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August 2, 2019

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

Engineer's Certification of Demonstration of Compliance with Design Criteria
Peninsula Disposal Area Phase II-Cell 1
EPA Final CCR Rule
TVA Kingston Fossil Plant
Harriman County, Tennessee

1.0 PURPOSE

The purpose of this document is to certify that the Demonstration of Design Criteria for the liner and leachate collection system for the TVA Kingston Fossil Plant Peninsula Disposal Area (PDA) Phase II Cell 1 (Lateral Expansion) is in compliance with the design criteria demonstration specified in the Final CCR Rule at 40 CFR § 257.70. Presented below is the project background, summary of findings, limitations and certification.

2.0 BACKGROUND

Lateral expansions of CCR Landfills must be designed, constructed, operated, and maintained with either a composite liner that meets the requirements of paragraph (b) of 40 CFR § 257.70, or an alternative composite liner that meets the requirements 40 CFR § 257.70(c), and a leachate collection and removal system that meets the requirements of paragraph 40 CFR § 257.70(d). A brief description of the alternative composite liner and leachate collection system is provided below. Both systems meet the requirements of 40 CFR § 257.70.

3.0 SUMMARY OF FINDINGS

Calculations associated with the liner, including materials that have appropriate chemical properties, sufficient strength, thickness, shear resistance and component interface interactions are provided in the Coal Combustion Residuals Disposal Facility Permit Modification, Permit IDL 73-0211, (Operations Manual) dated June 2014. Calculations indicate that the materials selected are of sufficient chemical properties, resistance, strength and thickness to prevent component sliding and failure due to pressure gradients at the KIF PDA Phase II Cell 1.

Calculations associated with the leachate management system, including generation calculations, pipe sizing and spacing, leachate storage sizing, leachate pump sizing, and pipe strength and deflection calculations are provided in the Operations Manual dated June 2014. Calculations indicate that the materials selected are of sufficient strength, thickness and permeability to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment to be used at the KIF PDA.

Prior to construction of the lateral expansion of the KIF PDA, a qualified professional engineer must certify that the design of the alternative composite liner and the leachate collection and removal system meet the requirements of § 257.70. This certification will be placed in the KIF CCR Disposal Facility operating record in accordance with 40 CFR § 257.105(f)(1). The certification will then be posted to TVA's CCR website within 60 days of commencing construction in accordance with 40 CFR § 257.107(f)(1).

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4.0 CERTIFICATION

I, Thomas A. Kovacic, being a Registered Professional Engineer in good standing in the State of Tennessee, do hereby certify, to the best of my knowledge, information, and belief that, the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above referenced CCR Unit, that the design of the alternative composite liner and leachate collection and removal system as included in the Demonstration of Compliance with Design Criteria dated August 2, 2019 meets the requirements of 40 CFR § 257.70.

SIGNATURE _____ DATE 08/02/2019

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ATTACHMENTS: Demonstration of Compliance with Design Criteria (40 CFR § 257.70) Lateral Expansion of CCR Landfill

TENNESSEE VALLEY AUTHORITY – KINGSTON FOSSIL PLANT
PENINSULA DISPOSAL AREA PHASE II- CELL 1
HARRIMAN, TENNESSEE

DEMONSTRATION OF COMPLIANCE WITH DESIGN CRITERIA (40 CFR § 257.70) LATERAL EXPANSION OF CCR LANDFILL

Prepared for

Tennessee Valley Authority
1101 Market Street
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August 2, 2019 – Rev A

Prepared by

AECOM

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1.0 INTRODUCTION

On April 17, 2015, the "Disposal of Coal Combustion Residuals (CCR) from Electric Utilities" (EPA Final CCR Rule) was published in 40 CFR Part § 257 and § 261 of the Federal Register. The Tennessee Valley Authority (TVA) retained AECOM to review the Peninsula Disposal Area Phase II Cell 1 at the Kingston Fossil Plant (KIF) for compliance with certain requirements of the EPA Final CCR Rule, including demonstrating and certifying compliance with CCR Rule requirements for the design of the liner and leachate design collection and removal system for the Phase II Cell 1 Lateral Expansion of the CCR unit.

