Design and Construction of a CCR Landfill
Adjacent to the Missouri River

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INTRODUCTION

Ameren Missouri (Ameren) operates four coal-fired energy centers in Missouri. The largest is the 2,405-MW Labadie Energy Center (LEC). The LEC is located on the right descending bank of the Missouri River near river mile 58 in Franklin County, Missouri, approximately 40 miles west of the City of St. Louis. This paper is the second of two papers presented on the LEC Utility Waste Landfill (UWL). The preceding paper discussed the challenges to locating and permitting the UWL. This paper presents a summary of how these challenges were met in the design and construction of the UWL. The project was successful due to extensive upfront planning, a knowledgeable client, and a cooperative effort between local consulting firms with specialized expertise in complimentary technical and regulatory areas. The ability of the project team to quickly adapt and adjust to the changing design requirements allowed the project to be delivered in the shortest practical timeframe despite the changing local, state and federal requirements.

The engineering challenges pertaining to the location of the UWL in the floodplain of the Missouri River were:

- Develop a Master Plan of the UWL to manage the plant’s maximum CCR volumes for a minimum specified operating life on a topographically flat, floodplain, agricultural setting
- Cell Design (before the EPA CCR Rule)
- Storm water containment and management
- Public participation and comment
- Meeting the EPA CCR Rule
- Franklin County requirements
- Design Impact due to periodic river flooding
- Geotechnical Evaluation of:
  o Seismic loading and liquefaction
  o Slope stability
  o Settlement in deep alluvial unconsolidated soils
- Locating sufficient quantity and quality of fill materials and clay liner materials
- Construction sequence and schedule
Many other issues pertaining to the construction of any landfill are not addressed in this paper but were effectively addressed in the design and construction of the LEC UWL.

**PROJECT TEAM SELECTION**

Ameren selected the project team of Reitz & Jens, Inc., GREDELL Engineering Resources, Inc. and CDG Engineers, Inc. based on their successful working relationships with Ameren and their qualifications associated with this specific work scope. Reitz & Jens, Inc. was the prime consultant for the landfill design project and was chosen due to their past knowledge of the LEC site and their geotechnical expertise. GREDELL Engineering Resources, Inc. was chosen for their expertise in geologic/hydrogeologic evaluations of proposed landfill sites and their landfill design/permitting expertise in the state of Missouri. Reitz & Jens and Gredell Engineering had successfully worked together on Ameren’s first UWL from 2005 to 2010 to site, design, permit and construct the first (and only) ‘wet gypsum stack’ utility waste landfill in Missouri. CDG Engineers, Inc. were chosen for their expertise and experience in floodplain modeling and mechanical/electrical design.

**MASTER PLAN OF THE UWL**

The ultimate goal of the project was to provide dry CCR disposal capacity for the maximum anticipated generation of CCR with limited recycle or reuse for a minimum 25+ year landfill life. The diverse and large number of client representatives that have a stake in the ultimate design required extensive public outreach, education, and coordination.

![Figure 1 – Detailed Site Investigation Layout; 400 acres; showing Borings and CPT Soundings Layout](image-url)
In order to assure an adequate footprint was available for the required capacity, Ameren began the evaluation with a 400-acre footprint (out of a possible 1040+ acres) for the Detailed Site Investigation, which is the second step in Missouri’s upfront geologic and subsurface hydrologic evaluation permit process. The initial plan from April 2009 is shown in Figure 1. While this required more initial expense in field investigation costs, it assured sufficient acreage was available for the final development of the actual disposal area and the associated support facilities. One factor which impacted the shape and size of the UWL was the presence of wetlands. A preliminary wetland determination was completed in 2009 for this purpose.

