

WWTP Landfill Cover

Paige Johnson, Nicholas Miller, Ian Walker, Marie Ngo Poua



ITASCA
COMMUNITY COLLEGE

Problem Statement

The Problem

- The current leachate production of landfill Phase 1-4 Kettle D is too high.
 - Leachate is water that becomes polluted from draining through buried waste.
 - The landfill is not able to officially close due to the high leachate production.



(Mattson, S., 2021)

Phase 1-4 Kettle D's Current Landfill Cover Issues

- Leachate production is too high.
 - 5,784,000 gallons of leachate on average annually (1,446 truckloads a year).
 - Should be around 100,000 gallons of leachate annually (25 truckloads a year).
- Investigate the possibility that high leachate production is caused by poor performance of the current landfill cover.
 - High leachate production is causing up to an extra \$225,000 in expenses annually.
 - Current cover consists of 48 in. of paper mill sludge, 12 in. sand drainage layer, 6 in. of rooting soil, and 6 in. of topsoil.
- Consider the possibility that high leachate production is caused by landfill design allowing most of the drainage to run directly into the leachate system.

(Mattson, S., 2021)

Our Mission

- Research 4 landfill cover designs and provide a recommendation to the WWTP and Blandin.
 - Each landfill cover should have the following information.
 - Different materials and their depths/amounts
 - The effectiveness of the landfill at other sites
 - Pros and cons
 - Economic analysis

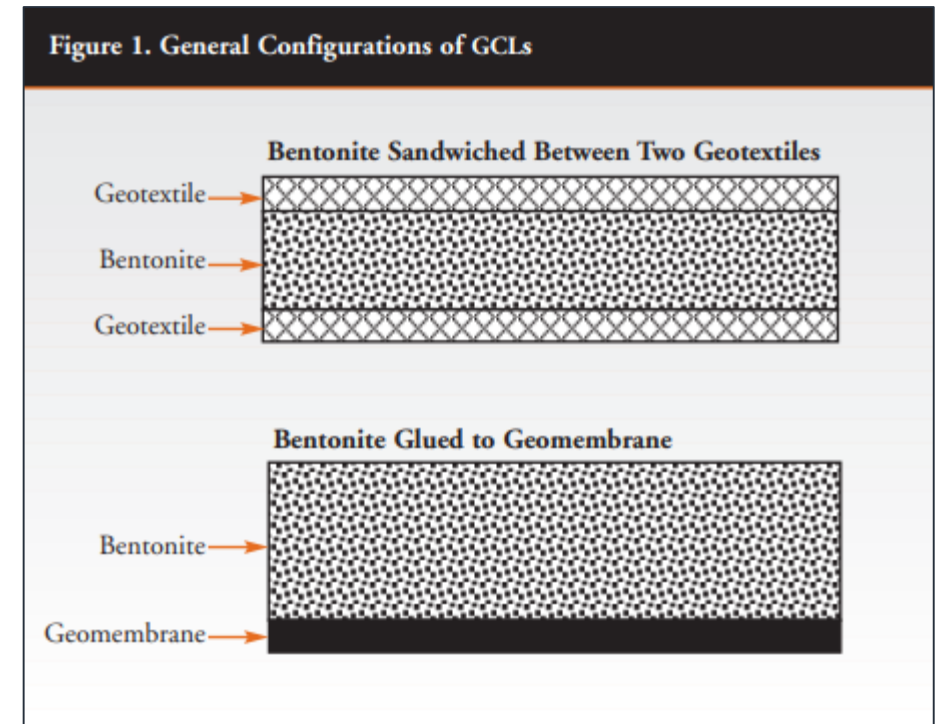


Linear Low Density Polyethylene (2017, March 2) Retrieved from <https://geotechpedia.com/Equipment/Show/2032/Enviroflex-Linear-Low-Density-Polyethylene--LLDPE--Geomembranes>

Geosynthetic Clay Liner (GCL) Cover

What is a GCL?

- A GCL is a thin layer of bentonite that is either bonded to a geomembrane or encased between two sheets of a geotextile.
- These covers are designed to act like a layer of compacted clay, but at a much-reduced volume.
- Ability to resist damage by freeze/thaw cycles.
- The first GCL was developed in 1986.
 - Traditionally used in hazardous waste landfills.