1.1 OBJECTIVE

As required by 40 CFR § 257.70 of the EPA Final CCR Rule, an owner or operator of new CCR landfills or lateral expansions of a CCR Landfill is required to demonstrate that the design of the liner and the leachate collection and removal system meets certain requirements. The objective of this report is to demonstrate compliance with liner and leachate collection and removal system design requirements.

1.2 UNIT DESCRIPTION

KIF is located at 714 Swan Pond Rd in Harriman, Tennessee, approximately 3 miles northeast of Kingston, Roane County, Tennessee. The CCR Disposal Facility, Peninsula Disposal Area (PDA), is located near the confluence of the Clinch and Emory Rivers. The PDA, an Existing CCR Landfill, is permitted and operational under the Operations Manual Coal Combustion Residuals Disposal Facility-Peninsula Site Permit Modification (June 2014), herein referred to as the Operations Manual.

The PDA is being developed in two phases to support plant operations. Phase 1 initial construction was completed in 2009 and following drop-out mitigation, Phase 1A was approved for waste disposal in February 2012. Phase II will consist of the construction of 4 individual cells with Cell 1 construction beginning in August 2019. Cells 2 through 4 will be constructed in future years as additional disposal capacity is needed. Phase II Cell 1 (and subsequent expansions) are subject to complete design criteria demonstrations per 40 CFR § 257.70, which states the CCR Rule requirements for design criteria for new CCR landfills and any lateral expansion of a CCR landfill. These regulations require the CCR unit owner or operator to obtain a certification from a qualified professional engineer that the design of the composite liner (or, if applicable, alternative composite liner) and the leachate collection and removal system meets the requirements of § 257.70. This certification must be obtained prior to construction of the CCR landfill or any lateral expansion of a CCR landfill.

The KIF PDA is permitted to receive gypsum, dry fly ash, and bottom ash CCR materials. The limit of waste proposed for Phase II will cover a disposal area of approximately 41 acres divided into 4 cells, developed in 4 overall phases, constructed sequentially with each new development

phase being constructed and certified prior to the commencement of each phase of operation. The leachate management system will be subdivided into the cells by sub-cell division berms. CCR waste will be deposited to the maximum disposal grade and elevation as permitted. Given the nature of the waste, daily cover material is not required. Waste grades that have achieved final development grades along the outer slopes of the landfill will ultimately receive the final cap and cover, while other slopes or areas where no active filling is expected within 180 days will receive intermediate cover consisting of twelve (12) inches of cover soil.

1.3 SITE GEOLOGY & HYDROLOGY

A hydrogeological evaluation of the CCR Disposal Facility site was conducted by the TVA in 2005. A groundwater monitoring plan was submitted in accordance with the Operations Manual (June 2014). The PDA is located in the Appalachian Valley and Ridge Physiographic Province characterized by narrow, subparallel ridges and valleys trending northeast to southwest.

The on-site native soil below the structural fill or liner system consists of alluvial or residual clays. Alluvial soils are occasionally present near the ground surface and extended to depths ranging from about 2.5-47.8 feet and consisted of clayey silt, silty clay, and sandy silt. Residual soils were encountered in all test borings below alluvium or topsoil and extended to refusal (8.5-120 feet). The residual soils generally consist of clay and silts with sand and chert fragments.

Bedrock present beneath the native alluvial and residual soil consists of limestone, dolomite, or shale. In particular, the site is geologically mapped to be underlain by the Knox Group which is mainly composed of hard dolomite with a few limestone layers in the upper part. The Knox Group is regionally characterized as being prone to solution weathering particularly along joints and joint sets, resulting in a highly variable top of rock surface elevation. This is evident at the CCR Disposal Facility area, where the top of the bedrock surface varies in elevation by over 150 feet.

