بيروت، في _____

قرار رقم
المواصفات الفنية لكل نوع من المطامر الصحية

إن وزير البيئة،
بناء على المرسوم رقم 8376 تاريخ 2021/10/10 (تشكيل الحكومة)،
بناء على القانون رقم 216 تاريخ 1993/4/2 (إحداث وزارة البيئة)، لا سيما المادة الأولى منه،
بناء على القانون رقم 444 تاريخ 2002/7/29 (حماية البيئة)،
بناء على القانون رقم 690 تاريخ 2005/8/26 (تحديد مهام وزارة البيئة وتنظيمها)،
بناءً على القانون رقم 80 تاريخ 2018/10/10 (قانون الادارة المتكاملة للنفايات الصلبة)، لا سيّما المادة 24-2أ منه،
وبعد استشارة مجلس شورى الدولة (الرأي رقم 2021/91-2022 تاريخ 2022/2/22، الرأي رقم 2023/61-2024 تاريخ 2024/1/23، الرأي رقم 2023/88-2024 تاريخ 2024/2/22)،

يقرّر ما يلي:

المادة 1 - تحديد المعايير والشروط الدنيا
تحدد المواصفات الفنية لكل نوع من المطامر الواجب التقيّد بها بالنسبة لعملية إنشاء المطامر الصحية وفق أحكام الملحق المرفق.

يتوجب على كل جهة تتولّى عملية إنشاء مطامر صحية اتخاذ الاجراءات الضرورية لوضع هذه المواصفات الفنية موضع التنفيذ.

المادة 2 - الملحق
يعتبر الملحق المرفق بهذا القرار جزءا لا يتجزأ منه.

المادة 3 - حق فرض معايير وشروط جديدة
تحتفظ وزارة البيئة بحق فرض معايير وشروط جديدة او تعديل اي منها عندما تدعو الحاجة.

المادة 4 - الغاء القرارات المخالفة
تلغى كافة القرارات المخالفة لأحكام هذا القرار او غير المتفقة مع مضمونه.

المادة 5 - نشر القرار والعمل به
ينشر هذا القرار ويعمل به فور نشره في الجريدة الرسمية ويبلّغ حيث تدعو الحاجة.

وزير البيئة
د. ناصر ياسين

Sanitary landfill specifications

Sanitary landfill for non – hazardous, hazardous and inert waste

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Law Number 80 regarding Integrated Solid Waste Management in Lebanon, provides a general framework for solid waste management in the country. Article 24 of this Law refers to sanitary landfills whereas a provision (par.2a) mentions that "The technical specifications for each type of landfill mentioned above shall be determined by a decision issued by the Minister of Environment."

This document proposes a technical specifications framework for the design, operation, closure, and post-closure care (aftercare) of new or expanding sanitary landfilling sites that and can be incorporated into the existing legislation. Moreover, this document provides standards and conditions for closure and rehabilitation of dumpsites as well for the aftercare period.

1 1. Waste characterization and Landfill classifications

Law Number 80 (Article 24, par.2) defines the different types of sanitary landfills based on the waste input received. This classification leads to some modifications necessary in every different type of disposal facility, based on the potential risks and necessary measures that must be taken for the protection of public health and the environment. In this direction the sanitary landfills are divided into three classes:

- landfills for hazardous waste (HWSL);
- landfills for non-hazardous waste (NHWSL);
- landfills for inert/Construction and Demolition (CD) waste.

The following guidelines refer all types of sanitary landfills.

2 2. General requirements

2.1 2.1 Planning and Siting Considerations

The location of a landfill and the type and amount of waste it is to receive are the primary determinants of the extent to which the landfill will pose an environmental risk. Landfill site selection is a complex multi-criteria and time-consuming process that usually raises arguments and conflicts between different stakeholders with different interests and opinions. Therefore, the landfill siting procedure needs the use of a widely and transparently acceptable decision tool that utilizes clear and comprehensive criteria and represents a multidisciplinary approach that takes into consideration the interests of all stakeholders. Landfill siting procedures should follow the minimum requirements mentioned in ANNEX 1.

2.2 2.2 Environmental Impact Assessment (EIA)

Decisions regarding the siting, design, construction, operation, closure, and post-closure/aftercare period of a landfill must be supported by an assessment of the environmental risk and impacts. The main decisions relating to the risk from a landfill in its specific location, the need to collect contaminated water and leachate, and the standards of protection for soils and water.

Permitting agencies must be informed by the Environmental Impact Assessment (EIA) submitted by a landfill owner/operator during the permitting process. EIA should address both normal, unusual, and unplanned operating conditions. It should cover the entire lifecycle of the landfill from initial construction to the point where the landfill no longer poses a risk to the environment. The eventual

submission of the landfill permit should form part of the EIA and needs to be explicitly considered at the permitting stage.

ANNEX 2 describes the minimum requirements for an EIA regarding landfills.

3 3. Design and Construction Requirements

A Sanitary Landfill must be designed, constructed and operated in such conditions that ensure the biodegradation of disposed waste taking into consideration the need for the protection of the environment and human health.

Landfill design comprises the following interconnected elements that are further analysed in the current document:

- Lining system for the base and the slopes of the sanitary landfill
- Leachate collection and treatment
- Landfill gas collection and management system
- Final capping
- Environmental monitoring system
- Infrastructure that support proper operation of the facility

ANNEX 3 provides minimum requirements and suggestions for the design of sanitary landfills.

4 4. Landfill management and operation requirements

The proper operations of a landfill are equally important with the quality of its construction and infrastructure. The operations include general requirements, waste acceptance procedures, registration and reporting activities, waste placing processes etc.

ANNEX 4 pronides minimum requirements and suggestions for proper landfill operations.

5 5. Landfill aftercare and post-closure management

Landfill aftercare and post-closure mamagement ensures the minimization of the environmental impacts and the maximization of public health protection.

ANNEX 5 provides the minimum requirements and suggestions for landfill aftercare and post-closure management.

6 ANNEX 1: Landfill siting procedures

The landfill siting procedure must be based on the following factors for the candidate locations:

- Geographical and geological considerations: locations that are very sensitive in possible unintended leakage of pollutants that can cause permanent effects in the surrounding area must be avoided. Consequently, candidate landfill areas that must be avoided for the development of a landfill are the ones with problems related to landslides, intense seismic activity, flooding, geotechnical instability, protected species habitats, etc.
- Physical planning and zoning considerations like distance to residential areas, natural reserves, historical sites, facilities like airports, ports, etc., lakes, rivers, wetlands, and other features that are considered based on the location characteristics
- Hydrogeological considerations, like distance to and use of the underground water table, local surface water flows and their destination, etc.
- Landscaping: the operation of a sanitary landfill can cause permanent changes to site topography. Locations with minimal effect on the greater area's morphology and attractive landscaping and future use of the rehabilitated landfill that adequate to the characteristics of the surrounding area increase public acceptance of the candidate location
- Selection procedures: the site selection procedure must be clear, straightforward, open to all stakeholders based on widely used and accepted decision making supporting tools like GIS, Environmental Impact Assessment, Life Cycle Analysis, clear and comprehensive criteria, and weighting ranking, etc and updated and valid data
- Public involvement from the beginning of the site selection process is vital to gain public acceptance of the selected location. Issues like real estate values, aesthetics, heavy vehicles traffic, land use, concerns about the environment and public health, etc. should be raised and discussed during the public consultation process

The site selection process should normally include the following processes:

- Initial desktop study: the candidate landfill locations must be examined based on characteristics like geology, hydrogeology, surface water flows and hydrology, environmentally sensitive areas, vegetation types, land stability, topography, land uses, etc.
- Site investigations, that will provide detailed information regarding the characteristics of candidate locations. Site investigations can include mapping of site geology, geotechnical investigations, identification of nearby groundwater wells and uses, sampling of water quality, flora and fauna, population and areas in the vicinity, cultural heritage sites, etc.
- Environmental Risk Assessment (see par.2.2)
- Economic assessment that will examine every candidate site with economic criteria like land acquisition costs, construction, operation and monitoring costs, waste transport costs, etc.
- Community consultation that focuses on community engagement and involvement in the site selection process. The community must be provided with all the necessary information and the opportunity to comment. The level of detail to be provided will vary depending on the nature and scale of the landfill proposed but should include as a minimum, an assessment of the impact of the proposal on the surrounding community e.g. employment opportunities, altered traffic volumes, noise, dust, and odor, access and distance to travel,

etc. Additionally, consultation with the surrounding community may provide useful information on the community waste management needs and requirements of the facility. The following table presents the main criteria that should be considered for a site selection.

CRITERIA	DESCRIPTION
GEOLOGY	Suitable geology is important to ensure containment of leachate in the long term, or in the event of engineered containment systems failing. Geology should be assessed with regards to the movement of leachate and landfill gas. An assessment of geology and site soils should consider: • The availability of on-site materials for lining, cover and capping. Soils with a high percentage of clay particles are generally the preferred soil type; • The suitability of on-site materials for the construction of dams and drainage systems; • Potential sediment management problems, with highly erodible soils; • Existing site contamination and discharges, if present; • Suitability for on-site disposal of leachate by surface or subsurface irrigation; and • The potential effects of failure of leachate containment and collection systems. Geological factors also influence stormwater, silt and groundwater controls, the containment and control of leachate and gas, as well as the availability of final cover materials.
HYDROGEOLOGY	A suitable hydrogeological location is important to protect groundwater resources and understand the likely fate and rate of discharge of contaminants which may enter groundwater. The purpose of a hydrogeological assessment is to determine the relationship between the landfill and surrounding hydrogeology in order to ascertain the potential risk the landfill facility will have on the environment. In assessing the suitability of a site for a landfill with respect to hydrogeology, the following need to be considered: • Depth to water table and seasonal water table fluctuations; • Location of aquifer recharge areas, seeps or springs; • Distance to water users; • Sensitivity of water users; • Dispersion characteristics of aquifers; • Variations in groundwater levels; • Rate and direction of groundwater flow; • Existence of groundwater divides; • Baseline water quality; and • The potential effects of failure of leachate containment and collection systems.
SITE STABILITY	Site stability should be considered from both short and long-term perspectives, including the effects of settlement. In assessing the suitability of a site for a landfill the local soils need to be considered with respect to the following: • Localised subsidence areas. Differential movement could render a landfill unusable due to rupture of liners, leachate drains or other structures. • Landslide prone areas. The future weight could, through a wide variety of mass movement, destabilise the landfill. Instability may also be triggered by earthquakes, rain and seepage. • Local/onsite soil conditions that may result in significant differential settlement, for example compressible (peat) or expansive soil, or sensitive clays or silts.
HYDROLOGY	The pollution of surface water by leachate is one of the principal concerns in relation to landfill location. If landfills are located in close proximity to waterways there is an increased risk of water pollution. The potential impact of water pollution is greater in waterways that are used for drinking water or aquaculture. When assessing the suitability of a site for a landfill, the local surface hydrology needs to be considered in regards to the sensitivity of the receiving environment, including the following: • The proximity of water bodies or wetlands; • The risks of pollution of water bodies used for drinking water or aquaculture; • Sensitive aquatic ecosystems; and • Potential for impact from cyclones and tsunamis. An assessment of the stormwater catchment above the site should be made to identify the extent of any drainage diversion requirements that may need to be addressed. An assessment report of the local hydrology needs to be undertaken prior to the establishment or expansion of a landfill site. The report should contain plans, specifications, and descriptions of the surface water conditions of the site, adjacent and nearby properties, and the regional area in

