Pilot Project C-5

Detailed Design and As-built Drawings for Improvement Work at Sisdol Short-term Landfill

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CHAPTER 1 GENERAL PROEJCT INFORMATION

1.1 Site Location and Project Background

The Sisdol Landfill Site is located at Ward 4 - Sisdol of Okharpauwa Village Development Committee (VDC) in the Nuwakot District. It lies on the northern bank of *Kolpu Khola*, immediate near to the confluence: *Thulo Khola - Kolpu Khola*. The altitude at landfill site is about 1,150 m above mean sea level (asl) and 350m below Tinpiple, the point of diversion of the existing road to Trishuli from the newly constructed access road to Okharpauwa. Through this road, the site is now well connected to Kathmandu with a distance of 16 km to the north-west from *Balaju -Bypass* and about 29 km from the existing waste transfer station at Teku.

The proposed landfill site covers a total area of 15 ha, out of which the actual landfill area should cover 2 ha, site protection/ buffer zone including the forest up to the hill on the northern side of the newly constructed access road to Okharpauwa should cover 12 ha, and the rest 1 ha will be covered by other facilities for waste management such as administrative complex, internal service road, leachate treatment facilities, etc. Taking into consideration the existing case of urgency for a landfill, it has been planned to develop the site immediately as part of the Pilot Project C under the technical assistance of Japan International Cooperation Agency (JICA) and to operate it for a short-term period (2-3 yrs.) to bridge the time till the development of a long-term sanitary landfill for proper management of solid waste in the cities of the Kathmandu Valley.

1.2 Assessment of Existing Natural Conditions

For the purpose of detailed design of the site, the natural conditions survey of the site was carried out as follows;

1.2.1 Topographical Survey

A detailed topographical survey was carried out in and around the site covering a total area of 6 ha. Main outputs of the survey were the preparation of:

- a topographic-map of the landfill site and immediate surroundings in scale 1:500, with 50 cm contour intervals,
- several longitudinal and cross-profiles through the two valleys, and across Kolpu Khola in scale 1:500.

Topographically, the site consists of two small valleys. Valley I (with an average width of 40 m) stretches from north to south downwards, between a level of147 m (flood level) and 174 m (existing road level). But the landfill in this valley should start only from a level of 153 m so that leachate treatment facilities can be safely accommodated within the level difference of 6m to the flood level. The valley II (with an average width of 60 m) stretches from north-west to south-east downwards between a level of 151 m (flood level) and 174 m (existing road level). But the landfill in this valley should start only from a level of 157 m to make provision for leachate treatment facilities at the downstream.

1.2.2 Soil/ Geo-technical Investigation

In order to know the nature of soil, especially that of sub-soil within the landfill area, four bore holes were drilled (locations are shown in as-built drawings). Three bore holes (#0, #1 and #3) are within valley I and one (#2) in valley II. The bore hole #0, located near the existing waste bordering at a distance of 15m upstream was explored to a depth of 10 m; borehole #1, located at about 32 m downstream outside the landfill area of valley I, was explored to a depth of 5 m; and borehole #3, located at about 110 m upstream from valley I, was explored to a depth of 5 m. However, borehole #2, located at downstream and outside the landfill area of valley II, was explored also to a depth of 5 m. The boreholes log along the longitudinal profile of valley I and the projected soil profile are represented in Section 4 hereafter. The log profile shows that the nature of sub-soils varies from pervious to impervious type with stagnant seepage waters in gravelly sandy layers.

1.2.3 Hydro-Geological Investigation

As several surface water flows were seen at the site crossing longitudinally through valley I, existence of some ground/ spring water within the landfill area of valley I was initially suspected. In order to clear this matter, a hydro-geological investigation was carried out by digging 4 pits (dia. 30-150 cm) across valley I to a depth of 150 cm each. Two days of observation about water levels in the pits and the soil profile indicated that there is no permanent spring or groundwater source within the landfill area, which means that there is no need of managing groundwater drainage to protect against any liner to be placed for basement sealing. For locations of these pits, refer to as-built drawings.

CHAPTER 2 CONCEPT DESIGN FOR THE TOTAL SITE

2.1 Technical System

An appropriate system (in Nepalese context) of sanitary land filling with controlled input (i.e. the incoming waste to be finally disposed of) and outputs (i.e. leachate and the landfill gas) should be adopted, which is scientific, but technically and financially sustainable. As regards the classification of sanitary landfill by level, the proposed system should correspond to a level higher than 3[1].

The well-known Fukuoka method of semi-aerobic landfill system, the generic concept of which has been developed at the Fukuoka University of Japan in early 1970's and so far very successfully practiced in the Asian countries like Malaysia and the Islamic Republic of Iran, should be adopted. This technical system is to be described in brief as follows.

2.1.1 Landfill Type: Semi-aerobic

Leachate produced due to infiltration of water percolated through the waste layers should be collected in a collection pond (leachate retention pond) through properly sized perforated pipes (main leachate pipes and branch leachate pipes) embedded in graded gravels/ boulders as filter material. Aerobic condition in the waste layer around the pipes should be introduced by keeping the outlet of the main leachate collection pipe always open to air to allow free entry of fresh air into the waste mass. By giving proper slope to the pipes over the liner system, quick removal of leachate is achieved, which facilitates lower water content in the internal waste layers.

2.1.2 Leachate Treatment System

As regards the treatment of leachate collected, there should a retention pond with its volume sufficient for retaining the leachate produced (at the rate of design leachate volume of 45 cum/d) for a period of more than 7 days. The leachate collected in the pond should be regularly aerated through proper aerator system, which can be regarded as biological aerobic treatment. The aerated leachate should be further re-circulated by means of a pump to spray the leachate over landfill cells for a simple anaerobic biological treatment. It is to be noted that this type of leachate treatment integrated in the so-called "Fukuoka Method" of semi-aerobic landfill system has experienced a significant improvement in the leachate quality. As regards the Japanese experience on efficiency of this type of treatment (*Source: Landfill sites in Japan 2000/ The Journal of Waste Management*), the following observation has been made in connection with the improvement of leachate quality of the "continuing landfill" vs. "2 years after landfill":

- pH value is changed from 6 to 7-8,
- BOD_5 of range 40,000 – 50,000 mg/l was improved to 50 mg/l,
- COD of range 40,000 – 50,000 mg/l was improved to 1,000 mg/l, and
- NH_4 –N of range 800 – 1,000 mg/l was improved to 100 mg/l.

[1] Landfill levels have been discussed in Interim Report 1 and Workshop 1. Level 3 calls for provision of major facilities of cover soil, fence, storm water drainage, waste containment, landfill gas vents, leachate collection system, biological leachate treatment (aeration and re-circulation), and environmental monitoring. Level 4, in addition to these facilities provides liner system and advanced chemical leachate treatment system.

As regards the leachate quality in Nepal, the following values for leachate quality were observed in Gokarna-landfill (Source: NESS, Dec. 1996), about 10 years after the landfill:

- pH value of 6.8
- BOD5 of 3,500 mg/l
- COD of 45,500 mg/l, and
- NH4 –N of 808 mg/l.

On the other hand, the results of leachate analysis at different locations at the dump site Balkhu, under this Study, reflects some better quality, e.g. pH of 6.2-6.3, BOD_5 of 2,450-3,600 mg/l, COD of 5,232-41,420 mg/l, and NH_4–N of 20.97-93.26 mg/l. Based on good Japanese experience for the relatively worse leachate compared to that of Kathmandu, it is to be expected that the leachate quality in case of Sisdol LF will also be improved to the level of acceptable standard in Nepalese context. Further treatments (in addition to that integrated in the well-known Fukuoka method), e.g. through a natural treatment system such as a constructed wetland plant (reed bed) or charcoal plant, deserve due consideration, depending upon necessity, after future monitoring.

The above-mentioned technical system is to be elaborated in flow-diagrams as follows.