Twenty-six borings were drilled during the preliminary hydrogeological investigation of the PDA between April and June 2005, 13 of which were completed as monitoring wells to assess groundwater conditions at the site. A second investigation with an additional 26 borings, 3 of which were completed as monitoring wells was performed between November 2005 and January 2006. If encountered, groundwater levels were measured in all test borings at the time of drilling.

2.0 CRITERIA

The EPA Final CCR Rule 40 CFR § 257.70 requirements for liner and leachate collection and removal system design are:

> **40 CFR § 257.70**. *New CCR Landfills and any lateral expansion of a CCR Landfill must be designed, constructed, operated, and maintained with either a composite liner that meets the requirements of paragraph (b) of this section or an alternative composite liner that meets the requirements of paragraph (c) of this section, and a leachate collection and removal system that meets the requirements of paragraph (d) of this section*.

2.1 LINER SYSTEM

The EPA Final CCR Rule 40 CFR § 257.70 requires the liner system to be:

> **40 CFR § 257.70(b)(1).** *Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the CCR or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;*
>
> **40 CFR § 257.70(b)(2).** *Constructed of materials that provide appropriate shear resistance of the upper and lower component interface to prevent sliding of the upper component including on slopes;*
>
> **40 CFR § 257.70(b)(3).** *Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift;*
>
> **40 CFR § 257.70(b)(4).** *Installed to cover all surrounding earth likely to be in contact with the CCR or leachate.*
>
> **40 CFR § 257.70(c)(1).** *An alternative composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil GM, and a lower component, that is not a geomembrane, with a liquid flow rate no greater than the liquid flow rate of two feet of compacted soil with a hydraulic conductivity of no more than $1x10^{-7}$ cm/sec. GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick. If the lower component of the alternative liner is compacted soil, the GM must be installed in direct and uniform contact with the compacted soil.*

2.2 LEACHATE COLLECTION AND REMOVAL SYSTEM

The EPA Final CCR Rule 40 CFR § 257.70 requirements for the leachate collection and removal system are:

> **40 CFR § 257.70(d).** *The leachate collection and removal system must be designed, constructed, operated, and maintained to collect and remove leachate from the landfill during the active life and post closure care period. The leachate collection and removal system must be:*
>
> ***(1)*** *Designed and operated to maintain less than a 30-centimeter depth of leachate over the composite liner or alternative composite liner;*
>
> ***(2)*** *Constructed of materials that are chemically resistant to the CCR and any non-CCR waste managed in the CCR unit and the leachate expected to be generated, and of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment used at the CCR unit;*
>
> **(3)** *Designed and operated to minimize clogging during the active life and post-closure care period*.

3.0 DEMONSTRATION OF COMPLIANCE WITH DESIGN CRITERIA

Cell 1 of Phase II of the PDA at KIF was evaluated with respect to the requirements outlined in Section 2.0. A summary of the relevant engineering analyses and results are provided in this section.

3.1 LINER

The composite liner system design for Phase II considered as the primary option (referred to as Liner System) will consist of the following layered components from top to bottom:

- 2-foot sand filter layer; or a 1-foot fine sand filter layer underlain by a 6-inch fine gravel layer and a 6-inch coarse gravel layer;
- Double-sided geocomposite cushion layer;
- 60-mil High Density Polyethylene (HDPE) textured geomembrane; and
- 2-foot thick Compacted Clay Liner (CCL) with a hydraulic conductivity of no greater than $1x10^{-7}$ centimeters per second (cm/sec). The top 0.5-foot of the CCL will be constructed using screened soils with maximum particle size of 0.5 inches as a puncture protection measure for the overlying membrane.

A second option for the composite liner layers (referred to as Alternate Liner System) may be considered if the soils selected for use in the CCL are identified as marginal materials through geotechnical laboratory testing (i.e., hydraulic conductivity values reported by the laboratory are higher than the maximum hydraulic conductivity requirements). Alternative methods such as optimizing the field compaction efforts and addition of bentonite amendments can be used to construct the CCL. The following may be considered, from top to bottom, underlying the 60-mil HDPE:

- Reinforced geosynthetic clay liner (GCL); and
- 2-foot thick CCL with a hydraulic conductivity of no greater than $1x10^{-5}$ cm/sec.