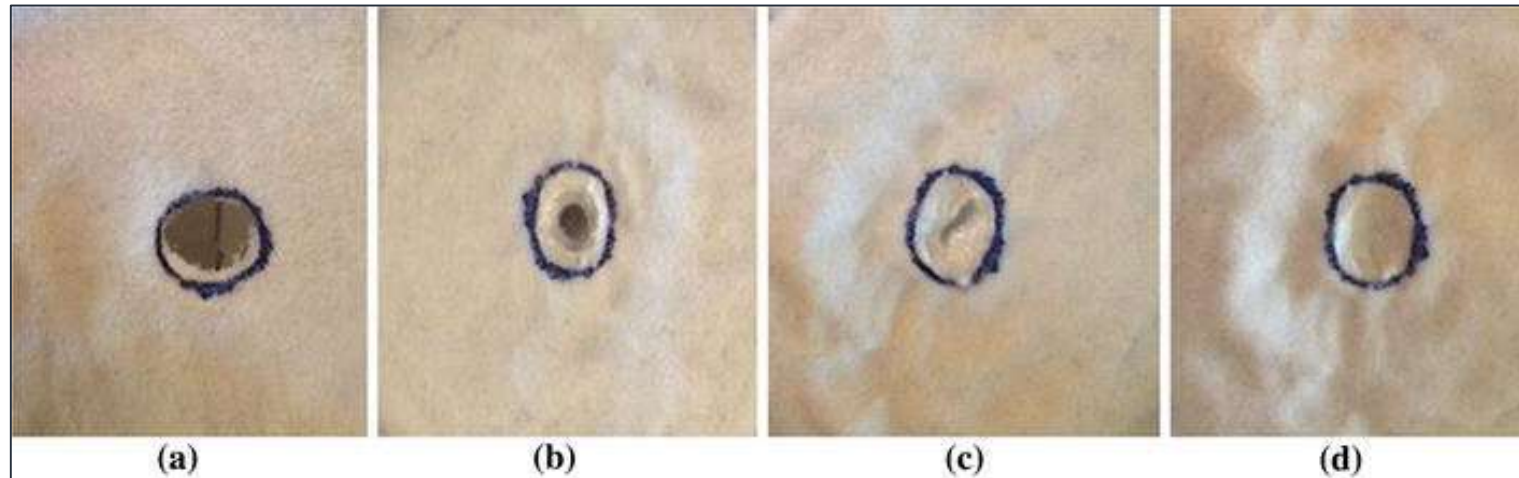


(USEPA) United States Environmental Protection Agency. (2001). Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills.

(USEPA, 2001)

What makes GCLs special?

1. Bentonite is a polar compound, so it attracts water.
2. When the bentonite “absorbs” water, it swells.
3. This swelling allows it to “heal” itself.

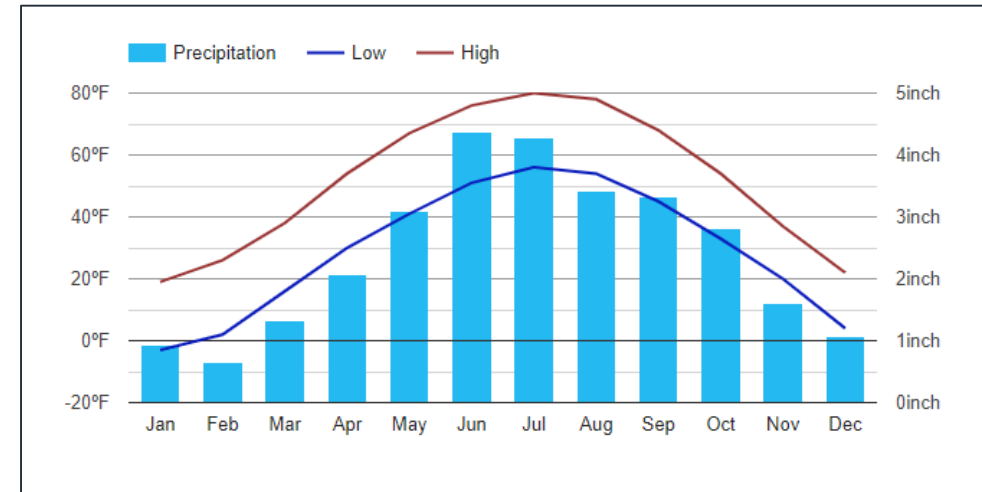


Salemi, N., Abtahi, S., Rowshanzamir, M., & Hejazi, S. (2018). *Gcl Self-Healing Test*. Research Gate. Retrieved April 29, 2022, from https://www.researchgate.net/figure/Self-healing-test-damaged-GCL-before-test-a-GCL-containing-5-SAP-after-16h-b-GCL_fig10_323383992.