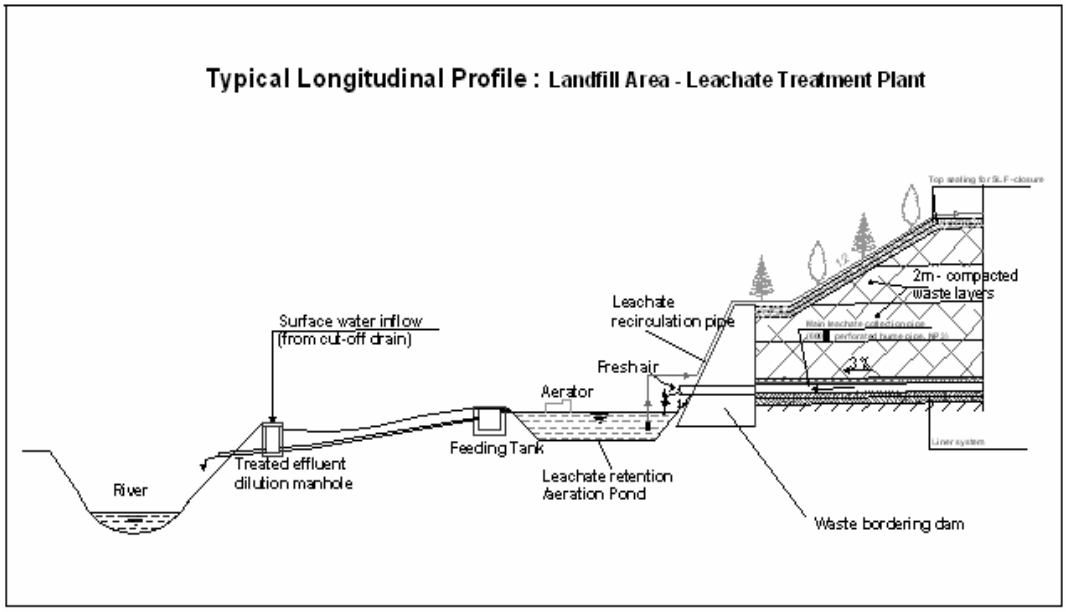

Figure 2-1 Typical Longitudinal Profile: Landfill Area – Leachate Treatment Facility

Source: JICA Study Team

2.2 Construction and Operation

Construction of the site with adequate facilities and their proper operation and maintenance thereafter are two important aspects, which are complementary to each other for management of a sanitary landfill site in a safe and environmentally sound manner. In concept, they are to be described as follows.

2.2.1 Facilities

With due consideration of a short-term but proper operation of the proposed landfill for a period till the development of a long-term landfill site, the facilities that are going to be constructed/ developed / provided are as follows.

- Natural liner system,
- Leachate collection system,
- Gas vent system,
- Leachate retention pond,
- Leachate re-circulation and aeration system,
- Storm water/ surface water drainage system,
- Improvement of waste bordering dam,
- Improvement of control room,
- Weighbridge, and
- Internal service road.

The above-mentioned facilities should be the components of Sisdol LF Pilot Project for the development of valley I. It is however to be noted that other measures such as:

- improvement of the existing drainage pipe culverts (including the sealing of damaged black-topped surface) in the north under the recently constructed access road to Okharpauwa,
- extension of about 5m length of the existing gabion wall constructed along the west border of valley I to retain the road structure (including improvement/ sealing of the black-topped surface),
- temporary storm water cut-off drains to be constructed phase-wise, however to be completed in right time till the time of construction of permanent drains, completion of administrative complex (including gates and fencing), and
- provision of utilities (e.g. site electrification, drinking water supply, telecommunication etc.)

are not included in the pilot project.

2.2.2 Operational Management

Proper operation of the site is very vital for a safe and environmentally sound waste disposal. Major aspects to be considered in this regards are:

- daily monitoring of incoming waste
- daily, intermediate, and final covering of waste
- preparation of tipping area for every 2m of compacted waste filling layer, e.g. slope protection, temporary storm water cut-off drain, extension of leachate collection system and gas vent pipes, horizontal gas drainage carpet etc.
- 6-8hrs. daily operation of aerator
- regular re-circulation of aerated leachate over waste cells by mounting the sprinkler over different landfill gas vents as required
- slope compaction to ensure stability of the dumped waste
- special preparation for rainy season, e.g. preparation of ramps for easy access to the tipping area, stock-piling of waste covering materials etc.
- ground water and surface water monitoring (in regular intervals as mentioned in the operational manual for the impact, compliance monitoring etc.); and
- landfill gas monitoring.

CHAPTER 3 LANDFILL: PHASE-WISE DEVELOPMENT

Topographically, the proposed site (landfill area) consists of two small valleys bordered by the recently constructed black-topped road to *Okharpauwa* in the north and west and *Kolpu Khola* in the east and south. Valley I extends from north to south form a level of 147 m (high flood level of *Kolpu Khola*) to 174 m (existing road to the proposed sanitary landfill (SLF)- Okharpauwa). Similarly, Valley II extends from north-west to south-east form a level of 151m (high flood level of *Kolpu Khola*) to a level of 174 m.

With due consideration of the existing topography of the site and optimum land filling technique, the landfill operation of the total site should be developed in phases. Two alternatives for phased development are considered.

3.1 Alternative 1

The total landfill area (two valleys) can be filled in three phases of operation as follows (and shown in Table 3.1.1):

***Phase 1*:** Valley I should be filled for a filling height of 11 m, i.e. from a level of 153 to a level of 164 m from south to the north, which should have an estimated capacity of 48,110 cum.

***Phase 2*:** After Valley I should be filled up to a level of 164 m by starting from south to the north, Valley II should be operated to a filling height of 7 m, i.e. from a level of 157 to the same level of 164 m as attended by Phase 1 of operation. In other words, Phase 1 and Phase 2 should attend the same common level of 164 m. Phase 2 should have only an estimated capacity of 32,073 cum.

***Phase 3*:** After Valley I and Valley II attend the same common level of 164 m, landfill should be continued on top of both the valleys up to a level of 180 m, i.e. a maximum filling height of about 16 m. This phase of filling should have a total estimated capacity of 194,812 cum.

Table 3-1 Landfill Phasing - Alternative 1

Phase of Operation	* Filling Level (m)	Landfill Capacity (cum)		
		Valley I	Valley II	Total
1	153 – 164	48,110	-	48,110
2	157 – 164	-	32,073	32,073
3	164 – 180	117,975	76,837	194,812
Total	SLF - site	166,085	108,910	274,995
* Note: with reference to the level at Tinpiple as +500m				

Source: JICA Study Team

3.2 Alternative 2

The total landfill area (two valleys) can also be filled in two phases of operation as elaborated below.

***Phase 1*:** Valley I should be filled up to the maximum filling height from the level of 153 m to the level of 180 m by starting from south (i.e. valley downstream) to the north (i.e. valley

upstream). This filling should have an estimated capacity of 166,085 cum, which is the total capacity of valley I itself. It is however to be noted that after the land filling attends a height of 164 m, which is the existing level of common platform of the two valleys, a waste dam between the two valleys may need to be constructed on the side of valley II before continuing the filling of waste to a higher level.

***Phase 2*:** After Valley I should be filled up to a maximum level of about 180 m, Valley II has to be operated by starting waste filling from the waste bordering dam (to be constructed at the downstream of valley II) at a level of 157 to the maximum level of 180 m, so as to match with the level attended by phase 1 of operation in valley I. This filling should have an estimated capacity of 108,910 cum, which is the total estimated capacity of valley II itself.

This alternative, which basically requires a waste dam between the two valleys, should have the features as tabulated below.

Table 3-2 Landfill Phasing – Alternative 2

Phase of Operation	* Filling Level (m)	Landfill Capacity (cum)		
		Valley I	Valley II	Total
1 (Valley I)	153 – 180	166,085	-	166,085
2 (Valley II)	157 – 180	-	108,910	108,910
Total	SLF - site	166,085	108,910	274,995

* Note: with reference to the level at Tinpiple as +500m
Source: JICA Study Team

3.3 Comparison of Alternatives

As regards the landfill technique and landfill capacity, there is practically no difference between the two above-mentioned alternatives. However, one has some advantages over the other while operating the site, which can be comparatively elaborated as follows.

Table 3-3 Comparison of the Alternatives

Alternative 1 (3 Phases)	Alternative II (2 Phases)
1. Filling of valley I and then after of valley II to a common platform of the same level favors better stability of waste layers with no fear of collapse at the slopes. 2. Milder temporary internal service roads with gentile slopes and flat bends can be constructed during phase 3 of operation in valley 1 and valley 2 simultaneously. 3. For filling of waste to a level of 164m in the valley I, the first phase of operation should have only a capacity of 4-5 months for the proposed target of 313 tons/d of incoming waste. It means that, by this time, valley II has to be set ready for operation, which may not be easy for various reasons.	1. Filling of valley I up to the maximum height should allow more time (14 – 15 months at the targeted rate of 313 tons/d of incoming waste) for the development of valley II. 2. Less amount of total leachate generation can be expected compared to alternative 1, as the exposed area of the active waste cells should be less for the volume land filled. 3. More rapid stabilization of valley I can be expected, as waste filing proceeds in height within a limited area. 4. A waste dam between valley I and valley II needs to be constructed (which practically separates the two valleys) to facilitate the land filling above the level of 164 m within valley I. The side slopes towards valley II (i.e. south-east side) needs to be topped with clayey-soil in 2 layers @ 30 cm thick. This dam, in total, may decrease the landfill capacity by 1,000cum. The waste dam can be however, constructed step-wise for every 2m of waste filling till the ultimate height to be attained. 5. Internal service road to be constructed during site operation to access the tipping areas at higher levels may not be easy, which may result in less volume of waste filling than expected, although cutting of side hill may be positive.

Source: JICA Study Team

3.4 Calculation of Landfill Capacity

The landfill capacities of the site have been calculated by considering the cross-sectional waste filling areas at 10m-intervals along the longitudinal profiles. The total site is estimated to have a capacity of 274,995 cum (Valley I with 166,085 and Valley II with 108,910 cum).

