QUARTERLY PROGRESS REPORT 1

Title: Equivalency of Double Liner System for Florida Coal Ash Landfills

Project Duration: October 1st, 2020 – September 30th, 2021

Investigator: Tarek Abichou, Ph.D. P.E.
FAMU – FSU Dept. of Civil and Env. Eng.

PROJECT WEB SITE:

https://ww2.eng.famu.fsu.edu/~abichou/Equivalency.html

Present Goals:

We will **first** review the process used by EPA to calculate leakage flow rates through the federal proposed composite liner system and through the Florida Class-I landfill double liner system. **Second**, we will review all previous documentations (FDEP reports, published journal and conference papers) used by the State of Florida to successfully obtain approval for their double liner system as Florida's Subtitle D alternative. **Third**, we will use the findings of first two tasks to recalculate theoretical leakage flow rates through Florida and EPA liner systems to assess if any errors were committed, by not actually comparing the two liner systems, but comparing only theoretical leakage rates through parts of each liner system. **Finally**, we will collect actual leachate flow rates into the leak detection system (LDS) at Florida's active and closed double-lined Subtitle D landfills to update the performance and see if liner leakage rate equations should be updated.

Next, we will showcase some of the work accomplished during this reporting on Quarter 1:

Literature Review:

We conducted a literature review (including FDEP reports, journal, and conference papers) on the equivalency of the double-liner in Florida and compared the leakage rate of the double-liner to the Subtitle D composite liner. There were studies conducted earlier to compare the Florida minimum design standard to the Federal minimum design standard, one of which is the "*A comparison of the Florida Landfill Liner system standards to Federal standards*" which was prepared by J.E. Fluet, Jr., P.E for the FDEP. In this report the leakage through minimum allowable design standards in state of Florida was calculated and compared to that of the federal standards. In this no real time data was collected but all the comparisons were made based on the theoretical data. The leakages were calculated using several equations which will be explained later in this section. This report proved that the Florida minimum design standard were equivalent to, and in most cases, more protective to the environment, than the federal standards.

Another study was conducted by Landfill Technical Advisory Group and the FDEP in the year 1994, in which the TAG answered several questions such as "*Are the Assumptions to calculate the Leakage rate accurate? If they are Uncertain, have sufficiently conservative measures been employed*", "*Is predicted leakage likely to pose any significant threat to the public health or violate existing regulations?*". The TAG recommended some changes to the chapter which states to increase the minimum hydraulic conductivity of the LDS to 0.1 m/sec.

In 1995, A report on leachate flow rates from Double-lined landfills in Florida was performed by the FDEP to compare the Design leakage rate to the Actual leakage rate for 9 different landfills located in Florida. This report was prepared as a response to the concerns raised by MFM Environmental, Inc. relating to the elevated leachate levels in Medley landfill in Dade county. This report calculated the design leakage of all the cells included in the 9 Landfills under study. Real-time date was acquired from the landfills to compare this with the design leakage. This report concluded that the Double liners were performing well, and the TAG recommended to apply the design assumptions in the report to design double-lined landfills in Florida.

The calculation of leakage through the double lined systems were proposed by many researchers and one such attempt to calculate the leakage rate through a hole in a geomembrane was proposed in 1989. The following are the equations for leakage through the primary geomembrane.
Equation for Free flow through an orifice, (Giroud 1989)

$$Q_1 = C_B a\sqrt{2gh} \tag{1}$$

Where, Q_1=Leakage through geomembrane(gal/acre/day) (gpad), h=head of liquid over hole (m), C_B= Dimensionless coefficient, 0.6, a= area of hole (0.0001 m^2).

Leakage through Geomembrane overlaying a highly permeable layer, (Giroud 1989)

$$Q_1 = 3a^{0.75}h^{0.75}{k_{sand}}^{0.5} \tag{2}$$

Where, Q_1=leakage through geomembrane (gpad), k_{sand}=Hydraulic conductivity of sand on top of geomembrane (m/sec), h=hydraulic head over geomembrane, a=area of hole.

