GUIDELINES FOR THE CLOSURE OF LEGACY WASTE SITES

The Local Government Association of the Northern Territory acknowledges the work of

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LGANT Guidelines for the Closure of Legacy Waste Sites 2016
EXECUTIVE SUMMARY

When a solid waste disposal facility, commonly called a “dump” or a “landfill”, reaches the end of its capacity to accept any more garbage, or is scheduled for closure, care must be taken to ensure that it is properly closed so that its environmental impact is minimised. This also applies to individual burial areas within facilities, commonly known as “cells” or “Pits”.

Proper closure of a facility or cell will help ensure that the area can be revegetated, that leachate is minimised, and that the buried garbage does not pose a physical hazard to people or animals that may use the site in the future.

The main objective of this handbook is to provide guidelines for the closure and remediation of Legacy Waste Facilities by:

- defining Legacy waste facilities
- identifying key stakeholders
- identifying regulatory and statutory requirements
- explaining key stages in the remediation process

A “legacy waste facility” for the purpose of these guidelines is defined as:

- landfill sites at capacity
- landfill sites scheduled for closure
- legacy illegal dump sites
- legacy hazardous waste sites

At the time of closure a record of site specific information such as the site history (physical environment & operational environment) and remediation and closure plans need to be documented, retained and archived by the landfill manager.

These plans are made to reduce social and environmental impacts and to meet or exceed requirements set out in applicable law, regulations and standards.

Site closure can be expensive and unless council has established budgets for remediation works, careful planning will be required to apply for funding or grants to implement the closure plan.

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The Guidelines for the Closure of Legacy Waste Sites

Introduction

These guidelines have been made possible through funding from the NTEPA. The Local Government Association NT would like to acknowledge the assistance of the ‘Central Australian Waste Management Working Group’ and the ‘Big River Waste Management Working Group’ in putting the guidelines together.

The ‘Guidelines for the Closure of Legacy Waste Sites’ (GCLWS) or (Guidelines) needs to be read and applied in conjunction with the “Big Rivers / Central Australian Landfill Operational Guidelines”. The GCLWS is specifically aimed at

- operational landfills
- identification and data of legacy landfills
- remediation and closure and of legacy waste sites.

At the time of writing Licensing for Landfills servicing communities of less than 1000 people was not required. Licensing may be introduced for community landfills servicing less than 1000 people and will be subject to NT EPA regulations and relevant Territory planning approvals.

When a solid waste disposal facility, commonly called a “dump” or a “landfill”, reaches the end of its capacity to accept any more garbage or is scheduled for closure, care must be taken to ensure that it is properly closed so that its environmental impact is minimised. This also applies to individual burial areas within facilities, commonly known as “cells” or “Pits”.

Proper closure of a facility or cell will help ensure that; the area can be successfully revegetated, buried garbage does not pose a physical, chemical or biological hazard to people or animals that use the site in the future and risk of damage to the surrounding environment are minimized.

Once a landfill is at the end of life stage, it should be closed by constructing a final cover, or cap, which is the component to minimising:

- Infiltration of rainfall to control the volume of leachate produced, thus minimising groundwater impacts
- The potential for waste to come in contact with humans and other environmental receptors
- Vermin access and impact
- Discharge of Landfill Gas and fire/explosion potential
- Odours
- Erosion, while providing a surface to sustain landscaping and improving visual aesthetics

At the time of closure a summary should be prepared of the operational history of the site including; maps, GPS coordinates, any corrective actions that have been carried out, the location of any bores, water sources and monitoring points and documentation of all remediation activities including the final cap details. Copies of these records should be retained and archived by the manager of the landfill. Such records provide a means of
meeting the reporting requirements of licences or other regulatory and statutory obligations. It also helps to ensure that buildings and structures are not constructed, or the area utilised by the community if it is not appropriate to do so.