	which the site is located.
TOPOGRAPHY	Careful consideration needs to be given to the landforms in the vicinity of the disposal site as they may influence: • The type of disposal method that can be utilised; • The suitability of the site for construction of service facilities; o Surface water drainage management; • Groundwater conditions; • Soil erosion risk; • Access to the site; • Ability to screen the site from view; and • The impact of winds on the site. Modest slopes enable easier stormwater control, leachate control and site stability measures, as well as facilitating the operation of the site. When considering potential landfill sites an assessment of the potential for existing topographical features to assist in minimising impacts should be made.
FLORA & FAUNA	The development of landfills may impact on the flora and fauna of the local area. The potential impacts on flora and fauna are: • Clearing of vegetation; • Loss of habitat and displacement of fauna; • Loss of biodiversity by impacts on rare or endangered flora and fauna; • Potential for spreading plant diseases and noxious weeds; • Litter from the landfill detrimentally impacting on flora and fauna; • Contamination of sensitive ecosystems, such as wetlands, by leachate; • Creation of new habitats for scavenger and predatory species; • Erosion; and • Alteration of water courses A survey of the site and collection of comprehensive baseline environmental data are essential steps in the assessment of potential impacts from proposed landfilling operations. An assessment of the local flora and fauna needs to be undertaken prior to the establishment or expansion of a site. This report should contain maps, specifications, and descriptions of the flora and fauna of the site, adjacent and nearby properties, and the regional area in which the site is located.
CLIMATE CONDITIONS	Consideration should be given to the local climatic conditions when siting a waste disposal facility. Heavy rainfall situations can cause severe erosion and stormwater drainage issues if landfills are not sited and designed in an appropriate manner. Hot, dry windy conditions can cause dust and windblown waste issues.
ENVIRONMENTAL SENSITIVE AREAS	Landfills should not to be located in areas of high environmental value, or in areas subject to considerable environmental constraints and high environmental risks. Such areas should be excluded from further consideration. An indicative but not exhaustive list regarding the environmental sensitive areas, not including local legislation issues, is presented below. Minimum distance of 500 meters from • national parks, marine national parks; • historic and heritage areas, buildings or sites protected under the Heritage Conservation Act; • sites of conservation significance; • world heritage areas; • wetlands protected under RAMSAR treaties; • residential zone; • dwelling, school or hospital • a permanent or intermittent water body (including rivers, lakes, bays or • wetlands) and the 100 year flood plain;
INFRASTRUCTURE	Local infrastructure must be able to sustain the operation of a landfill. Landfilling requires the transportation of waste. The capacity of the road network to cope safely and with a minimum of disturbance to the local community, with any increased traffic load should be examined. The preferred transportation route should minimise the transport of waste through residential and other sensitive areas. This consideration may influence the placement of the entrance to the landfill. A transportation study may reveal the need for additional road infrastructure, such as highway interchanges, turning lanes or signals. The availability of services such as reticulated water, sewerage and power will influence the facilities provided for staff at the landfill and perhaps indicate a need to provide additional services, such as water storage for fire-fighting

	purposes.
ACCESS	A landfill facility must have all weather access. Access roads should be located to minimise erosion and the alteration of drainage systems. Landfill development and operations can generate significant flows of heavy vehicle traffic. The following need to be considered when locating and determining access to landfills • type and number of vehicles accessing the site; • types of traffic using roads adjoining landfill access road; • the standard and capacity of the road network, with respect to accommodation of traffic generated by the landfill; • whether the traffic can avoid residential areas; • road safety considerations in regards to the landfill entrance (vehicles using the landfill should not be required to queue on a main road).
LAND USES	Adjacent existing and future land uses should be investigated to identify sensitive areas and other protected areas that are likely to be adversely impacted by landfill operations. Long term planning projections need to be considered when assessing the suitability of a site. The requirement for and extent of buffer areas should be determined on a site- specific basis. Where possible, the buffer area should be controlled by the landfill operator. An assessment of the suitability of a site for a landfill, and/or appropriate buffer zone, in regards to reducing the potential for adverse effects on surrounding land use should consider: • existing property boundaries and ownership; • statutory planning constraints including; • zoning (the protection of amenity associated with residential, commercial or rural zones from nuisances associated with odour, vermin, birds and flies, noise, litter, dust and visual effects, or failure of containment, leachate collection or landfill gas systems) • land designated for a special purpose (e.g. hospitals and schools) o airport safety; and • proximity to sites with cultural or historical significance. A buffer zone is not an alternative to adopting the management practices detailed in this guideline, but an adjunct to support these management practices.
OPERATIONAL NEEDS	Landfill site selection should consider the potential methods of leachate treatment and disposal or leakges and its effect on site neighbours. The potential for landfill gas migration in surrounding sub-strata needs to be considered with respect to containment proposals. Landfill site selection should consider the various potential methods of landfill gas treatment and disposal and its effect on site neighbours. The life of the landfill and the demand for future landfill space should be considered during the site selection process. Proponents should consider the type and quantities of waste generated within the area being serviced by the landfill, the current disposal pathways for these wastes, projected quantities and types of waste requiring disposal and the remaining landfill capacity at existing landfills sites which service the area. Landfills should be designed to ensure that sufficient capacity exists for the current and future waste management needs of the community into the foreseeable future.
LAND OWNERSHIP	Land ownership will influence the siting of landfills. It is preferable to construct landfills and waste management infrastructure on public land, but in cases where public health emergencies or other public interest priorities are valid, private land should seriously be considered.

7 ANNEX 2: Minimum requirements for an EIA for sanitary landfill

The following minimum requirements concern EIAs for new landfills, landfill expansion and landfill rehabilitation projects. These minimum requirements concern onlyn the technical part and they should be considered as additional technical demands to the EIA requirements

ISSUES	DESCRIPTION
Landfill siting	How was the landfill location decided? Alternatives sites and evaluation of them, minimum criteria for siting, stakeholders involvement etc.
Water control and leachate management	Water control is a crucial issue for the long-term viability and environmental impacts of a landfill. Issues like the hydrological water balance, the local rainfalls, the existing flood plains, underground water horizons and water bodies should be analyzed in details.
Protection of soil and water	Is the landfill location and design suitable to provide protection of the water and soil in the area? What are the main risks for water and soil? How these risks will be mitigated?
Lining system	The selection of a proper lining system is one of the most important elements of a sanitary landfill and it determines its long-term environmental performance. How the lining system was selected and what is the protection it provides and for how many years it should be considered safe? Is there a leakage control system? What is the combined performance of the liner on top of the local soil strata?
Leachate collection/removal/treatment	How much leachate is generated and how it will be collected? How the landfill design ensures safe and 100% collection of the leachate generated? How leachate is treated (leachate treatment method) and what is the expected outcome of the treatment? How the treatment outcome is further managed?
Final capping	What is the waste body final shape and design and how the final cap will be put on it? What are the elements of the final cap and the final height of the waste disposal hip?
Landfill gas management	How much biogas is expected to be generated and how it will be managed (vertical wells and/or horizontal trenches). The landfill requires an active or a passive system? Is biogas enery utilization possible and what is the expected benefits and emissions from it? How about odor management?
Stability of waste body	The stability of the waste hip is crucial and relevant geotechnical analysis should be incorporated for earthquakes, settlements, slope stability etc. The calculations should concern both the waste body and the bottom and top liners.
Nuisances and hazards	How direct contact with the waste and its pollutants will be avoided? What are the health and safety measures that should be kept by workers and visitors? How the direct contact with the food chain will be avoided?
Accidents and emergency response	Each l;andfill an emergency response plan for accidents, and especially for a. managing unexpected fires, and b. slope failure
Environmental monitoring system	How environmental monitoring will be achieved? What kind of equipment and automations are required and where they will be located? The environmental monitorimng should integrate leachate and biogas leakages, water and soil quality as well as the mechanical behaviour of the waste disposal hip.

8 ANNEX 3: Landfill design requirements

a) Lining system

A landfill must be designed and constructed to meet the necessary conditions for the protection of the environment, i.e. soil, underground, and surface water and air. For this reason, the construction of the landfill lining system is necessary. The lining system must be constructed in such a way that:

- Minimizes the possibility of leachate leakage and landfill gas migration from the landfill basin
- Creates the necessary conditions for the effective collection of leachate and landfill gas

The lining system consists of a combination of a geological barrier and a bottom liner that must be applied in the whole surface of the active landfill cell/cells.

The detailed description of the lining system components and materials must be subject to a detailed geological and hydrogeological study for the selected location for the construction and operation of the landfill and its vicinity.

8.1.1 Geological barrier

The first (lower) layer in the landfill lining system consists of a mineral layer which must meet the permeability (K) and thickness equivalence requirements for every different landfill type, presented in the following table:

Table 1: Geological barrier's requirements

	Equivalent to:
Non hazardous waste SL	A mineral layer with thickness ≥1m and permeability K≤1.0 x 10^{-9} m/sec
Hazardous waste SL	A mineral layer with thickness ≥5m and permeability K≤1.0 x 10^{-9} m/sec
Inert SL	A mineral layer with thickness ≥1m and permeability K≤1.0 x 10^{-7} m/sec

In case that the existing/natural geological barrier does not meet the above requirements of permeability and thickness, the lining system must be enforced with other materials (e.g. bentonite) that can provide the equivalent protection. The overall thickness of the artificial geological barrier after the compaction cannot be less than 0.50m. The layer is constructed in at least 2 layers with a final compacted thickness of 25cm each. The compaction rate must be at least 95% of the maximum dry density according to the standard Proctor test. After the compaction works, the upper surface of the geological barrier must have slopes at least 3% longitudinally and 5% in transverse directions.

Alternatively, the geological barrier can be substituted with Geocomposite Clay Liner (GCL), a bentonite layer encapsulated between two geotextiles. This material must meet the permeability and thickness requirements for the geological barrier as described above.

