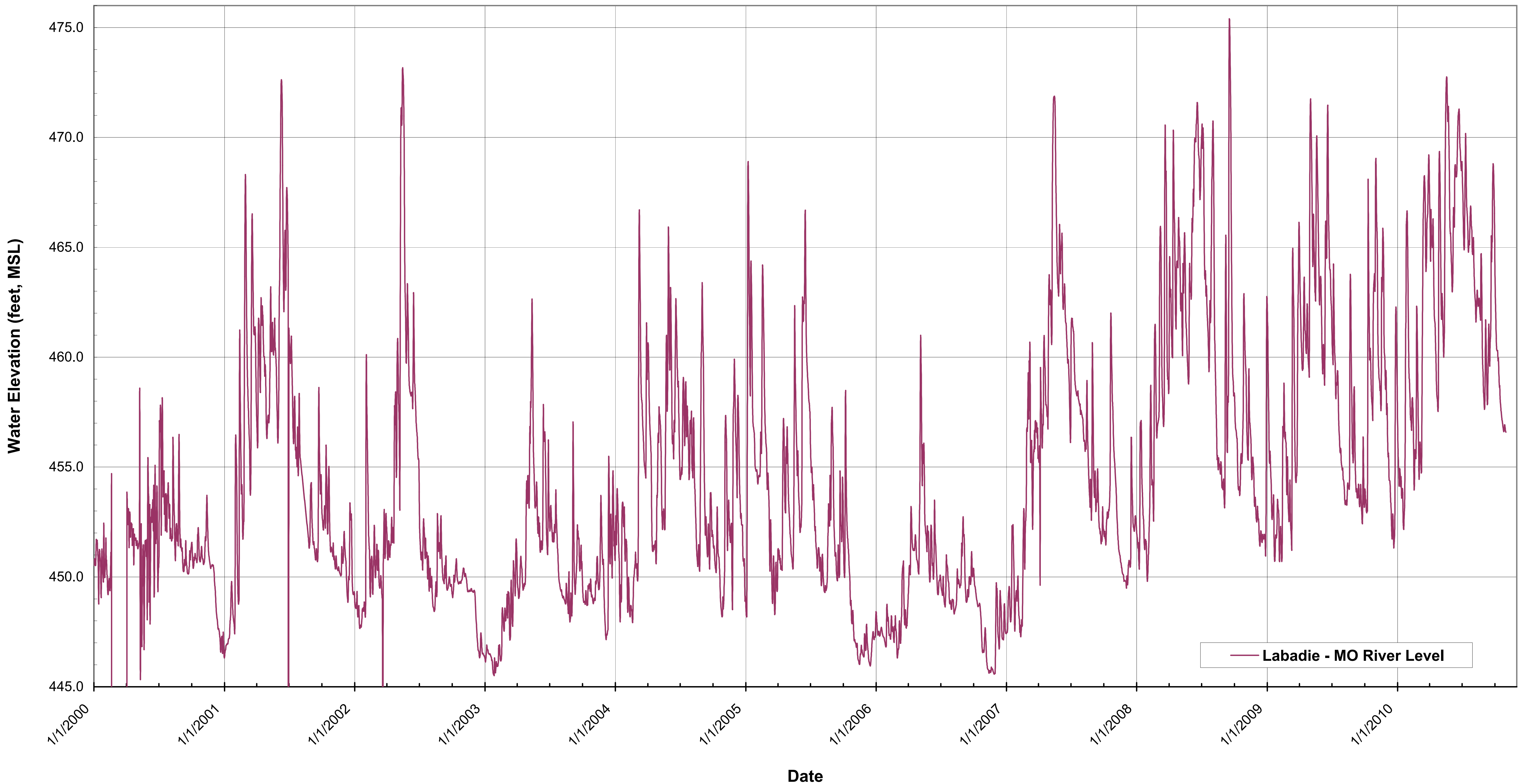
**FIGURE 31**



**Detailed Site Investigation**
**Proposed Utility Waste Disposal**
**Ameren Missouri Labadie Power Plant**

**Missouri River 10-Year Historical Data (2000-2010)**

**FIGURE 32**



## CONFIDENTIAL BUSINESS INFORMATION

**Ameren Missouri Labadie Power Station**
**Utility Waste Landfill**
**DESIGN BASIS FOR EXTERIOR BERMS**
April 10, 2012

Introduction and Purpose

The County Commission amended the County's Unified Land Use Regulations on October 25, 2011 to add regulations concerning Non-Utility Waste and Utility Waste Landfills (UWL) in Franklin County, Missouri. Article 10, Section 238(C)(3) of these amended regulations requires in part that:

*d.) All "cells" shall be designed and constructed so that they shall be protected by an exterior berm meeting the following criteria:*

*i.) The top of the berm at a minimum shall be equal to the five hundred (500) year flood level in the area of the proposed Utility Waste Landfill.*

*ii) … All berms shall be constructed of concrete or cement-based material sufficiently thick for the purpose intended and approved by the Independent Registered Professional Engineer.*

The amended County Unified Land Use Regulations allow the Independent Registered Professional Engineer to review and approve certain UWL requirements after evaluation of a specific UWL site and consultation with the UWL owner and engineer. This paper will help define the "purpose intended" as it applies to the exterior berms for the proposed UWL at Ameren Missouri's Labadie Power Station and present a recommended design. This report was prepared at the request of Ameren Missouri by Reitz & Jens, Inc., the Designer of Record for the Labadie UWL.

Brief Project Description

The Labadie UWL will be developed on property contiguous with the boundary of property upon which the Labadie Power Station is situated, on the right descending (south) overbank area of the Missouri River between River Miles 56.71 and 57.38. The UWL site is currently protected from regular Missouri River flooding by the Labadie Bottom Levee District agricultural levee with heights at or near the 100-year flood elevation. In the unlikely event that the agricultural levee is overtopped or breached, the UWL site is further protected from direct Missouri River flood currents by the Labadie Power Station itself which is upstream and higher than the 500-year flood elevation, creating a low velocity shadow, or ineffective flow area, over the entire UWL site. The regulatory 100-year base flood elevation (BFE) of el. 483.98[1] at the upstream end of the UWL site became effective on October 18, 2011. The 500-year flood elevation at this river station is reported by FEMA to be el.

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[1] All elevations refer to the North American Vertical Datum of 1988 (NAVD88) which is the datum used in FEMA's new Flood Insurance Rate Maps (FIRM).

487.55. By comparison, the flood crest at this location in August 1993 was about el. 483.6. The planned top of the constructed perimeter berms of the Labadie UWL will be at el. 488.
The total area of the UWL when completed will be approximately 280 acres. The UWL will be constructed in cells, as defined by the Franklin County land use regulations, with each cell designed to contain a minimum of 5 years of the coal combustion residuals (CCRs) produced by the Labadie Plant. As planned prior to adoption of the new Land Use regulations in October 2011, each cell will be fully surrounded by a perimeter berm. The primary purpose intended for these berms is to separate the CCRs in the UWL from coming in contact with floodwater. The internal angle of friction of the CCRs that will be deposited in each cell will be sufficiently high so as to create a stable fill that does not require the perimeter berms for stability.

