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Provision of Engineering Design, Supervision and Associated Services for Sanitary Landfills and Solid Waste Treatment Facilities, Lebanon

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Operation Manual -
SRAR- AKKAR

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1 Introduction

Lebanon is characterized by regional socio-economic disparities with almost 30% of the population living under the poverty line and 8% under the extreme poverty line.1 Due to the absence of a modern legal framework on decentralization, a lack of appropriate human and financial capacities and a non-performing fiscal system the quality and accessibility of public services is often quite low.

Since the start of the Syrian conflict in 2011, Lebanon has witnessed a massive influx of refugees. According to the United Nations High Commissioner for Refugees (UNHCR), on 31.05.14, the total number of Syrian refugees in Lebanon was equivalent to 1,087,814 (including those which are registered and those awaiting registration). This number constituted around 37% of the total number of the 2.7 million Syrian refugees recorded across the region on the same date. When the remaining refugees from the Syrian conflict are taken into account (unregistered Syrian refugees residing in Lebanon, Palestinian Refugees from Syria (PRS) and Lebanese returnees from Syria), the total number of refugees in May 2014 becomes equivalent to 1,403,718 persons, which constitutes 28.9% of Lebanon's pre – conflict population estimated at around four million persons in 1997.

Efforts to coordinate the humanitarian response in Lebanon have been deployed at central, local and interagency levels. The Prime Minister's Decision no. 146/2013 (amended respectively by Decisions no. 72/2014 and no. 75/2014) established a committee to prepare an assessment of the needs for the humanitarian response for the refugees and the hosting communities, addressing in particular developmental aspects. Humanitarian response and coordination efforts are jointly led by the Prime Minister's Office, the Ministry of Social Affairs (MOSA) and UNHCR.

In November 2013, the Government of Lebanon with the support of the World Bank and the United Nations prepared the "Lebanon Roadmap of Priority Interventions for Stabilization from the Syrian Conflict" based on the "Economic and Social Impact Assessment of the Syrian Conflict" which was also prepared by the World Bank and the United Nations in September 2013. The Roadmap included a preliminary set of priority interventions intended to contribute towards qualitatively and quantitatively alleviating the impact of the Syrian conflict on Lebanon. While the Roadmap includes some environmental considerations linked to service delivery, it adopts social and economic aspects as the main drive for analysis and costing of interventions for stabilizing the Syrian crisis.

With a resident population of 4.2 million and an average waste generation rate of 0.95 kg/capita/day (1.1 kg/d in urban areas, 0.7 kg/d in rural areas), Lebanon generates about 1.57 Million tons of waste per year (SWEEP-NET 2010, CAS 2008, and UNRWA 2008a). Waste generation is expected to increase by 1.65% annually to reach 2.3 Million tons by 2030, notwithstanding potential waste recovery from sorting and composting facilities (WB/METAP, 2004). Waste disposal is particularly difficult in Lebanon because of its rugged terrain and limited surface area.

Population growth, urbanization and dwindling land areas are exacerbating solid waste management (SWM) issues in Lebanon to the brink of a national crisis. Nationwide, an estimated 51% of all municipal solid waste (MSW) is landfilled, 32%is dumped, and the remaining 17%is recovered through sorting and composting (SWEEP-NET 2010). Government and donor – funded studies and master plans related to

SWM have to date not generated the desired long-term results. Political wrangling and indecision as well as environmental constraints have so far prevented the implementation of a comprehensive plan for SWM in Lebanon.

In Beirut and Mount Lebanon (excluding the Caza of Jbeil), Solid Waste Management (SWM) is still based on the 1997 Emergency Plan. Waste collection from curb side containers and other designated disposal areas is provided by Sukleen and transported to two sorting plants in Aamrousieh and Quarantina respectively. The (original) Emergency Plan assumed that Sukleen would collect 1,700 tons per day (equivalent to 620,000 t/y); and recover 160 tons per day of recyclables (9.41% of incoming waste). As the geographic coverage of Sukleen expanded, the design capacity of 1,700 tons per day was quickly exceeded to reach about 2,200 tons per day in 2008, and waste recovery rates dropped to around 6-7% (SWEEP-NET, 2010). Recyclables include cardboard (about 40-45%), plastics (27-29%), and other items (tins, wood, tires, glass, and aluminium).

About 300 tons of organic waste (about 13% of incoming waste) is processed in the Coral compost plant producing 110 tons of finished compost. The remaining waste fraction (about 1,800 t/d or 82% of waste stream) is baled, wrapped and hauled for final disposal at the Naameh Landfill. Bulky items are sent to the Bsalim Landfill site. As reported in the 2001 SOER, and notwithstanding compost quality, the GOL faulted in the implementation of the Emergency Plan by not providing an additional composting plant. The current compost plant (Coral) is small and cannot handle more than 300 tons per day (equivalent to 109,500 t/y), about 17.6% of the waste stream envisioned in the CDR-SUKOMI contract.

Outside Beirut and Mount Lebanon (minus the Caza of Jbeil), municipalities continue to assume lead responsibility for carrying out SWM operations (sweeping, collection and disposal), pursuant to Municipal Law No. 118 (dated 30 June 1977). Municipalities either use their own waste collection vehicles and workers or outsource the service to private contractors. Towns with no municipal councils typically piggyback on the collection and disposal system of neighboring municipalities based on mutual agreement, or illicitly. Recycling and composting outside Beirut and Mount Lebanon is estimated at 5 and 13% of the waste stream, respectively (SWEEP-NET, 2010).

Under the EU-funded program Assistance to the Rehabilitation of the Lebanese Administration (ARLA), OMSAR launched a municipal SWM program to improve the provision of solid waste services in rural areas. A new unit was created within OMSAR to manage the implementation of the €14.2 million Euros EU-funded program (to build and equip the facilities) and related investments worth $36 million US dollars from the National treasury (to operate and maintain the facilities). The program has to date financed 18 SWM activities targeting 177 municipalities representing about 1.15 Million people. The cost of each activity varied between €100,000 and €1.4 Million. The type of assistance provided was determined through Expressions of Interest submitted by individual municipalities or groups of municipalities. Some municipalities received waste containers; others received waste collection vehicles, and/or sorting and composting facilities. The program also financed one sterilization center for medical waste in Abbassiyeh (south Lebanon). In 2010, the program lobbied the GOL and secured a financial commitment to operate and maintain the facilities using funds from the national treasury (COM decision 34 dated 31/5/2010 and Decree 3860 dated 19/4/2010).

The project of which this contract will be a part the "Upgrading Solid Waste Management capacities in Bekaa and Akkar regions in Lebanon (SWAM I)" programme aims at improving the overall efficiency and effectiveness of Waste Management in the targeted areas. The action will directly contribute to address the medium and longer term needs of the Lebanese communities highly affected with Syrian refugees concentrations for increased and improved waste disposal services, by building and upgrading SWM infrastructure and equipment at local level and by enhancing the overall management capacity of local administrations i.e. Municipalities in the SWM sector.

Furthermore, the European Union Delegation in Lebanon and the Office of the Minister of State for Administrative Reform (OMSAR) are in the process of obtaining additional grant to fund projects in solid waste management sector with same objective, however, it will be financed under new financing agreement and it will be named SWAM II.

Figure 1: Administrative map of Lebanon

The overall objective of the present project "Provision of Engineering Design, Supervision and Associated Services for Sanitary Landfills and Solid Waste Treatment Facilities, Lebanon" under the

"Upgrading Solid Waste Management capacities in Bekaa and Akkar regions in Lebanon (SWAM I)" programme is to improve the overall efficiency and effectiveness of Waste Management in the targeted areas.

The present report stands for the operational and maintenance manual of the Landfill, Sorting Station and Composting in the Waste Management Facility in Srar Akkar.

The structure of the study includes two parts:

- Operational manual of Landfill and Sorting - Composting Facilities
- Drawings

2 Information about the Srar Akkar Waste Management Centre

2.1 General information

The new landfill and waste management facilities (sorting station and composting facility)are located in Srar village at the North of the Akkar Governorate in North Lebanon, close to the Lebanese – Syrian border.

Akkar Governorate is one of eight governorates of Lebanon and it stretches from El Bared River south to El Kebir River along the Lebanese – Syrian border in the north, an area of up to 776 km^2.The waste treatment facilities to be constructed in Srar will serve all the Municipalities and Villages located within the Akkar Governorate.

Srar village is located at an altitude varying between 90 to 200 m above sea level (asl) and it distances around 11Km to the North of Halba (Akkar's capital), and around 40 km to the north east of Tripoli (main North Lebanon's city) and around 125 km to the North East of Beirut, the Lebanese Capital. Also Srar is located at only 2 km to the South of Al Abboudiye borders with Syria and around17 km to the East of the Lebanese Coast as shown in Figure 2.

Figure 2: Proposed site map location (coordinates: 34°37'01.6"N 36°07'47.4"E)

Key characteristics of the landfill are:

Table 1-1: Key characteristics of the landfill

Landfill gross capacity	1,000,000	m^3
Landfill net capacity	909,091	m^3
Ascent of slopes (landfill base)	1:2/1:5	
Ascent of slopes (top)	1:3	
Max. height above sea level	165	m
Max. height of waste Phase A	29.30	m

Bottom area	12,000	m²
Size of waste disposal area (landfill base)	27,915	m²

The administrative address of the Waste Management Centre is:

[The administrative address of the Waste Management Facilities]

2.2 Landfill class / Waste types

The new Waste Management Centre is classified and constructed as a "non-hazardous waste management center", and will as such only receive domestic (municipal solid) residual waste.

The detailed list of the waste types allowed and prohibited for reception at the facilities is presented in Appendix.

2.3 Owner and operator

The owner of the Waste Management Centre is:

[Administrative address, phone number]

and the Operator is:

[Administrative address, phone number]

The Operator is responsible for the security and the legal exploitation of the Waste Management Centre in accordance to the actual regulations and legislation. Main tasks are:

- Implementation of all control and monitoring documentation including reporting of the waste
- Visual control of the waste at the entry of the Waste Management Centre and at the place of waste disposal
- Specimen samples from the waste, which are saved minimum three months by the operator
- Regular visual inspection of the waste at the place of their disposal for ensure that on the landfill is disposed of only permitted waste
- Control of the kind and composition of the coming waste
- Following strictly the technology of waste disposal
- Monitoring the situation of the technological equipment and the reliability of the ground and construction and installations

- Temporary covering of the filled cells
- On time information of the responsible supervising authority about every kind of pollution of the environment
- Closure of the entry gate of the Waste Management Centre outside the working hours in order to avoid free access to the site and to prevent illegal waste disposal;
- All necessary activities for restrict from danger and injuries, caused by:
  - Smell and dust emissions
  - Carried by the wind waste
  - Sources of noise and such caused by the transport on the Waste Management Centre territory
  - Birds, pests and insects
  - Aerosol formation
  - Waste flare
- All necessary activities and supplies to prevent from waste distribution out of the Waste Management Centre over the roads and the surrounding area.

2.4 Supervisory and regulatory authorities

Table 1-2: Data of supervisory and regulatory authorities

Area of supervision	Authority		
	Name	Administrative address and telephone	Contact person
Operation and monitoring	[Fill in]	[Fill in]	[Fill in]
Discharge of Sewage to public sewerage system	[Fill in]	[Fill in]	[Fill in]
Fire safety	[Fill in]	[Fill in]	[Fill in]
Occupational health and safety	[Fill in]	[Fill in]	[Fill in]

Any revisions of the Operation and Maintenance Manual shall be coordinated with the above - mentioned instances.

2.5 Permission for operation

The Operator is in possession of the following permits for the operation of the facility:

Table 1-3: Data of permits for operation

Title	Competent Authority	Date of issue or revision	Location of permit
[Fill in]	[Fill in]	[Fill in]	[Fill in]
[Fill in]	[Fill in]	[Fill in]	[Fill in]
[Fill in]	[Fill in]	[Fill in]	[Fill in]
[Fill in]	[Fill in]	[Fill in]	[Fill in]

The original permits shall be kept with other required and/or legal documentation. In case only a copy of the permit is available, it must be stated where the original is located.

2.6 Working hours

The Waste Management Centre is open for waste suppliers:

Table 1-4: Working hours for waste suppliers

Monday	[Fill in]	-	[Fill in]
Tuesday	[Fill in]	-	[Fill in]
Wednesday	[Fill in]	-	[Fill in]
Thursday	[Fill in]	-	[Fill in]
Friday	[Fill in]	-	[Fill in]
Saturday	[Fill in]	-	[Fill in]
Sunday and holidays	[Fill in]	-	[Fill in]

The working hours for the Waste Management Centre staff are:

Table 2-5: Working hours for landfill staff

Monday	[Fill in]	-	[Fill in]
Tuesday	[Fill in]	-	[Fill in]
Wednesday	[Fill in]	-	[Fill in]
Thursday	[Fill in]	-	[Fill in]
Friday	[Fill in]	-	[Fill in]
Saturday	[Fill in]	-	[Fill in]
Sunday and holidays	[Fill in]	-	[Fill in]

Information about the opening hours shall be announced on a signboard located at the entrance to the facility. Outside the opening hours the facility is closed for reception of waste, the main gate is locked and the area shall be under surveillance of a guard. Admission to the facility outside opening hours is only possible by individual and special arrangement / agreement, e.g. in the event of campaigns for municipal solid waste collection (sanitary days). Outside opening hours the facility may only be open upon specific order from:

[Position and name of the person]

2.7 Admission

The Waste Management Centre is open for waste suppliers:

The total facility area is surrounded by a security fence preventing unauthorized admittance to the facility. Access to the landfill is through the main gate only.

Admission to the Waste Management Centre is restricted to the following:

- Waste Management Centre staff
- Representatives of the Waste Management Centre Operator and/or Owner

- Representatives of the Regional Environmental or other relevant authorities
- Customers, delivering waste
- Others, who are granted permission to enter the site by the Waste Management Centre Manager

Any person seeking access to the Waste Management Centre area must approach the personnel at the gate for identification and for approval of admission.

Representatives from the relevant authorities visiting the Waste Management Centre area in course of their supervisory duties must inform the Waste Management Centre Manager or his representative upon arrival to the facility.

The staff of the Waste Management Centre is responsible for visitors and must ensure that they are familiar and comply with existing safety regulations during their visit to the Waste Management Centre site.

2.8 Waste types and tariffs

The landfill can only receive the waste types stated in appendix:

Table 1-6: Accepted waste types and tariffs

No.	Types of waste	Tariff (€/ton) *)
1.	[Fill in]	[Fill in]
2.	[Fill in]	[Fill in]
3.	[Fill in]	[Fill in]
4.	[Fill in]	[Fill in]
5.	[Fill in]	[Fill in]
6.	[Fill in]	[Fill in]
7.	[Fill in]	[Fill in]

The calculation of the tax for disposal waste must restore the expenses for construction of the landfill and to cover the expenses for work, monitor, closure and after work care of the landfill for a period of time between 6.5 – 16 years.

Information about the tariffs must be announced on a signboard located at the entrance to the facility.

2.9 General regulations

- Traffic regulations for public roads are valid on the site of the facility
- The staff of the facility shall secure the safe operation of the facility and carry out necessary maintenance and urgent repairs of the machinery and equipment available
- 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 order of the staff of the facility
- Scavenging and open fire is forbidden at the facility
- Smoking, eating and drinking is not allowed outside the designated premises

2.10 Contact list in case of emergency

Table 1-7: Responsible person and telephone in case of emergency

Authority	Responsible person	Telephone
Landfill Operator	[Fill in]	[Fill in]
Office of Mayor of Srar Akkar	[Fill in]	[Fill in]
Department of Environment	[Fill in]	[Fill in]
Fire Department	[Fill in]	[Fill in]
Urgent Medical Aid	[Fill in]	[Fill in]
Police Office	[Fill in]	[Fill in]
Electricity Supply	[Fill in]	[Fill in]
Water Supply and Sewage	[Fill in]	[Fill in]
[Other relevant authorities - Fill in]	[Fill in]	[Fill in]

The procedures in case of emergency are presented in Chapter No.4.

Table 1-8: Authority to call in case of emergency

Emergency Authority to call	Accidents	Fire	Earthquakes and floods	Failure in supply systems
Landfill Operator	X	X	X	X
Municipality of Srar Akkar	X	X	X	X
Department of Environment		X	X	
Fire Department		X	X	
Urgent Medical Aid	X	X	X	
Police Department	X	X	X	
Electricity Supply			X	X
Water Supply and Sewage			X	X

The content of the above tables shall be displayed on readily accessible and readable signboards on the site of the facility.

2.11 Maintenance of technical facilities and equipment

Technical facilities, equipment and machinery used at the landfill must be maintained and repaired according to the supplier's/producer's specifications. Instructions on the frequency and methods of lubrication, oil change and inspections must be followed strictly.

In so far the warranty of technical facilities and equipment allows this, the technical staff of the facility shall carry out the following works:

- reoccurring technical maintenance work
- minor repairs
- control inspections

Further the staff shall ensure that major repairs and maintenance works are ordered and carried out in time according to the requirements in the suppliers' specifications.

Detailed information on the maintenance procedures is presented in Chapter No. 4 "Maintenance Procedures".

2.12 Recording and reporting of data

The Operator of the landfill is responsible for the registration and reporting of data from the Landfill, and is obliged to keep a "Landfill Report Book" on the quantity and types of waste, which are received and accepted for disposal at the landfill, or which are rejected. In the report book the following information should be registered as a minimum: the date of delivery, the owner of waste and the person who delivers and collects the waste, the origin and code of waste. If possible the Landfill Report Book should use the digital information from the weighing.

Not later than by the end of each month a printed report containing daily statistics and a summary of the monthly registration shall be inserted in the "Report Book".

A "Landfill Annual Report" (printed report), containing statistics and summaries for the weighing-data of the year, including all other data related to the operation and control of the facility, shall be issued to:

- Deadline for issuing the annual report is 31. March of the following year.

A printed copy of "Landfill Annual Report" shall be kept in the administration building of the landfill and shall be accessible to the public upon request

2.13 Occupational health and safety

All works and operations at the facility shall be carried out in accordance with current rules and legislation regarding occupational health and safety. Details are presented in Chapter 7 "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.

3 Landfill, sorting (mechanical treatment) and composting facilities design

The area of the site for the waste management facilities including the sorting and composting facilities is 197,702.51 m^2. The area of the landfill is foreseen at the southern part of the site, whereas the sorting and composting facilities are located at the central and northern part of the site.

The entrance to the site is carried out through the existing road on the northeast border of the field. Passing the entrance gate and following the main internal road after 50 m and with direction to NE the waste collection vehicles are being directed to the weighing facility.

The weighing facility comprises the erection of the weighbridge as well as the weighing building (Guard house). All the entering vehicles that do not have to be weighed can bypass the weighbridge through a separate lane of the main internal road.

Passing the weighbridge and following the internal road after 100m with direction to N, vehicles are being directed to the plateau where the Mechanical Sorting Building is located. Near the Mechanical Sorting Building there is a storage area for recyclables, a biofilter and a fan-bag filter. Also there is enough space for containers for the storage of glass and ferrous metals. Close to the storage area of recyclables, there is the administration building and the water tank. In the same plateau the refinery area and the storage area for compost are located. The whole plateau covers an area of 18,516 m2at a mean elevation of +133.60 m and it has been designed with an inclination of 1.50% so that all washings and rainwater will be collected in one point, the lowest point of the plateau (+131.61m).Before the beginning of construction, 3.00m of unsuitable soil should be firstly removed from the sorting area and a part of the composting and 1.00m of unsuitable soil should be removed from the rest area of composting and maturation

Passing the plateau of the sorting and composting area, the main road leads to the perimetric berm of the landfill. Through this road the access to the basin and the beginning of waste disposal is achieved.

Finally, a secondary internal road ends to the Leachate collection tank area. The facilities of this area are located at the lowest part of the site at a mean elevation of +91 m, by that the leachate will be collected by gravity (reference drawing 2-TOPO-8a, b of Design Report). The leachate treatment plateau is approximately 1,490 m^2. In this plateau, the biogas flare system is also located.

3.1. Landfill design

The landfill includes the following activities:

- The entrance area including the entrance gate, weighbridge, tire washing system,fencing and a fire protection zone in the perimeter of the Waste Management Center (WMC)
- The road system with access road, internal access road and temporary ways for the trucks to enter the waste treatment facilities and disposal areas
- The landfill cell
- Landfill degassing
- Leachate collection and treatment

- Landfill administrative and maintenance building with social rooms, machine washing for landfill equipment

The design of the landfill is described briefly in the following.

All incoming waste is controlled, weighed and registered at the weighing bridge at the entrance. Waste not fulfilling the acceptance criteria is rejected while vehicles transporting acceptable waste are directed to the appropriate landfill cell currently in operation.

At the landfill cell the waste is unloaded from the transportation vehicles and the empty transporting vehicles leave the landfill area after weighing and registration at the weighing bridge. If necessary the vehicles will be cleaned before departure.

Waste unloaded in the cells is spread in layers and compacted by the landfill compactor. By the end of each day the waste is covered using soil or equivalently suitable waste materials, e.g. crushed bricks, concrete, etc.

The landfill is constructed with a membrane system covering the internal surfaces of the bottom and sides of the landfill cells, and a leachate drainage system. The combined function of the two systems is to prevent the leachate from infiltrating in to the soils and groundwater below or surface water in the vicinity of the landfill. Leachate is collected from the bottom of the landfill and transported (pipe) to the leachate treatment facilities.

The main infrastructure on site is the following:

- Security guardhouse
- Weighbridge
- Administration building
- Water tank
- Fire Protection zone in the perimeter of the landfill

3.1.1 Security Guardhouse

The building is located next to the weighbridge of the facility. It shall be a conventional building, covering a total surface of 24.30 m^2. The inner height will be 3.00 m. The building shall consist of two rooms:

- a security and weighing office
- a WC

The weighing building shall be equipped with a desk where the necessary equipment (for weighing of the incoming vehicles and recording of data) will be installed.

The outer door and the windows will be aluminum. The inner doors will be MDF lam press panel.

The floor in all internal places is of ceramic tiles. The external staircase and the terrace are tiled with burned marble.

3.1.2 Weighbridge

The facility will have one (1) weighbridge installed at the reception area of the landfill. The delivery shall be in accordance with the specifications below:

- Weighbridge, capacity: 60 tons with maximum intervals of 20 kg. Size approx. 18 x 3m.
- Six weighing cells with built-in temperature compensation and 40 tons capacity, protection class IP68. All material shall be of stainless steel.
- One (1) external weighing terminal for registration of in- and outgoing vehicles with display, information data display, keyboard, ticket-printer, installed in watertight casing according to protection class EP65. The casing must be of stainless steel mounted on a steering knuckle arm fixed to a fixed post of corrosion-protected steel. All necessary cables for sub-ground cabling between the weighing bridge, weighing terminal and main terminal in the weighing operators' office shall cover a min distance of 15 m from the weighbridge to the point of connection in the control booth. All visible steel parts not being of stainless steel must be protected according to corrosion class 3.
- Main weighing terminal and registration system in the operator's office: One main weighing terminal or -display installed in the Traffic Control Building booth connected to the PC-system with database for registrations.
- Specifications (min. requirements) for PC-system: The system must be compatible with weight bridge software. The hardware should at least consist of: a) 17" monitor, b) pin-printer as OKI LED 10 ex or equivalent, for printing of individual weigh receipts with up to 4 copies, c) A4 black and white laser printer.
- Complete software package for control of weighbridge, weighing terminal and registration system including printing / export of report files. Printing of invoices. Possibility for coupling to administrative network via net card or modem.
- One UPS, (Un-interruptible Power Supply) unit for safe closedown of the weighbridge, weighing terminal and PC-system in the event of power failure.
- Protection: All electronic equipment must be protected against damage from induction and variations of the voltage.

Additionally all necessary software and hardware equipment will be installed, as described in Srar Akkar Final Design report.

✓ **Installation and calibration/ Structural design and civil works**

The supply must include a fully operational weigh bridge with equipment and registration system as stated above, installed and calibrated. The supply must also include all necessary signal and power supply cables between the weighbridge and the operator's office. Furthermore, all structural design, calculus and civil works necessary for adapting the weighbridge shall be carried out in accordance with guidelines and instructions received from the Manufacturer / Supplier of the equipment.

✓ **Training and manuals**

The Contractor/ weighbridge manufacturer shall perform the necessary instruction in the utilization of the weighbridge and the registration system including maintenance of the mechanical parts. The

Contractor / manufacturer must foresee 5 working days for installation, calibration and commissioning of the weighbridge. Staff appointed by the facility owner/ operator will participate during the whole installation, calibration and commissioning process as "on the job" training. A qualified interpreter must be present during the entire period of installation.

The Contractor shall include all necessary manuals for operation and maintenance of the weighbridge and the registration system. 3 manuals in French and 3 manuals in English shall be delivered.

✓ **Service**

The Contractor/ weighbridge manufacturer shall perform the necessary instruction in the utilization of the weighbridge and the registration system including maintenance of the mechanical parts. The Contractor/ manufacturer must foresee 5 working days for installation, calibration and commissioning of the weighbridge. Staff appointed by the facility owner/ operator will participate during the whole installation, calibration and commissioning process as "on the job" training. A qualified interpreter must be present during the entire period of installation.

The Contractor shall include all necessary manuals for operation and maintenance of the weighbridge and the registration system. 3 manuals in French and 3 manuals in English shall be delivered.

3.1.3 Administration building

The administrative building covers a total surface of 144.70 m² and shall consist of the following rooms:

- Hall room
- Control room
- Office
- Office
- Laboratory
- Storage
- Kitchen
- Medical Assistance
- WC - Showers

It shall be a prefabricated building with inner height 3.75 m at least.

The system of the outer and inner walls will be constructed by press panels of two fiber cement boards and intermediate insulation of rock wool.

Concerning the roof coat of the building, it will be constructed by suspended ceilings of gypsum plates, with an insulation of rock wool and the roof coat will be constructed by pre-painted trapezoidal galvanized steel. The floors in all internal places are of ceramic tiles. The external terrace is tiled with burned marble.