Since the head of leakage in the LDS is not equal all over the landfill and will only be covering a certain area which is called the Wetted area. The Depth of the leachate in the LDS has to be calculated.

$$D = \frac{Q_1}{B_{ave}k_d \sin\alpha} \tag{3}$$

Where, D_{ave}=Depth of leachate in LDS, Q_1=leakage through top liner as calculated from (1) or (2), k_d=hydraulic conductivity of LDS, α=slope of LDS. Width of wetted area is calculated as follows:

$$B_{ave} = \frac{2\sqrt{\frac{Q_1}{k_d}}}{sin\,\alpha} * \sqrt{1 + \frac{2X_{ave}\,sin\,\alpha}{\sqrt{\frac{Q_1}{k_d}}}} \tag{4}$$

Here X_{ave}=Average distance between the leachate collecting pipes.

The leakage through the secondary liner which is called as design leakage into the ground in this report can be calculated as follows:

$$Q_2 = \beta_c(1 + 2\left(\frac{D}{L_s}\right)^{0.95})a^{0.1}D^{0.9}{k_s}^{0.74} \quad (5)$$

Where, Q_2=Design leakage into the ground; β_c=constant,0.68, L_s=thickness of the component under the secondary geomembrane, k_s=hydraulic conductivity of the soil component underneath the secondary geomembrane.

The calculated design leakage shall then be compared to the actual leakage obtained from real time data from double-lined landfills around Florida.

Data Collection:

To compare the design leakage to the actual leakage real-time date has been obtained from several double lined landfills in Florida. Some of the data was obtained directly from the landfills whereas the remaining data has been acquired from the FDEP Oculus database. The data obtained from the landfills was the amount of leachate collected in through the LCS and LDS, Rainfall Data, Lining profile and areas of all the cells associated with a particular data. The Landfills for which data has been obtained:

Landfill	District	County	Remarks
Test Site A	SW	Hernando	Data Processing in Progress
Test Site B	SED	Palm Beach	Data Processing in Progress
Test Site C	SW	Orange	Data Processing in Progress
Test Site D	SD	Hillsborough	Data Processing in Progress
Test Site E	CD	Sarasota	Data Processing in Progress
Test Site F	CD	Volusia	Data Processing in Progress

Table. 2 Landfills with Data given by the landfill Authorities.

Data for 6 more landfills has been obtained from the FDEP Oculus Database and is being converted to processable format. The data obtained from the database is very inconsistent and, in some cases, recent data is not available. We are trying to fetch New data for these landfills. There are some more landfills which we are considering including in the study but there is no proper data available in the Oculus database and we are trying to fetch data for these.

Example Data:

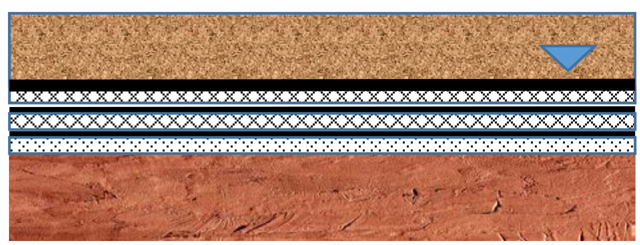
Design Leakage through the liners has been calculated using the equations in the earlier section. The design leakage is calculated for RCRA Subtitle D standard, double liner system of Test Site B. For this site there are 16 cells and data for cell 8 is presented below.
The design leakage through RCRA Subtitle D is as follows:

Variable	Value	Units
Area of Hole	1	cm^2
Leachate Head above primary Liner	0.3	m
Hydraulic Conductivity of Soil beneath Liner	$1x10^{-9}$	m/sec
Assuming Medium Contact, β	0.68	
Thickness of Soil	0.61	m
Leakage through Composite Liner	0.9439	gpad

Table. 2 Leakage calculation for RCRA-D.

The Liner system for Cell-8 is as follows (Top to Bottom) (**Fig. 1** showing liner system):

- 2 feet protective sand layer
- 8 oz/sy geotextile
- 250 mil geonet
- 60 mil HDPE geomembrane
- 2@250 mil geonet
- 60 mil Geomembrane
- GCL



Design Leakage through the primary liner is calculated for all the cells using equations (1) and (2). From this the depth of leachate (3) in the LDS is calculated by calculated the width of wetted area (4). The design leakage into the ground is calculated using equation (5).

