• Planning and permitting
• Design
• Operation
• Closure and Rehabilitation
• Aftercare
SUSTAINABLE WASTE MANAGEMENT STRATEGY

- Objectives:
  - Adopt good practice
  - Provide effective mitigation of GHG emissions
  - Seek Opportunities to reduce GHG emissions
  - Interrogate various management technologies
  - Ultimate improve economic, social, and environmental outcomes
Traditional Waste Systems

1. WASTE GENERATION
2. STORAGE
3. COLLECTION
   - TRANSFER/TRANSPORT
   - PROCESSING/RECOVERY
4. DISPOSAL
Advanced Practises

- EU Directive 2008/98/EC
- Waste > 5% Total Organic Carbon banned from landfill!
Waste disposal ~ 1 billion tons of CO₂ per annum
GLOBAL PERSPECTIVE ON WASTE MANAGEMENT

- Waste disposal ~ 1 billion tons of CO₂ per annum

- MSW ~ 4 billion tons/annum with following waste management solution:
  - 70% landfill
  - 20% recycled &
  - 10% incinerated

- 125 million tons of plastic produced per annum ~ 80% ends up in rivers!
So, WHY LANDFILL?

- ‘Disposal of waste on land’
- Oldest from of waste disposal
- *Other waste management options ultimately rely on landfill*
- Best Practicable Environmental Option (BPEO) for disposal of waste for the foreseeable future
NO MORE LANDFILLS...

STRIPPED DOWN, IT TAKES 40 TONS OF GARBAGE, ONE WAY.
HIGH LEVEL UNDERSTANDING - LANDFILL DEGRADATION PROCESSES

• All landfills undergo biological degradation
• Large proportion of landfill wastes contain degradable matter (putrescible), which undergo natural degradation
• Combination of physical, chemical and biological processes
• Produces liquid and gaseous emissions
• After a short period of time, waste body becomes anaerobic

• Anaerobic decomposition:
  
  - Organic Matter $\rightarrow$ CO$_2$ + CH$_4$ + new cells + energy + resistant organic matter + NH$_3$ + H$_2$S

• Anaerobic decomposition can be seen to proceed in 3 stages (Christensen and Kjeldsen, 1989)
Factors affecting rate of degradation

- Substrate
- Moisture
- Nutrients
- Temperature
- Toxins
- pH
• **Leachate**
  - “An aqueous solution with a high polluting potential, arising when water is permitted to percolate through decomposing waste. It contains the final and intermediate products of decomposition, various solutes and waste residues” (DWAF, 1998)

• **Landfill Gas**
  - Landfill gas is a product of decomposing waste and predominately consists of methane and carbon dioxide, together with many other trace components
Leachate

• Composition highly variable
  • Depends on a number of factors (e.g. moisture content, age of waste, waste composition etc.)

• Can be considerably stronger than sewage or industrial waste waters

• Has physical, chemical and biological characteristics
Wastes

Acetogenesis

High BOD compounds (fatty acids, simple organics etc)

Ammonia

Acetogenic leachate

Methanogenesis

Relatively stable organic compounds (e.g. humic acid)

Ammonia

Landfill gas

Methanogenic leachate
Landfill Gas

- Arises as the end product of waste degradation
- Consists primarily of methane and carbon dioxide, together with a number of trace components
- Changes in gas composition over time due to sequence of waste decomposition
Leachate

- Potential watercourse and groundwater pollution if released uncontrolled to the environment

- Typically consists of high levels of ammonia (toxic) and organic matter (creation of septic conditions)
PROBLEMS ASSOCIATED WITH LANDFILL EMISSIONS

The different scales of landfill gas effects (from Kjeldsen, 1996)
LANDFILL SITE SELECTION – KEY CONSIDERATIONS

ISN'T THIS CANYON BEAUTIFUL?

YESS!!

...OUR SEARCH FOR A LANDFILL IS OVER!
LANDFILL SITE SELECTION

- Process begins when it is determined that a landfill site is required to meet the long-term waste disposal needs of a community, town, city or region.