In any case, the required equivalence of permeability and thickness must be proved with the necessary geotechnical studies and calculations which will determine whether enforcement of the geological barrier will be needed or not.

8.1.2 Artificial barrier

Additional to and above the geological barrier, an artificial barrier must be installed in direct and uniform contact with the compacted soil or lower liner component. The artificial barrier must consist of the following layers (from bottom to top):

- Geosynthetic Geomembrane from HDPE (High-Density Polyethylene). The minimum thickness of the geomembrane must be 1.5mm for non hazardous landfills and 2.5mm for hazardous waste landfills
- Non-woven, needle-punched geotextile made of PP (Polypropylene) for the protection of the geomembrane
- A sand layer of 10cm for the additional protection of the geomembrane as well as for the installment of the leachate collection pipes

The artificial barrier must be:

- Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeological forces), physical contact with the leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

- Constructed of materials that provide appropriate shear resistance of the upper and lower component interface to prevent sliding of the upper component including on slopes;

- Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

- Installed to cover all surrounding earth likely to be in contact with the leachate.

- The HDPE geomembrane must be accompanied by a guarantee of a minimum of 40 years to cover the active landfill lifetime and the post-closure period (see par. e)). Geotextiles must have a guarantee of at least 20 years.

The artificial barrier is required for sanitary landfills for both hazardous and non-hazardous waste and must follow the minimum specifications indicated in this paragraph. Specifications and requirements for the artificial barriers in inert waste landfills must be identified in the environmental risk assessment and the geological and geotechnical studies.

8.1.3 Drainage layer

Above the artificial barrier, a leachate drainage layer of thickness ≥0.50m and hydraulic permeability ≥1.0 x 10^{-3} m/sec must be installed. This layer must cover the entire base of the landfill cell and it will be consisted of aggregate material with the following requirements:

- It will be free of silt and clay with organic material of less than 1%.
- It will be non-reactive in mildly acidic conditions and chemically resistant to the leachate in the landfill, with a calcium carbonate content of less than 8.5% by mass
- The material's nominal particle size must be greater than 16mm with a maximum of 32mm.

- the shape and angularity of the material will not damage the underlying lining materials (rounded and smooth-surfaced gravel is the ideal material for this layer)

The drainage layer must be separated to the above layers of disposed waste with a geotextile with similar characteristics to the geotextile for the protection of the geomembrane. Additionally, the separation geotextile must have appropriate filtration characteristics to limit the effects of clogging and appropriate UV resistance properties based on the estimated exposure of the material before covering.

In case that the sanitary landfill slopes are steep (usually over 1:3 v:h) and the gravel of the drainage layer is not possible to be installed, geosynthetic materials that can achieve the same permeability rates (≥1.0 x 10^{-3} m/sec) can be used. The specifications of the geosynthetic materials that can achieve the drainage layer requrements, must be identified in the geotechnical studies and calculations.

A summary of the requirements for artificial barrier and drainage layer is presented in the following table

Table 2: Lining system minimum requirements

	HDPE geomembrane	Geotextile	Sand layer	Drainage layer
Non hazardous waste SL	thickness ≥1.5mm	Non-woven, needle-punched geotextile made of PP (Polypropylene)	thickness 10cm	thickness 0.5m and permeability ≥ 10^{-3} m/sec
Hazardous waste SL	thickness ≥2.5mm			
Inert SL	Identified in the EIA and geological/geotechnical studies			

A typical section of the landfill's lining system is presented in Figure 1

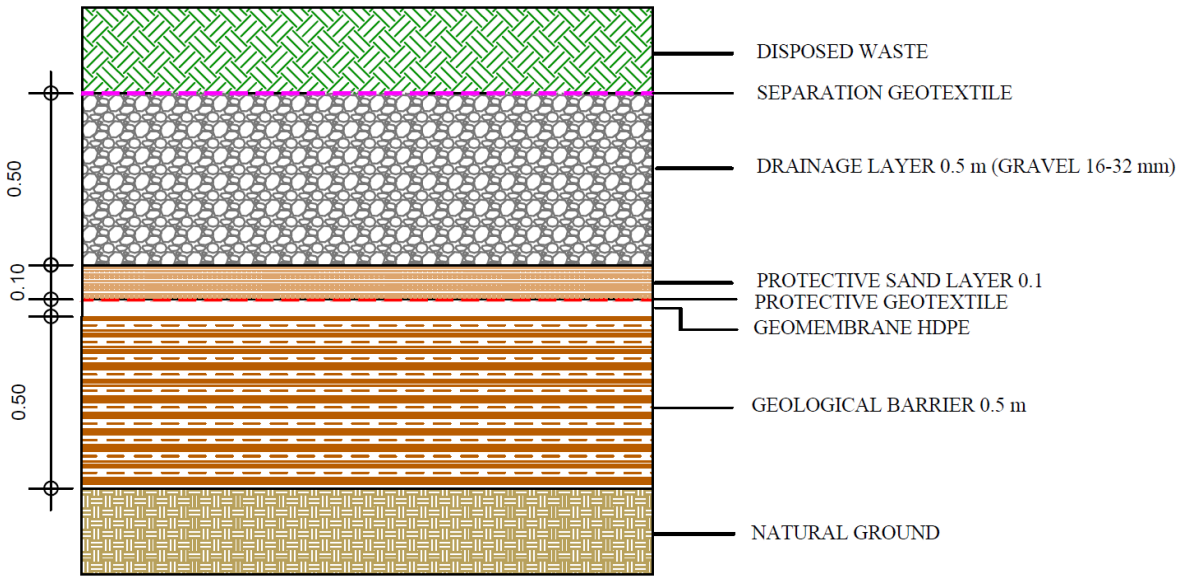

Figure 1: Typical section of Sanitary Landfilll lining system

b) Leachate management

8.1.4 Leachate Collection

The leachate collection and removal system must be designed, constructed, operated, and maintained to collect and remove leachate from the landfill during the active life and post-closure care period. The leachate collection and removal system must be:

- Constructed of materials that are chemically resistant to the leachate expected to be generated, and of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment used in the landfill
- Designed and operated to maintain the hydraulic head of leachate less than 50cm within the leachate drainage layer
- Designed and operated to minimize clogging during landfill active operations and post-closure period
- Designed to be able to receive and effectively drain the maximum rainfall of the last 20 years

The leachate collection system consists of a network of HDPE (High-Density Polyethylene) pipes that will be installed within the drainage layer and based on the sand layer of the lining system (see Figure 2). The pipes must have the capacity to collect and transfer the total amount of leachate generated in the landfill. They shall have a minimum internal diameter of 150mm and they will be perforated at the 2/3 of their surface with 12mm diameter holes. The leachate collection pipes must be laid at gradients of at least 3% longitudinally and 5% in transverse directions.

The leachate drainage system must be sealed to prevent the release of landfill gas and air being drawn into the landfill

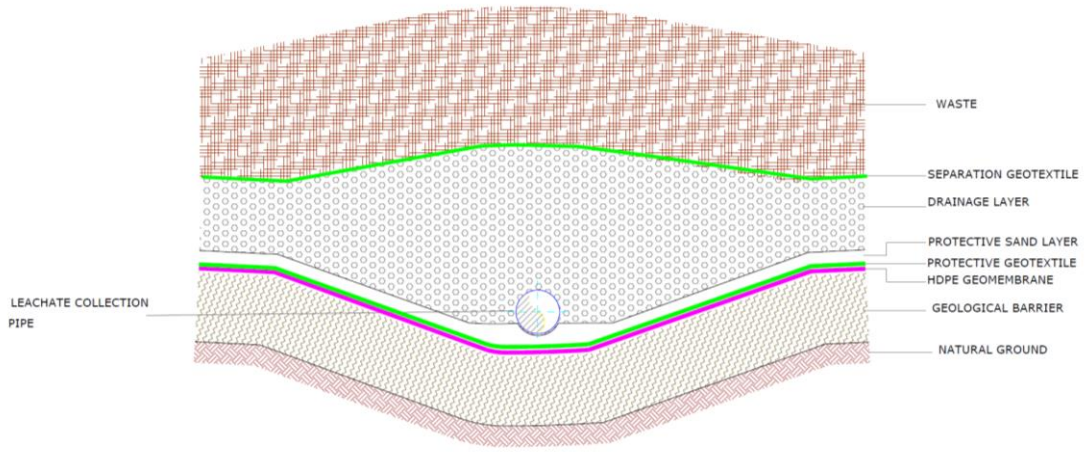

Figure 2: Detail of leachate collection pipe arrangement

The leachate will be collected in a leachate collection tank outside the active landfill area. The tank will be able to store the maximum leachate produced in 6 days. The design of the tank will be based on the maximum rainfall of the last 20 years.

The leachate can be transmitted to the leachate collection tank either by connecting the tank directly with the leachate collection system or with the use of pumping system installed inside the landfill cell. In the latter case the leachate is collected in a sump in the lower point of the landfill cell and it is pumped out to the leachate collection tank. The submersible pump must be suitably corrosion protected to a high standard and always accessible for maintenance and/or subtitution. The pump must be equipped with level sensor and leachate flow sensor. The operation of the pumping system must be supported by a level control panel.

8.1.5 Leachate treatment

Once collected and stored in the collection tank, the leachate must be treated in a leachate treatment plant. Since the leachate contamination load is typically much higher than wastewater, the establishment of a separate leachate treatment plant in the landfill site is the most feasible option for the proper treatment of leachate. The objective of the leachate treatment process is to produce a liquid that can:

- Be disposed to the municipal sewage system and the local wastewater treatment plant for further treatment
- Be discharged in the nearest surface water recipient
- Be collected and processed for further use inside the landfill site for several purposes like irrigation, circulation back to cells, firefighting, dust suppression, etc.
- Evaporation ponds may be used seasonally but not as a stand-alone system, since the annual precipitation rates in most areas are higher than the annual evaporation rates.

A range of different technologies is applied for leachate treatment including physical, biological, and chemical methods as well as a combination of them. According to the leachate characteristics of each landfill area and the requirements of the possible effluent recipient (wastewater treatment plant and natural recipient) and the requirements for further uses like irrigation and firefighting, the preferred and most appropriate treatment technology is selected.

8.1.6 Leachate recirculation

Under some circumstances, treated leachate may be injected back into the waste, provided that it is at a sustainable rate and the risk of adverse impacts can be managed.