CHAPTER 4 DETAILED DESIGN OF FACILITIES FOR PHASE 1 DEVELOPMENT

A sanitary landfill must be designed with consideration of preserving the living environment by preventing undue incidents such as overflowing of the waste and leachate seepage, propagation of vectors, scattering of wastes and emission of unpleasant odor. Necessary design facilities for the land filling of valley I of the proposed Sisdol LF area are to be described hereafter. This landfill has been designed as a semi-aerobic landfill with facilities necessary to attain level 3.

4.1 Earthwork / Soil Provision for Cover Material

Earthwork in excavation and in filling in the valley I should be done for the purpose of preparing proper liner basement for the clay liner in slope, line and level as detailed in the drawings. The excavation of the sub-soil should be from the existing ground level to the depth required to attend the design level after proper compaction in-situ to a proctor density of Dpr-95%. For the preparation of liner basement in phase 1, the earthwork in excavation has been estimated at 22,432 cum. The excavated material, as shown by the bore hole log profile of the area, will be a mixture of silty clay, gravelly sand and soft rock to some extent. The hydraulic permeability of the soil is found to be in the range of10^{-4}-10^{-9} m/s, which means that it can be categorized in terms of perviosity (as per USBR) to be of type ***pervious*** to ***impervious***. The excavated material is therefore suitable for waste covering purposes, e.g. daily covering, intermediate covering and final covering as well. As far as possible, permeable and porous sandy types should be used for daily covering to ensure easy spreading and compaction of the solid wastes, and stabilize the landfill waste layers by not hindering the waste decomposition process. Clayey soil is suitable for intermediate covering to prevent gases from dispersing or rainwater from seeping into the waste layers. The final cover soil should be resistant to erosion by rainwater, low permeability and suitable for plants.

The quantity of covering soil required for filling of waste in valley I is estimated at 25,000 cum. As the surplus excavated material (difference of excavated and filling quantity) amounts to 21,886 cum, the deficit of about 3,114 cum. of covering material for the filling of valley I (estimated capacity: 166,085 cum.) can be gained through possible side slope cuttings during landfill operation, i.e. while preparing the site for every 2 m of waste filling beforehand. The material should be stored at any point just outside the basement area, so that it can be easily used at the tipping area currently in operation.

4.2 Liner System/Clay Liner Procurement

Under level 3 landfill, basically liner is not provided. The proposed semi-aerobic system will improve the leachate quality and hasten waste degradation, which will both contribute to reducing the leachate polluting impact on the surrounding hydrology. However as the EIA of 2000, has specified a form of liner, the natural clay liner has been considered for this site.

The structures and types of liner facility used should be conformed to the topographical and geological conditions of the landfill site, soil conditions, groundwater conditions, as well as the location of leachate collection facility. Theoretically, for a site with hydro-geological

barrier, i.e. a sub-soil of minimum thickness 3 m with a maximum permeability of 10^{-7} m/s and highest ground water table minimum 1 m below the geological barrier, a low-cost mineral liner system is sufficient for bottom sealing of the landfill area for the disposal of municipal waste (i.e. general waste of non-hazardous type).

The bore hole logs of valley I and the projected soil profile along the bore holes (Figures 4-1 and 4-2) show favorable situation of the sub-soil quality at the concerned depths, as indicated by the lab-tested hydraulic permeability of 1.27-2.05 x 10^{-9} m/s. Besides, the hydro-geological investigation on the existence of any spring/ ground water source within the landfill area shows that there exist no such water sources, except seepage water-flows to be seen on the surface at the natural site condition. Out of various liner systems practiced in different countries (e.g. mineral liner, bentonite, geo-membrane, and other sealing layers), compacted clay liner and HDPE geo-membrane are to be considered as two major types that can be applied in Nepal. Clay liner is preferable to the plastic liner (HDPE geo-membrane) mainly for the reasons of relatively difficult joining / lining technique, more cautions to be taken against damage during operation and relatively higher cost of the geo-membrane which has to be imported. Besides, costly measures have to be provided for the management of ground water drainage under the geo-membrane to prevent the possible uplifting of damage to the geo-membrane. Good quality clay for the purpose of miner liner ($k < 10^{-9}$ m/s), as confirmed by the laboratory test, has been found in the proximity (within 500 m.) of the site. Use of HDPE geo-membrane and proper leachate treatment facilities (without any specified type) as recommended by the EIA study conducted in 2000, seems to be as such over cautious and needs to be justified with due consideration of technical/operational and financial aspect as well. Under these backgrounds, the sealing layer for liner system has been selected as 2 layers of clay liner @ 25 cm compacted thickness over prepared liner basement compacted to a proctor density of Dpr-95%.

Procurement of 2,500 cum. good quality clay as specified (confirmed by required tests e.g. compaction test, permeability test etc. as described in the technical specification) from nearby sites has to be ensured beforehand. It seems that some clay of good quality may also be gained from site excavation work, but however with uncertainty about its quality.

4.2.1 Preparation of Liner Basement and Laying of Mineral Liners

Liner basement should be prepared by excavating the sub-soil to the depth required to attend the design level after compacting (compacted in-situ) to a proctor density of Dpr-95%, giving a longitudinal slope of 3% and two-way cross slope of 4% to the central line of the valley. Over this compacted liner basement, bottom layer of clay liner should be laid properly, compacted in-situ to a proctor density of Dpr $\geq$ 95% with a compacted thickness of 25 cm. Over this "bottom layer" with uniformly defined density, a second layer of clay (top layer) should be brought and compacted similarly for another compacted thickness of 25 cm. It is to be noted that before bringing the second layer on top of the bottom layer, the compacted surface of the bottom layer is to be made rough enough for its good adhesion with the coming top layer of the clay liner.

4.2.2 Laying of Jute Mat and Drainage Carpet

A layer of jute mat of standard quality is placed over the top layer of the mineral liner to protect its top surface. The surface of jute mat is then covered with a thick layer of gravel (river bed shingles/ pebbles of grain size 30-50 mm) forming a drainage carpet.

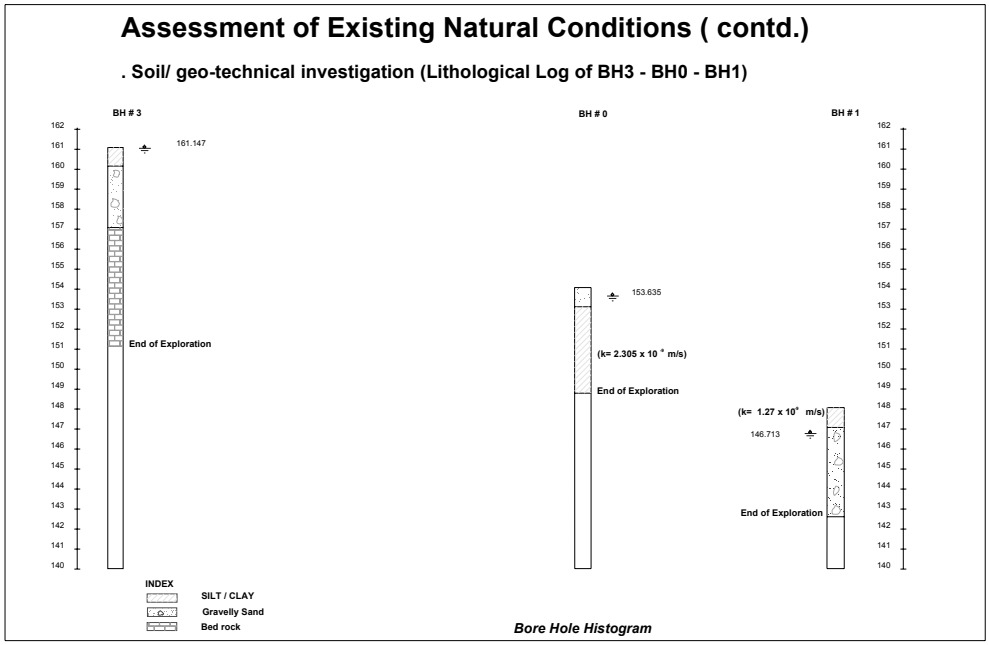

Figure 4-1 Soil Investigation (Lithological Log of BH3 – BH0 – BH1)

