Leachate Collection System Clogging in Florida
A Reality Check

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TAG Meeting 1
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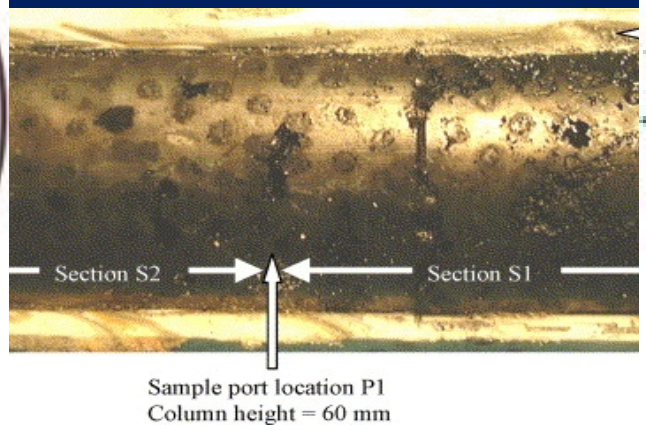


TAG Meeting 1: Agenda

- Call meeting to order (Abichou)
- Introductions
- Overview of Project Scope and Objectives (Abichou)
- Research Tasks (Abichou)
- Expected Research Outcomes (Abichou)
- Update on Project Progress (Daria)
- Challenges with Data collection (Abichou)
- Discussions (Group)

Hinkley Solid and Hazardous Management Center has sponsored two studies on clogging of LCS:

- In 1998, an effort examined the extent of clogging, LCS designs and safety factors at existing Florida landfills ,and recommended design practices and safety factors.
  - Surveying landfill designers and FDEP Officers indicated that in general, Florida landfill LCSs are well-designed, state-of-the-art facilities.
  - Both designers and regulators **expressed concerns over clogging** of the LCS components but, material deterioration has not been addressed in past designs.
- In 2004, a project was funded to assess biogeochemical deposits in LCS. This research was conducted to evaluate clogging of leachate collection systems due to co-disposal of MSW and combustion residues from WTE facilities.
  - Data from this research confirmed that co-disposal of MSW and WTE residuals is a major cause of the production of precipitates in leachate collection systems.

Our overall long-term Research Objectives

We want to:

- **Introduce clogging verification into design approaches and into design manuals**
- **We feel that LCS design has not received the attention it should to allow for long-term impact of landfills**

Rationale

- The purpose of LCSs is to collect and remove the leachate from the bottom of landfill and therefore minimize the leachate head which provides the driving force for the leakage of contaminants to the surrounding environment.
- Since the contaminating lifespan of a landfill may be decades or even centuries, the performance of the LCS is critical for a well-designed modern landfill
- There is a need to be able to predict the service life of a given system.

A Reality Check

CHAPTER 62-701, SOLID WASTE MANAGEMENT FACILITIES:
(4) Leachate collection and removal system. Landfills shall have a leachate collection and removal system that is designed, constructed, maintained, and operated to collect leachate and convey it to collection points for removal.

- (a) The primary and secondary leachate collection and removal systems shall:

  1. …….

  2. ……..

  3. Have granular material or synthetic geotextile filter overlying or surrounding the leachate collection and removal system **to prevent clogging of the collection system by infiltration of fine particles; and**

  4. Have a method to test that the pipes in the system are not clogged, and a method for cleaning the pipes in the system if they become clogged. If any part of the system cannot be tested for clogging, the design shall assure that leachate can be rerouted from that part to a leachate sump in the event of collapse.

- (b) The primary leachate collection and removal system shall have a granular drainage layer above the top geomembrane liner, at least 12 inches thick, **with a hydraulic conductivity of not less than 1×10^{-3} cm/sec**, …….Leachate collection systems incorporating synthetic drainage materials may be used if it can be demonstrated that they are equivalent to or more effective than the granular design, including chemical compatibility, flow under load, and protection of the geomembrane liner.
- (c) The leachate collection and removal system shall be designed **with a bottom slope to achieve the required leachate head after the predicted settlement determined by the foundation analysis. The minimum slope for the leachate collection system, in areas which drain to lateral collection pipes and header pipes, shall be 1.0** percent after predicted settlement. **The minimum slopes for the collection pipes of the leachate collection system, i.e., lateral and header pipes, shall be 0.3 percent after predicted settlement**. Minimum slopes shall be measured from the peak grade to the lowest grade along the design flow path. ……

How to Deal with Clogging (EPA):

- **Clean-ou**t access ports are required in leachate collection systems. Ports must be placed at locations that allow cleaning equipment and chemicals to the whole system.
- **Suggested** method for removal of mineral deposits is to **flush the system** with a liquid that contains biocides and cleaning agents.
- Cleaning is intended to remove mineral precipitates and biofilm buildup in the pipes, **but does not prevent** the formation of future clogs.
- **Cleaning** frequency is determined by **local regulations** and landfill operating protocols.