Following MDNR’s approval of the 400-acre tract for further landfill development (April 2011), the master planning effort began to consider disposal cell (phase) size and configuration, internal drainage and stormwater control. This process included several iterative designs. In March 2011, one of the first preliminary layouts covered about 331 acres, with 5 development phases (or cells) and 2 stormwater ponds. The next generation layout in December 2011 covered about 247 acres, with 5 development phases and 3 stormwater ponds. In March 2012, the U.S. Army Corps of Engineers – Kansas City District completed a preliminary Jurisdictional wetland Determination and the UWL footprint was subsequently modified to avoid impacts to the jurisdictional Waters of the United States.

Figure 2 – Final Master Plan of UWL.
The final masterplan of the UWL is shown in Figure 2. The jurisdictional wetlands required that cells and stormwater ponds were irregularly shaped to avoid impacts to jurisdictional areas. Also, a major existing pipeline runs north-south through the site; so instead of relocating the pipeline, the UWL was designed to be developed as two distinct disposal areas.

The CCR area is 166.5 acres, divided into four cells. The cells are sized to provide about 5-years disposal capacity at maximum, projected generation rates and no recycling or reuse. The total final volume of CCR storage is approximately 13.7 million CY, which will provide a minimum life of about 24 years. Also included in the plan are three storm water and contact water collection ponds to comply with the design intent of having zero water discharge during the 25-year 24-hour design storm. The water management plan was to use the collected water to condition the CCR for placement in the cells, as well as use the water for dust control on interior surfaces of the working disposal cell. The first stage of construction of the UWL consisted of Cell 1 (31.4 acres) and the adjacent Pond 1 (5.7 acres), which were completed in September 2016.

**OVERVIEW OF DISPOSAL CELL DESIGN**

The composite bottom liner of each cell has 24-inch compacted clay with a minimum hydraulic conductivity (k) of $1 \times 10^{-7}$ cm/sec overlain with a 60 mil HDPE geomembrane liner. This liner design was based on the 1993 federal Subtitle D rules for Municipal Solid Waste Landfills. When the project began, Missouri’s UWL rules allowed a minimum design of 24-inch compacted clay with a minimum hydraulic conductivity (k) of $1 \times 10^{-5}$ cm/sec and no geomembrane liner. However, Ameren chose to be proactive and protective of the sensitive environment in which the landfill was being sited.

The grading pattern on the bottom of the landfill utilized a relatively flat 1% slope, the minimum allowed by Missouri design practice. A uniform, undulating grade design was utilized wherever possible in the landfill cells to simplify both design and construction, resulting in a series of very small ‘hills and valleys’ on the bottom of the landfill. The distance between the ‘hills’ were optimized to minimize the number of leachate collection pipes and sumps, as well as minimize the amount of cut and fill required to grade the landfill.

On top of the HDPE liner in each cell is a geocomposite drainage layer to collect leachate. The geocomposite layer drains to lateral slotted pipes that is installed in the bottom of each ‘valley’ in the bottom of each cell and run the length of the valley. Each pipe drains at a design grade of 0.5% to a leachate sump pump at the interior toe of the berm. A 12-inch thick protective aggregate layer, composed of non-calcareous sand, covers the geocomposite to protect it during initial filling operations. The sand also acts as a filter to prevent long-term geocomposite clogging due to fly ash intrusions.

Missouri’s landfill rules require protecting all landfills from inundation by a 100-year flood event. Therefore, each disposal cell was surrounded by a perimeter berm that functions as a flood protection levee. The exterior and interior sideslopes of the perimeter berms are 1(v) to 3(h). The top of the berms is at el. 488, which is about 0.5 feet above the FEMA 500-year flood elevation and about 4.0 feet above the FEMA 100-year flood elevation.
The UWL final grading plan of the CCR utilizes 1(v) to 3(h) sideslopes and one stormwater diversion bench on the approximate 65 feet tall slopes and a minimum 2\% slope on the flatter top of the UWL. When each cell is full, the maximum elevation of the UWL will be about 100 feet above the surrounding natural grade. Early in the design process and during initial public meetings, Ameren committed to limiting the height of the final landfill to 100 feet.