Two types of perimeter berms will be built. Exterior berms are those that will form the perimeter of the fully developed 280-acre UWL. Interior berms are those that initially will form a portion of each cell's perimeter, but will ultimately be covered with CCRs as future cells are developed. Some exterior berms infrequently may be in contact with a flow of flood water of the Missouri River, but only when the Labadie Bottom Levee District levee is overtopped or breached. The interior berms may also infrequently come in contact with flood water, but the water velocities will be too low to cause erosion. In both instances a vegetated cover alone would provide sufficient erosion protection, as with standard levee design. Because the CCR mass and perimeter berms are inherently stable, concrete and/or cement-based material will be used only to prevent possible erosion of the exposed slopes of perimeter berms that may be subject to the flow of flood water.

The general height and geometry of the exterior and interior berms will be as shown in Figure 1. The exterior berms will be constructed with compacted soil and the inside slope will be covered with a composite liner in accordance with the Missouri Department of Natural Resources (MDNR) regulations. The outside slope of the exterior berms will have a concrete or cement-based layer to protect against erosion from flood water (the "purpose intended"). Interior berms will be constructed with a core of CCRs and a compacted clay cap and vegetated cover on their outside slope. The composite liner will extend under the interior berm and tie into the exterior slope's clay cap to encapsulate the CCRs in accordance with MDNR regulations and allow extension of the composite liner beneath the next cell. Both side slopes of the perimeter berms will be 3 horizontal to 1 vertical (3:1). The top of the perimeter berms will be constructed to el. 488.0, that is 0.45 feet above the 500-year flood level, as required by the Franklin County Land Use regulations. The height of the berms above existing ground surface will vary but average about 23 feet.

Berm Design Basis Using Concrete or Cement-Based Materials

Reitz & Jens has researched and evaluated alternatives for using concrete or cement-based materials for erosion protection of the exposed slopes of exterior berms at the Labadie UWL. Our

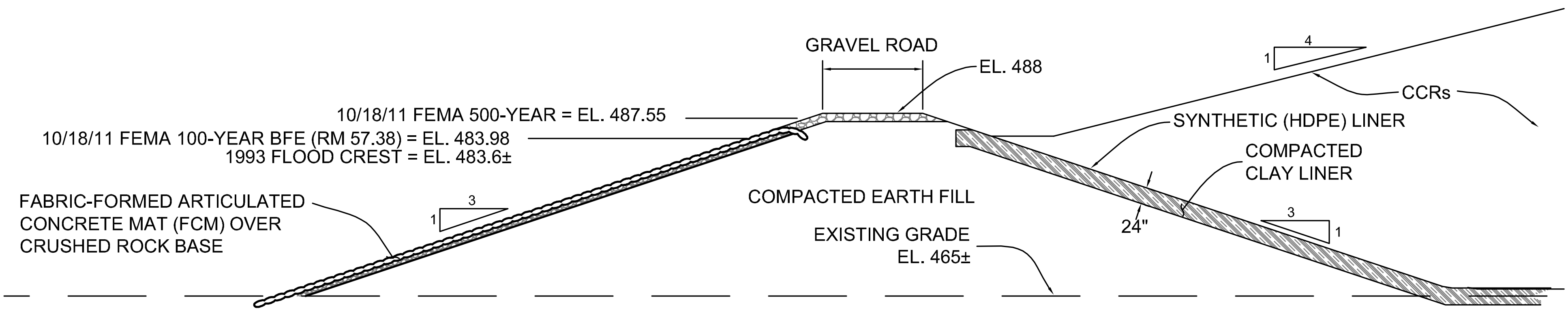

recommendation is to incorporate fabric-formed concrete mats (FCM) constructed using manufactured fabric forms and cast-in-place concrete (example shown in photo below). Evenly-spaced sewn filter “windows” or inserted plastic weep holes prevent excess hydrostatic pressures beneath the FCM as floodwater that may be present from time to time recedes. Some options include windows in the FCM to permit growing a vegetative cover. The forms are typically available in 4-, 6- or 8-inch thicknesses. The required thickness will be determined based on the hydraulic conditions. The ducts between the block compartments are limited to 10% of the maximum thickness of the blocks to achieve flexibility and articulation of the finished FCM, to accommodate differential settlement. Reinforcing cables may be inserted through the block compartments to provide additional strength, if necessary for severe applications or for slopes up to 2:1. The design of the FCM will be based upon hydraulic analyses of the maximum flow that may result from overtopping or a breach of the Labadie Bottom levee at the worst case location for each section of the exterior berms. The FCM will be placed on geotextile filter or crushed rock base to prevent loss of soil.

Summary

The current Franklin County Land Use regulations for Utility Waste Landfills require that all exterior berms be constructed of concrete or cement-based material sufficiently thick for the purpose intended. As explained above, the primary purpose intended for these berms is to separate the coal combustion residuals in the UWL from coming in contact with flood water. To comply with these regulations, the UWL design includes building the exterior berms with a soil core and fabric-formed concrete mat surface to protect the exterior slopes from floodwater that could result from a breach or overtopping of the existing Labadie Bottom Levee District levee along the Missouri River. The FCM has the following advantages:

- construction uses pre-manufactured fabric forms,
- erosion-resistant concrete face,
- weep holes or “windows” to relieve excess hydrostatic pressure,
- exposed exterior concrete for visual inspection,
- can be installed without heavy construction equipment (disturbing surrounding areas),
- articulated to compensate for differential settlement, and
- does not create rigidity within berms that could cause cracking and piping.

