Geomembrane Barriers In Bottom Liner and Cover Applications At Landfill Sites

Presented to:

B.C. MEND Metal Leaching / Acid Rock Drainage Workshop

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Agenda

1. Geomembrane Applications
2. Materials and Engineering Properties
3. Subgrade Suitability
4. Friction Angle and Stability
5. Installation
6. Landfill Gas and Air Intrusion
7. Drainage Control
8. Costs

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Selected Geomembrane Projects completed by SHA

- *Hartland South Face Closure*
- *Knockholt Lagoon*
- *Hartland North Face Lagoon*
- *Norampac Lagoon*
- *Iona Grit Landfill Closure*
- *Nanaimo Progressive Closure*
- *Nanaimo Phase 3 Geogrid Berm and Liner*
- *Gibraltar Mine Landfill Bottom Liner and Closure*
- *Bailey Chilliack - Bottom Liner*
- *Minnies Pit – Mission, Bottom Liner and Closure*
- *Highland Valley Copper – Centre for Waste Management*
- *Skimikin Landfill Closure*
- *Fernie Landfill Closure*
- *Vancouver Phase 1 Closure*
- *7 Mile Phase 3 Liner & Treatment Pond*

Objectives of Liners and Covers

In landfill applications geomembranes are used in three ways:

1. *Impervious bottom liner*
   - *Contain leachate*
   - *Prevent landfill gas migration*
2. *Impervious final cover*
   - *Prevent infiltration of rainfall*
   - *Contain fugitive landfill gas emissions*
   - *Control odours*
3. *Leachate treatment pond liner*
   - *Contain leachate for treatment*

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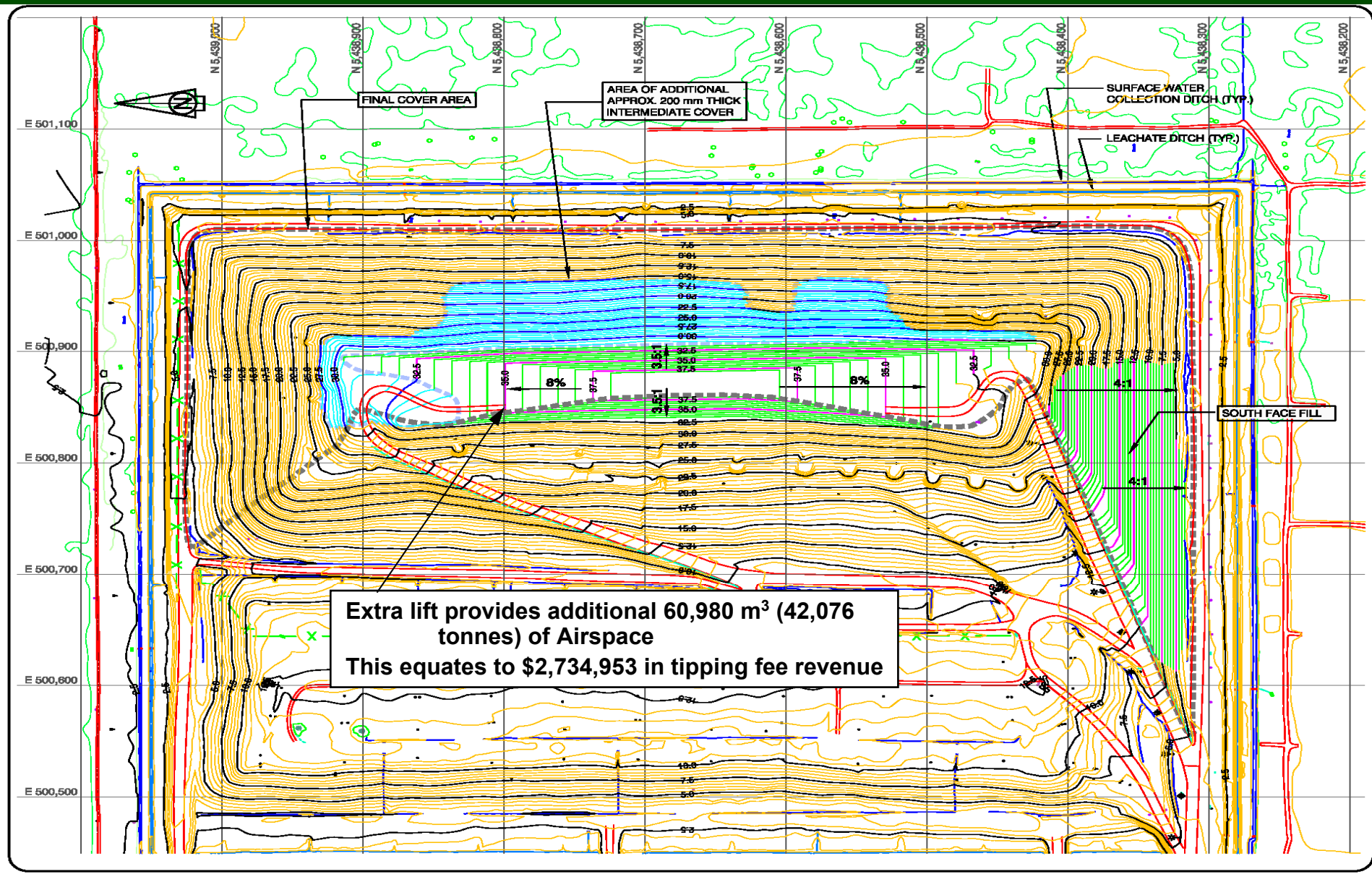
Bottom Liner at Whistler