The geologic buffer (subgrade) underlying the CCL is estimated to have a minimum thickness of 19 feet for Phase II and exhibits a maximum conductivity of $1x10^{-5}$ cm/sec. The hydraulic conductivity of the Liner System does not exceed $1x10^{-7}$ cm/sec. The liner system contains the required 2-feet of compacted clay liner and a 60-mil HPDE geomembrane, and therefore meets the requirements of the Rule. The Alternate Liner System includes a GCL to improve the performance of the liner system. Furthermore, manufacturer testing indicates that materials which make up the GCL are chemically resistant to the facility's CCR.

In accordance with the CCR Final Rule, the KIF PDA Phase II Cell 1 Liner System and the Alternate Liner System, as demonstrated in the Operations Manual, is:

- Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the CCR or leachate to which they

are exposed, climatic conditions, the stress of installation, and the stress of daily operation.

- Constructed of materials that provide appropriate shear resistance of the upper and lower component interface to prevent sliding of the upper component including on slopes.
- Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift.
- Installed to cover all surrounding earth likely to be in contact with the CCR or leachate.

3.1.1 CHEMICAL RESISTANCE

Literature suggests that HDPE exhibits satisfactory resistance to chemical attack from compounds associated with CCRs (Ineos, 2012).

3.1.2 LINER INTEGRITY

The liner will be constructed across a suitable subgrade to promote uniform bearing conditions. Material selection and installation procedures are intended to reduce the potential for damage during construction and operations and protect the liner from climatic conditions.

Additionally, due to the presence of localized construction drop-outs, identified during construction of Phase 1, a drop-out mitigation plan was developed. The drop-out mitigation plan has been revised to reflect on-going site work. (Geosyntec, 2019). The intent of the revised plan is to serve as a guide to the investigation and mitigation of dropouts in the PDA Phase II area. Drop-out susceptible areas will be excavated to a pre-determined critical depth, soft material removed, the excavation floor proof-rolled, and backfilled with compacted soil to reach liner grades. Additionally, ground penetrating radar will also be utilized over the entire Phase II footprint to confirm that no shallow subsurface voids remain after proof-rolling an area.

The liner subgrade was designed to achieve a minimum 5-foot separation above the hydrostatic impact from the design phreatic condition. This reduces the potential for damage to the liner due to uplift forces.

The liner will be covered by a minimum of two feet of protective cover that will act as a buffer between any heavy equipment and geosynthetics prior to operations within Cell 1.

3.1.3 SHEAR RESISTANCE

The layers of the Liner System and Alternate Liner System were evaluated and met shear resistance objectives.

The design provides for conformance testing of materials used to construct the bottom liner to meet required shear resistance. Based on available manufacturer's data (Koerner, Narejo, 2005), and data provided in the Operations Manual the required interface strength between various layers is attainable.

3.1.4 LINER EXTENTS

The design limits of the liner placed within Phase II of the PDA extend past the limits of waste.

3.1.5 PERMEABILITY COMPARISON

The proposed liner consists of a 2-foot compacted clay liner with a hydraulic conductivity less than $1x10^{-7}$ cm/sec and is considered the primary option.

Alternatively, the primary Liner System can be supplemented with a geosynthetic clay liner if the 2-foot thick compacted clay liner has a hydraulic conductivity of no greater than $1x10^{-5}$ cm/sec, as presented in the Alternate Liner System.

3.1.6 UPPER COMPONENT LINER THICKNESS

The upper component of the liner is a 60-MIL thick HDPE liner, which meets the required 60-mil thickness for geomembrane components consisting of HDPE set by the EPA CCR Rule.

3.2 LEACHATE COLLECTION AND REMOVAL SYSTEM

The KIF PDA Phase II leachate management system consists of a double-sided geocomposite cushion layer with 8-inch perforated leachate collection piping to direct collected leachate to leachate collection sumps at the southeast portion of Cell 1. In addition, the perforated leachate collection pipes are overlain by a 1-foot think coarse gravel drainage layer (1-foot over top of the leachate collection pipe), 1-foot fine gravel drainage layer, and the 2-foot sand filter layer.