**Public Participation and Comment**

The Missouri UWL permit process requires 3 opportunities for public input throughout the 4- to 5-year permit process. Public notices are initially required, followed by a public information session near the end of the Detailed Site Investigation process and ending with a public hearing hosted by MDNR near the end of the construction permit process.

In addition, Ameren’s proposal to permit the LEC UWL led to revision of the Franklin County zoning laws, which resulted in several public hearings held by the County Zoning Board. Each public participation event was followed by internal discussions about the County or public comments made and whether or not the design needed to change in order to address or accommodate public comments.

**Franklin County Requirements**

The initial Construction Permit Application (CPA) was submitted to the Missouri Department of Natural Resources – Solid Waste Management Program (MDNR-SWMP) in January 2013. By law, MDNR-SWMP has one year to review a CPA. At the same time MDNR-SWMP was conducting their review, Franklin County’s Independent Registered Professional Engineer (IRPE) was conducting their review. In late summer 2013, the County provided comments on the design. The timing of the County comments conflicted with Missouri’s statutory timeframe to complete their review in one year, so Ameren withdrew their application to MDNR in late October 2013. The application documents were revised and resubmitted to MDNR in December 2013. The final permit was issued on January 2, 2015.

Franklin County’s regulations for a UWL were amended in July 2015. One stipulation included the requirement that the top of the perimeter berm be above the 500-year flood level. Another stipulation was that “all exterior berms shall be armored with concrete ... for the purpose intended…” The design team proposed to cover the exterior surfaces of the berms with a cast-in-place fabric-formed concrete mat (FCM) for erosion protection, which was accepted by Franklin County and MDNR. A typical cross-section of the perimeter berm is shown in Figure 3.

Figure 3 – Typical Cross-Section of Perimeter Berm as Constructed
EPA CCR Rule – Aquifer Separation

The EPA proposed the new CCR Rule in December 2014. The requirement for a 5-foot separation between the bottom of the UWL and the uppermost aquifer was an important issue for the design team to address. Because there is significant groundwater fluctuation in this area due to the riverine environment, the design needed additional investigation and analysis.

The site of the LEC UWL is in deep alluvial deposits of the Missouri River, which consist of irregular surface deposits of clays, silts and sandy silts of thin, but varying thickness, over fine- to coarse-grain sands with some gravels. The alluvial aquifer is underlain by limestone bedrock which is over 100 feet deep. The subsurface hydrogeological investigation (Detailed Site Investigation or DSI) determined that the underlying bedrock had no impact on the alluvial aquifer. The approximately 100 piezometers that were measured monthly during the DSI found that the water table fluctuated greatly with the Missouri River levels. Because of the fluctuation in the groundwater level, the design team proposed and MDNR agreed that the existing ground surface could be considered the highest water level of the uppermost aquifer. The design of cells was then revised to achieve a minimum of 5 feet of structural fill above the existing ground surface. The lowest elevation of the UWL occurs at the leachate collection sumps located at the inside toe of the perimeter berms. Since the existing ground surface varied a few feet over the footprint of the UWL, the amount of fill required at each cell varied.

Stormwater Containment

Stormwater management on a 166+ acre, flat site that is to be protected from inundation during the 100-year flood is more challenging than it would first appear. The management challenges include:

1. Managing runoff during operations.
2. Designing a stormwater conveyance system around the perimeter of a 166+ acre, flat site.
3. Determining how much accumulated stormwater to store.
4. Determining the ultimate disposition of accumulated stormwater.

Protection from flood inundation is the overriding design parameter for the landfill. This required the landfill to be completely surrounded by an up to 20 tall perimeter berm. Besides keeping flood waters outside of the landfill, the perimeter berms keep stormwater inside the landfill. One inch of rain over 1-acre can produce up to 27,000 gallons of stormwater run-off. The LEC site averages ~35 inches of rainfall each year. Over the 166 acres landfill footprint, the quantity of stormwater to manage can be as much as 70 to 80 million gallons of water per year (assuming 50% runoff).