Soil Drainage Layer

k required by various US states

k (cm/s)	# of States
$\geq 10^{-2}$	10
$\geq 10^{-3}$	14
$\geq 10^{-4}$	1
Site Specific	25

$k \leq 0.01$ cm/s is LOW!

k is only specified at the beginning of the landfill's life. The k at the end of the service life will surely be lower due to clogging and compression.

Research Objectives of this Proposal

- Use a “film growth approach” to simulate/account clogging of pore space and the mass production of clog material with time.
- Use the reduction in pore space to predict change of hydraulic properties
- Predict leachate head on liner with time using Florida specific leachate composition and generation data for typical landfills operated in different micro-climates of the state.
- Assess Effects and the extent of the co-disposal of MSW and WTE by-products.
- Examine the adequacy of the current design methodology of leachate collection systems in the state of Florida.
- Develop a protocol to estimate service life of LCSs in different regions of Florida for different landfill disposal practices.

Current Design Criteria of LCS:

Methods to Calculate y_{max}
Moore's (1980) Method

$$y_{max} = L\left(\frac{r}{k}\right)^{1/2}\left[k\left(\frac{S^2}{r}\right) + 1 - \left(\frac{kS}{r}\right)\left(S^2 + \frac{r}{k}\right)^{1/2}\right]$$

y_{max} = max liquid head (in.)

L = horizontal drainage distance (in.)

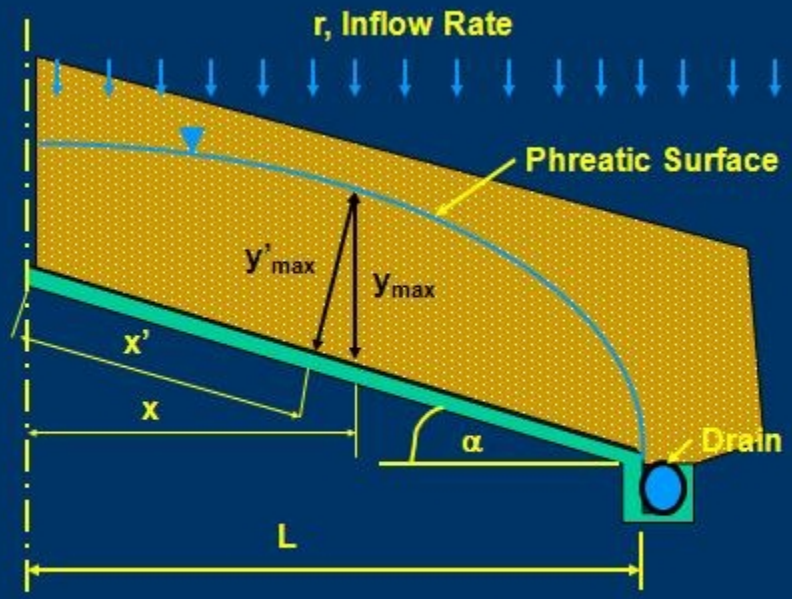
r = rate of vertical inflow per unit horizontal area (in./day)

k = hydraulic conductivity of drainage layer (in./day)