In accordance with 40 CFR § 257.70(d)(1) the PDA Phase II leachate management system has been designed to maintain less than a 30-centimeter depth of leachate over the composite liner. In addition, the HELP model analyses provided in the Operations Manual (2014) estimates the peak leachate depth calculated is estimated to be less than 2.6-inches (6.6 centimeters), which is less than the maximum allowable leachate depth. Leachate generated is gravity drained to low points, or sumps within in the cell and conveyed through perforated leachate collection pipes to the collection system (sump, extraction pumps, and riser pipes). Any liquid collected from the leachate collection and removal system will be treated and discharged in accordance with the current NPDES permit, or a under a modification to the existing NPDES permit.

Details and the locations of the sump and side slope risers associated with the leachate collection system are depicted in the drawings found in the Operations Manual (June 2014).

Calculations associated with the leachate management system, including generation calculations, pipe sizing and spacing, leachate storage sizing, leachate pump sizing, and pipe strength and deflection calculations are provided in the Operations Manual (June 2014). Calculations indicate that the materials selected are of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment to be used at KIF PDA.

3.2.1 Leachate Depth and Conveyance

Phase II of the CCR Disposal Facility was assessed under open, intermediate, and closed conditions to determine leachate production. The HELP model analysis performed under these conditions indicate that leachate generation was greatest under open conditions. The peak daily infiltration rates under this condition resulted in 9.37×10^{-7} inches/day of head on the liner system. The pipe system was hydraulically sized to accommodate predicted flows from the HELP model.

3.2.2 Chemical Resistance and Structural Strength

The materials used in the leachate collection and removal system are HDPE pipes, HDPE drainage netting, geotextiles, and non-calcareous granular drainage media. HDPE has satisfactory chemical resistance properties (Ineos, 2012) to chemical attack from compounds associated with CCRs. Non-calcareous drainage media is generally inert.

The HDPE pipe system was determined to meet criteria for crushing, deflection, ring bending, etc. Designed protective cover thickness over the liner and leachate components is in accordance with manufacturer recommendations.

3.2.3 Design Mitigative Measures Against Clogging

The leachate system has been designed with access through manholes and pipe cleanouts for the cleanout of the system.

TVA will maintain the integrity and effectiveness of the leachate collection and removal system, and properly operate it in accordance with 40 CFR §257.70.

3.4 Certification and Recordkeeping Requirements - § 257.70(e), .70(g), .105(f), .106(f), and .107(f)

Prior to construction of the lateral expansion of the KIF CCR Disposal Facility Phase II, a qualified professional engineer must certify that the design of the alternative composite liner and the leachate collection and removal system meet the requirements of § 257.70. This certification will be placed in the KIF CCR Disposal Facility Phase II operating record. The certification will then be posted to TVA's CCR website within 60 days of commencing construction.

4.0 Conclusions

Based on this assessment, the Phase II, Cell 1 lateral expansion of the PDA located at KIF meets the requirements of 40 CFR § 257.70 of the EPA Final CCR Rule.

5.0 References

- Ineos Chemical Resistance Guide, INEOS Olefins and Polymers, USA February 2012, https://www.ineos.com/globalassets/ineos-group/businesses/ineos-olefins-and-polymers-usa/products/technical-information--patents/ineos-hdpe-chemical-resistance-guide.pdf

- Operations Manual: Coal-Combustion Residuals Disposal Facility Permit Modification – Peninsula Site. Geosyntec Consultants. Permit IDL 73-0211 (June 2014).
- Report of Additional Geotechnical Exploration Proposed Gypsum Disposal Area Kingston Fossil Plant Kingston, Tennessee. MACTEC Engineering and Consulting, Inc. February 2006.
- Work Plan for Identification and Mitigation of Drop-outs Coal-Combustion Residuals Disposal Facility – Peninsula Site – Phase II Area. Geosyntec Consultants. June 2019.