Source: JICA Study Team

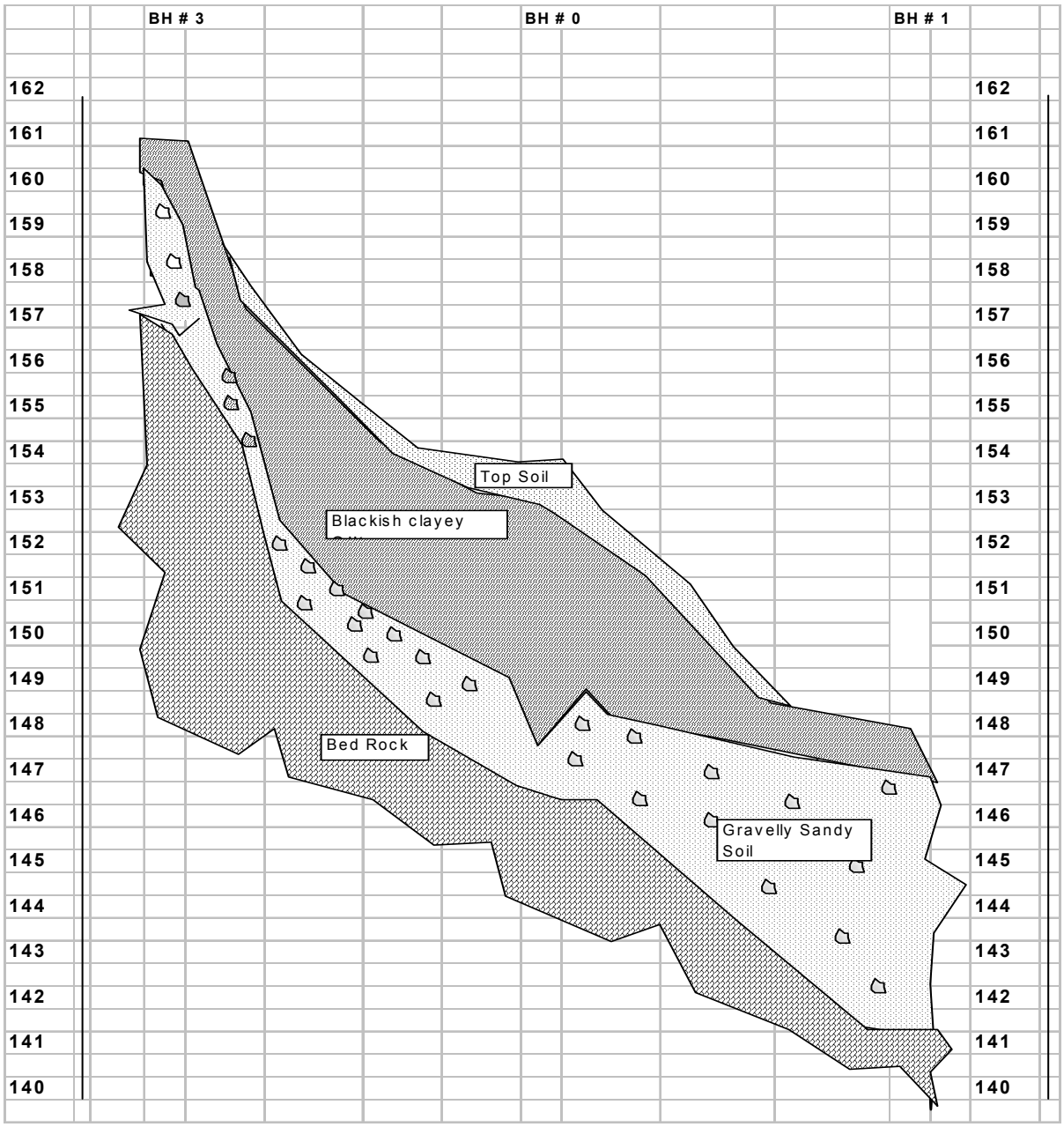

Figure 4-2 Projected Soil Profile along (BH3 – BH0 – BH1)

Source: JICA Study Team

4.3 Leachate Collection System

4.3.1 Leachate Collection Pipes

The general function of leachate collection facility is to quickly collect and channel the leachate generated from the rainfall on the land filled waste layers to the leachate treatment facility. For the proposed site, the system for proper and quick leachate collection at the landfill basement should consist of main leachate pipes and branch leachate pipes, which are to be hydraulically big enough to allow the maximum leachate flow and structurally strong enough against maximum static and dynamic loads coming over from ultimate height of waste filling and equipment in operation. Besides, they are also to be big enough to maintain permanent semi-aerobic condition within the waste layers for the proposed landfill system (Fukuoka method of semi-aerobic system).

(1) Main Leachate Collection Pipe

Perforated NP3 hume pipe of internal diameter 600 mm should be selected for the main leachate pipe. The pipe should be perforated in upper 2/3 part with circular holes of 25 mm diameter and in distance interval and pattern. The lower 1/3 part should be non-perforated (full section) to allow smooth flow of the leachate collected without leaking out from the pipe.

The laying of main leachate collection pipes longitudinally over the prepared top layer of compacted clay liner and along the gutter of basement prepared (sloped at 3%) deserves special attention for technical perfection, i.e. for being in line, level and position as shown in the typical cross-section. It is to be noted that laying of the main leachate pipe over the jute mat (underlined additionally with a sheet of 350 micron-HDPE sheet extended to the full width at the base of the filter material to be placed over the pipe) should be such that the top of its lower 1/3 part (i.e. the part without perforation) should be in level with the finished level of the top clay liner. This should happen only when the curved surface of contact of the pipe with the underlying jute mat, plastic sheet and top layer of compacted clay liner are accordingly concavely shaped beforehand.

The leachate pipe is then covered longitudinally with well-compacted filter material of riverbed shingles/ pebbles (grain size: 50 – 150 mm) packed in shape and size as shown in the drawing. The proposed width (more than 3d at the top and bottom) and thickness of the packed filter material should not only facilitate the filtration of leachate entering into the pipe perforation, but also increase the bearing capacity of the pipe under static and dynamic loading coming over it during operation at critical conditions.

(2) Branch Leachate Collection Pipe

With due consideration of design calculations (i.e. hydraulic and structural design as well) and adequate sizing for the very important circulation of fresh air coming from main leachate pipe through the connected manholes to maintain the permanent semi-aerobic condition within the waste layers, branch leachate pipe of diameter 250 mm HDPE (strength 10 kgf/cm^2) should be selected.

The pipe should be perforated in upper 2/3 part with circular holes of 10 mm diameter. The lower 1/3 part should be non-perforated (full section) to allow smooth flow of the leachate collected without leaking out from the pipe.

The laying of branch leachate collection pipes over the prepared top layer of compacted clay liner and cross to the main leachate pipe deserves special attention for technical perfection, i.e. for being in line, level and position. They should be laid laterally (at intervals of 20m) inclined on both sides of the main leachate pipe over the prepared top layer of clay liner (sloped at 4% cross to the longitudinal direction of the valley). It is to be noted that laying of the branch leachate pipe over the jute mat should be such that the top of its lower 1/3 part (i.e. the part without perforation) should be in level with the finished level of the top clay liner. This should happen only when the curved surface of contact of the pipe with the underlying jute mat over top layer of compacted clay liner is accordingly concavely shaped beforehand.

The leachate pipe is then covered longitudinally with well-compacted filter material of riverbed shingles/ pebbles (grain size: 50-150 mm) packed in shape and size as shown in the drawing. The proposed width (more than 3d at the top and bottom) and thickness of the packed filter material should not only facilitate the filtration of leachate entering into the pipe perforation, but also increase the bearing capacity of the pipe under static and dynamic loading coming over it during operation at critical conditions.

4.4 Gas Vent System

Various types of gases are generated by decomposition of organic materials in the landfill sites, which may cause fire disasters or affect the surrounding environment and human health. Therefore, it is necessary to carry out gas venting facility at landfill sites in order to prevent the adverse impacts of these gases. Besides, the gas venting facility also has an effect on accelerating the decomposition process of organic materials and promoting the stabilization of waste mass within the sanitary landfill site.

Collection and utilization of landfill gas is usually not cost-effective under normal condition. But however, it is necessary to carry out gas venting facility at landfill sites in order to prevent the adverse impacts caused by the accumulation of these gases within the waste mass. Besides, the gas venting facility also has an effect on accelerating the decomposition process of organic materials and promoting the stabilization of waste mass of the sanitary landfill site. The proposed simple but effective system for quick and effective gas venting system is to be described as follows.

4.4.1 Gas Vent System (Over Main Leachate Pipe)

The main gas vent system should be built over each and every main manhole that connects the main leachate pipe with the two lateral branch leachate pipes. Perforated PVC vent pipe of diameter 160 mm should be vertically fixed at the centre of the RCC manhole cover. This vent pipe should be surrounded by gravel/boulder filled in cylindrical gabions (size 750 mm diameter and height 2.5 m) of strong mesh wire. Five numbers of MS rods (diameter 12 mm) fixed vertically on the side of the mesh wire should help not only held the gabion in vertical position but also ease the further extension for every 2 m of waste filling. For installation of the first gabion over the manhole, fixing of 5 MS rods in the manhole slab while concreting is highly recommended. During operation, on top of every 2 m of compacted waste layer, placing of a 30 cm thick horizontal gas drain of length 3 m around each and every gas vent is recommended, which should facilitate better venting and aeration

through several waste layers inside the waste mass. Use of limestone for boulder/stone filling in gas vent is to be avoided.

4.4.2 Gas Vent System (over Branch Leachate Pipe)

The gas vent system over branch leachate pipe that ends at the foot of steep slope should be built by using perforated used oil drums of diameter 600 mm. The branch leachate pipe (HDPE pipe of 250 mm diameter) at the bottom should be connected to the perforated PVC vent pipe of 160 mm diameter and 6 kgf/cm^2 strength. The perforated vent pipe is surrounded by gravels/ boulders filled and packed in the oil drum. Four number of 12 mm dia. MS rods, welded on the interior side of oil drum, should ease further extension of the gas vent system for every 2 m of waste filling. However, the gas vent system to be built over branch leachate pipe, that has to be extended laterally at the bottom, should have a manhole similar to that to be built over main leachate pipe as described above.