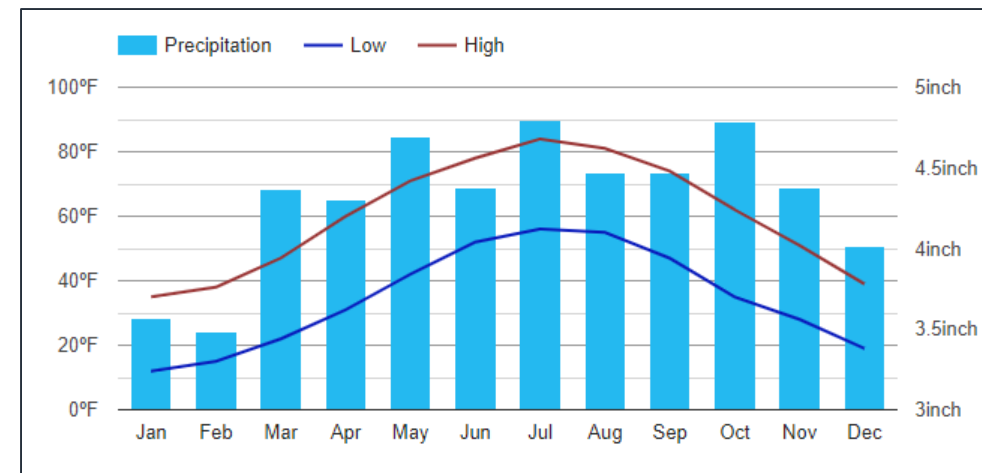
(USEPA, 2001)

GCL Studies

- Pueblo, Colorado
 - Liner System
 - Gundseal GCL
- Greenville, South Carolina
 - Cap System
 - Bentofix GCL
- Thomaston, Connecticut
 - Cap System
 - Claymax GCL



Grand Rapids Climate Graph. (2022). U.S. Climate Data. Retrieved April 30, 2022, from <https://www.usclimatedata.com/climate/grand-rapids/minnesota/united-states/usmn0309>.