1. **Rehabilitation Legacy Waste Facility Definition & Source**

A “Legacy Waste Facility” for the purpose of these guidelines is defined as:
- Landfill site at capacity
- Landfill site scheduled for closure
- Legacy dump sites
- Legacy hazardous waste in old landfill pits

2. **Guideline Objectives**

The main objective of this handbook is to identify the volume of waste at legacy landfill sites in remote communities in the Northern Territory and provide guidelines for the closure and remediation of these sites by:
- Identifying key stakeholders
- Complying with Regulatory & Statutory Requirements
- Recording the sites History
- Planning for site remediation
- Establish budgets for the remediation
- Implementing the closure plan
- Post closure maintenance
- Identification and audit of legacy waste sites

3. **Key stakeholders**

When planning any closure or rehabilitation works at a legacy site it is important to first identify and involve potential key stakeholders. This ensures that all interested parties have been given the opportunity to have an input prior to the commencement of the closure process.

Landfill operators in the Northern Territory are currently controlled or influenced by the following stakeholders:
- Land owners
- Landfill managers
  - Regional Council
  - Municipalities
  - Homelands Association and Resource Centres
- Local authorities
  - Land Councils
- NT EPA
- LGANT
- Department of Lands, Planning and the Environment.
- Department of Health

4. **Legislation and Standards**

Legislation and Standards Landfill design, operation and closure in Northern Territory are currently controlled or influenced by the following key statutory and planning documents, including:
  - Waste Management and Pollution Control Act 2007
  - Waste Management and Pollution Control (Administration) Regulations 2004
  - Water Act 2004

Department of Planning (www.dlp.nt.gov.au/)
  - Land use Planning

Department of Health (www.health.nt.gov.au/environmental health/)
  - Northern Territory Public and Environmental Health Act
  - Northern Territory Public and Environmental Health Regulations

Department of local Government, Housing and Community Services (www.dlgh.nt.gov.au)
  - Local Government Act 2007

NT WorkSafe (www.worksafe.nt.gov.au)
  - Work Health and Safety (National Uniform Legislation) Act
  - Work Health and Safety (National uniform Legislation) Regulations

Local Government Association (www.lgant.asn.au)
  - LGANT “Waste Management Guidelines for Small Communities in the Northern Territory, Working Towards Best Practice 2009”
  - Landfill Operational Guidelines – Central Australia / Big Rivers

NT EPA (www.ntepa.nt.gov.au/)
  - The EPA Waste Management Policy (Site, Design and Management of Landfills) December 2004 (the Waste Management Policy)
  - NT EPA “Asbestos Disposal in the Northern Territory
  - The NT EPA “Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites, In the Northern Territory” January 2013

Note: The landfill site may also fall under additional regulations imposed as part of an Environmental Protection Licence by the NT EPA

5. Site history

At the time of closure a summary should be prepared of the history of the site, including maps, GPS coordinates, site layout, site conditions, any corrective actions that have been carried out and the location of any bores or water sources. Such records provide a means to ensure that the appropriate plans are made for the proper closure of a facility or cell, so the area can be revegetated, leachate is minimised, and the buried garbage does not pose a physical hazard to people or animals that may use the site in the future. The physical and operational actors Which NEED to be considered are summarised is below.
Example; Yuendumu legacy waste facility

Site Physical Environment
- Development Approval
- Location and Site Layout
- Site Conditions
  - Landform
  - Storm water
  - Rainfall
  - Surface Hydrology
  - Water Supply
  - Dust & Noise
  - Odours
  - Soil Type & Geology
  - Regional Groundwater Map
  - Ground Water Hydrology

Site Operating Environment
- Site Overview
- Landfill Pits/Cells
- Nature of Operation & Capacity

The above information can be found in the site’s Environmental Management Plan (EMP). If an EMP has not been developed, or the information above is not within the plan, provide as much detail in the summary as can be obtained. This may include desktop research and collecting ground truth data.

6. Planning for site remediation

All information relating to the site, including community area plans, will need to be gathered in order for Rehabilitation and Closure Plans to be developed to achieve a remediated state. Future land use will be a key factor in determining the extent of remediation to occur.
I. Waste Audits

Site remediation must start with the removal of waste not contained within the pit or cell. The volume and characteristics of the waste will need to be recorded and equipment, including plant and operators, organised for its removal or burial.

Note: Using undersized plant to clean the site will damage the equipment, make the job harder and cost the Council time and money.