- Basic parameters need to be determined in the planning stage:
  - Size of site and desired lifespan
  - General location (in terms of haul distances, legal requirements etc.)

- Legislation in the form of the ‘Minimum Requirements for Waste Disposal by Landfill’ or similar guides the process.
The Minimum Requirements have various classes of landfill, with graded standards to ensure:

- Affordability
- Suitability to the circumstances
- Environmental protection

Classes are based on:

- Waste type (hazardous or general)
- Size of waste stream
- Potential for significant leachate generation
LANDFILL SITE SELECTION

• Waste type
  • General
  • Hazardous
    • 4 hazard ratings

• Size of waste stream
  • Based on current waste generation and projected growth rates
  • Communal, Small, Medium, Large

• Leachate generation potential
  • Sporadic (B−)
  • Significant (B+)
  • Climatic water balance
    • B = R − E
LANDFILL SITE SELECTION

- The class of landfill ultimately governs the type of lining system required

- Once these factors have been considered, various potential sites will be earmarked via desktop studies

- Gradually sites will be eliminated when fatal flaws are analysed (e.g. near an airport, sensitive ecological areas, high groundwater tables)

- Window areas of available land are then determined for potential sites, after which feasibility studies and site investigations are undertaken. *The more the better…*

- Once the most suitable site is found, a full EIA is undertaken prior to the start of construction (infrastructure, cell construction etc.) and issuing of a permit/license to operate
Phase 1: Identification & evaluation of window sites

- Phase 1a: Desktop to identify broad areas suitable for landfill
- Phase 1b: Field Verification of Suitability
- Phase 1c: Initial Screening & description of window areas
- Phase 1d: Evaluation of acceptable window with public engagement

Phase 2

- Identification & Evaluation of Candidate Landfill within acceptable window with public engagement

Phase 3

- Scoping/Feasibility of Candidate Sites

Phase 4

- Environmental Impact Assessments (EIA) for selected site/s with public scoping

Phase 5

- Planning Permissions and Licensing
## Factors for Identification & Evaluation

### Economic Criteria
- Transport Distance
- Size (Regional Potential)
- Site Access
- Cover Material
- Cost of Land Acquisition
- Socio Economic Factors

### Public Acceptance Criteria
- Proximity to Residential Areas
- Displacement of Residents
- Visibility
- Prevailing Wind Direction
- Bufferzone – Set Back Space
- Safety Risk – Health, Air Quality, Fire etc.

### Environmental Criteria
- Distance to Significant Water Bodies
- Importance of Ground & Surface Water
- Soil Permeability
- Availability of Suitable Cover Material
- Ecological Factors
- Climate
STAKEHOLDER ENGAGEMENT

- Make sure selection can be defendable if challenged
- Demonstrate due consideration to alternatives
- NIMBEY, NIMTO, NIMEO & BANANA
- Throughout specialist studies with sound results
- 80/20 Principle to mitigate delays with landfill development
- Objectivity needed – Multi-discipline professional team
SITE SELECTION & CONCEPTUAL DESIGN

- Potential for Maximizing **Airspace**
- Engineering Aspects with respect to local and potential Fatal Flaws
- Stability Checks
- Availability of Cover Material & Flood Levels
- Integration of Alternatives – waste management facility
- Feasibility Study considerations for detailed design
Detailed Investigation

