Environmental Containment Using Field & Factory Fabricated Geomembranes

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TIME STUDY BACKGROUND

OBJECTIVE

- Opportunity to observe two unique styles of lining systems on the same site footprint
  - Primary & secondary membrane
  - Specified by lead engineer
- Product installation performance and characteristics for seepage containment geomembranes
- Variable: Location of fabrication
- System types:
  - Field-Fabricated Lining System
  - Factory-Fabricated Lining System

STUDY DESIGN

- Installation speed
- Seam testing requirements
  - Time for completion
- Seam quality in-field and factory seams
- Total cost to site owner

Qualitative Caveat: The results presented in this report are qualitative in nature and caution should be used when interpreting them given the small sample sizes.

HOLISTIC PRODUCT ANALYSIS

- Use of qualitative and quantitative methods to understand the technical performance and context for use case
- Holistic technical evaluation
- Actionable results
- Tools Leveraged
  - Time Studies
  - Stakeholder Interviews
  - Field-installations
  - Prototype Mockup & Reviews
  - Decision Criteria
  - Selection Motivation
  - Preference
- Result >> Meaningful, Differentiated Innovation

APPLY QUALITATIVE & QUANTITATIVE DATA

METHODOLOGY

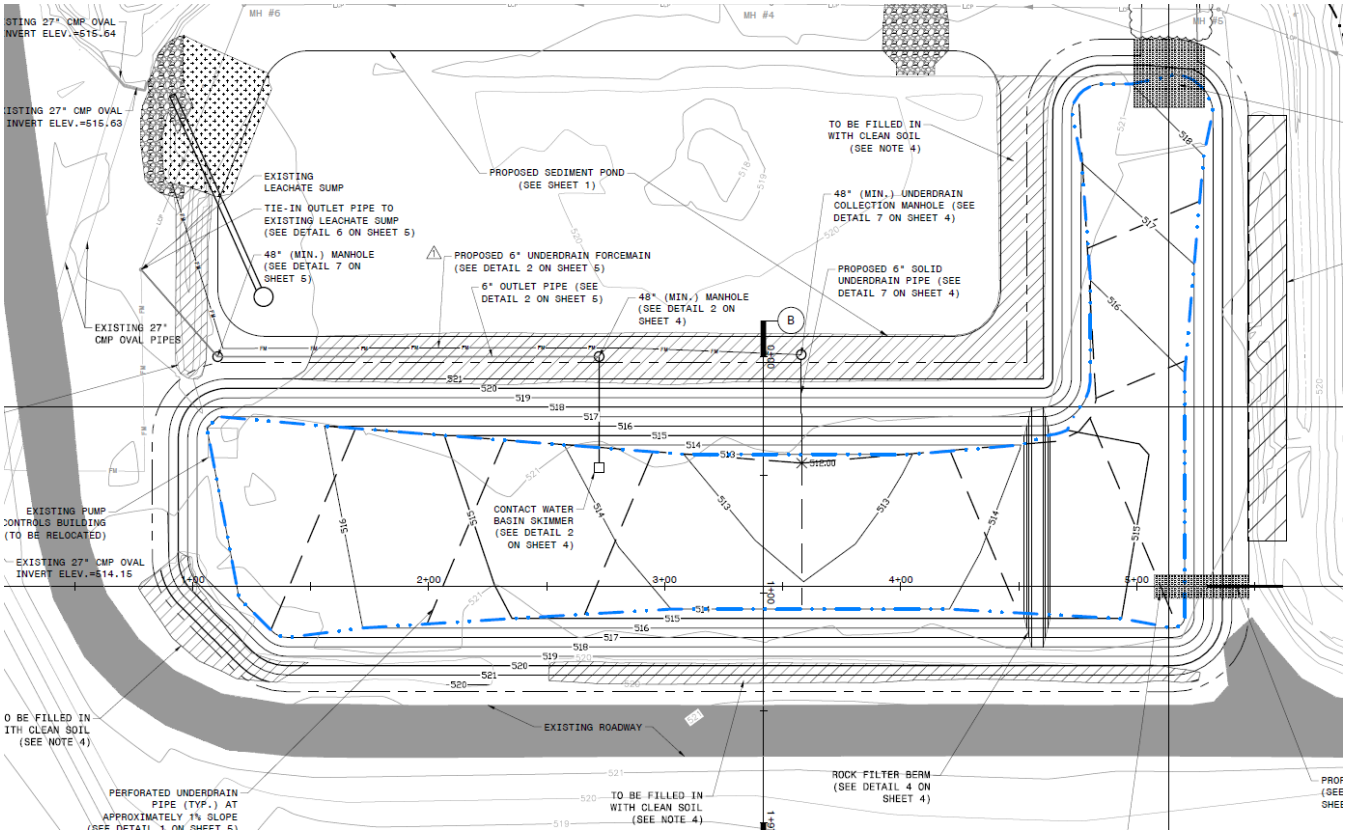
- Identify two or materials, technologies with similar use cases
- Complete technical analysis
- Stakeholder mapping
- Stakeholder interviews
- Identify an appropriate test-site to verify use case
- Identify tangible, quantitative metrics

STAKEHOLDER MAP

USE CASE

- New product development
- Product innovation
- Market understanding

TIME STUDY JOBSITE SELECTION



- 7,500 square meter (78,7450 sqft) storm water retention pond
- Designed to store runoff from ash landfill operations
- 3rd party owned coal-fired power plant and residual disposal landfill

JOBSITE SELECTION

Location: Northeastern

EVALUATION CRITERIA

TOTAL INSTALL COST

- Labor skill level and time required
- Site owner 3rd party expense for QA testing
- Quality Control (QC) included in install price

INSTALL QUALITY

- Wrinkles as environment changes (potential leak locations)
- Lay flat
- Seam quality

MATERIAL DURABILITY

- Puncture resistance
- Tensile strength

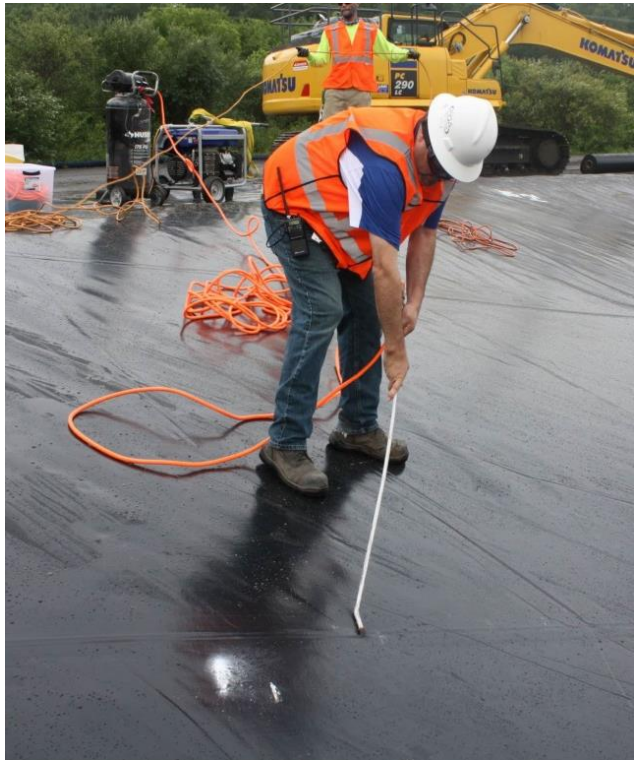
FITNESS FOR USE

- Specific to material being contained
- Lasts for specified time

METHODOLOGY

Pond Specification

- 1.5 mm (60 mil) Field-Fabricated Lining System
- Geosynthetic Clay Liner (GCL)
- 1 mm (40 mil) Factory-Fabricated Lining System



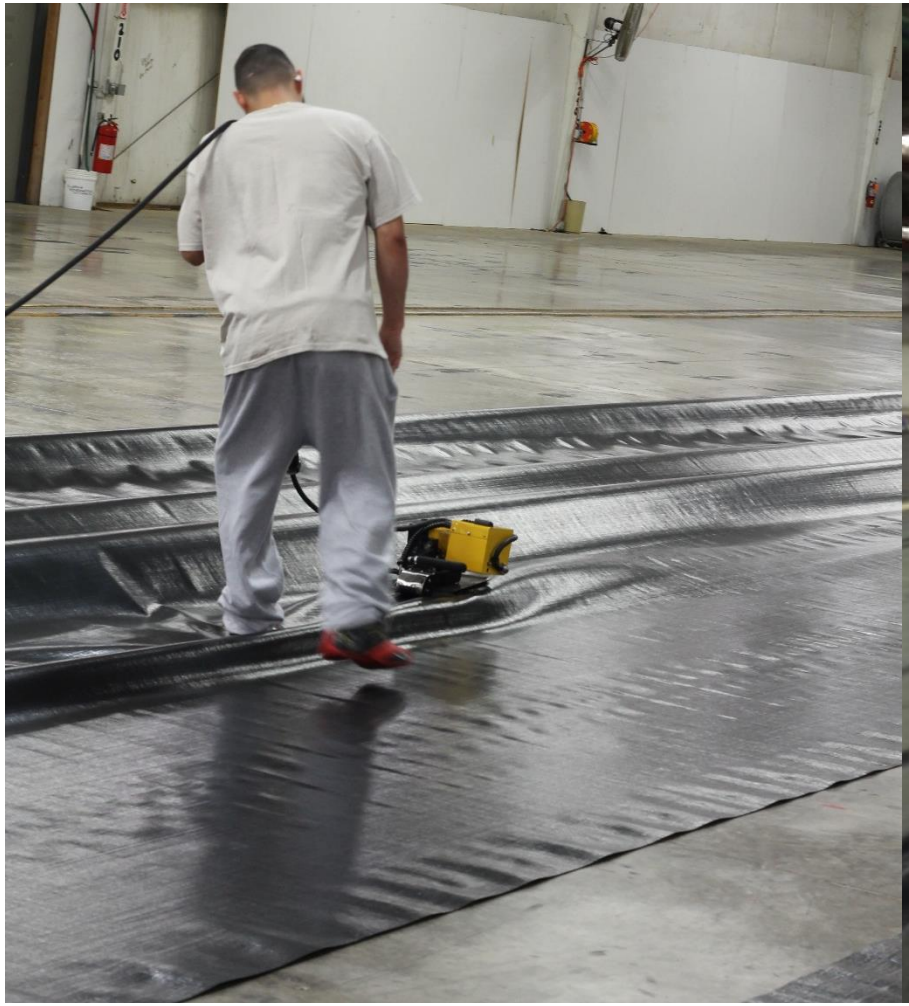
Quantitative & Qualitative

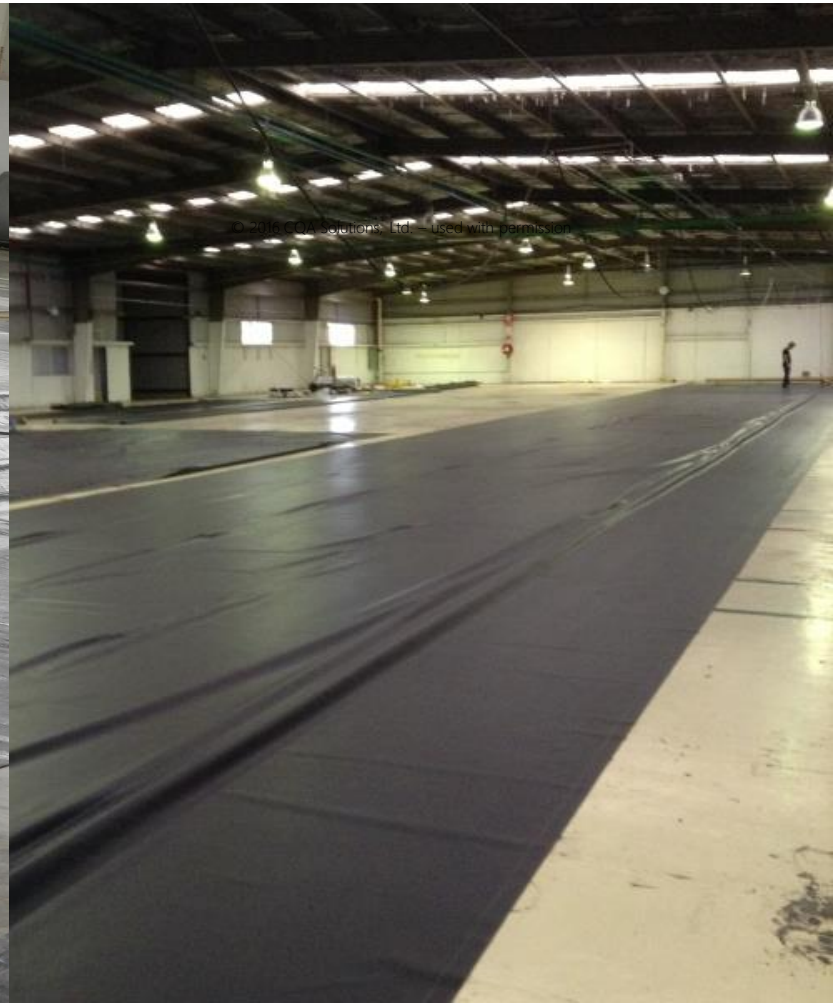
- Installation complexity
- Labor requirements
- Stakeholder interviews

Installation Protocol

1. Subgrade preparation
2. Install 1.0 mm (40 mil) factory-fabricated lining system
3. Install Geosynthetic Clay Liner
4. Install identical quantity of 1.5 mm (60 mil) field-fabricated lining system

FACTORY-FABRICATED LINER FABRICATION





Rolls are seamed in a controlled setting into panels

FACTORY-FABRICATED LINER INSTALLATION

Large panels are pre-welded into custom sizes, and delivered to the jobsite

Panels are unfolded and deployed in place

Unfolded panels are opened and pulled across coverage area

Field seaming is needed where panels require connection

FOLDED

FACTORY-FABRICATED LINER INSTALLATION

Typically delivered in rolls:

- 6.7-7.62 meters [22-25ft] wide
- 243- 275 meters [800 to 900 ft] in length
- 2 tons [4,000 lbs] in weight

Typically deployed mechanically, one roll at a time

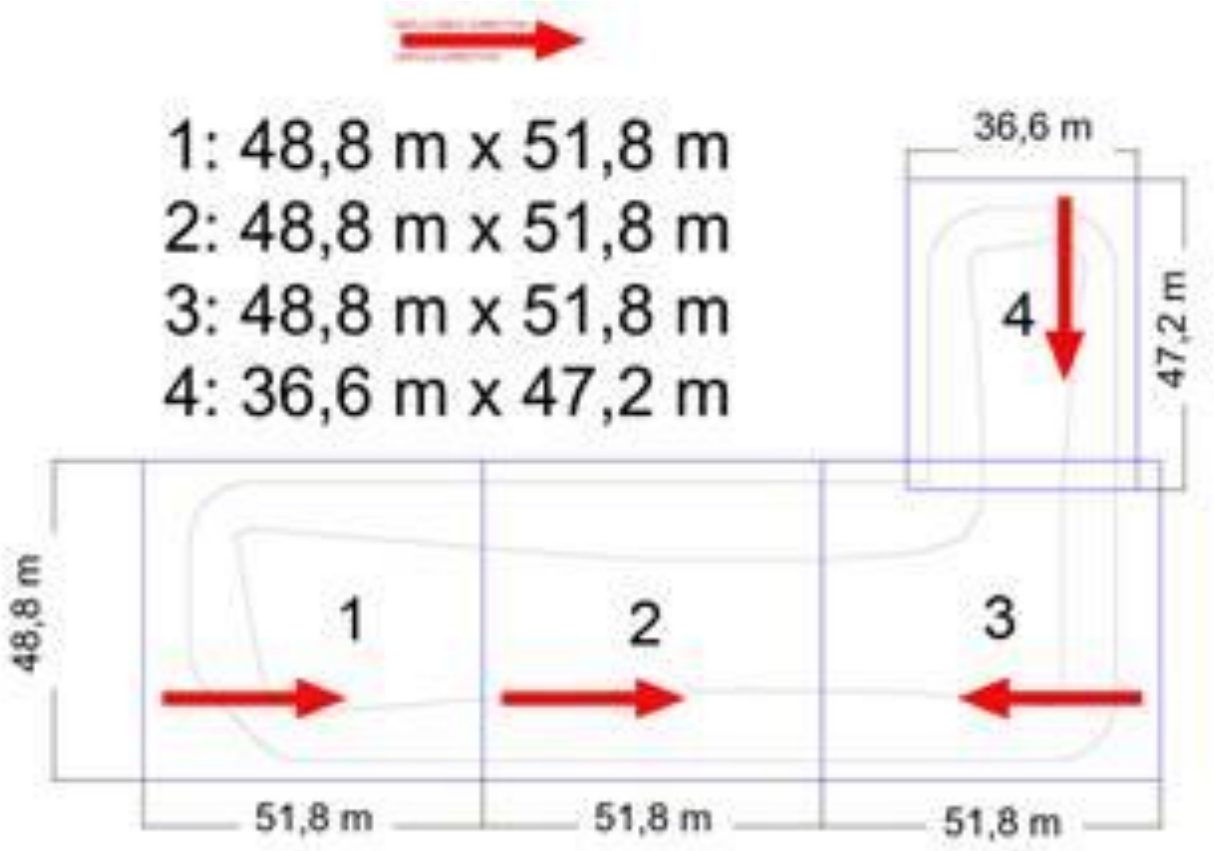
Panels are unfolded and deployed in place

ROLLS

SUBGRADE PREPARATION

- Ready for the installation
- Sandbags in position to ballast membrane
- 1 pipe penetration
- Installation Company: CQA Solutions

INSTALLATION PLAN FACTORY-FABRICATED LINER



Panel diagram “shop drawing” – created by fabricator for installers use

Fabrication Company: EPI

FACTORY FABRICATED LINING SYSTEMS INSTALLATION

3000X speed, 10 sec

FIELD FABRICATED LINING SYSTEM INSTALLATION

3000X speed, 1 min

WELDING & QA/QC

Factory-Fabricated Liner

- Field seams completed with single-track wedge welder
- Airlanced all factory seams

Field-Fabricated Liner

- Field seams completed with dual-track thermal fusion welder
- Completed air channel and destructive testing

WRINKLES

EXAMPLE
Photo from different installation project

FACTORY-FABRICATED

FIELD-FABRICATED

FIELD-FABRICATED WRINKLES

- Field-fabricated liner displays expansion with ambient temperature rise.
- This can create challenges in welding, and prevent intimate contact with the ground, thereby potentially compromising performance.

FACTORY-FABRICATED LINER WRINKES

STAKEHOLDER PERSPECTIVES

Stakeholder se
as a benefit

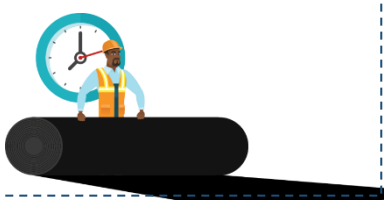
STAKEHOLDER	FACTORY-FABRICATED	FIELD-FABRICATED
ENGINEER SPECIFIER	3 Seams	191 seams
	Less Documentation	
SITE OWNER	Fewer Welds	
INSTALLATION COMPANY OWNER	Puncture resistance and tensile strength higher	Lower puncture resistance and tensile strength
	Fewer wrinkles	More wrinkles (in similar conditions)
	Less time to install (half day)	More time to install (two days)
	Pre-fabricated panels/corners	Field Seams
	Fewer seams	More seams
	4 panels	95 panels
	Less destructive testing needed	More time spent for destruct testing
		Have to cut product in field to seam length needed
INSTALLATION DAY OF MANAGER	Fewer QAs needed	More QAs over more days
		Need to abrade surface

STAKEHOLDER PERSPECTIVES

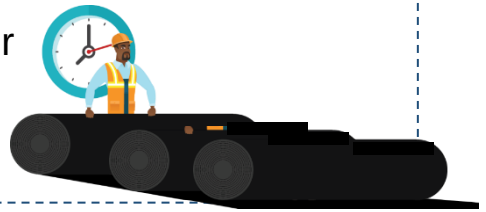
Stakeholder se
as a benefit

STAKEHOLDER	FACTORY-FABRICATED	FIELD-FABRICATED
INSTALLER	Quick to install	
	Wider panels/covers more	More panels needed
	Fewer destructs	More destructs
CREW SIZE	20-25 crew members	11-12 crew members
	More, lower skilled labor ($10-13/hr)	
WELDING	Wedge weld	Hot air weld
	Increased time finding weld setting on first experience with product	Installers accustomed to welding material, fast
	Scrim could cause welding to be more difficult	Requires grinding before extrusion welds
PRODUCT DIFFERENCES	Trial Weld	Trial Weld
	Airlance prefabricated seams	Air channel test field seams
	40 mm thick	60 mm thick

Estimated total for Factory-fabricated:
5 hours 37 mins*



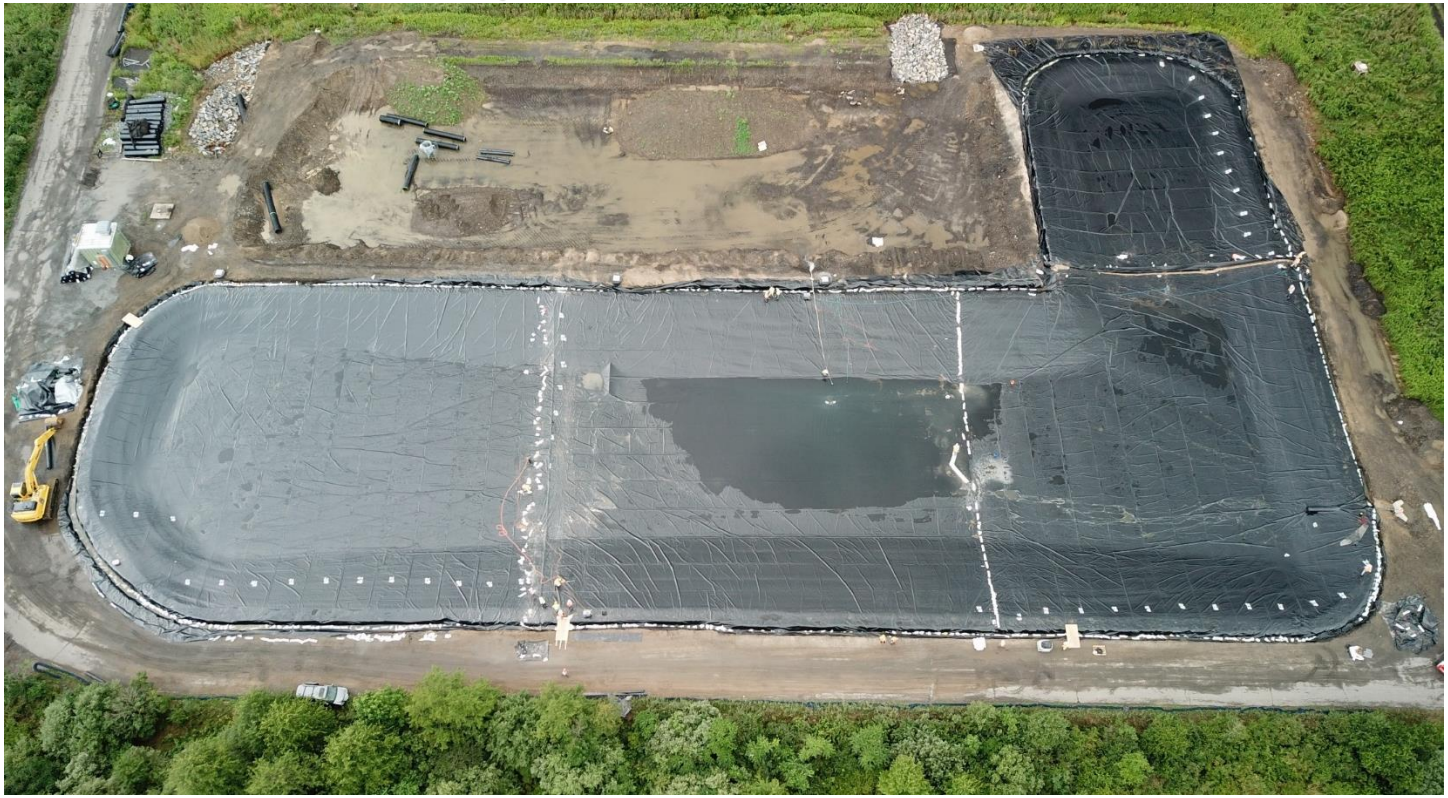
Estimated total for Field-Fabricated:
16+ hours*



* Time associated with adverse weather conditions removed

COMPLETED INSTALLATION

Completed installation time 6 hours



INSTALLATION TIME

Panels were welded together using a DemTech VM 20 single-track wedge welder. Average temperature setting was between 700° F and 750° F, with speed setting at approximately 14 ft/min.

STAKEHOLDER PERSPECTIVES

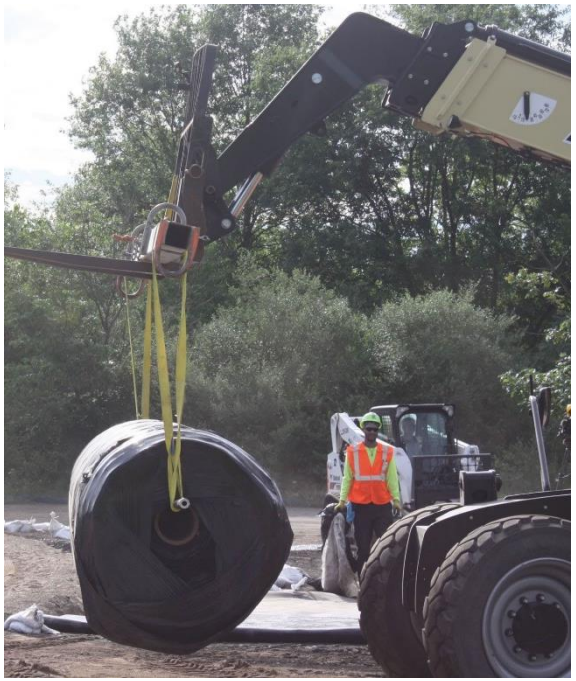
"If it's in big sections … it's going to be much better because **you have a lot less welds [with Factory-Fabricated Geomembrane] than you will with the normal 15 or 20 foot wide rolls."** – Site Owner

"It makes it a little more foolproof. The less seams …, the less holes, the less […]walking on it. **Ease of installation makes a big difference."**
– Installation Company Owner

"[Factory-fabricated] Covers a lot more. With **one [Factory-Fabricated] panel, it'd probably take you about 6/7 panels with [Field Fabricated system]**." – Installer

"If the material is cheaper, performs well, installs quicker, then there is no reason not to make that change."
– Engineer

"…when you talk about the reduction of QA time, it is very serious… **[Factory-Fabricated Geomembrane] is a big reduction in third-party cost."**
– Installation Day of Manager



ATTRIBUTE SUMMARY

Field-Fabricated

Factory-Fabricated

SUMMARY

Field-Fabricated

- Smaller, consistent width panels
- 95 panels deployed
- 191 field seams
- All Field seams
- Total Field Seam Length: 5387 LF
- Length Extrusion Weld Repairs: 2145 LF
- # Extrusion Weld Repairs: 253
- Smaller rolls
- Installer familiarity
- Proven field performance
- Fewer, high skilled labor

Factory-Fabricated

- Larger, customizable size panels
- 4 panels deployed
- 3 field seams
- Factory-fabricated + field seams
- Total Field Seam Length: 418 LF
- Length Extrusion Weld Repairs: 108 LF
- # Extrusion Weld Repairs: 12
- Higher puncture resistance
- Higher tensile performance
- More, low skilled labor
- Approx. 1/3 time required to install
- Less time, risk of subgrade exposed to elements

Proper material selection & due diligence considers holistic evaluation of material properties in addition to cost to site owner, test method requirements and labor costs.

THANK YOU

Questions?

Thank You For Attending!

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