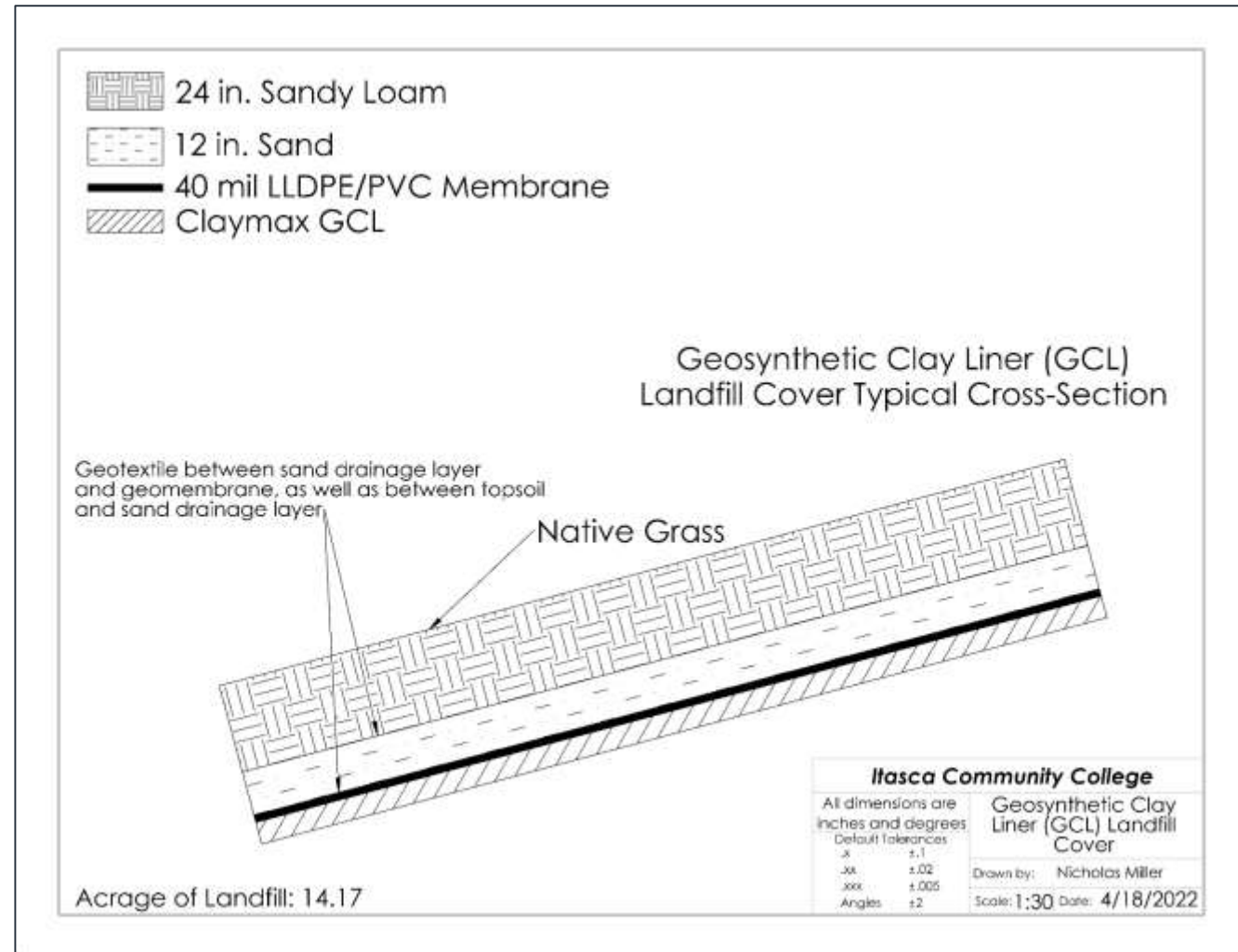


Thomaston Climate Graph. (2022). U.S. Climate Data. Retrieved April 30, 2022, from <https://www.usclimatedata.com/climate/thomaston/connecticut/united-states/usct0465>.

(USEPA, 2001)

GCL Cover Design

- Thomaston, Connecticut Cap Design
 - 6 inches of topsoil
 - 24 inches of earthen material
 - Geogrid
 - Geotextile
 - Polyvinyl chloride geomembrane (30 mil)
 - Claymax GCL
 - Geotextile



(USEPA, 2001)