4.5 Leachate Retention Pond

For collection of leachate flowing out of the landfill site through the main leachate pipe, a leachate retention pond of 408 cum. capacity (more than 7-days retention for design leachate quantity of 45 cum./d) should be constructed immediately outside the landfill area and along the existing waste retaining dam in length. The retention pond should have a surface area of 334 sqm and a maximum depth of 1.25 m with the maximum leachate retention level at a depth of 1.25 m below the invert level of leachate outlet pipe, so that fresh air can easily pass though the pipe opening into the waste layers. The leachate retention pond should be of excavated grub, well compacted at the bottom and slopes in line and level. The well-compacted bottom and slopes should be lined with 2 layers of 350 micron HDPE sheet covering all surfaces. The pond should be bordered at the top of its embankment along all four sides with stone masonry work. This should not only increase its retaining capacity beyond the overflow level, but should also fix the plastic sheet in position. The closing of over-flow valve (at the manhole outlet) should retain additional volume of about 2 days more. This additional volume for retention may be of importance in monsoon period when there is more rain and accordingly more leachate generation than expected.

During heavy monsoon periods, it may be often necessary to discharge the treated effluent through a manhole to the *Kolpu Khola*. For this purpose, the over-flow of the pond is connected with the manhole by 250 dia. hume pipe, and further via. an outfall structure down to the river. In dry season however, the leachate can be retained for more days in the pond. Regular aeration and re-circulation as well may also be necessary, despite more evaporation to be expected due to hot and dry weather. The outlet of the manhole can be kept open during heavy monsoon period (June-September). For the rest 8 months (October-May) it can be kept closed, except when there is sometimes heavy rainfall and leachate in the pond crosses its maximum level of retention, i.e. beyond its design capacity.

4.6 Leachate Aeration and Recirculation System

Leachate re-circulation is a method using the landfill site itself as bioreactor. It collects leachate from the leachate control facility, then recalculates the leachate by sprinkling it over to the surface of the landfill waste layers. Collection of leachate by the leachate collection pipes and storage of leachate in leachate retention pond are prerequisite for leachate

recirculation as well as for other treatment methods. As pre-treatment, supplying oxygen to leachate by aeration process will accelerate the decomposition process by micro-organisms, and it will be effective in reduction of offensive odor from the landfill site.

In the proposed system for Sisdol LF, aerobic biological treatment of the leachate collected should be performed by means of a floating type slow speed surface aerator of 15 HP (11 KW), which should be operated, in principle, for 6-8 hrs. daily. For regular recirculation of the aerated leachate retained in the leachate retention pond and spraying leachate over waste cells within the landfill area, there should be a complete system consisting of an efficient recirculation pump (capacity 5 kw), a long portable flexible hose pipe (175 m length and 80mm diameter) and two sets of standard sprinklers made out of perforated PVC pipe. For the leachate spraying purpose the two sprinklers can be shifted from one vent pipe to other, depending upon necessity. The sprinkler to be used for the spraying of re-circulated leachate over waste cells should be a device of perforated PVC pipe (80 mm dia.) with necessary bends and tees combined with a simple mounting structure (of steel bars) which can be mounted easily on top of any gas vent pipe as and when required.

4.7 Storm Water and Groundwater Drainage

Proper storm water and groundwater drainage system of any landfill site is of utmost importance to minimize all possible water inflows into the landfill area. In general, storm water drainage facility is installed to reduce the amount of leachate generated from landfill sites. In other words, it functions to prevent storm water from surrounding areas to enter the landfill sites.

The following conditions are generally required for the construction of storm water drainage facility:

- Drains should be constructed surrounding the landfill site to prevent the outside storm water from flowing into the landfill site.
- Dikes or embankments should be installed if necessary to prevent the storm water from landfill areas where land filling activities have not started to flow into the waste layers.
- Drains should be constructed on the surface of landfill final soil cover at completed landfill areas to separate the storm water from leachate and drain off the storm water from the landfill areas.

As far as the ground water drainage of the Sisdol LFS is concerned, the hydro-geological investigation shows no existence of groundwater/ spring water source within the landfill area. Installation of a proper underground drainage system is therefore not necessary. However, for surface water drainage system, there are certain concerns, which deserve due consideration.

Improvement of the existing drainage through pipe culverts under the recently constructed road in the north (including the sealing of black-topped surface) and extension of some 4 m length of the existing gabion wall constructed to retain the road structure in the western side (including improvement/ sealing of the black-topped surface) must be done before starting earth work for preparation of the liner basement.

The total length of permanent storm water cut-off drain to be constructed with due consideration of situation after complete land filling is 580 m, out of which about 100 m length to be built on the eastern hill of the valley I and about 230 m length to be built on the

western side of the Valley I correspond to the operation in Valley I and the rest 250 m length to be built on the north-eastern side corresponds to the operation in Valley II.

The length concerned for operation of Valley I could be omitted, only if temporary cut-off drains (open ditch with gravel/boulder filling) at appropriate heights are constructed step-wise depending upon the statuesque of site operation to substitute the permanent drain structures to be constructed on top of the ultimate heights after completion of the landfill. And in this case too, 100 m length on the eastern hill of the valley I deserves first priority.

4.8 Improvement of Waste Bordering Dam

In general, retaining facility is constructed to prevent outflow of land filled wastes, collapse of working face and to ensure that the land filled wastes are stored safely. In many cases, these structures also prevent discharge and seepage of leachate from the landfill site. In short, the functions of retaining facility can be summarized as follows:

- Store the designated landfill volume.
- Prevent collapse of working face and overflow of land filled wastes.
- Prevent discharge of leachate and seepage from the landfill site.
- Retain rainwater in the landfill site, temporarily but safely.
- Retain wastes safely during the landfill operation as well as after completion.

At Sisdol LFS, the existing waste bordering dam of stone masonry which was constructed about a year ago (total height 6.35 m, crown width 1.05-1.20 m) is found to be of poor quality. Besides, the total height of waste filling has to be necessarily increased for the optimum use of the given limited capacity of the site. Furthermore, it is found that the eastern corner of the dam needs to be extended in length by 2 m towards the hill so as to close the valley on the southern side. Taking into consideration all these aspects, the recommended improvement measures to be taken should be:

- increasing the overall height by 0.963 m,
- extension of total length by 2 m
- 15 cm thick concrete work (with light reinforcement) and 45cm thick additional stone masonry work over the southern-sloped face of the existing dam, and pointing the finished stone masonry surface.

It is necessary for the SWMRMC to prepare detailed design for the existing waste dam improvement to ensure its stability and the sufficiency of the above recommendations.

4.9 Improvement of Control Room

The existing small building structure of dimensions 5.2 m x 3.9 m, located very near to the eastern side of the proposed leachate retention pond, should be improved adequately, so that it can be used properly for the purpose of controlling aerator and leachate re-circulation system.

4.10 Weighbridge

Weighbridge is the basic requirement at a landfill site to record the quantity of incoming wastes to the landfill site. Weighbridge should be installed at the entrance of the landfill site to measure and record the incoming wastes.

In the case of Sisdol LFS, there should be two entrance gates to the site. The left entrance gate (by entering the site) should be for the incoming waste collection/transportation vehicles, which have to pass over the weighbridge for recording the waste that they bring in. For other non-waste transporting vehicles such as staff vehicles, visitors' vehicles the right entrance should be used. The proposed weighbridge should have a weighing capacity of 40 ton. The weighing platform should be of size 9 m x 3 m and is connected by two ramps (in and out) of length 5.5 m. Total size of the weighing bridge (including ramps) should be 20 m x 3.5 m. The incoming waste-loaded vehicles with pre-recorded empty weights should be weighed out only once while entering the site. These vehicles, while leaving the site after unloading of wastes, should use the right gate. However, the incoming waste-loaded vehicles with no pre-recorded empty weights (e.g. new vehicles from private parties or public bringing their waste directly to the site, without via. municipal service) should have to be weighed twice, i.e. firstly while entering the site with loaded waste and secondly while leaving the site empty. The difference between the two weights should be the weight of incoming waste carried by the waste collection/ transportation vehicles.

A small graveled area of 495 sq. m, proposed on the west side of the entrance, should serve for emergency cases, e.g. to avoid queue in peak hours, to detain vehicles bringing prohibited wastes (i.e. special wastes of hazardous type instead of municipal waste of non-hazardous type) etc. It is to be noted that the steel structure of the weighbridge should be of flexible type, so that after the closure of landfill operation at the site, it can be dismantled and re-installed at another site for its reuse.