- **Climatic Data Collection**
  - Evaporation/Rainfall
  - Temperature
  - Prevailing Wind Direction/s
- **Geology & Geotechnical**
  - Detailed Mapping of geological & structural environment
  - Hydrological assessment!
  - Surface Soil Conditions
- **Geotechnical**
  - Soil Testing – inform design and material balancing
  - Permeability: Min $1 \times 10^{-6}$ cm/s
- **Boreholes**
  - Geohydrological assessment
    - Typically Drilled for testing pressure & pumping
  - Geotechnical Profiling
    - Soil Profiling via Inspections Pits – Subsoil exposure using earthmoving equipment
    - Suitability of materials for construction use – cover material, liner (Clay) material, bedrock for drainage etc.
- **Seismic**
- **Dynamic Cone Penetration (DCP)** – Soil consistency & depth
- **Baseline Monitoring**
<table>
<thead>
<tr>
<th>Determined Characteristic</th>
<th>TP4</th>
<th>TP5</th>
<th>TP6</th>
<th>TP10</th>
<th>TP11</th>
<th>TP13</th>
<th>TP15</th>
<th>TP18</th>
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<td>Sample Depth</td>
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<td>Material Type</td>
<td>Colluvial Clay</td>
<td>Colluvial Clay</td>
<td>W5 Shale</td>
<td>Gravely Colluvial Clay</td>
<td>Colluvial Clay</td>
<td>W5 Shale</td>
<td>Colluvial Clay</td>
<td>Residual Clay</td>
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<td>M.I.T Size Classification</td>
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<td>Clay</td>
<td>Clay</td>
<td>Clay</td>
<td>Clay</td>
<td>Clay</td>
<td>Clay</td>
<td>Clay</td>
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<td>Liquid Limit</td>
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<td>49.00</td>
<td>43.00</td>
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<td>45.00</td>
<td>35.00</td>
<td>57.00</td>
<td>61.00</td>
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<td>Plasticity Index</td>
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<td>17.00</td>
<td>17.00</td>
<td>18.00</td>
<td>17.00</td>
<td>18.00</td>
<td>32.00</td>
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<td>Linear Shrinkage %</td>
<td>6.7</td>
<td>5.1</td>
<td>5.6</td>
<td>7.3</td>
<td>8.5</td>
<td>7.7</td>
<td>9.0</td>
<td>14.3</td>
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<td>Potential Expansiveness</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Unified Classification</td>
<td>CL</td>
<td>ML-OL</td>
<td>CL</td>
<td>CL</td>
<td>ML-OL</td>
<td>CL</td>
<td>OH-MH</td>
<td>CH</td>
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<td>Revised US Public Roads Clasification</td>
<td>A-6</td>
<td>A-7-6</td>
<td>A-7-6</td>
<td>A-7-6</td>
<td>A-7-6</td>
<td>A-6</td>
<td>A-7-5</td>
<td>A-7-6</td>
</tr>
<tr>
<td>Clay Content %</td>
<td>31.58</td>
<td>57.77</td>
<td>36.81</td>
<td>39.18</td>
<td>47.81</td>
<td>35.28</td>
<td>55.69</td>
<td>69.53</td>
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<td>D10 Size (mm)</td>
<td>0.0006</td>
<td>0.0003</td>
<td>0.0005</td>
<td>0.0005</td>
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<td>0.0006</td>
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<td>K Value-Hazen's Formula (cm/s)</td>
<td>$3.6 \times 10^{-7}$</td>
<td>$9 \times 10^{-7}$</td>
<td>$2.5 \times 10^{-7}$</td>
<td>$2.5 \times 10^{-7}$</td>
<td>$1.6 \times 10^{-7}$</td>
<td>$1.6 \times 10^{-7}$</td>
<td>$9 \times 10^{-7}$</td>
<td></td>
</tr>
</tbody>
</table>

**Borehole Geological and Construction Log**

- **CONSTRUCTION DETAILS**
  - 0-24m 216mm Rotary Percussion
  - 0-12m 177mm x 3mm Plain Steel Casing
  - 12-24m 177mm x 3mm Slotted Steel Casing

- **GEOLOGICAL LOG**
  - 0-4m: CLAY, Pale brown, soft and crumbly.
  - 4-7m: CLAY, Dark brown, stiff with W5 residual SHALE fragments.
  - 7-16m: SHALE (Pp), black in places brown, W3 medium rock.
  - 16-20m: SHALE (Pp), black to grey, W2, medium rock fractured.
  - 20-30m: SHALE, grey, W2, baked and fractured with calcite veins.
  - 30-70m: DOLERITE (d), light grey, W3, medium grained.
  - 70-80m: SHALE (Pp), dark grey to black, W1, medium hard rock.
  - 80-95m: DOLERITE (d), medium grey, W3, medium grained, medium to soft rock.
  - 95-100m: SHALE (Pp), grey to black, W1, medium hard rock, with occasional calcite veins.
Specialist Studies