S = slope of drainage layer

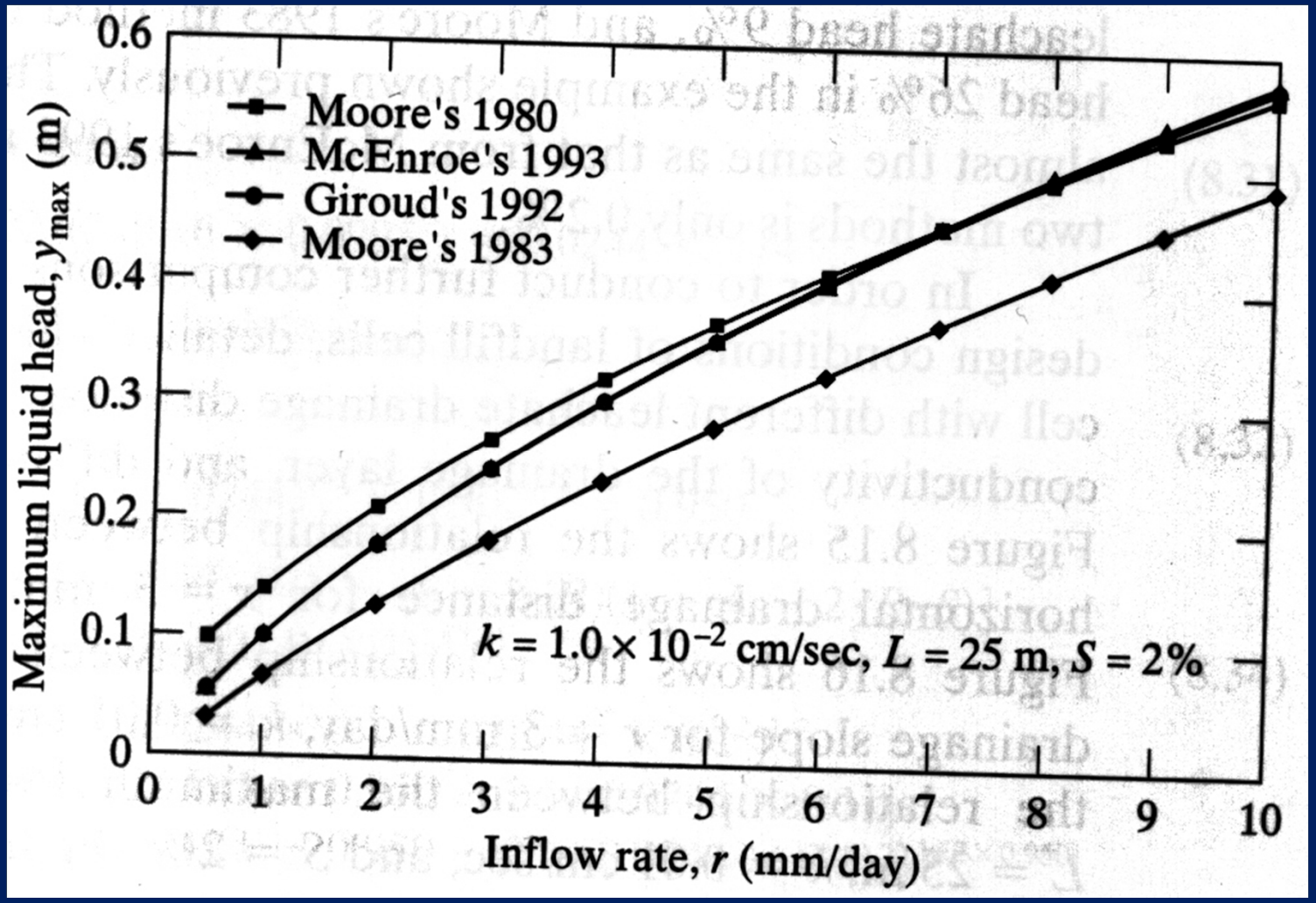
= tan α

α = slope angle of drainage layer

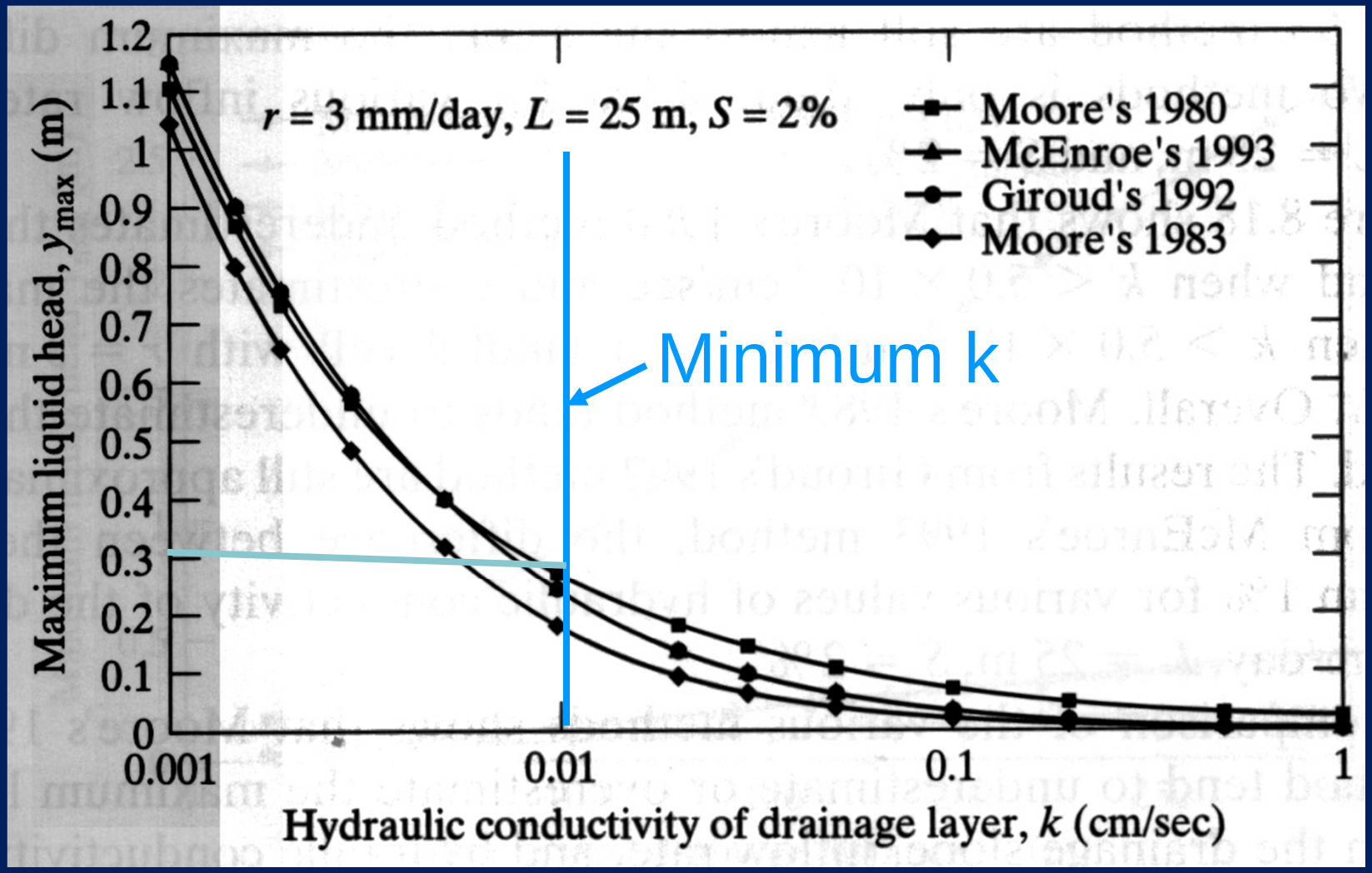


Phreatic Surface in Landfill Drainage Layer

y_{max} vs Leachate Generation Rate, **r**



y_{max} vs Hydraulic Conductivity **k** for LCS



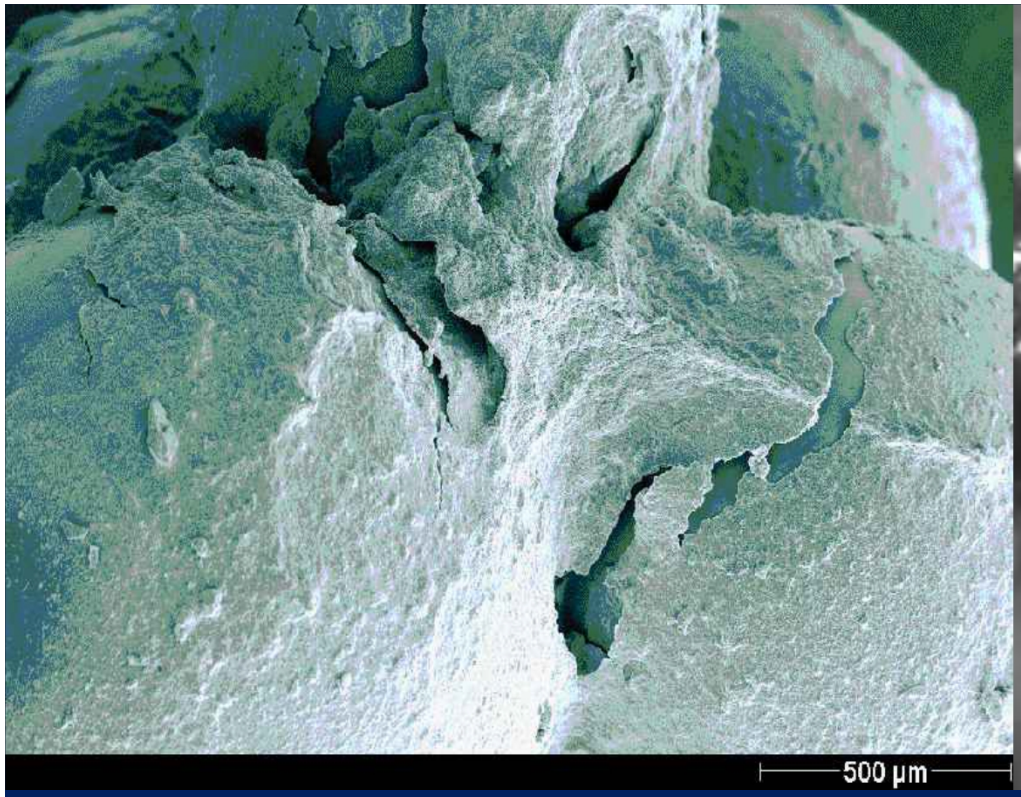
Can we account/describe clogging

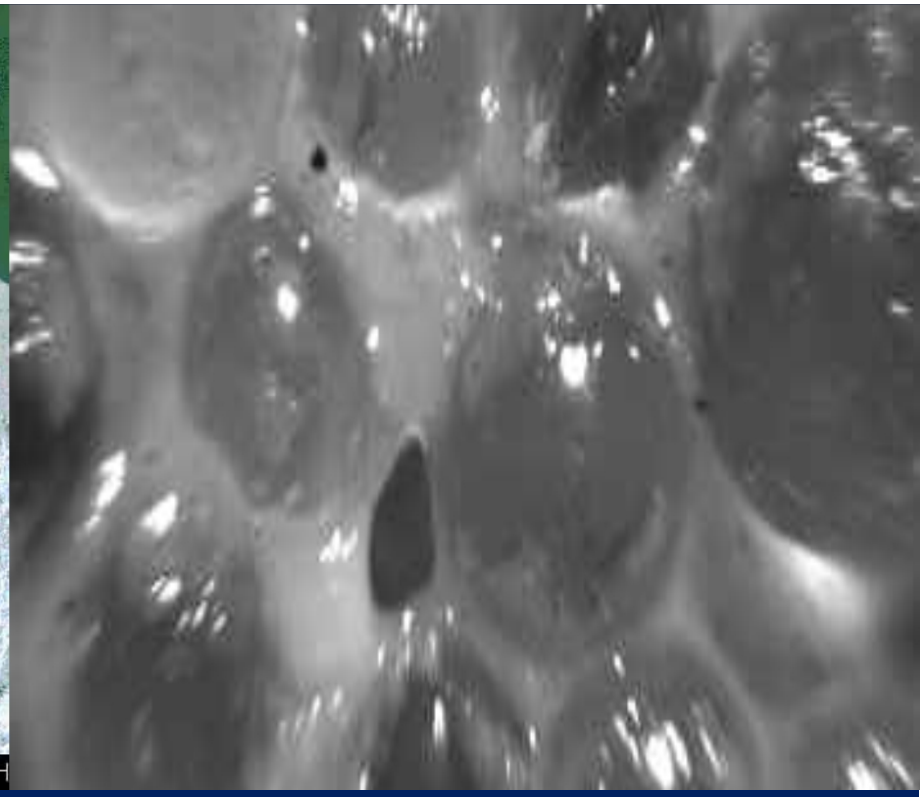
- Clogging is : A build-up of biofilm, chemical precipitates
- This buildup progressively reduces the hydraulic conductivity of the system and hence its ability to drain fluids (e.g. leachate).
- Field studies of landfill LCS have provided direct evidence that the granular layer can experience a significant **decrease in porosity** and **hydraulic conductivity** due to the **formation of clog material** within the **pore space** of the porous media.
- In MSW, the availability of **calcium** rather than the carbonate limits the formation of calcite in leachate drainage and collection systems (Rowe et al. 2002).

Can we account/describe clogging, cont'

$$CO_3^{2-} + Ca^{2+} \rightarrow CaCO_3(s)$$

- Clogging occurs when the equilibrium among **calcium species** is disrupted by **microbial activity**, the presence of **additional minerals**, and a change in **oxidation conditions**.