PVC Final Cover – Hartland South Face

HDPE Aeration Pond at 7 Mile Landfill

Value of Landfill Air Space $75 to $100/m^3



Nanaimo Berm Project - 2004

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Liner Materials

- **Compacted Clay Liner**
  - 1 m thick (consumes air space)
  - $K < 1x10^{-7}$ cm/s – clay or silty clay (hard to come by)
  - Good compaction required
  - Subject to desiccation cracking
- **Geosynthetic Clay Liner (GCL)**
  - Bentonite clay between two geotextiles
  - Wet dry cycles - dessication
  - Ion exchange with divalent cations can lead to collapse of double layer
  - Hydration is tricky
  - Need good confining pressure

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Liner Materials (cont.)

- *HDPE*
  - *Very low permeability*
  - *Requires knowledgeable installer*
  - *Seams must be welded*
  - *Antioxidant depletion (function of T)*
  - *Textured Sheet adds stability*
- *LLDPE*
  - *Slightly lower density than HDPE*
  - *More flexible than HDPE*
  - *Material of choice for cover systems*

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Liner Materials (cont.)

- *PVC*
  - *Can be welded or solvent seamed*
  - *More flexible than HDPE*
  - *Can be installed in large panels*
  - *Subject to plasticizer loss over time (material can become brittle)*

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Critical Properties

- *Permeability (transmissivity)*
- *yield strength*
- *friction angle (interface)*
- *Longevity*
  - *Thermal*
  - *Ultraviolet*
  - *Chemical*
  - *Stress*
- *Price*
- *Installation Cost (ease of installation)*
- *Air Space Consumption !!!*

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Permeability

- *Clay Liners* *$1x10^{-7}$ cm/s or less*
- *GCL* *$1x10^{-9}$ to $5x10^{-9}$ cm/s*
- *Geomembrane* *depends on defects*

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Lifespan a Function of Antioxidant Depletion

Temperature °C	Service Life (years)
20	565 - 900
30	205 - 315
35	130 - 190
40	80 - 120
50	35 - 50
60	15-20

After Rowe (2005)

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Shear Strength Summary

		Friction Angle		Slope	Slope
		Minimum	Maximum	Minimum	Maximum
HDPE Membrane	Non Woven Geotextile	21	32	2.6:1	1.6:1
Textured	GCL	28	38	1.9:1	1.3:1
	Sand	28	35	1.9:1	1.4:1
	Clay	21	41	2.6:1	1.2:1
HDPE Membrane	Non Woven Geotextile	8	10	7.1:1	5.6:1
Smooth	GCL				
	Sand	16	23	3.4:1	2.3:1
	Clay	8	26	7.1:1	2.0:1
LLDPE	Non Woven Geotextile	21	21	2.6:1	2.6:1
PVC Membrane	Non Woven Geotextile	18	23	3.0:1	2.3:1
	GCL	NA	NA	NA	NA
	Sand	19	35	2.9:1	1.4:1
	Clay	21	23	2.6:1	2.4:1
GCL	Non Woven Geotextile	16.7	21	3.3:1	2.6:1
Agru Super Grip	Non Woven Geotextile	41		1.15:1	