4.11 Access Road (Internal Service Road)

About 210 m long internal access road is planned for construction in phase 1. Initially it will be constructed only up to sub-grade coarse. Taking into consideration the existing level at the site entrance and existing topography at strategic points within the site, the maximum slope of the road has been kept below 12% and minimum radius by 8 m. The carriageway width of this road is designed to be 5 m wide with road cross slope of 3%. Earthen drainage is provided wherever found necessary. Truck scale and parking area for vehicles are planned for construction on the west side of this access road adjoining to the entry point. Sub-base course, base course and black topping works will be taken up later on.

4.12 Proposed Construction Methods

Taking into consideration the urgency of site development for proper management of solid waste, the project components of the Sisdol LF pilot project are divided into two terms, named as *Term 1* and *Term 2*.

The project components to be completed under ***Term 1*** are as follows:

- Internal Service Road
- Landfill Area Development
- Leachate Collection System

- Landfill Gas Vent System
- Leachate Retention Pond
- Leachate Recirculation System, and
- Improvement of Control Room

Similarly, the project components to be completed under ***Term 2*** are as follows:

- Aeration System and
- Weighbridge.

Although it is a project of the first of its type, the maximum efforts have to be made to involve the local people as much as possible in the works and oblige them by employing in the project, with due consideration of the required quality.

CHAPTER 5 AS BUILT DRAWINGS

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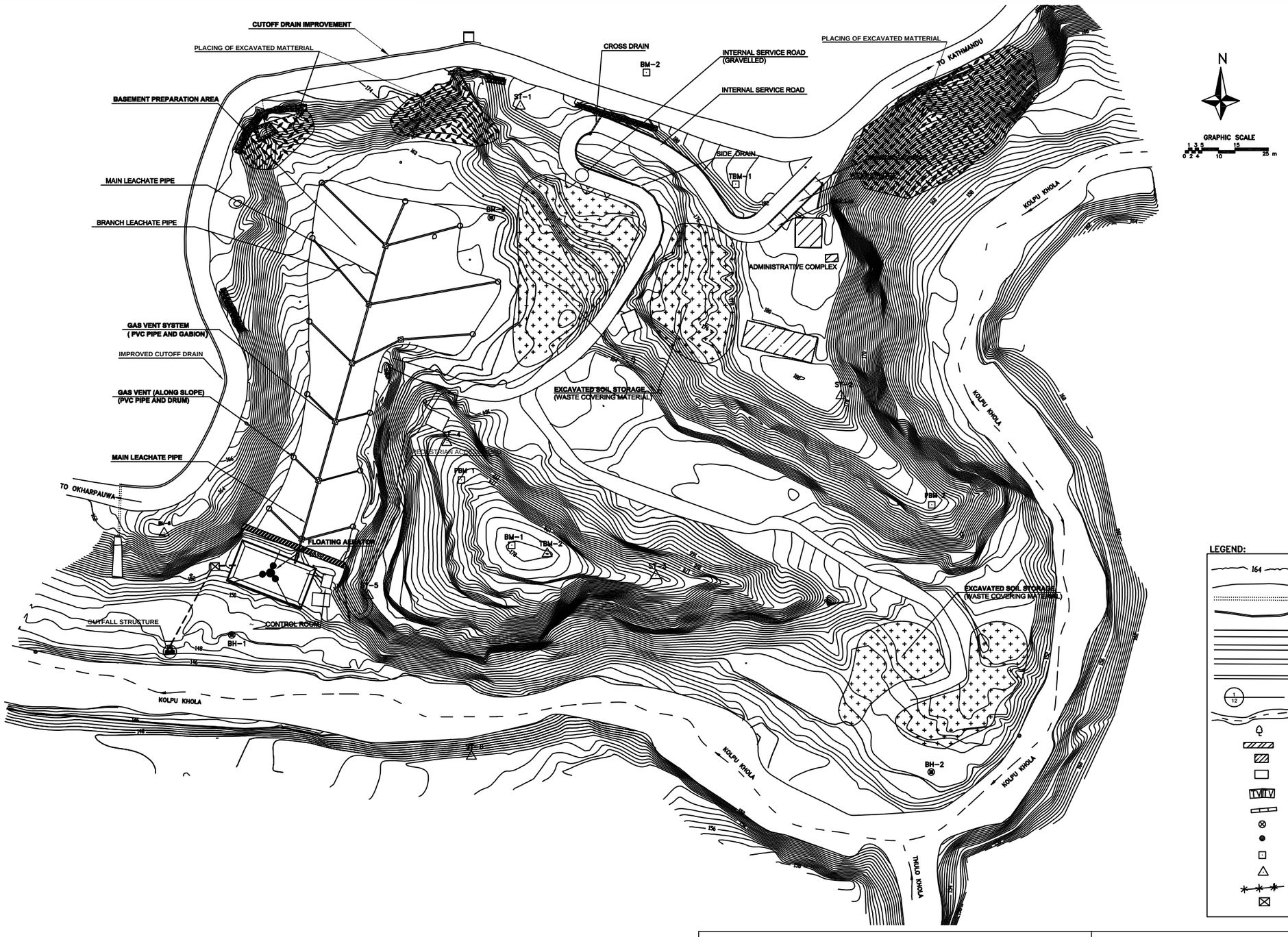

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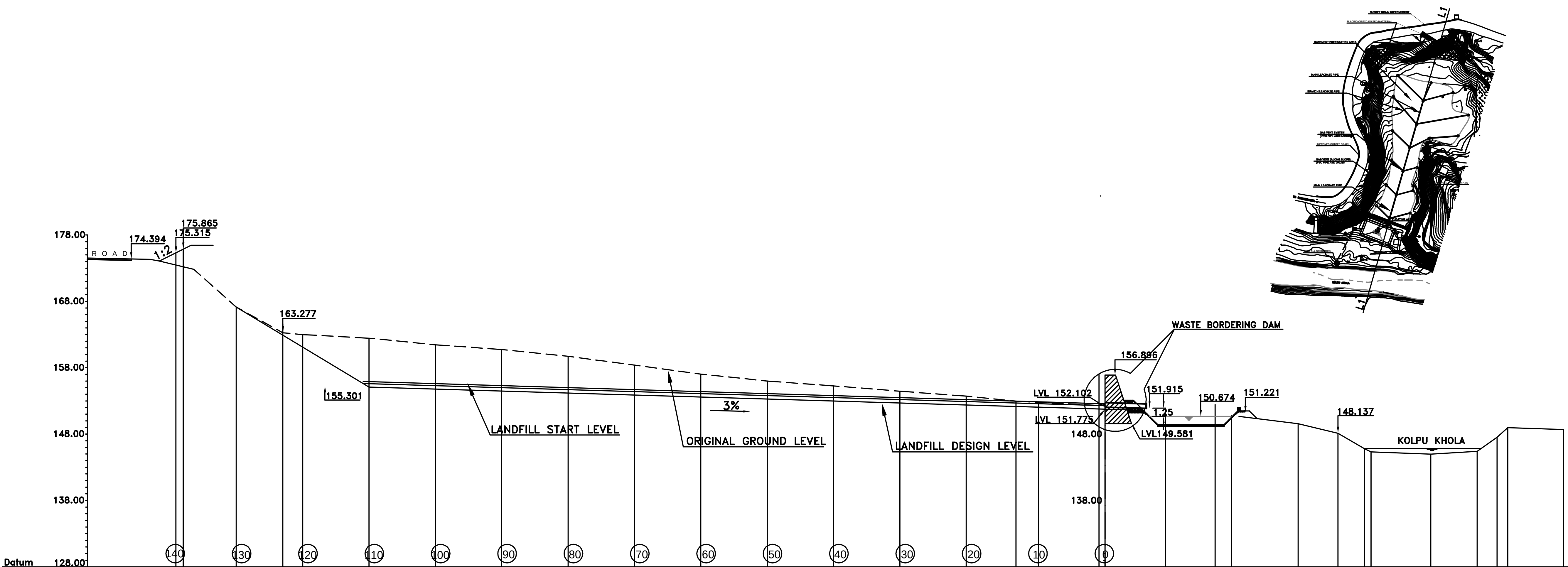
Figure C.5-1
Phase 1, Site Development



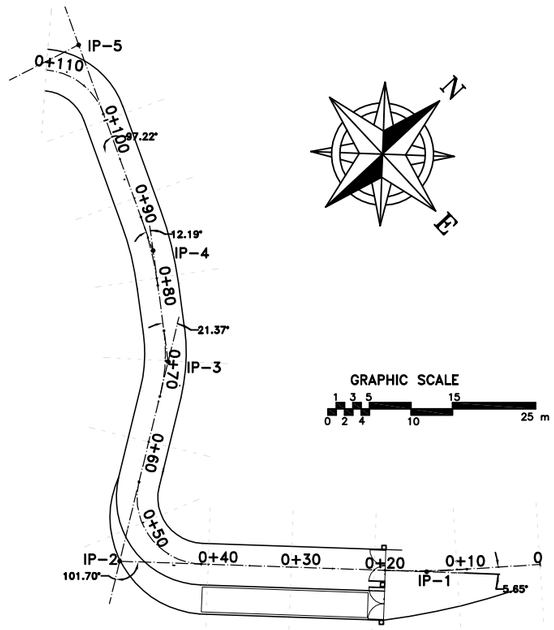
Distance (m)	151.00	141.00	139.00	131.00	124.00	121.00	111.00	101.00	091.00	081.00	071.00
Origional Level(m)	174.555	174.325	174.237	167.147	163.277	162.999	162.461	161.471	160.750	159.732	158.397
Design Level(m)					160.943	158.285	155.102	154.802	154.502	154.202	153.902
Landfill Start Level (m)					160.943	158.285	156.221	155.921	155.620	155.320	155.020

