SCS ENGINEERS

Transmittal

West Des Moines, IA

PROJECT:	WC,2025 LF Permit Renewal LH,IA 27225577.00	DATE:	12/30/2025
SUBJECT:	Loess Hills Regional Sanitary Landfill 65-SDP-01-72 Permit Renewal Application and Request for Permit Amendment	TRANSMITTAL ID:	00001
PURPOSE:	For Record	VIA:	Info Exchange

FROM

NAME	COMPANY	EMAIL	PHONE
Kasi Province West Des Moines, IA	SCS Engineers	KProvince@scsengineers.co m	

TO

NAME	COMPANY	EMAIL	PHONE
Mike Smith 502 East 9th Street Des Moines IA 50319- 0034 United States	Iowa, State of	mike.smith@dnr.iowa.gov	515-725-8200
beck.jolly@dnr.iowa.gov		beck.jolly@dnr.iowa.gov	

REMARKS:

Good Afternoon, Mike,

Please see the attached Permit Renewal Application and Request for Permit Amendment - Equivalent Landfill Liner Evaluation for the Loess Hills Regional Sanitary Landfill.

Let us know if you have any questions.
Thank you,

Kasi Province, PE*, Project Professional
SCS Engineers
1690 All-State Court, Suite 100
West Des Moines, Iowa 50265
(515) 779-2227 (C)
kprovince@scsengineers.com

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Transmittal

DATE: 12/30/2025
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DESCRIPTION OF CONTENTS

QTY	DATED	TITLE	NOTES
1	12/30/2025	Loess Hills Regional Sanitary Landfill Permit Renewal Application 65-SDP-01-72P 2025.12.30.2025.pdf	
1	12/30/2025	Loess Hills Request for Permit Amendment - Liner Equivalency Evaluation 2025.12.29.pdf	

COPIES:

Kelly.Danielson@WasteConnections.com	
Rachel Hanigan	(Waste Connections, Inc. (99))
Zach Mahon	(SCS Engineers)
Tim Buelow	(SCS Engineers)
Christine Collier	(SCS Engineers)

December 29, 2025
File No. 27225577.00

Mr. Mike Smith, P.E.
Iowa Department of Natural Resources
Land Quality Bureau
6200 Park Avenue
Des Moines, Iowa 50321

Subject: Request for Permit Amendment
Equivalent Landfill Liner
Loess Hills Regional Sanitary Landfill
Permit No. 65-SDP-01-72
Project No. 27225577.00

Dear Mike:

On behalf of Iowa Waste Services (IWS), SCS Engineers (SCS) is requesting approval from the Iowa Department of Natural Resources (DNR) for an equivalent composite liner design to provide a second construction option for landfill disposal cells in the Municipal Solid Waste Landfill (MSWLF) unit at the Loess Hills Regional Sanitary Landfill (Landfill). The proposed equivalent liner design discussed herein replaces the 2-foot compacted clay layer with a geosynthetic clay liner (GCL) and a 2-foot compacted clay layer with a higher allowable permeability. It should be emphasized that this request for an equivalent liner is to provide a second option for liner construction at the Landfill and does not require IWS to construct the equivalent composite liner, should it be approved, for any future cells. Additionally, it is understood that as this request is for an equivalent liner, as opposed to an alternative liner, continued recirculation of leachate would be allowed over areas constructed with the equivalent composite liner.

Landfill Geology Summary

The geology of the landfill property is summarized in the following documents, which include citations from earlier geological and hydrogeological investigations at the site dating back to the 1990's:

1. Hydrogeologic Investigation Workplan for East Expansion Area, Loess Hills Regional Sanitary Landfill, Evora Consulting, October 21, 2020. (Doc # 98739)
2. Site Exploration and Characterization Report for Loess Hills Regional Sanitary Landfill, Evora Consulting, September 2022. (Appendix 2B of Doc # 105401).

Very succinctly, the geology of the Landfill property can be summarized as 100 to greater than 175 feet of unconsolidated materials consisting of loess and glacial till (oxidized and unoxidized) overlying Pennsylvanian age bedrock consisting primarily of shale with some limestone, silt stone, and minor sandstone units.