## CONFIDENTIAL BUSINESS INFORMATION

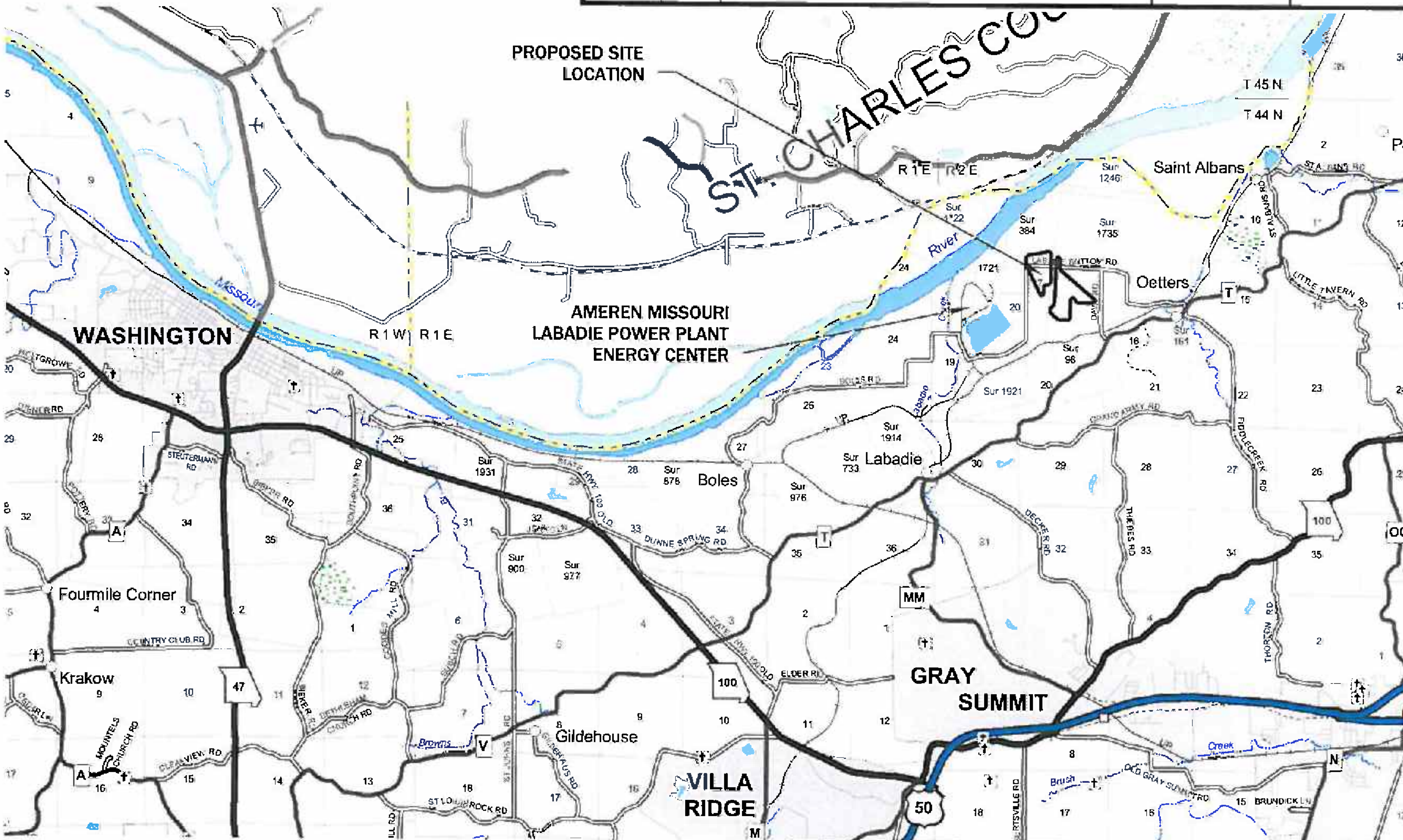



Ameren Labadie UWL
RECOMMENDED DESIGN FOR
EXTERIOR BERMS

Reitz & Jens, Inc.

Figure 1

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | REV | DESCRIPTION | DATE | APPROVED |

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SCALE: 1" = 10000'

0 5000 10000

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GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING

PREPARED FOR Ameren

| | |
|---|---|
| DRAWN W.J.A. (G.E.R.) | FIGURE 1 LABADIE ENERGY CENTER PROPOSED UTILITY WASTE LANDFILL SITE LOCATION MAP |
| CHKD R.L.R. (G.E.R.) | |
| SUPV T.R.G. (G.E.R.) | |
| APPD T.R.G. (G.E.R.) | LOCATION 001009 — LABADIE ENERGY CENTER — 02010 |
| Ameren ST. LOUIS, MISSOURI | JANUARY 2013 |

M:\Share\CADDFiles\AMEREN-UE\LABADIE\CONSTRUCTION PERMIT\2012 DRAWINGS\FIG 1 ENGR REPT.dwg, Cover Sheet, 1/23/2013 2:39:22 PM

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REVISIONS

| ZONE | REV | DESCRIPTION | DATE | APPROVED |
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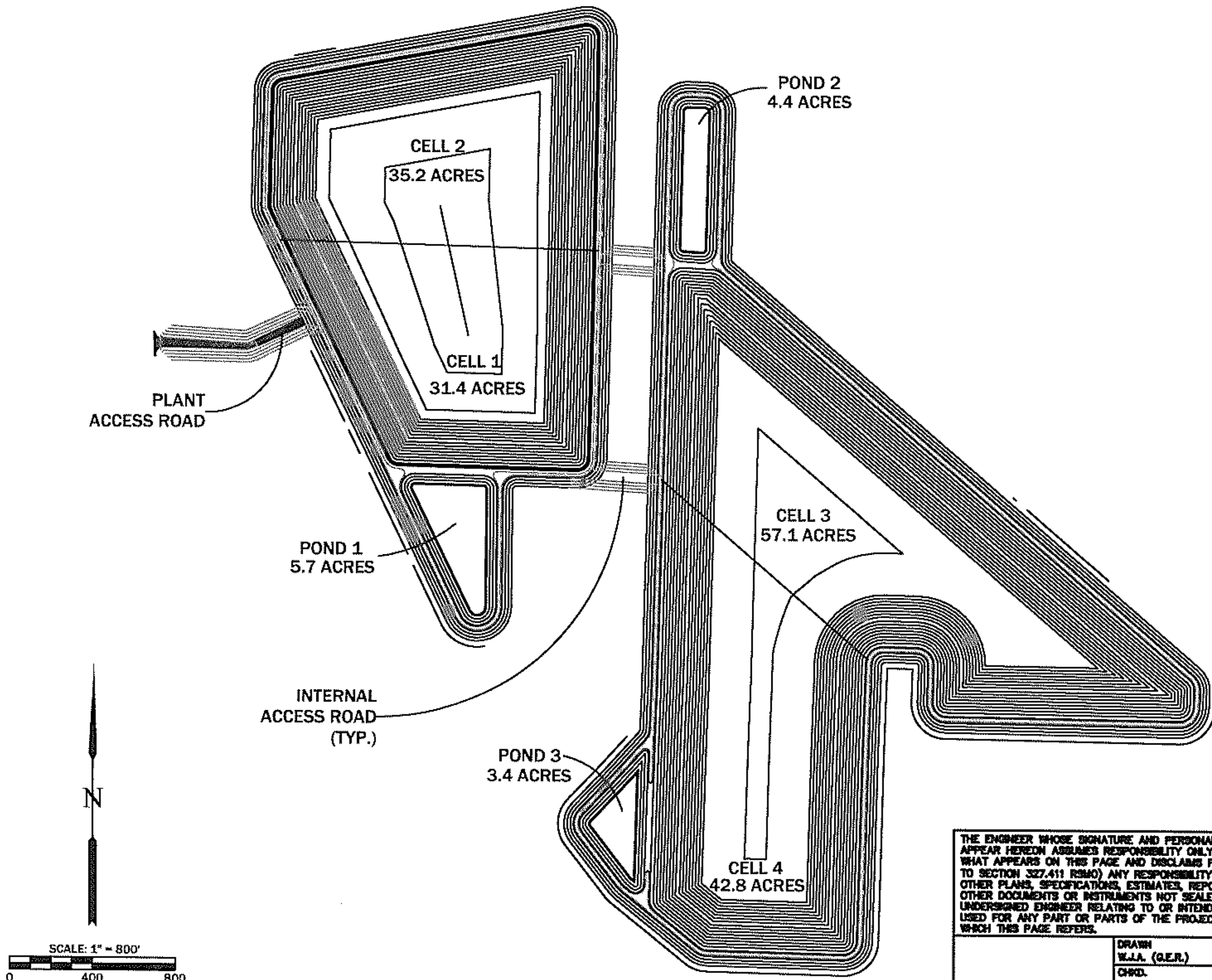