Distance (m)	061.00	051.00	041.00	031.00	021.00	013.50	001.00	000.00	003.30	009.00	016.50
Origional Level(m)	157.048	156.001	155.271	154.469	153.720	152.973	152.315	152.435	151.572	151.909	152.446
Design Level(m)	153.602	153.302	153.002	152.702	152.402	152.177	151.802	151.775			
Landfill Start Level (m)	154.719	154.419	154.119	153.819	153.518	153.293	152.918	152.891			

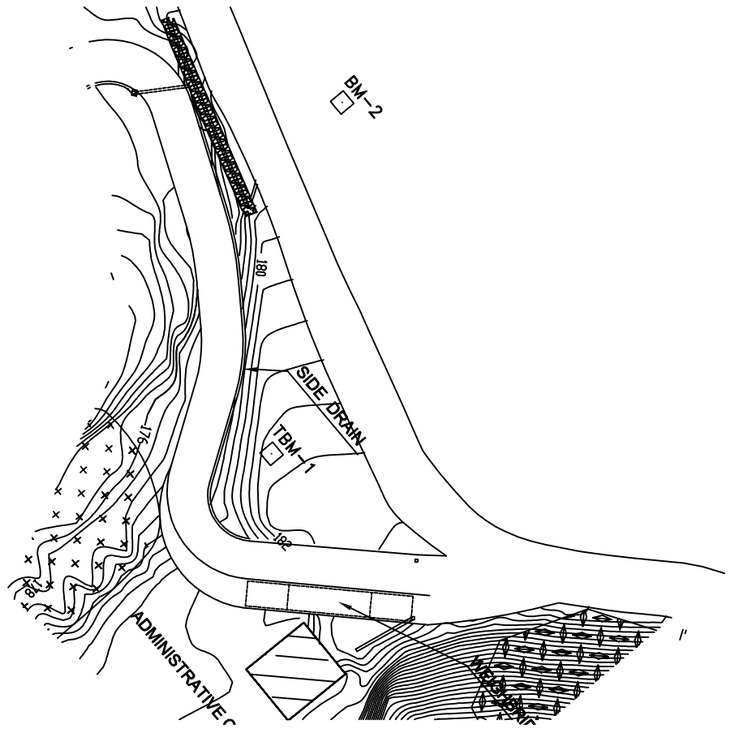
Distance (m)	019.00	029.00	035.00	039.00	040.00	049.00	056.00	059.00	060.60	069.00
Origional Level(m)	150.806	149.558	148.137	145.812	145.315	144.981	145.399	147.539	148.979	148.693
Design Level(m)										
Landfill Start Level (m)										

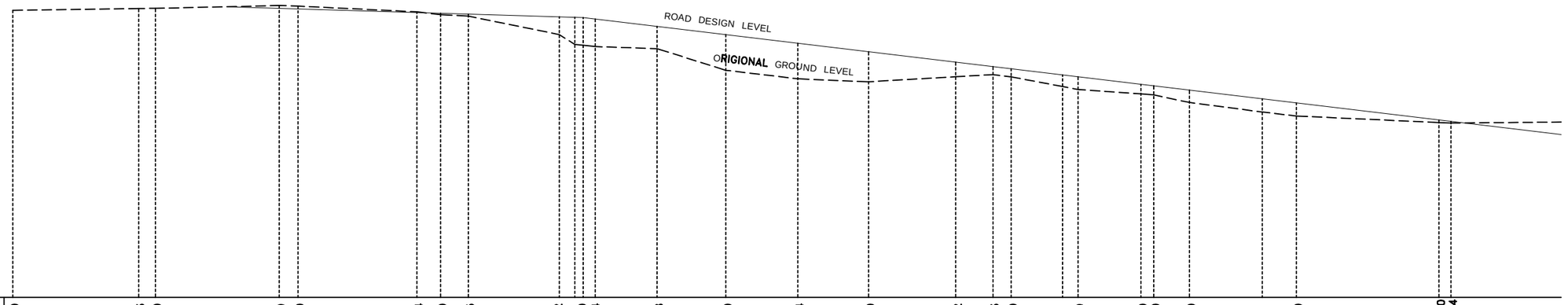
LONGITUDINAL PROFILE L1 OF VALLEY I

The Study on the Solid Waste Management for the Kathmandu Valley	**Figure C.5-2 Longitudinal Profile L1-Valley1**
Japan International Cooperation Agency	



PLAN





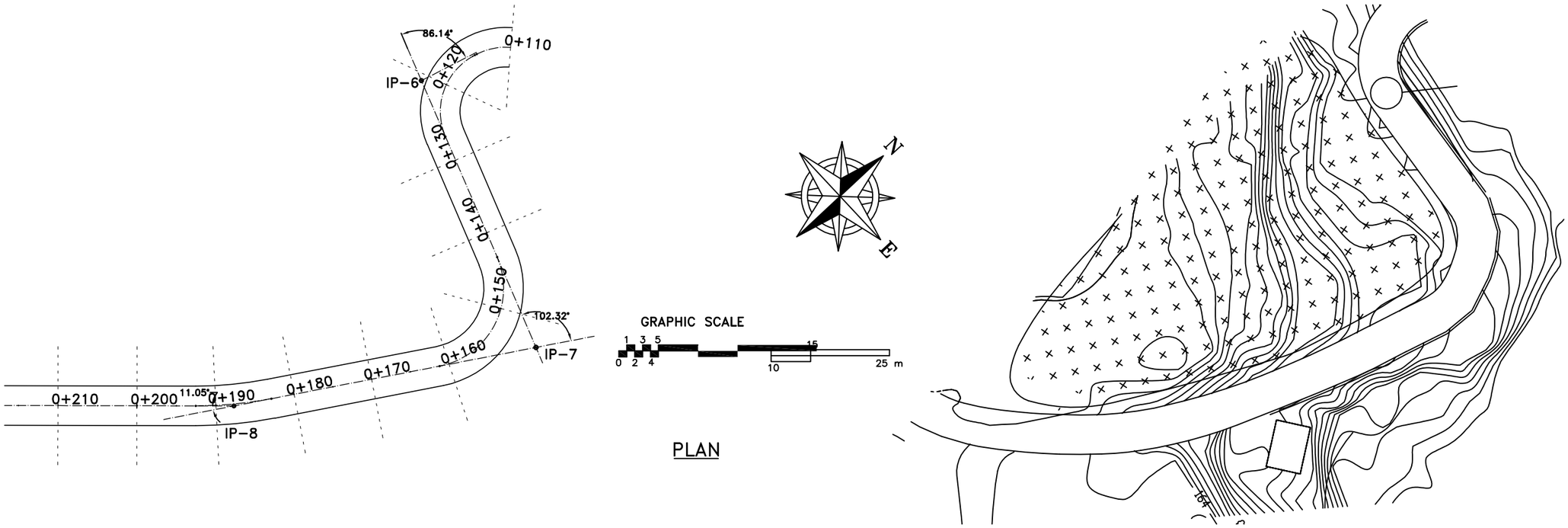
CHAINAGE(m)	0+00.00	0+08.83	0+10.00	0+18.69	0+20.00	0+28.34	0+30.00	0+31.95	0+38.32	0+39.41	0+40.00	0+40.84	0+45.18	0+50.00	0+55.04	0+60.00	0+66.12	0+68.73	0+70.00	0+73.61	0+74.69	0+79.10	0+80.00	0+82.50	0+87.61	0+90.00	0+100.00	0+100.84
ORIGIONAL GROUND LEVEL(m)	183.029	183.157	183.168	183.364	183.323	182.923	182.720	182.623	181.330	180.636	180.575	180.490	180.343	178.828	178.232	178.021	178.379	178.525	178.371	177.687	177.485	177.175	177.108	176.572	175.904	175.626	175.168	175.132
DESIGN LEVEL(m)	183.029	183.157	183.168	183.170	183.131	182.881	182.831	182.772	182.581	182.548	182.531	182.430	181.911	181.334	180.731	180.138	179.406	179.093	178.941	178.509	178.380	177.852	177.745	177.446	176.834	176.548	175.352	175.251