Roof drainage is provided by PVC gutters.

The outer doors and the windows will be aluminum. The inner doors will be MDF lam press panel.

The laboratory will have access also from outside from a separate entrance.

In wash rooms, showers and laboratory the wall is tiled with faience up to a height of 2.45 meters.

3.1.4 Water tank

The water tank has a supporting structure of reinforced concrete and consists of two chambers and the pumping station. The total area of the construction is 91.56 m^2.

The tank will be divided either physically of via internal floating – level controlling devices, so that the minimum water volume is ensured. The total water volume of the tank will be 188.8 m^3, while the total volume will be 236 m^3. The minimum water volume for firefighting purposes is 124.80 m^3 and the relevant water volume for service water is 64.00 m^3.

The tank will be underground.

On the roof are situated two manholes 0.90 x 0.90 m by which, through a ladder, it will be possible to visit and clean the bottom of the two chamber tanks.

3.1.5 Fire protection zone in the perimeter of the landfill

Inside and parallel to the fence, a fire protection zone of 10.00 m width is foreseen for the perimeter of the site. All plants or flammable objects shall be removed from this zone.

3.1.6 Roadworks

Road design is important to provide access to cell and all the landfill site's facilities. The internal roadways circulation is used mostly from heavy vehicles so the roadway must be built in a way that can ensure the easy movement.

✓ **Internal Roads**

Internal road is the main road, road 1, beginning from the entrance of the landfill site and moving towards to the landfill basin. Internal main road provides access to the sorting and composting area, as well as is given access to the landfill basin (Drawing 7-ROAD-1).

Road 1 will be constructed with 6.80 m width, 3.40 m in each direction. On each side of the road, a triangular ditch of 40 cm or 70 cm depth is constructed along the excavation areas. They are triangular ditches and their dimensions differ according to the runoff calculations and the slopes.

The main road, road 1, is attached to a local soil road and begins from the site's entrance.

The main road leads to the landfill basin are passing along the sorting and composting area.

The total length of the main road is 670.78 m.

Internal road 2 provides access to the leachate collection tank. The road 2 will be constructed with 6.80m total width, 3.40m on each direction. The total length of road 2 is 115.38m.

✓ **Horizontal and vertical alignment – Typical Cross Section**

The horizontal alignment of the main road, road 1, has five curves with minimum radius 20m and maximum 50 m. The full length of the road is 670.78. m. The road surface has slope 2.5% which is towards the external side of the area, in order to runoff water from roadways. The vertical alignment

has nine curves with minimum radius 100m and maximum 2000 m and grades with range 0.00% - 10.84% (Drawing 7-ROAD-3).

The horizontal alignment of road 2 has one curve with radius 20m. The full length of the road is 115.38 m. The road surface has slope 2.5%, in order to runoff water from roadways. The vertical alignment has three curves with minimum radius 500m and maximum 2000 m and grades with range 10.11% - 11.04% (Drawing 7-ROAD-3).

The perimeter berm is 638.03 m long. The horizontal alignment has six curves with minimum radius 12m and maximum 25 m. The road surface has slope 2.0% which is towards the internal side of the basin, in order to runoff water from roadways. The vertical alignment has eleven curves with minimum radius 80m and maximum 1000 m and grades with range 0.00% -26.11%.(Drawing 7-ROAD-4).

Also the ramp into the landfill will be made of gravel. The Ramp is 56.39 m long. The horizontal alignments of ramp have one curve with radius 18m. The road surface has slope 2.5%, in order to runoff water from roadways. The vertical alignment has one curve with radius 80m and grades with range 2.05% -10.74%. All vertical alignments are illustrated in drawings 7-ROAD-3, 7-ROAD-4.

Main roads, road 1, cross sections are in drawings 7-ROAD-5A, 7-ROAD-5B and 7-ROAD-5C, road 2 also ramp cross sections are in drawing 7-ROAD-6,

Pavement in working area for vehicle movement in front of composting and maturation cells shall be constructed by laying and compacting of the following layers:

- 4 cm of high density asphalt mixture
- 8 cm of low density asphalt mixture
- 10 cm of Foundation layer
- 20 cm of Subbase layer

Pavement in road 1, road 2 ramp, area for sorting and composting and leachate collection tank area, shall be constructed by laying and compacting of the following layers:

- 10 cm of Foundation layer
- 20 cm of Subbase layer

The typical cross sections are in drawing 7-ROAD-7.

For the access to the bottom of the landfill and the beginning of the waste disposal, one ramp will be constructed from the perimeter of the landfill, along the slope to bottom. The ramp will have width of 4.00 m.

3.1.7 Landfill cells

The total area reserved for waste disposal designed as three (3) cells. The landfill basin will be constructed in stages, having the first Cell in Phase A. In order to control and minimize the amount of leachate produced and to reduce any other nuisances induced by the operation of the landfill, the area open for filling shall be kept at a minimum at all times. Thus as a main principle only one cell area shall be in operation at any given time, and temporary layers or the final closure layers shall be installed as the final filling level is reached.

3.1.7.1 Lining system

The selection of the appropriate type of liners was based on:

- The type of waste to be disposed (municipal solid waste)
- The availability of materials in the area
- The hydro geological conditions of the site (depth of groundwater table, usage of water and distance of exploitation points from the landfill site).

The liners were selected upon the following requirements:

- to keep the cell sealed from precipitation and surface water
- to be resistant to temperature of at least 70oC
- to seal the produced gas and leachate
- to be resistant to any sedimentations and erosions
- to be resistant to the effect of the microorganisms
- to be easy to install
- to be easy to check during both the construction and the operation
- to be easy to mend
- not to be of high expenditure

The sealing system of the new landfill bottom includes (from the bottom to the top):

- Subbase of compacted soil 50 cm
- Geosynthetic Clay Liner (GCL)
- Geomembrane HDPE 2.0 mm thick
- Protective geotextile 1,200 g/m²
- Gravel layer 50cm thick
- Separation geotextile PP 300 g/m²

Therefore the sealing system at the sides includes (from bottom to the top):

For slopes 1:2

- Subbase of compacted soil 50 cm
- Geosynthetic Clay Liner (GCL)
- Geomembrane textured on both sides HDPE 2.0 mm thick
- Protective geotextile 1,200 g/m²
- Geosynthetic drainage layer with embedded geotextile

For slopes 1:3-1:5

- Subbase of compacted soil 50 cm
- Geosynthetic Clay Liner (GCL)
- Geomembrane HDPE 2.0 mm thick
- Protective geotextile 1,200 g/m²
- Geosynthetic drainage layer with embedded geotextile

The above systems are presented in drawing 3-DET-1.

3.1.7.2 Surface Sealing works

In order to prevent leachate formation in the aftercare phase of the landfill as well as the diffusion of odors and other emissions, a surface sealing will be applied. The surface sealing will be applied only at the final landscape according to the filling sequence plan of the landfill.

The temporary sealing of the landfill will consist of a temporary cover layer with thickness 0.50m.

On the other hand, the final surface sealing of the Srar Akkar landfill site, will consist of the following layers (from bottom to top):

- Temporary cover layer (Levelling layer).
- Gas drainage layer (Collecting the landfill gas).
- Mineral lining layer.
- Rainwater Drainage layer (The lining layer for the drainage water).
- Separation Geotextiles as protective layers.
- Top soil cover (vegetal and subsoil).

The above-mentioned layers are described in the following paragraphs and shown in drawing 12-DET-1.

➢ **Temporary cover layer**

The temporary cover layer thickness will be 0.50 m for the temporary capping and 0.20 m for the final capping of the landfill. The soil allows the gas to move and takes over the static and dynamic charges that appear with the lining system. The temporary cover layer must not contain organic components (wood), plastic materials and concrete with tar content, iron/steel and metals. It must be homogenous and have endurance at constant efforts. At the top of the layer the surface must be flat and levelled. Attention should be paid at the content of calcium carbonate which must not exceed 10% of the mass as well as at the mass of the maximum length particles, which must not exceed 10%.

Table 2-1: Technical Specifications of support layer

CHARACTERICS	REQUIREMENT
Type of material	Inert Soil
Thickness	0.2 m
Elasticity Module	40 MN/m^2
Permeability coefficient	$1x10^{-4}$ m/s
Restrictions	Calcium Carbonate <10 % of mass particles with maximum length <10% (mass)

➢ **Gas drainage layer (collecting the landfill Gas)**

Above the support layer, a gas drainage layer with thickness of 0.30 m shall be applied. The draining material shall be granular with permeability coefficient (hydraulic conductivity) of $1x10^{-3}$ m/s. The length of the granules must not be more than 32 mm; the optimal domain of the diameter of the granules is between 16 and 32 mm. The percentage of superior and inferior granules must not exceed 5%. The

content of calcium carbonate must be lower than 20% (mass). The safety at diffusion towards the support layer must be assured.

Table 2-2: Technical Specifications of gas drainage layer

CHARACTERICS	REQUIREMENT
Type of material	Granular material (e.g. gravel)
Thickness	0.30 m
Permeability coefficient	$1x10^{-3}$ m/s
Diameter of granules	Less than 32 mm (optimal domain between 16 and 32 mm)
Restrictions	Calcium Carbonate <20 % of mass Percentage of superior and inferior granules <5%

- **Mineral lining layer**

Above the gas drainage layer, the mineral lining layer is applied. The layer consists of compact clay of minimum thickness 0.50 m and permeability coefficient $<5x10^{-9}$ m/s. The contest of calcium carbonate must be lower than 10% (mass), clay content with granules diameter <0.005 mm must be minimum 20% (mass). The maximum length of granules is limited at 63 mm. The content of organic components of clay is limited at maximum 5% (mass) and the wood components (roots, branches, etc.) are not allowed.

Lining with clay material will be applied in two compact layers with roller compactor. The lining layer must have tolerance at planarity of maximum 2 cm/ 4.0 m. Proctor density must be> 95%.

- **Rainwater Drainage Layer**

The rainwater drainage layer will be realized with thickness of 0.50 m and it will consist of granular material. The permeability coefficient (hydraulic conductivity) shall be $1x10^{-3}$ m/s. The draining material must be applied evenly on the entire surface of the landfill. The length of the granules of the draining material must be between 16 mm and 32 mm.

Table 2-3: Technical Specifications of rainwater drainage layer

CHARACTERICS	REQUIREMENT
Type of material	Granular
Thickness	0.50 m
Permeability coefficient	$1x10^{-3}$ m/s
Diameter of granules	Between 16 mm and 32 mm

- **Separation Geotextiles**

On the top of the gas drainage layer and the rain water drainage layer a separating layer should be applied, to prevent the components from the recultivation layer to enter the drainage layer. The geotextiles shall consist of polypropylene (PP) with mass unit on surface equal to 300 gr/m^2. Geotextiles must allow the water to enter and to follow the quality requests according to the provisions of the standards into force.

Installation

Simple overlapping with a width of min. 0.5 m shall connect lanes of installed geotextile. Alternatively sewn connections may be used. Sewn connections shall have tensile strength equal to the tensile strength of the geotextile.

The geotextile shall be delivered at the site with a datasheet from the producer certifying the characteristics of the material. Further the delivery shall be accompanied by a protocol with the results of the producers quality check for the specific batch delivered to the site.

The geotextile shall be protected against physical damages and soiling during transport to the site and during storage at the site.

- **Topsoil cover**

The primary function of the topsoil is to enable the planned after use to be achieved. The topsoil should be uniform and have a minimum slope of 1 to 30 to prevent surface water ponding and to promote surface water runoff. The maximum slope will depend on the after use but it is recommended that the slope be no greater than 1 in 3.

The topsoil should be thick enough to:

- Accommodate root systems;
- Provide water holding capacity to attenuate moisture from rainfall and to sustain vegetation through dry periods;
- Allow for long term erosion losses; and
- Prevent desiccation and freezing of the barrier layer.

The combined thickness of the topsoil and the subsoil shall be realized with thickness of 1 m, from which the upper 0.3 m should be enriched topsoil (vegetal). Planting of bushes is allowed only after 2 years

from the planting of the grass. It can be planted only bush species with short roots. The material for the sub soil (retaining water layer) is made of lightly cohesive sand and gravel.

Table 2-4: Technical Specifications of enriched top soil

CHARACTERICS	REQUIREMENT
Thickness	1.00 m: from which the upper 0.3 m should be enriched topsoil
Restrictions	Planting of bushes only after 2 years from the planting of grass Minimum slope 1:30 Maximum slope 1:3.

3.1.8 Leachate management system

Generation of leachate is an inevitable consequence of the waste disposal practice. It arises from precipitation entering into the waste mass, as well as from the humidity content of waste and in the result of biodegradation of organic compounds into the waste.

Leachate contains suspended solids, soluble waste components, soluble decomposition products and microbes. The most of leachate components have the potential to be toxic and could cause the death of river life, directly (through toxins and BOD_5) or indirectly (via eutrophication). They can also contaminate drinking water. Therefore, under no circumstances should the leachate be discharged to surface and underground water. Besides, the legislation is very strict concerning this matter. The composition of the leachate produced in a landfill, depends on the type, composition and age of waste, the degree of compression in landfills, etc.

Experience has shown that the isolation of the base itself, without collection and removal of leachate, can ultimately cause more harm than good. Therefore, a collection and drainage system is essential, and is one of the most important stages in the construction of a landfill, as the lifetime of the isolation is largely dependent on this.

The principles of leachate collection system that rule the proposed design are:

- The input amount of rainwater should be reduced as much as possible. Leachate collection system is designed in accordance with the surface water management, as the correlation between them is strong. Trenches parallel with the footprint of the landfill will be developed in order to prohibit the runoff into the landfill's body.
- The collection and drainage system should ensure long-term collection of the total quantity of leachate and exclude any admixture with rainwater.

The system for leachate management was chosen upon the following requirements:

- not to cause damage, deformities or shifts in the isolation system during its placement
- the pipes should be hydraulically efficient and should withstand chemical, industrial and physical burdens, not only during the phase of operation, but at the phase of the landfill aftercare as well (50 years. 40 ^{o}C. waste density: 1.5 Mg/m^3)

- free flow of leachate towards its collection tank should be enabled and leachate should be treated in a rather easy way
- the hydraulic height of leachate should not exceed 50 cm above the geomembrane.

In the proposed design, leachate flows due to gravity from the various points of the landfill basin and slopes to the collection pipes. The basin of the landfill is shaped to have slopes at least 3% transversal on the drainage pipe network and about 12.5 % longitudinal. All collection pipes from Cells are gathered finally by gravity into manhole W1 inside the bottom of the landfill. Another pipe is transferring the leachate to the leachate collection tank.

The collection of leachate shall be facilitated by pipes, which will be positioned having an adequate inclination to achieve effective flow of leachate to the lower level of the basin, installed within the drainage layer in a special surface formation of the deposition basin. The collection pipes shall be made of HDPE perforate by 2/3 of their diameter and shall have a nominal diameter D = 315 mm (main collection pipes in the bottom's "deep point" and along the interim berms) and D = 250 mm ("fishbone" shape), according to the Drawing 4-TOPO-1. The diameter has been selected taking into consideration precipitation data of the area, as well as the slopes of the landfill basin. The pipes will be installed into the gravel layer. For the installation of the leachate collection pipes a special topical formation of the basin is constructed.

According to the proposed design, in the landfill three (3) main routes of pipes (P1 – P3) will be established. For each route different pipes will be placed in order to conform to the distinct operation phases. By the proposed design, rainwater falling into the areas above from the operating area will be diverted as clean rainwater to the surrounding ditch and therefore the leachate production is eliminated.

The pipes P1a and P1b enter the central collection well in the deepest point of the landfill and from there the leachate is directed to the leachate collection tank via one HDPE DN500 PN10. The secondary pipes on the bottom of the landfill are connected with special joints to the main pipes.

For the cleaning of the main leachate collection pipes, there are reduced Tees DN315/250 with a HDPE PN10 DN250 pipe and a DN250 blind flange at the end.

For the collection of the leachate of Cell A, two perforated HDPE DN315 PN10 pipes will be installed along the deepest line of the bottom of the landfill and will end into the collection well. From the collection well one HDPE DN500 PN10 pipe passes through the embankment and ends to the leachate collection tank.

Finally, a network of collection pipes will be established in the area of composting to transfer contaminated water to the leachate tank.

From the Leachate collection tank, there will be the possibility to recirculate the leachate via a pumping station to the recirculation network. In the recirculation line, wells will be included every 80 m.

- **Description of the leachate recirculation system**

Recirculation of untreated leachate to the landfill body will be possible to take place directly from the leachate tank in order to regulate moisture and promote biological reactions. The recirculation pipe will be established in the framework of the landfill construction.

The recirculation pipe will be made of HDPE PN10 and it has a diameter of 75 mm. It will be placed in ditches of 80 cm depth and it will be based on a layer of gravel 10 cm thick. The main points of the pipe are presented in the relevant, whereas the elevation mentioned in the drawing represents the final soil level above the recirculation ditch.

- **Leachate collection tank**

The leachate tank is a closed tank from all sides, made of concrete C30/35. The inner dimensions are 15.30 x 10.30 x 3.60 (w x l x d). The net volume is 540 m^3, and it corresponds to a level of leachate up to 3.50 m, so the free height above the water level will be 1.00 m. The net volume of the tank is adequate to the leachate for 1 to 3 days depending on the weather conditions and the production of leachate due to heavy rain.

The tank will be emptied by tankers occasionally, whenever the water level reaches the upper limit. Leachate will be disposed in a municipal wastewater treatment plant.

Two submersible pumps (one spare for cyclic operation) are placed in the bottom of the tank. The pumps will be centrifugal (impeller type macerator) installed with characteristics: capacity 15 m^3/h, head 57 m, 11 kW.

The tank shall include a jet (venturi) aerator 6 kW in order to avoid sediments on the bottom of the tank and continuously supply oxygen to leachate mass. The analysis and calculations for the efficiency of the aeration shall be given by the manufacturer of the aerators and the Contractor, along with the technical data sheets of the equipment.

The tank will be closed and the deodorization shall be made through absorption in a filter with activated carbon or other active chemical media. The deodorization system shall be suitable to be placed outdoors and shall have high anticorrosive resistance. It will be made of stainless steel painted with electrostatic paint. The access to this unit shall be made from the top, where a lid will be placed. The lid shall be firmly closed with stainless closures. The filter shall be able to be connected with circular duct. The dust shall be connected with the closed area of the tank, in several points in order to create sub pressure in the area. In the inlet duct the filter shall have a manual damper for regulating the flow rate. The damper shall be made of plastic with high anticorrosive properties. The total efficiency in removing odors will be 99%. The manufacturer must hold a valid ISO 9001 certificate.

The smells shall be sucked from the deodorizing system through a fan, of suitable airflow rate, according to the manufacturer. The fan shall be placed on the upper removable lid of the system. In case of a big size model, the fan is placed beside the unit and it is connected via a circular duct. The fan shall be antioxidant, centrifugal single suction made of plastic, with back oblique blades made of plastic, as well.

3.1.9 Biogas management system

A sanitary landfill can be defined as the biochemical reactor of the anaerobic fermentation of organic and other biodegradable fractions included within disposed municipal solid waste (MSW). Landfill

control systems are employed to prevent unwanted movement of landfill gas into the atmosphere or the surrounding soil. Recovered landfill gas can be used to produce energy or to be flared under controlled conditions to eliminate the discharge of greenhouse gases to the atmosphere.

Landfill gas is composed of a number of gases, but mainly methane (CH_4) and carbon dioxide (CO_2) at a ratio of 50:50. The rest gases represent no more than 3 – 5% of the total landfill gas volume. The principal gases are produced from the decomposition of the organic fraction of MSW. Landfill gases occur in five or less sequential phases:

- **Aerobic phase**

In the 1st phase organic biodegradable components undergo microbial decomposition as they are placed in the landfill and soon after under aerobic conditions until entrapped O_2 is consumed. This may last for a few weeks up to several months. The predominant gases synthesized during this stage are carbon dioxide (CO_2) and water vapor (H_2O).

- **Transition phase**

The second phase begins as conditions shift from aerobic to anaerobic as a result of oxygen depletion. The principal gases produced are CO_2 – and – to a lesser extent – hydrogen (H_2)

- **Acid phase**

The microbial activity initiated during phase II accelerates with the production of significant amounts of organic acids and lesser amounts of hydrogen gas. This three steps phase includes:

- The hydrolysis of higher-molecular mass compounds into compounds suitable for use by microorganisms as source of energy and cell carbon.
- The microbial conversion of the compounds resulting from step 1, into lower molecular mass intermediate compounds (CH_3COOH).
- The last step involves the conversion of the intermediate compounds produced in phase b into carbon dioxide and lesser amounts of hydrogen gas.
- **Methane fermentation phase**

Another group of microorganisms convert the acetic acid and hydrogen gas into CH_4 and CO_2. Microorganisms responsible for this conversion are strictly anaerobic and are called methanogenic.

- **Maturation phase**

The maturation phase occurs after the readily available biodegradable organic material has been converted to CH_4 and CO_2 in phase IV. The rate of landfill gas generation diminishes significantly since most of the available nutrients have been removed with leachate.

During the anaerobic phases, production of sulfur and carbon compounds in trace concentrations (sulfides and volatile organic acids) is observed.

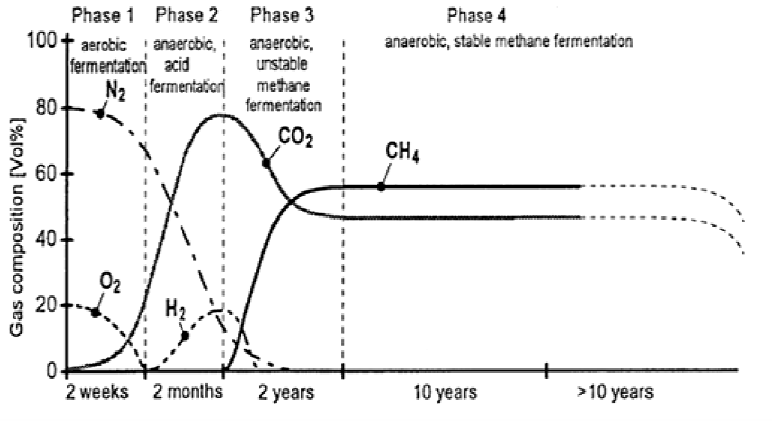


Figure 3: Variation of landfill gas composition over time

The gases generated within the fill, if uncontrolled, will disperse and migrate beyond the boundary of the fill. Accumulated gases and uncontrolled dispersal and migration can represent a potential hazardous situation, due to several characteristics of the landfill gases. These characteristics include flammability, asphyxiating properties and trace organic concentrations. The slightly positive gas pressure usually existing within a landfill permits gases to flow uncontrolled from the fill to areas of lower gas pressure by connective gas transport. Furthermore, gases with higher concentrations of CO_2 and CH_4 can diffuse into regions containing gases with lower concentrations of these two gases. Finally, if landfill gas accumulates in the fill, the growth of plants rooted in the cover can be inhibited, unless appropriate precautions are taken.

In the absence of adequate methods of gas control, landfill gases migrate to the atmosphere through the landfill cover. They can, also, migrate laterally through the soil around the fill. If they reach areas from which they cannot escape (such as a building), an accumulation occurs. As long as the concentrations are relatively low, the gases pose only a potential nuisance. However, when the concentration (i.e. accumulation) reaches a critical value (the flammable concentration of methane in air is between 5 and 15% by volume), methane gas is flammable and there is a strong possibility of explosion, if the gas is confined and ignited. At higher concentrations, methane is flammable only when diluted (usually by air) to within the above range and when in presence of oxygen. Under these conditions, the accumulation of methane represents a hazard of fire and explosion. Because of the possibility of gas accumulation, buildings on or near landfills should not have underground structures, unless such structures are thoroughly and continuously ventilated.

The total biogas production and recovery from phase A as well as in all phases of the landfill site is presented in following figures.