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ENVIRONMENTAL ENGINEERING
LAND AIR WATER

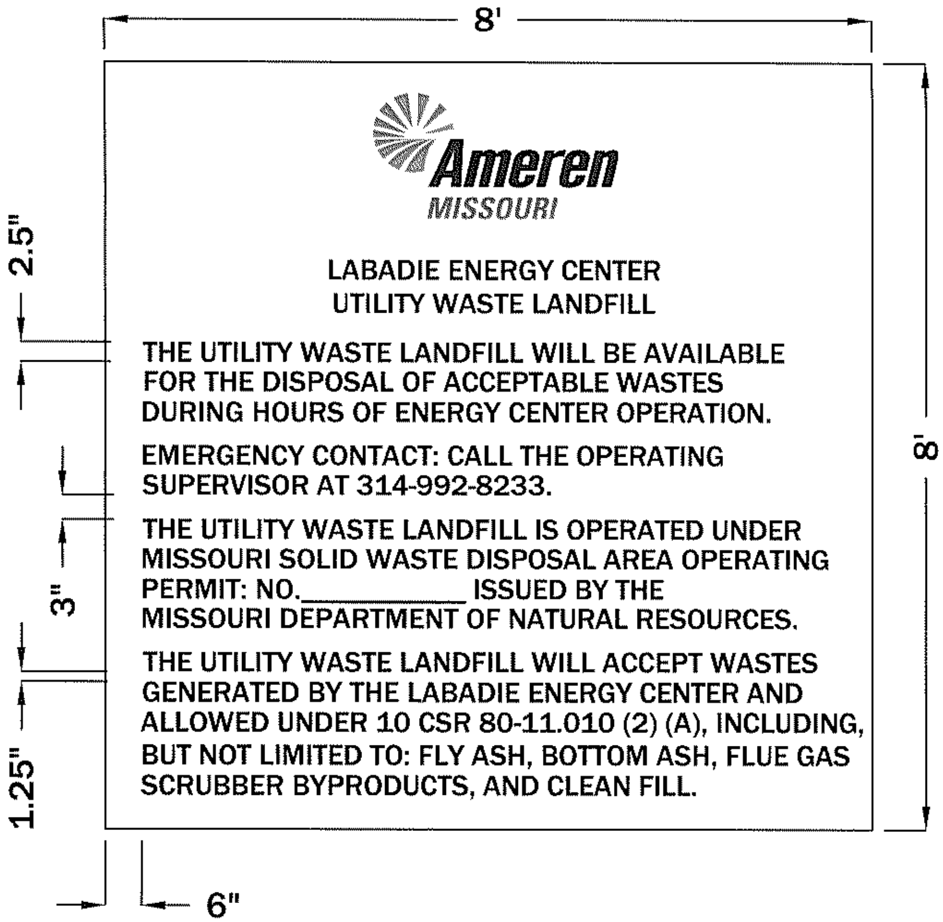
PREPARED FOR Ameren MISSOURI

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 2
LABADIE ENERGY CENTER
PROPOSED UTILITY WASTE LANDFILL
SEQUENCE OF CELL CONSTRUCTION

LOCATION 001009 | LABADIE ENERGY CENTER | CLASS 02010

Ameren MISSOURI | ST. LOUIS, MISSOURI | JANUARY 2013 | REV.

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LAND AIR WATER

PREPARED FOR Ameren MISSOURI

| | |
|---|---|
| DRAWN W.J.A. (G.E.R.) | FIGURE 3<br>LABADIE ENERGY CENTER<br>PROPOSED UTILITY WASTE LANDFILL<br>ENTRANCE SIGN DETAIL |
| CHKD R.L.R. (G.E.R.) | |
| SUPV. T.R.G. (G.E.R.) | |
| APPD. T.R.G. (G.E.R.) | LOCATION 001009 \| LABADIE ENERGY CENTER \| CLASS 02010 |
| Ameren MISSOURI ST. LOUIS, MISSOURI | JANUARY 2013 \| REV. |

M:\Share\CADDFiles\AMEREN-UE\LABADIE\CONSTRUCTION PERMIT\2012 DRAWINGS\FIG 3 ENGR REPT.dwg, Cover Sheet, 1/23/2013 2:42:30 PM

# TABLES

**Ameren Missouri Labadie Energy Center**
**Construction Permit Application for a Proposed Utility Waste Landfill**
**Franklin County, Missouri**

**Applicable Regulatory References**
**Sorted by Table of Contents**
**Table 1A**

| TITLE | REFERENCE (10 CSR 80-) |
|---|---|
| Construction Permit Application Form | 2.020(2)(A)2.A |
| Construction Permit Application Fee-MDNR ($2,000) | 2.020(2)(A)2.G; 2.020(2)(A)5 |

| | | |
|---|---|---|
| **1.0** | **INTRODUCTION** | |
| 1.1 | Site Background | 11.010(4)(A) |
| 1.2 | Proposed Facility | 2.020(2)(A) |
| 1.3 | Landfill Owner and Operator | 2.020(2)(A); 2.010(67); 2.010(68) |
| 1.4 | Applicant Violation History | 2.020(2)(A)2.I; 2.070 |
| 1.5 | Request for Recommendation from East Central Solid Waste Management District, Region I | 260.205.7 (MO Statute) |
| **2.0** | **SITE SELECTION** | 11.010(4) |
| 2.1 | Site Location | 2.020 |
| 2.2 | Legal Description of the Property | 2.020(2)(A) |
| 2.3 | Site Access | 11.010 (4)(C)1; 11.010(16)(B)1; 11.010(16)(C)2 |
| 2.4 | Zoning and Land Use | 11.010(4)(B)5.B |
| 2.5 | Surrounding Land Use | 11.010(4)(B)5.B; 2.020(9)(B)8.C |
| 2.6 | Site Topography | 11.010(4)(B)5.A |
| 2.7 | Utilities | 11.010(4)(B)5.B |
| 2.8 | Site Selection Location Restrictions | 11.010(4) |
| 2.8.1 | Preliminary Site Investigation (PSI) | 2.015(1)(A); 260.205.2 (MO Statutue);11.010 |
| 2.8.2 | Detailed Site Investigation (DSI) | 2.015(1)(D) |
| 2.8.3 | Floodplains | 11.010(4)(B)1 |
| 2.8.4 | Wetlands | 11.010(4)(B)2 |
| 2.8.5 | Seismic Impact Zone | 11.010(4)(B)3; 2.010(96); 2.010(57) |
| 2.8.7 | Unstable Areas | 11.010(4)(B)4; 2.010(114); 2.010(77);2.010(6); 2.010(49), 3.010 |
| 2.9 | Geotechnical Investigations | 11.010(4)(B)5.D |
| 2.9.1 | Soils | 11.010(4)(B)5.D |
| 2.9.2 | Bedrock | 11.010(4)(B)4.A |
| 2.9.3 | Groundwater Occurrence | 11.010(8)(B)1.C; 11.010(8)(B)1.D; 2.010(5) |
| 2.10 | Survey Control | 11.010(7) |
| 2.10.1 | Boundary Survey | 11.010(7)(B)1 |