- The most important factor is the **type of waste** being disposed of, since this correlates directly with levels of **calcium and alkalinity**.
- Based on most field and laboratory findings: **calcium carbonate or calcite is the dominant fraction in the clog formation under anaerobic conditions in MSW landfills**.
- **Clogging is more rapid and more extensive in landfills where WTE and MSW are being co-disposed**.





Our experience with “Particle Growth” modeling:
We can predict soil property change as the space between grains is being filled.

We used a similar approach to model sand-bentonite mixtures

Task 1 – FDEP Database, and other Literature (Leachate composition, Leachate generation, Leachate Leak Detection System, etc.)

- Conduct an extensive review of the FDEP database and characterize the changes in leachate generation and quality in Florida landfills.
- Perform a literature and available databases searches for leaching characteristics of MSW, WTE by-products, and their mixtures to identify the chemistry and the biology of the liquids **before reaching LCS in landfills**.

Task 2 – Model calcium carbonate (calcite) growth in LCS

- Based on input generated in Task 1, the change in the porosity and hydraulic conductivity of the components of leachate collection system will be predicted. The results of this task will consist of tabulated clogging predictions for the different leachate strengths associated with Florida landfills (monofills, co-disposal), the type of drainage materials currently being used (sands, gravel, geotextile, geonet,…), and the different leachate generation rates (GPD per acre).

Task 3 – Analysis of LCS clogging results

- As soon as Tasks 1 and 2 are completed, key landfills and key locations, to be used as case studies, will be identified. The case studies identified in this manner will be carefully evaluated to assess the performance of the leachate collection system for the past few years. A technical review of the design of the leachate collection system at each chosen landfill site will be performed in Task 3. Data from these locations will be used to calibrate the clogging model predictions.

Task 4 – Revisiting Florida Regulations concerning design and maintenance of LCS

- Based on Task 1 to Task 3, the predicted change in hydraulic properties, along with the existing leachate collection system layout (design), will be used to re-evaluate the head on liner for all the selected case studies. The results of this investigation will be used to examine the adequacy of the design methodology of leachate collection systems at those particular locations. The findings of this study will also be used to estimate the service life of LCSs in different regions of Florida.