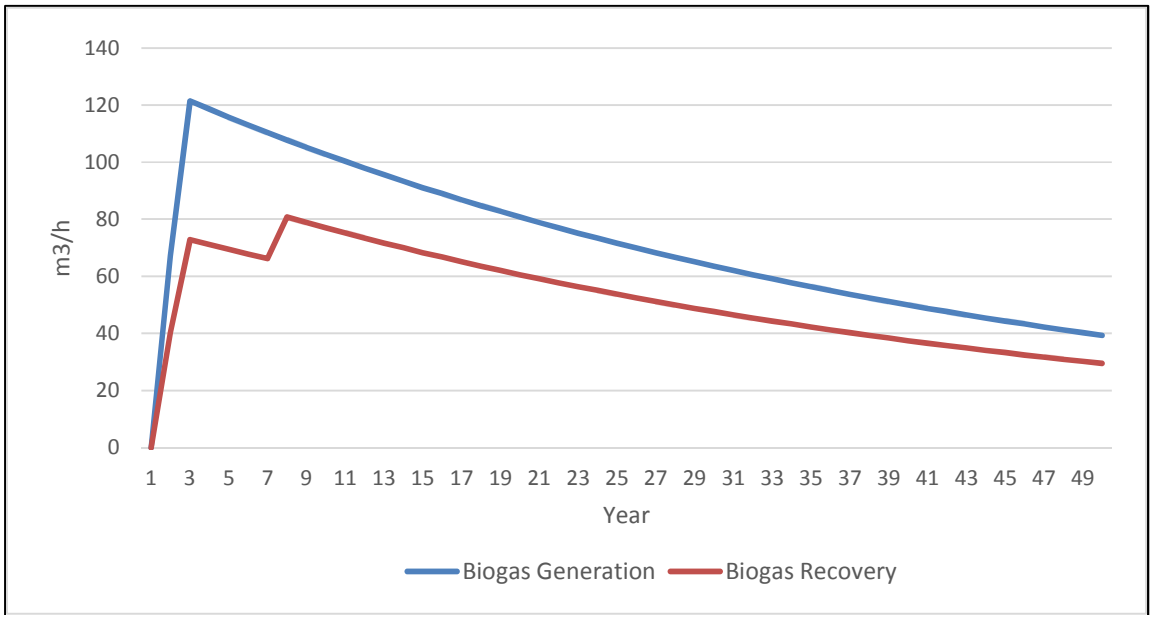


Figure 4: Landfill Gas generation and recovery from phase A over time

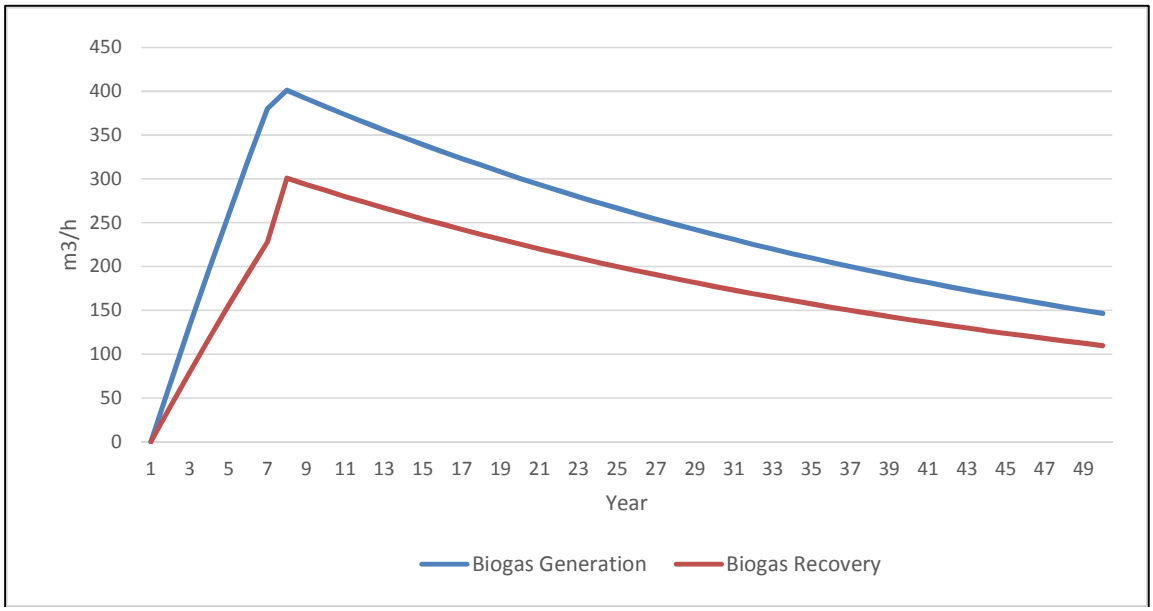


Figure 5: Landfill Gas generation and recovery from all phases over time

As it can be seen from the above, the maximum biogas quantity from phase A is observed in the 3rd year (which is the year after phase A will accept waste). This maximum quantity reaches 121.5 m^3/h. What is more, it is estimated that the biogas quantity that it can be recovered is 72.9 m^3/h with recovery rate equal to 60 % since phase A is not fully rehabilitated and 80.8 m^3/h after the rehabilitation of the landfill site. As regards all phases of the landfill site, the maximum biogas quantity is estimated in the 8th year, reaching 401.2 m^3/h. Hence, the biogas quantity that it can be recovered is 300.9 m^3/h with recovery rate equal to 75 % since the landfill site is rehabilitated. The flare unit should be able to cover the maximum expected amount of the recovered biogas from all phases of the landfill site. Therefore, it

is selected to install one (1) flare unit with capacity of 300 m^3/h (turn down ratio 1:5), which based on the abovementioned estimations can sufficiently cover the needs of biogas management works in the landfill site.

The landfill gas management system shall consist out of the following components.

- **Biogas collection wells**

The collection wells will be developed as it is presented in drawing 5-DET-1. The well's base has to be installed at least 3 m above the leachate drainage layer. The gas wells will be uplifted with the increase of the waste body height, up to the maximum filling level.

The wells will have a diameter of 800 mm and they will be filled with a material with permeability of at least $1x10^{-3}$ m/s and d = 16 – 32 mm (gravel or crashed stone). In this filter, the drainage pipe (screen pipe) with a diameter of 110 mm will be immersed. This ensures a uniform extraction of the gas generated inside the deposit's body, with a supra pressure of about 40 hPa. To cover enough volume of the deposit body and to be able to drive the collected gas toward the desired direction, it is necessary to generate an effective sub pressure of 30 hPa at the top of the gas well.

The walls of the screen pipes will be perforated and the diameter of the holes (according to the granulation of the gravel or crashed stone filters) will be smaller than 0.5 x d, which means 8 – 12 mm. Pipes with circular perforations are preferred because of their higher strain and shear resistances, and their higher stability against the loads resulted in compaction of the waste body procedure.

It is proposed that screen pipes are made of HDPE, which is an erosion resistant material. The material of the pipe of HDPE should conform to specifications DIN 8074, 8075, 19537 and 16776, or alternatively DIN 16961, or EN 13476-1.

At their final height, all pipes from the vertical wells shall end up to a well head, having a side branch for the connection with the horizontal piping network. The well head shall be made of HDPE and shall be equipped with press relief valve, flow, temperature and sampling access points. At the branch of the well head a butterfly valve shall be positioned assisting the landfill gas control from the specific well. A special fitting made of flexible HDPE shall be used for the connection to the horizontal transfer pipeline. In order to protect the well head a prefabricated concrete pipe (approximately 2 m high and 1.8 m diameter) shall be positioned on top of each well with a metal cap for protection and easy access.

The distance between two biogas wells shall be approx. 40 – 50 m, considering a radius of influence of 25 m around each well. The relative positioning of the wells is represented in the following figure.

By applying the above coefficients the 17 wells for phase A and the 40 wells for all phases can recover a total biogas amount of 81 m^3/h and 300 m^3/h approximately. So the proposed biogas net is considered to be sufficient and efficient.

The wells will be positioned, as it is shown in drawing 5-TOPO-1A for phase A and in drawing 5-TOPO-1B for all phases. They will be located as close as possible to berms and access roads, and the distance from the wells to the external limit of the deposit body will be at least 20 m, in order to cover the intake (aspiration) area and the edge of the deposit.

The collection wells data (height, flow) are given to the table below. The flow of each well was calculated taking into account the percentage of the well's height to the total height of the wells, as well as the total biogas amount that will be recovered by these wells for phase A and for all phases. It is noted that the height of the wells is up to the final height of the waste and don't include the height of the final cover.

Table 2-5: Collection wells data for phase A

Well	Height (m)	Biogas flow (m^3/h)
W1	5	2.4
W2	9	4.4
W3	7	3.8
W4	6	2.9
W5	3	1.7
W6	13	6.5
W7	13	6.7
W8	11	5.8
W9	5	2.6
W10	4	2.1
W11	18	9.3
W12	17	8.9
W13	18	9.4
W14	4	1.8
W15	7	3.6
W16	10	4.9
W17	9	4.4
Total	**157**	**81.0**

Table 2-6: Collection wells data for all phases

Well	Height (m)	Biogas flow (m^3/h)
W1	5	2.5
W2	9	4.6
W3	7	3.9
W4	6	3.0
W5	4	1.9
W6	13	7.1
W7	13	7.0
W8	12	6.3
W9	5	2.8
W10	12	6.3
W11	18	9.5
W12	20	10.8
W13	17	9.0
W14	5	2.4
W15	23	12.1
W16	24	12.9
W17	18	9.4
W18	2	0.8
W19	2	1.2
W20	14	7.5
W21	8	4.0
W22	7	3.6
W23	20	10.8
W24	27	14.3

Well	Height (m)	Biogas flow (m^3/h)
W25	28	15.2
W26	20	10.8
W27	6	3.2
W28	23	12.1
W29	32	17.2
W30	26	13.7
W31	8	4.3
W32	10	5.4
W33	23	12.3
W34	28	15.0
W35	11	5.6
W36	10	5.4
W37	26	13.8
W38	9	4.6
W39	7	3.8
W40	8	4.0
Total	**560**	**300.0**

- **Biogas transfer piping network**

The transfer piping network will be developed, as it is shown in drawing 5-TOPO-1A for phase A and in drawing 5-TOPO-1B for all phases. Each gas collection well will be connected to the gas collection stations through a gas collection pipe.

Gas collection pipes shall be installed with a slope of at least 5 % accountable to the gas collection station, to evacuate the water condensed inside the pipe.

These pipes shall be provided with flexible devices that allow the connection to the gas collection stations in a way that damage from tamping, pressure forces, transversal forces and torsion forces are minimized. The pipes and the flexible connections shall be of HDPE with a pressure resistance PN10. The collection pipe diameter will be 90 mm. The gas collection pipes will bear butterfly valves at their connection to the collection stations, assisting the landfill gas control from the specific pipe and allowing stopping gas flow. The pipes shall be protected at the surface of the deposit with a layer of soil or waste, as it is shown in drawing 5-DET-1.

The biogas collection stations are connected through a main pipe that leads biogas to the blower, as it is illustrated in drawing 5-DET-2. Its slope shall be at least 0.5 %, in order to evacuate particles contained within condensate. The nominal diameter of the pipe will be 110mm with a pressure resistance PN10. Such pipes will be installed at bigger depths, as it is presented in drawing 5-DET-3, and will be located outside the sealing surface area, and by no means below the storm water collection equipment (ditches). The proposed design, allows for such specifications to be met.

- **Biogas collection stations – Condensate trap**

Within the gas collection stations, the individual collection pipes are connected to the main discharge pipe. The gas collection stations should be installed in such positions that can facilitate their inspection and maintenance. In these stations, several parameters of biogas (e.g. CH_4, CO_2, O_2, CO, H_2, H_2S) as well

as its pressure can be measured which is collected from different wells. It is also possible to take samples for further analysis in the laboratory.

The number of the gas collection stations is determined accounting the landfill dimensions, number of gas collection wells and their distribution within the deposit. Based on the proposed design 1 collection station is necessary for phase A (namely BCS1) and 2 collection stations in total (namely BCS1 and BCS2). It will be positioned as it shown in drawing 5-TOPO-1A and 5-TOPO-1B. Within the gas collection stations, each collecting pipe is fitted with a specific portion provided with a sampling device. Between the measuring area and the collecting cylinder (where the collection pipes end), a butterfly valve for closing and adjusting is placed. A butterfly valve is placed between the collection cylinder and the main discharge pipe, as well.

The gas collection stations will be placed inside a prefabricated container with dimensions 2.4 m x 1.0 m x 0.975 m. They will be installed over a foundation base of 30 cm, made of mineral mixture of 0/32, as it is shown in drawing 5-DET-2. The infrastructures containing the gas collection station should be well ventilated and only authorized personnel should have access to them. Warning signs on the potential risks related to biogas presence shall be located within the gas collection stations area, no smoking and no fire signs included.

Since biogas is saturated with water vapors it leads to condensate formation in the pipe network. Based on the literature, 100 ml of condensate are produced per cubic meter of biogas. Taking that into account, the maximum expected quantity of condensate in the landfill site is estimated as follows:

100 ml/m^3 x 81 m^3/h = 8.1 lt/h or 194.4 lt/d for phase A and

100 ml/m^3 x 300 m^3/h = 30 lt/h or 720 lt/d for all phases

The biogas main pipe will be connected in the lowest level point of the container of the biogas collection stations with a condensate trap for collecting all generated condensates, as it is shown in drawing 5-DET-2. From the condensate traps the condensates will lead back to the landfill site using a portable pump.

- **Flare unit**

In order to pump the landfill gas out of the deposit (1) one flare shall be installed in site. As mentioned previously, the proposed flare unit has capacity of 300 m^3/h (turn down ratio 1:5), which will sufficiently cover the needs of biogas management works for all phases of the landfill site. The landfill gas flare will be compact design and will mainly consist of the blower unit and the combustion unit.

3.2. Storm water management system

The main aims of this section are the following:

- To avoid the inflow of storm water in the landfill and in this way protect its structural stability
- To avoid the inflow of storm water in the landfill and in this way reduce the leachate production
- To protect the structures and the roads of the landfill site from storm water erosion

The overall design is presented in the general layout of the flood protection works which accompanies this text (Drawings 6-TOPO-1A,6-TOPO-1B).

- The flood protection works of the site consist of the following:
- Two internal circumferential ditches (ditches A, B) which are non-lined These ditches stretch around the landfill and prevent storm water from entering in it, as well as collect the storm water from the surface of the final cap after the landfill closure. They are trapezoidal ditches and their dimensions differ according to the runoff calculations and the slopes. In the parts Aiii-Aii, Biii-Bii, rectangular ditches-stepped gutter-lined with armed concrete C20/25 (10cm thick), should be placed in order to avoid erosions.
- Trapezoidal ditches (C, D, E, F, G2,) non-lined will be constructed to collect the runoff from the parts outside the landfill (mostly roads, buildings and treatment areas and the embankments surfaces). Their dimensions differ according to the runoff calculations.
- Triangular roadside ditches R1, R2 G1which are non-lined, will be constructed to protect the integrity of the road from external catchment areas. Their dimensions differ according to the runoff calculations. The parts of triangular roadside ditches, have high slope, should be lined with armed concrete C20/25 (10cm thick), in order to avoid erosions.
- P HDPE pipes with diameter 500mm will be constructed along the roadside in order receive the runoff rain from the triangular ditch and remove it off site. Manholes will be placed, in order to give access to the pipes for maintenance reasons. .An embankment areas will be constructed at the east of the basin in order to prevent any water puddles.
- It should be noted here that crucial element of the flood protection system is the slope free surfaces of the ground inside the site: all the surfaces must be sloped towards the nearest ditch in order to prevent the retention of water in hollows of the ground. The slope of the free surfaces must be at least 0.5% with the directions shown in the general layouts of flood protection works.
- The previous works appear in drawings 6-TOPO-1A, 6-TOPO-1B

3.3. Sorting and composting facilities design

3.3.1. Flow – diagram of waste treatment and disposal facilities

Waste Management Centre (WMC) in Srar Akkar is designed to accept an average of 500 t/d mixed municipal solid waste, operable 365 days per year, with two 10h shifts. After the mechanical treatment process and recovery of recyclable materials and RDF, the organic fraction, enters the Biological Treatment Plant (Windrow Composting) for the production of compost.

The dimensioning of the Mechanical Sorting Unit is based on the total input quantity of mixed waste, whereas, at this stage, the dimensioning of the Windrow Composting is made for 43 t/d organic waste.

The biological treatment plant will have the capacity to process the total quantity of organic material (220 – 250 t/d) by expansion of the composting area. The selected option will be decided during the operational period and depends on the end use of the compost and the quality/ extent of stabilization required. The residues from mechanical and biological treatment are transferred and disposed to the landfill site.

The following table presents the indicative overall mass balance of the plant both for the design and the future period.

Table 2-7: Mass Balance of MBT Plant (estimation)

Design period (43 t/d organic waste goes to windrow composting)

Input MSW	Quantities 182,500t/y	Percentage 100%
Output		
Recyclables	21,900.00	12.00%
RDF	34,675.00	19.00%
Compost	16,060.00	8.80%
Losses	11,242.00	6.16%
Residues	98,623.00	54.04%

Future period (250 t/d organic waste goes to windrow composting)

Input MSW	Quantities 182,500t/y	Percentage 100%
Output		
Recyclables	21,900t/y	12.00%
RDF	34,675t/y	19.00%
Compost	45,625t/y	25.00%
Losses	31,025t/y	17.00%
Residues	49,275t/y	27.00%

Table 2-8: Quantities and recovery rates in Mechanical Treatment

Fraction	To treatment	% Recovery in each fraction	% Final Recovery
Paper/Cardboard	15%	25.00%	3.8%
Plastic	10%	30.00%	3.0%
Glass	3%	50.00%	1.5%
Fe	3.75%	75.00%	2.7%
Al	1.25%	75.00%	1.0%
Total	33%	-	12%

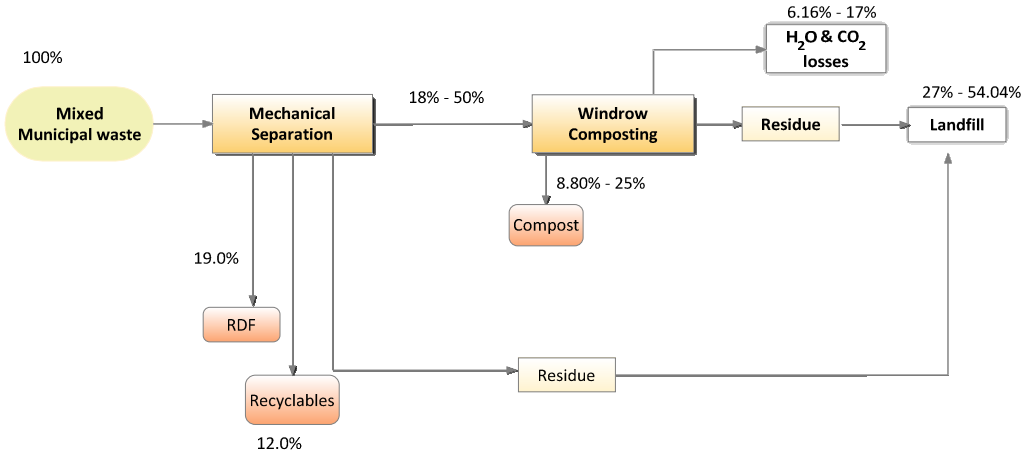


Figure 6: Indicative Mass Balance of MBT Plant

3.3.2. Mechanical Treatment Plant – Architectural Description

3.3.2.1. Mechanical Sorting building

The Mechanical Sorting building is located in the North corner of the Waste Management Facility. The external dimensions of the building are 73.50 and 60.40m. The total area is 2780.64 m^2.

Main role at Mechanical Sorting Building realization is attributed to Technological design. Architectural part aims to fulfill technological solution provisions.

The Building consists of three discrete areas:

- The reception area at the North part of the building,
- The Presorting and Facilities area at the South,
- The Mechanical sorting area towards the East of the building.

A joint is left between the three areas.

The reception area (with dimensions 19.30m X 36.70m = 708.31 m^2) is divided into 2 parts:

The north-western part consists of the reception bunker with dimensions 22.50 m x 17.10 m. The bottom slab of the bunker is sloped at -6.00 m. One bridge crane runs along axes 4' and 8' above the bunker of the reception area which is controlled from the control room. The bunker area has a total height 16.45 m above ±0.00 level.

The second part of the reception area consists of the bag opener area and storage for bulky items. The bottom slab of the bag opener area is sloped at ±0.00m except an area of 7.50 m x 2.00 m = 15 m^2 which is slopped at -1.00. The total height is 16.45 m above ±0.00 level. The Reception area is equipped with 4 gates with the dimensions 4 (width) m x 7.5 (height) m, 2 gates with the dimensions 4 (width) m x 4.5 (height) m and one door for building access.

The Reception area is also supervised by the control room.

The pre-sorting and facilities area have dimensions 18.00 m x 18.80 m = 338.4 0m^2. There are 2 separate a two storey structures. The first one is for the pre-sorting cabin with dimensions 5.90 m x 7.05 m = 41.60 m^2 at the level 3.30 m. The stairs and the corridor is located in such a way as to provide access to the pre-sorting installation while non-interrupting the conveyor belts from entering inside the hand-sorting cabin.

The second one with dimensions 15.60 m x 5.50 m is for the future electro mechanical facilities at the level ±0.00 m. At the level +3.30 are located the control room, and the facilities for the staff (day room, dressing rooms and the toilets for the personnel working at the hand-sorting installations) with the access staircases.

The pre-sorting and facilities area is equipped with a 1 gate with the dimensions 4 (width) m x 4.5 (height) m and one door 1.60 m x2.40 m for building access.

Inside the **Mechanical sorting area** and between axes A1-A2 and 1'-14', there are 2 separate two storey structures, for the hand-sorting of waste with the access steel staircases at level +3.30. The stairs and the corridors is located in such a way as to provide access to the hand-sorting installation while non-interrupting the conveyor belts from entering inside the hand-sorting cabin. These staircases and corridors have a width of 1.20 m and are covered with steel grating. The two storey units have dimensions 20.05 m x 4.45 m and the second 20.05 m X 5.90 m.

The external dimensions of the **Mechanical sorting area** are 73.50 m x 23.40 m. The total area is 1719.90 m^2. Columns inside the hall are avoided or reduced to a minimum to allow an undisturbed operation and freedom in arrangement of the machines. The Mechanical Sorting area is equipped with a

3 gates with the dimensions 4 (width) m x 4.5 (height) m and sufficient emergency exits and additional gates where it is necessary for material handling.

3.3.2.2. Communication and transport

The building is to be provided with large road access for the trucks and a truck unloading area (to the north).

3.3.2.3. Architectural image

The spatial composition is based on simplified volumes and shapes. For the exterior walls steel sheets and concrete walls are provided. Roofs are from steel sheets. For the exterior and interior finish materials of high and long-lasting quality, such as exposed smooth finish reinforced concrete, steel galvanized facade elements etc. will be used, designed and detailed in contemporary style.

Portal gates and doors for access are provided at the perimeter of the building.

External walls bear windows for natural lighting.

Roofs are inclined and also have natural roof lighting.

3.3.2.4. Storage Shed for Recyclables

The Storage area for recyclables is located the North corner of the Waste Management Facility.

The assumed dimensions of the Storage Area are:

18.50 m x 30.40 m = 562.40 m^2 with a total height 7.05 m (including the roof construction)

The floor is made of concrete.

Columns inside the storage area are avoided or reduced to a minimum to allow an undisturbed operation and freedom in arrangement of the recyclable's.

3.3.3. Mechanical Sorting and Composting – process description

The Sorting plant will be positioned within the premises of the central waste management facility. The Sorting Plant is designed to accept an average of 500t/d mixed municipal solid waste, operable 365 days per year, with two 10h shifts

The process from which the recyclable products of the facility are produced, takes place within the Mechanical Sorting Plant.

The mixed solid wastes are treated though a single mechanical screening production process line which separates the waste into the following product streams:

a) The organic fraction - The flow of the organics that are derived from the less than 50mm sized material fraction from the screen drum, are led off via conveyor belt passing metallic separator, to the composting/ maturation area, finally producing compost.

b) The non-metallic fraction – This is to be found in the oversized stream (>50mm) that derive from the screen drum, this being mainly a mixture of paper and plastics. This stream is fed to the ballistic separator where it is further separated into 'Fine', Light' and 'Heavy' fractions. The 'Fines' (less than 80mm) are led off to composting area, while the 'lights' mainly consisting of plastic films, paper,

printed paper and the 'heavies' mainly consisting of PET and PE / PP are led separately to hand picking cabins. The recyclables materials are compressed into bales in the recyclable baler.

c) The ferrous metals fraction – This is derived from the two separate points of magnetic separation. The materials recovered by the two magnet separators. The ferrous metals are collected loose in a dedicated container.

d) The aluminum metal fraction – This is derived from the 'Eddy current' separator, these then being compressed into bales.

e) The RDF – This is the remaining stream after the hand sorting of 2D fraction

The operational process of the facility from which the product streams are produced is summarized in the following 'Flow Diagram'.

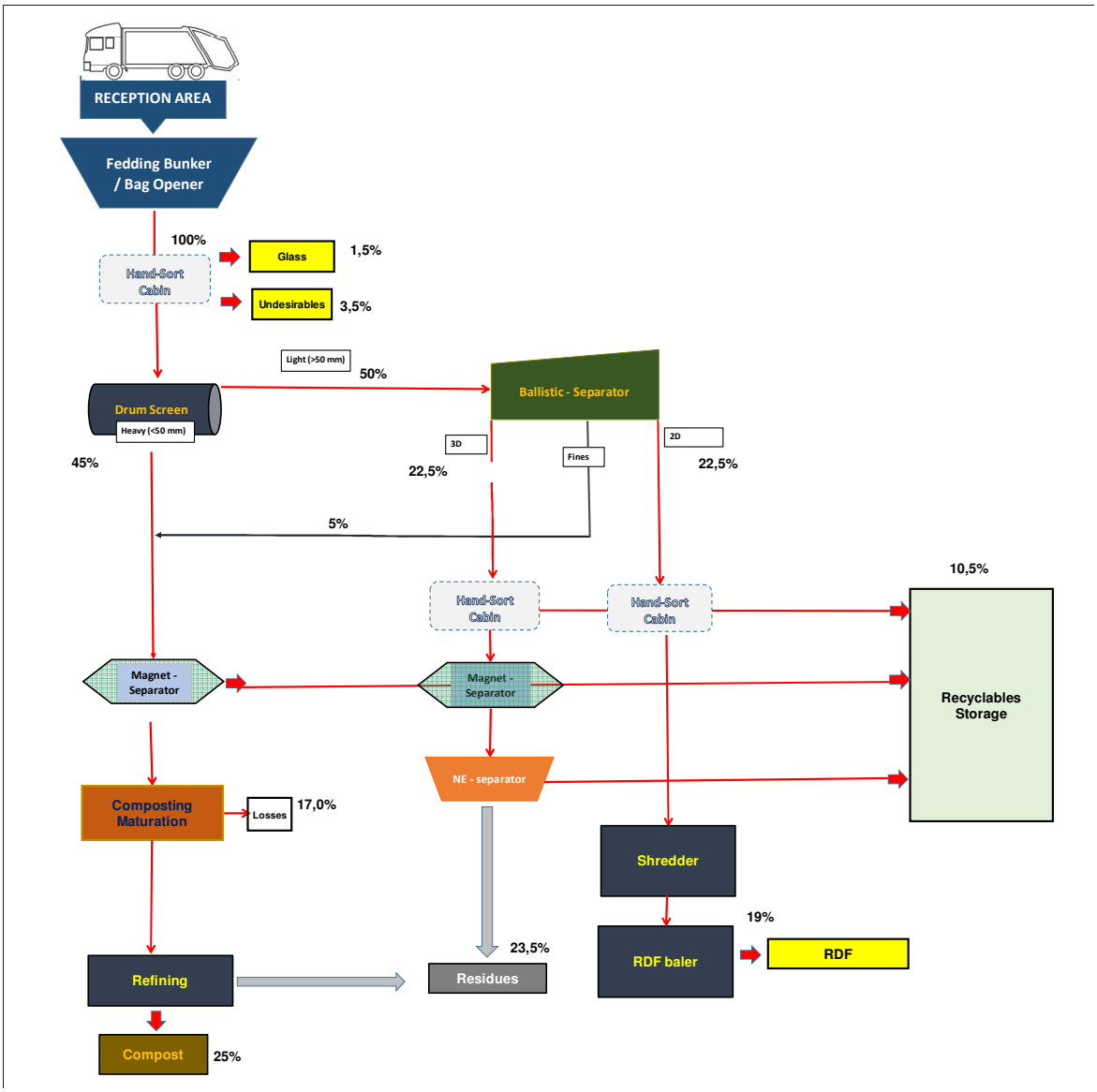


Figure 7: Indicative flow diagram

The Sorting process is to be housed within a building sized approximately 2,780.64 where 708.31m2 is dedicated to the waste acceptance area and bag opener and 2072.33 m2 dedicated to the sorting area. Within the main sorting area there are three hand picking cabins.