- ***Textured liners can support covers at slopes to 2.5H:1V***

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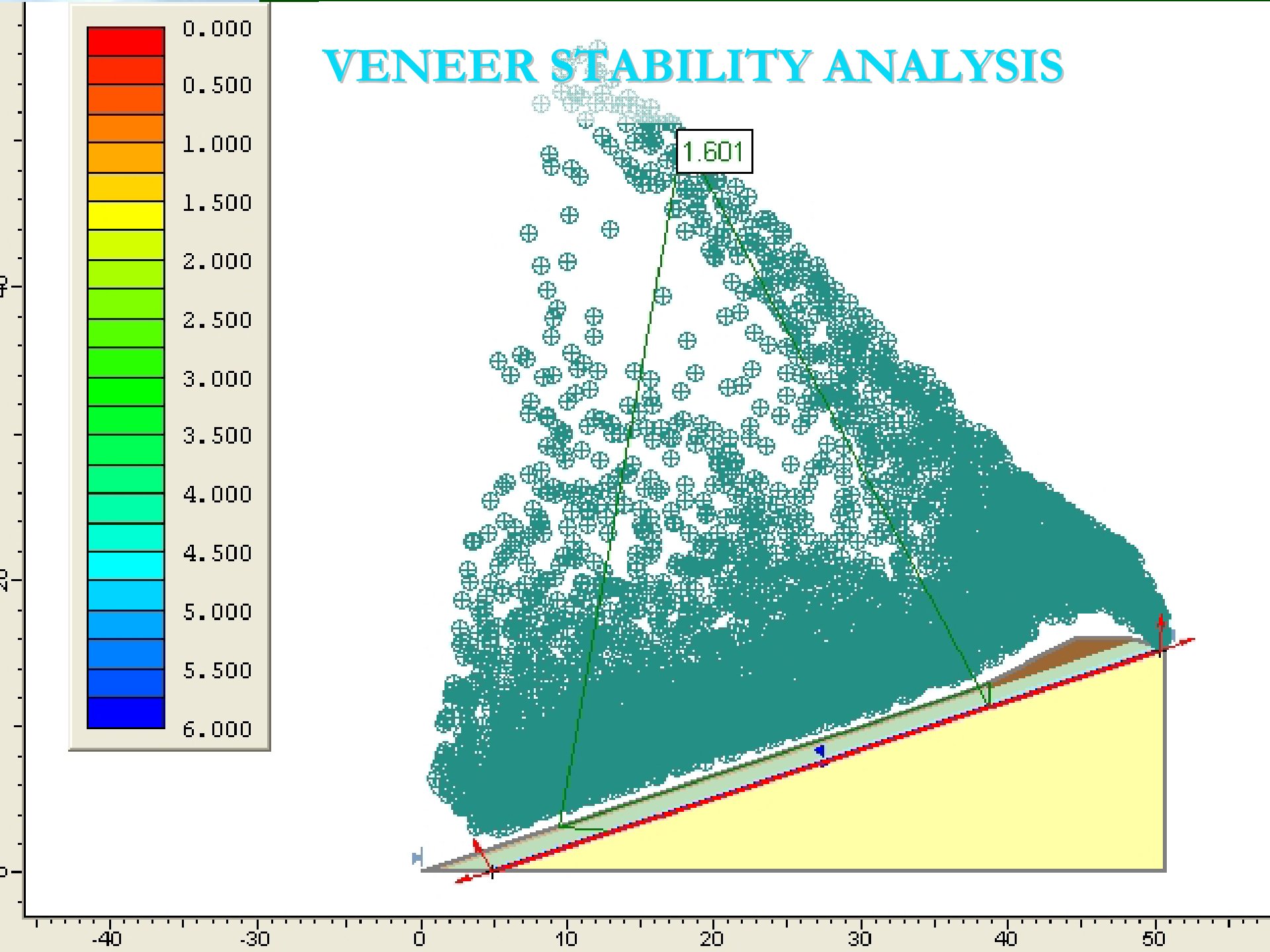
VENEER STABILITY ANALYSIS



Landfill Bottom Liner – Hope

Textured Liner on 2H:1V Slope - Chilliwack

Training for the 2010 Olympic Skeleton Team

GCL – Nu-drain interface resulted in failure

Nanaimo Geogrid Berm – Test Pad

Preparing Subgrade

- Base must be smooth and firm
- No sharp rocks or objects
- Stones finer than 25 mm
- Proof roll smooth with smooth drum roller
- Use cushion geotextile to protect liner unless soil cushion first class
  - Sand is great cushion
  - Clay is great cushion
- Deal with leachate breakouts before hand

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Gib East ARD Waste Dump

Deployment Methods

- ***State-of-art is evolving***
  - ***Excavator to spool liner out***
  - ***Quads or "buggies" pull liner***
  - ***Labour can pull liner out***
  - ***Velcro effect can be significant***
  - ***Slip sheet may be needed***
  - ***Skilled crew can install 5,000 m²/day***