Papermill Sludge Cover

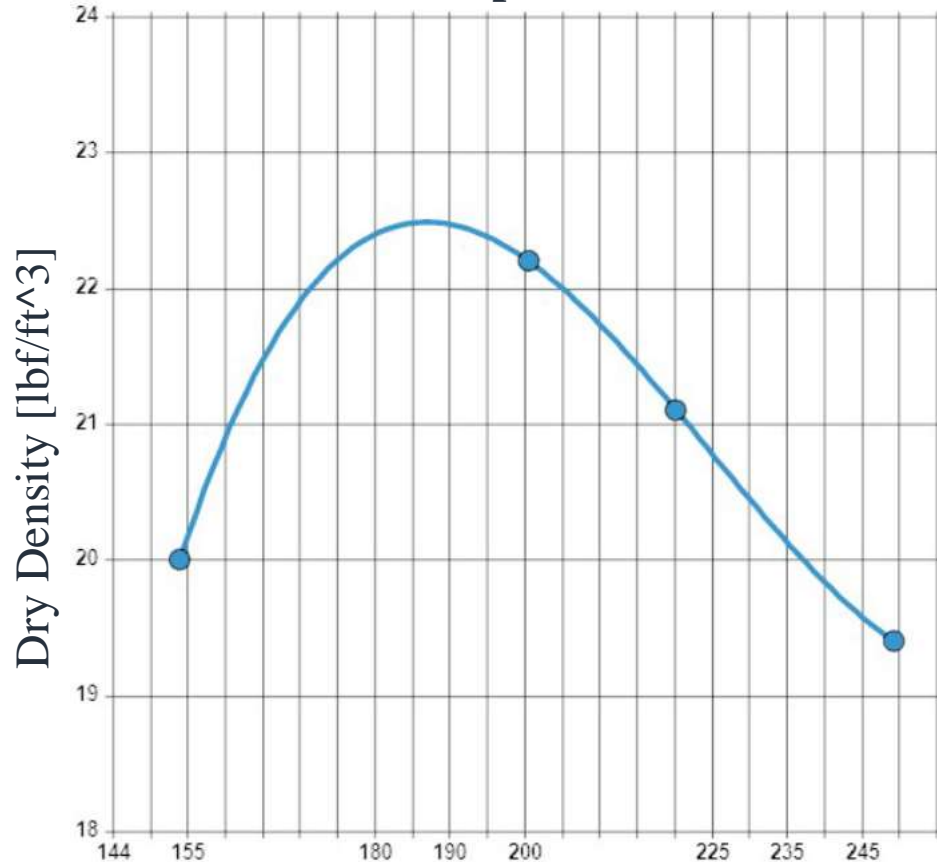
Paper Mill Sludge

- Used in the current landfill cover
 - Seemed like a poor idea at the time of first learning of it
 - Through research found out that paper mill sludge has been used in several landfill covers
- Started looking into the effectiveness of paper mill sludge as a barrier layer



Testing the Paper Mill Sludge

ASTM D698 Compaction Test Results



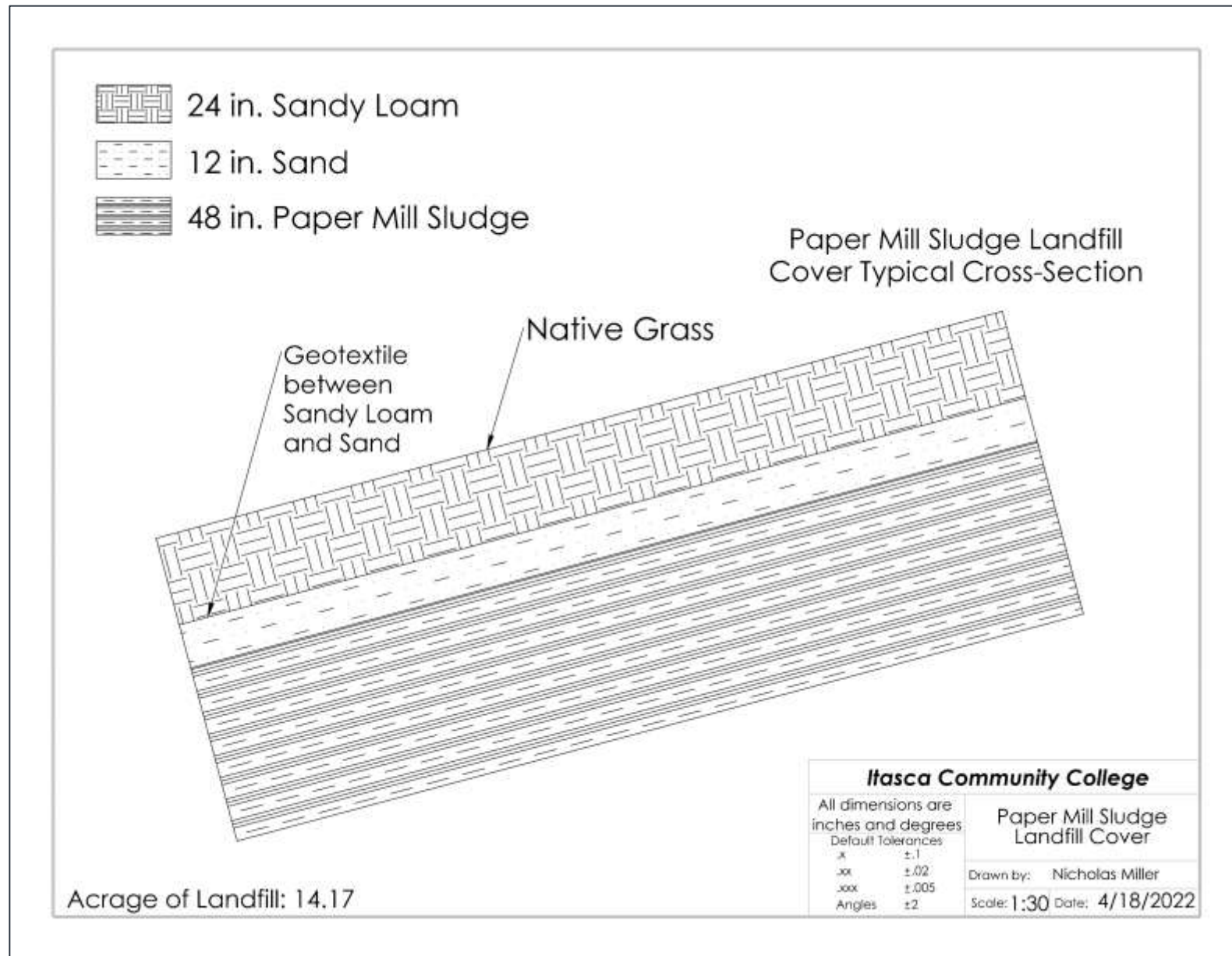
Classification: Paper Mill Pulp

Moisture Content [%]