The Actual leakages through RCRA-D, and Each cell are plotted to compare with the design leakages. And one such plot is presented below:

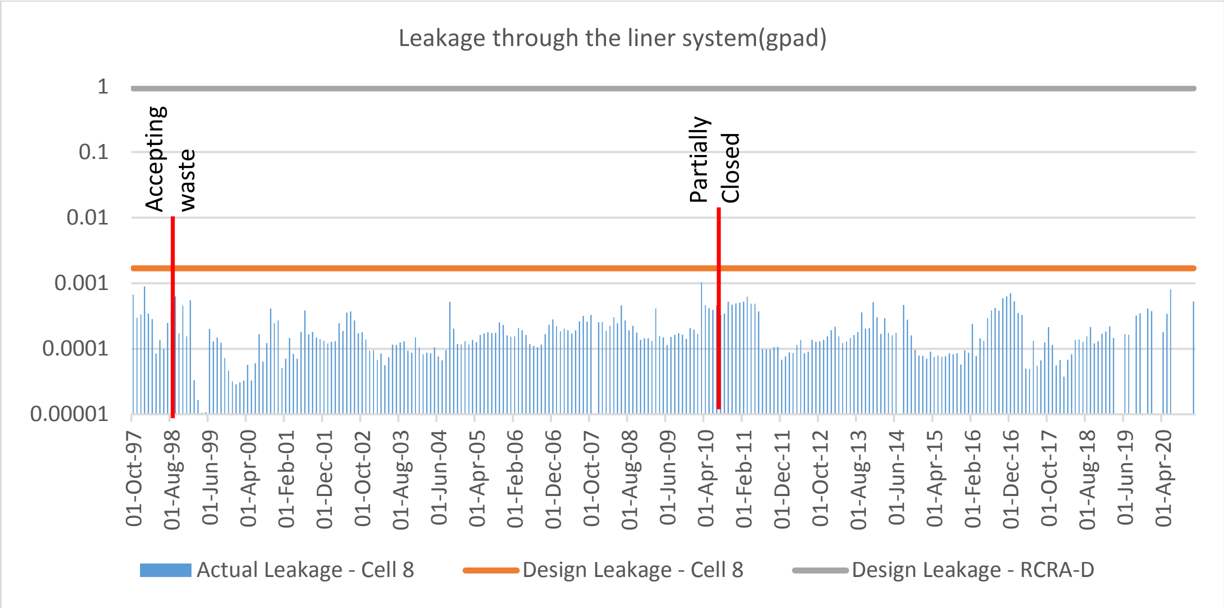


Fig. 2 Preliminary LDS data collected from one cell at a participating landfill.

It can be seen from the graph that the Actual leakage from the Liner system is lower than the Actual leakage and which in turn is much lower than the leakage through RCRA-D.

Ongoing and Future Tasks:

Information Dissemination Activities: We scheduled our first TAG 1 Meeting April 2nd or April 16th from 10:00 AM to 12:00 PM.

Metrics:

1. List of graduate student or postdoctoral researchers **funded** by **THIS** Hinkley Center project

Last name, first name	Department	Professor	Institution
Prashanth Reddy Biyyani	Civil & Environmental Engineering	Dr. Tarek Abichou	FAMU-FSU College of Engineering

2. List undergraduate researchers working on **THIS** Hinkley Center project
   Present Undergraduate Researchers (None)

3. List research publications resulting from **THIS** Hinkley Center project (use format for publications as outlined in Section 1.13 of this Report Guide).
   NOT YET

4. List research presentations (as outlined in 1.13.6 of this Report Guide) resulting from **THIS** Hinkley Center project.
   TAG Meeting presentation
5. List who has referenced or cited your publications from this project?
   NO
6. How have the research results from **THIS** Hinkley Center project been leveraged to secure additional research funding? **NO**
7. How have the results from **THIS** Hinkley Center funded project been used (**will be used**) by FDEP or other stakeholders? (1 paragraph maximum).

TAG members:

	First name, Last name	Email
1	Ron S. Beladi, P.E.	ron.beladi@neel-schaffer.com
2	Wester Henderson	wester.henderson@essie.ufl.edu
3	Nathan P. Mayer, P.E.	nmayer@swa.org
4	Sam Levin, P.E.	slevin@s2li.com
5	Kwasi Badu-Tweneboah Ph.D., P.E.	KBaduTweneboah@geosyntec.com
6	John Schert	jschert@ufl.edu
7	Michael Donovan, Ph.D	michael.donovan@mineralstech.com
8	Kuo Tian, Ph.D	ktian@gmu.edu
9	Bob Mackey	Bmackey@S2Li.com
10	John Schert	jschert@ufl.edu
11	Joseph Dertien	joseph.dertien@dep.state.fl.us
12	Ron Beladi	ron.beladi@neel-schaffer.com