| TITLE | | REFERENCE (10 CSR 80-) |
|---|---|---|
| 2.10.2 | Permanent Survey Control Points | 11.010(7) |
| **3.0** | **LANDFILL DESIGN** | 11.010(5) |
| 3.1 | Description of the Landfill Design | 11.010(5) |
| 3.1.1 | Project Background Summary | 11.010(4)(5) |
| 3.1.2 | Technical Background Summary | 11.010(4)(5) |
| 3.1.3 | Environmental Protection | 11.010(1) |
| 3.1.4 | Compliance with 10 CSR 80-11.010 | 11.010; 2.010(11); 2.010(118) |
| 3.2 | Volume of the Proposed Landfill | 11.010(5)(B); 11.010(17)(C)1.D |
| 3.2.1 | Landfill Life Expectancy | 11.010(17)(C)1.D |
| 3.2.2 | Soil Material Volume | 11.010(10)(B)1; 11.010(14)(B)1 |
| 3.3 | Construction Sequence | 11.010(5)(B)1 |
| 3.3.1 | UWL Construction Sequence | 11.010(5)(B)3 |
| 3.3.2 | UWL Disposal Area Construction Sequence | 11.010(5)(B)3 |
| 3.3.2.1 | Phase Construction Sequence | 11.010(5)(B)3 |
| 3.3.2.2 | Flood Impact Mitigation Plan | 11.010(5)(B)3 |
| 3.3.2.3 | Franklin County Requirement - Erosion Protection | Article 10 Section 238 C,3d.) |
| 3.3.3 | Phased Development | 11.010(5)(B)3; 2.010(74) |
| 3.3.4 | Excavaton to Proposed Subgrade | 11.010(5)(B)3 |
| 3.3.5 | Miscellaneous Construction | 11.010(5)(B)3 |
| 3.4 | Final Contours | 11.010(4)(B)5.A |
| 3.5 | Solid Waste Accepted | 11.010(2)(A); 11.010(2)(B); 2.010(118) |
| 3.6 | Solid Waste Excluded | 11.010(3)(A); 11.010(3)(B) |
| 3.7 | Stormwater Management System | 11.010(8)(B)1.F; 11.010(8)(C)1 |
| 3.7.1 | Stormwater Runoff Controls | 11.010(8)(B)1.F; 11.010(8)(C)1 |
| 3.7.2 | Water Quality Permits | 2.020(2)(A)2.J |
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| 3.9 | Leachate Management System | 11.010(9)(B) |
| 3.9.1 | Leachate Generation Rate | 11.010(9)(B) |
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| 3.10.2 | Groundwater Monitoring System | 11.010(11) |
| 3.10.3 | Corrective Action | 11.010(11)(C)6 |

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| 3.11 | Cover Material | 11.010(14)(C)1 |
| 3.11.1 | Soil Cover Sources | 11.010(14)(B)1 |
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| 3.12.1 | Materials and Construction | 11.010(14)(C); 11.010(14)(B) |
| 3.12.1.1 | Soil Component | 11.010(14)(C )1; 11.010(14)(C)3; 11.010(14)(C)10 |
| 3.12.2 | Vegetation | 11.010(14)(C)7 |
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| 3.14 | General Maintenance of Landfill Systems | 11.010(4)(B)5.C |
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| 4.1.1 | Phased Development | 11.010(5)(B)3 |
| 4.1.2 | Sequence of Phase Construction | 11.010(5)(B) |
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| 4.12 | Records | 11.010(17);11.010(9); 11.010(11); 11.010(3)(B); 2.030(4)(A) (B) (C) |

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| 2 | Existing Site Conditions | 11.010(4)(B)5 |
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| 4 | Land Use and Zoning within 1/4 mile | 11.010(4)(B)5 |
| 5 | Overall Bottom Grading Plan (Top of Liner) | 11.010(4)(B)5 |
| 6 | Cell 1 Grading Plan (Top of Liner) | 11.010(4)(B)5 |
| 7 | Cell 2 Grading Plan (Top of Liner) | 11.010(4)(B)5 |
| 8 | Cell 3 Grading Plan (Top of Liner) | 11.010(4)(B)5 |
| 9 | Cell 4 Grading Plan (Top of Liner) | 11.010(4)(B)5 |
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| 14 | Phase 4 Final Grading Plan | 11.010(4)(B)5 |
| 15 | Geomembrane and Cover Details | 11.010(10)(B)2.(14)(A) |
| 16 | Stormwater Pond Storage and Transfer Details | 11.010(5) |
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| 18 | Miscellaneous Details 1 | 11.010(5) |
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| 20 | Leachate Collection System Details | 11.010(5) |
| 21 | Stormwater Drainage Details | 11.010(5) |
| 22 | Cross Sections A-A' and B-B' | 11.010(5) |
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**Ameren Missouri Labadie Energy Center**
**Construction Permit Application for a Proposed Utility Waste Landfill**
**Franklin County, Missouri**

**Applicable Regulatory References**
**Sorted by Regulatory Citation**
**Table 1B**

## STATE OF MISSOURI REVISED STATUTES (RSMo)

| RSMo | REPORT SECTION | TITLE |
|---|---|---|
| 260.205.2 | 2.8.1 | Preliminary Site Investigation (PSI) |
| 260.205.7 | Appendix E | Request for Recommendation from East Central Solid Waste Management District, Region I |
| 260.205.7 | 1.5 | Request for Recommendation from East Central Solid Waste Management District, Region I |

## STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
## MISSOURI SOLID WASTE MANAGEMENT
## 10 CSR 80-2 RULES

| 10 CSR 80- | REPORT SECTION | TITLE |
|---|---|---|
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| 2.020(1)(2)(A)(B) | Appendix B | Articles of Organization |
| 2.020(1)(2)(A)(B) | Appendix C | Good Standing Certificate |
| 2.010(5) | 2.9.3 | Groundwater Occurrence |
| 2.010(6) | 2.8.7 | Unstable Areas |
| 2.010(11) | 3.1.4 | Compliance with 10 CSR 80-11.010 |
| 2.010(49) | 2.8.7 | Unstable Areas |
| 2.010(57) | 2.8.6 | Seismic Impact Zone |
| 2.010(67) | 1.3 | Landfill Owner and Operator |
| 2.010(68) | 1.3 | Landfill Owner and Operator |
| 2.010(74) | 3.3.3 | Phased Development |
| 2.010(77) | 2.8.7 | Unstable Areas |
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| 2.010(118) | 3.1.4 | Compliance with 10 CSR 80-11.010 |
| 2.010(118) | 3.1.4 | Compliance with 10 CSR 80-11.010 |
| 2.015(1)(A) | 2.8.1 | Preliminary Site Investigation (PSI) |
| 2.015(1)(D) | 2.8.2 | Detailed Site Investigation (DSI) |
| 2.020 | 2.1 | Site Location |

## STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
## MISSOURI SOLID WASTE MANAGEMENT
## 10 CSR 80-2 RULES (continued)

| 10 CSR 80- | REPORT SECTION | TITLE |
|---|---|---|
| 2.020(2)(A) | 1.2 | Proposed Facility |
| 2.020(2)(A) | 1.3 | Landfill Owner and Operator |
| 2.020(2)(A) | 2.2 | Legal Description of the Property |
| 2.020(2)(A)2.A | N/A | Construction Permit Application Form |
| 2.020(2)(A)2.C | Appendix U | Draft FAI |
| 2.020(2)(A)2.D | Appendix R | Closure and Post-Closure Plan |
| 2.020(2)(A)2.F | Appendix G | Adjacent Landowners or Landowners within 1000 ft |
| 2.020(2)(A)2.G | N/A | Construction Permit Application Fee - MDNR ($2,000) |
| 2.020(2)(A)2.I | 1.4 | Applicant Violation History |
| 2.020(2)(A)2.J | 3.7.2 | Water Quality Permits |
| 2.020(2)(A)5 | N/A | Construction Permit Application Fee - MDNR ($2,000) |
| 2.020(6) | Appendix F | Franklin County Requirements |
| 2.020(7) | Appendix U | Draft FAI |
| 2.020(8) | Appendix D | Habitual Violator Disclosure Form |
| 2.020(9)(B)8.C | 2.5 | Surrounding Land Use |
| 2.020(9)(B)8.H | Appendix S | Utility Waste Landfill Emergency Contacts |
| 2.030(4) | Appendix R | Closure and Post-Closure Plan |
| 2.070 | 1.4 | Applicant Violation History |
| 3.010 | 2.8.7 | Unstable Areas |

## STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
## MISSOURI SOLID WASTE MANAGEMENT
## 10 CSR 80-11 RULES

| 10 CSR 80- | REPORT SECTION | TITLE |
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| 11.010 | 2.8.7 | Preliminary Site Investigation (PSI) |
| 11.010 | 3.1 | Description of the Landfill Design |
| 11.010 | 3.1.1 | Project Background Summary |
| 11.010 | 3.1.2 | Technical Background Summary |
| 11.010 | 3.1.4 | Compliance with 10 CSR 80-11.010 |
| 11.010 | Appendix Y | Miscellaneous Engineering Calculations |
| 11.010(1) | 3.1.3 | Environmental Protection |
| 11.010(1) | Appendix Z | Groundwater Demonstration and Design Basis Memoranda |
| 11.010(2) | 4.3 | Solid Waste Accepted |

**STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES**
**MISSOURI SOLID WASTE MANAGEMENT**
**10 CSR 80-11 RULES (continued)**

| 10 CSR 80- | REPORT SECTION | TITLE |
|---|---|---|
| 11.010(2)(A) | 3.5 | Solid Waste Accepted |
| 11.010(2)(B) | 3.5 | Solid Waste Accepted |
| 11.010(2)(3)(16) | Figure 3 | Entrance Sign Detail |
| 11.010(3) | 4.4 | Solid Waste Excluded |
| 11.010(3)(A) | 3.6 | Solid Waste Excluded |
| 11.010(3)(B) | 3.6 | Solid Waste Excluded |
| 11.010(4) | 2.0 | Site Selection |
| 11.010(4) | 2.8 | Site Selection Location Restrictions |
| 11.010(4)(A) | 1.1 | Site Background |
| 11.010(4)(5) | 3.1.1 | Project Background Summary |
| 11.010(4)(5) | 3.1.2 | Technical Background Summary |
| 11.010(4)(B)1 | 2.8.3 | Floodplains |
| 11.010(4)(B)1 | Appendix H | Floodplain Documentation |
| 11.010(4)(B)2 | 2.8.4 | Wetlands |
| 11.010(4)(B)2 | Appendix I | Wetland Assessment |
| 11.010(4)(B)3 | 2.8.6 | Seismic Impact Zone |
| 11.010(4)(B)4 | 2.8.7 | Unstable Areas |
| 11.010(4)(B)4.A | 2.9.2 | Bedrock |
| 11.010(4)(B)5 | Plan Sheet 1 | Cover Sheet |
| 11.010(4)(B)5 | Plan Sheet 2 | Existing Site Conditions |
| 11.010(4)(B)5 | Plan Sheet 3 | Project Overview |
| 11.010(4)(B)5 | Plan Sheet 4 | Land Use and Zoning Within 1/4 Mile |
| 11.010(4)(B)5 | Plan Sheet 5 | Overall Bottom Grading Plan (Top of Liner) |
| 11.010(4)(B)5 | Plan Sheet 6 | Cell 1 Grading Plan (Top of Liner) |
| 11.010(4)(B)5 | Plan Sheet 7 | Cell 2 Grading Plan (Top of Liner) |
| 11.010(4)(B)5 | Plan Sheet 8 | Cell 3 Grading Plan (Top of Liner) |
| 11.010(4)(B)5 | Plan Sheet 9 | Cell 4 Grading Plan (Top of Liner) |
| 11.010(4)(B)5 | Plan Sheet 10 | Overall Final Grading Plan |
| 11.010(4)(B)5 | Plan Sheet 11 | Phase 1 Final Grading Plan |
| 11.010(4)(B)5 | Plan Sheet 12 | Phase 2 Final Grading Plan |
| 11.010(4)(B)5 | Plan Sheet 13 | Phase 3 Final Grading Plan |
| 11.010(4)(B)5 | Plan Sheet 14 | Phase 4 Final Grading Plan |

**STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES**
**MISSOURI SOLID WASTE MANAGEMENT**
**10 CSR 80-11 RULES (continued)**

| 10 CSR 80- | REPORT SECTION | TITLE |
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| 11.010(4)(B)5 | Figure 2 | Sequence of Cell Construction |
| 11.010(4)(B)5.A | 2.6 | Site Topography |
| 11.010(4)(B)5.A | 3.4 | Final Contours |
| 11.010(4)(B)5.B | 2.4 | Zoning and Land Use |
| 11.010(4)(B)5.B | 2.5 | Surrounding Land Use |
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| 11.010(4)(B)5.C | 4.2.1 | UWL Disposal Operation Operational Description |
| 11.010(4)(B)5.C | 4.2.2 | Flood Impact Mitigation Plan |
| 11.010(4)(B)5.D | 2.9 | Geotechnical Investigations |
| 11.010(4)(B)5.D | 2.9.1 | Soils |
| 11.010(4)(B)5.D | Appendix J | Geotechnical Investigation for Construction Permit Application by Reitz & Jens, dated June 2011 |
| 11.010(4)(B)5.D | Appendix K | Soil Material Volume and Balance Calculations |
| 11.010(4)(B)(6) | Appendix Z | Groundwater Demonstration and Design Basis Memoranda |
| 11.010(4)(C)1 | 2.3 | Site Access |
| 11.010(5) | Plan Sheet 16 | Stormwater Pond Storage and Transfer Details |
| 11.010(5) | Plan Sheet 17 | Liner Details |
| 11.010(5) | Plan Sheet 18 | Miscellaneous Details 1 |
| 11.010(5) | Plan Sheet 19 | Miscellaneous Details 2 |
| 11.010(5) | Plan Sheet 20 | Leachate Collection System Details |
| 11.010(5) | Plan Sheet 21 | Stormwater Drainage Details |
| 11.010(5) | Plan Sheet 22 | Cross Sections A-A' and B-B' |
| 11.010(5) | Plan Sheet 23 | Cross Sections C-C' and D-D' |
| 11.010(5) | Figure 1 | Site Location Map |
| 11.010(5) | 3.0 | Landfill Design |
| 11.010(5) | 3.1 | Description of the Landfill Design |
| 11.010(5)(A)4 | Appendix J | Report Titled "Geotechnical Engineering Report for Construction Permit Application" by Reitz & Jens, dated November 2012 |
| 11.010(5)(B) | 3.2 | Volume of the Proposed Landfill |
| 11.010(5)(B) | 4.0 | Landfill Operation |
| 11.010(5)(B)1 | 3.3 | Construction Sequence |

**STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES**
**MISSOURI SOLID WASTE MANAGEMENT**
**10 CSR 80-11 RULES (continued)**

| 10 CSR 80- | REPORT SECTION | TITLE |
|---|---|---|
| 11.010(5)(B)1.2 | 4.1 | Construction and Development |
| 11.010(5)(B) | 4.1.2 | Sequence of Phase Construction |
| 11.010(5)(B)3 | 3.3.1 | UWL Construction Sequence |
| 11.010(5)(B)3 | 3.3.2 | UWL Disposal Area Construction Sequence |
| 11.010(5)(B)3 | 3.3.2.1 | Phase Construction Sequence |
| 11.010(5)(B)3 | 3.3.2.2 | Flood Mitigation Plan |
| 11.010(5)(B)3 | 3.3.3 | Phased Development |
| 11.010(5)(B)3 | 4.1.1 | Phased Development |
| 11.010(6)(B) | Appendix P | Construction Quality Assurance Plan |
| 11.010(6)(B) | 4.1.3 | Construction Quality Assurance (CQA) |
| 11.010(7) | 2.10 | Survey Control |
| 11.010(7) | 2.10.2 | Permanent Survey Control Points |
| 11.010(7) | 4.1.4 | Survey Control |
| 11.010(7)(B) | Appendix V | Survey Plat |
| 11.010(7)(B)1 | 2.10.1 | Boundary Survey |
| 11.010(8) | 4.5 | Water Quality |
| 11.010(8)(A)(B) | Appendix W | Groundwater Hydraulic Data |
| 11.010(8)(B)1.C | 2.9.3 | Groundwater Occurrence |
| 11.010(8)(B)1.C | Appendix Z | Groundwater Demonstration and Design Basis Memoranda |
| 11.010(8)(B)1.D | 2.9.3 | Groundwater Occurrence |
| 11.010(8)(B)1.F | 3.7 | Stormwater Management System |
| 11.010(8)(B)1.F | 3.7.1 | Stormwater Runoff Controls |
| 11.010(8)(B)1.F | Appendix M | Erosion Calculations |
| 11.010(8)(B)1.F | Appendix N | Stormwater Calculations |
| 11.010(8)(B)1.F | Appendix O | H.E.L.P Model Results |
| 11.010(8)(C) | Appendix N | Stormwater Calculations |

## STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
## MISSOURI SOLID WASTE MANAGEMENT
## 10 CSR 80-11 RULES (continued)

| 10 CSR 80- | REPORT SECTION | TITLE |
|---|---|---|
| 11.010(8)(C) | Appendix O | H.E.L.P Model Results |
| 11.010(8)(C) | 4.5.1 | Stormwater Management |
| 11.010(8)(C)1 | 3.7 | Stormwater Management System |
| 11.010(8)(C)1 | 3.7.1 | Stormwater Runoff Controls |
| 11.010(9) | 4.5 | Water Quality |
| 11.010(9)(B) | 3.9 | Leachate Management System |
| 11.010(9)(B) | 3.9.1 | Leachate Generation Rate |
| 11.010(9)(B) | 3.9.1.1 | Pre-Closure Generation Rate |
| 11.010(9)(B) | 3.9.1.2 | Post-Closure Generation Rate |
| 11.010(9)(B) | 3.9.2 | Water Storage and Disposal |
| 11.010(9)(C) | 4.5.2 | Leachate Management in the UWL |
| 11.010(10)(B) | 3.8 | Landfill Liner |
| 11.010(10)(B)1 | 3.2.2 | Soil Material Volume |
| 11.010(10)(B)1 | 3.8.2.1 | Soil Component |
| 11.010(10)(B)2 | 3.8.2.2 | Geomembrane Component |
| 11.010(10)(B)2.(14)(A) | Plan Sheet 15 | Geomembrane and Cover Details |
| 11.010(10)(B)4 | 3.8.1 | Grading Plan |
| 11.010(10)(C) | 3.8.2 | Materials and Construction |
| 11.010(11) | 3.10 | Groundwater Monitoring |
| 11.010(11) | 3.10.2 | Groundwater Monitoring System |
| 11.010(11)(A)(B) | Appendix X | Documentation of Groundwater Monitoring Well Design |
| 11.010(11)(C)2 | Appendix Q | Groundwater Sampling and Analysis Plan |
| 11.010(11)(C)2 | 4.5.3 | Groundwater Sampling and Analysis Plan |
| 11.010(11)(C)3 | 3.10.1 | Groundwater Quality |
| 11.010(11)(C)6 | 3.10.3 | Corrective Action |
| 11.010(12) | 3.13 | Air Quality |
| 11.010(12) | 4.6 | Air Quality |
| 11.010(12)(B) | 4.6.1 | Dust Control |
| 11.010(13) | 4.7 | Aesthetics |

**STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES**
**MISSOURI SOLID WASTE MANAGEMENT**
**10 CSR 80-11 RULES (continued)**

| 10 CSR 80- | REPORT SECTION | TITLE |
|---|---|---|
| 11.010(13) | 4.7.1 | General Aesthetics |
| 11.010(13)(C)3 | 4.7.2 | Mining for Beneficial Reuse |
| 11.010(14) | 3.12 | Landfill Final Cover |
| 11.010(14) | 4.9 | Final Cover Material |
| 11.010(14)(B) | Appendix R | Closure and Post-Closure Plan |
| 11.010(14)(B) | 3.15 | Closure and Post-Closure |
| 11.010(14)(B) | 3.12.1 | Materials and Construction |
| 11.010(14)(B)1 | 3.2.2 | Soil Material Volume |
| 11.010(14)(B)1 | 3.11.1 | Soil Cover Sources |
| 11.010(14)(C) | 3.12.1 | Materials and Construction |
| 11.010(14)(C) | 3.12.1.1 | Soil Component |
| 11.010(14)(C)1 | 3.11 | Cover Material |
| 11.010(14)(C)3 | 3.12.1.1 | Soil Component |
| 11.010(14)(C)7 | 3.12.2 | Vegetation |
| 11.010(14)(C)10 | 3.12.1.1 | Soil Component |
| 11.010(15) | 4.8 | Equipment and Staffing |
| 11.010(15) | 4.10 | Compaction |
| 11.010(15)(B)1 | 4.8.2 | Equipment Maintenance |
| 11.010(15)(B)1 | 4.8.3 | Back-Up Equipment |
| 11.010(15)(C) | 4.8.4 | Staffing |
| 11.010(15)(C)1 | 4.8.1 | Primary Equipment |
| 11.010(16) | 4.11 | Safety |
| 11.010(16)(B)1 | 2.3 | Site Access |
| 11.010(16)(B)1 | 4.0 | Landfill Operation |
| 11.010(16)(C)2 | 2.3 | Site Access |
| 11.010(17) | 4.12 | Records |
| 11.010(17) | Appendix T | Recordkeeping and Reporting Forms |
| 11.010(17)(C)2.A(I) | Appendix A | Property Deeds |
| 11.010(17)(C)1.D | Appendix L | Landfill Life Estimate |
| 11.010(17)(C)1.D | 3.2 | Volume of the Proposed Landfill |
| 11.010(17)(C)1.D | 3.2.1 | Landfill Life Expectancy |

NOTE: Franklin County Requirement for Erosion Protection, Article 10 Section 238 C 3d is referenced in 3.3.2.3.

**From:** Skitt, Barbara S
**Sent:** Thursday, November 15, 2012 5:39 PM
**To:** pnwakoby@expl.com
**Cc:** Reynolds, Renee M; Gerhardt, Kevin J
**Subject:** Ameren's Labadie Plant UWL Layout

Hi Patrick,

Thank you so much for your time again yesterday. Please find attached the revised layout of the Labadie UWL landfill. As we discussed the proposed landfill will no longer require a relocation of the pipe line. The new layout has the toe of the berms set back 100' off the centerline of the pipeline. The first 2 phases of the landfill will be west of the pipeline with no impact to the pipeline and phases 3 and 4 are east of the pipeline. Once phases 3 and 4 are constructed, 2 roads will be installed perpendicularly over the pipeline. These roads are for Ameren traffic only and are planned to only be gravel at a height of around 15'. These roads will be constructed in a way as not to impact the pipeline. These road will be able to be removed in short order if Explorer has a need to access their pipeline. Phases 1 and 2 have a life expectancy of 10-15 years after they go in service in 2015. Construction on phase 1 is scheduled for 2014. If you have any question feel free to call and discuss. **Please treat this email and attachment as confidential.**

Have a good evening.