- Needed values of the WWTP's paper mill sludge to compare and analyze whether it would work well as a barrier layer.
- Contacted a known employee at Braun Intertec about testing the paper mill sludge for:
 - Hydraulic conductivity
 - Water content
 - Organic content
 - Optimum moisture content

Design

- Cover design based on a paper mill sludge cover from Corinth, NY
 - Similar climate and paper mill sludge to Grand Rapids, MN



(Floes et al., 1998)

Subtitle C Cover



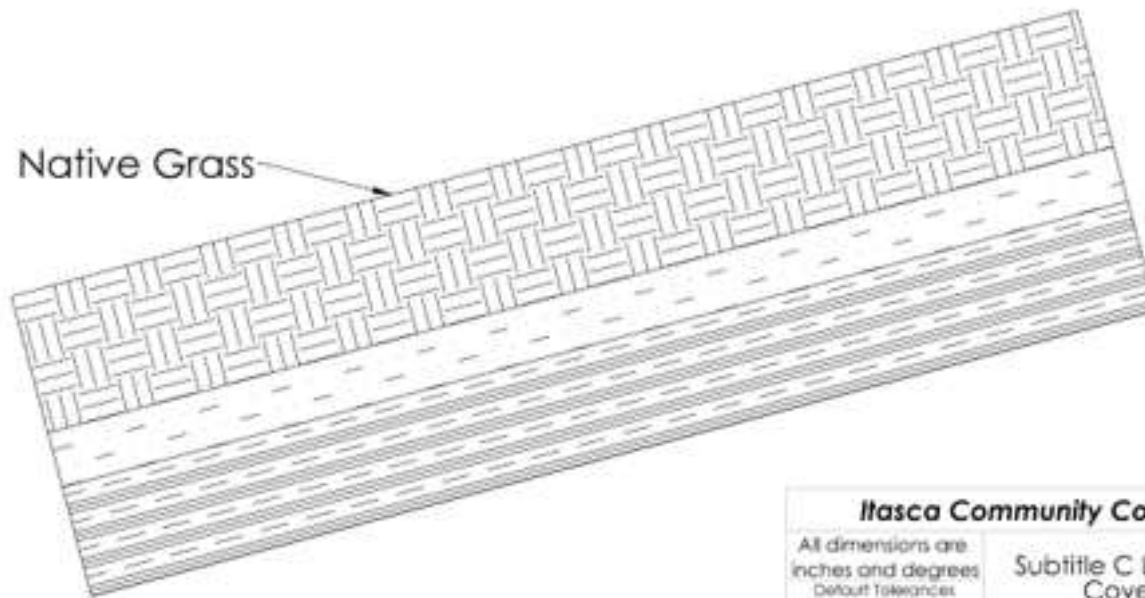
General Information

- Aimed at managing hazardous waste to protect the environment and human health.
 - Landfill Phase 1-4 Kettle D does not contain hazardous waste, it is an industrial sludge landfill.
 - Subtitle C was researched due to its stringent requirements so comparisons could be made.
- There are SC regulations for generation transportation and treatment, storage, or disposal of hazardous waste
- Hazardous waste is processed as described below.
- **Treatment:** Using chemical processes to alter the composition of hazardous substances and sometimes recover and reuse it for manufacture purposes.
- **Storage:** Holding the waste before it is processed or disposed of
- **Disposal:** Permanently containing hazardous waste.