- Noise
- Air Quality & Odour
- Traffic Impact Assessment
- Flora & Fauna
- Visual
- Heritage
- Technical
  - Containment and Lining
  - Stability
- Land Use Integration
LINER DESIGN ASPECTS

• Purpose of the liner is to provide a barrier & prevent leakage
• Materials that make good liners often have poor shear properties
LANDFILL LINER DESIGNS

General B+ Landfills

FIGURE A.8.1
G:S:B+ Landfills

G Layer

Waste body
150 mm Base preparation layer
In situ soil

FIGURE A.8.2
G:M:B+ Landfills

O Layer
B Layer
B Layer
G Layer

Waste body
150 mm Desiccation layer

300 mm Compacted clay liner (in 2 x 150 mm layers)

150 mm Base preparation layer
In situ soil

FIGURE A.8.3
G:L:B+ Landfills

O Layer
B Layer
B Layer
B Layer
G Layer

Waste body
150 mm Desiccation layer

450 mm Compacted clay liner (in 3 x 150 mm layers)

150 mm Base preparation layer
In situ soil

LANDFILL LINER DESIGNS

General B+ Landfills

FIGURE A.8.4
G:S:B+ Landfills

A Layer
B Layer
B Layer
G Layer

Waste body
150 mm Leachate collection layer

300 mm Compacted clay liner (in 2 x 150 mm layers)

150 mm Base preparation layer
In situ soil

FIGURE A.8.5
G:M:B+ and G:L:B+ Landfills

A Layer
B Layer
B Layer
C Layer
D Layer
B Layer
B Layer
G Layer

Waste body
150 mm Leachate collection layer

600 mm Compacted clay liner (in 4 x 150 mm layers)

Geotextile layer
150 mm Leakage detection and collection layer

150 mm Compacted clay liner

150 mm Base preparation layer
In situ soil
Ladder!
Liner Design Process

1. Preliminary Cell Design
2. Stability Analysis
3. Choosing a Liner
4. Shear Strength Testing
5. Additional Design Checks
# Liner Options

<table>
<thead>
<tr>
<th>Liner Option</th>
<th>Stability</th>
<th>Barrier Protection</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay Liner</td>
<td>Good</td>
<td>Medium</td>
<td>Low - if clay is from site</td>
</tr>
<tr>
<td>Clay from site or imported</td>
<td></td>
<td></td>
<td>High - if clay is imported</td>
</tr>
<tr>
<td><strong>Geosynthetic Clay Liners (GCL’s)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCL’s with soil protection layers</td>
<td>Generally Good</td>
<td>Medium to poor if protection soil is sandy</td>
<td>Medium if protection soil from site</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good if protection soil is clayey</td>
<td>High if protection soil imported</td>
</tr>
<tr>
<td>GCL’s with geofabric protection</td>
<td>Generally Poor</td>
<td>Poor</td>
<td>Medium</td>
</tr>
<tr>
<td>layers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Geomembrane Liners (GM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM with soil protection</td>
<td>Medium (if protection soil is sandy, Poor (if protection soil is clayey)</td>
<td>Medium to poor if protection soil is sandy Good if protection soil is clayey</td>
<td>Low if protection soil from site Medium if protection soil imported</td>
</tr>
<tr>
<td>GM with geofabric protection</td>
<td>Poor</td>
<td>Poor</td>
<td>Medium</td>
</tr>
<tr>
<td>protection</td>
<td>Medium if GM is textured</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Composite Liners, i.e.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay and GCL or GCL and Geomembrane</td>
<td>Variable depending on type</td>
<td>Good</td>
<td>High</td>
</tr>
<tr>
<td>or Clay and Geomembrane</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Stability Aspects