Dry landfill operation principals require stormwater to be separated from waste as much as practical. A combination of operational considerations and design of water conveyance systems and storage ponds was included in the design. Accumulated stormwater cannot remain in contact with CCR and must be removed from the active disposal area. During initial disposal activities, stormwater in contact with CCR must be pumped into the storage ponds. Once the in-place CCR rises above the elevation of the stormwater inlet, gravity conveyance systems are preferred.
A perimeter ditch was designed inside of the perimeter berm at the toe of the future landfill to convey water around the toe of the landfill to strategically placed stormwater storage ponds. Typical stormwater conveyances might be built with a 1% to 2% slope on the bottom to transport stormwater by gravity. However, half the length of the perimeter ditch around the toe of the first two disposal cells is 2,000 feet long. To achieve even a relatively flat 1% slope over that distance requires an elevation difference of 20 feet, which was not available on the existing flat topography. Therefore, a larger, flat ditch was required that will slowly move accumulated water by head differential.

MDNR rules require stormwater conveyances be designed to manage the 25-year, 24-hour rainfall event. At LEC, this equates to approximately 6 inches of rain in 24 hours. So, the minimum quantity of water to be stored was the estimated run-off for the 25-year, 24-hour rainfall event. For the first two cells, the estimated total is approximately 5 million gallons. However, overtopping of the stormwater pond would cause back flooding into the active disposal area which was not acceptable. Instead, the pond was designed to hold approximately 11 million gallons, which will hold the runoff from TWO, back-to-back 25-year, 24-hour rainfall events. In Missouri, two back-to-back 25-year 24-hour storms approximately equals the 100-year, 24-hour rainfall event. These events can potentially occur when a remnant gulf coast hurricane travels through Missouri.

Stormwater that has been in contact with CCR must be discharged through an NPDES permitted outfall. At a minimum, primary treatment (i.e., settling and possibly pH adjustment) would be required. While the LEC has an existing NPDES permit with multiple outfalls, the design considered alternatives to discharge. Options considered for using accumulated stormwater included: dust control on the active landfill (both internal haul roads and the uncovered surface of in-place CCR); re-use to condition the dry CCR materials (e.g., fly ash) prior to transport and placement in the landfill; and direct or indirect evaporation. Ultimately, the success of these non-discharge options is dependent on operational controls, as well as the weather.

Ameren must maintain the closed UWL for 30-years and that management involves continued stormwater runoff management. However, runoff from a properly closed UWL with a vegetated cap or an alternative synthetic cap can be directly discharged without going through an NPDES permit. Until final closure, all runoff drains to the perimeter ditch, which drains (via head differential) to one of two storage ponds. During post-closure, the perimeter berms will remain in place to protect the closed landfill from inundation by Missouri River floodwaters. Accumulated stormwater inside of the perimeter berms will be conveyed through the perimeter berms or pumped over the perimeter berms. However, the majority of the closed landfill acres are at an elevation higher than the perimeter berms and will gravity drain over the top of the berms. The runoff from these elevated, closed areas is already collected in swales and let-down channels to manage erosion. Therefore, the design includes an innovative feature to create elevated water channels over the perimeter ditch and perimeter berm during post-closure to minimize the effort required to manage runoff for the 30 years following closure.

**DESIGN FEATURES TO ADDRESS PERIODIC RIVER FLOODING**

The UWL is located in the Missouri River floodplain downstream of the actual power plant, which was built in the late 1960’s on dredged fill at an elevation that is above the 500-year flood level.
In addition, an agricultural flood control levee exists between the UWL and the Missouri River. However, the agricultural levee is built on top of sandy alluvium and there is substantial seepage that can infiltrate under the levee during prolonged flood events. During prolonged flooding, the water level in the agricultural fields surrounding the UWL may rise nearly the same level as the river. This condition that potentially would be created during periodic flooding creates two main issues that must be considered in design of the UWL: 1) maintaining access to the UWL from the plant during floods, for continued operations; 2) preventing unmitigated hydrostatic uplift on the bottom liner in the disposal cells and stormwater ponds.