(USEPA, 2001)

-  30 in. Sandy Loam
-  12 in. Sand
-  24 in. Clay

Subtitle C Landfill Cover
Typical Cross Section



Acreage of Landfill: 14.17

Itasca Community College	
All dimensions are inches and degrees	
Default Tolerances	
\pm	$\pm .1$
$\pm .01$	$\pm .02$
$\pm .001$	$\pm .005$
Angles	± 2
Subtitle C Landfill Cover	
Drawn by: Nicholas Miller	
Scale: 1:30 Date: 4/18/2022	

Subtitle D Cover



ITASCA
COMMUNITY COLLEGE

ENGINEERING

Subtitle D Landfill

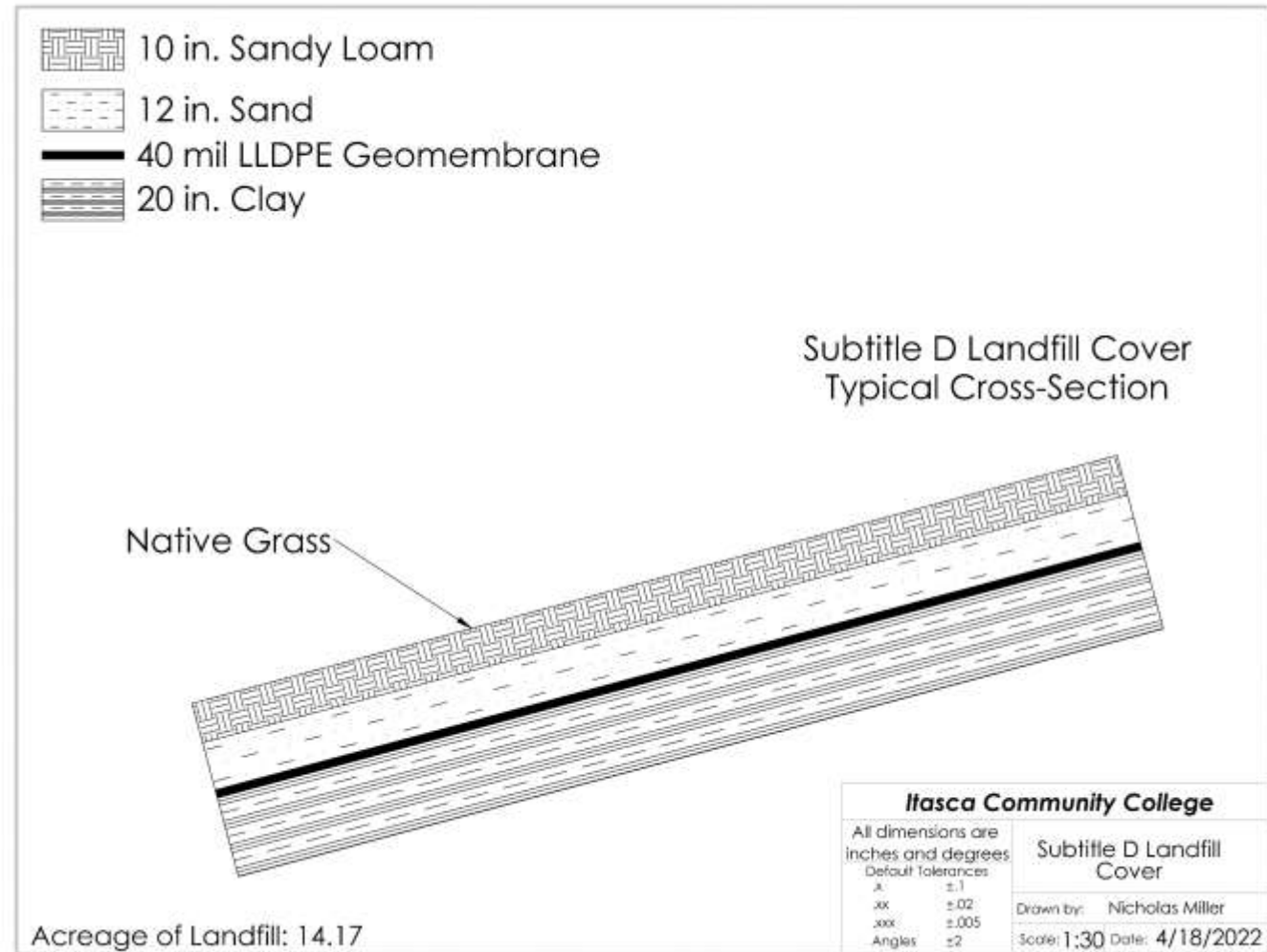
- Regulation that aims for the management of municipal waste.
- One of the most relaxed regulations as it manages low hazard waste.
- The primary design regulation for subtitle D landfill cover are as follows
 - 15 cm or roughly 6 in of erosion controls
 - 45 cm or roughly 18 inches of a barrier layer or a layer with a permeability $\leq 1 \cdot 10^{-7}$ cm/s