The water table present in the loess and glacial till deposits is considered the uppermost aquifer based on the Iowa Administrative Code (IAC) 567-100.2 (455B) definition of an aquifer being *"a saturated geologic formation or combination of formations which has appreciably greater ability to transmit* *water than do adjacent formations. Typically, an aquifer is capable of yielding usable quantities of water to a well."* In consideration of this definition, the loess and oxidized glacial drift typically have higher hydraulic conductivities than the adjacent deeper unoxidized gray tills, thereby satisfying the IAC definition; however, the formation likely would not yield usable quantities of water to a well. The Iowa's Groundwater Basics, 2003, stated the following with regard to glacial drift and its function as a hydrogeologic unit:

> *When shallower glacial drift aquifers were described earlier, we noted that their porous sands and gravels occur within more widespread fine-textured glacial till. It is this massive blanket of clayey glacial till that acts as an aquitard over much of Iowa's landscape, separating the land surface from the underlying bedrock aquifers.*

Private water wells in the area are reportedly screening in sand/sandstone layers encountered in the upper portion of the Pennsylvanian bedrock.

Introduction

Modern waste disposal cells at the Landfill have been constructed in accordance with Iowa Administrative Code (IAC) 567-113.7(5)a.(1) - Composite Liner Systems. The composite liners have consisted of a 60-mil high-density polyethylene (HDPE) flexible membrane liner underlain by a 2-foot compacted clay liner (CCL) with a hydraulic conductivity construction specification of 1×10^{-7} centimeters per second (cm/sec). The equivalent liner proposed herein proposes no change to the HDPE component of the composite liner but instead substitutes a GCL underlain by a 2-foot thick CCL with a maximum hydraulic conductivity of 5×10^{-7} cm/sec. For discussion herein, the following definitions are used (liner sequences are provided from the uppermost layer to the bottommost layer):

- Prescriptive Liner – 60 mil HDPE, 2-ft CCL with hydraulic conductivity of 1×10^{-7} cm/sec
- Proposed Equivalent Liner – 60 mil HDPE, GCL with hydraulic conductivity of 1×10^{-9} cm/sec, 2-ft CCL with hydraulic conductivity of 5×10^{-7} cm/sec

Numerous composite liner equivalency evaluations have been conducted by academia and published in technical journals. The consistent findings of these evaluations are that a GCL underlain by a mineral layer (either constructed or in-situ) of equivalent thickness to the prescriptive mineral layer (in this case, the prescriptive 2-foot, 1×10^{-7} cm/sec CCL) performs better than the Prescriptive Liner. Below are a handful of the equivalence evaluation findings from the technical literature.

- Diffusion and Advection: *"For the cases and parameters examined, the GM/GCL/AL liners were found to provide the same or even greater environmental protection to the underlying aquifer relative to the GM/CCL/AL liners provided the total thickness of the liner system with the GCL was the same as that with the CCL."* (GM: geomembrane, GCL: geosynthetic clay liner, CCL: compacted clay liner, AL: attenuation layer) (Rowe and Brachman, 2004)
- Diffusion and Advection: *"Both liners were very effective at controlling leakage even with a 12 m leachate mound but the system with the GCL allowed almost 40 times less leakage (43 lphd for CCL versus 1.1 lphd for the GCL) even allowing for some clay leachate interaction with the GCL." "The leakage results given in Table 33 suggest that the GCL system is hydraulically as good as, if not better than, the system with a CCL."* (lphd: liters per hectare per day) (Rowe, 1998)