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Spooling out geomembrane with spreader bar

Pulling sheet with Quad at Whistler

Crew pulling geotextile – note sandbags

Seaming Geomembrane

- *Double Wedge Welder is standard*
  - *Provides double seam*
  - *QA/QC easy with pressure test*
- *Extrusion Weld for patches, "T" junctions and boots*
  - *Test with vacuum box*

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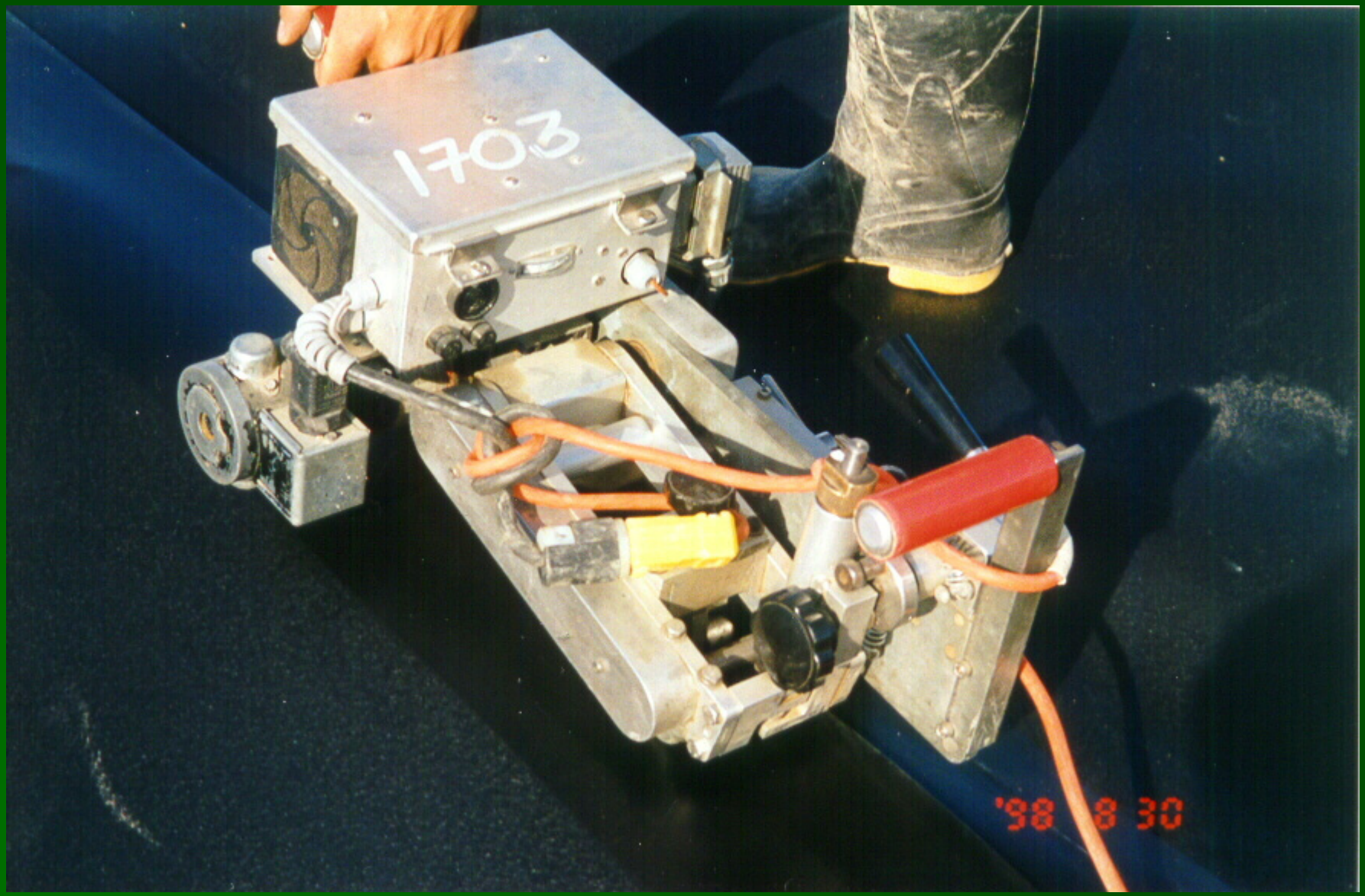
Welding Geomembrane

Wedge Welder melts fuses two sheets together



Extrusion welding custom boot at Knockholt

Vacuum Box testing extrusion weld

QA/QC at Gibraltar

Managing Penetrations

- *Penetrations need to occur for:*
  - *Landfill gas wells*
  - *LFG horizontals and headers*
  - *Leachate clean-outs*
- *Key issues are:*
  - *Differential settlement*
  - *Membrane displacement during construction*
  - *Pond liner freezing*

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Well head stressed from liner creep

Designing For Settlement

Covering Geomembrane

- *Covering liner is the most critical step and requires strict QA/QC*
- *Cushion geotextile improves liner survival*
- *Must avoid "pushing wave"*
- *Preferred approach is to push uphill (not always possible due to access)*
- *Must maintain minimum thickness (depends on equipment)*
- *Cones work best for layer thickness control*

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Minimum Cover Thickness to avoid damage

Minimum Lift Thickness	
Backfill Thickness	Placement Equipment
No Backfill	Foot Traffic or Quad ATV Only
150 mm or less	Hand Placement or Stone Slinger
200 – 300 mm	D3 –D4 LGP Cat
300 mm	Bobcat (Skid-Steer)
300 mm	D4 – D6 LGP Style Cat
600 mm	D7 – D9 Style Cat
900 mm	Loaded Scrapers, Motor Graders
900 – 1200 mm	Loaded Tandem Axle Trucks

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Articulated Rock Truck – More versatile, but requires double handling

Using small LGP dozer – avoid “wave”

Survivability Testing of Geomembrane

No Damage with 5 to 25 mm Crushed Gravel and Glass

Numerous Punctures with Coarse Concrete

Managing Air Intrusion

- *Air intrusion is a risk factor at landfills*
  - *Reduces methane concentration in LFG*
  - *Inhibits methanogenic bacteria*
  - *Increases risk of landfill fire*
- *Key design factors*
  - *Boots that can accommodate settlement*
  - *Air intrusion seals at edges of liner*
  - *Air intrusion seals on leachate lines*

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Landfill Gas Well at Hartland

Air Entry Seal on leachate outlet

Major Fire at Yellowknife Landfill

Providing Drainage

- *Sand Layers*
- *Gravel Layers*
- *Geonet*
- *Drain Tube*
- *Agru Liner*

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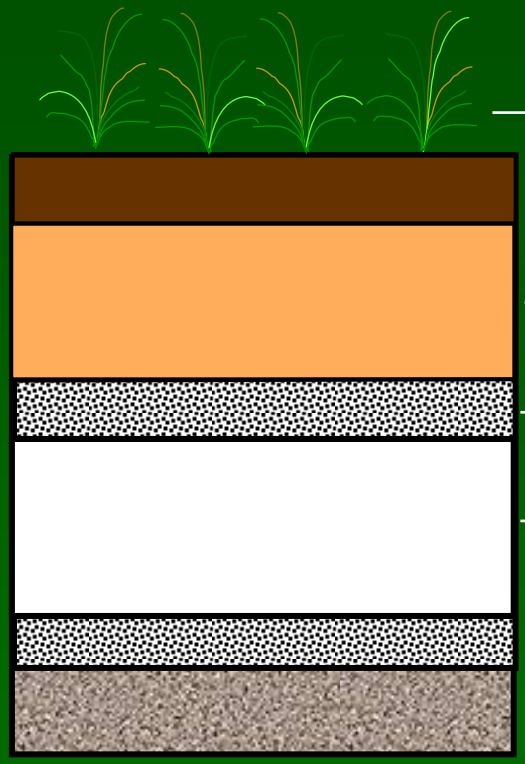
Leachate Collection System and Drainage Layer

Drainage Tube Replaces Gravel

FINAL COVER SYSTEM ELEMENTS CONCEPTUAL DESIGN



GENERIC FINAL COVER VENEER

- Healthy Vegetation
- Top Soil: ensures a healthy and sustainable vegetation
- Subsoil: provides a deep soil horizon for root establishment
- Drainage Layer: quickly conveys water passing through topsoil horizon
- Barrier Layer: prevents infiltration, reduces leachate production
- Leachate/ Gas Collection Layer: pathway for leachate-breakouts and gas
- Intermediate Cover: Existing

Capping Vancouver Landfill

Geomebranes in Final Closure

Costs

• Textured Membrane	$8 - $12/m²
• GCL	$10 – 12/m²
• Geotextile	$2 - $3.50/m²
• Closure System	$40 - $50/m²
• Liner / Leachate Collection	$40 - $60/m²

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THANK YOU FROM SHA

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