3.3.3.1. Reception Bunker

The municipal solid waste is delivered with waste transportation trucks in the WMC where it is weighed on the weighbridges at the entry point. After the completion of the weighing and the recording of vehicle loading, the waste is transferred to the waste reception bunker. The waste reception bunker is designed in order:

- To accommodate the daily incoming waste quantity
- Allow easy unloading of waste.
- Have adequate lighting for visual inspection of the waste.
- To allow access for the removal of unsuitable waste.
- Not allow waste dispersed in the surroundings.

Waste vehicles will discharge waste down into the waste reception bunker. Four doors are foreseen for waste acceptance, so municipal waste could be arranged as evenly as possible inside the bunker. Entrance doors of the reception hall will be opened and closed at a great speed whereby possible risk of escape of unpleasant smells is prevented.

The bunker is equipped by a reception crane. The crane ensures three functions, the optimum utilization of the bunker volume by moving the waste, the mixing of different composed waste fractions and also the continuous filling of dosing system – bag opener.

The bridge crane operator has a direct view to the crane unloading point. Bigger pieces of waste which are not suitable for mechanical separation are separated out at the bridge crane and discharged in containers, at the area adjacent to the bag opener. The removal of these materials ensures minimum interruptions of the plant operation.

The bunker is made from reinforced concrete. The finished floor level of the waste reception bunker will be approximately 6m below the finished level of the external area.

The bottom is formed with lateral inclination in both sides 1.5%, towards to a central channel for collecting any leachate. The leachates, through the channel, are led to a well outside the building, and then are collected and fed through the sewage network to the leachate collection tank.

3.3.3.2. Feeding system – Bag opener

Located within the waste acceptance area, the dosage bunker & bag opener is the first mechanical operation of the mechanical process. The feeding and dosing of the material is combined in one unit, which also is responsible for the opening of the bags. The combined unit opens the bags and transfers the metered material to the next pre-treatment step.

The bunker conveyor is constantly filled by the reception crane. In particular, the bunker conveyor is equipped with a chain belt. It has a reception volume 19 m^3 enough to receive the material from the grapple crane.

The chain conveyor feeds the bag opener that is connected to the head of the conveyor. The bag opener has the function to open the waste bags. This is done by means of a drum with knives. This drum rotates forward. The waste is pushed by the former chain conveyor against the cutting drum. On top of the drum a set of counter knives are positioned that tear the bags open while the drum rotates underneath it. The bag opener controls the speed if necessary. It is reversible in case bulky material blocks the line. The bag opener unit is to be capable of opening and emptying a very high percentage of waste in plastic bags, approx. 95%, and is to be suited to accept a wide range of materials, e.g. packaging materials, bio-waste, residuals etc. The bag opener is integrated to the bunker conveyor.

The waste exits bag opener through a conveyor and then is transported to following hand-sorting cabin for removal of undesirable materials and glass through handpicking.

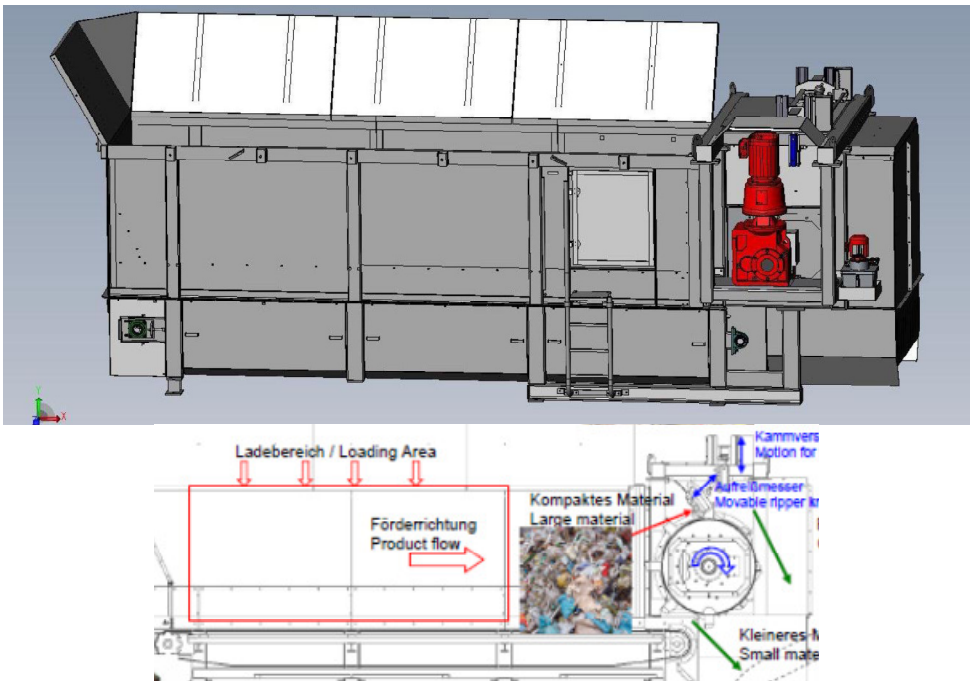


Figure 8: Bag opener installation

3.3.3.3. Pre-sorting bulky and glass

After the bag opener, pre – sorting follows. An inclined chain conveyor will fed material to the pre-sorting cabin.

The purpose of pre – sorting is to get out dangerous waste as well as valuable material. With pre – sorting, materials which could possibly cause malfunction of downstream equipment and processes are removed and larger materials and glass are recovered. Unwanted materials and glass are hand sorted and discarded in containers beneath the hand sorting posts. The filled containers are removed by a vehicle while other empty containers are mounted in place.

Within the pre – sorting hall the materials sorting will be performed over a slowly moving belt conveyor in front of the hand – sorting personnel. There are considered 2 independent separation sections. Each section will have two chutes on the upper level for receiving materials. Each collection chute are designed so that it can be served by 2 workers, thus, each section occupy 4 hand sorters. The personnel

of each section are responsible for the collection of a specific material type dropping it though the chute to the containers at the lower level.

The pre – sorting cabin comprise:

- completely enclosed cabin of sufficient size;
- workplaces arranged on either side of the picking conveyor;
- discharge chutes;
- walkways next to the picking belt;
- entry and exit ports for belt conveyors;
- connection to heating and ventilation;
- access ways;
- heating and cooling provisions to maintain an acceptable working environment.

The inlet air will be fresh air. The air pressure within the sorting cabin will be slightly positive with respect to the surrounding building or environment in which it is located. The quantity of inlet air will be greater than outlet air. Each job position will be separately ventilated and the correct air flow speed will be guaranteed and additionally allow for switching off the ventilation system at a given job position. Ten times air changes each hour will be proposed and the air rate exchange will be adjustable.

3.3.3.4. Trommel screen

The waste is transported by conveyor belt [C3] into a drum screen to divide the waste streams into two fractions:

- the mainly organic 'small fraction' (<50mm)
- the oversized fraction>50mm

The trommel screen operates on a totally horizontal inclination; the material's promotion through the screen is to be realized through an incorporated screw with adjustable rotation speed. The screen enables the separation of the material into two fractions.

The screen oversized >50mm usually contains the dry fraction like paper, plastics and others. Food waste and organics are mainly concentrated in the screen undersized <50mm.

Separated oversized fraction (>50mm) will be transported directly for further mechanical treatment by conveyors [C4, C5], while undersized fraction (<50mm) will be transported to the biological treatment unit by conveyor [C6B].

Figure 9: Trommel Screen

3.3.3.5. Ballistic Separation

The fraction >50mm from the output conveyor of the screen is transferred by conveyors [C4, C5 (vibrating feeder)] to the ballistic separator. The ballistic separator is used in order to further separate this fraction by weight. The bulky "3D" materials (PET, mixed bottles, other plastics such as PE / PP) through the vibrations of the separator 'roll' toward the lower edge of the inclined sorting surface, while the light "2D" materials (such as plastic films and paper) are moved along and collected at the upper end of the device. This light fraction of waste is collected by conveyors and transferred to hand sorting cabin. Then the bulky "3D" fraction is transferred to the hand sorting cabin for recovery of plastics. The fine fraction is transferred to biological treatment by the conveyor [C6A].

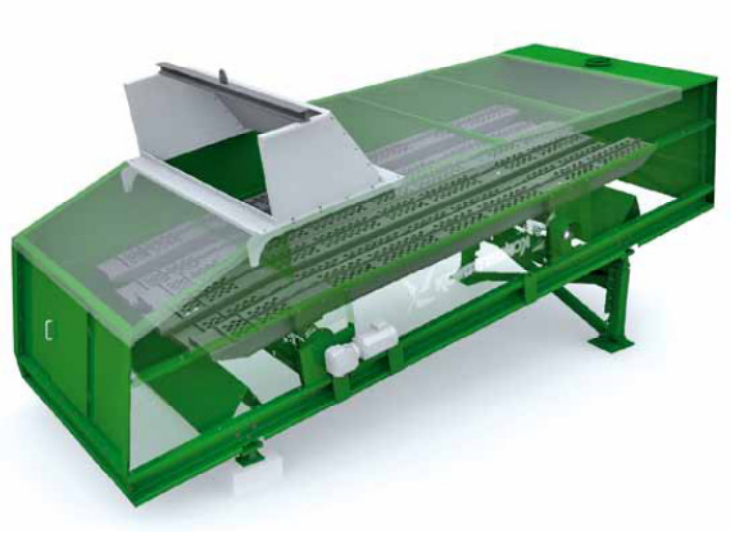


Figure 10: Ballistic Separator

3.3.3.6. Hand sorting Cabins

The 2D and 3D fractions from ballistic separator are transferred separately to hand – picking conveyors. Six independent separation sections have been considered in each hand picking conveyor.

Each section, in the hand sorting cabin for the 3D fraction will have two collection chutes on the upper level for receiving materials. Each collection chute will be designed so that it can be served by 2 workers, thus, each section can occupy up to 4 hand – sorters. The personnel will be responsible for the collection of specific material dropping it through the chute to the temporary storage area (silo) at the lower level.

Hand – sorted materials are temporary stored beneath the sorting platform in silos prior to being sent to the balling units. As soon as a silo is filled, or according to a predetermined operational program, a forklift vehicle with appropriate accessory, mini front – end loader or similar appropriate mobile equipment will promote the materials from the silos onto a chain conveyor leading to the balling unit.

At the end of the hand sorting belt conveyor, for 3D fraction, the non- recovered material, after exiting the hand sorting cabin they will passed under an over band magnet for the recovery of ferrous metals, and then under an eddy current separator for the collection of non – ferrous metals. These metals will be collected in dedicated containers. Following to this process the residue material will be collected in a container for residues.

Each section, in the hand sorting cabin for the 2D fraction will have one collection chutes on the upper level for receiving materials. Each collection chute will be designed so that it can be served by 2 workers. The personnel will be responsible for the collection of specific material dropping it through the chute to the temporary storage area (silo) at the lower level.

Hand – sorted materials are temporary stored beneath the sorting platform in silos prior to being sent to the balling units.

As soon as a silo is filled, or according to a predetermined operational program, a forklift vehicle with appropriate accessory, mini front – end loader or similar appropriate mobile equipment will promote the materials from the silos onto a chain conveyor leading to the balling unit. At the end of the hand sorting belt conveyor, for 2D fraction, the residue material, containing at a major part from paper & plastic, is transferred with a reverse conveyor [C10] either to RDF shredder or to storage area underneath the cabin of 2D fraction.

3.3.3.7. Ferrous separator

At the end of the hand sorting belt conveyor, for 3D fraction, the non- recovered material, after exiting the hand sorting cabin they will passed under an over band magnet for the recovery of ferrous metals. The technical characteristics of the unit are:

- Frame made by strong steel sheet plasma cut;
- Special steel covering structure in low-carbon steel and at high magnetic permeability in order to extend the life of the magnet to the maximum possible;
- "Sr-Ferrite" magnets at high magnetic induction and strong coercive force;
- The drums are built on self-aligning bearings in waterproof execution, complete of a grease-valve, two of them are mounted on plates with slides and steel turnbuckles;
- Worm attachable gear motor - 3 kW controlled by a control cabinet, integrated in the main MDB of the complete plant - IP54.
- All possible vibration is controlled through the shock absorbing heels of the torque reaction bar holding the gear motor

- Self-Cleaning by an Extracting belt made in black rubber resistant to abrasion, with high resistance synthetic clothes, easily replaceable, on location as installed due to the stainless Steel connecting Splices;
- The belt travels at the approximate speed of 1.8 m/s
- Stainless steel protection guards;
- Estimated magnetization life: 20 years.
- Execution according to 42/2006/CE Machine Directive;
- Weight: 1600 kg;
- Working distance: 250 ÷ 300 mm;
- Magnetic field intensity: 500 Gauss at 250 mm;
- Installed perpendicular to the flow of the materials — Cross installation
- Equipped with an emergency shut down button

3.3.3.8. Aluminium separator (Eddy Current)

Once ferrous materials have been separated, they are passed on to the 'eddy current' aluminium separator. The aluminium separator is equipped with vibrating feeder and a rotating drum magnetic type separator, so as to break the consistency of the materials and to remove any remaining ferrous materials from the stream which could cause damage to the aluminium separator because of the strong forces that are applied on them. The forces that are applied over the aluminium materials due to inductive currents that develop when they go through the aluminium separator cause these materials to be 'repelled' from the conveyor, therefore being diverted and collected separately. The non-ferrous metals that are collected are stored in containers.

3.3.3.9. Baler for RDF and Recyclables

Two balers will be used for compacting and baling one for the recyclable materials (these being: mixed papers, cardboard, plastic film, PET bottles, other plastics) and the other one for RDF. The bales exiting the machine should be taken away with forklift and they are transferred to the storage area.

3.3.3.10. Shredder

At the end of the hand sorting belt conveyor, for 2D fraction, the residue material, containing at a major part from recyclables, is transferred with a reverse conveyor [C10] either to RDF shredder or to storage area underneath the cabin of 2D fraction.

3.3.3.11. Biological treatment of the waste

Aeration of the composting heaps is achieved by the use of dedicated compost turning equipment that provides the necessary oxygen for the organic carbon bio-oxidation reaction. In order to achieve the stabilization level, a retention time of 60 days has been chosen (according to Circular No8/1/16-11-2015). Moreover, the duration of the composting phase depends on the end use of the compost and the quality required, thus the duration can be degreased accordingly

During this period temperature inside the cell exceeds 55 °C for more than 72 hours, as requested by the typical practice for sanitisation. The 21 windrows are formed. The particular pile dimensions depend on the design and the compost turning equipment. The windrows have selected dimensions width 5 m, length 30 m, and height 2.4 m with useful volume 210 m^3.

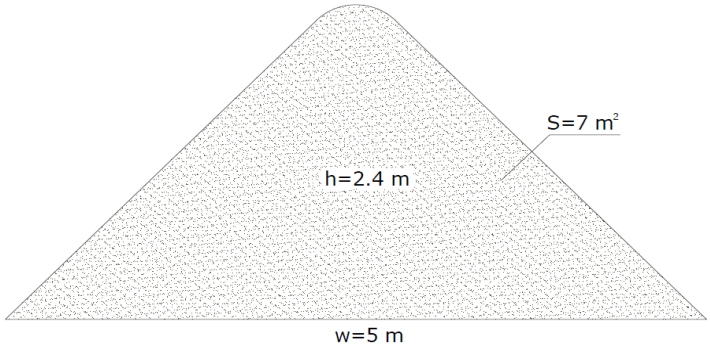


Figure 11: Windrow geometry

Also, approx. 15 m working area for vehicle movement etc., along the front sides of windrows is allocated. The windrows are periodically turned, by means of a compost turner.

The fresh undersize compost is directed to the 8 maturation windrows (similar shape as above). Also, working area for vehicle movement etc., along the front sides of windrows is allocated.

The compost windrows will be placed upon concrete slab. The slab will be made of reinforced concrete C20/25 and shall have 15.5 cm thickness.

A long mesh fabric (C283) of minimum 2.61 kg/m2 shall be used as reinforcement of the concrete slab. The standard sheet size will be approximately 4.8 m long x 2.4 m wide. The mesh size shall be of 10 cm (main) x 40 cm (cross) and the wire size shall have a thickness of 6 mm (main), 5 mm (cross).

3.3.3.12. Refinery

A mobile drum screen separates oversize and foreign material (plastics, glass, etc.) from fresh compost. The oversize fraction is disposed in the landfill; the under size fraction is transferred to the storage area prior to further transport for final use.

3.3.3.13. Water, wastewater, drainage and other works

Auxiliary works for water, wastewater, drainage systems as well as fire protection shall be installed to facilitate the needs of the plant. All the above mentioned auxiliary works will be connected to the main networks of the waste management facility. Wastewater produced in the composting-maturation area, as well as polluted rainwater, will flow by gravitation, to the leachate collection tank.

3.3.3.14. Compost area retaining wall

The organic output from the sorting building will be disposed outside of the building in front of a retaining wall in order to facilitate the loading of the material and transportation to the windrows. The wall shall have a net height of 3.00 m and length of 3.00 also. The construction details are shown in drawing 9-STR-RW-01-S-01.

4 Operation procedures

4.1. General descriptions of the procedures

At the current project we study the implementation of the new WMC in Srar Akkar which is consisted of a mechanical sorting and composting facility as well as a sanitary landfill site, the leachate and biogas treatment facilities which are an integrated part of the designed waste management installations.

The operator of the landfill does the entrance control, which consists of check of the documentation attended the waste, visual check of the waste at the entry gate of the landfill and the place of deposing to determine the correspondence of the waste with the description in the documents given by the possessor of the waste and taking of representative samples of waste, which have to be saved over three months by the operator. The operator immediately informs the competent authority if it is made a refusal for access.

All incoming vehicles carrying waste shall pass through the main gate and in open body trucks is visually inspected for acceptance or rejection and the waste declaration is checked. Incoming waste carried in compaction vehicles or in closed containers is inspected after unloading at the landfill cell for acceptance or rejection. Trucks delivering waste to the facility are not allowed to leave the facility before the delivered waste is accepted.

In case the delivered waste is rejected the waste shall be loaded back into the delivering truck, but if this is not possible, e.g. for compaction vehicles, the landfill staff shall load the waste in a container. All costs connected with handling of rejected waste (i.e. loading, transportation and disposal) shall be paid by the transport company delivering the rejected waste.

All data on received and rejected waste shall be recorded in a data system which in the future will be integrated with a weighbridge. These data will indicate the type and composition of the incoming waste, quantity (in tons), the origin of the waste (i.e. the producer of the waste) and the waste declaration (permission for disposal of the waste on the regional landfill).

The Operation and Maintenance Manual is prepared on the basis of the following operation procedures:

- Reception
- Unloading and Control
- Waste transport at the mechanical sorting and composting facilities
- Waste Transport from mechanical sorting and composting facilities at the Landfill
- Compaction of Waste
- Daily and Intermediate Cover
- Gas Collection Wells
- Temporary Cover and Top Cover System
- Leachate Management
- Waste Water Management
- Landfill Gas Management
- Measures for Reduction of Nuisances

- Management of ground and surface water.

4.2. Reception

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.

✓ **Waste acceptable for reception at the facility**

The facility can receive only solid waste. The waste must be in a form ready for disposal. All admissible waste must be in such a condition that allows its correct and secure disposal with the available machines and technology. Waste types not conforming with the below criteria shall be categorized as unfit for disposal.

- Any single waste fragment which cannot be handled by the equipment operating at the tipping front
- Construction rubble, concrete, slag and stones longer than 0.4 m
- Beams, pillars, shanks, logs, pipes, poles, profiles, etc. longer than 1.2 m and with a diameter more than 0.3 m

Hazardous waste shall be packed in authorized plastic containers (barrels or drums) labeled according to the current legislation. Any container shall be accompanied by a separate declaration for the waste. In order to provide efficient operation of the facility the Operator can impose further restrictions with regard to:

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

✓ **Permission for disposal:**

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

- Together with the first delivery the waste producer must submit an application for delivery of waste to the facility. The application shall state the following data:
  - Full name of the company
  - Address
  - Telephone number
  - Managers' names.
  - Registration number/code of the truck(s) to be used for 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
- The facility Operator can only receive waste depending on test results or declarations
  - The Operator can require declarations from an acknowledged expert. The costs for declarations are at the expense of the waste producer

✓ **Delivery of Large quantities**

In case of delivery of large quantities of waste the facility must be informed in advance. The facility determines the time for the delivery. If the delivery exceeds more than 200 m³ the Operator reserves the right to 2 days' notice for the delivery.

✓ **Exclusion of waste suppliers**

The landfill Operator can deny suppliers to use the facility if the suppliers intentionally deliver inadmissible waste or repeatedly violates the User Regulations.

✓ **Reception of Waste in Small Vehicles or Private Cars**

Private citizens can deliver waste for disposal at the landfill by their own transport without prior agreement. The landfill Operator can at his choice establish an area in close connection with the reception area, where private citizens can unload their waste into e.g. open containers, thereby avoiding traffic of private cars in the landfill cells.

✓ **Control of incoming waste**

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

- Registration of the waste transportation truck and the waste producer
- 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 at the unloading platform. Waste delivered in closed trucks shall be visually inspected at the landfill cell after unloading and before the waste is compacted and covered
- It is strictly forbidden to open sealed containers with hazardous waste. Such containers can only be controlled by the declaration following the waste

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

✓ **Registration**

Records of all data concerning reception and transport of waste to and from the landfill are registered in the software data system. The operator of the 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 on a regular basis 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.

✓ **Rejection of Waste**

If the control shows that the waste is not in compliance with the types of waste permitted to be disposed 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) in order 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 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 final decision can be made.

All cases of temporary and final rejection for waste reception must be registered in the "Landfill Report book".

For all incidents where a delivery is rejected, the landfill Manager must issue a violation statement and inform the Regional Environmental Authorities.

✓ **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.

Fees are calculated automatically by the data system.

All vehicles departing the landfill area shall be inspected and if necessary cleaned in the truck wheel wash facility located at the reception area.

4.3. Waste Transport at the Mechanical Sorting and Composting Facilities

The shift mechanical sorting and composting facilities operator shall supervise the unloading of Permitted Waste in the waste reception area and shall check that the deposited Permitted Waste conforms to the description provided by the weighbridge personnel as described on the waste delivery note. This incoming waste inspector could be the MBT operator or any other trained figure such as nominated by the Operator. He shall call his supervisor in case of doubt. Unloading shall then be suspended if materials are found which are suspected of not complying with Permitted Waste. No waste acceptance is to be resumed until the matter is resolved.

This section discusses the following topics concerning the operation of the mechanical sorting and composting facility:

- Program of continuous operation of the facility.
- Process description of facility
- Maintenance program facility.
- Implementation of control program.
- Site Engineering for pollution prevention and control

4.3.1. Program of Continuous Operation of the Facility

The management and proper operation of Treatment Plants are particularly important and requires systematic and responsible approach. The operational program concerns the continuous placement and training of personnel within the facility, the maintenance of all electrical and mechanical equipment of the facility, of the mobile equipment and vehicles of the facility, and the buildings of each unit of the facility and all related infrastructure (roads, rainwater, fire, sanitation installations) to enable the proper and efficient processing of all the wastes to be received according to the designed exploitation plan.

The operations performed in the under examination facility are classified into the four following categories:

a) General organization and control of areas

b) Monitoring, control and maintenance of plant operation

c) Environmental monitoring and control works

d) Staff training

e) Tasks and activities for information dissemination.

The below summarizes the main items included in each category of work.

4.3.2. General Organization and Control of Areas

These operations are to be performed daily and concern the organization and systematic monitoring of all work performed within the facility so that the waste treatment plant operates efficiently (in accordance with the relevant standards) environmentally and legislatively acceptable.

It includes all works relating to the daily recording of data on both incoming materials (waste type, supply vehicle data, point of collection of the vehicle and driver name, payload, etc.) and the outputs

(product type, receiving vehicle data, carrier and consignee name, payload, etc.). These data are recorded by weighbridge software and then sent to the central server of the facility for storage and preparation of reports. It is advisable that the Operator prepare monthly, quarterly and annual operation reports with all features and results of operation of the unit.

Specifically, the services provided in connection with organization and systematic monitoring of all operations performed within the area:

a) Implementation and monitoring of the daily and long-term operation program of the facility, especially:

- The drawing up of rules of operation and monitoring of operations
- Planning of long-term operation of the facility based on the finalized 'as built' design documentation of Contractor, actual operational data, the results of environmental audits and existing legislation.
- Establishment daily operating program of facility.
- Establishment of emergency response procedures.
- Daily recording data on both incoming materials (waste type, delivery vehicle data such as collection location-kind collection vehicle carrier and driver name, payload, etc.) and the outgoing products (product type, receiving vehicle data, carrier and consignee name, payload, etc.).

b) Collection and processing of data from the operation of the units, including:

- Collection and processing of data relating to the quality, type and quantity of incoming waste and outgoing respectively per unit and the final recovered materials and products.
- Collection and processing of data related to environmental control (odours and dust emissions, noise etc.)
- Collection and processing of data relating to the smooth and efficient operation of processing units (efficiencies, maintenance, damages, operational capacities achieved depending on the period and the categories of incoming materials)

c) The briefing of National and Local Authorities and other responsible bodies on the operation of the facility, including:

- Contacts with third parties visiting the facility (public visitors, environmental inspectors, officials, etc.)
- Formulation and transferral of suggestions of necessary interventions for the better and more efficient operation of the unit
- Operational bookkeeping, control and monitoring
- Compilation of monthly, quarterly and annual reports for the beneficiary (local authority) of the facility with all the necessary information on the plants operation.