- Site Selection determines the extent of stability analysis
- Design parameters obtained from the site testing of soils
- Simple sliding wedge type analysis used
- Evaluate need for veneer reinforcement – geogrids
(a) Failure of leachate collection system

(b) Failure of final cover system

(c) Soil slope, toe, or base failures

(d) Foundation failure through subsoil, liner and waste

(e) Failure within waste mass

(f) Translational failure along liner system at base and up through waste or liner
Cover Soil Stability Analysis - Stabilised Protection Layer

Cover Soil - 125mm stabilised sand

Calculation of FS

Active Wedge:
- \( W_a = 111.8 \text{ kN} \)
- \( N_a = 100.5 \text{ kN} \)

Passive Wedge:
- \( W_p = 0.4 \text{ kN} \)

\[
FS = -b + \frac{1}{2a} \left( \frac{c}{2a} \right)^2 - 4ac
\]

- \( a = 19.3 \)
- \( b = -27 \)
- \( c = 1.6 \)

\[
FS = 1.32
\]

- thickness of cover soil = \( h = 0.13 \text{ m} \)
- soil slope angle beneath the geomembrane = \( \beta = 26.0^\circ \) = 0.45 (rad.)
- length of slope measured along the geomembrane = \( L = 500 \text{ m} \)
- unit weight of the cover soil = \( \gamma = 18.0 \text{ kN/m}^3 \)
- friction angle of the cover soil = \( \phi = 30.0^\circ \) = 0.52 (rad.)
- cohesion of the cover soil (avg of 1MPa over 125mm thickness) = \( c = 125.0 \text{ kN/m}^2 \)
  \[ C = 35.64 \text{ kN} \]
- interface friction angle between cover soil and geomembrane = \( \delta = 8.0^\circ \) = 0.14 (rad.)
- adhesion between cover soil and geomembrane = \( c_a = 0.0 \text{ kN/m}^2 \)
  \[ C_a = 0 \text{ kN} \]

Note: numbers in boxes are input values

numbers in Italic are calculated values

based on spreadsheets set up by Naue Fasertechnik
Stability Aspects

- Liquid / leachate build up – saturation & loss of shear strengths
- Leachate head on liner (300 mm – 1000 mm)
- Groundwater on liner – hydraulic pressure effects and or saturation
- Liner protection
- CQA
### Table: Residual Shear Strengths of Weakest Liner Layer

<table>
<thead>
<tr>
<th>Cell No.</th>
<th>Liner Composition</th>
<th>Weakest Layer in Liner</th>
<th>Representative Residual Shear Strengths of 'Weakest Layer'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell 1A / 1B VSL</td>
<td>Stone Drainage BIDM A4 Clay</td>
<td>Clay</td>
<td>$\phi = 17^\circ$  $C_u = 10$ kPa</td>
</tr>
<tr>
<td>Cell 2A / 2B VSL</td>
<td>Stone Drainage BIDM A4 Silty Sand GCL x 2000</td>
<td>Silty Sand GCL x 2000</td>
<td>$\phi = 17.7^\circ$  $C_u = 12$ kPa ($&lt;30$ kPa)</td>
</tr>
<tr>
<td></td>
<td>HOPE (Double Textured / CO-EXTRUDED - EL) G6 + 20mm Plaster Sand</td>
<td></td>
<td>$\phi = 19^\circ$  $C_u = 13$ kPa ($&lt;30$ kPa)</td>
</tr>
<tr>
<td>Cell 2C VSL</td>
<td>HOPE (Double Textured / CO-EXTRUDED - SRL) GCL x 2000</td>
<td>HOPE vs GCL x 2000</td>
<td>$\phi = 12.7^\circ$  $C_u = 6$ kPa ($&lt;200$ kPa)</td>
</tr>
<tr>
<td>Cell 2D VSL</td>
<td>Stone Drainage BIDM A10 HOPE (Double Textured / CO-EXTRUDED - SRL) G6 + 20mm Plaster Sand</td>
<td></td>
<td>$\phi = 8.0^\circ$  $C_u = 10.3$ kPa ($&lt;200$ kPa)</td>
</tr>
</tbody>
</table>

**Key:**
- **CSL:** Cross Section Lines
- **ALC:** Analyzed Landfill Confinement
Design Requirements

- Liner Design based on Minimum Requirements or Equivalent
- Minimum Standard adopted due to Geology and Waste Type.