::::::::::::::::::::::::::::::
**BARBARA S. SKITT**
Managing Supervisor
Real Estate Department
T 314.554.2249
C 314.401.8674
F 314.554.2570
E bskitt@ameren.com
..............................

**Ameren Services**
1901 Chouteau Avenue
PO Box 66149, MC 700
St. Louis, MO 63166-6149
Ameren.com

RECEIVED

MAR 18 2013

FRANKLIN COUNTY MO
PLANNING & ZONING DEPT

# FLOODPLAIN DEVELOPMENT PERMIT/APPLICATION

Application No. 120219 Date: ____________

TO THE ADMINISTRATOR: The undersigned hereby makes application for a permit to develop in a floodplain. The work to be performed, including flood protection works, is as described below and in attachments hereto. The undersigned agrees that all such work shall be in accordance with the requirements of the Floodplain Management Ordinance and with all other applicable county/city ordinances, federal programs, and the laws and regulations of the State of Missouri.

| | | | |
|---|---|---|---|
| AMEREN MISSOURI | | NOT DETERMINED | |
| Owner or Agent | Date | Builder | Date |
| 10 LABADIE POWER PLANT RD. LABADIE, MO 63055 | | | |
| Address | | Address | |
| (314) 554-2249 | | | |
| Phone | | Phone | |

## SITE DATA

1. Location: — 1/4; — 1/4; Section 17, 20; Township 44N; Range 2E
   Street Address 10 LABADIE POWER PLANT RD. LABADIE, MO 63055
2. Type of Development: Filling X Grading ____ Excavation ____ Minimum Improvement ____
   Routine Maintenance ____ Substantial Improvement ____ New Construction X Other ____
3. Description of Development: CONSTRUCTION OF UTILITY WASTE LANDFILL
4. Premises: Structure Size N/A ft. By N/A ft. Area of Site 10,092,852 Sq Ft
   Principal Use UTILITY WASTE STORAGE Accessory Uses (storage, parking, etc.) —
5. Value of Improvement (fair market) $ 14,000,000 * Pre-Improvement/Assessed Value of Structure $ 0
6. Property Located in a Designated FLOODWAY? Yes ✓ No ____
   * COST ESTIMATE FOR FIRST PHASE
   IF ANSWERED YES, CERTIFICATION MUST BE PROVIDED PRIOR TO THE ISSUANCE OF A PERMIT TO DEVELOP, THAT THE PROPOSED DEVELOPMENT WILL RESULT IN NO INCREASE IN THE BASE (100-YEAR) FLOOD ELEVATIONS.
7. Property Located in a Designated Floodplain FRINGE? Yes ✓ No ____
8. Elevation of the 100-Year Flood (ID source) 482.5 - 483.5 FRANKLIN CO FIS, OCT 18, 2011 NAVD88 NGVD/NAVD
9. Elevation of the Proposed Development Site 465 NGVD29 GROUND ELEVATION. HIGHEST POINT 564. NGVD29 NGVD/NAVD
10. Local Ordinance Elevation/Floodproofing Requirement N/A NGVD/NAVD
11. Other Floodplain Elevation Information (ID and describe source) N/A
12. Other Permits Required?

| | Yes | No | Provided |
|---|---|---|---|
| Corps of Engineer 404 Permit: | | ✓ | |
| State Department of Natural Resources 401 Permit: | | ✓ | |
| Environmental Protection Agency NPDES Permit: | | ✓ | |

All Provisions of Ordinance Number ____________, the "Floodplain Management Ordinance", shall be in Compliance.

## PERMIT APPROVAL/DENIAL

Plans and Specifications Approved/~~Denied~~ this 19th Day of MARCH, 2013

Barbara Skitt
Signature of Developer/Owner

Authorizing Official

BARBARA SKITT, MANAGING SUPERVISOR, REAL ESTATE
Print Name and Title

TORI KARIM FLOODPLAIN MANAGER
Print Name and Title

THIS PERMIT IS ISSUED WITH THE CONDITION THAT THE LOWEST FLOOR (INCLUDING BASEMENT FLOOR) OF ANY NEW OR SUBSTANITALLY IMPROVED RESIDENTIAL BUILDING WILL BE ELEVATED 2 FOOT/FEET ABOVE THE BASE FLOOD ELEVATION. IF THE PROPOSED DEVELOPMENT IS A NON-RESIDENTIAL BUILDING, THIS PERMIT IS ISSUED WITH THE CONDITION THAT THE LOWEST FLOOR (INCLUDING BASEMENT) OF A NEW OR SUBSTANITALLY IMPROVED NON-RESIDENTIAL BUILDING WILL BE ELEVATED OR FLOODPROOFED 2 FOOT/FEET ABOVE THE BASE FLOOD ELEVATION.

THIS PERMIT IS USED WITH THE CONDTION THAT THE DEVELOPER/OWNER WILL PROVIDE CERTIFICATION BY A REGISTERED ENGINEER, ARCHITECT, OR LAND SURVEYOR OF THE "AS-BUILT" LOWEST FLOOR (INCLUDING BASEMENT) ELEVATION OF ANY NEW OR SUBSTANTIALLY IMPROVED BUILDING COVERED BY THIS PERMIT.

II. THIS PERMIT IS CONTINGENT UPON AMEREN UE MISSOURI OBTAINING A "CONSTRUCTION PERMIT" FROM THE DEPARTMENT OF NATURAL RESOURCES. WITHOUT THE DNR PERMIT, THIS APPROVAL WILL BECOME NULL AND VOID

**FRANKLIN COUNTY**

Franklin County Highway Department
Eva Gadcke, Highway Administrator

400 EAST LOCUST STREET
ROOM 003A
UNION, MO 63084
MAIN LINE (636) 583-6361
FAX (636)584-0902
www.franklinmo.org

July 24, 2013

Craig Giesmann, PE, PMP
Managing Supervisor
Ameren – Power Operations Service
3700 S. Lindbergh Blvd., MC F-604
St. Louis, MO 63127

RE: Labadie Bottom Road Relocation

Dear Mr. Giesmann,

As part of the proposed landfill plans Labadie Bottom Road, a county road, will need to be relocated and an overpass from the plant to the landfill will need to be installed. I have been in contact with your engineer, Reitz & Jens, to review the county design requirements for these improvements. The traffic on this county road is mainly Ameren employees on the asphalted west end, and agricultural traffic on the graveled east end. We have not worked through final details of the roadway design or determined the extent of hard surfacing and gravel roadway. Our intent is to work with Reitz & Jens to come up with final plans for the roadway and submit them to the County Commission for approval.

Conceptually, the proposed relocation and overpass is accepted. The county reserves the right to approve the final plan details before construction can begin. Please let me know if you need additional information on this subject.

Sincerely,

Joe Feldmann

Joe Feldmann
Franklin County Highway Dept.
County Engineer

CC: Mark Vincent
Paul Reitz, Reitz & Jens