To address the first issue, a bridge was constructed over Labadie Bottom Road from the existing ash pond on the west to Cell 1. In the future as Cells 3 and 4 are needed, additional, elevated access roads will be constructed from Cells 1 and 2 to Cells 3 and 4, over the pipeline. The bridge over Labadie Bottom Road is a pre-cast concrete bridge, supported on shallow footings. The wingwalls for the bridge are mechanically-stabilized, reinforced earth (MSE) precast concrete blocks. The bridge was designed to carry loads as great as fully loaded off-road dump trucks carrying ash from the LEC to the UWL in the future.

The potential for periodic hydrostatic uplift on the bottom liner in each cell was solved by operational methods. Once a cell is constructed and approved for active disposal, a concerted effort will be made to place CCR ballast fill in the cell to a calculated height sufficient to provide a factor of safety of 1.1 against uplift. The requirement for the placement of ‘ballast fill’ was made a part of the construction contract of Cell 1 and will be made a part of all future cell construction contracts.

Hydrostatic uplift on the bottom liner of the stormwater pond was more difficult to address. If full, the uplift on the liner would be mitigated by the water level in the pond. But if the pond is not full, or low, at the time of a significant flood, the weight of the bottom liner can only resist a net differential head of about 3.3 feet. Therefore, the design needed to include an economical way to rapidly fill the stormwater pond in the event the water level was low. The solution was a flood water inlet constructed in the perimeter berm of each pond. A typical cross-section is shown in Figure 4.

![Figure 4 – Cross-Section of Flood Water Inlet and Wet Well for Pond 1 (valves not shown due to scale)](image)

If a significant flood is predicted on the Missouri River at the LEC that could exceed the corresponding water level in the pond by 3.3 feet or more, the gate valve in the storm water wet
well on the flood water inlet conduit will be opened. As the water level outside the pond rises above the inlet, water flows into the pond to equalize the water levels. The diameter of the inflow conduit is sized to fill the pond at the estimated rate of the typical rise in the flood water. A check valve on the inlet conduit in the wet well prevents water from flowing out of the pond once the flood level outside the pond drops before the gate valve is closed.

**Seismic Loading and Liquefaction**

The LEC UWL is in a seismic hazard zone due primarily to the proximity of St. Louis to the New Madrid Seismic Zone. The Peak Horizontal Ground Acceleration (PHGA) due to a design seismic event was calculated using two methods. The design seismic event is a 2% probability of exceedance in 50 years or approximately a 2500-year reoccurrence earthquake. The first method was to use the 2008 and 2014 USGS hazard maps. The design earthquake for the site has a PHGA of 0.179g (17.9% of standard gravity acceleration). The corresponding peak bedrock acceleration at the site is 0.111g, and the most probable magnitudes (Mw) are between 7.0 and 8.0. The second method was to complete a site-specific seismic analysis using the program SHAKE2000. This analysis has two components: to determine the probable seismic acceleration (or “time history”) for the bedrock beneath the site, and to determine the impact or amplification of the seismic acceleration at the ground surface due to the soil stratigraphy. SHAKE2000 has 10 pseudo bedrock acceleration time histories for St. Louis and illustrate the variety of earthquakes that affect this area. This is conservative since the Labadie site is located a greater distance from the probable sources of the events than is St. Louis. From the 10 pseudo bedrock time-histories, the calculated average PGHA was 0.144g, or slightly less than the 0.179g determined from the USGA hazard maps. The PGHA of 0.179g was used in our analyses since it was a published value, and the higher value did not impact the design of the UWL.