Proposed Containment Barriers as at 15 June 2010 for the Revised Waste Classification System

Classification “C”

- Waste body
- Geotextile
- 150 mm Stone leachate collection system
- 100 mm Protection layer of silty sand or a Geotextile of equivalent performance
- 1.5 mm HDPE geomembrane
- 600 mm Compacted clay liner (6 x 100 mm layers)
- Under drainage and monitoring system and 150 mm Base preparation layer
- In situ soil

150 mm LEACHATE COLLECTION LAYER

600mm COMPACTED CLAY

GEOTEXTILE

150mm LEACHATE DETECTION / COLLECTION LAYER

150mm COMPACTED CLAY

150mm BASE PREPARATION LAYER
Actual Design

- Allow for GCL on side slopes.
- Stability Analysis based on peak and residual shear strength.
- Factor of Safety 1.3. BUT RISK OF FAILURE
- Both Ring and Shear Box Tests to identify weakest interface
Double Liner

- Use Finite Element and Stability Analysis Software to predict strain and stresses.

- Best Practice
  - Minimum movement by having side slopes <1 in 3.
  - Design liner layers as ‘strong’ as possible.
  - Ensure ‘weakest’ plane is above the geomembrane.
Key Design Considerations

• Key aspects of Landfill Design are stability and integrity.
• Three Design Options:
  • Where slopes exceed 1 in 4 use residual shear strength parameters and pack shear in basal area. Design F.O.S. >1.5. Side slope residual is based on the weakest pack.
  • Use residual strength everywhere. Design F.O.S. >1.3 without seismic and 1.1 with seismic. Analysis is done using the lower range of combined residual shear strength.
  • Conservative approach is to force the slip plane above the geomembrane by using aggressive texturing to achieve high interface strength below the geomembrane, and that residual shear strengths be used everywhere the slip plane occurs in the liner system.
GOOD WORK, BUT I THINK WE MIGHT NEED JUST A LITTLE MORE DETAIL RIGHT HERE
Landfill Gas

- There are a number of models available for the prediction of landfill gas yields

- Typically based on first order kinetic equations

- Involves the determination of the ‘gas producing’ fractions of the waste body.

- Usually 3 fractions considered:
  - Readily biodegradable (e.g. Food wastes)
  - Biodegradable (e.g. Garden refuse)
  - Slowly biodegradable (e.g. paper)
MANAGEMENT OF LANDFILL EMISSIONS

- Leachate prevented from entering the natural environment by construction of lined landfill

- Lining systems vary in design - dependent on site specific conditions

- Typically consist of an impervious barrier which may be natural (clay) or synthetic (HDPE, geosynthetics) and a drainage system
Typical Landfill Lining
OUTSIDE KZN

Typical KZN Lining
300mm thick stone drainage layer required for unit hydraulic gradient. Drainage performance affected by ingress of fines and precipitate.

Acknowledgment: J Shamrock
Desiccation
Cracking
A Major Problem With Compacted Clay Liners . . .

Picture: Peter Davies
“Intimate Contact” Is Not Easy To Achieve With HDPE!

Picture: Peter Davies
Leachate Philosophies

- Dilute and Disperse
- Contain and Concentrate

Attenuation

Containment

Both of Them
Total Water on Earth

Largest Sphere - Total
Diameter ≈ 1 380 km
Volume ≈ 1,39 billion km³

Smaller Sphere - Fresh
Diameter ≈ 273 km
Volume ≈ 10,6 million km³

Tiny Sphere – Lakes & Rivers
Diameter ≈ 56 km
Volume ≈ 93 000 km³

(USGS, 2016)
How do you handle your toxic waste?
I pour it down the drain.
ISN'T THAT DANGEROUS?
NO...
I WEAR RUBBER GLOVES
LEACHATE TREATMENT

