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March 30, 2018

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

Engineer's Certification of Demonstration of Compliance with Design Criteria
North Rail Loop Landfill
EPA Final CCR Rule
TVA Gallatin Fossil Plant
Sumner 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 Gallatin Fossil Plant Cell 2 Lateral Expansion of the North Rail Loop Landfill 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 are provided in the Part II Permit Application CCP Disposal Facility 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 GAF North Rail Loop Landfill.

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 Part II Permit Application CCP Disposal Facility dated 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 the GAF North Rail Loop Landfill.

Prior to construction of the lateral expansion of the GAF North Rail Loop Landfill, 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 GAF North Rail Loop Landfill 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, Gabriel W. Lang, 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 March 30, 2018 meets the requirements of 40 CFR § 257.70.

SIGNATURE _____ DATE 3/30/2018

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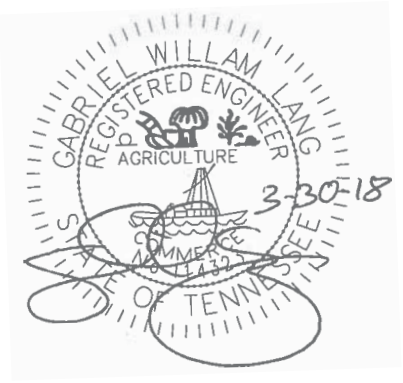
ATTACHMENTS: Demonstration of Compliance with Design Criteria (40 CFR § 257.70) Lateral Expansion of CCR Landfill



TENNESSEE VALLEY AUTHORITY – GALLATIN FOSSIL PLANT
NORTH RAIL LOOP LANDFILL CELL 2
GALLATIN, TENNESSEE

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

Prepared for

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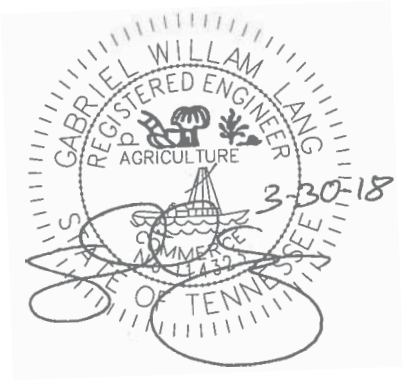
Chattanooga, TN 37402-2801

March 30, 2018 – Rev 1



Prepared by

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TABLE OF CONTENTS

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 North Rail Loop Landfill (NRL) at the Gallatin Fossil Plant (GAF) 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 Cell 2 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

The GAF is located at 1499 Steam Plant Road in Sumner County, Tennessee, on the north bank of the Cumberland River, approximately four miles southeast of the juncture of U.S. Route 31E and Tennessee State Route 109 in Gallatin. The NRL site is located on the northern portion of a parcel of land within the Gallatin Site surrounded by an inactive TVA Rail Line.

The NRL is being developed in a series of 3 cells, to support plant operations. Cells 1, 2, and 3 will be constructed sequentially, moving east to west as additional disposal capacity is needed. Cell 1 is currently operational, and Cell 2 is scheduled to begin construction in April 2018. Cell 2 (and subsequent expansions) is 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 GAF NRL Landfill is permitted to receive bottom ash and dry fly gas desulfurization. The limit of waste proposed for the GAF NRL Landfill will cover a disposal area of approximately 52.4 acres divided into 3 overall development phases constructed sequentially, with each new development phase being constructed and certified prior to the commencement of each phase of construction. 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

On January 16, 2013, a hydrogeologic evaluation report for the NRL site was submitted to the Tennessee Department of Environment and Conservation (TDEC). A Groundwater monitoring plan was submitted in accordance with the Part II Permit Application for the NRL. The NRL is located in the outer (north central) portion of the Central Basin, which is a large topographic lowland resulting from the erosion of the Nashville dome. The central basin has an average elevation range between 450-650 feet above mean sea level (ft msl).

During the hydrogeologic investigation of the NRL, soils ranging in thickness from less than 1 foot to approximately 29 feet were encountered. Generally, the soils are less than 15 feet thick and were identified as primarily lean clay. Lesser amounts of silty clay (CL), clayey silt (ML), high-plasticity clay (CH) and silty sand (SM) were encountered.

Moderately to slightly weathered, medium hard to hard limestone bedrock is present beneath the residual soils. The formations encountered during the investigation area, in descending stratigraphic order, are the Bigby-Cannon Limestone, the Hermitage Formation, the Carters Limestone and the Lebanon Limestone. The Carters Limestone is subdivided into upper and lower members, which are separated by a marker bed of bentonite clay.

One hundred twenty-nine borings were drilled during the hydrogeologic investigation at the NRL site, 36 of the 129 borings were completed as monitoring wells to assess groundwater conditions at the site. Some wells encountered water at a shallow depth during drilling (perched in bedrock), some borings encountered groundwater at depths greater than 150 feet below ground surface (ft bgs), and some borings did not encounter groundwater.

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 2 of the NRL Landfill at GAF 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 design bottom liner will consist of the following materials and thickness, as listed in order of construction (bottom to top):

- A 3-foot geologic buffer with a permeability less than $1x10^{-6}$ cm/sec;
- A 2-foot compacted clay liner with a permeability less than $1x10^{-7}$ cm/sec;
- A geosynthetic clay liner (GCL) composed of a polymer amended GCL formulated and manufactured by placing bentonite between a scrim-nonwoven carrier geotextile and a nonwoven cap geotextile which are needle punched together;
- A textured 60-mil High Density Polyethylene (HDPE) flexible membrane liner;
- Double sided geocomposite drainage layers; and
- A 2 foot Protective cover layer composed of bottom ash and/or sand.

The composite liner proposed at the GAF NRL Landfill consists of a high density polyethylene (HDPE) 60-mil thickness flexible geomembrane layer, a geosynthetic clay liner, and a 2-foot compacted clay liner with a permeability less than $1x10^{-7}$ cm/sec. The hydraulic conductivity of this alternate composite liner does not exceed $1x10^{-7}$ centimeters per second (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. In addition to this, a GCL was included in the design to improve the performance of the liner system. The Part II Permit Application also includes drawings that contain details 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 GAF NRL Landfill composite liner 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, as demonstrated by a Stability Analysis in the Part II Permit Application dated June 2014.
- 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, as demonstrated by a Stability Analysis in the Part II Permit Application dated June 2014.
- 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, as demonstrated by a Stability Analysis in the Part II Permit Application dated June 2014.
- Installed to cover all surrounding earth likely to be in contact with the CCR or leachate, as shown on the drawings in in the Part II Permit Application dated June 2014.

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.

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 2.

3.1.3 SHEAR RESISTANCE

The design incudes a 60-MIL thick textured HDPE liner and reinforced GCL. The layers of the composite liner system were evaluated and determined to meet 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), the required interface strength between various layers is attainable.

3.1.4 LINER EXTENTS

The design limits of the liner placed within the NRL Landfill extend past the limits of waste.

3.1.5 PERMEABILITY COMPARISON

For a GCL to be superior to a given soil layer under all head conditions, the permittivity of the GCL must be less than the permittivity of the given soil layer, as shown by the following equation:

$$\frac{k_{GCL}}{t_{GCL}} \leq \frac{k_{buffer}}{t_{buffer}}$$

Where:
t= thickness of the geologic buffer or GCL (m)
k= hydraulic conductivity of the geologic buffer or GCL (m/s)

In comparing two feet of geologic buffer versus GCL, the GCL has a lower permittivity than the geologic buffer, as calculated in Part II Permit Application CCP Disposal Facility – North Rail Loop Engineering Plans and Narratives.

3.1.6 Upper Component Liner Thickness

The upper component of the liner is a 60-MIL thick HDPE liner, in accordance with 40 CFR § 257.70 (c) of the EPA Final CCR Rule which requires GM component of HDPE to be at least 60-MIL.

3.2 Leachate Collection and Removal System

The GAF NRL Landfill leachate management system consists of a geocomposite drainage layer with 6-inch perforated leachate collection piping to direct collected leachate to the perimeter of the landfill. In addition, a protective cover layer, two feet of sand, will be placed over the geocomposite drainage layer. This layer serves to protect both the geocomposite drainage layer as well as the underlying geomembrane. Together, the protective cover layer and the top geotextile filter layer will serve to prevent fines (particles smaller than U.S. Sieve No. 200) from clogging the system.

In accordance with 40 CFR § 257.70(d)(1) the NRL Landfill leachate management system has been designed to maintain less than a 30-centimeter depth of leachate over the composite liner. Leachate generated by the deposited waste is carried by the geocomposite layer to the collection system (collection pipes, sumps, extraction pumps, and riser pipes). Leachate will be collected at low points, or sumps within the cell. Once waste is placed within the cells, any water collected from the leachate collection and removal system will be handled as leachate and will be collected for treatment and discharge under a modification to the existing NPDES permit.

Details and the locations of all sumps and side slope risers associated with the leachate collection system are depicted in the drawings found in the Part II Permit Application dated 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 Part II Permit Application dated 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 the GAF NRL Landfill.

3.2.1 Leachate Depth and Conveyance

The NRL Landfill 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 0.20373 inches/day (0.51747 cm/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, non-calcareous washed river gravels and granular drainage

media. HDPE has satisfactory chemical resistance properties (Ineos, 2012) to chemical attack from compounds associated with CCRs. Granular drainage media and river gravels are 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 for cleanout of the system. Geotextile material surrounds the gravel envelope around the collection pipes to reduce sediment infiltration.

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 GAF North Rail Loop Landfill, 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 GAF North Rail Loop Landfill 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 Cell 2 lateral expansion of the North Rail Loop Landfill located at GAF meets the requirements of 40 CFR § 257.70 of the EPA Final CCR Rule.

5.0 References

- Part II Permit Application CCP Disposal Facility – North Rail Loop Engineering Plans and Narratives. AECOM. June 2014

- 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