The impact of the design seismic event was analyzed for the stability of the slopes, the occurrence of liquefaction, and the potential settlement due to liquefaction. The requirement in Missouri for a detailed site investigation for a landfill is one boring or test hole for every two acres. In the Detailed Site Investigation, MDNR-SWMP approved substituting some Cone Penetrometer Test soundings for geologic borings. This allowed Reitz & Jens to satisfy both the geologic/hydrogeologic investigation needs, while also obtaining a large quantity of necessary geotechnical data. Therefore, the field investigation for the LEC UWL consisted of 97 geologic borings with piezometers, 22 geotechnical borings, and 93 Cone Penetrometer Test (CPT) soundings. The potential of liquefaction of the subsurface strata at each geotechnical boring and CPT sounding was analyzed using the latest published methods. From the many borings and CPT soundings the areas of potential liquefaction over the existing site were mapped. The potential for liquefaction was very extensive for the existing site conditions. Analyses demonstrated that the potential for liquefaction beneath the UWL became negligible when the vertical effective stress was increased by the placement of 10 feet or more of subgrade fill or CCR fill. Liquefaction is still a potential for the outer portion of the perimeter berms and areas beyond the berms where there is little or no increase in the effective vertical stress. However, this will have no impact on the integrity of the UWL and any area impacted by liquefaction can be repaired with typical earthwork construction techniques. The residual shear strengths of potentially liquefiable soil strata were determined using several published methods for slope stability analyses.
SLOPE STABILITY ANALYSES

Reitz & Jens analyzed the stability of the slopes of the perimeter berms and CCR fill at eight sections through the UWL by choosing locations which had varying subsurface soil profiles. Each section was analyzed for the intermediate height of CCP fill using both short-term and long-term shear strength properties, for both static and seismic (pseudo-static), and with potential liquefaction. Each section was also analyzed for the full height of CCP fill using long-term shear strength properties, for both static and seismic (pseudo-static), and with potential liquefaction. All of these analyses demonstrated that the proposed design meets or exceeds the slope stability requirements for static load and post-seismic conditions with residual shear strengths due to liquefied soil strata where applicable.

The Missouri solid-waste regulations do not state a minimum factor of safety for the stability of slopes under seismic load. Rather, the regulations state that the expected deformation cannot exceed a maximum of 6 inches (for a sanitary landfill). The procedure is to calculate a yield acceleration (Ky) for the slope geometry for which the pseudo-static horizontal seismic load results in a minimum factor of safety against slope failure of 1.0. The Ky is compared to the ground accelerations in a time-history in SHAKE2000. The lateral displacements are cumulated over the time history assuming that all of the displacements when the acceleration exceeds Ky are in the same direction. The proposed geometry of the berm and CCP fill were analyzed for both a short-duration time-history and a long-duration time-history. These analyses demonstrated that the estimated probable horizontal deformations of the UWL are much less that the maximum acceptable deformation of 6 inches. An example of slope stability analyses is shown in Figure 5.
SETTLEMENT ANALYSES

Settlement analyses were completed using the program SETTLE3D. Consolidation coefficients for the natural fine-grain soils and “lightly compacted” CCR were based on one-dimensional consolidate tests. The stress-strain modulus (Es) for the subsurface sands were estimated using the data from the CPT soundings. The estimated settlements after the initial construction of the perimeter berms and subgrade fill (for the CCR Rule) ranged from about 3 to 5 inches within the limits of the cells, and from about 5 to 8 inches beneath the perimeter berms. The maximum estimated total settlement under the full UWL ranged from 23 inches to about 32 inches. Since the estimated settlements are almost entirely due to consolidation of the natural sands, the settlements due to the initial construction will occur prior to the installation of the composite liner and the leachate collection system. These components will be subjected to the additional settlements which will occur with the placement of the CCR fill and final cover.