Low cost, robust biological treatment system
Removes COD (organics) and ammonia from the leachate
Effluent is used for dust suppression and irrigation to conservancy areas
Treated Leachate

- Raw Leachate
- Treated Leachate (Post SBR)
- Treated Leachate (Post Reedbed)
KEY DESIGN CONSIDERATIONS

• Leachate Quality & Quantity Prediction
• Treated Leachate Compliance with Discharge Standards
• Synergy with Landfill Design & LTP
• Flexibility in the Design
  • Factor in Local Experiences
LEACHATE VOLUMES & PLANT SIZING

• Leachate $f(\text{rainfall, waste organic content})$

• Best Practices – to minimise leachate
  • Storm Water Diversion Outside Lined Footprint
  • Limit Exposed Waste Areas
  • Storm Water Diversion within Lined Footprint
Cell area ±20,000 m²

Typical Landfill Cell PLAN

Cell Sub-division to limit leachate area
Limit exposed working area ~ 10 000m²
Leachate Management Plan
LANDFILL GAS - LFG

Wastes
  ↓
Acetogenesis
  ↓
High BOD compounds
  ↓
Acetogenic leachate
  ↓
Relatively stable organic compounds
  ↓
Landfill Gas
  ↓
Methanogenic leachate

Ammonia
  ↓

Ammonia
  ↓

Methanogenesis
  ↓

- Fatty acids
- Simple organics
- Humic acid
Methane (CH₄) is a significant contributor to global warming. Its Global Warming Potential (GWP) is estimated to be between 21 and 25 times that of CO₂.
The operation of a landfill site can be compared to a large earthworks operation.

Waste is placed and compacted typically using purpose built landfill compactors and dozers:
- To prevent moisture ingress (increase run-off) and minimise leachate generation.
- To maximise airspace and improve stability.

Landfill equipment will typically include water tankers for dust suppression and road making equipment for upkeep of internal road networks.
LANDFILL SITE OPERATION

- Cover material (sand) is placed on the waste at the end of each day
  - Minimises odour
  - Wind scattered litter
  - Improve aesthetics
  - Prevents the occurrence of flies

- The working area of the landfill is termed the ‘working face’, which moves daily as landfill operations proceed in a landfill cell. It is usually kept as small as possible
Back to Basics – Maximise Compaction

• Thick layers only compact the surface
  – Subsequent passes only compact the surface
  – Waste below the surface compacts slightly but remains spongy

• Thin layers, blend, bind, shred, compact uniformly
  – Subsequent passes keep binding together
Landfilling Systems Best Practice

• Dozer Spread / Pushes & Compactor **only** blades uneven areas!
• Dozer must lead to spread into layers & allows for “pre – compaction”
• Tandem Systems Operation – “Husband & Wife” …push & compact
  \( f(\text{density}, \text{Maint}, \text{Fuel}, \text{Cycle times}, \text{compliance}) \)
• Improvement - increased compacted density i.e sweat existing airspace

![Graph showing layer thickness](image)
Perhaps it's time to turn to Pedigree light dog food.
ENVIRONMENTAL ASSET CONCEPTS

See the Value
The shift from the dump to sanitary landfill demands the involvement of engineers.
Transformation Focus Areas

- Compact, Compact & Re-Compact
- Shape, grade and Re-Shape
- Cover the site – “Dress to Impress”
- Separate Clean and Dirty Water
- Leachate containment
- Deep “Cut-Off” trench along for leachate out
- Develop a progressive improvement master plan
- Adopt a phased capping plan
- Rehabilitate & Restore Natural Habitat
- Landfill Gas Options – Flare?
- Odour Improvements
- If it looks good, smells good – then it must be good!
- Consider wet weather handling – onsite transfer station
- Access and Traffic circulation
Capping needs to achieve requirements separates the waste body from the atmospheric environment.

1. protecting and isolating the waste from the long term effects of wind and surface water erosion, burrowing animals, etc.

2. limit and control the quantities of precipitation that enter the waste.