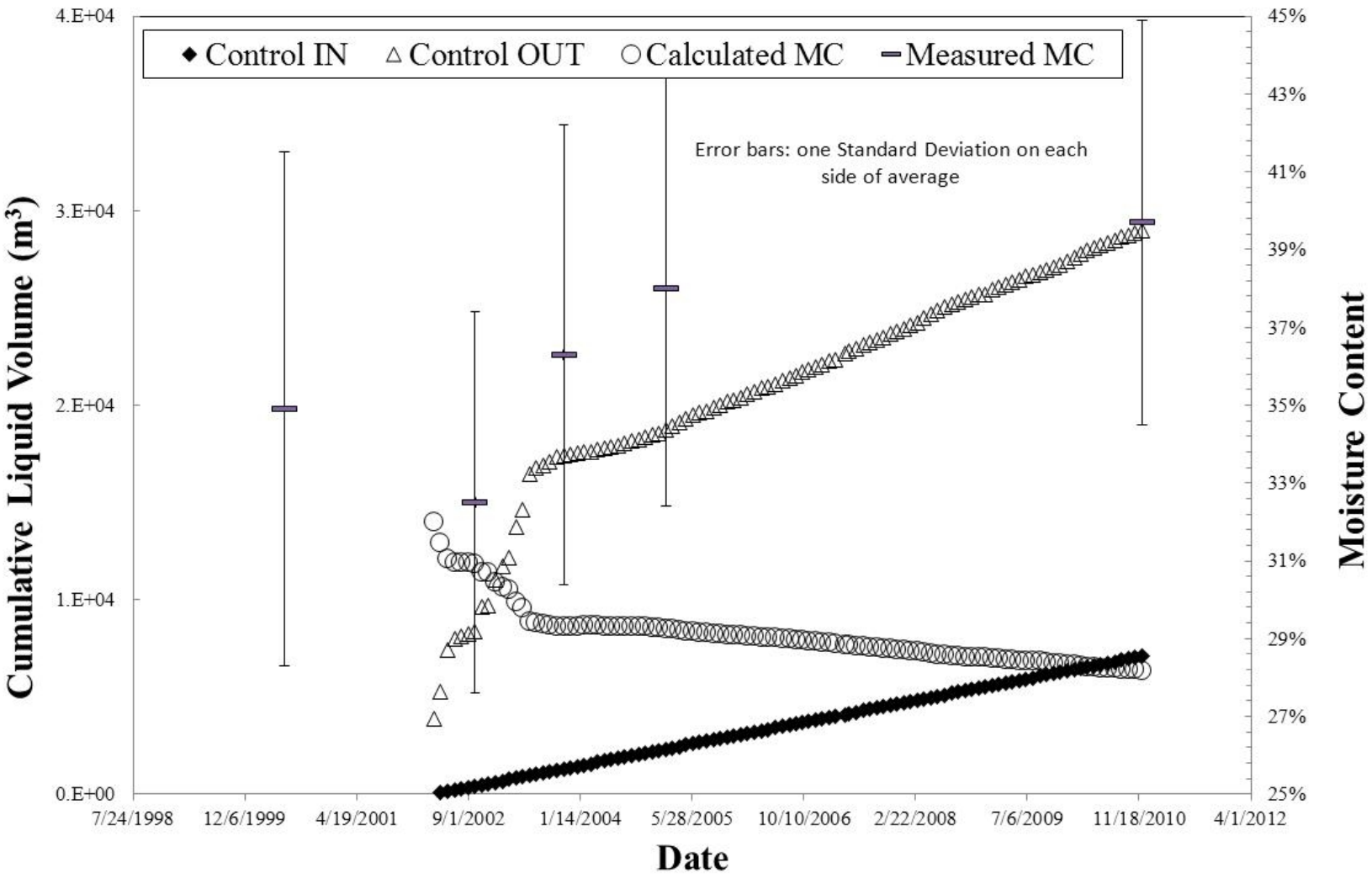
Data Collection Challenges

Leachate Quantity Generations:

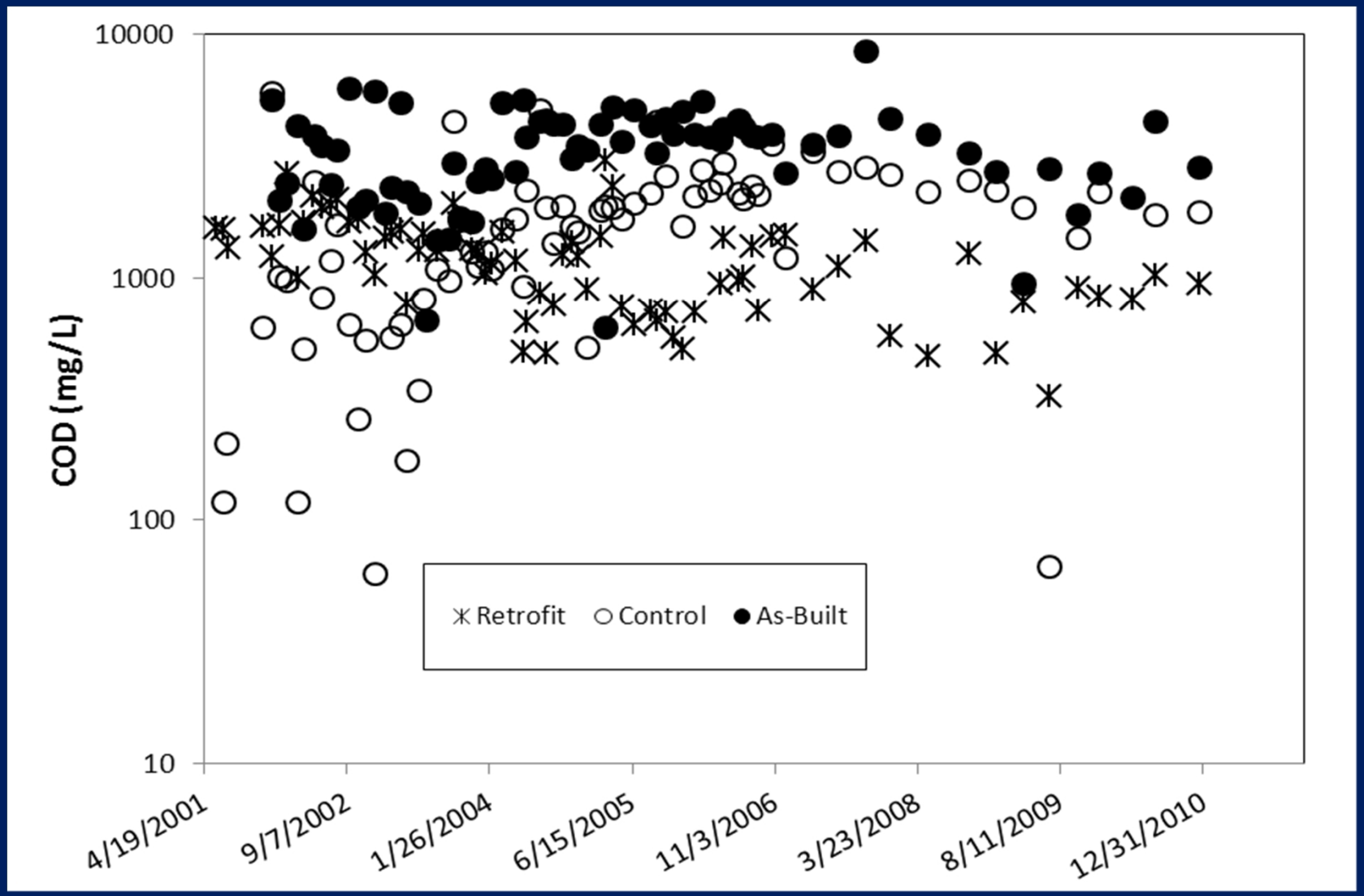
Scenarios of Landfills Types. We plan to use HELP to generate leachate quantities at different FL locations with time during active and post closure periods.

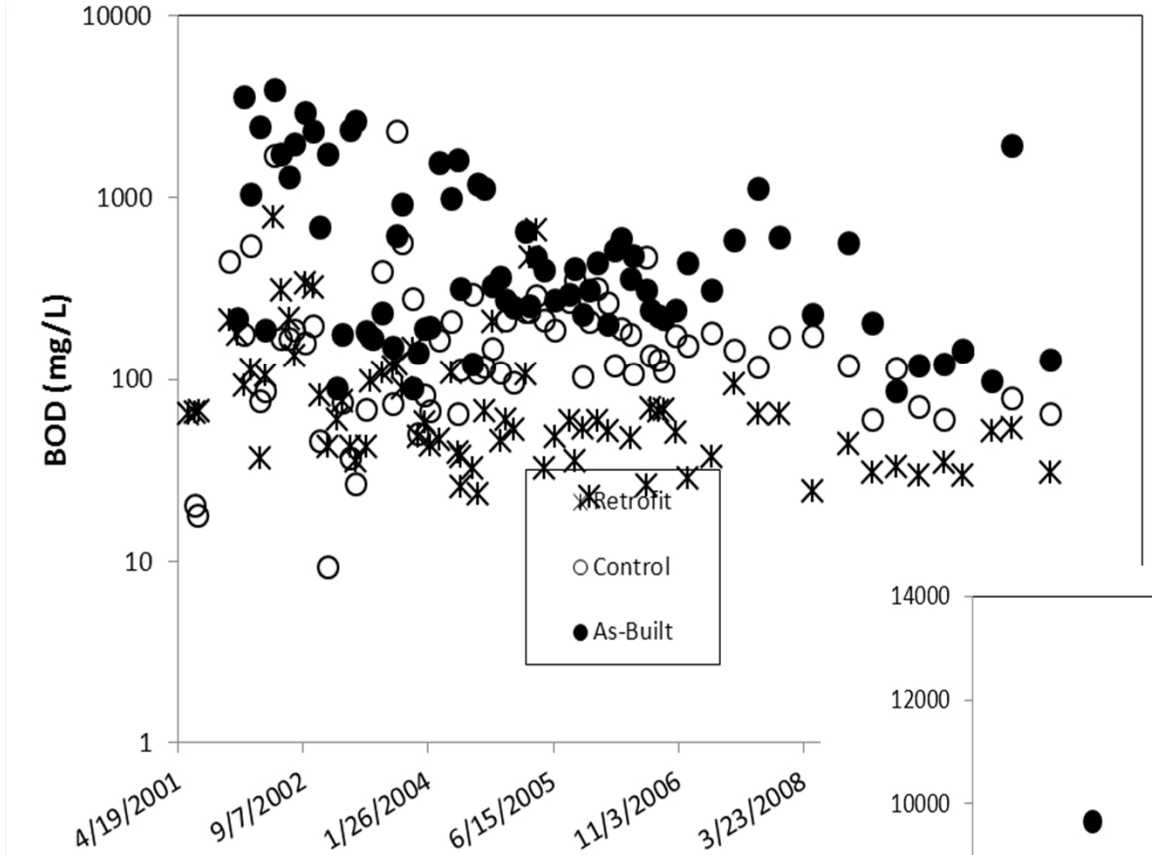
Daily MSW Disposal (tpd)	Cell Geometry	Daily Lift Size	Leachate Generation gal/acre-day
500	5 acres/100 ft high	50x50 x7 feet	Active, Post Closure
2500	10 acres/100 ft high	100x100 x8 feet	Active, Post Closure
5000	20 acres/100 ft high	100x200 x8.5 feet	Active, Post Closure