Note: The removal or disposal of Listed Wastes such as asbestos, chemicals and Ewaste requires NT EPA and Worksafe approvals.

II. Waste Identification

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<th>Metals</th>
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III. Future land use planning

Properly restored landfill sites can be used to the benefit of communities. Future land use may include open space which can be used for sports and recreational purposes. Structures cannot be built on closed landfills until complete stabilisation takes place, which may take several decades. Potential problems include on-going settlement and the possible generation of landfill gas. It is therefore important to ensure that the use of such sites is restricted to activities which are not adversely affected by these hazards.

When a landfill’s life is over, the land’s life goes on. And when there’s a plan in place for the landfill site’s next use, the landfill operator is usually at the centre of the sometimes-complicated effort to prepare the location for that purpose.

One of the most important points for future development is to not wait until the end to decide. The earlier the end use is identified the greater number of steps can be taken during the landfills life to achieve this outcome.

For example, it’s easier to shape the landfill into the form needed as it is being built.

Examples of afterlife use include:

- Open space
- Sport fields
- Park land
- Other public amenity appropriate for the land use
- Transfer station
- Solar farm
- Storage for recyclables
- Community enterprises (plant breeding, men’s / ladies shed, recycling centre, animal breeding, community business/service, tourism, etc.)

Hazards such as asbestos contamination would result in the area being unfit for reuse. In the case of contamination the site should be fenced with signage erected and closed to the community. If there is uncertainty about the presence of old buried asbestos the area should be considered as contaminated and treated as such.
IV. Rehabilitation Plan

A Rehabilitation Plan is normally compiled at the time of planning and construction of a landfill site. This is to reduce social and environmental impacts associated with poor landfill management and to meet or exceed requirements set out in applicable law, regulations and standards.

Objectives of the rehabilitation plan include:

- Providing long-term protection of human health and the environment
- Minimising the generation and uncontrolled emissions of leachate and landfill gas, which may have adverse impacts on human health and the environment
- Promoting responsible land management and ensuring that the rehabilitation and closure plan are compatible with an appropriate post-closure use of the site.

Required outcomes:

- Progressive rehabilitation of the landfill.
- Strive for the highest value after-use of the site in operation and rehabilitation considerations.
- Design and operate the landfill to accommodate the desired after-use.
- Develop the rehabilitation plan in consultation with the local community and regulatory authorities.
- Regularly review the rehabilitation plan to ensure that changed circumstances are reflected in the plan.
- Consider the impacts of settlement on any potential after-use of the landfill.
- Design the cap gradient to be between five and 20 percent.
- Where a geomembrane is to be used in the cap, consider manufacturers’ recommendations during design and installation.
- Vegetate cap or take other measure to minimise erosion as soon as possible.
- Where trees or small shrubs are to be planted on the site, incorporate a greater thickness of soil in the cap to prevent the roots from penetrating the cap.

V. Closure Plan

The objective of the closure plan is to leave the landfill area in a condition that minimizes adverse impacts on the social and natural environment and with a legacy that makes a positive contribution to sustainable development.

The suggested headings for inclusion in a Closure Plan, under which varying levels of information may be provided, are as follows:

- Brief history
  - Site location (maps & GIS coordinates)
  - Site ownership and occupiers details
  - Locations of waste deposition
  - Depth and volume of waste disposal
  - Procedure for disposal
  - Type of waste disposal
  - Operational timeframe
  - Method of construction (e.g. cells, engineering)

- Site information summary:
  - Local geology
  - Depth to groundwater
  - Quality of groundwater
- Local landscape
- Surface waters and channels
- Surrounding land-use including sensitive receptors

- Site condition / general service

Exposed waste - the site may need to be shaped to cover exposed waste on site, or as necessary, site clean-up may be required to remove residual exposed waste and litter to a suitable disposal facility.

- Post-closure use

The proposed post-closure use of the site must be outlined in the closure plan.

The closure design will need to support the end use for the site. For example, council should consider whether the site will be revegetated and left as open land or used as waste transfer station.

Management of site hazards for ongoing use must also be considered including site access, security, fencing, WHS, signage, fire, amenity, vermin and ongoing monitoring and maintenance.