3. allow water to leave the landfill by evapotranspiration

4. vent landfill gas in a safe manner.

5. allow for a suitable end use for the landfill.
Proposals for the capping detail were made 2002 and discussed with DWAF in Durban.

The basis of the proposals: at least 600mm of clay and/or silt soils from excavations in the floodplains of the Umgeni River was placed on the covered Municipal Solid Waste.

The drainage / gas venting layer was excluded as active landfill gas extraction was planned, and is being undertaken, to reduce odour emissions.

The capping of some 9ha (90 000m²) was undertaken based on this.

The capped areas were to establish a buffer on the south western edge of the site as agreed with DWAF and it now provides a staging area for the eThekwini Municipal Parks Department. The way forward for this area is needed.

Also guidance for the capping of the balance of the site for closure is sought.
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td>separates the waste body from the atmospheric environment.</td>
<td>soil and vegetation cover is well established and has achieved this</td>
</tr>
<tr>
<td>protecting and isolating the waste from the long term effects of wind and surface water erosion, burrowing animals, etc.</td>
<td>the waste is isolated from wind and water erosion by 600mm of soil.</td>
</tr>
<tr>
<td>limit and control the quantities of precipitation that enter the waste.</td>
<td>the capping is well compacted and relatively impermeable (to be checked).</td>
</tr>
<tr>
<td>allow water to leave the landfill by evapotranspiration</td>
<td>the capping sustains good vegetation and is not totally impermeable. This will allow evapotranspiration.</td>
</tr>
<tr>
<td>vent landfill gas in a safe manner.</td>
<td>there is active gas extraction on the site and 4 000Nm³/h is being flared or used to generate electricity.</td>
</tr>
<tr>
<td>allow for a suitable end use for the landfill.</td>
<td>the “capped” area to have synergy with end use plans. Green open space? Or AWT?</td>
</tr>
</tbody>
</table>
### From the "Minimum Requirements"

<table>
<thead>
<tr>
<th>Key</th>
<th>Thickness</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200</td>
<td>Topsoil</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>Compacted clay soil 0,5m/y allowable leakage.</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>Geofabric filter layer Foundation &amp; gas drainage layer 26-50mm stone.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shaped &amp; compacted waste.</td>
</tr>
</tbody>
</table>

### Proposed Capping System Alternatives

<table>
<thead>
<tr>
<th>Key</th>
<th>Thickness</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150</td>
<td>Topsoil with compost etc</td>
</tr>
<tr>
<td></td>
<td>450 MIN</td>
<td>Compacted clay/silt soil 0,5m/y allowable leakage.</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>Leachate interception drains – as needed</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>Topsoil with compost etc</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>Compacted soil with max. particle size of 20mm.</td>
</tr>
<tr>
<td></td>
<td>GCL</td>
<td>Cover soil to waste.</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>Leachate interception drains – as needed</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>Compacted MSW.</td>
</tr>
</tbody>
</table>
Competitive Practices

• GIGSA Newsletter 1999
• Treasury Regulations
• Competitions Act on alignment

“When assessing the affected files, it is important that you ensure that the alternative proposed by the applicant will achieve the objective of water resource protection or performs equally to the barrier system prescribed by the related regulations.” – 29/06/2016
Service Life Considerations

- Hydraulic head
- Heat
- Dissipation
- Desiccation
- Diffusion
Affordability?

- Barrier Performance is a function of drainage and liners
  - MR1998 CCL seepage variability $\approx 1000x$
  - CCL retention $<<$ Composite GM + CCL up to $1,000,000x$
  - Composite GM + CCL $<<$ Composite GM + GCL
    $\approx 200 - 300x$

- Financial
  - Class B $\approx$ GMb+
  - Cost of water supply augmentation and purification, community health and similar.

- Global Impact from actions now
Thank you C40, CCAC for the opportunity

Thanks for your Attention
HAPPY TO ENGAGE FURTHER....

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Cleansing & Solid Waste Unit – DSW
Kwa-Zulu Natal – Durban
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THANK YOU – ANY QUESTIONS?

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