Leachate recirculation is the small-scale, temporary, controlled, and additional to other treated leachate disposal methods. It is used to bring the waste up to an optimum moisture content (usually the water- holding or field capacity of the waste) for enhanced anaerobic biodegradation of organic materials in the waste. In any case, treated leachate recirculation must be done according to the following requirements:

- Recirculation should be done at a sustainable rate, enabling the waste to absorb the leachate. There should be sufficient storage volume within the waste and the leachate

management system to contain the reintroduced leachate. Proposals should be supported by water balance modeling demonstrating sufficient storage capacity.

- Recirculation should be applied only to sanitary landfill cells where the cell is lined and has an engineered leachate extraction and level-control system.
- Recirculation should not create excessive leachate levels over cell liners. Leachate above the waste's holding capacity should be continuously withdrawn from the cell to ensure that the depth of leachate over the liner does not exceed 0.50m.
- Recirculation points must be properly designed, constructed and operated
- Recirculation must be done in a controlled manner and based on the moisture level of the waste body. Recirculation must be done below the surface of the waste by using trenches, wells, and pipes that will distribute treated leachate throughout the entire waste body.
- Spray irrigation over the waste surface is not allowed to be used as recirculation method since it cannot distribute the liquid thought the waste body and it can pose significant risks of leachate spread

c) Landfill gas management

Landfill gas management practices must be adopted to:

- minimize emissions of untreated landfill gas to air and through sub-surface strata and services
- minimize greenhouse gas emissions
- minimize emissions of offensive odor
- minimize the explosive risk to humans from gas build-up in confined spaces
- ensure that, wherever feasible, landfill gas is sustainably utilized for energy recovery
- minimize emissions of air pollutants from the combustion of landfill gas in flaring or electricity-generating equipment.

Landfill gas should be collected by installing a network of wells, drainage layers, pipework, and an extraction system within the waste. Such a system should be installed in all landfill cells and designed to cover the entire area of the expected waste volume. Based on the expected landfill gas generation quantities, the gas extraction may be active (forced) or passive. In the active extraction systems, landfill gas is removed under vacuum and pumped for energy recovery or treated in a flare. The biogas velocity inside the landfill gas piping system must be less than 10m/sec.

The landfill gas wells must have a maximum distance of 25m between them and their catchment radius must be maximum 25m. The landfill gas wells must penetrate the waste volume and their depth must be equal to 80-90% of the waste volume height. In any case, the lower part of the wells must be at least 2m above the upper limit of the landfill cell lining system.

The materials used for the construction of the landfill gas wells must be resistant to chemical and biological loads.

Landfill gas wells will be connected with a gas piping network that will transfer landfill gas collected to the gas collection station before the flare or the electricity generation system. Gas transfer pipes shall be installed with a slope to the gas collection station, to evacuate the water condensed inside the pipe. The pipes shall be provided with flexible devices that allow the connection to the gas

stations in a way that damage is minimized. The pipes and the flexible connections shall be of HDPE with a pressure resistance ≥ PN 6. The pipes are solid and made of HDPE.

The gas pipes will bear butterfly valves at their connection to the station. Within the stations, individual pipes are connected via a manifold to the main discharge pipe. The number of gas stations is determined upon the landfill shape, the number of wells, and their distribution and will be defined in the technical design.

The landfill gas flare stations shall be a closed-type, allowing high efficiency with combustion at least at 1000 °C. It shall be of compact design and consists of blower, analyzer, controlled combustion unit and local PLC. It must be designed with a 15-20% safety factor, as well as to allow combustion of variable gas flow rate at a typical ratio 1:5.

The above landfill gas collection and management requirements are applied to the sanitary landfills receiving biodegradable waste with, i.e. landfills for hazardous and non hazardous waste. The need for establishment of landfill gas management system in a landfill for inert waste and the relevant technical specifications and requirements must be identified in the EIA study.

d) Surface water management

Landfills must be designed to prevent the contamination of surface water from activities conducted at the site and to avoid waste and leachate to come into contact with surface waters. This minimizes the potential generation of leachate.

In this framework the landfill must have a complete surface water system that usually consists of trenches, drainage pipes, culverts, etc. that will be able to manage properly the surface water quantities in the landfill site including the surface water entering the site from the surrounding area. The surface water system must be designed taking into consideration the maximum rainfall of the last 50 years. The surface water velocity inside the system components must be kept at such a level that will not damage the materials i.e. concrete, soil, etc.

The water collected by the surface water management system must be either diverted outside the landfill site or collected and stored into tanks for further use e.g. irrigation, fire-fighting, dust suppression, etc.

Surface water management systems at landfill site must be regularly maintained and managed including at least the following:

- Maintenance of ditches, culverts, and ponds
- Management and control of vegetation that affects the water runoff quantities
- Habitats and ecology outside the landfill site that are affected by the surface water management system
- Monitoring and permitted discharge requirements
- Control systems (e.g. penstock, outlet valves, etc.)
- Storage on-site for dust suppression and fire fighting

e) Final capping

This section provides standards and conditions for the closure and capping, of the landfill, so as to minimize penetration of surface water into the landfill cells and to provide protection of atmospheric air and surface water against contamination from the waste cells. The same standards must be considered as a minimum also for the closure and rehabilitation of the dumpsites.

The objectives of the final capping system are to:

- Minimize infiltration of water into the waste;
- Allow surface drainage and maximize outflow;
- Control the landfill/dumpsite gas emission, and
- Enable a physical separation between waste and plant-animal life.

The landfill /dumpsite final capping system will consist of the following layers (from top to bottom):

- The surface layer of soil with a thickness of at least 1,0 m, from which the upper 0,6m will consist of enriched topsoil for vegetation purposes;
- Separation geotextile between the surface layer and drainage layer
- Drainage layer with thickness 0,5 m with a coefficient of water permeability K ≥1,0 x10^{-3}m/s;
- Compacted mineral layer from clay with a minimum thickness of 0,5m with a coefficient of water permeability K≤ 1,0 x 10^{-9}m/s. Alternatively, HDPE geomembrane can be used especially in the case of steep (>1:3) slopes of the landfill volume. The membrane must provide equivalent protection to the clay layer, meeting the thickness and permeability equivalence.
- Separation geotextile between the mineral layer and gas drainage layer
- Gas drainage layer with a minimum thickness of 0,3 m;

A typical section of a landfill's capping system is presented in Figure 3.

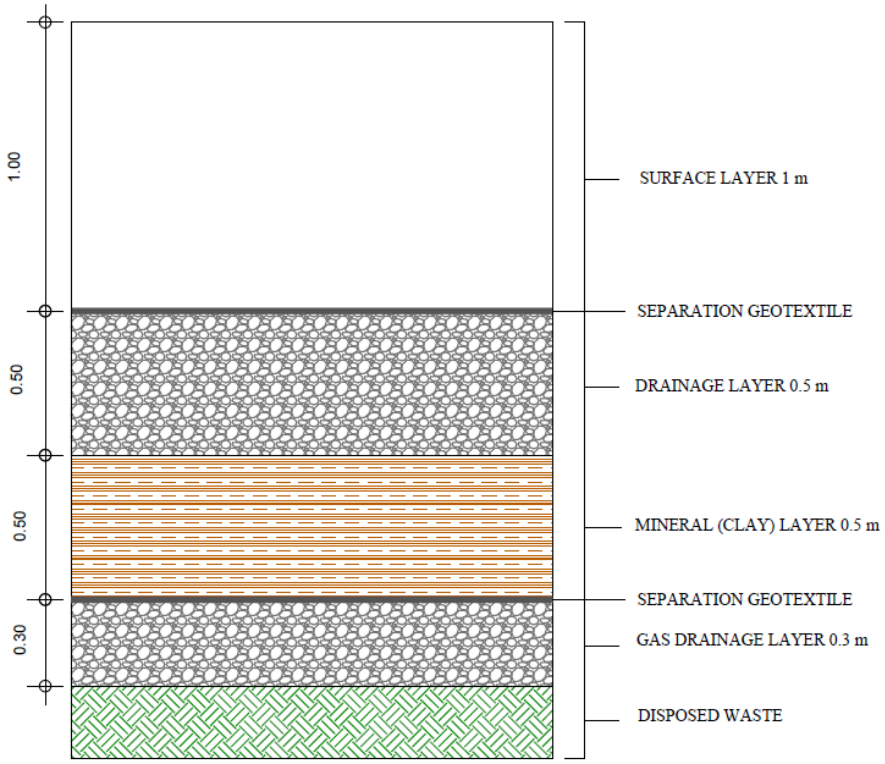

Figure 3: Typical section of landfill's capping system

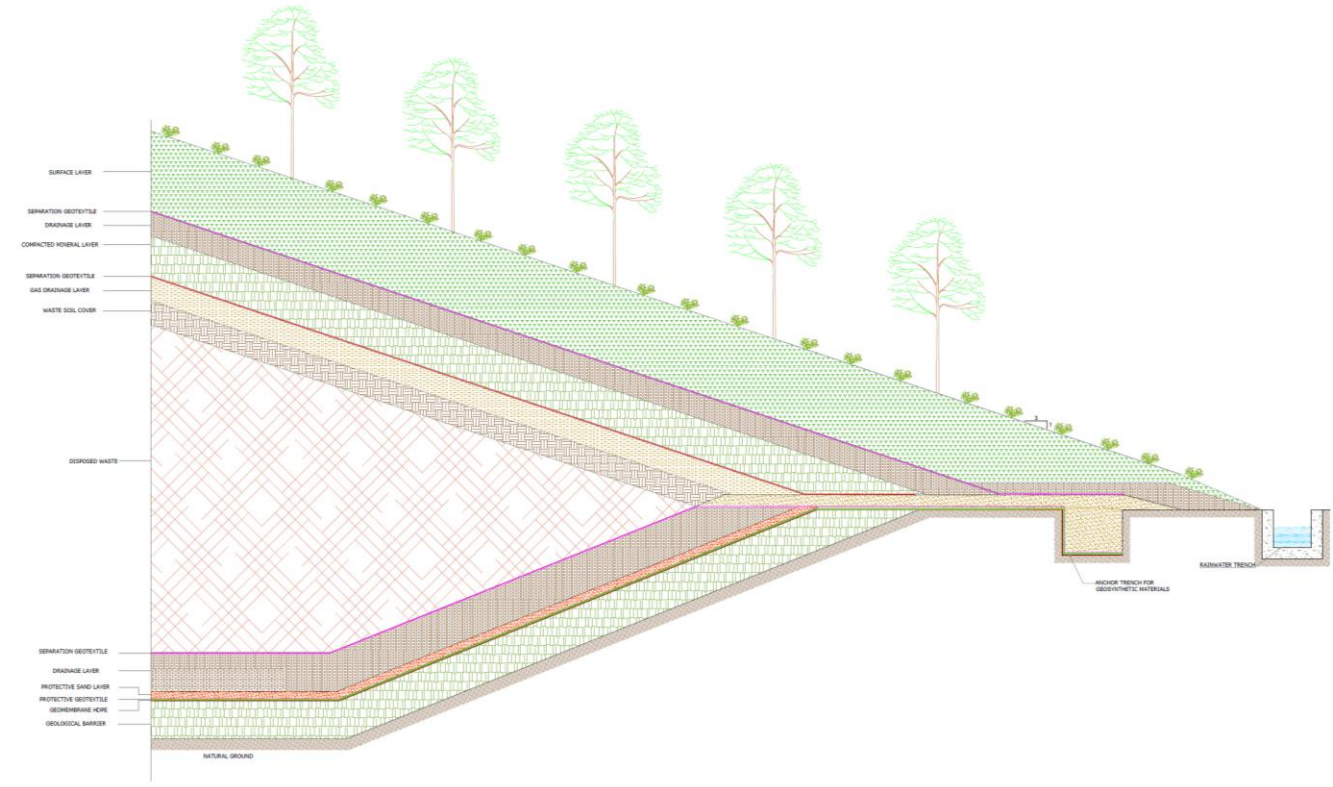

Figure 4: Final capping detail

The above standards are the minimum specifications for final capping for both landfills and dumpsites. The details for a specific landfill site or dumpsite must be provided by the EIA and the environmental permits.