The drafting of the operational regulations is to include all details on how to perform specific tasks in the facility as well as measures for the health and safety of workers which must be respected and adhered to.

The implementation of the daily operation program of the facility covers the methods of how to carry out each individual work tasks per day and includes:

1. The recording of the daily amount of incoming waste and outgoing Product
2. How to perform the work
3. Maintaining records on all equipment (machinery, fuel, damage, maintenance, etc.)
4. Check individual facilities and project settings yields

The drawing up of a Emergency Response Plan is to include:

- The name of the potential occurrence and its description
- Reasons for its occurrence
- The effects that the occurrence cause
- Methods of mitigation / correct handling of the situation

As regarding the collection of data from the operation of the units, a record of the qualitative and quantitative data of incoming waste, qualitative and quantitative data of outgoing materials from the mechanical sorting and composting facilities and all data from environmental monitoring parameters required by the Legislation are to be recorded.

The organization and control of the above operations is of the most important parameters for increasing the lifetime of the project, to achieve the continual goals of the efficient utilization of the facility and harmonization with existing legislation for the operation of the project and protection of the environment.

4.3.3. Monitoring, Control and Maintenance of Plant Operation

This section covers the following basic activities:

- Carrying out of maintenance programs on all electromechanical equipment and vehicles (daily – weekly – monthly – quarterly – yearly, etc.), troubleshooting and repairing any chance operating anomalies
- Carrying out of maintenance programs on all buildings (doors, panels, flooring, windows, ventilation, sanitary units) and building electro-mechanical installations (lighting, drainage, water supply, fire, telephone networks)
- Supplies and maintenance of stock inventory of parts and wear parts for all the electromechanical equipment of all facilities
- Organisation of products warehouse
- Maintenance of internal roads and storm water ditches, cleaning of grounds and fencing from windblown litter.

- Monitoring and maintaining external networks (lighting, drainage, water supply, fire, telephone networks).
- Control and regulation of plant efficiency
- Check green areas and irrigation
- Implement of programme of control of areas

For the smooth, correct and efficient operation of all units of the installation, a set of activities are to be implemented as follows:

Carrying out of maintenance programs:

This regards the implementation of the maintenance programs of all electromechanical equipment and vehicles (daily-weekly-monthly-yearly), troubleshooting and repair of any operational anomalies and as also for the electromechanical installations associated with building installations (lighting, drainage, water, firefighting, etc. systems).

Maintenance of stocking levels of spare parts for all the electromechanical equipment

Maintenance of complete stock of spare parts for all the electromechanical equipment. Particular emphasis is given to the requirements of the basic operational units of the facility (critical list units), where any failures require immediate repair to restore the total facility back to full normal operation. These basic operational units on the critical list which are absolutely necessary for the full normal operation are to be identified and listed by the works contractor in their 'as built' operational manual. Within the works contractors operation manual, a specific assistive manual is to have been prepared in which the type of spare part, unique order number and the operative hours to replacement are stated, in order to give the necessary priority of these items in the stock room, as well as assisting in the collation of statistics concerning the most common malfunctions every part of the basic equipment, methods of dealing with these and related spare/wearing parts.

Maintenance of internal roads and storm water ditches, cleaning of grounds and fencing from windblown litter

Periodical visual inspections of all aspects associated to roads and associated storm water runoff (grates, manholes, etc.) are required. A Regular cleaning and de-clogging program of these aspects should be implemented, to be programmed at least bi-annually and most certainly before periodical rainy seasons. In addition, interior and exterior areas are to be cleaned periodically by motor sweeper and cleaning crew.

Monitoring and maintenance of external networks of water, firefighting, drainage, phones, electrical, and automation

Periodical visual inspections by experienced professionals of all aspects associated relating to external networks of water, firefighting, drainage, phones, electrical, and automation and conducting of immediate repairs for any identified wearing/malfunctions. In addition, all network connection grids are to be opened and checked / cleaned at regular intervals.

Control and regulation of plant efficiency

The control and regulation of basic process equipment of the facility is based on the recorded and expected performances of each unit, the qualitative and quantitative characteristics of each incoming and outgoing material (product) as well as any additional comments / observations of the respective manufacturers. The majority of manufactures maintain databases of operational parameters from their unit operating in various installations which may be requested in order to optimize the performances of each unit of the facility.

Implement of programme of control of areas

Full records of visitors to the facility are to be maintained with all relevant information (name, purpose of visit, person to be visited, etc.). A manual (printed literature and video) for the purposes of site training of visitors without work (visitor's badge, etc.) is to be kept updated and readily available.

4.3.4. Bale handling and storage

Properly handled and stored bales help maintain the quality of prepared commodities prior to sale and help improve workplace safety. In general, baled materials should be stored in a fashion that keeps them clean and dry.

Bales should always be transported in a fashion that keeps them elevated off the floor surface. When transporting bales throughout a facility, take caution not to push bales directly across the floor surface, as this may embed unwanted contaminants into the bale.

Minimizing the number of times a bale is handled is the best practice for maintaining bale integrity through storage, loading and shipping. Excessive handling increases the probability of bale breakage and introduction of contaminants.

4.4. Waste Transport from mechanical sorting and composting facilities at the Landfill

Neither the compactor nor any other vehicles are under any circumstances allowed to drive directly on the drainage layer at the bottom or inner slopes of the landfill cells, as this may cause damage to the drainage pipes or the liner. Before any traffic enters into these areas the layers must be protected using additional layers of gravel (min. 0,5 m above the drainage layer), initial layers of waste (see below) or load distributing plates of steel or concrete.

- ✓ **Traffic**

After control and registration at the entrance the operator of the weighing bridge directs the driver of the truck to the appropriate landfill cell for unloading of the waste.

The Operator of the Landfill shall install traffic signs and/or road markings inside the landfill area directing the drivers of the trucks to reach the landfill cells as instructed.

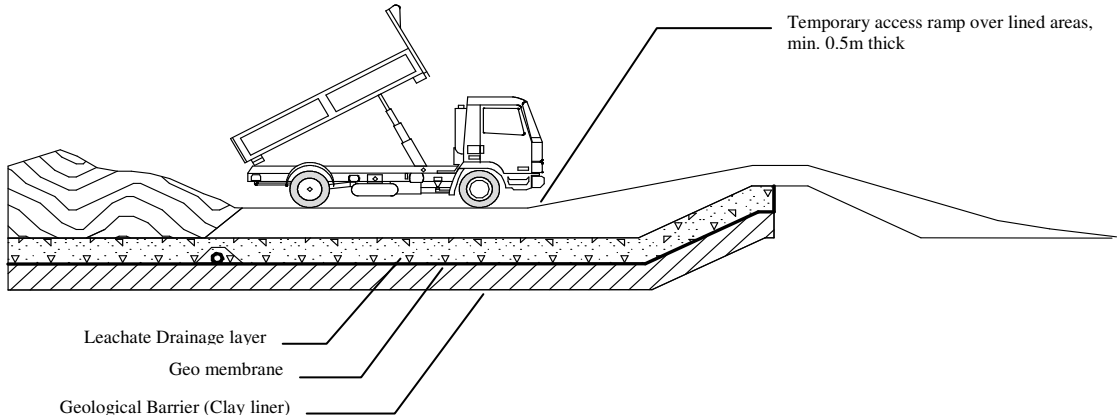
The common Traffic Regulations are valid inside the facility area. The speed limit for all vehicles is 30 km/h maximum.

In order to ensure a safe transportation of the waste at the facility all displayed traffic signs shall be observed. This applies whether it is a signboard or signage on the road surface.

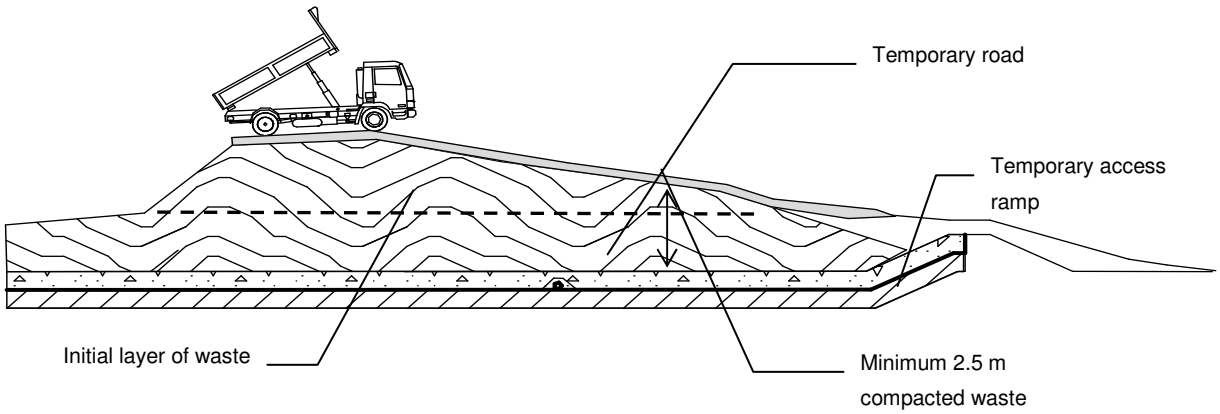
The truck drivers shall at all times comply with requests and directions given by the receiving staff.

- ✓ **Temporary roads**

No traffic is allowed directly on top of drainage layer in the landfill cells or on the intermediate dikes. The landfill staff shall establish and maintain access ramps and temporary roads over the dikes and the drainage layer with a min. thickness of 0.5 m ensuring a min. distance from wheelbase to the geo membrane of min. 1.0 m.



The landfill staff shall establish and maintain access ramps and temporary roads over the already deposited waste inside the landfill cells, securing the safe access of waste delivery trucks for unloading in the cells. The roads can be established using gravel and/or stone, crushed mineral debris from construction and demolition waste or moveable plates of concrete or steel. The thickness of compacted waste below the temporary roads shall be at least 2.5 m.



4.5. Unloading and control

When the delivery truck arrives at the landfill cell the operator of the compacter points out to the driver the exact location for unloading the waste.

After unloading at the appointed position, the landfill compactor or a bulldozer spreads the waste and the operator visually inspects the waste for compliance with the waste type and composition, which is acceptable in the landfill cell. The delivery truck is not allowed to leave the landfill cell before the waste has been finally accepted or rejected.

In case the waste is rejected the waste shall be loaded back into the truck and the truck driver shall be instructed to return to the waste producer.

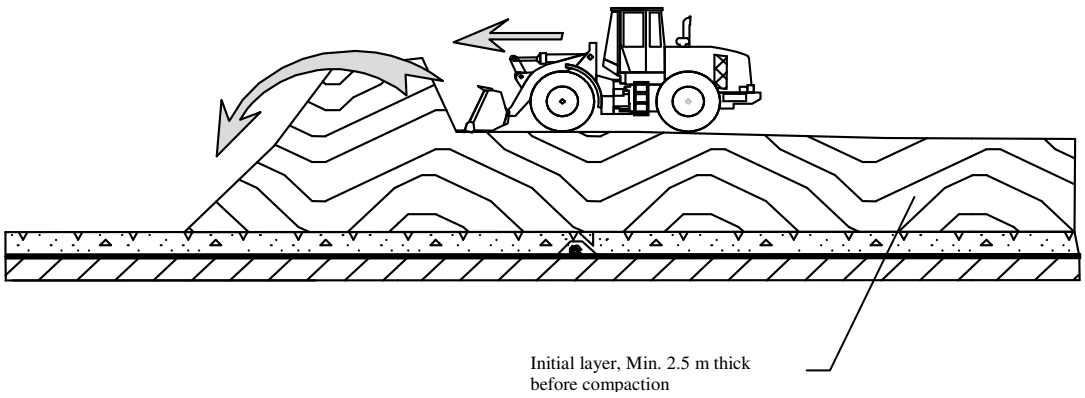
In case it is not possible to re-load the waste into the truck (e.g. when the waste has been delivered in closed or compacting trucks) the waste will then be loaded into an open maxi-container and returned to the waste producer.

4.6. Compaction of the waste

General: Neither the compactor nor any other vehicles are under any circumstances allowed to drive directly on the drainage layer at the bottom or inner slopes of the landfill cells, as this may cause damage to the drainage pipes or the geo membrane. Therefore an initial layer of mainly fine grained waste without large objects (longer than 1 m), hard or sharp objects, which could perforate the plastic membrane shall be placed before any compaction of the waste takes place. Nor may the initial layer contain sludge or liquid waste. The initial layer is installed using a bulldozer or the compactor to position the waste by "over-rolling" - not pushing -in to a single layer of approx. 2.5 m height before compaction.

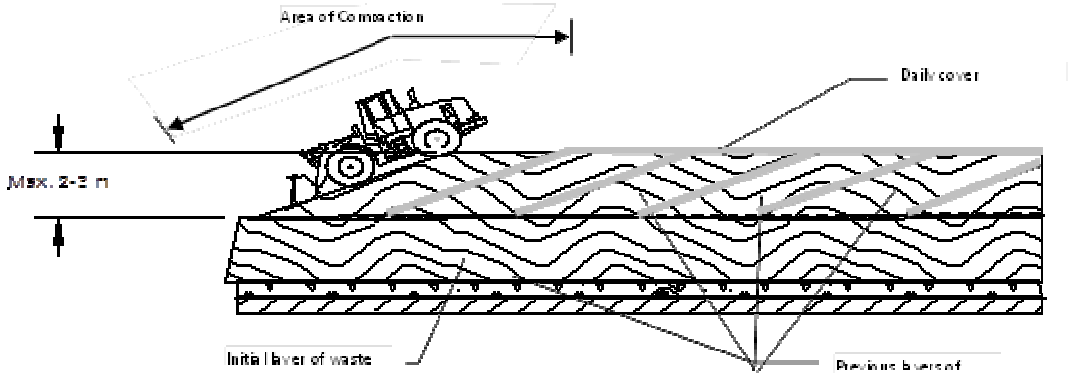
The initial layer shall be covered using a daily or intermediate cover, see the description below.

After the initial layer has been placed concurrent layers are installed using the compactor or a bulldozer to push the unloaded waste to its final position in the landfill cell and spread it to a layer no more than 0.5 m in thickness. The waste is crushed and compacted by 3-5 passes by the landfill compactor. Larger objects in the waste may require additional passes to be crushed adequately.



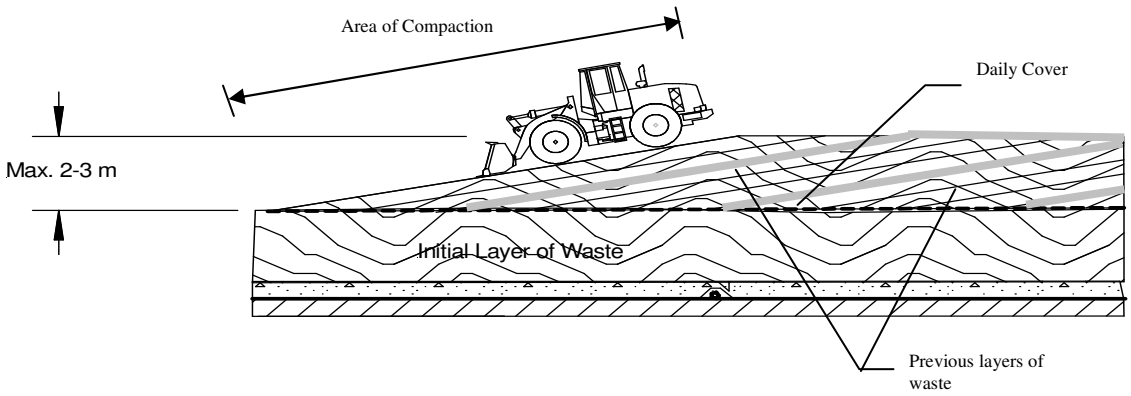
The compacted waste layers are installed with a sloping face to promote surface water run-off and to minimize the total open area of uncovered waste during operation. The installation shall follow the techniques portrayed diagrammatically below.

- ✓ **Face tipping:**



The waste is tipped out and compacted into a bench. The bench continues level across the cell for a period of days or weeks until the cell is filled in its full width. The height of the bench is 2-3 m, and the compactor is working down the face of the bench as well as along the surface of the bench.

- ✓ **Onion Skin Tipping:**

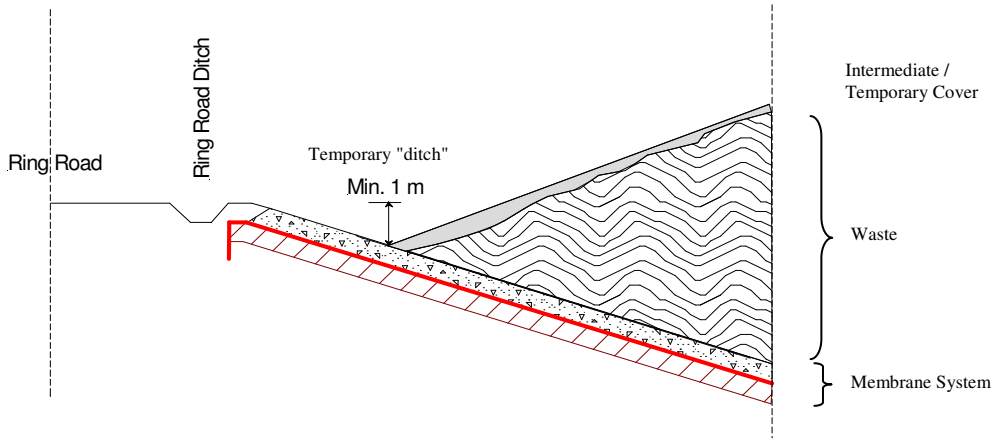


The gradient of the face slope is considerably shallower than for the Face Tipping method, and the compactor operates solely on the face. This method generally results in higher compaction degree of the waste and reduces the risks for litter being blown of the face by the wind.

- ✓ **Counteracting seepage and overflow:**

Irrespective of the chosen installation technique, the landfill operator shall ensure, that neither during filling of the landfill cells, nor after installation of intermediate, temporary or final cover may overflow or seepage of leachate occur, that results in leachate flowing to the surroundings.

Until the top cover system has been installed a temporary ditch shape shall be maintained between the deposited waste and the side of the dike along the surrounding dike and the ring road see the below illustration:



Each lift of waste shall be installed and compacted with a slight gradient of the near-horizontal surface towards the central part of the landfill cell. This will reduce the risks for leachate inside the waste body to move horizontally towards the outer slopes of the deposited waste and consequently reduce the risks for seepage through the cover system.

- ✓ **Special measures**

The operators of any machinery operating in the landfill cells shall pay special attention not to cause damages to inspection wells, gas collection wells or other structures inside the landfill cell. The compactor and other vehicles may not operate within a 2.0 m distance from these structures.

4.7. Daily and intermediate cover

- ✓ **Daily cover:**

At the end of each working day the working face of the waste shall be covered with free-draining soil or other suitable inert and permeable material, e.g. crushed construction and demolition wastes. The implementation of a daily cover decreases the risks for fires and odours, for windblown litter, and impedes the access for vectors to the waste. When resuming operations the following day, the daily cover is, to the extent possible, scraped off for subsequent reuse.

The daily cover shall be at least 10-15 cm thick in order to cover the waste adequately. Low permeability soils shall be avoided as they can negatively affect leachate transport in the waste body.

- ✓ **Intermediate Cover:**

Intermediate cover is used when filled surfaces are likely to be left for a period of weeks or months before additional lifts of waste are to be added. The cover significantly reduces rainfall infiltration, whilst it effectively reduces the risks for windblown litter. Intermediate cover materials shall be materials as used for daily cover.

The thickness of the intermediate cover shall be 30-50 cm. The area covered by an intermediate cover shall be inspected regularly and as minimum after any heavy rainstorms in order to detect and repair any defects in the cover caused by e.g. erosion.

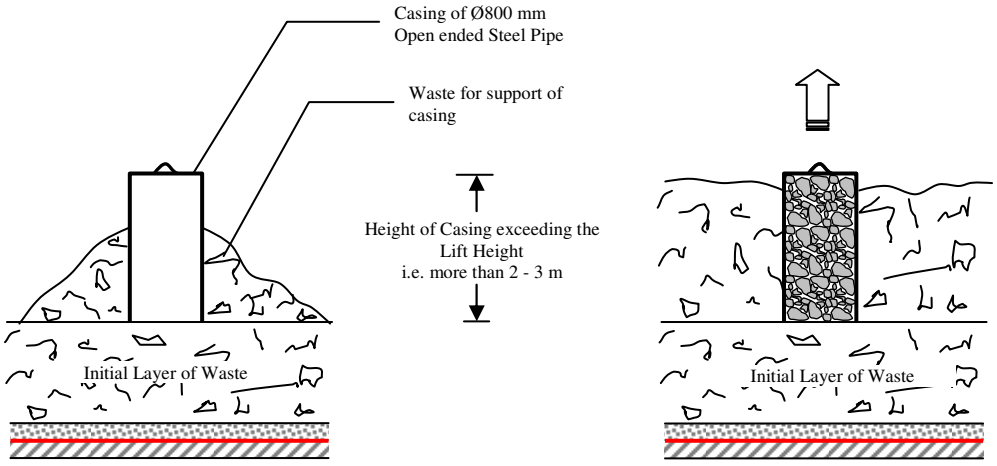
When resuming operations in the area subject to intermediate cover, the daily cover is, to the extent possible, scraped off for subsequent reuse.

4.8. Gas collection wells

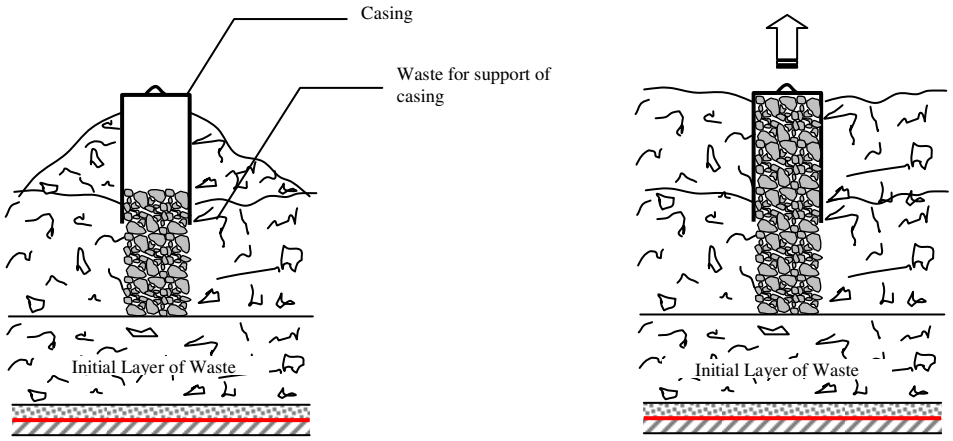
After installation of the initial layer of waste at the bottom of the landfill cells, gas collection wells shall be erected concurrently with the increasing fill height. The wells shall be established using coarse grained gravel and stones or crushed mineral debris from construction and demolition wastes installed as vertical "chimneys" through the waste body. Installation takes place using a steel tube as casing as described in the following:

The open ended pipe casing is positioned vertically at the surface of the initial layer of waste using the compactor or equivalent machinery, lifting the casing by chains attached to handles welded to the casing. The casing shall be stabilized, e.g. with waste positioned up to the casing.

When the filling of waste reaches the lift height the casing is filled with the gas drain material. The drainage material shall not be compacted as this may impede the extraction of the casing without dislocation of the drainage material.



The casing is lifted corresponding to the height of the next lift of waste, again using chains and the compactor or equivalently suitable machinery. The operations above are then repeated for each lift of the waste up to the last lift before reaching the final filling height in the landfill cell.



In the final lift the vertical gas collection pipe in the centre of the well is installed inside the casing before filling the casing. When the final filling height has been reached the casing shall be removed in which process special care shall be exercised securing, that the vertical collection pipe is not damaged or dislocated.

When the final top cover system has been installed, see the below operations, then the remaining components of the gas collection well shall be installed, ref. descriptions in Chapter 5, Design.

4.9. Temporary cover and top cover system

- ✓ **Temporary Cover:**

The utilisation of a temporary cover reduces the area of exposed waste and thus diminishes negative visual impacts and reduces leachate generation. The temporary cover is used when filled surfaces are likely to be left for a period of 1 year or more. Further the temporary cover is used to cover the waste in the period of time between the final filling height being reached and the final top cover system being

established. Materials used for the temporary cover shall be low-permeable - but not impermeable - soils.

The thickness of the temporary cover shall be approx. 50 cm or more. In order to protect the surfaces from erosion and to reduce the risks for drift of dust from the surface, a thin layer of topsoil is applied and seeded using grass and herbs with strong root systems.

In areas where filling operations are resumed at a later stage and prior to installation of the final top cover system, the temporary cover is scraped off for subsequent reuse.

The temporary cover shall be inspected regularly and as minimum after any heavy rainstorms in order to detect and repair any defects in the cover caused by e.g. erosion.

4.10. Leachate management system

Leachate management at the landfill includes the operation of the following units:

- Leachate drainage system (drainage layer and drainpipe at the bottom of the landfill cells, the leachate outlet structures in the lowest and in the highest positioned corners of each cell
- Inspection shafts
- Valves installed in the Inspection shafts
- Leachate transportation pipe

During normal operation the equipment is totally self-reliant requiring no input by the site personnel. The inspection shafts positioned inside the area of the cells shall however be prolonged appropriately as the level of in filled waste is rising, and regular inspections – see Chapter 4, Design - shall be exercised to ensure the proper function of the system at all times.