- Final Shape (landform)

The final landfill shape must be compatible with the surrounding landscape and land uses including post closure use of the facility.

Surface profile work may need to be done to ensure there is a final surface contour, stormwater shedding and runoff and erosion controls/detention ponds/swales to direct stormwater away from waste disposal areas. Usually final slopes are no greater than one metre vertical to three horizontal metres or around 30% to avoid serious erosion issues.

- Hazard and loss of service

The closure plan must consider hazards and service issues. The plan must identify hazards and include measures to manage these risks (e.g. asbestos contamination, requiring no reuse of site, fencing, signage etc.).

- Capping system

The landfill must be covered by a capping system that provides a long-term separation layer between the waste and the final surface protects human health and the environment and is compatible with the intended post-closure use.

Presence and nature of any cover already existing (type, thickness, method of placement and vegetation) should be assessed. A separation layer between the waste and the final surface is needed.

- Stormwater and erosion control

Stormwater management strategies must consider the following:

  - Management of surface water on site and control and monitoring of off-site stormwater discharge
  - Erosion and sediment control along drainage lines, disturbed areas and soil stockpiles. This includes stormwater flow control, vegetation use, installation of detention ponds, minimal land disturbance and other temporary and permanent erosion protection measures.

- Landfill gas management

The closure plan must consider management of landfill gas.
Older and smaller sites with low landfill gas generation potential, but some risk of emission, may consider whether methane oxidation layers can be incorporated into the capping system for management of residual landfill gas. A gas distribution layer such as gravel, separated with a geotextile filter from overlying capping soil and compost that supports microbes in order to oxidise methane into carbon dioxide could be considered. It is recommended that licensees utilise the expertise of an experienced consultant in this area.

- Leachate management
  The closure and capping design must include measures to limit the generation of leachate. Consideration should be given to the need of collection and storage systems such as sediment ponds

Small landfill sites will simply need to shape the waste disposal areas and apply a cover of soil and vegetation to minimise the potential for leachate generation by shedding water away from waste disposal areas.

- Termination of waste disposal
  The plan must consider measures to provide sufficient notice to users of the site that the landfill will be closing and will no longer accept waste. Measures will also be required to prevent post-closure waste disposal or illegal dumping.

- Measures for post-closure management
  Post-closure management must be addressed in a closure plan to ensure waste disposed at the site does not pose an unacceptable risk to the public or environment.

Post closure monitoring in some form is required to monitor the integrity of the cap, revegetation, stormwater, groundwater and the presence of landfill gas. The timeframe and regularity of monitoring at the site will depend on the specific risks of the site.

Importantly, the proposed closure design needs to align with any proposed post-closure use.

The extent of information that each site may need to address will vary depending on the level of risk posed and current state of closure achieved at the site. This may extend from a site conducting a general desk top assessment of data at hand including groundwater depth, waste types and extent of land filled and current landform.

Small sites may only require some additional cover material, contouring and revegetation work to shed water away from waste disposal areas and control stormwater runoff and erosion. Other sites may require more extensive investigation including some additional field investigation to understand risk better and may require an engineered capping system to be applied.

Importantly, the proposed closure design needs to align with any proposed future uses for the site and as such the closure procedure, landform and materials used need to ensure this will be supported.

Much of this information may be gained from site records of monitoring conducted, from regional bore networks, or from existing geological information.

Note: It is common for the Rehabilitation and Closure Plans to be combined into a signal document.
VI. Establish budgets for remediation works

Remediation costs can be vast for Council’s and work will need to be planned and budgets organised to ensure funding is available upon the closure of the site. Quotes can be obtained by following the council’s procurement process or estimates of the cost of plant, labour and materials completed.

To assist with estimating the funding required for the remediation work, historical costs should be referred and amended for any increase in labour, plant and material costs.