The estimated differential settlements will occur over long distances such that the incremental settlements will be small. The maximum increase in lengths, or strains, of the HDPE liner after full settlement has occurred were estimated to be 0.3% to 0.7%. A strain of less than 1% is acceptable since the yield strength of most HDPE membranes occurs at strains of 12% or more. Since the leachate collection pipes below the CCR fill, where the settlements are the largest, run back to the leachate collection sumps at the toe of the berms, where the settlements are much less, there is significant differential settlements along the entire length of the pipe, which potentially decreases the slope of the pipe toward the sump. Changes in the slopes of the leachate collection pipes were estimated to range from about 0.4% to 0.7%, and the design grades of the leachate collection pipes included an inflection point at the approximate top of the final grade sideslope to account for the anticipated settlement, so that after final settlement the leachate collection pipes will still slope down to the sumps.

INITIAL CONSTRUCTION SEQUENCE AND SCHEDULE

The construction period for Cell 1 and Pond 1 was going to extend over two construction seasons, due in part to the time required to stockpile offsite fill materials. So that the clay liner was not exposed over the winter, the construction was broken down into two parts or phases, and the first phase was further broken down into sub-phases.

MDNR issued the UWL construction permit on January 2, 2015. Phase 1 construction began in February 2015. Phase 1 included stockpiling clay liner material in the area of the future Cell 2. The contractor obtained suitable clay from a bluff area west of the LEC, which Reitz & Jens visually approved (for sand content) before it was hauled to the site. Stockpiling the clay liner material also gave Reitz & Jens time to complete the extensive laboratory testing on the clay liner material which is required by MDNR-SWMP prior to construction of the liner. Phase 1 also included stripping about 12 inches of topsoil from the area of Cell 1 and Pond 1. This was stockpiled for future use for the Cell 1 cap. It was graded so that the area could continue to be farmed. Phase 1 also included placement of the fill below Cell 1 to satisfy the EPA CCR Rule separation requirement. The primary source of this fill material was a large stockpile of river sand to the northeast of the site which was a remnant from the 1993 flood. Phase 1 was completed in September 2015.
Phase 1A began in July 2015 and included the construction of the perimeter berms. The contractor obtained miscellaneous clay fill from a large borrow area on land on the bluffs the south of the site. The contractor built a temporary haul road from the bluff to the site so that large off-road equipment could be used to haul the fill and avoid construction traffic on public roads. The fill used to construct the haul road was used toward the end of construction to complete the perimeter berm. Phase 1A also included construction of the overpass and construction of a liner test pad. MDNR requires the construction of a test pad of the clay liner material using the same compaction equipment that will be used for construction of the clay liner and with multiple field hydraulic conductivity tests. After the clay liner material stockpile was completed in September 2015, the test pad was constructed in the stockpile area, so that it did not interfere with ongoing construction of the cell. The results of the first test pad showed that a heavier pad-foot compactor would be required to achieve a well-compacted, homogeneous clay liner due to the shear strength of the compacted clay. As a result, a second test pad was constructed, tested, and approved by MDNR prior to the start of the clay liner. Phase 1A was completed in April 2016.

Phase 2 construction, which began in February 2016, included: the composite liners in Cell 1 and Pond 1; the leachate collection system in Cell 1; the protective aggregate layer; the flood water inlet, conduits and wet well; the FCM, the storm water weir inlet from Cell 1 to Pond 1, emergency spillway in Pond 1, electrical service from the LEC to the UWL, and other appurtenances. The sand for the protective aggregate layer was obtained by dredging the Missouri River, and was stockpiled at the LEC a short distance from Cell 1. Construction was essentially completed September 6, 2016. With the cooperation of the MDNR-SWMP, construction quality assurance reports had been submitted for review and approval as parts of the construction were completed. As a result, with the submittal of the final CQA report for Phase 2 on September 16, MDNR-SWMP issued an Operating Permit for the Labadie Utility Waste Landfill on October 27, 2016. With the Operating Permit, the contractor began Phase 3, placement of the CCR ballast fill in Cell 1, which was completed in early 2017.

Figure 6 – Completed Cell 1 and Pond 1 with Ballast CCR Fill