4.11. Landfill biogas management

✓ **General**

The emission of landfill gas is controlled by the operation of the gas collection system, which will be installed and set in to operation immediately after the top cover system has been installed. The principles for the design and function of the gas collection system are described in Chapter 5 Design. When installed and running at a stable level the biogas management system is in principle self-reliant. In order to secure the most efficient gas control it is however necessary, that the Operator of the landfill monitors and adjusts the system on a regular basis.

✓ **Installation of wells, etc.**

During filling operations the landfill operator ensures, that the biogas collection wells are installed as described above. As the filling of waste reaches its final height and the top cover system is installed, the collection gas drain pipes in the top cover system shall be connected to the biogas collection well, the remaining parts of the biogas collection wells (see chapter 5 Design) shall be installed and connected with the biogas transportation pipes.

It is strongly recommended that the installations and the initial adjustments are undertaken by a contractor experienced with this kind of work under the supervision of an experienced engineer.

The quality (composition) of the biogas and the pressure inside the wells vary from well to well and over time for the individual well. Each well must be adjusted individually at start-up of operation, and it is further necessary to monitor end adjust the wells later during the operation.

In order to adjust a biogas well, it is necessary to know 3 parameters:

- The vacuum or the flow in the boring
- The methane content (CH_4)
- The oxygen content (O_2)

✓ **Running-in**

In the initial phase of the operation and after any major changes to the system (e.g. the addition of new biogas collection wells) the system shall be adjusted to the new conditions through the below procedures.

- All the biogas wells are checked for water and emptied if necessary
- The above stated parameters are measured and registered for each well, as is the corresponding atmospheric pressure
- All valves at the biogas wells are opened corresponding to the maximum flow from each well
- All valves at the in-flow manifold at the pump are opened, and the pump is adjusted to a biogas flow of approx. 2-3 m^3 / year / tonnes waste covered by the installed biogas extraction system.
- Pumping continues for approx. 1 week. Every 24 hours readings are taken of all the above stated parameters
- In case the content of oxygen increases significantly and above 1.0% in either one of the wells, the valve at the well is adjusted in small increments to reduce the flow from that well, until the content of oxygen is below 1.0 %
- The measurements and consequent adjustments are continued until the contents of methane and oxygen are stable for each well. In this stable situation the content of methane shall not be less than 35% and the content of oxygen not more than 1.0%
- When a stable situation is reached, the total flow is increased by about 20% by adjustment of the pump
- The above procedures - items 5 to 8 - are repeated until the maximum flow, i.e. the maximum gas production, at a stable content of methane is reached.

During the first 48 hours the quality of the gas most likely will be better (i.e. have a higher methane content), than when the stable situation is reached.

✓ **During operation**

When the plant is operating at full capacity the content of methane and oxygen, the vacuum and/or the flow shall be measured once every week at the in-flow manifold at the pump. All measurements are registered in the log book for the biogas management system.

If the total oxygen content measured in the pump house increases to approx. 1.5%, measurements shall be done at the individual biogas wells. At all wells, where the oxygen content is more than 1.0%, the valve is adjusted in small increments until a stable level of oxygen below 1.0% has been reached. It may prove necessary to make several rounds of measurements and adjustments.

Adjustments of the flow from individual gas wells and especially the closing of individual gas wells will influence the flow from the other gas wells in the system. The resulting vacuum (suction pressure) at the in-flow manifold of the pump must therefore be checked after significant adjustments and after closure of one or more gas wells, if necessary the pump must be adjusted accordingly to obtain an acceptable suction pressure.

Closed gas wells shall be monitored every month. If the methane content increases above 35% the well shall be re-opened.

4.12. Measures for Reduction of Nuisances

Odors, dust, wind-blown litter, vermin and noise can become significant nuisance factors for the surroundings during the operation of the landfill.

✓ **Odor:**

Offensive odors may arise from:

- Digging activities in previously deposited waste
- Handling of malodorous wastes, e.g. sewage sludge
- Open leachate lagoons or containers
- Emission of landfill gas

The principal means of minimizing landfill odors include:

- Effective compaction
- Provision of adequate cover especially the daily cover
- Immediate deposition and covering of especially malodorous wastes
- Effective gas collection and treatment system
- Immediate deposition and covering of excavated wastes

✓ **Dust:**

Emission of dust may occur under windy conditions:

- During unloading of waste
- During installation of cover materials
- When driving on dry, unpaved areas
- When driving on paved but poorly cleaned areas

The Landfill Operator shall organize the operations at the landfill in such a way, that emission of dust is kept to a minimum. The following measures can be used:

- Surfaces with dry soil and service roads are sprinkled with water
- Transportation activities are restricted to the service roads
- Paved service roads are cleaned by sweeping
- Sprinkling of dry soil or waste during excavation and reposition
- Areas with temporary cover area seeded with grass

✓ **Litter**

A frequent reason for complaints is litter blowing outside the landfill area. The perimeter fence installed around the landfill helps to contain litter and prevents it from being scattered to adjacent properties. Cleanups, particularly at the end of the working day, limit the quantity of litter that can be carried to adjacent properties.

The amount of wind-blown litter can further be substantially reduced by:

- Keeping the working area as small as possible
- Placement and compaction of the waste immediately after unloading
- Installation and maintenance of daily, intermediate and temporary covers
- Restricting unloading on windy days to areas of the landfill cells sheltered from the wind

✓ **Vermin:**

Vermin include rats and other rodents, insects, birds and other animals, each of which can carry disease agents and therefore becomes a health hazard.

The most effective practice in the control of vermin is rapid and complete compaction and covering of all waste. The territory of the landfill must be maintained clean and tidy. The accumulation of stagnant water anywhere on the site must be prevented by proper grading, filling low spots, and placing cover soil over waste material.

Rats and mice may be brought into the site with the solid waste. Regular site inspections will indicate the prevalence of these animals. When significant numbers are identified, an experienced pest control specialist should be employed to deal with the problem.

✓ **Noise:**

Nuisance from noise mainly may arise from mechanical equipment operating or moving at the site.

In order to mitigate noise all mechanical equipment shall be kept in good working order at all times. Special attention shall be given to the fitting and maintenance of any sound reducing equipment to vehicles, machinery and fixed plant. The strict enforcement of speed limits will reduce noise from vehicles moving in the area.

5 Cleaning and maintenance procedures

5.1. General

The operator shall plan and execute cleaning and maintenance procedures ensuring, that:

- The buildings, structures, seeded and planted areas, paved and un-paved traffic areas etc. are maintained clean and proper without damages, that may impede their functionality or appearance
- All moving or fixed equipment and machinery are maintained clean and in good working condition
- All service facilities, e.g. outdoor sewage system, leachate management system, etc., are inspected regularly, cleaned and maintained

All mechanical equipment and machinery used at the landfill must be strictly maintained according to the supplier's/ producer's specifications.

Every day at closing time the internal roads and other paved areas shall be inspected, and any spillage of waste shall be collected and disposed of in the landfill cell currently in operation. If necessary the paved areas shall be swept using a street sweeper. During dry periods dust emission shall be controlled by sprinkling the surfaces with water in connection with sweeping activities.

5.2. Facility maintenance program

A necessity for the proper operation of all the facilities is the performance of a series of tasks related to the proper operation and maintenance of all these facilities.

Regarding the maintenance works of the general environment and infrastructure, these consist in the following:

a) Maintenance of roads: Cleaning and restoring wear and damage to road works. The basic guidelines for the keeping of internal roads in good condition are:
   - Conservation of road surface width
   - Removal of unwanted objects or materials that interfere with transport

Keeping the surface in good condition (rehabilitation of potholes) so that waters are not collected on it or so as not to cause damage to vehicles. In summer months, wetting of the surface may be necessary for the control of dusts.

b) Maintenance of flood protection works: Remove sediment (twigs, dirt, etc.) from the stormwater channels and more generally all the projects flood protection project.
c) Cleaning of general areas and fencing of windblown litter: Regular monitoring and cleaning the area fencing.
d) Maintenance of team for monitoring and maintenance of the site: Which consists of technical and scientific staff and deal with the issue of protection and maintenance of the site.
e) Other works for general maintenance of the facility and infrastructures.

The aim of the maintenance service is to ensure proper and satisfactory operation of the electromechanical equipment of the facilities and factory areas.

Maintenance can be defined as 'All necessary tasks and actions to ensure the quality and operation of a productive whole, in the general sense, within the designed limits performance' and that the necessary work includes among other inspections, preventative controls and procedures, lubrication, repairs, periodic replacements, alterations and modifications, studies of reliability and maintainability, spare parts management, technical documentation, specifications, technical guidance, etc.

The programming of these necessary actions and works are aimed at:

- The maintenance of existing equipment in excellent working condition and readiness
- Improvements of existing equipment with repairs and or improvements, which cost much less than potential replacements.

5.2.1 Main Areas of Maintenance

Maintenance of plant and auxiliary equipment and units such as:

- Basic electromechanical equipment of all units
- Equipment for the operation and protection of all instruments
- General electrical panels
- Automation panels
- Light night arrester
- Internal and external lighting networks
- Distribution networks for water and fire protection
- Electric substations
- Telephone installations
- Automatic weighing installation
- Installation of central monitoring and control system
- Installations for air-handling, filters, ducting, bag filters and biofilters
- Compressed air network
- Drainage networks and channels
- Buildings and facility security
- Education

Especially in an area where the proper maintenance and upkeep in perfect condition of electromechanical equipment plays a key role for the smooth operation of the facility, as is also proper and constant training of personnel.

The Electromechanical Maintenance Schedule is directly related to the actions to be carried out by the Maintenance department and is related to:

- Preventive Maintenance: Performed with varying degrees of severity depending on the importance of equipment or ancillary facilities. Its purpose is the disclosure and identification of the type of repairs and interventions needed before damage occurs, so that the necessary work may be scheduled without interruption of basic functions.
- Lubrication: Includes choice, use, purchase, storage and handling of lubricants, as well as the timing of fertilization. The program also provides for the correct control / disposal of used lubricants.

- Fault correction: Operational faults of the mechanical equipment are generally due to the interaction of various unfavorable factors. It is emphasized here that correction works are a small, unavoidable portion of maintenance works typically accounting for 5% to 10% of the total. What is important in the case of the fault correction is the right way to make corrections, document findings and the reasons for occurrence to enable better avoidance of non-repetition.
- Emergency Plan: The planning includes the preparation of plans for dealing with emergencies such as fire, flood, sabotage, protection against dangers, which in any way may be due to maintenance issues. At the same time, staff practiced regularly in addressing them.
- Communications and Information System: In this context includes all the printed media, primarily, but also verbal communication, such as application forms and outsourcing, reporting's, analyses and reports, audiovisual educational methods, electronic warning systems, etc. The quality and efficiency of communication and information finally contributes significantly to increase the efficiency of the maintenance program and thereby reducing investment costs in spare parts and equipment and ensuring the continuation of operation.
- Education: Modern maintenance requirements of mechanical equipment pass on to the area supervisor an additional responsibility including the responsibility of training their subordinates. To change or increase the knowledge or skills of an individual, it is necessary to correct their mistakes or failures. But it may not only refer to current needs, but also those for the future and the results can be seen immediately or later on. Regardless of the type of education, the aim has to be the continued informing and maximization of the human potential in the organization. The importance of this aspect is evident more and more every day, by observing the speed with which technology is evolving in present times.

5.2.2 Routine Maintenance

An indicative list of regular cleaning operations, maintenance and repairs or restorations which commonly arise as necessary for the proper operation of all units is presented below:

- Cleaning and/or washing of covered and uncovered spaces within the facility, with special attention to areas working staff and/or those that come into contact with waste, which is to be carried out on a daily basis.
- Periodic cleaning of the grates of drainage sumps and cleaning and maintenance of storm water and sewage networks.
- Periodic cleaning of the all machinery within installation, not just those for processing or separation of materials but also those for the transportation between these machines (conveyors belts, chain conveyors), and their respective guards, covers and/or guardrails.
- Point restoration of paint on metal parts of all machinery, metal frames and metallic constructions of the facility. (excluding the periodical repainting, this being included in the extraordinary maintenance).
- Lubrication and greasing of any moving parts within the facility, which is necessary both to achieve the best functioning, as also as a protection measure of these, even when this is not explicitly planned and indicated by the manufacturers.

- Maintenance of all electrical installations including the periodic internal and external cleaning of electrical switchboard cabinets, and periodic verification and repair of all control, handling and safety factors.
- Maintenance of instruments of control, adjustment, measurement etc., including supply and replacement of paper, ink and other consumable materials.
- Listing and regulation of chains, belts, conveyors, etc.
- Maintenance of the installations and auxiliary equipment and units such as:
  - Power distribution equipment for the handling and protection of all instruments
  - General electrical panels with sub panels
  - Automation panels
  - Surge arresters
  - Installation indoor and outdoor lighting
  - Water distribution and fire protection installations
  - Electrical substation
  - Telephone installations
  - Automatic weighing installation
  - Central monitoring and control system installation
  - Air-treatment installations, filters, channels, cyclone separator, humidifiers, biofilter
  - Compressed air network
  - Drainage networks and channels
  - Etc.
- Maintenance of constructions, window and door frames of different areas and sanitary facilities, fencing and all gating to installation, to buildings and to various areas.
- Maintenance of all electronic equipment of the installation, maintenance of laboratory equipment, etc.
- Verification restoration and maintenance of all necessary signage for services, safety and prevention of accidents as prescribed by applicable laws.
- Maintenance of the internal road network, paved and hardcore surfaced pavements, including the cleaning of snow and possible placement of salt in the case of ice.
- Maintenance of vehicles, machinery and special auxiliary equipment (wheeled cages, etc.) including periodic washing, lubrication, retouching of paints, etc.
- Maintenance of the biofilters and all deodorizing-dedusting systems.
- Maintenance facility for collection, transportation, storage and processing of leachates.
- System Maintenance harvesters transport and combustion of biogas.

5.2.3 Scheduled Maintenance

To prevent damage arising from the use of all equipment as also damage due to corrosion of metal parts, the yearly scheduled maintenance program of electromechanical equipment as well as all other parts of the facility, vehicles, machines and auxiliary equipment in accordance with specific daily, weekly and monthly maintenance cards, etc. The above cards are updated periodically in relation to the actual needs of the operation and subsequent progressive wear and tear of machinery, both the manner and frequency of conducting the maintenance, as also for choice and use of consumable materials.

All maintenance cards are to be controlled by the Operations Director.

It is understood that the planned maintenance program also contains all periodic replacements of worn parts of machines, such as hammers or blades of the shredders, the anti-friction protective metal wall surfaces of the compression chambers, the parts of the blaing wire feeders, the parts of the tensioning systems, the slats of sieves, etc., as well as the inner tubes, used fluids and other consumables of vehicles and engines, etc.

5.2.4 Extraordinary Maintenance

Extraordinary maintenance are any act of repair or replacement of mechanical, electrical or components not foreseen by either the manufacturer or the works contractor of the facility, as routine or scheduled maintenance and not due to the negligence of the Operator, but derived from normal physiological wear as a consequence of use or unforeseen events. Anything stated above also applies to buildings, roofs, metallic structures, roads, sewers, periodical painting everything associated with them. Within the limits of possible and excluding emergency situations, the operator is to gathers all required actions and perform these during periods of routine maintenance.

5.2.5 Organization of Maintenance

For the proper operation of the maintenance program this is organized in three basic levels:

Technical Planning: The planning concept is intertwined with the development, of all parts, places and pieces of equipment, the methods and procedures necessary to a balanced continuous updating to ensure:

- The technical inspection and monitoring
- Planning of works
- Technical support

Programming: The execution of programming of maintenance is to ensure that all instruments required to perform any planned work, are available before starting execution. Maintenance is scheduled according to the priorities and the availability of manpower and resources and done optimally.The Programming generally includes:

- Schedule workload and backlog
- Allocation and distribution of human resources
- Determining of execution time and end task execution
- Reports progress works
- Organization and monitoring of subcontractors (external)
- Scheduling preventive maintenance
- Keeping of records and statistics of maintenance
- Monitoring of needs for parts and materials.

Operational Maintenance: The responsibilities of the leader or person in charge of maintenance include:

- Checking availability of materials

- Supervision of quality of work
- Assuring the taking protective measures
- Daily contact with the production process
- Report the actual working times
- Report progress on completion
- Participation in the preparation of the budget and monitoring costs.

5.2.6 Prerequisites

The necessary prerequisites to proceed with the planning of maintenance, is to set objectives, policies and regulations and evaluation of the benefits expected with the development and implementation of the system and how to evaluate the results, review of operating procedures, review of system etc. In particular it should be noted that success depends:

- On the development decision of the means available
- The study of the system
- Understanding of what is expected from the application
- The impact that the results obtained will have, how and how much they will affect our decisions and actions.

There is no organized system that can perform correctly if all the functions do not follow those procedures which enable them to. They are related to the flow of information, commands, approvals, authorizations, conclusions and decisions.

Maintenance procedures are designed to provide reasonable services cost. However daily departures from it can generate significant differences on an annual basis. Effective supervision and coordination of the operation of the maintenance service, has as a result the qualitative upgrading, better use of time, the reduction of human effort and increased efficiency.

The execution of a job in the desired time with the best results, is possible only if there are methods, procedures, programs and the most importantly control. As control we mean all activities related to planning, monitoring, completion and evaluation of the results of any works, from the time you give the execution command, until the operational handover. This can only be achieved by coordinating resources and human capabilities, construction and operational details and information, methods and standards. These are the main objectives of the control and coordination.

5.2.7 Coordination of Maintenance

The main objectives of coordination, is the technical planning and scheduling of inspections and maintenance, monitoring and measurement of performance and efficiency. At the same time, points of the production process where it is needed to make improvements or economies are recognized and identified. Such procedures, depending on the type and size of installation can be addressed with either by creating a separate tactical force forming the link and the reference centre or through the structure of the service maintenance or management of the facility.

5.2.8 Responsibilities and Duties of Coordination Centre

The main functions and tasks of the coordination centre are:

- The drafting instructions for all functions and processes such as:
  - Conducting any kind of works
  - Award for execution and receiving of works
  - Approval processes and supply of spare parts and materials
- Creation of:
  - Equipment records
  - Maintenance Guides
  - Technical information records
- The processing, monitoring and review of all programs and procedures followed:
  - Control of critical and special parts
  - The tracking of orders
- The monitoring and control of works: Development of a work request system, technical and time scheduling, distribution of materials, implementation of standards of measurement
- Scheduling Maintenance: Development, analysis and monitoring system of maintenance for the facilities
- Measuring performance: Analysis, measurement and comparison of all operations against standardized capacities and forecasts
- The economic and technical assessment of projects: Comparison with the budget and justification for deviations. Study of methods.
- The systematic preventive maintenance: Design and planning of all operations on a periodic basis.
- Materials and parts: Inventory tracking, creating inventory safety buffer and per order. The objective is keeping the inventory costs at low levels.
- References to the management: Development of realistic and reliable way of reporting the results of the activities of Maintenance.
- Computer records: Operation and monitoring of the system.
- The preparation and monitoring of the budget:
  - Expenses forecast.
  - Rate of execution.
  - Control of direction.

5.2.9 Documentation of Electromechanical Equipment

The concept of documentation of equipment is concerned with the creation of the appropriate file. This file gives an overview of the type of equipment that is installed in a unit, and allows among other things:

- The archiving and grouping of all machines
- Spatial recognition
- Recording of technical specifications
- The date of construction, installation or purchase
- Data for the creation of parts lists
- Archiving and organization of plans and technical details of the equipment.

Also a general plan of production facilities, gives a simple and figurative view of the areas. All lines of production processes and devices placed on drawings (plans) places. These plans, beyond the exact locations of equipment, include regulatory and other useful information, such as codes of machinery, engine power, amenities and size networks etc.

Finally, the paper hard copy machinery file, in the format of forms, is one of the key organizational elements of an effective maintenance control system.

The design of appropriate forms of the class depends on several factors, the main ones are:

- Plant size
- The number and variety of equipment to be controlled
- The amount of information needed
- Task time work is available
- The importance of cost control maintenance.

The answer to all these individual issues outlines the design of the necessary forms. The purpose of creation also is:

- The concentration of all essential data of the equipment
- The concentration of all data on the type of maintenance required
- The concentration of all economic data
- The full parts list
- Gathering of all historical data from the various interventions.

The last fact is particularly important and can give us information about whether:

- Each machine after long-term use is appropriate or not
- Checks whether maintenance costs are reasonable or excessive
- Necessity for Improvements
- A more meticulous and detailed programming is needed.

They also serve to gather data on the financial budget or maintenance account, for the evaluation and review of programs followed.

From a correct machinery file, it is possible to decide replacements beyond this selection most suitable machinery. The below table provides an example template for a Mechanical Equipment Filing form.

Table 5-1: Mechanical Equipment File Form

Description:	**Manufacturer:**	**Serial No.:**
Order.: Received: Installed:	Length: Width: Height: Weight:	Technical specifications
DETAILS:		

Location: Code:	Changes: Movements:	Dates
Lubrication Data Maintenance Data:		Parts
Responsible Technician:		Responsible agent:

The back side of the same form is used as a historical archive

Date.	Type of Work	Command No.	Job Description	W/H Estimate	W/H Real	Parts
F: fault, PM: Prog. Maint., PPM: Prog. Preven. Maint., L: lubrication, W/H: work hours, etc.						

5.2.10 Permanent Maintenance Procedures

They describe in detail the manner and procedures for conducting any work, from the instant a machine is installed for the first time, until it reaches its replacement time. The use of a piece of equipment essentially starts from the moment that it is designed and selected. The Maintenance Service, has the ability and experience to control everything that is chosen, to comment on operational advantages or weaknesses of each item or machine, and check for maintenance that has every kind of equipment. The introduction of a further selection process, machinery use, where the Maintenance Service is involved is very important.

The main points of such a handbook of permanent procedures are as follows:

1. **Selection:**
   - Control of specifications of the equipment according to the requirements.
   - Check requirements, of capacity and installation area.
   - Comparison with existing equipment.
   - Check maintenance requirements.
   - Type and cost of parts.
2. **Acceptance:**
   - Check possible damage during transport.
   - Qualitative and quantitative acceptance of all accessories and parts.
   - Check instructions.
   - Storing shipping and acceptance documents, etc.

- Filing of drawings and other technical guidance documents.
- Compilation of spares sheet.
- Coding of the necessary data and
- Entries in the equipment file.

3. Installation and operation:

- Installation, connection to electricity networks, water, steam, etc.
- Cleaning internally and externally.
- Lubrication.
- Check all functions.
- Technical support function
- Initial burn-in mode.
- Operator training.
- Maintenance training.
- Issuance of operating and emergency guidance.
- Normal operation, control and regulation.
- Issuing maintenance directives, lubrication, operation etc.

5.2.11 Technical Maintenance Instructions

Contain elements of what should be done, when, how and why. It is the information database for the technical support of the installations. It includes all the technical expertise and solutions needed to conduct the various tasks. Highlighted are:

1. General instructions for the whole installation

2. Instructions for categories of machinery like:

- Technical instructions for certain tasks
- Instructions for startup and shut down of machinery.
- Decommissioning instructions
- Instructions for use machines and assemblies.
- Safety regulations.

5.2.12 Administrative and Organizational Maintenance Instructions

Administrative maintenance instructions provide information and guidance on various topics such as:

- Accident announcement and reporting.
- Announcement and reporting of downtime.
- Reporting of repairs etc.

The organizational maintenance instructions fully describe the requirements of the job, and the qualifications of those who hold or will assume them. They give a clear picture of the tasks, and determine the obligations and rights.

5.2.13 Spare Parts Management

The availability of spare parts and materials is crucial to the performance of maintenance services. Regardless of its value, the lack of a replacement can significantly delay the completion of a task with incalculable, initially at least, consequences.

All staff of the technical maintenance personnel must be aware of the procedures in procurement, storage, distribution and delivery of spare parts they need to perform any work at maximum efficiency and productivity.

The stock of spare parts and materials (and associated inventory costs) can be determined by the following economic assumptions:

1. Reduction of the cost of equipment malfunction due to lack of spare parts, having readily available spare parts.
2. Reduction of workings, having the right parts in the numbers needed to avoid delays.
3. Reduction of maintenance costs by using appropriate and good quality parts, avoiding purchases of parts of lesser quality.
4. Reduction of inventory costs with the economical order of quantities when needed.

Each case is examined and tested on an ongoing basis to achieve the best financial results.

The process of managing materials and spare parts is work for which they are responsible Technical (Production and Maintenance) and Financial (Supplies, markets, warehouses, statistical services, etc.) Services.

All those directly or indirectly employed in maintenance services, must be aware that spare parts stored in the warehouse still incur a cost, in addition to that of their market value, since it is an invested capital. The additional costs can be compared with the benefits resulting from the operation of its production facilities. In order words, for there to always be a particular spare part in the warehouse, the cost losses resulting from not having its availability should be accurately estimated.

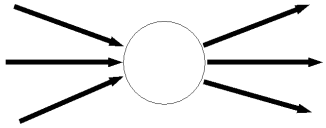
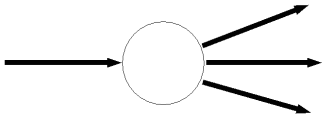
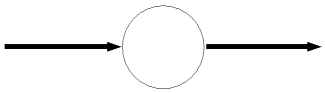
Considering the above, the application for creating different categories of stock parts, should be done:

- In case of installation or purchase of new equipment, so that there are the necessary parts for the initiation and initial operation
- If a replacement is needed in large numbers and the delivery time is long
- When the parts are particularly critical or special construction and the lack of them can lead to costly downtime

The Maintenance Service should develop methods for monitoring the performance of production machines and behaviour of components and spare parts to keep statistics of consumption and production, so that decisions can be made with technical and economic criteria.

For the policy of control of parts inventories and supply of new, there are no set ways and rules. In general, depending on the use and destination of the parts are classified according to the following table

Table 5-2: Recommended Categorisation of Parts

TEAM	ORIGIN	CATEGORY	USE
1		 GENERAL Spare Parts	GENERAL USE
2		 COMMON Spare Parts	IN VARIOUS POSITIONS
3		 SPECIAL Spare Parts	SPECIAL ITEM OR USE

Generally, the procurement policy followed is based on the criticality of the replacement. In order now to implement a procurement policy based on criticality, parts are divided into three main categories:

1. **General parts and materials:** Are those used in all areas of the facility, is usually low value and consumed in large numbers. The tracking and replenishment is done by the stock room manager.
2. **Safety spare parts:** Safety spare parts belong to the category, whose existence is necessary, regardless of their consumption pattern. They are usually spare parts for critical units, where their stopping means interruption of the production process and significant damages. The tracking is done with the help of appropriately designed reports to avoid shortages.
3. **Critical specific parts:** These are spares, of special construction, that relate to specific machines, the management becomes the responsibility of both the Maintenance Service, as also the Operation Manager. They are usually of great value and their supply is through the investment process.

By the term warehouse management, we mean the processes that ensure proper receipt, inspection, storage and issuance of materials and spare parts to ensure a seamless flow and continuity of maintenance works.

"A place for everything and everything in its place" is the principle behind the warehouse management system.

The planning, warehouse equipment, placement and classification of parts depending on the type, class, method and frequency of administration, are also factors taken into account in order for the system to be effective.

There are three key elements needed to locate any item in the warehouse:

- ✔ The category or classification

- The identity or recognition
- The position (location)

Besides the above date, it is also needed to know:

- The name
- Description
- The serial number

to avoid multiple names and create more records and increase inventory and search problems, especially in the case of use computer systems.

In a well-organized warehouse the number of parts is recorded. The management of spare parts maintenance does not follow legally obliged 'accounting rules'. It is functional in the sense of "Billing" in work orders and charged to corresponding "cost centers."

Based on the foregoing, each spare part included in the file (directory) of the warehouse is distinguished according to:

- Stock number
- Description
- Location code
- Type
- Unit number code

The warehouse file includes all spare parts and materials used in the maintenance of equipment and facilities in general. Besides coding is fundamental to maintenance systems with the use of computer filing systems, the following data can also be entered:

- Lists of suppliers for each category of parts
- Parts nomenclature
- Description and instructions
- Alternative uses
- Alternative suppliers
- Designation
- Unit of measurement
- Unit cost

The main elements which underpin the management of maintenance are:

- Technical management of equipment
- The management of works

- The management of financial resources and manpower
- The management of the spare parts inventory

5.3. Fence and surrounding areas

The fence, the windbreak zone and the surrounding areas in the vicinity of the landfill shall be inspected and windblown litter removed on a regular basis, e.g. once every week. Collected litter shall subsequently be disposed of in the landfill cell currently in operation.

Registered damages of the fence and gate must be repaired immediately.

5.4. Reception area

The reception area shall be kept free from dropped and windblown waste and soil/mud.

5.5. Buildings, structures and installations

Observed damages to buildings, structures and installations must be repaired immediately.

For all significant incidents a damage report shall be prepared and send to the Owner of the landfill.

All working spaces must always be kept clean and tidy for optimal working conditions for the maintenance and repair of facility machinery.

5.6. Equipment and machinery

Equipment and machinery used at the landfill must be strictly maintained according to the supplier's/producer's specifications, which are attached as Appendix and are an integral part of this manual. Instructions on the frequency of lubrication, oil change and inspections must by strictly adhere to.

The equipment and machinery must be kept clean and protected from corrosion.

A log-book must be kept for each main element of equipment. Log-books shall as a minimum be available for:

- Landfill compactor
- Wheel loader
- Container truck
- High pressure water cleaner (if any)
- Emergency generator
- Pump for the gas management system
- Solar warm water system (if any)
- Air-conditioning system in the office building
- Video Control System at the entrance

All data regarding service, maintenance and repair of the equipment shall be recorded in the log-books as well as the operating time of the compactor, the bulldozer, the tractor and the pumps.

5.7. Access and service roads

The roads must be inspected regularly. Any potholes or other damages must be repaired within the shortest period of time ensuring, that minor damages do not develop in to an extent, which may impede the function of the facility.

By the end of each working day all paved areas at the landfill and the external access road shall be inspected for dust, litter and spillage of waste. If required they shall be cleaned and swept using a street sweeper.

5.8. Dams and surface water ditches

Dams must be inspected regularly and at least twice a year. Further the surfaces of dams and slopes shall be inspected after any heavy rainfall. Registered damages to the surface of the surfaces, e.g. from surface water erosion, landslides etc., shall be repaired immediately and if damaged the vegetation shall be restored.

In places where the same kind of damage is registered repeatedly special attention shall be given to determine the cause of the damage and to determine appropriate countermeasures. It is strongly recommended that an experienced engineer is consulted in this case.

Surface water ditches shall on a regular basis be inspected and kept clear from waste, vegetation, soil and sand to prevent clogging of the system. The ditches must be inspected at least twice a month and supplemental after any heavy rainfall. Any damages to the lining of the ditches shall be repaired immediately.

5.9. Leachate management system

The following on site incidents may impede the proper function of the leachate management:

- Intrusion of fine particles in to the drainpipes and subsequent clogging of the pipes
- Mechanical malfunction of the electrical valves in the leachate pipe
- Water / mud level in the leachate evaporation basin

In general the above incidents are avoided by the regular inspection, cleaning and maintenance of the components in the system. Inspections shall comprise:

- Visual control of the landfill cell for accumulations of leachate above the drainage layer
- Monitoring of the electrical valve function (operation time, registration of start and stop, registration of unscheduled stops and alarms)
- Registration of the quantities of leachate delivered to the treatment plant

The inspections shall be exercised on a monthly basis and in addition after heavy rain storms

Each incident and pursuant counter measure shall be recorded in a log-book.

✓ **Clogging of the drainpipe**

Indications of clogging of the drainpipe in the landfill cell can be:

- Little or no leachate outflow after heavy rain

The drainpipe shall be flushed using a high-pressure water jet well respectively, ensuring that the drainpipe is flushed in its entire length. If possible a pursuant TV-inspection can disclose whether the flushing has been effective or has to be repeated.

The risk of the drainpipes being clogged is increased during the initial 1-2 years of operation of a landfill cell, and in this period the function of the drain pipes shall be followed even closer.

In case of entering the leachate shafts by the staff of the landfill operator or any other person it must be checked that the shaft is free of landfill gas. For this the mobile multi-gas detector shall be used.

For cleaning and video inspection of the leachate drainage pipe a qualified company should be contracted.

5.10. Top cover and other covers

Areas covered by intermediate, temporary or the final top cover shall be inspected at least once every two months for damages, e.g. erosion, slides, cracks or significant subsidence. Seeded areas shall be inspected for signs of vegetation die-off. Inspections shall also be carried out after heavy rain storms.

Any registered damages shall be repaired ensuring the continued function of the cover. In places where the same kind of damage is registered repeatedly special attention shall be given to determine the cause of the damage and to determine appropriate countermeasures. It is strongly recommended that an experienced engineer is consulted in this case.

Vegetation die-off may indicate migration of landfill gas through the cover, which may be caused by reduced efficiency of the land fill gas collection system in the area in question or by damages to the top cover. Where the surface of the landfill at the same time exhibits significant subsidence, the reduced efficiency may have been caused by discontinuities in the gas drain layer in the top cover. The efficiency of the gas collection system shall be increased by regulation of the vacuum in the nearest gas wells or by adding new gas wells to the system. It may prove necessary to excavate the top cover in the subsidence area, level the subsidence and reinstall the top cover.

The vegetation shall be restored following the above repair works.

5.11. Landfill biogas management

The pump unit shall be checked, cleaned and serviced as required by the supplier.

The efficiency of the landfill biogas management system can be influenced by condensate accumulated in water traps in the transmission pipes - created by subsidence in the waste - or by excessive accumulation of condensate in the condensate wells. The Operator shall check the system for such disturbances whenever the gas flow seems to be reduced and at least once every month.

5.12. Wastewater management system

All the shafts in the waste water management system shall be inspected at least once every two months. In case significant sedimentation or other blockage is registered the wells and the pipes of the system shall be cleaned. Wells can be emptied using a vacuum tanker / gully emptier and pipes can be flushed using a high-pressure water jet. If possible a pursuant TV-inspection can disclose whether the flushing has been effective or has to be repeated.

If it is necessary for personnel to enter any of the shafts, the special measures for work in confined areas containing hazardous fumes shall be observed at all times.

Any damaged well cover in the trafficked areas shall be replaced immediately.

TO BE DELIVERED BY THE SUPPLIERS OF FACILITIES AND EQUIPMENT

6 Monitoring procedures

6.1. Organization of monitoring system

Environmental monitoring refers to periodic inspections and testing performed to assess the impacts of the landfill on its surrounding environment.

The overall monitoring system of the landfill will consist of the following parts:

- Leachate monitoring system;
- Groundwater monitoring system;
- Surface water monitoring system;
- Biogas monitoring system;
- Settlements monitoring system;

Part of the overall monitoring system is also a series of parameters, which have a significant role in organizing and monitoring the various processes and operations of the landfill. These parameters are the following:

- Meteorological data;
- Volume and composition of the incoming waste;
- Volume and composition of the incoming soil material;
- Monitoring of all the supportive works and registering of all their problems that affect the proper operation of the total plant;

All the data collected from the monitoring systems should be kept on-site in appropriately organized records.

6.2. Leachate Monitoring System

Since the landfill is equipped with a leachate treatment plant, leachate sampling and testing is considered to be of vital importance. Slight changes in Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD) or heavy metals concentration, can affect the efficiency of the treatment system used. The operator of the treatment plant should also be able to have an estimation of the produced quantities of leachate, while he must be able to check the effectiveness of the leachate treatment plant.

The parameters measured as well as the frequency of sampling are shown in the following table:

Table 6-1: Parameters and Frequency for Leachate Monitoring

PARAMETERS	FREQUENCY	
	Operational	Aftercare period
Leachate volume	Monthly	Every 6 months
Leachate composition	Every 3 Months	Every 6 months
Treated leachate composition	Monthly	Monthly

Leachate samples will be taken from the landfill's discharge pipe at the leachate collection tank and at the composting and maturation area, while treated leachate samples will be taken from the effluent tank of the leachate treatment plant, three (3) in total, as presented in drawing 11-TOPO-1A.

The parameters to be measured and the relative standards are shown in the following table.

The sampling must be done according to the ISO 5667-11 while the chemical analysis should be according to the "Standard methods for the examination of water and wastewater" by AWWA, APHA, WEF, as shown in the following table:

Table 6-2: Standard methods for the examination of water and wastewater

No	PARAMETER	Standard Method
1	pH	DIN 38 404-C 5
2	Conductivity	EN 27 888 (C 8)
3	Odors	DIN EN ISO 7887
4	B.O.D.	DIN EN 1899-1 (H 51)
5	C.O.D.	DIN 38 409-H 41
6	T.O.C	DIN EN 1484 (H 3)
7	SO^{-}_{4}	DIN ISO 10304
8	Ammonium (NH_4-N)	DIN 38 405-D 9-2
9	Nitrogen total (org. and inorg.) Total Kjeldahl nitrogen	DIN EN 25663 (H 11)
10	Nitrate (photometric)	DIN 38 405-D 9-2
11	Nitrite (photometric)	EN 26777(D 10)
12	Cl	DIN 38 405-D 1-1
13	Zn	DIN EN ISO 11885 (E 22)
14	As	DIN EN ISO 11885 (E 22)
15	Cd	DIN EN ISO 11885 (E 22)
16	Cu	DIN EN ISO 11885 (E 22)
17	Ni	DIN EN ISO 11885 (E 22)
18	Phenols	DIN 38 409-H 16-3
19	Total Hydrocarbons (Oil-grease (mg/l))	DIN EN ISO 9377-2 (H 53)
20	Phosphate	DIN EN 1189 (D11-4)
21	Total Solids (TS)	DIN 38 409-H 2
22	Extractable lipophilic substances	DIN 38 409-H 17
23	Dissolved Solids (DS)	DIN 38 414-S 3

6.3. Groundwater Monitoring System

In order to guarantee an efficient and environmentally safe treatment for monitoring of the site, there needs to be a thorough check on possible contamination and / or contamination of groundwater and subsoil from an arbitrary leachate leaking. Moreover particular emphasis must be given in monitoring the quality of groundwater aquifers.

For this purpose, based on the requirements of current legislation, groundwater monitoring wells will be constructed at the site. The wells will be covering the total area of the site including the new waste treatment facilities. That's why the groundwater monitoring wells will be constructed under the provision of the Waste Treatment Facilities tender procedure.

If aquifer is not detected, the maximum drilling depth is 70 m.

To achieve full environmental monitoring, it is proposed to monitor the water level and carry out regular sampling of the wells each semester including full range of water analysis for all the parameters that are sensitive to pollution / contamination from escaped leachate / wastewater.

The parameters measured as well as the frequency of sampling are shown in the following table:

Table 6-3: Parameters and frequency of measurements for groundwater monitoring

PARAMETERS	FREQUENCY	
	Operational Phase	Surveillance phase Aftercare period
Level of groundwater	Per three months	Per semester
Groundwater composition	Per three months	Per semester

The up-gradient wells will show the pre-existing condition of the groundwater prior to any effect of the landfill. The down-gradient wells will be located downstream in order to detect any sign of leachate leaking out of the landfill. The up-gradient wells will be sampled along with the down-gradient wells. This will provide information on seasonal or long-term trends in the groundwater. Even though the condition of the groundwater may change over time as a result of natural or other (not related to the landfill) affects, however by monitoring both the up-gradient and down-gradient wells, any landfill related change can be identified.

The frequency of measurements can be increased if the water level presents a variation or if there is pollution due to leachate escaping. The sampling will be carried out by both the upstream and the downstream wells.

The results will be evaluated with monitoring charts, with established rules and levels for each position downstream of the hydraulic gradient. The control levels will be determined by local variations in groundwater quality.

For the implementation of the environmental monitoring program, sampling from both the upstream and downstream wells should take place. With these samples will be conducted a full range of analyses, including all the parameters that are sensitive to pollution / contamination from escaping leachate.

The parameters to be considered derived from the expected composition of the leachate and the groundwater quality. The characterization of groundwater should be measured by the parameters presented in Table 6-2.

The measurement of groundwater level in the wells precedes all sampling. Sampling of groundwater will be conducted in accordance with standard sampling procedures in accordance with ISO-5667-1 and ISO-5667-11 on sampling groundwater. It will take two samples, one from the surface of the water and at a depth of 5m from the surface of the water. The chemical analyses will be conducted under the "Standard Methods for the Examination of Water and Wastewater, by AWWA, APHA, and WEF".

Two down-gradient (wells 1 and 2) and one up-gradient well (well 3) will be drilled at specific locations as presented in the reference drawing 11-TOPO-1A. The detail of groundwater monitoring well is shown in drawing 11-DET-2.

The drilling of the wells will be preferably with reverse circulation drilling, without prejudice to the positive. The drilling will be done with cutters which will intersect samples of rock fragments from the returning waters.

For all wells, the following will be illustrative, but not limiting operations:

- Initial drilling and sampling;
- Extensions;
- Cleaning of well;
- Piping;
- Control verticality of tubes;
- Gravel filter;
- Cementation;
- Well vents and pressure gauge;
- All E/M equipment, i.e. pumps, filters, motors, wiring, electrical panels, pipes, special parts, measuring, necessary for pumping water and transfer to the respective tanks etc.;
- Various other works to complete construction and operation in accordance with the specifications of drilling;

Initial Drilling: This will be everywhere with a cutter 6'' diameter cutter at all the projected depth.

Sampling: During drilling, a sample of the material that is being drilled will be taken, every 10 meters. A portion of the samples (500 g.) will be placed in a nylon, transparent bag, and then in boxes dimensions 100 × 50 × 15 cm, which will be divided into small apartments. The boxes will be made of strong wood and will remain closed on site and available to the Engineer and the Employer.

Extensions: The extensions will be made on the basis of initial drilling, electrical dispensing, and all kinds of other information gathered during drilling. Generally it will done with an extension reamer diameter 10'' throughout the depth of the well until the final depth when the well will be piped.

Cleaning wells: After the extension the purification of the well with positive movement will follow. This work will be done with the 10'' reamer gradually until the final depth of extension and using new pulp if necessary. The duration of treatment will be determined by the supervisor.

Piping: In the well a perforated HDPE pipe diameter 3'' will be placed. The first five meters of the pipe will be imperforate, while the remaining portion of the well to the end of it will be pierced. The thickness of the pipe will be at least 6 mm and bearing welded joints with 5 threads on the link.

Verticality check of pipe: The well will be checked for vertical and straight pipes - filters of the final piping. This work will be carried out immediately after the installation of the pipe in the well and before placing the gravel filter, thus enabling corrections. The check will be done by vertical photometer suitable for small and large diameters. The supervisor will determine the number of measurements and depths that will make these. The vertical deviation will not be more that 1% of the measured section and any costs to correct deviations will be borne by the Contractor.

Gravel filter: The well will be coated with gravel, at the ring space between the outer surface of the pipe of final piping and the walls thereof. The gravel filter must consist of well graded gravel, free of clay materials. It must be absolutely clean without clay materials or fragments of rocks (marls, clays, etc.) to be washed on site before being placed into the well, and the dimensions of comply with the instructions

of the supervisor. To avoid creating bridges the gravel filter will be placed carefully and with reverse movement.

Development of well: The development plays a key role in the good performance of a water well and therefore should be carefully done and immediately after graveling the well. The Contractor is required to deliver the well:

- With clear water, free from solid substances e.g. from bentonite, clay, sand, etc. when the maximum water supply is pumped from the well;
- No precipitate throughout the depth of piped well;
- With normal load losses;

For this purpose it should be developed properly and possible use of chemical substances, if necessary. The development includes the following works, or part thereof as appropriate:

- Rinse of well with clean water;
- Pumping water with system AIR – LIFT maximum supply, in accordance with instructions of the supervisor;
- Developing pump vertical axis. This should be done with very frequent interruptions;

During development with AIR – LIFT, and the pump, flow measurements of water level and content of sand must be obtained, at intervals to be specified by the supervisor. The development is considered finished when it is found that the water contains no impurities and is clean, without unusual load losses.

Cementation: The first 1m from the ground surface section of the borehole will be cemented. The cementation will be ordered by the supervisor. The work will include pouring cement (C35/45, XF3) into the ring space to a depth of 1m, waiting coagulation and removing any obstruction in the placed piping and parts of the well that are not piped. At the end of the well operations, a cement base measuring $1 \times 1 \times 0.92$ m can be placed or metal clamp can be mounted to hold the final column of well piping.

Well vents and pressure gauge: On the vent of the pipe, a cap will be placed to prevent the entry of foreign bodies into the well. The cap will be locked and will be able to be opened only by appropriate persons. The upper part of the well will be well protected and will close with a lid.

6.4. Surface Water Monitoring

Frequent visible inspections will be made. Evidence of degradation may include obvious signs, such as dead or unhealthy flora and fauna, visible leachate pools or streams, unnatural water clarity or color and unusual odors.

Besides the visual inspections, surface water should be checked quarterly in the operating phase and every six months in the aftercare phase. During those sampling rounds, field measurements at six (6) representative surface water locations (ref. drawing 11-TOPO-1) should be taken for phase A and seven (7) for all phases, measuring the following parameters as shown in Table 6-2:

6.5. Landfill gas Monitoring System

Monitoring of biogas is a twofold procedure that involves:

- Knowledge of the produced landfill gas volume and composition;

- Monitoring of possible landfill gas migration;

The first goal of landfill gas monitoring will be achieved via a portable landfill gas measurement device (landfill gas analyzer). This device is equipped with gas probes and a data logger (for data storage and uploading to a PC). Measurements will take place at landfill gas collection boreholes and at least include: pressure, methane content, carbon dioxide content and oxygen content.

The amount of produced biogas can be recorded via the flare. Other constituents of biogas may also be monitored by adding probes to the analyzer such as hydrogen sulphide (indicative also of odors), hydrogen, nitrate, etc. For further analysis of compounds such as hydrocarbons, non-methane organics, etc., sampling and use of air chromatography is required. The parameters measured as well as the frequency of the measurements are shown in the following table.

Table 6-4: Parameters and Frequency for Biogas Monitoring

PARAMETERS	FREQUENCY	
	Operational Period	Aftercare period
Produced biogas volume	Monthly	Every 6 months
Pressure, methane content, carbon dioxide content and oxygen content	Monthly	Every 6 months

The second goal regarding landfill gas migration requires specific procedures to be established for its assessment. The need for gas migration monitoring comes from its flammability and explosive potential. The purpose of gas migration monitoring is to ensure that the biogas does not migrate to and accumulates in on-site structures or to off-site locations, in concentrations that could be hazard for humans or property.

The concentration of methane gas should not exceed 25% of the Lower Explosive Limit (LEL) in the landfill structures and 100% of the LEL at the property boundary. The LEL for methane is 5% (methane/air).

For monitoring the escape of biogas it is recommended to construct monitoring wells along the perimeter of the landfill's basin.

There will be constructed six (6) landfill gas monitoring wells in total of which four (4) will be around phase A as it is shown in drawing 11-TOPO-1A.

The wells will have a minimum depth of 5m, be located outside the waste disposal site. Checks at the monitoring wells will be conducted every six months with appropriate portable device. The components of biogas that will be measured in the long run is: Methane, carbon dioxide, oxygen, carbon monoxide, hydrogen sulfide.

Samples are also taken with the use of the gas analyzer from these monitoring wells to assure that landfill gas does not migrate from the sides of the landfill basin.

In addition, five (5) gas control units for inspecting flammable methane concentrations will be installed. The detectors - transmitters will be installed in the material sorting facility, the administrative building, the workshop building, and the security guardhouse, as presented in the 11-TOPO-1 drawing.

The gas control units are equipped with a system of alarm signaling which will be activated, when the methane concentration exceeds the LEL.

In this way, a high safety level will be achieved for the human activities inside the site. The result will be the full monitoring of the biogas behavior.

6.5.1 Technical specifications for the portable gas analyzer

The portable gas analyzer must be able to measure % CH_4, CO_2, and O_2 volume, static, differential and barometric pressures. It should have the possibility of measuring additional gases with optional gas pods and the possibility of reading gas temperature with optional temperature probe.

It must be ATEX certified and have the following features:

- Easy field calibration by user;
- Self-test and monitoring on startup;
- Storing readings;
- Easy-to-read;
- User interchangeable filters;

Gases Measured:

- CH_4, CO_2, by dual wavelength infrared cell with reference channel.
- O_2 by internal electrochemical cell and.
- H_2S by optional external gas pod.

Range:

- CH_4 0 – 100 vol. % Reading;
- CO_2 0 – 100 vol. % Reading;
- O_2 0 – 25 vol. %;

Gas Accuracy:

	CH_4	**CO_2**	**O_2**
0-5%	±0.5%	±0.5%	±1.0%
5-15%	±1.0%	±1.0%	±1.0%
15% - Full Scale	±3.0%	±3.0%	±1.0%

Other Parameters:

	Unit	**Range**	**Comments**
Static Pressure	mbar	±500	Direct Measurement

- Operating Temperature Range: 0 °C – 40 °C;
- Relative Humidity: 0 – 95% non-condensing;
- Barometric Pressure Range: ± 200 mbar absolute;
- Barometric Pressure Activity: ± 5 mbar absolute;
- Battery Life: Typical use 10 hours from fully charged;
- Charge Time: Approximately 2 hours from complete discharge;

The gas control unit must be equipped with:

- Digital display panel showing the gas concentration in the atmosphere;
- 4 independent channels each one fitting with 1 transmitter 4 – 20 mA;
- Alarm thresholds indicated by LED;
- An audio signal automatically generated with the visual alarms;
- Appropriate network and software for the centralisation and the visualisation of all the alarms;
- Protection rating IP66;
- Working temperature –10 °C to + 60 °C;
- Conformity: EN 50054 and EN 50057;
- CEM: EN 50082-2 and EN 50081-1;

Application:	**CH4 measurement 0-100% LEL**
Type of sensor:	electrochemical
Response time:	~ 20 s
Operating temperature:	-20 to +50 °C
Relative humidity:	10% to 95%
Output signal:	4 - 20 mA
Protection:	IP 66
Conformity:	ATEX 1

6.5.2 Technical specifications for Wells for Monitoring Contingent Subsurface Migration of Biogas

For proper environmental monitoring of projects and monitoring potential migration of biogas, biogas monitoring wells of constant depth will be constructed, around the area. The wells will have a minimum depth of 5m.

The wells will be drilled within the site and outside of the perimeter of the rainwater collection trench, on natural ground.

For all the wells, the following will take place, illustrative but not limiting works. It is proposed to use a rotary drilling rig, which will be reamed with a cutter 6 ½'' diameter and place temporarily HDPE piping length 5 m and diameter 6''. Inside the temporary piping and in the center another steel pipe 2'' diameter will be placed.

The steel pipe in the lower part and the length of 4 m from the bottom is pierced with holes of circular diameter of 3 mm, density 1/100 cm^2. The out of land head tube is properly configured to adjust the measuring instrument.

Until the middle of the depth of the soil, gravel is placed outside of 2'' pipe and inside 6'' pipe so to cover fully the perforated pipe section. Immediately after, the 6'' pipe is removed and the vacant area inner the pipe is filled with soil material, well compacted to prevent aspiration of air during sampling. In the upper part of the shaft clay and compress soil thickness of 1m is placed to prevent entry of atmospheric air and water in the well. The vent of the remaining 2'' pipe is capped tightly with removable plug.

6.6. Settlements Monitoring System

Another important problem that occurs during long-term retention of landfills is the phenomenon of settlements of the surface, with adverse consequences for the stability of the project, and the likelihood that one or more pits forming concentration of water eventually penetrates inside the volume of waste and increases the production of leachate. The rate of settlements in landfills is around 10-30%. Also, settlements may occur by various uncertain reasons such as very heavy rainfall, etc., resulting in the appearance of transitions in coverage, inflection, creating cracks, pits, etc., and the resulting potential escaping gases, creating stagnant water etc. For this reason, the surfaces must be monitored and, in case of change of the initial configuration and the deviation from the desired value to be corrected, with the necessary earthworks.

For long-term monitoring of the final relief of the landfill, a network of settlements monitoring indexes will be installed.

There will be installed 19 settlement monitoring indexes in total, where 6 of them will be installed in phase A as it is shown in drawing 11-TOPO-1A.The detailed drawing 11-DET-1 shows how the settlement plates are constructed and installed.

The iron pipe is used to measure height reduction. The elevation of the pipes is measured and compared with the elevation of stable points of the plant (reperes). The measurements should be done every month at the beginning of the rehabilitation works and till their completion, every 3 months the next year and every 6 months till the expiration of the aftercare period of the landfill.

6.6.1 Settlements Monitoring - Construction and Installation Settlements Index

Monitoring and measurement of settlements in the vertical and horizontal sense on the surface of the landfill, will give details of the expected size and the likely time for completion. The vertical settlements depends on the thickness of the waste, the age, the quality and the type, the initial degree of concentration during the deposition and the covering at the time.

The settlements index locations will have to cover the surface of the landfill, emphasizing the most important sections. The control-monitoring of settlements will be conducted on an annual basis.

In particular, for monitoring the speed of landfills sedimentation, concrete slabs thickness 20 cm and dimensions 0.6x0.5m are placed, in the center of which is placed a shaft with a diameter of 2'' and length of 2m. The indexes are sited in the installation of landfill with spacing not greater than 100m. Measurements of settlements stop when the difference between two adjacent control precipitations is less than the threshold of the semester.

6.7. Monitoring of weather conditions-Recording of data

The meteorological – climatic data should be determined by an exciting meteorological station located near to the project area, which is Tripoli station. According to the EU Directive 1999/31/EC, the following checks – with record keeping – must be carried out:

Table 6-5: Meteorological data monitoring

Measured Parameter	Operation Phase	Surveillance Phase after completion
Amount of precipitation	Daily	Daily, in addition to the monthly rates
Temperature (Highest, lowest, 14.00 h CET)	Daily	Monthly average
Direction and intensity of predominant wind	Daily	Not required
Evaporation (lysimetric or other appropriate methods)	Daily	Daily, in addition to the monthly rates
Atmospheric moisture (14.00 h CET)	Daily	Monthly average

6.8. Volume and composition of incoming waste and soil material

The operator of the plant must keep records for a series of information collected during the weighing of the collection vehicles in the entrance of the landfill.

These information are:

- Title and address of the owner of the vehicle, full name and telephone number of the responsible;
- Title and address of the producer of the waste, full name and telephone number of the responsible;
- Source of waste;
- Type of waste;
- Weight of waste;

That means that statistical records will be kept for the volume and the type of the incoming waste according to their source for the whole period of operation of the landfill.

In order to avoid the reception in the landfill of non-acceptable waste and for statistical reasons as well, two sampling inspections of incoming waste must be executed every day.

In every inspection the following information will be registered:

- Date and time of inspection.
- Source of incoming waste.
- Vehicle and driver's necessary data.
- Observations of the inspector.

The above-mentioned inspections will give information for the composition of the incoming waste and its variation through the year and according their source.

Finally, during the entrance of the transportation vehicles, the volume the composition and the source of the incoming soil material will be registered as well.

7 Emergency plan

7.1 General

Emergency situations are defined as events:

- When danger to the health and safety or for human life are eminent
- When injury to persons increases the risk to life or mobility.
- When risk for pollution of the environment is eminent
- When pollution of the environment has occurred

The Operator of the facility is responsible for:

- Establishing and maintaining emergency plans at the landfill
- The education of the staff of the facility in acquaintance with the emergency plans
- The training of the staff in ability to follow the emergency plans under such situations.

The content of the emergency plans shall be approved by the control authorities, e.g. the local fire department etc.

Keeping self-control and composure is essential in all cases. Thus the prime objective of the emergency plan is to ensure, that all personnel in an emergency situation are aware of their duties and tasks and will act accordingly.

In the case of an emergency the Operator or the appointed representative of the Operator will be responsible for the initiation of the correct emergency procedures, including contact with any competent authority as may be required according to the plan.

The Operator or his appointed representative has the authority to cancel an emergency status and to restart the work, unless superseded by a competent authority, e.g. the local fire department, the police, the Regional Inspectorate for Environment and Water, etc.

The emergency status can be cancelled after complete elimination of the cause, when there is no longer a risk for reoccurrence or when all possible measures have been taken to ensure safe operation of the facility can resume.

Emergency situations may arise in the case of:

- Traffic accidents, industrial accidents or personnel injuries
- Exceptional storms or thunderstorms
- Fire
- Floods and earthquakes
- Failures in electricity supply

7.2 Traffic accidents and industrial accidents and injuries

In case of incidents of:

- Industrial accidents or injuries,
- Traffic accidents,

- Breakdowns of machinery

Where potential risks arise for serious personnel injury or unacceptable pollution of the area and the surroundings, or such injury or pollution takes place, then an emergency situation is at hand.

The staff of the facility will then:

- Immediately call for an ambulance or other rescue bodies as appropriate
- Perform first aid as appropriate
- Immediately inform the police
- Take the necessary steps to reduce the harmful effect of the situation
- Inform the Operator or his appointed representative of the facility, the Owner and the municipality

The appropriate contacts and their telephone nos. are posted at the office entrance notice board and in this manual Chapter 1.10: "Contact List in Case of Emergency".

The Operator shall always be informed of all accidents, where personnel have been injured as well as of more serious accidents. Breakdowns will be notified to the Operator. In each case of such incident a report shall be filed with the Operator.

7.3 Storms

In case of strong wind with wind speed higher than 28 m/s. (i.e. hurricane) or thunderstorm the facility staff must:

- If at all possible secure the open tipping front by covering the waste with soil
- Immediately stop all outdoor activities and seek shelter in the buildings until the storm has ceased

7.4 Fires

- **Fire prevention**

The Operator of the facility shall prepare general fire defense instructions; indicative are given in Appendix of this manual, with precautions which the staff will adhere to for the purpose of preventing fire.

The use of open fires is strictly prohibited in the area of the landfill.

No waste containing hot ashes and similar materials must be disposed of in the landfill. The waste shall be segregated until it does not pose a further fire danger, or it must be extinguished using the appropriate methods prior to tipping and compaction at the landfill.

- **Fire fighting**

In case of fire the facility staff must act in accordance with the general fire defense instructions, prepared by the facility Operator. These instructions are enclosed in Appendix of this manual.

In order to assure an effective firefighting all fire extinguishing equipment (fire hydrants, pumps, hoses etc.) must be present and properly maintained.

In the case of fire the landfill staff must immediately:

- Stop all works and evacuate any personnel on foot from the area.
- Switch off electricity supply for all types of equipment in the threatened area
- Initiate fire fighting

Table 7-1: Fire fighting

Fire in the waste in the landfill cells	Fire in waste outside landfill cells	Fires in machinery, buildings
Smother the fire by covering with soil and compaction using the bulldozer, compactor and/or front loader	If possible smother the fire by covering the waste with soil	Use fire extinguishers and/or water as appropriate
If necessary use water or leachate	If necessary use fire extinguishers and/or water	

- In case of a more extensive fire call the local fire department and the police as appropriate
- If necessary, perform first aid and call for an ambulance
- Take the necessary steps to reduce the harmful effect of the situation, being especially aware of risks for polluted water from the firefighting to reach the surroundings.
- Inform the Operator or his appointed representative at the facility, the Owner and the Municipality of Srar Akkar

The cause of the fire must be identified and the appropriate measures taken to prevent new fires or re-ignition.

Deep-seated fires, i.e. fires which have extended deep in to the waste body, calls for special precautions. The extension of the fire must be determined, e.g. by measuring the temperature in the waste in the area around the suspected fire. A safety zone around the fire area shall be established through deep trenching and subsequently filling of the trench with inert material such as sand. Firefighting comprises smothering by covering the area with soil, and the use of water or leachate e.g. by injecting through the safety trenches.

The area of deep-seated fires can become unstable. Personnel and vehicles should therefore not approach affected areas.

7.5 Floods and earthquakes

In the case of floods and earthquakes the facility staff will immediately:

- Stop all works and cut power to all major electrical installations
- If necessary, perform first aid, call for an ambulance, the fire department and police as appropriate
- Inspect all facilities and equipment present at the facility for possible damage and take measures to limit the extent of damage
- Inform the Operator of the facility or his appointed representative, the Owner and the Municipality

7.6 Contact list in case of emergency

The appropriate contacts and their telephone nos. are given in Chapter 1.10 "Contact List in Case of emergency", and are posted on the notice board of the facility office.

7.7 Accidents and Other Incidents

The operator of the landfill will report and registration for all the cases:

- Accidents connected with risks for health and people safety
- Other incidents connected with job health and safety
- Unexpected stop of the planned operations of the landfill including fire, explosion, damage of important facilities

The reports will be sent to the control authorities and registered there.

7.8 Complaints

All the complaints coming from citizens and neighbors will be registered at the control authorities with a description of all measures undertaken by the Operator for elimination the reasons for these complains and their final settle.

7.9 Measures for recover

Any kind of incident, which causes pollution of the surrounding area, like outlet of leachate, not cleaned sewage water, fire smoke, polluted surface water and e.g., immediately will be reported to the control authorities. The incident and the immediate activities executed to recover, according the instructions of the competent authorities, will be reported and registered.

8 Occupational health and safety

8.1 General

There are inherent hazards associated with the operation of any waste disposal site, let alone one operated in line with international best practice. Historically, accidents at landfills have resulted from the temporary nature of much of the site's infrastructure – e.g. site roads, sharp bends and steep gradients - and because vehicles and machinery are often operated in confined areas and in close proximity to each other. Reversing vehicles are a significant problem, particularly where staff is required to cross the working area on foot or direct vehicles at the landfill face.

In such circumstances, accidents can be minimized by the implementation of safety and training programmes and by effective site management. These programmes 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
- On-going monitoring to ensure proper implementation of safe working procedures

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

- The landfill should be constructed and maintained in a safe condition
- A safe means of access to the site for staff and vehicles should be provided
- 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
- Adequate welfare facilities for staff must be provided and maintained

This section sets out the basic requirements of the effective control of health and safety at landfill sites. It constitutes general guidance which should be considered and enacted by all site operators.

8.2 Personnel

One or more persons must be formally designated for site safety issues. Individuals so designated 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 latter 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.

8.3 Training

One or more persons must be formally designated for site safety issues. Individuals Operators should provide suitable training and instruction to site employees, both full time and part time. The operator should also ensure that any 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 are able to act as competent project supervisors in relation to 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 should be prominently displayed for use in the event of an emergency. An indicative format of a possible emergency contact is presented in the following table.

Table 8-1: Indicative format of an emergency response sheet

Name of site:	……		
Location:	……	**Grid Ref.:**	……
Operator:	……	**Phone:** **Fax:**	……
Safety officer:	……	**Phone:** **Fax:**	……
Licensing authority:	……	**Phone:** **Fax:**	……
Doctor:	……		……
Ambulance:	……	**Phone:**	……
Hospital:	……	**Phone:**	……
Police:	……	**Phone:**	……
Fire station:	……	**Phone:**	……
Location map:	(showing site location)		
Other information:			

8.4 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.

8.5 Medical

Good personal hygiene is essential to workers on landfill sites and hence hot and cold washing facilities must be provided. All workers at landfill sites, including those employed temporarily by the operator, or by contractors working on the site, should have adequate protection against tetanus. This protection must be kept up to date, with boosters given at 10 yearly intervals. The onus should be on the employer

to ensure that these injections have been received by employees and to require appropriate assurances from contractors working on the site.

Workers have to pass mandatory preliminary and periodical medical examination in accordance with the existing requirements.

8.6 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.

8.7 Personal protection equipment

High visibility clothing should be provided and worn by all site staff and visitors. Safety boots and/or wellingtons should be issued 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 issued as required. The type of glove should be puncture resistant and should be suitable for the relevant task, e.g. litter collection, vehicle fueling, cold weather conditions. Safety helmets 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.

8.8 Landfill biogas

All site staff should be made aware of the possible hazards from landfill gas. Smoking on site should be forbidden except in designated areas. Buildings and other enclosed structures located at the landfill should be designed to prevent the accumulation of flammable gas within them. It is imperative that all cabins, other store rooms and voids should be regularly monitored for the presence of flammable gas.

The flammability, toxicity, and asphyxiate characteristics of landfill gas requires personnel involved in the monitoring, operation, construction or any other aspect of a gas management system to be adequately trained. A written safe system of work with rehearsal emergency procedures should be provided before work on landfill gas management system commences.

Stringent safety measures should be incorporated into equipment for landfill gas collection, utilization, flaring and venting. If "trigger values" for gas concentrations are exceeded in buildings, then emergency monitoring should be undertaken to identify the point of gas ingress and control measures implemented to prevent further ingress.

Ideally any indoor air testing, soil gas sampling, and ambient air testing are conducted simultaneously to determine if any elevated indoor air concentrations, for example, are from the sub-surface, indoor sources, or the background outdoor air. In terms of monitoring the indoor air for the presence of gas emissions, several technologies can be used which include obtaining grab samples, real-time and near-real-time sampling, and passive sampling.

The most common methods for monitoring indoor air are through grab samples – particularly via the use of Summa Canisters. These are small airtight metal containers which fill with air at a fixed flow rate over a preset period of time with the use of a flow controller. Real time and near-time sampling uses analyzers which can be used to collect multiple samples that locate problem structures, vapor migration routes into structures, and volatile sources inside the structures. Passive samplers are less commonly used for vapor intrusion assessments, and basically use an adsorbent to capture organic gas concentrations over a set period of time. Irrespective of the method used, the technology must be used to measure levels of contamination at health-based thresholds.

Health and safety issues should have particular priority where any site works involves the disturbance of filled areas.

8.9 Site infrastructure, signs and barriers

Steep gradients and sharp curves on site access roads should be avoided. If this is not possible warning signs and crash barriers must be provided. Speed limits should be displayed and enforced by the site operator. Vehicles should not travel over unstable areas on a landfill surface, and neither should they travel with their vehicle bodies raised up or being lowered.

Sites should be provided with adequate lighting to allow for safe and efficient operation at the tipping area at dawn and dusk in the winter period. Trenches and lagoons used for liquid or sludge disposal should be fenced, or be clearly marked with poles and bunting and each trench should be labelled to indicate the type of wastes allowed to be deposited. When filled, trenches should be covered immediately.

Hazard notices should be utilized on the site in relation to deep water or steep faces. Physical barriers should be in place to prevent unauthorized access to culverts and other confined spaces.

8.10 Hazardous substances

The operator should ensure that exposure of persons at a landfill to hazardous substances, is minimized or, where exposure cannot be avoided, adequately controlled. Employees should be trained regarding:

- Potential risks
- Associated preventative measures and precautions
- Existence of occupational exposure limits
- Actions to be taken
- Hygiene requirements
- Personal protective equipment

Landfills represent working environments where employees could be potentially exposed to a variety of different substances. Operators should assess the types of substances likely to be received at their sites and identify the risks they pose.

8.11 Electrical hazards

The electricity distribution system should be inspected annually by a qualified electrician. Residual current breakers should be fitted to all power outlets. Electrical equipment located in areas where

accumulations of flammable gas could occur should be selected, installed, and maintained in accordance with relevant safety requirements. Overhead power lines may cross the site. These should be either diverted or measures should be taken to ensure that the level of waste does not rise above a level agreed with the relevant authority. At no time should vehicles or equipment be able to get within arcing distance of any electrical cables. All power lines should be signposted by protective barriers. Any damage to these barriers should be dealt with immediately.

8.12 Scavenging

Scavenging is the separation and removal for re-use of items such as scrap metal by informal waste pickers. In the past, it provided a means by which materials were recovered and recycled. 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.

9 Site closure and aftercare

9.1 General

Restoration and aftercare are both essential steps in the process of waste disposal, and must be considered at all stages of the life of the site if landfilling is to be managed in a way that minimizes environmental impacts. Restoration includes design, initial landscaping works, soil spreading and aftercare. Aftercare is the work that is carried out after replacement of the soil and includes all operations necessary to establish and maintain the after use of a restored site. Aftercare includes cultivations, vegetation establishment, maintenance and an ongoing long term commitment to the restored land.

The proposed after use should be realistically achievable in terms of site topography, geology, soil types and particularly the quantity of soils available for restoration. The long term requirement of the environmental pollution control systems on the landfill and the need to provide access for use and monitoring purposes must be built into the chosen after use. The financial costs involved in restoration need to be considered and provision needs to be made during the lifetime of the landfill to ensure adequate funding is available for restoration, aftercare and post closure management.

Once the land disposal site is full it must be properly closed in such a way as to continue to minimize the impact upon the environment. Site operators are required to continue to maintain the site and monitor for impacts long after the site has closed. This "aftercare" may need to cover a period of up to thirty years.

9.2 Final cover

Leading up to completion of fill operations sufficient material must be accumulated to cover the site with a low permeability cap. The cap must be designed to:

- Encourage the controlled run-off of surface water
- Prevent release of landfill gas if generated
- Facilitate appropriate after-use
- Have final cover which facilitates growth of vegetation
- Be resistant to soil and wind erosion
- Minimize surface water "ponding"

Final cover generally consists of 1 m of topsoil, which must be planted to prevent erosion. Slopes should generally not exceed 5% although this may be exceeded slightly for landfills in dry climatic conditions provided that they are well planted. Following closure, the site operator must periodically inspect the landfill cap / final cover to ensure that there is no erosion / degradation of the final cover and that there is no settlement or subsidence affecting the security of the cap or final cover. If any significant degradation is observed, the site should be re-graded as necessary.

9.3 Decommission site infrastructure

Site infrastructure, which is surplus to requirement, should be decommissioned, including temporary storage areas (for waste and/or raw materials). This may include temporary storage facilities that may

have been used for storage of hazardous wastes. Such facilities must be decontaminated and properly decommissioned. This activity may itself give rise to wastes, which must be treated and/or disposed of at a suitable waste management facility.

9.4 Leachate collection and treatment

After final cover, operational activities continue for a while with periodic leachate extraction from the completed cells and treatment of leachate collected. Leachate collection and treatment must continue until no further leachate is being generated.

Appendix 1: Detailed list of waste types

Table A1-1: Checklist for monitoring landfill area

A/A	Waste type	EWC Code
1	Generated municipal solid waste out of which:	20 03
1.1	Mixed domestic waste	20 03 01, 20 01
1.2	Similar mixed waste from commerce, industry, institutions	20 03 01, 20 01
1.3	Municipal and similar waste collected separately	20 01
1.3.1	Paper/cardboard	20 01 01
1.3.2	Glass	20 01 02
1.3.3	Plastic	20 01 39
1.3.4	Metal	20 01 40
1.3.5	Wood	20 01 36
1.3.6	Biodegradable	20 01 08
1.3.7	Other	20 01
1.4	Bulky waste	20 03 07
1.5	Parks and gardens waste	20 02
1.6	Markets waste	20 03 02
1.7	Streets waste	20 03 03
1.8	Generated but uncollected waste	20 01 15 01

Appendix 2: Landfill fires

Appendix 2.1 Fire characterization

Fires at landfills can be classified into four categories, corresponding to the level of alert:

Level 1 alerts	Small fires occurring on the landfill property, but not actually involving landfilled waste, compost or stockpiled recyclables, e.g. car fires, bin fires, equipment fires, office fires.
Level 2 alerts	Small waste fires that can be contained by on-site resources within 24 hours and fully extinguished within 48 hours. Level 2 fires will typically involve less than 200 m^3 of burning material.
Level 3 alerts	Medium size waste fires or large fires at compost facilities that can be contained in less than one week and that can be fully extinguished in less than two weeks. Typically, 200 to 5,000 m^3 of waste material is involved.
Level 4 alerts	Large or Deep Seated Landfill Fires that require more than two weeks to contain typically involving more than 5,000 m^3 of burning waste.

Appendix 2.2 Immediate actions

Fires at Level 2 or 3 alert levels have the potential to turn into a Level 3 or 4 fires if an immediate and effective response plan is not applied. This is the reason why quick recognition and spotting of fires is essential. The prevention of the escalation of a fire is related to the delineation of flammable waste, the application of immediate soil cover, and the potential for access and immediate excavation of the landfill slopes.

It is very important also, in the case of a Level 4 fire, to have ensured exact spotting of the fire as well as an assessment of the current and potential extent it could attain. Spotting should be linked to mobilization of fire-fighting resources from the outset.

In any case, the first actions that must be taken at a landfill, during a fire of level 2 or above are:

- Shut-off of the landfill gas collection and management system (if present)
- Water services must be available for firefighting, including treated leachate if available
- Standby electricity generators should be available for use, in case of power failure

The following actions need to be taken in the case of a landfill fire of level 2 or above:

- Immediate spotting of the fire
- Call to the fire department
- Characterization of the fire – choice of alert level
- Appointment of an incident commander
- Application of communication plan
- Selection of the most appropriate firefighting equipment
- Activation of alternative working face
- Monitoring of the air emissions and the course of the fire

- Application of the communication plan for the local community
- Application of the evacuation plan for residential areas if necessary
- Use of soil reserves
- Use of health and safety equipment by staff

Appendix 2.3 Extinguishment methods

The approach taken to extinguishing a landfill fire depends on the type of fire.

Selection may be dependent on the wind direction and intensity, the location of the flammable materials and the ability to mobilize personnel, fire department equipment and the potential for impact on local communities.

Appendix 2.3.1 Water application

Although water is an effective firefighting agent for near surface fires, ensuring that water reaches a deep-seated fire can be problematic. Water tends to flow along paths of least resistance in the waste such as through poorly compacted pockets. This process of channeling can result in significant short-circuiting, and inability of the water to reach the active burn zone at depth. Water does not readily penetrate cover layers composed of low permeability soils, especially if the cover has been compacted by vehicular traffic.

In situations where soil cover is present at surface or at depth, surface application of water is often ineffective. However, stripping of the soil cover should never be considered because it will facilitate air entry, which will accelerate the burn. To deliver water beneath cover soils, the preferred approach is to inject water into wells or other available injection points. Wells can be quickly drilled with a 150 to 300 mm diameter auger rig. Well screens can be dropped into the boreholes to keep them open. Water can then be deployed into the injection wells from tank trucks or pumped in directly if a fire hydrant or water body is located nearby.

Large volumes of water may be required as 5000 h of water is required to absorb the energy released by the full combustion of 1 tonne of garbage. The use of foam and surfactants can reduce this volume markedly.

The firefighting team has to consider that the use of large amount of water for the extinguishing of a fire can produce large amounts of leachate, which may possibly, overload the leachate treatment facility or require temporary containment or ponding.

Appendix 2.3.2 Excavate and overhaul

For deep-seated fires, where water application may not be an effective fire-fighting tool the most appropriate method for extinguishing the fire is often to excavate and "overhaul" the waste.

The first step in controlling a fire in such way is the filling of parallel trenches previously excavated by the landfill operator. Next, smother the fire zone with a 2 to 3m thick lift of refuse or soil and smooth (overhaul) the landfill surface. These actions reduce the amount of air fanning the burn, reduce the rate of burn and the amount of smoke that the fire emits, and make the landfill surface a safer work environment.

Appendix 2.3.3 Oxygen suppression

By limiting the amount of oxygen within the burn zone it is possible to extinguish a landfill fire over time, but this is usually a slow process.

This method is similar to excavating and overhauling, since it is based on the isolation of the burning section of waste from the rest of the landfill. Isolation is achieved by excavating around the burning mass, until inflammable material (usually soil or rock) is found. The excavated trench is filled with low permeability material in order to limit the flow of oxygen through the burning waste mass.

After applying this method, long term temperature and gas monitoring data needs to be collected in order to determine whether the selected method was effective or not. Also, the collection of the monitoring data indicates when the fire is extinguished and the materials from the trenches can be removed in order to fill them with waste.

Appendix 2.4 Fire prevention and control plan

It is very important for every landfill to have an established and maintained fire prevention and control plan. In this plan, essential issues related to the landfill must be included such as site characteristics, Fire Fighting Resources, Landfill Fire Alert Levels, Incident Command Structure, Fire Response Actions and Responsibilities, Fire Fighting Methods, Landfill Fire Risk Reduction Strategies, Personal Protective Equipment etc. All site personnel need to be aware of the plan, and trained in its application.

Appendix 2.5 Checklist

The following checklist can help operators to assess their readiness to handle a landfill fire and identify possible gaps that have to be covered. Where "no's" are ticked in the remedial action must be considered.

Table A2-1: Checklist for monitoring landfill area

BUI LDINGS	**Yes**	**No**
Workplace clean and orderly		
Emergency exit signs properly illuminated		
Fire alarms and fire extinguishers are visible and accessible		
Stairway doors are kept closed unless equipped with automatic closing device		
Appropriate vertical clearance is maintained below all sprinkler heads		
Fire extinguishers are serviced annually		
Corridors and stairways are kept free of obstructions and not used for storage		
The roads that lead to the buildings are clear and accessible to the fire engine		
TRAINING	**Yes**	**No**
There is specific training program for fire prevention and extinguishment		
New employees are given basic fire training		
Job-specific fire training held for employees on a regular basis		
Personnel familiar with applicable Material Fire Data Sheets		
All personnel familiar with emergency evacuation plan		
Training documentation current and accessible		
The guests of the landfill are informed that have to follow the staff's instructions		
LANFILL	**Yes**	**No**
There is stockpile of earth close to the working face		
There is on site equipment to move earth		
Alternative working face has been planned		
There is adequate supply of water under pressure for fire-fighting purposes		
There is a water storage tank for fire-fighting purposes		
Fire-fighting equipment is readily available		
Record-keeping procedures for all fires		
Electricity generators are available for use		
There is suitable access road for the fire engine to reach the working face and the burning mass		
All the equipment maintenance procedures are followed		
All flammable materials are stored properly		
The most dangerous locations of the landfill for fire, are signed properly		
The emergency telephone numbers (fire department, hospitals, police etc.) are displayed in approachable places		
There is an adequate network of lightning conductors for protection from lightning strike		