f) Supporting infrastructure

8.1.7 Fencing – entrance gate

All landfills should have a barrier around the perimeter of the site to prevent the unauthorized entry of people and input loads. For this reason, the perimeter of the areas of the landfills must be protected via a fence that will ensure the protection of the site. The fence must be made of galvanized iron ducts of 5 cm diameter, 2.50 m height, which will be encased in a concrete basis below the ground. The ducts will be vertical and will reach a height of 2.00 m above the ground. In the last 50 cm, the ducts will have a gradient of 30o to the external side of the fence. The edges of the ducts will be connected with a prickle wire net.

The prickle wire net will be 2 mm thick and will be installed in 2 rows. In both the vertical and the sliding parts of each duct, holes will be made for the reinforcement wire and the prickle wire net to be developed. The reinforcement wire will be 4 mm thick and will be installed in 3 rows. A rhomboid wire net with loops (5 X 5 cm) will be used to restrict the trespassing of rodents.

The distance between the ducts will be 3.00 m., and every 6.00 m iron struts will be placed of the same diameter as the ducts. The struts will be encased in a concrete basis, of dimension 0.50 X 0.50 X 0.60 m.

The entrance gate consists of two doors with 4.00 m length each and 2.50 m height. The entrance doors will open either automatically or manually. The doors will be coated with a wire net and be secured with a lock.

Right after the entrance gate, there will be posted an information sign that will include at least the following information:

- Landfill site name
- Landfill type (i.e. for non-hazardous, for hazardous waste, for inert waste)
- Name and contact details of Owner/Authority
- Landfill's operator name and contact details
- Working hours of the facility
- Landfill supervisor

8.1.8 Green Belt

Along to the boundary of the facility and right after the fence, a green belt area must be developed to serve as visual barrier and to reduce dust and noise levels in the surrounding area. The trees that will be planted in this zone should be fast growing, have a thick canopy, perennial and evergreen, should have high carbon dioxide sink potential and that they should be effective in absorbing pollutants without significantly affecting their growth.

8.1.9 Weighbridge building

The weighbridge building is foreseen to serve landfill's weighbridge. For this reason, it is located next to the weighbridge. The building must have at least one main workroom with a sanitary unit and an entry hall with a kitchenette. The building shall be equipped with a desk and the necessary electronic equipment for weighing and data recording of the incoming/departing vehicles.

8.1.10 Weighbridge

The landfill weighbridge is located close to the entrance of the site. It ensures the accurate and systematic recording of incoming waste. All the incoming vehicles carrying waste loads are weighted before discharging their load in the active landfill cell. The weighbridge must be operating fully automatically. The weight of any vehicle must be recorded in dedicated software that must be installed in the computing system in the weighbridge building. The Weighbridge should provide data with increments of at least 5Kg. The computing system shall have the capacity to print receipts per vehicle and to store data of various incoming and outgoing vehicles and generate daily and periodic reports.

8.1.11 Wheel washing system

Before leaving the landfill site and entering the public roads, the waste vehicles will undergo wheel cleaning. The purpose of the wheel washing system is to wash the tyres of waste vehicles from mud and waste residues from the landfill site

The wastewater from the washing basin must be collected and transmitted to the leachate treatment plant.

8.1.12 Internal roads

A road network inside the facility will ensure access to all facility infrastructure. The surface of the internal roads will be asphalt and it will be designed and constructed for heavy vehicles according to local regulations. Based on the expected traffic loads, the road network can have 4m or 8m width (for one or two traffic lanes respectively) and the maximum longitudinal slope must be 8%.

8.1.13 Incoming loads sampling area

A special area for the sampling of loads of incoming waste vehicles must be included in the landfill site. This area will be accessible in every weather condition, fenced, and paved with asphalt. It must be constructed in an area close to and after the weighbridge building.

8.1.14 Administration building

This building serves the landfill administration, the personnel, and visitors. The administration building must have at least the following rooms:

- Offices
- First aid provision office
- Resting room for the people working on site
- Meeting room
- WC
- Washroom/Showers/WC/Lockers (separate for men and women)
- Kitchen

The Administration building can be also equipped with a control room for different operations i.e. SCADA system for the operation of the leachate treatment plant, Laboratory for environmental monitoring sampling and tests

8.1.15 Maintenance building/workshop

This building will be used to cover maintenance, repair, and lubricating purposes of the machinery operating in the landfill site. The maintenance building must be equipped with all the necessary equipment for the maintenance of the machinery and must have at least the following room:

- Main maintenance area/workshop
- Storage room for materials and tools
- Office for the maintenance personnel

- WC
- Kitchenette

8.1.16 Fuel tank

A fuel tank with a minimum volume of 5m3 must be installed in the landfill. This tank will serve only the machinery operating on site. The tank must be equipped with a fuel pump for the supply of the machinery. The design of the tank must follow the local regulations for this type of tanks

8.1.17 Parking space

The vehicles of the landfill visitors and personnel must be parked in a dedicated area with an adequate number of parking spaces. The parking area in a landfill must be developed close to the administration building

8.1.18 Water tank-Firefighting system

A firefighting system must be installed in the landfill that will cover the whole area of the facility. The firefighting system must follow the local regulations and the requirements of the local firefighting department. One water tank must be installed in the site that will supply with water the firefighting system and firefighting vehicles that will visit the site in case of a fire event.

The water tank can be supplied by the surface water management system and must be full and accessible by heavy vehicles all the time.

8.1.19 Fire protection zone

Inside and parallel to the fence, a fire protection zone of 10.00 m width must be foreseen for every landfill site. This area will be kept free of any vegetation and it will prevent the spread of any fire event from the landfill site, to the surrounding area.

g) Environmental monitoring

Environmental monitoring is an essential component of the management plan for a landfill site. It provides operators with information to assess the effect of the landfill on the surrounding environment and assists in ensuring that the landfill is operated and controlled to the specified standards and permits.

8.1.20 Meteorological data

The measurement of the meteorological conditions at a landfill site is an integral part of the overall monitoring programme. Precipitation, temperature, evaporation, atmospheric pressure and humidity are important influences in water balance, leachate and landfill gas generation. The meteorological data can be collected from either an in situ weather station at the landfill site or a nearby meteorological station. The meteorological data and the collection frequency is presented in the following table:

Table 3: Meteorlogical data monitoring and frequency

	Operation phase	Aftercare phase
Volume of precipitation	daily	Daily
Temperature	daily	Monthly average
Direction and force of prevailing wind	daily	Not required
Evaporation	daily	Daily
Atmospheric humidity	daily	Monthly average

8.1.21 Leachate monitoring

A leachate monitoring program should be established to provide data on the composition, height levels and volumes of leachate produced by each landfill cell, and to record details about any irregular discharges or overflows of leachate from the site.

The leachate monitoring program should address the following requirements:

- Leachate composition: Leachate should be sampled from different points within the landfill site, i.e. leachate sumps and collection wells, leachate storage tank to characterize leachate composition, and contaminant loads. Leachate composition samples must be also taken from the different stages of the treatment plant's processes and in the effluent to estimate the efficiency of the treatment process and the effluent's possible final disposal option.
- Leachate volume: Leachate generated volumes and removed from landfill cells must be obtained from continuous flow records. The leachate volume data are useful for the following reasons:
  - To assess the performance of the final capping system
  - To assess the validity of the landfill water balance
  - To assess the cell capacity for treated leachate recirculation

Leachate volume must be monitored in monthly basis during the landfill operation and every 6 months during the post-closure and aftercare period

Leachate composition must be monitored every 3 months during the landfill operation and every 6 months during the post-closure and aftercare period. The parameters that must be analyzed are pH, BOD5, COD, TOC, SO4, NH4-N, NO3-N, NO2-N, Organic Na, Cl, Fluorine, fluorides, phenols, heavy metals (As, Cd, Cu, Cr, Pd, Hg, Ni, Zn), Total P, phosphate, ammonium nitrogen, organic nitrogen, total solids, suspended solids, dissolved solids, microbiological parameters, odors, opacity, conductivity, temperature, and hydrocarbons

8.1.22 Surface water monitoring

A surface water monitoring program should be established to detect possible contamination of surface water from landfill leachate.

The surface water monitoring program should include sampling from the surface water collection tank and in different points of the surface water management system. In the surface water trenches, samples must be taken from at least 3 points: 1 upstream and 2 downstream.

Surface water must be monitored quarterly during the landfill operation and every 6 months during the post-closure and aftercare period. The parameters that must be analyzed are the same as the leachate monitoring system.

8.1.23 Groundwater monitoring

A groundwater monitoring program should be established and the results regularly assessed to detect any pollution of groundwater by leachate.

For the groundwater monitoring system, a network of monitoring wells must be established which must be sufficient to detect any pollution of soil and groundwater by the landfill. The minimum number of groundwater monitoring wells is 3; 1 hydraulically up-gradient of the aquifer and 2 down-gradient of the aquifer. The exact number of the wells must be indicated in the hydrogeological analysis of the environmental risk assessment

A section of a typical groundwater monitoring well is presented in Figure 5

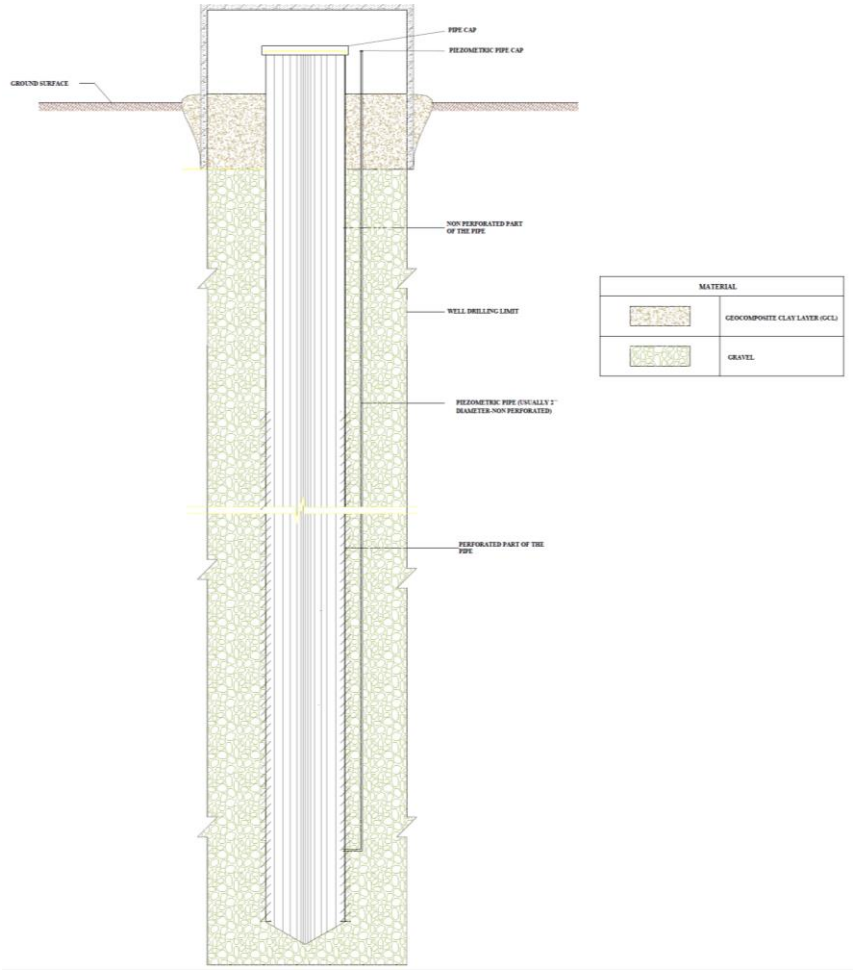

Figure 5: Groundwater monitoring well typical section

When there is no evidence of groundwater, suction lysimeters should be installed to monitor the unsaturated zone below the landfill and at suitable locations surrounding the landfill liner. A suction lysimeter is used to extract pore water when groundwater is absent. It will indicate the presence and

character of any leachate in the geological formation. The need for use of this technique will depend on hydrogeological risk assessment and the locations of any sensitive receptors.

Both groundwater table level and composition must be monitored every 6 months or sooner (based on the geological and hydrogeological characteristics of the landfill) during the landfill operation and every 6 months during the post-closure and aftercare period. The parameters that must be analyzed are the same as the leachate monitoring system.

8.1.24 Landfill gas monitoring

A. Landfill gas surface emissions monitoring

A surface gas monitoring program should be established to detect any emissions through the cover/capping material and fugitive emissions from any gas extraction system present.

Landfill gas must be tested in the atmosphere 5cm above the landfill surface in areas where intermediate or final capping has been applied. Testing should be conducted in a grid pattern across the landfill surface at 25m spacing. Surface gas emissions monitoring should be done during operation on a monthly frequency or sooner if the environmental risk assessment indicates so.

B. Landfill gas sub-surface monitoring

In every landfill, a landfill gas sub-surface monitoring system must be established to demonstrate that landfill gas is not migrating off-site. For this reason, a network of landfill gas monitoring wells must be installed around the perimeter of the landfill cells. The wells should be spaced at sufficiently small intervals to detect any off-site migration to potential receptors. The required spacing and design of the wells will depend upon the environmental risk assessment addressing the source, potential gas migration pathways, and potential receptors. The distances between the wells cannot be more than 50m.

A section of a typical groundwater monitoring well is presented in Figure 6

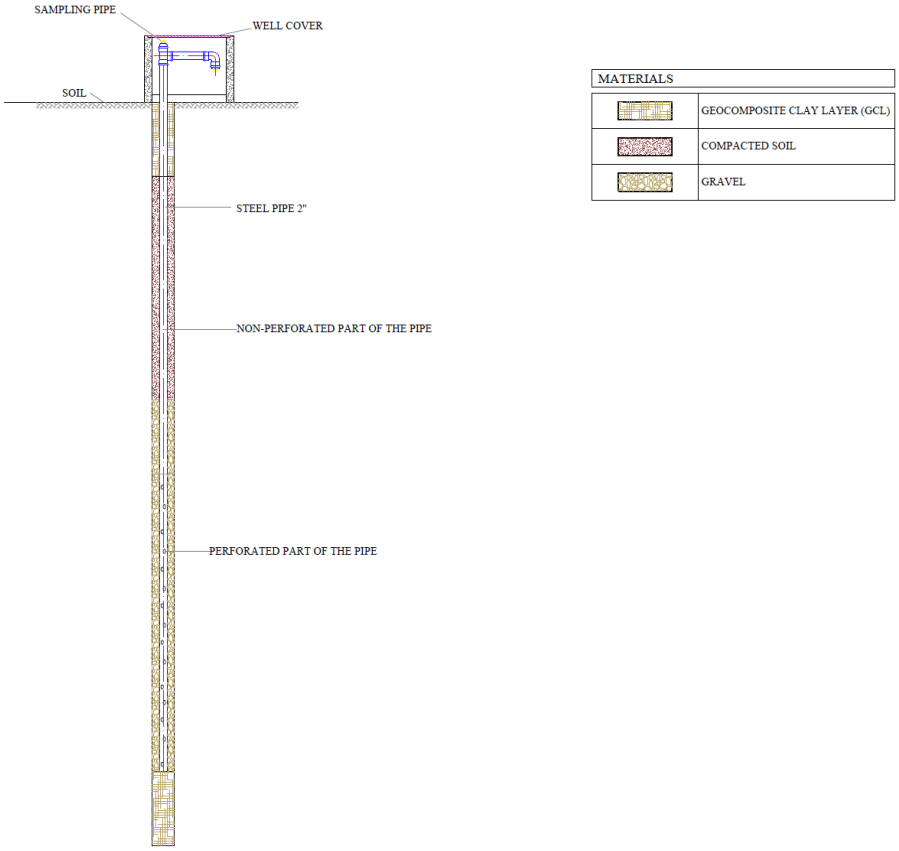

Figure 6: Landfill gas monitoring well typical section

Samples for landfill gas sub-surface monitoring must be taken and analyzed monthly during the operational phase of the landfill and in 6 months frequency during the post-closure and aftercare period.

The parameters that must be measured and analyzed in both surface and sub-surface landfill gas monitoring systems are CH_4, CO, CO_2, O_2, H_2S, H_2, total Cl, total S, N, and total F.

C. Gas accumulation monitoring in enclosed structures

A landfill gas accumulation monitoring program should be implemented to demonstrate that gas is not accumulating at dangerous levels in enclosed spaces on or near the landfill.

Landfill gas is primarily made up of methane and carbon dioxide and must not accumulate in buildings. Methane is explosive in the range of 5% to 15% (volume/volume), and landfill gas can be an asphyxiant in enclosed spaces.

The threshold level for further investigation and corrective action is the detection of methane at concentrations above 1% (volume/volume).

Measurements for gas accumulation in buildings as well as other enclosed structures must be done in monthly frequency with a gas analyzer, the same that will be used for the surface and sub-surface landfill gas monitoring system. The least parameters that need to be measured are biogas amount, CH_4, CO_2, CO and H_2S. Additionally and for the buildings that are closer to the landfill cells gas

detectors will be installed with alarm that will be activated when the landfill gas concentration reaches the limit of 1%

8.1.25 Waste body monitoring

Waste disposal must take place in such a way to ensure the stability of the waste body and the other components of the landfill cell (landfill gas wells, daily and intermediate cover, etc.). For this, survey works must be done regularly that will demonstrate the movements and settlements observed in the waste body. The measurements must be done monthly at the beginning of the operation of a landfill cell every 3 months after the completion of the cell operation and for 1 year and every 6 months in the post-closure and aftercare period.

9 ANNEX 4: Landfill operations

a) General Regulations

- The maximum speed for all vehicles inside the landfill area must be 30 km/hr. Traffic regulations for public roads will be valid also in the facility if no other specific guidance and/or traffic sign is in place.
- The staff of the facility shall secure the safe operation of the facility and carry out the necessary maintenance and urgent repairs of the machinery and equipment available.
- The staff of the facility is not allowed to carry out construction works on the site.
- External users (suppliers of waste) shall comply with the instructions and orders of the staff of the facility.
- The suppliers of waste shall accomplish their task and leave the site without any delay. Exemptions can be made only by the order of the staff of the facility.
- The fees for disposal of the waste received are calculated based on the weight, determined at the weighbridge.
- Scavenging and open fire is forbidden at the facility.
- Smoking, eating, and drinking are not allowed outside the designated premises.

b) Recording and reporting of data

The Landfill operator is responsible for the registration and reporting of data from the landfill and must keep a "Landfill Report Book" regarding the quantity and types of waste, which are received and accepted for disposal at the landfill, or which are rejected.

The Landfill operator shall establish and maintain an operating record for the landfill, and shall provide the operating record and its contents to the supervising authority, or any other Delegated Authority, upon request. The operating record must be maintained throughout the whole lifetime of the landfill and shall contain the following information:

i. a copy of the site permit;

ii. survey records of the landfill including waste body measurements indicated fill areas and other relevant information;

iii. the last version of landfill operation plan;

iv. records of the handling of any wastes accepted at the landfill, including the amounts accepted and disposal locations within the landfill;

During the active life of the landfill, the Landfill operator shall prepare **an annual report** for the landfill covering the calendar year from January 1 to December 31 and shall place the report in the operating record by March 31 of the following year. The annual report shall contain at least the following information:

i. the types and volume of wastes disposed of at the landfill in the reporting period, and the locations of disposal of wastes requiring special handling;

ii. the following environmental monitoring records and their interpretation:

   a. weather conditions/meteorological data

   b. leachate monitoring tests and results,

   c. leachate treatment plant's effluent monitoring tests and results,

   d. groundwater monitoring tests and results,

   e. landfill gas monitoring tests and results,

   f. records on the quality of surface water released to the environment,

   g. waste body settlements

iii. any remedial action is taken.

Typical Contents for the Annual Report are given in Appendix I.

Copies of the annual report shall be submitted in both hard and soft copies (in both pdf and editable format) to the contracting authority and to MoE. A printed copy of the "Landfill Annual Report" shall be kept in the administration building of the landfill and shall be accessible to the public upon request.

c) Health and Safety

All works and operations at the landfills shall be carried out in accordance with current rules and legislation regarding occupational health and safety.

Regular and documented instructions of the facility staff concerning safety rules are mandatory. Such documented instructions are further required for the newly employed staff and when new machinery, equipment or facilities are taken into operation.

Accidents can be minimized by implementing regularly safety and training programs and effective site management. These programs should include the following:

- Identification of potential sources of risk;
- Assessment of the degree of risk from these sources;
- Determination of procedures for addressing the risks;
- Development of procedures to minimize accident/risks when they occur; and
- On-going monitoring to ensure proper implementation of safe working procedures.

In light of these provisions, the operator should ensure the safety, health, and welfare at work of all persons employed in the landfill. This duty should include the following priorities:

- Plant and machinery should be maintained in a safe condition;

- Risks should be appraised and safe systems of work planned, organized and performed;
- Suitable safety information, instruction, training, and supervision should be provided;
- Suitable protective clothing and equipment should be provided and maintained;
- Emergency plans should be prepared and revised as necessary;
- That the presence of any article or substance on the site must not present unacceptable risks to health; and
- Adequate welfare facilities for staff must be provided and maintained.

d) Personnel

One or more persons must be formally designated for site safety issues. These persons should understand the statutory requirements, be able to act as competent persons under the legislation, and ensure the continued maintenance of a safe system of work. The later tasks should include matters relating to training and supervision. They should be responsible for the identification of hazards and designated managers should transmit such information by verbal or written instructions to the workforce, contractors, site users, and site visitors. Designated persons should undertake regular site safety inspections, with written reports of inspections maintained at the site.

e) Training

Operators should provide suitable training and instruction to site employees, both full time and part-time. The operator should also ensure that any contractor and sub-contractor working on site is also informed of the hazards and the necessary precautions. There is also a responsibility for persons employing contractors to ensure that the latter can act as competent project supervisors concerning the safety aspects of the relevant design and construction elements of their work. All site personnel should be familiar with contingency procedures in the event of accident, injury, fire, etc.

The locations of emergency equipment should be identified during routine employee training. Phone numbers for local police, fire and ambulance services, hospitals, and other relevant information should be prominently displayed for use in the event of an emergency.

f) Staffing Levels

All staff and users of the site should be effectively supervised. No site open to receive waste should be manned by one member of staff working on their own. Similarly, no unloading of vehicles should occur in the absence of site staff or out of their immediate view.

g) Medical

Good personal hygiene is essential to workers on landfill sites and hence washing facilities supplied with hot and cold water must be provided. It is suggested that all workers at landfill sites, including

those employed temporarily by the operator, or by contractors working on the site, should have adequate medical protection and vaccination against diseases and tetanus. This protection must be kept up to date, with boosters given at 10 yearly intervals or sooner according to the medical instructions. Workers have to pass a mandatory preliminary and periodical medical examination in accordance with the existing requirements.

9.1.1 First Aid

A first aid box should be available on-site in a clearly marked location. The contents of the box should be monitored for use so that supplies are checked regularly by a named individual responsible for its upkeep. The operator should arrange for recognized occupational first aid training, with a minimum of one person with a first aid qualification normally present on site. All staff should be familiar with the first aid facilities available on site.

9.1.2 Personal Protection Equipment

High visibility clothing should be provided and worn by all site staff and visitors at all times during their presence in the landfill site. Safety boots and/or wellingtons should be supplied to all site workers. They should have steel toecaps and have a steel insert in the sole to resist injury from projections of glass, metal, or other items in the deposited wastes. Gloves should be supplied as required. The gloves should be puncture-resistant and should be suitable for the relevant task, e.g. litter collection, vehicle fuelling, cold weather conditions. Safety helmets, earplugs, and eye protection should be available as necessary. Operatives at landfill sites work in all weather conditions and will need to be provided with suitable windproof wet weather clothing.

When working at the tipping front or any other place in the landfill cells, where waste is handled, the following personal protective equipment shall be used additionally:

- Dust masks or respirator devices.
- Goggles or full face masks.
- Pressurized cabins on the equipment operating at the landfill tipping front.

Reflective safety jackets or waistcoats must be worn all the time. The Operator of the facility is responsible for providing necessary personal protective equipment as stated above or which might be needed in a specific situation or for a specific assignment.

h) Traffic and Machinery

General rules for traffic at the premises:

In general, rules, which apply to traffic on public roads, also apply to the premises of the landfill. Additionally, an overall speed limit for all vehicles and mobile machinery of a maximum of 30 km/h shall apply inside the landfill site.

The Operator of the facility shall display clear markings and signboards stating the directives for all traffic at the premises. Signs stating the overall speed limit must be placed at the entrance gate. Other signs within the premises must show driving directions for the incoming and outgoing vehicles with clear marking of one-way roads and right of way at crossings.

Areas where traffic of transport vehicles and mobile working machinery, e.g. the front loader, are mixed and areas, where staff may be working, are potential risk spots. These areas shall be clearly marked for the attention of the drivers and pedestrians, and the speed limit shall be reduced even further.

Vehicles and mobile machinery:

Only vehicles and other mobile machinery that either belong to the facility or have a legal task are allowed at the premises of the landfill. The vehicles may only move along the internal roads of the facility observing the above-stated rules for traffic.

Pedestrians and staff working on the ground:

When moving by foot on the premises or working on the ground all staff and visiting personnel shall always watch out for traffic. Special attention shall be paid to reversing vehicles and to machinery in operation.

Illumination:

The Operator is responsible for maintaining sufficient illumination of trafficked and working areas during working hours.

Use of machinery:

Any machinery may only be used for the purpose it was constructed. The following general rules must be observed:

- Any adjustments of machinery and its movable parts may only be done while the machinery is turned off.
- A machine may never be left running idle. The engine shall be turned off and the key removed from the machinery/vehicle when the operator leaves the machine.
- No machinery or vehicle may be left with movable parts - e.g. the shovel of the front loader - lifted.
- The areas, where vehicles or other machinery usually heats up, shall be kept free from combustible materials to minimize the risks for fire.
- At all times the windows of the cabin of any machinery or vehicle shall be kept clean, to ensure a clear view for the operator.

i) Scavenging

Scavenging is the separation and removal for re-use of items such as scrap metal. The practice is dangerous and interferes with the efficient operation of a landfill. Scavenging is perhaps the greatest single cause of accidents and fatalities at landfill sites, due to the partially obstructed view of drivers

of vehicles when they are reversing. For these reasons, scavengers should be prohibited by an operator wishing to manage its site in line with international best practice.

j) Input acceptance procedure

Incoming traffic enters at the main entrance of the Site and proceeds to the weighbridge. Procedures for receiving vehicles at the weighbridge are as follows:

- Vehicles drive onto the weighbridge scale and stop
- The Weighbridge Operator records the date and time, vehicle account number (this will reference the waste origin/hauler), waste type, approved application number if applicable, the current location of solid waste placement, gross vehicle weight, tare weight and the net weight of waste in the computer.
- Vehicles are directed to the active working area of the landfill cell
- At the end of each day, the Weighbridge Operator generates a report showing the total tonnage received, and tonnage received from individual sources. The weighbridge computer database allows several reports to be generated depending on the nature of the information required in the report.

9.1.3 Waste acceptable for reception at the facility

During the reception procedures, the Operator shall ensure, that only waste, which can be accepted for disposal at the landfill is admitted and that the waste is controlled and registered before admittance. Prohibited wastes are to be rejected.

The facility must receive only solid waste as listed in the environmental and operational permit of the landfill. The waste must be in a form ready for disposal.

To provide efficient operation of the facility, the Operator must also impose further restrictions concerning:

- the condition and composition of waste
- waste packaging
- preliminary treatment, e.g. sorting

9.1.4 Permission for disposal

Only wastes from waste producers, who have a valid permit for disposal, are accepted.

Together with the first delivery, the waste producer must submit an application for the delivery of waste to the facility. The application shall state the following data:

- Full name of the organization/company
- Address
- Telephone number
- Managers' names.
- Registration number/code of the truck(s) to be used for the delivery of waste to the facility.

- Types of waste to be delivered
- Documentation for the waste disposal approval licensed by the Municipality

After the first delivery the waste producer receives the following documents for admissible waste:

- A registration card containing Client No, which will define the registered names, address, telephone- and truck registration number(s).
- Waste declaration, which specifies the types of waste that the waste producer, is allowed to deliver to the facility.
- Waste collection companies must obtain similar registration cards for each of their collection trucks at the first delivery of waste to the facility.

9.1.5 Non-Conforming Waste Consignments

Non-conforming waste consignments arriving at a waste disposal site may be identified at:

- Site reception;
- Weighbridge;
- Waste inspection facility; and
- Disposal face.

Non-conformances may be due to the documentation being incorrect, insufficient, or inaccurate, or due to the waste not conforming to the documentation, the waste management license, or other legal requirements. The site's management team should compile a written procedure detailing how to deal with nonconforming wastes. All site personnel should be aware of the chain of reporting and the actions to be taken. An area should be set aside for vehicles to be held, pending a decision regarding their future. The regulatory authority should be contacted to provide advice regarding whether the load can be accepted or whether it should be recognized to another location.

In the case of the delivery of large quantities of waste, the facility must be informed in advance. The facility determines the time for the delivery.

9.1.6 Exclusion of waste suppliers

The Landfill Operator can deny suppliers to use the facility if the suppliers intentionally deliver prohibited waste or repeatedly violates the site regulations.

9.1.7 Reception of Waste in Small Vehicles or Private Cars

Private individuals can deliver waste for disposal at the landfill by their transport without prior agreement. The Landfill Operator must direct the relevant vehicles in the incoming loads sampling area for load control.

9.1.8 Control of incoming waste

All waste delivered to the facility shall be controlled by the Landfill Operator. The control comprises:

- Registration of the waste transportation truck and the waste producer.
- Weighing and registration of the waste.

- Control of delivery documents (i.e. declaration and registration card).
- Direct visual control of the waste for type and composition for compliance of waste type with documentation.
- Waste delivered in open trucks shall be inspected visually at the reception area in connection with the weighing procedure and after unloading in the landfill cell. Waste delivered in closed trucks shall be visually inspected at the landfill cell after unloading and before the waste is compacted and covered.

All information is recorded in the data system, stored and secured.

k) Registration

Records of all data concerning reception and transport of waste to and from the landfill are registered in the software data system connected to the weighbridge. The operator of the weighbridge and registration system is responsible for the input to the data system of all relevant data for each incoming truck, for each shipment of waste leaving the landfill or being rejected at the gate. Input data will consist of:

- Date and time for the arrival of the delivery to the landfill.
- Data regarding the waste supplier:
- Full name of the company.
- Address.
- Telephone number.
- Managers' names.
- Registration number/code of the truck.

Companies delivering waste regularly will receive a registration card as described previously. The above data is encoded in the card and will automatically be recorded in the computer system.

The waste producer and the origin of the waste as stated in the waste declaration

If the waste is delivered in trucks that have no registration card the above-mentioned data shall be recorded manually.

9.1.9 Weighing and registration of the waste

All incoming and outgoing trucks carrying waste shall pass over the weighbridge and be weighed and registered. Data from the weighing procedure (including data for rejected waste and waste transported from the landfill) shall be recorded in the data system.

Persons specifically trained in its use shall operate the systems. A special instruction manual for operating the data recording system will be prepared for the staff by the supplier of the weighing system.

The manufacturers' operation manuals for the individual units shall be adhered to strictly.

Each weighing procedure shall as a minimum comprise:

- Truck registration number
- Owner of the truck
- Waste origin/producer
- Waste type
- Weight of the waste.
- Acceptance/non-acceptance of the waste at the landfill
- The place - Cell no - of disposal of each load.

Data from each weighing procedure shall be recorded in a database. At the end of each day, a back-up copy of the weighing of the day shall be produced in an adequate storage unit i.e. USB flash drive, CD, etc.. The back-up files shall be stored in the Administration Building.

l) Rejection of Waste

If the control shows that the waste is not in compliance with the types of waste permitted to be disposed of at the landfill, then the waste shall be rejected.

- If the waste is still on the delivery truck, the driver will be required to return the waste to the producer of the waste. The waste producer can then perform a pre-treatment (e.g. sorting) to bring the waste into compliance with the types of waste for which he has an approved declaration and which will allow the landfill to receive the treated waste.
- If the waste is already unloaded at the landfill cell, but not yet compacted and covered, the waste shall be loaded back into the truck and returned to the waste producer at his expense.
- In case it is not possible to re-load the waste into the truck (e.g. when the waste has been delivered in closed or compacting trucks) the waste will then be loaded into an open maxi-container and returned to the waste producer or the transporting company at his expense.

If a more detailed analysis of the waste is required before final acceptance or rejection, the waste load temporarily rejected and is returned to its producer for storage until the final decision can be made.

For all incidents where delivery is rejected, the Site Manager must issue a violation statement and inform the competent authorities.

m) Waste Supplier Departing the Facility

For conforming waste the truck driver will receive a confirmation of the delivery. The receipt documents will indicate the basic delivery data, the delivered quantity (tons), and the fee for receiving the waste at the facility.

n) Sanitary landfilling process

The basic parameters of the sanitary landfilling are:

Daily cell: it is the basic structural unit of the landfill. The shape of the cell is usually slanted cube. The dimensions of the cell may differ from day to day. The main objective is to construct a cell that can handle the day's volume of solid waste and which will require the minimum amount of daily cover soil.

Lift: a set of cells with the same altitude forms a lift. Lift is the ground where the movement of the trucks takes place.

9.1.10 Daily cell geometrical characteristics

The shape of the daily cells in a landfill is usually slanted cube. Dimensions of the daily cell may differ from day to day. The main objective is to construct a daily cell that can handle the daily waste volume and which will require the minimum amount of daily cover soil i.e. the daily cell will have the minimum amount of surface area.

The first step of the daily cell design is to determine the cell width. In general, the width of a cell must be kept in a minimum size. A narrow daily cell will help reduce litter and cover soil use. At the same time, the daily cell must be wide enough to allow the day's maximum number of trucks to unload as well as to allow the compactor to operate efficiently.

It is important for the stability of the daily cell and safety reasons, that the slope of the daily cell and the working face will be kept in a maximum of 1:3 (height: advance)

9.1.11 Daily cover

At the end of the day, all waste must be covered to protect it against rodents and to avoid air blown litter leaving the landfill. This requirement may be fulfilled by the use of tarps and/or soil. When using tarps for daily cover material of the current waste slope ensure all waste is covered and the tarps have been overlapped.

When using soil as daily cover at least 20 cm of compacted soil must cover the slopes and the top deck by the close of business each day. In some cases, more soil than the minimum amount may be required so that after compaction, the slope layer and top deck will have 20 cm of cover material. For example, loose soils such as sand and silt may drop into voids in the waste. For this reason, proper compaction is essential to minimize the amount of daily cover soil required.

The material used for daily cover must be preferably free draining i.e. with hydraulic conductivity of greater than 5×10^{-6} m/s 1 and of a low clay content.

9.1.12 Intermediate cover

The intermediate cover is a more substantial cover than the daily cover. It is used to close off a cell that will not receive additional lifts of waste for some time or will not be finally capped for some time.

Any waste-filled areas that have not been landfilled for more than 90 days should have an intermediate soil cover meeting the following requirements:

- the cover layer should be a minimum 30cm layer of virgin excavated natural material in the form of a fine-grained, largely cohesive soil
- soil should have a saturated hydraulic conductivity of less than 1×10^{-5} meters/second

- the cover layer should restrict the rainfall infiltration rate into the waste to 20% of the total rainfall

9.1.13 First layer of waste

The first layer is very crucial for the landfill operation. During the placement of the first layer, the following problems may occur:

- Damage to the lining system of the landfill
- Disruption of the leachate collection system of the landfill

The procedure for the right construction of the first layer is the following:

- The access road to the working face must be constructed from the top to the bottom in a way that ensures that the landfill vehicles will roll on soil ramps instead of the bottom of the landfill
- At the end of the access road, a relatively wide temporary area must be constructed for the manoeuvering of the trucks
- The first trucks must dispose of the waste at the end of the access road or the temporary movement area on the landfill bottom
- Bulky and wastes capable of puncturing the liner must be removed
- The first waste should be disposed, at a vertical height of about 20 – 40 cm and must not be compacted, so as to constitute a protection – layer of the liner system

The above procedure will cease when the whole area of the landfill bottom is covered with waste at a vertical height of about 20 – 40 cm so that no landfill equipment will roll onto the liner or the drainage system of the landfill.

9.1.14 Waste Compaction / Placement

Waste compaction is the most important process during landfilling. Proper compaction of the disposed waste increases landfill's lifetime, it is essential for the development of a stable and safe waste body and creates the necessary conditions (anaerobic conditions) for the quicker generation of landfill gas and the biodegradation of the waste disposed of.

Layer thickness is a function of waste characteristics and equipment size. Waste that is wet and homogeneous with few large items may be compacted in thicker layers without compromising waste density, waste containing large items such as appliances or wood may require more passes and thinner layers to break and compact it. Similarly, large, heavy equipment such as compactors may be able to work effectively with thicker layers, whereas, smaller dozers or compactors may require thinner layers to provide good waste density.

APPENDIX I Typical Contents for the Annual Report

Executive Summary

1. Overview
2. Facility Information
3. Landfill Capacity Analysis
    3.1. Capacity Analysis
    3.2. Landfill Development Status
4. Waste Disposal Quantities
5. Summary of Groundwater, Surface Water, Leachate, and Landfill Gas Monitoring Results
    5.1. weather conditions/meteorological data
    5.2. leachate monitoring tests and results,
    5.3. leachate treatment plant's effluent monitoring tests and results,
    5.4. groundwater monitoring tests and results,
    5.5. landfill gas monitoring tests and results,
    5.6. records on the quality of surface water released to the environment,
    5.7. waste body settlements
    5.8. Proposals on Environmental Monitoring Program
6. Summary of Landfill Personnel Training Program
7. Emergency and/or corrective actions and measures
8. Attachments

Attachment A – Data and analysis regarding the remaining Capacity Analysis

Attachment B – Annual Permit Renewal Application and Disposal Fees

Attachment C – Environmental monitoring tests results

Attachment D – Topography, Cross-Sections, and Settlement Monitoring Stations

10 ANNEX 5: Landfill aftercare and post-closure management

After the rehabilitation, and during the post-closure or aftercare period, landfill/dumpsite owner must monitor the integrity and performance of the final capping. The post-closure period must finish when the site is stable and not polluting i.e. leachate and landfill gas are not generated any longer. The duration of this period is different from site to site and is affected by various factors like specific site's characteristics, the type and amount of waste disposed of, the operational techniques used during disposal, the compaction rate of the waste, etc. An indicated duration of the aftercare period is 30 years after the application of the top cover system.

To assess the continued integrity and performance of the final capping, post-closure monitoring for landfills and dumpsites must include the following components:

- regular visual inspections for deterioration of the capping's condition, including erosion, cracking, dead or stressed vegetation, ponding, differential settlement, slope instability, and damage to any pipes, drains and other works installed on the final capping
- regular surveys for indications of differential settlement, using appropriate techniques such as topographic surveys and settlement plates
- repair and/or replacement of portions of the final capping found to be damaged
- monitoring of leachate and rainfall volumes
- measurement of landfill gas emissions.
- Maintenance of the site facilities like leachate treatment plant, biogas management system, roads, surface water management system, etc.

Additional to the above activities, during the aftercare period the vegetation and planting system's integrity and performance must be also monitored, including the following:

- monitoring (sampling and testing) of water used for irrigation of the vegetation and planting system
- removal/replacement of trees and plants that have failed to establish
- soil maintenance operation
- vegetation maintenance, i.e. mowing, pruning, thinning, etc

For the completion of the aftercare period of a landfill/dumpsite the following minimum criteria must be met:

- Landfill gas concentration levels in all wells have fallen to less than 1% methane (volume/volume) and less than 1.5% carbon dioxide (volume/volume) above the established natural background for 24 months.
- Analysis of the leachate composition indicates low levels of contamination posing no hazard to the environment, and surface water and groundwater monitoring indicate no water pollution.
- The final capping system has been assessed over some years and found to be in good condition and stable, with acceptable surface water drainage and with no evidence of erosion, cracking, dead vegetation, ponding, differential settlement, or slope instability.

- The level of suspended solids in rainwater running off the final capping should be less than 50 milligrams/liter.
- The methane concentration at the surface of the final capping should not exceed 500 parts per million at any point.
- The closed landfill no longer poses an adverse amenity risk. It does not generate offensive or excessive odor, dust, noise, litter, and debris, present a fire risk, or attract scavengers and vermin.