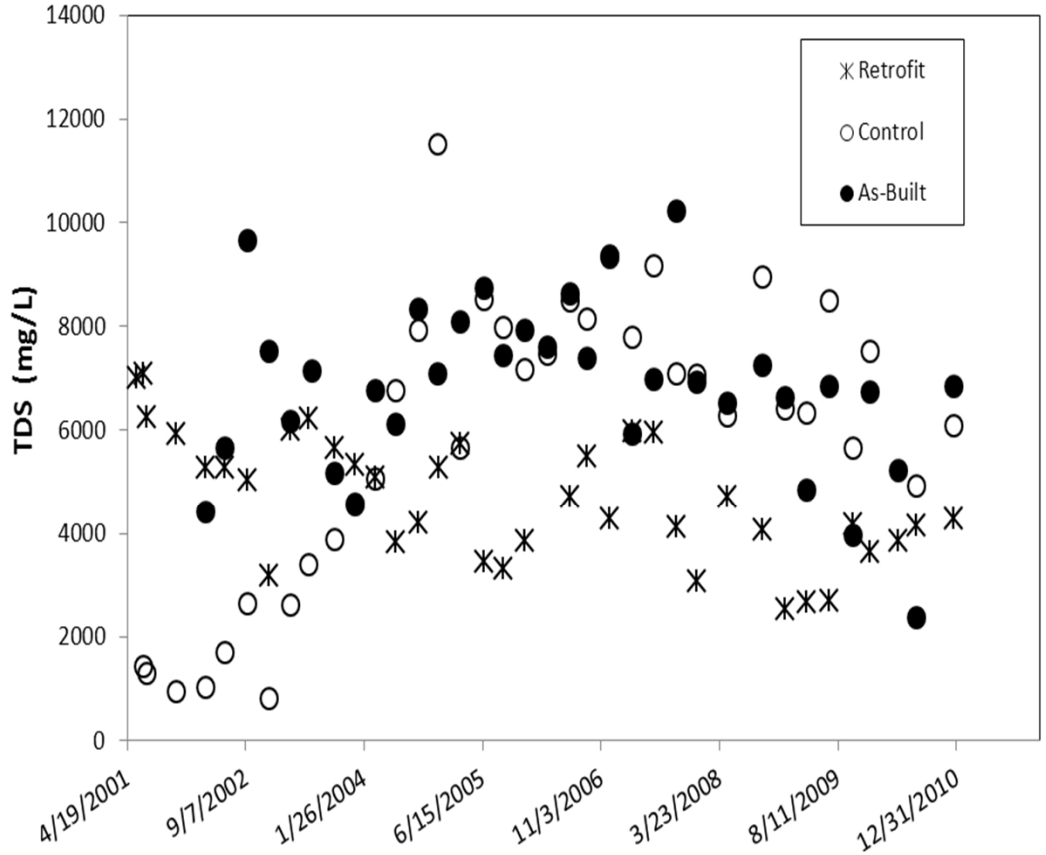
We also have long term measured leachate volumes from other studies



Leachate Quality Data: Just started to identify long term data from other projects we are involved in.




BOD (mg/L)
10000
1000
100
10
1
4/19/2001
9/7/2002
1/26/2004
6/15/2005
11/3/2006
3/23/2008
Retrofit
Control
As-Built


TDS (mg/L)
14000
12000
10000
8000
6000
4000
2000
0
4/19/2001
9/7/2002
1/26/2004
6/15/2005
11/3/2006
3/23/2008
8/11/2009
12/31/2010
Retrofit
Control
As-Built

Discussions