(Albright et al., October 2002)

ENGINEERING

Landfill Design

- Design is very simple
 - 10 inches of topsoil for erosion control
 - 12 inches of sand drainage
 - A LLDPE Geomembrane
 - 20 inches of a clay for barrier layer



Determining The Right Cover



Landfill Cover Decision Matrix

<i>Criterion related to Different Specifications for your project</i>											
<i>Specification Criteria</i>	Procedure: 1) Prioritize the criteria according to the specification and its importance for the project. 2) Rate the criteria for each of the specifications. 3) Multiply the rating for each option with the criteria priority.										
Criteria for Comparison	Priority 5 = High 1 = Low	Rating 5 = High 1 = Low Proposed LLDPE		Rating 5 = High 1 = Low Geosynthetic Clay Liner		Rating 5 = High 1 = Low Papermill Sludge		Rating 5 = High 1 = Low Subtitle C		Rating 5 = High 1 = Low Subtitle D	
<i>Score = (priority x rating)</i>	5 = High 1 = Low	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
<i>Criteria 1 Leachate Production</i>	5	1	5	5	25	1	5	2	10	5	25
<i>Criteria 2 Capital Costs</i>	2	4	8	2	4	2	4	3	6	1	2
<i>Criteria 3 Operation & Maintenance Costs</i>	4	2	8	5	20	2	8	3	12	5	20
<i>Criteria 4 Lifecycle Cost</i>	4	4	16	2	8	2	8	3	12	1	4
<i>Totals</i>		37		57		25		40		51	

High Scores = Good



Criteria 1: Leachate Production (gal.)	High levels	1	2	3	4	5	Low Levels
		1,000,000 - 750,001	750,000 - 500,001	500,000 - 250,001	250,000 - 100,000	< 100,000	
Criteria 2: Capital Cost (\$)	High Cost	1	2	3	4	5	Low Cost
		> 4,000,000	4,000,000 - 3,000,001	3,000,000 - 2,000,001	2,000,000 - 1,000,000	< 1,000,000	
Criteria 3: Operation & Maintenance Cost (\$)	High Cost	1	2	3	4	5	Low Cost
		> \$40,000	\$40,000 - \$30,001	\$30,000 - \$20,001	\$20,000 - \$10,000	< \$10,000	
Criteria 4: Lifecycle Cost (\$)	High Cost	1	2	3	4	5	Low Cost
		> \$4,000,000	\$4,000,000 - \$3,000,001	\$3,000,000 - \$2,000,001	\$2,000,000 - \$1,000,001	< \$1,000,000	

Conclusion

- Based on the decision matrix, the cover that meets the criteria the best was the Geosynthetic Clay Liner (GCL).
 - Excellent leachate control
 - Very low operation and maintenance costs
 - Higher capital cost
- If the current landfill cover is indeed the issue it would be recommended that it be replaced.

References

- Albright, W. H., & Benson, C. H. (n.d.). (rep.). Alternative Cover Assessment Program 2002 Annual Report (pp. 1–1).
- Floess, Carsten H.; Harris, Warren A. IV; Moo-Young, Horace K. Jr.; and Zimmie, Thomas F., "A Municipal Landfill Cover With a Paper Sludge Barrier Layer" (1998). International Conference on Case Histories in Geotechnical Engineering. 8. <https://scholar.mst.edu/icchge/4icchge/4icchge-session09/8>
- Grand Rapids Climate Graph*. (2022). U.S. Climate Data. Retrieved April 30, 2022, from <https://www.usclimatedata.com/climate/grand-rapids/minnesota/united-states/usmn0309>.
- Mattson, S. (2021, December 14). Landfill cover for Phase 1-4, Kettle D. Grand Rapids, Minnesota; 500 SE 4th St.
- Salemi, N., Abtahi, S., Rowshanzamir, M., & Hejazi, S. (2018). *Gcl Self-Healing Test*. Research Gate. Retrieved April 29, 2022, from https://www.researchgate.net/figure/Self-healing-test-damaged-GCL-before-test-a-GCL-containing-5-SAP-after-16h-b-GCL_fig10_323383992
- (USEPA) United States Environmental Protection Agency. (2001). Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills.