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Exposed Geomembrane Covers (EGCs) for Landfills

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Presentation Outline

- History of EGCs
- Evolution of EGCs
- Feasibility of EGCs
  - ✓Technical
  - ✓Regulatory
  - ✓Financial

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History of EGCs for Landfills

Note that:

- Exposed geomembranes have been used in dams since the 1970s.
- Several geomembrane wind uplift papers were publications in the 1970s.

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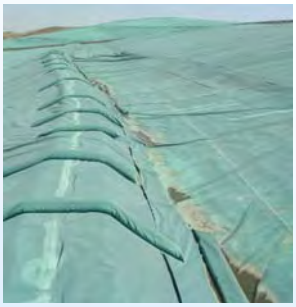
Delaware Solid Waste Authority, DE

- 35-mil scrim-reinforced fPP, Green
- Stevens Geomembranes
- Construction 1997
- Area 42 acres
- Long-term Interim Cover



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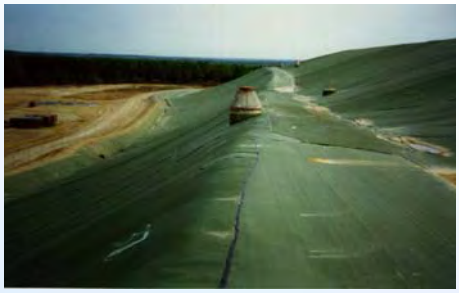
Sabine Parish, LA

- 60-mil HDPE Textured, Green
- GSE
- Construction 1999
- Area 15 acres
- Approved as Final Cover



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Other Examples of EGCs

Yolo County landfill near Davis, CA
Reinforced Polypropylene Geomembrane

Coffin Butte Landfill, Corvalis, OR
EPDM Geomembrane

Polk County, FL
HDPE Geomembrane GSE

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Evolution of EGCs

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Solar Caps

- Hickory Ridge Landfill, Atlanta, GA
- Area 45 acres, ~10 with solar
- Construction 2011
- 60-mil scrim-reinforced TPO, Green

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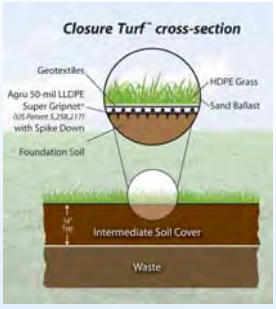
Closure Turf

- Crazy Horse Landfill, CA
- 50-mil structured LLDPE
- Construction 2011-12
- Area 63 acres
- Anchored with Closure Turf
- Approved as Final



Sand is applied as a ballast eliminating the need for anchoring.

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Technical Feasibility of EGCs

Advantages and Disadvantage

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Advantages of EGCs (1)

- Reduced Construction Materials, Cost, and Effort
  - Elimination of the topsoil, cover soil, drainage, and vegetation components of a final cover system may reduce total construction costs by as much as $25,000 to $60,000 per acre

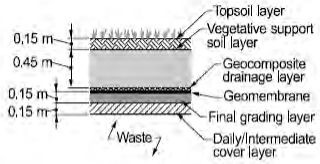

Figure 1. Typical Final Cover System

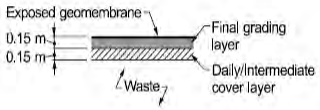

Figure 2. Exposed Geomembrane Cover System

Gleason M.H., Houlihan M.F., Palutis J.R. (2001) Exposed geomembrane cover systems: technology summary. Proc. Geosynthetics Conference 2001, Economics, Performance and Constructability Advantages of Geosynthetics, IFAI, Roseville, MN, pp.905-918.

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Advantages of EGCs (2)

- Reduced Greenhouse Gas Emissions
  - 80% less CO2 emissions than Subtitle D cover construction
- No Cover Soil Erosion and Reduced O&M Costs and Effort
  - Subtitle D covers:
    - require mowing, tree removal, weeding/herbicide, frequent erosion damage repair, reseeding, sediment removal from SWM system
  - EGCs:
    - require only minor patching and seaming, sedimentation reaching the stormwater system from an EGC is minor

Advantages of EGCs (3)

- No stability issues
  - Veneer stability of soil on geomembrane is not an issue
  - Can place EGCs on steeper slopes
- Settlement effects on EGC are not significant and settlement is easier to repair
- Can capture airspace created by waste settlement in the future much easier than with a Subtitle D cover

Disadvantages/Design Considerations of EGCs

- Aesthetic Concerns
- Limited Cover Access
- Limited Design Life
- Wind Uplift of EGC (need anchoring)
- Increased Volume and Velocity of Stormwater Runoff
- Potential for Damage by Birds, Hail, etc.

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Aesthetic Concerns

- Geomembranes are available in many colors (Black, White, Gray, Tan, and Green)

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Limited Cover Access

- Roads can be built on EGCs; they double up as anchors

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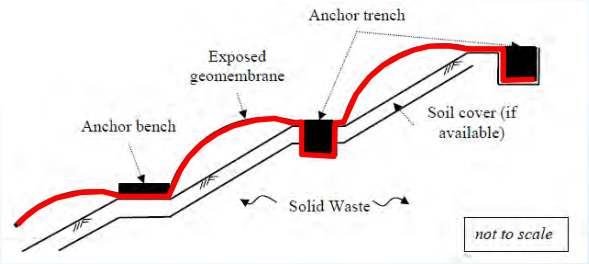
Limited Design Life

- All geomembranes are formulated materials consisting of:
  - resin, carbon black and/or other colorants, and short-term processing stabilizers
  - long-term "weathering package" containing UV light absorbers, light stabilizers, and antioxidants
- Expected exposed service life >30 years (GRI, 2010)

Material	First EGC Experience	Typ. Gauge (mil)	Warranty (years)
Reinforced fPP	1997	45	20
HDPE	1999	60	5-20
Reinforced TPO	2009	60	20-30
EPDM	2011	45	20

Wind Uplift – Typical Anchor Trench Design

- Vertical anchor trenches are the most common method
  - 3x3-ft trenches every 60-100 feet
  - Average cost $20,000 per acre



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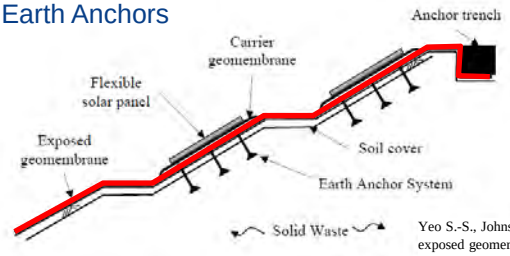
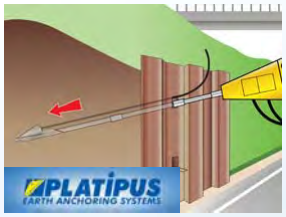
Wind Uplift – Earth Anchors

- Earth anchors are new, less costly method
  - No trenching/backfilling, geomembrane use reduced by 15%
  - Anchor every 15-25 feet
  - Average cost $10,500 per acre

Earth Anchors





Yeo S.-S., Johnson R.S., Corcoran G.T. (2011) Alternative anchorage methodology for exposed geomembrane installations with flexible solar photovoltaic panels, Proc. Geo-Frontiers 2011, 13-16 Mar 2011, Dallas, TX.

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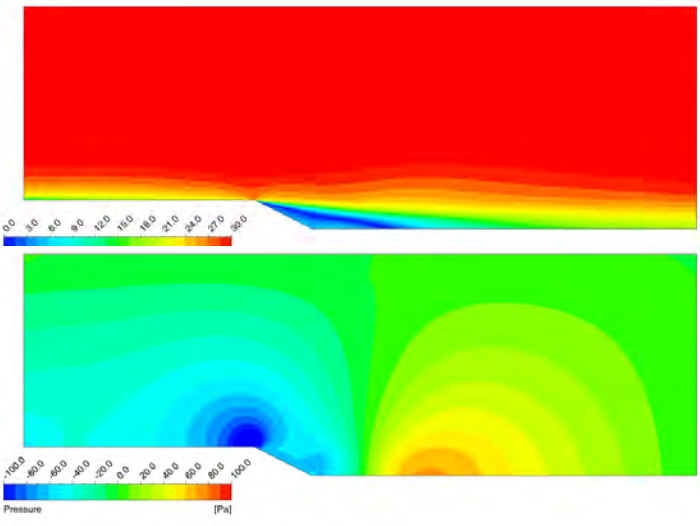
Wind Uplift Predictions using CFD Modeling



Wind Speed

Wind Uplift Pressure

Botelho, Heynes, and Giroud, "Evaluating Wind Uplift for Exposed Geomembranes using Computer Modeling", Geosynthetics 2013, April 1-4, Long Beach, California

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Increased Stormwater Runoff

- Need bigger capacity for perimeter ditches and ponds

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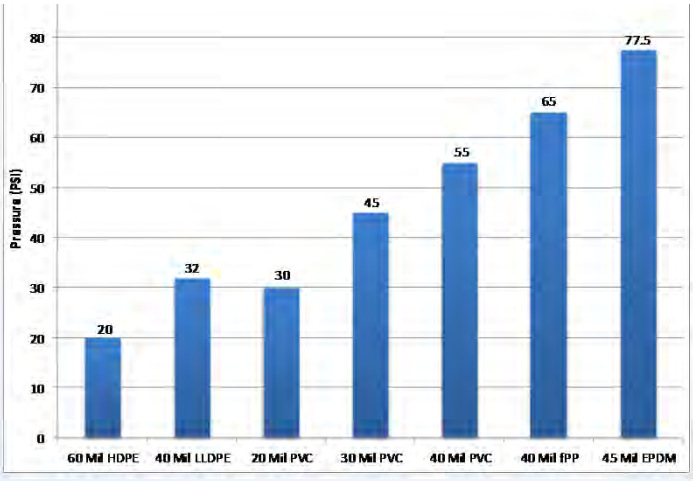
Potential for puncture by hail, animals, etc.

Hydrostatic puncture resistance per ASTM D 5514
Simulates a 1" Rock (Sharp) at a 1" Spacing on a 20" Pressure Surface



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Minimizing Potential Damage by Birds

Wires across cap discourage birds from landing on EGC

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Regulatory Feasibility of EGCs

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Precedents from Other States

- GSI survey, 2009 queried all 50 states on the issue of permitting EGCs as alternative covers
  - 32 responses
  - Is EGC allowed as an alternative cover design?
    - Yes = 7 (22%)
    - Yes, conditionally = 9 (28%)
    - No = 16 (50%)
  - Performance bonding and financial assurance requirements varied, about 50/50 split between bonding and FA
- Variances for EGCs at landfills have been granted since the 1990s in 16 states
  - 4 states (1996 – 2002)
  - 12 states (2009 – 2011)

U.S. EPA Position

- U.S. EPA encourages landfill owners to work with state regulators to reduce the environmental footprint of activities needed to install and maintain a cover system
- Integrating landfill cover designs with reuse of a site for generating energy from solar resources can meet this objective
- Solar geomembrane covers specifically identified as examples of covers that "can meet Subtitle D alternative cap requirements while converting solar energy to useable power"

Source: "Green Remediation Best Management Practices" for landfill cover systems and energy production (2011)

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Financial Feasibility of EGCs

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Example Cost Comparisons

- Unit Capital Costs (per acre)
  - Excl. Mob/demob., site grading and preparation, SWM, engineering and CQA, and contingency

Cover Type	Trenches	Anchors	No Anchors
Exposed (HDPE)	$52,700	$43,200	-
Exposed (TPO)	$67,900	$58,400	-
Subtitle D	-	-	$83,700

- Unit O&M Costs (per acre)
  - Routine activities on the cover only, not grounds maintenance, SWM systems, etc.

Cover Type	O&M	15-year Replac.	30-year Replac.
Exposed (HDPE)	$200	30%	70%
Exposed (fPP, EPDM, TPO)	$100	30%	70%
Subtitle D	$750	-	-

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Example Life Cycle Cost Scenarios

Closure Costs (-$MM, NPV basis after 30 years); 110 acres

Cover Type	Total Cost
Subtitle D (Baseline)	18.83
EGC (HDPE) – anchors	14.21
EGC (TPO) – anchors	17.13
EGC (HDPE) – trenches	16.14
EGC (TPO) – trenches	19.07

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Summary

- EGCs have been used for landfill closures since 1997
- EGCs provide environmental, technical, and financial benefits over Subtitle D covers at many landfill sites
- Design methods have been developed and implemented at many sites
- Improvements in geomembrane materials, design methods, and installation procedures are continuing.

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THANK YOU.
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