Excel work sheets can also be used to show the breakdown of costs for works required. The costs to complete the remediation works may include:

- Number of Staff required
- Number and type of Plant required
- Time taken to complete the work
- Mobilisation costs for plant and staff
- Accommodation required for staff and contractors
- The cost of materials
- Licences required
- Training required
- Ongoing costs and inflation

a. Examples of Excel works

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## Closure Cost Estimate

**Local Government Association Northern Territory**

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### Closure Cost Inflation Adjustment

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**Note:**

Inflation factor is based on the Implicit Price Deflator for the Australian, Gross National Product on the Trading Economics website
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7. Implementing Closure plan

The landfill must continue to be non-polluting and avoid causing environmental harm after site closure.

Following the closure plan will ensure that the landfill is closed in accordance with applicable local regulations, and that all appropriate controls are in place for the management of leachate, landfill gas and surface drainage.

Site closure/remediation could include a number of phases including:

a. Close existing landfill to the community

Advise the community of the closure date of the landfill and provide information on the new facility and waste management procedures.

- Local Authority meeting (ask for assistance from the community leaders to gain acceptance and support from the community)
- Posters around the community (e.g. shop, school parks, sport facilities etc.)
- Radio advertising (e.g. utilise the local school kids to create an advertisement in their native tongue and have it played on the local radio station)
- Community meetings (Arrange a community meeting to provide the closure information to the community and new waste management location and procedures)
- Work with local authorities to inform all incoming contractors of the change in landfill facilities

b. Isolation

To stop the public access the site the site will need to be closed and signage erected. Access to the site will determine the appropriate closure method. For example, a single road access could simply require the closure of the access road by constructing a dirt bund/mound stopping vehicle access. Ready access from a number of directions could require the construction of a temporary fence to stop access. Regardless of the method of closure, preferred signage advising of the closure and alternate landfill should be erected at the access points.
c. Clean site and remove legacy waste

i. Plant & equipment for landfill management

The remediation of a legacy landfill requires suitable plant and equipment. A minimum level of plant and equipment is required to manage the tasks as set out in these guidelines. All operators of plant should be suitably trained and/or licenced on that item of plant. Machinery that would typically be used for remediation works include:

<table>
<thead>
<tr>
<th>Backhoe</th>
<th>Front End Loader</th>
<th>Steel Wheel Compactor</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Backhoe" /></td>
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<td><img src="image2.png" alt="Front End Loader" /></td>
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<td><img src="image3.png" alt="Steel Wheel Compactor" /></td>
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<table>
<thead>
<tr>
<th>Bulldozer</th>
<th>Excavator</th>
<th>Tipper</th>
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<td><img src="image4.png" alt="Bulldozer" /></td>
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<td><img src="image5.png" alt="Excavator" /></td>
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<td><img src="image6.png" alt="Tipper" /></td>
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</table>

<table>
<thead>
<tr>
<th>Roller</th>
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<tbody>
<tr>
<td><img src="image7.png" alt="Roller" /></td>
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</table>

Using under sized plant will damage the equipment, make the job harder and cost the Council time and money.
Plant Item | Intended use
---|---
**Backhoe** | ○ waste movement  
○ loading waste  
○ applying cover  
○ minor compaction

**Front end loader** | ○ waste movement  
○ loading waste  
○ waste compaction  
○ applying cover/cap  
○ minor pit/cell construction

**Steel wheel compactor** | ○ major waste consolidation  
○ major waste compaction

**Bulldozer** | ○ waste movement  
○ waste compaction  
○ applying cover/cap  
○ pit/cell construction  
○ pit/cell compaction

**Excavator** | ○ waste movement  
○ load waste/cover material  
○ apply cover/cap  
○ construct pit/cell  
○ form cap

**Tipper** | ○ move waste/cover

**Roller** | ○ compact waste/cover/cap

**ii. Methods of Disposal or Removal**

- **Burial on site:**  
  ○ Construction of new pit  
  ○ Burial in operational pit

- **Removal to new landfill pit:**  
  ○ Waste sorted and transported to the new operational landfill to be disposed of in pit or relevant stockpile in the landfill Compound
Removal to external Source
- Items sent for recycling purposes.

D. Cover material

The use of soil cover material limits run-on and penetration of water, controls and minimises the risk of fire, minimises landfill gas emissions, suppresses site odour, reduces fly propagation and rodent attraction and decreases litter generation.

Cover material is usually classified as daily, intermediate and final.

i. Daily Cover

At least 150mm of soil should be spread over the waste deposited at the landfill tipping face so that no waste is exposed. The frequency and depth of soil cover application on the waste are also important in reducing the risks associated with uncovered waste.

It is important that cover material is readily available on site at all times. This applies particularly to above ground sites where no excavation has taken place. All landfills...
should maintain a minimum of two week’s cover as reserve on-site. As a guide, this is estimated to be one cubic metre of soil for every six tonnes of waste received.

Soil used as landfill cover should preferably have the following qualities:
- Good compaction characteristics;
- Good trafficability under all weather conditions;
- Resistance to swelling and cracking when wet and dry;
- Resistance to wind erosion;
- Good resistance to collapsing under all conditions; and
- Ability to support plant growth.

Loam, clay loam and some soils have these preferred characteristics, however where these are not available the best of the soils which is available should be used.

In order to maximise the available landfill capacity and avoid excessive layering of the waste, consideration should be given to the use of alternate daily cover materials. Alternative daily cover is typically placed on the active face (known as the working face) in lieu of soil. Types of alternate cover include:
- Geosynthetic blankets;
- Shredded green waste;
- Sawdust;
- Spray on foam;
- Stabilised sludge;
- Paper sludge;
- Paper pulp;
- Composted material;
- Small weave netting; and heavy-duty reusable plastic sheets or tarpaulins.

The selection and use of appropriate cover material requires consideration of a number of factors, including:
- Availability of material;
- Ease of material handling;
- Climatic conditions;
- Additional nuisance potential;
- Cost of material
- Potential contaminants within the material; and
- Potential effect on site stability.
ii. Intermediate Cover

Intermediate cover is used to close off a cell which will not receive additional lifts of waste or final cover for some time. At least 300mm of soil should be spread so that no waste is left exposed. The cover should always be sloped and graded to prevent ponding of water.

When waste is placed over an area where intermediate cover has been applied, it is vital that the cover is adequately penetrated or removed to render the surface permeable to gas and leachate. If this is not done, the landfill may become stratified with impermeable layers, and suspended leachate lenses could develop, which can potentially break through the surface.

iii. Final Cover

In addition to daily and intermediate cover, the final layer of cells must be covered with additional soil during decommissioning to further isolate the waste and help ensure long-term stability for the site.

The design of the final cap of the landfill is primarily influenced by:
- Landfill leachate and gas quality.
- Proximity to potential receptors.
- Landfill operations history, including type of waste accepted.
- Hydrogeological and meteorological factors.
- End use of the landfill.

The final cover system is represented in the above diagram. The final cover should be a minimum of 500mm of low permeable soil and be compacted and graded in order to shed water and prevent ponding.

Site capping and revegetation should ensure that the final surface provides an appropriate barrier to water infiltration, controls emissions to water and the air, promotes sound land management and conservation, prevents hazards and protects amenity. A final cover system generally includes (from bottom to top):
- Intermediate soil cover;
- Low permeability layer; and
- Topsoil layer

Final cover material should be placed as soon as practicable over the finished areas of the landfill above the previously placed intermediate cover.

Vegetation on the final cover should be established immediately following completion of the cover. Ongoing monitoring and maintenance of the final cover following placement is necessary to mitigate the effects of settlement, cracking or die-off.

### iv. Typical Engineered Cap

The recommended final cap from top to bottom consists of:

- 150mm top soil for vegetation
- 600mm compacted barrier layer (silt, silty clay, clay), and
- 300mm of compacted subgrade or foundation layer.

The 300 mm subgrade layer can be an intermediate cover placed after the landfill cell reaches its final grades. It can be a clean-fill layer consisting of approximately graded (less than 50 mm) demolition concrete chunks, brick, or inert natural material. The function of the subgrade layer is to cover the waste and provide a uniform surface for placing the barrier layer, followed by the topsoil layer.

### v. Alternate Final Cap Designs

The recommended final cap design may not be the most appropriate design for all landfills. Availability of suitable soils for the construction of the final cap, climate, maintenance, proximity to sensitive receptors and long-term performance of the cap may entail the use of an alternative final cap design such as one of those presented below.

### vi. Capillary barrier

In semi-dry and dry climates, capillary barriers can be more effective in restricting infiltration than traditional clay caps (the latter are also referred to as resistive barriers). In its basic form, a capillary barrier from top to bottom consists of:

- 150 mm topsoil layer
- ~ 500 mm finer-grained soil layer (for example, clayey silt or silt).
- ~ 500mm coarser-grained soil layer (for example, clean sand or gravel).
Advantages include:
- Neither moisture conditions of clay nor comprehensive compaction criteria are necessary for construction.
- There is far less potential for desiccation or freeze/thaw cracking.
- Animal burrows are less likely as coarse-grained soils collapse.
- Less maintenance is necessary (if properly vegetated).
- It is less expensive to construct if clay is not available.
- If designed properly, it allows less infiltration into the waste, thus reducing the quantity of leachate produced.

Disadvantages include:
- It is appropriate only to semi-dry or dry climates where annual precipitation is below 600-700 mm.
- It is prone to significant infiltration into the waste if stressed by extreme annual hydrologic events (such as large rainfall in short duration).
- Landfill Gas (LFG) leakage through capillary barriers is potentially larger.

Note: Not recommended for landfills where a shallow and sensitive groundwater aquifer exists at the site. The cost savings achieved by using the capillary barrier should be weighed against the potential risks, and the risks factored into the design of the cap.

vii. Geosynthetic barrier

Geosynthetic barriers typically consists of either a Geosynthetic clay liner or a geomembrane (for example, HDPE, PVC, PP, etc.), or a combination of both. Geosynthetic caps are used where it is necessary to limit infiltration and hence leachate production to a bare minimum. Use of a Geosynthetic cap should be considered where:
- A shallow and sensitive aquifer is located beneath an unlined landfill.
- Hazard waste is present.
- The landfill does not have a leachate collective system.
  
![](drawing.png)
viii. Phytocap

The use of phytotechniques is well established in waste management and the concept of a ‘phytocap’ from modern landfills is now being increasingly considered in the US & Australia.

Unlike the ‘raincoat’ system, phytocaps are constructed with a ‘sponge’ layer that stores water until it is ‘released’ by natural forces of evaporation and transpiration, hence ‘evapotranspiration’.

**HOW DOES IT WORK?**

The phytocap achieves the same result as an engineered cap, but achieves this by the use of plants and an appropriate designed growing medium made from locally sourced materials.

The phytocap has several advantages over engineered caps, e.g.:
- It is a natural ‘structure’ designed to operate in all climate conditions;
- It requires less maintenance;
- It generally is less expensive to construct.

**E. Erect security fence**

The erection of an 1800mm security fence around the closed site will assist with:
- Closing the site
- Assist with aftercare of landfill
- Generate regrowth
- limit with environmental contamination
It is possible with ready public access that dumping will continue after the closure of the landfill. The fenced should be locked to prevent access, and signs erected advising of the closed landfill and alternative disposal location(s). The site should be regularly monitored and any waste removed to minimise similar behaviour.

8. Post Closure Management

a. Post Closure Documentation

Following placement of final cover over the entire site, the site will be mapped and GPS coordinates recorded as part of the closure plan. A copy of this document should be kept with the Council's planning department & a copy kept in the Community Managers office.

b. Site Aftercare

Until the waste within the landfill has sufficiently decomposed or stabilised such that it no longer presents a risk to the environment, it must be managed so as to prevent any environmental impact.

The following areas must be considered in preparing the aftercare management plan:

- Maintenance of landfill cap, in particular to:
  - Prevent/control erosion;
  - Restore depressions, and seal and monitor cracks in the cap caused by settlement; and
  - Restore/maintain vegetation
Environmental monitoring of:
  - Groundwater;
  - Surface water;
  - Landfill gas;
  - Leachate; and
  - Settlement.
  - Weed Management

It is also possible that there will be a problem with vermin, notably rats, especially if these have become established during the operation of the landfill. A continued problem with rats (or birds or flies) suggests that the final cover is insufficient. However, before undertaking an upgrade of the final cover, a comprehensive programme of poisoning (with appropriate precautions to protect other species) should be undertaken.