- Specific to Diffusion: *"This suggests that when considering similar thickness barriers such as a 1-m thick compacted clay liner ($k = 10^{-9}$ m/s) versus 0.01-m-thick GCL ($k = 10^{-11}$ m/s) over an existing subgrade soil 0.99 m thick ($k = 5 \times 10^{-9}$ m/s), the diffusion transport will be equal to or better for the GCL system (provided the thickness of the two systems are similar)."* (Geosynthetic Institute 2013)
- Specific to Advection: *"A U.S. Environmental Protection Agency (EPA) study (Bonaparte, et al., 2002) indicates that GM/GCL composite liners have only nominal leakage (measurably less than geomembranes alone or GM/CCL composite liners) through the primary liners of 279 double lined landfill cells that were evaluated."* (Geosynthetic Institute, 2013)
- Specific to Advection: *"The leakage rate from the GCL composite liner ($K_s = 1 \times 10^{-9}$ cm/s) is about two orders of magnitude less than that for the Subtitle D liner. Eq. 1 tends to underpredict leakage from the GCL composite liner because (1)* [this is a reference to Equation 1] *is based on the assumption of a semiinfinite permeable medium, which does not correspond to a thin GCL. For small defects (radius ~ 1 mm), (1) underestimates the leakage rate by 11%. For larger defects (radium ~ 6 mm), (1) underestimates the leakage rate by 44%."* (Foose, Benson, Edil, 2001)

  It should be noted that in the above citation, even correcting for the noted underestimates of leakage, the GCL composite liner system would not reverse the conclusion of the comparison.

<u>**Liner Equivalency Demonstration**</u>

Based on discussions with Iowa Department of Natural Resources (DNR) staff, it is understood that the DNR is receptive to considering a liner design that is different from but equivalent to the Prescriptive Liner described previously. Additionally, it is understood that a demonstration of liner equivalency must consider both diffusive flux equivalence and advective flux equivalence and that the equivalence demonstration for these two aspects should consist of the following:

- Diffusive Flux Equivalence: Demonstration of adherence to Section 10.3.2 of GRI-GCL5, specifically with regard to CCL layer thickness and hydraulic conductivity. (Geosynthetic Institute, 2013)
- Advective Flux Equivalence: Demonstration of equivalent or lower hydraulic conductivity of the mineral portion of the equivalent liner to the Prescriptive Liner.

These two equivalency components are addressed individually below.

<u>Diffusive Flux Equivalence</u>

Diffusive flux equivalence is demonstrated by adherence to the findings presented in Section 10.3.2 Diffusion of Inorganic and Organic Contaminants of GRI-GCL5 (Geosynthetic Institute, 2013). Namely, an equivalent liner that utilizes a GCL must have a thickness equal to the Prescriptive Liner, with the clay component of the equivalent liner having a maximum hydraulic conductivity of 5×10^{-7} cm/sec.

For diffusive equivalence, the Proposed Equivalent Liner described herein replaces the 2-foot thick, 1×10^{-7} cm/sec CCL layer of the Prescriptive Liner with a layered system consisting of a GCL having a hydraulic conductivity no greater than 1 x 10^{-9} cm/sec underlain by a 2-foot thick CCL layer having a hydraulic conductivity no greater than 5 x 10^{-7} cm/sec.

Advective Flux Equivalence

To demonstrate advective flux equivalence, the hydraulic conductivity of the layered GCL/CCL component of the Proposed Equivalent Liner must be less than or equal to the specified hydraulic conductivity of the CCL component of the Prescriptive Liner (less than 1 x 10^{-7} cm/s).

An equation to determine the equivalent hydraulic conductivity of a layered system is as follows: (Guarena, et al. 2024)

$$k_s = (H_f + H_m)/[(H_f/k_f) + (H_m/k_m)] \qquad \text{Equation 1}$$

where:

- k_s = Equivalent hydraulic conductivity corresponding to the low-permeability mineral layer and the attenuation layer.
- H_m = Thickness of the mineral layer (CCL or GCL).
- H_f = Thickness of the attenuation layer.
- k_m = Saturated hydraulic conductivity of the mineral layer.
- k_f = Saturated hydraulic conductivity of the attenuation layer.

It should be noted that in using Equation 1 to calculate an equivalent hydraulic conductivity of the GCL/CCL portion of the Proposed Equivalent Liner, the GCL is considered the mineral layer and the underlying 5 x 10^{-7} cm/s CCL is the attenuation layer.

The resulting equivalent hydraulic conductivity of the layered system is a thickness-weighted harmonic mean value. The harmonic mean is the most appropriate average for ratios and rates and is used to mitigate the impact of large outliers and aggravate the impact of small outliers.

Using the Proposed Equivalent Liner configuration, the table below summarizes the inputs used for the hydraulic conductivity comparison for the GCL equivalent composite liner:

Parameter	Value	Comment
H_m	0.7 cm	Section 5.1.2 of Geosynthetic Institute, GRI-GCL5*, Revision 1 (Editorial), January 9, 2013.
H_f	60.96 cm	(2 feet) Equivalent thickness to the CCL layer of the prescriptive Subtitle D liner.
k_m	3.03x10^{-10} cm/s	Saturated hydraulic conductivity of the GCL mineral layer – see discussion below.
k_f	5.0x10^{-7} cm/s	Saturated hydraulic conductivity of the attenuation layer

Rowe summarized numerous GCL hydraulic conductivity measurements under various testing conditions of hydrating and final confining stresses and hydrating and permeating fluid. (Rowe, 1998). To be conservative, the values derived from tests that utilized real leachate as both the hydrating fluid and the permeating fluid were selected for this evaluation. The following table summarizes the information utilized for the equivalency calculation herein.

Generic Symbol	Hydrating Stress (kPa)	Final Confining Stress (kPa)	Hydraulic Conductivity (m/s)
BF2	35	35	$<1.0x10^{-12}$
BM	35	35	$2x10^{-10}$
CL	35	35	$7x10^{-12}$
GS	35	35	$3x10^{-12}$
GSC	35	35	$6x10^{-12}$

For calculation purposes, the $<1.0 \times 10^{-12}$ m/s measurement was assumed to be 1.0×10^{-12} m/s. Using these values, the harmonic mean hydraulic conductivity is 3.03×10^{-12} m/s or 3.03×10^{-10} cm/s. Using this value for the hydraulic conductivity of GCL, the equivalent hydraulic conductivity of the layered mineral portion of the Proposed Equivalent Liner resulting from Equation 1 would be 2.50×10^{-8} cm/s, which is four times less than the Prescriptive Liner's 1×10^{-7} cm/s CCL hydraulic conductivity specification.

As a further review of GCL hydraulic conductivity requirements for the Proposed Equivalent Liner, an additional GCL hydraulic conductivity calculation was performed as discussed below. The equation below referenced from the equivalency methodology developed by David E. Daniel, Ph.D., P.E. and Robert M. Koerner, Ph.D. P.E. (Golder Associates, Inc., 2021) can be used to calculate the minimum design hydraulic conductivity of a GCL to achieve a hydraulic conductivity equivalent to the hydraulic conductivity of the replaced CCL component of the Prescriptive Liner.

$$k_{GCL} = k_{CLAY}(t_{GCL}/t_{CLAY})/[(h+t_{CLAY})/(h+t_{GCL})] \qquad \text{Equation 2}$$

where:

- k_{GCL} = GCL saturated hydraulic conductivity (cm/s).
- k_{CLAY} = Compacted clay saturated hydraulic conductivity (cm/s).
- t_{GCL} = Thickness of the GCL layer (cm).
- t_{CLAY} = Thickness of the compacted clay layer (cm).
- h = Hydraulic head on top of liner (1 foot or 30.48 cm).

Using the Proposed Equivalent Liner configuration, the table below summarizes the inputs used for the minimum design GCL hydraulic conductivity calculation:

Parameter	Value	Comment
k_{CLAY}	$5.0x10^{-7}$ cm/s	Saturated hydraulic conductivity of the attenuation layer – see Diffusive Flux Equivalence section.
t_{GCL}	0.7 cm	Section 5.1.2 of Geosynthetic Institute, GRI-GCL5*, Revision 1 (Editorial), January 9, 2013.
t_{CLAY}	60.96 cm	(2 feet) Equivalent thickness to the CCL layer of the Prescriptive Liner.
h	30.48 cm	Compliance level for leachate head on a liner.

Inputting the above parameter values into Equation 2 yields a maximum GCL hydraulic conductivity of 1.68×10^{-8} cm/s to demonstrate hydraulic conductivity equivalence. This value is nearly two orders of magnitude greater than the harmonic mean of the measured GCL hydraulic conductivity values used to estimate the GCL hydraulic conductivity input value for Equation 1. It should also be noted that the equivalency calculation using Equation 2 is a one-for-one substitution of the GCL for the prescriptive 2-foot CCL and does not consider the additional 2-foot, 5×10^{-7} cm/s CCL below the GCL proposed herein.

With regard to confining stresses referenced above for the estimate of GCL hydraulic conductivity, a review of future cell construction at the Landfill indicates a minimum of approximately 30 feet of waste/daily cover/final cover over the basal portions of the cells, with this minimum occurring over the approximate sump location on the south side of future Cell I. Thirty feet of waste equates to approximately 90 kPa, which is significantly greater than the confining stress used in the derivation of the GCL hydraulic conductivities utilized herein. Increased confining stress has been shown to decrease the hydraulic conductivity of a GCL.

The literature review conducted for this equivalency evaluation identified that a composite liner that includes a GCL often performs better than hydraulic conductivity equivalence alone would indicate. This is evidenced by the significantly lower advective flux noted in the Introduction portion of this submittal from a composite liner with a GCL component as opposed to a composite liner with only a CCL as the mineral layer. Below are numerous literature citations documenting this performance observation:

- *It is shown that the leakage through composite liners with a geosynthetic clay liner (GCL) is typically much less than for composite liners with a compacted clay liner (CCL).* (Rowe, 2012)
- *In all cases, the calculated leakage through the GM/CCL/AL composite liners is larger than the leakage through the GM/GCL/AL alternatives. For example, the leakage through the GM + 0.6 m CCL + 0.5 m AL liner in Figure 1a is 30 times greater than that for the GM + GCL + 1.093 m AL system in Figure 1b, with a head of 0.3 m on top of the GM. Although the harmonic mean hydraulic conductivity of the GCL and attenuation layer are greater than the hydraulic conductivity of the CCL they are replacing, less leakage occurs for the GM/GCL/AL systems because of the much lower transmissivity between the GM and GCL compared with the GM and CCL.* (Rowe and Brachman, 2004)

The advective leakage through a defect in a GM is most commonly calculated using empirical equations such as those developed by Giroud and Bonaparte. These equations implicitly incorporate the interfacial transmissivity between the GM and underlying mineral layers. Rowe noted the following (Rowe, 2012):

> *These solutions assume that there is a zone between the GM and CL with transmissivity, θ. The transmissive zone between the GM and CL arises due to small irregularities at the interface … between the two materials that will allow fluid to migrate a distance called the wetted radius from the hole and then move by advection through the underlying liner. Thus the leakage, Q, will depend on (i) the size of the hole, (ii) the head difference across the liner, (iii) the hydraulic conductivity of the clay liner, and (iv) the transmissivity of the interface between the GM and CL. This very important parameter here is the transmissivity of the interface.*

The above citation indicates the significant influence the transmissivity of the zone between the GM and the mineral layer can have. G.J. Foose, C.H. Benson, and T.B. Edil stated the following regarding the importance of considering the transmissivity of the interfacial zone (Foose, Benson, Edil, 2001):

> *The rate of leakage and the breadth of flow in the soil liner depend on the ease with which flow can occur in the interfacial zone. All other factors being equal, a greater leakage rate and larger flow area occur when the interfacial zone is more permeable (Foose 1998; Rowe 1998).*

The equations used by Giroud and Bonaparte to estimate leakage through a liner account for the transmissivity of the GM-CCL interfacial zone indirectly using empirical equations established by curve-fitting families of solutions. The defined "good" and "poor" GM-CCL contact are how Giroud and Bonaparte empirically account for the transmissivity of the GM-CCL interfacial zone in addition to other factors mentioned above. Rowe related the "good" and "poor" descriptors to GM-CCL transmissivities as indicated in the citation below (Rowe, 2012) :

> 1. *for good contact*
>   [4] $\log_{10}\theta = 0.07 + 1.036(\log_{10}k_L) + 0.0180(\log_{10}k_L)^2$
>
> 2. *for poor contact*
>   [5] $\log_{10}\theta = 1.15 + 1.092(\log_{10}k_L) + 0.0207(\log_{10}k_L)^2$
>
> *where transmissivity, θ, is in m^2/s and CCL hydraulic conductivity, k_L, is in m/s. for a typical CCL design hydraulic conductivity $k_L = 1 \times 10^{-9}$ m/s, this corresponds to a transmissivity of 1.6×10^{-8} m^2/s for good contact and 1×10^{-7} m^2/s for poor contact.*

For comparison, Rowe summarized the results of numerous studies of the transmissivity of the GM-GCL interfacial zone (Rowe 2012) and stated the following:

> *Based on the foregoing, it appears that the reported GM-GCL interface transmissivity for reinforced GCLs (needle-punched and stitch-bonded) may vary between a high of 2×10^{-10} m^2/s and a low of 6×10^{-12} m^2/s with an average of about 4×10^{-11} m^2/s for all the reinforced GCL data and about 2×10^{-11} m^2/s for all the sodium bentonite data at 50 kPa.*

As indicated by the above, the transmissivity of the GM-GCL interface can be two to four orders of magnitude less than the transmissivity of the GM-CCL interface. The implication of the lower GM-GCL transmissivity value is a smaller wetted radius of the underlying clay layer, and, consequently, a lower leakage rate. Rowe noted the following (Rowe, 2012):

> *The leakage through a single CL is linearly proportional to k_L; however, this is not the case for composite liners where the GM is in direct contact with the CL. In this case, it is the interface transmissivity rather than the hydraulic conductivity of the CL that controls leakage.*

Factors that cause the GM-GCL interface transmissivity to be lower than the GM-CCL interface transmissivity are that the hydrated bentonite swells to fill gaps, creating more intimate contact with the GM and blocking water flow, particularly under the normal stresses experienced under a landfill. Golder reported the following (Golder and Associates, Inc., 2021):

> *In addition to its permeability properties, the GCL also has a swell index once it hydrates. The swelling allows the GCL to fill voids, imperfections, or penetrations within the FML (like pinholes) reducing the risk of contaminants percolating through the liner system. The GCL also provides a cushion to the FML to prevent stress on the FML.*

Therefore, based on a transmissivity comparison, a composite liner with equivalent hydraulic conductivity that includes a GCL is potentially significantly superior to a composite liner that only includes a CCL as the mineral layer, due to the GM-GCL interfacial transmissivity being two to four orders of magnitude lower than the GM-CCL interfacial transmissivity.

Groundwater Underdrain Shut-Off Implications

The modern waste disposal cells (existing and future) at the Landfill have groundwater underdrains to maintain a separation between the high water table and the bottom of the waste. It will be the intention of IWS to turn off the groundwater underdrains as site-specific conditions and regulatory guidance allow; therefore, the following comments are provided with regard to the Proposed Equivalent Liner under the conditions of the groundwater underdrains being turned off.

Diffusive Flux

The diffusive flux equivalence evaluation presented herein was based on mineral layer thickness and saturated hydraulic conductivities for the GCL and CCLs, neither of which is altered by turning off the groundwater underdrain, as saturation is assumed for both the Prescriptive Liner and Proposed Equivalent Liner configurations. The following should additionally be noted with regard to diffusive flux under the conditions of the groundwater underdrains being turned off:

1. With regard to volatile contaminants, the rate of diffusion is expected to be greater in unsaturated soils compared to saturated soils. Rowe stated the following with regard to gaseous (i.e. VOC) diffusion (Rowe, 2004):

   > *The diffusion coefficient in air, Da, and water, Do, typically differ by about four orders of magnitude.*

   It should be noted that the greater rate of diffusion is in air as opposed to water.

   Additionally, Celik, et al. stated the following (Celik, et al., 2009):

   > *Volatile contaminants (VOCs) such as dichloromethane (DCM), 1,2-dichloroethane (DCA), trichloroethene (trichloroethylene, TCE), benzene, toluene, ethylbenzene, m&p-xylene and o-xylene will diffuse orders of magnitude faster in a dry soil than they will through a saturated soil. In an unsaturated soil, they will diffuse in both the gaseous and dissolved phase, but diffusion will be predominantly through the gas-filled pores if the water content is low enough to have a significant number of continuous gas-filled pores.*

2. Liners beneath MSW landfills that are saturated are expected to have lower temperatures than those that are maintained in a vadose zone due to the cooling effects of contact with groundwater. As the rate of diffusion increases with increasing temperatures, a cooler liner will likely experience a lower diffusive flux. Additionally, the service life of the GM is likely to be extended with lower temperatures.

Advective Flux

With regard to advective flux, the most pronounced benefit of shutting off the groundwater underdrain is the likely reversal of the advective flow direction through defects in the GM from outward to inward, thereby largely eliminating the advective flux release component. Shutting off the groundwater underdrain would also reduce the potential for desiccation of the liner (GCL or CCL) and reduce the potential of exposure of the mineral liner to leachate (note that the hydraulic conductivity values utilized herein for the GCL were values resulting from tests in which the hydrating and permeating fluids were leachate to be conservative). Additionally, the suction influence present with a vadose zone would also be eliminated under the condition of the water table rising to at least the top of liner elevation.

Summary

Based on the sources and information provided, it is expected that the Proposed Equivalent Liner would perform the same as or better than the Prescriptive Liner and, therefore, should be considered equivalent. Additionally, in the event the groundwater underdrain is shut off beneath the Proposed Equivalent Liner, the equivalency finding remains valid. It is understood that as long as a liner is considered equivalent, the recirculation of leachate is allowed over the equivalent liner.

If the Proposed Equivalent Liner is permitted as an equivalent liner option for cell construction at the Landfill and in the event that IWS elects to construct the Proposed Equivalent Liner at the Landfill, then the Landfill's construction quality assurance plan will be modified to incorporate the Proposed Equivalent liner in general accordance with Geosynthetic Institute's GRI-GCL5 – Standard Guide for Design Considerations for Geosynthetic Clay Liners (GCLs) in Various Applications, Revision 1, January 9, 2013.

If you have any questions or need further information or clarification, please contact Tim Buelow at 515-681-5455.

Sincerely,

Timothy C. Buelow, P.E.
VP, Senior Project Advisor
SCS Engineers

Zachary Mahon, P.E.*
Project Manager
SCS Engineers
*Licensed in AK, NE, and SD

TCB/ZM

copies: Rachel Hanigan, Chaz Roberts, Bret Stephens, Kelly Danielson, Iowa Waste Services

Certification

LICENSED PROFESSIONAL ENGINEER Timothy C. Buelow 14445 IOWA	I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa. Date: 12/29/2025 Timothy C. Buelow, P.E. License No. 14445 My license renewal date is December 31, 2027 Pages or sheets covered by this seal: **Loess Hills Equivalent Liner Evaluation (pages 1-9).**

References

Celik, B., Rowe, R.K., and Unlu, K. 2009. Effect of Vadose Zone on the Steady-State Leakage Rates from Landfill Barrier Systems, Waste Management 29 (2009) 103-109.

Foose, G.J., Benson, C.H., Edil, T.B. 2001. Predicting Leakage Through Composite Landfill Liners, Journal of Geotechnical and Geoenvironmental Engineering, June 2001.

Geosynthetic Institute. 2013. GRI-GCL5, Revision 1 (Editorial), January 9, 2013.

Golder Associates, Inc. 2021. Wisconsin Department of Natural Resources Alternative Liner Study, July 2021,

Guarena, N., Dominijanni, A., and Manassero, M. 2024. Theoretical Assessment of the Advective-Diffusive Transport of Contaminants Through Landfill Composite Liners, XVIII European Conference on Soil Mechanics and Geotechnical Engineering, 2024.

Rowe, R.K. 1998. Geosynthetics and the Minimization of Contaminant Migration Through Barrier Systems Beneath Solid Waste, 1998 Sixth International Conference on Geosynthetics.

Rowe, R.K. 2012. Short- and Long-Term Leakage Through Composite Liners – The 7th Arthur Casagrande Lecture.

Rowe, R.K. 2004. Barrier Systems for Waste Disposal Facilities, 2nd Edition, E & FN Spon.

Rowe, R.K. and Brachman, R.W.I. 2004. Assessment of Equivalence of Composite Liners, Geosynthetics International, 2004, 11. No. 4.