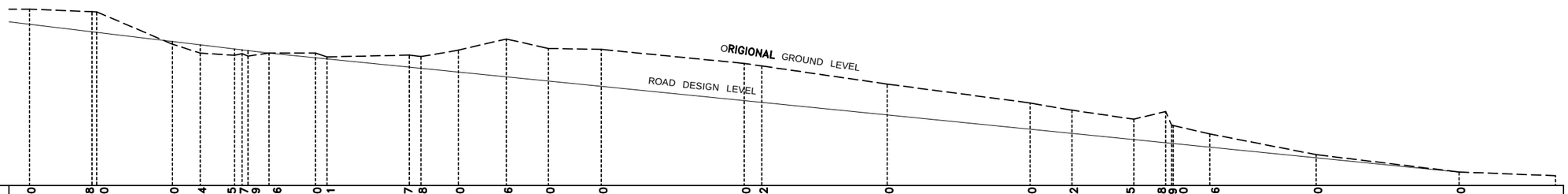
PROFILE OF INTERNAL SERVICE ROAD

The Study on the Solid Waste Management for the Kathmandu Valley

Japan International Cooperation Agency

Figure C.5-3
Plan & Longitudinal Profile from 0+00 to 0+110

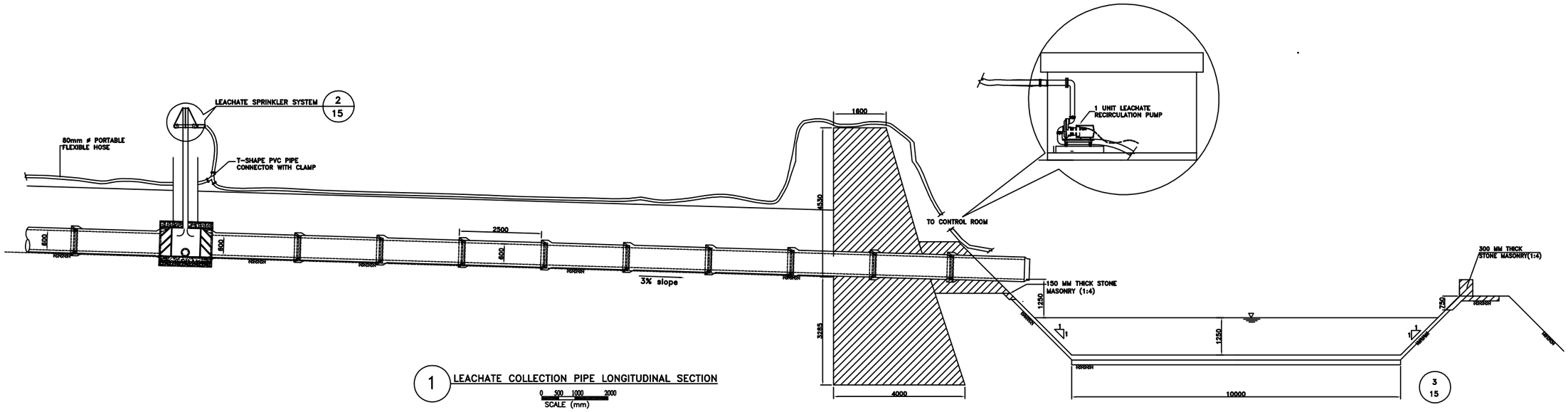




CHAINAGE(m)	0+110.00	0+114.38	0+114.70	0+120.00	0+121.94	0+124.35	0+124.87	0+125.29	0+126.76	0+130.00	0+130.81	0+136.57	0+137.38	0+140.00	0+143.36	0+146.30	0+150.00	0+160.00	0+161.22	0+170.00	0+180.00	0+182.92	0+187.25	0+189.48	0+189.89	0+190.00	0+192.56	0+200.00	0+210.00
ORIGIONAL GROUND LEVEL(m)	175.211	175.032	175.020	172.768	172.146	171.992	172.114	171.938	172.150	172.154	171.880	172.003	171.903	172.352	173.126	172.470	172.403	171.424	171.251	169.984	168.668	168.161	167.539	168.071	167.118	167.091	166.509	165.065	163.857
DESIGN LEVEL(m)	174.155	173.631	173.593	172.959	172.727	172.438	172.376	172.326	172.150	171.827	171.747	171.173	171.092	170.831	170.496	170.203	169.835	168.838	168.717	167.842	166.846	166.555	166.124	165.901	165.861	165.850	165.595	164.853	163.857

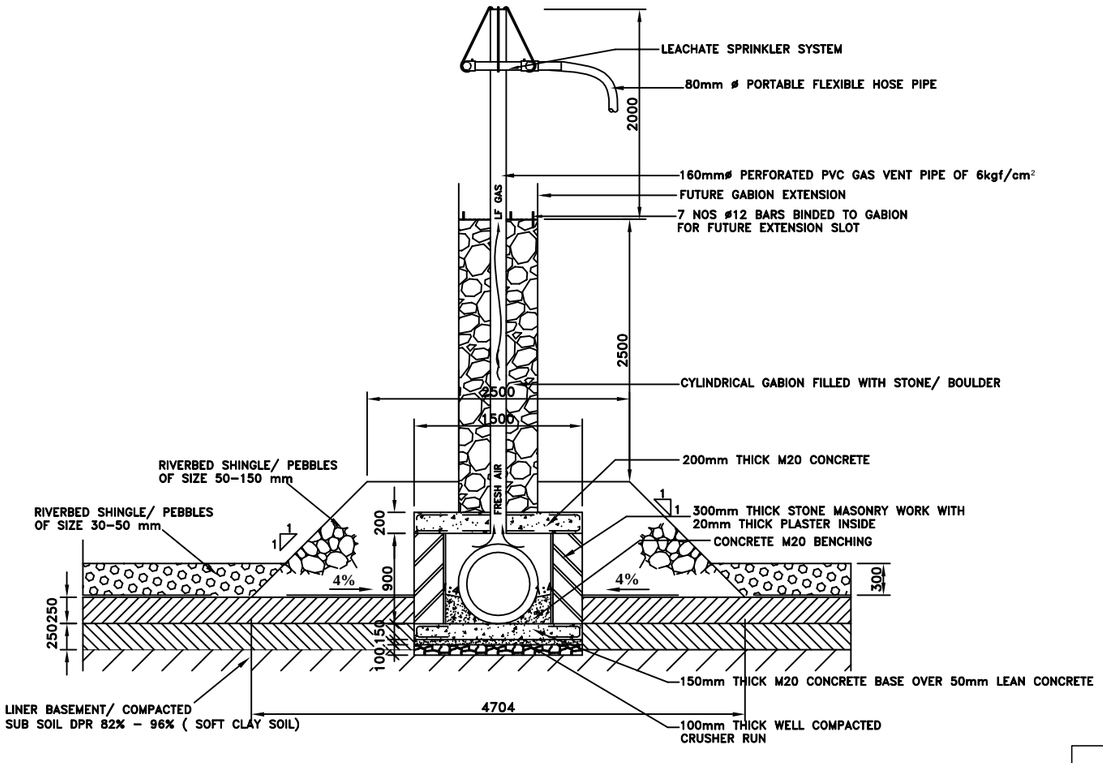
PROFILE OF INTERNAL SERVICE ROAD (CONTD.)

The Study on the Solid Waste Management for the Kathmandu Valley	**Figure C.5-4 Plan & Longitudinal Profile from 0+110 to 0+210**
Japan International Cooperation Agency	



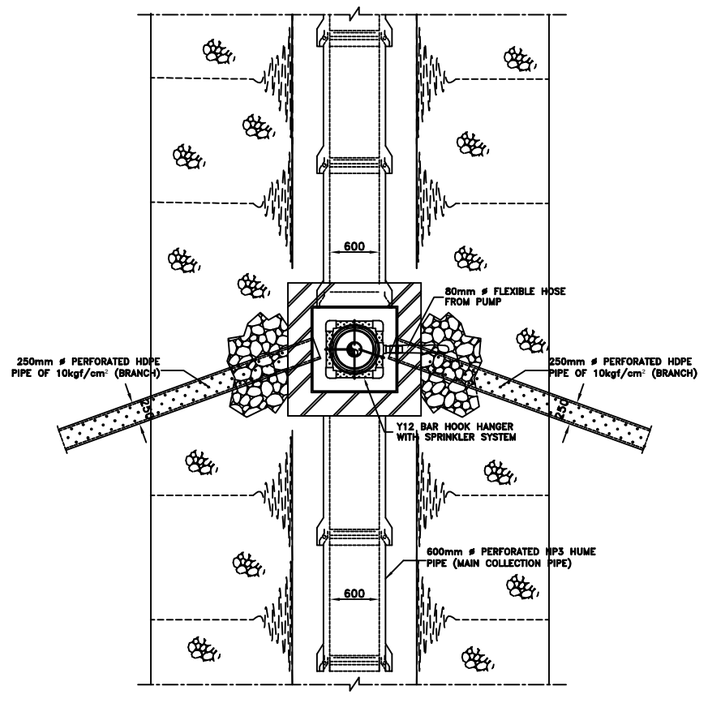
1 LEACHATE COLLECTION PIPE LONGITUDINAL SECTION

0 500 1000 2000
SCALE (mm)



2 GAS VENT SYSTEM (OVER MAIN LEACHATE PIPE)

100 500 1000
SCALE (mm)



GAS VENT/ LEACHATE PIPE

100 500 1000
SCALE (mm)

NOTE:
ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE MENTIONED

The Study on the Solid Waste Management for the Kathmandu Valley

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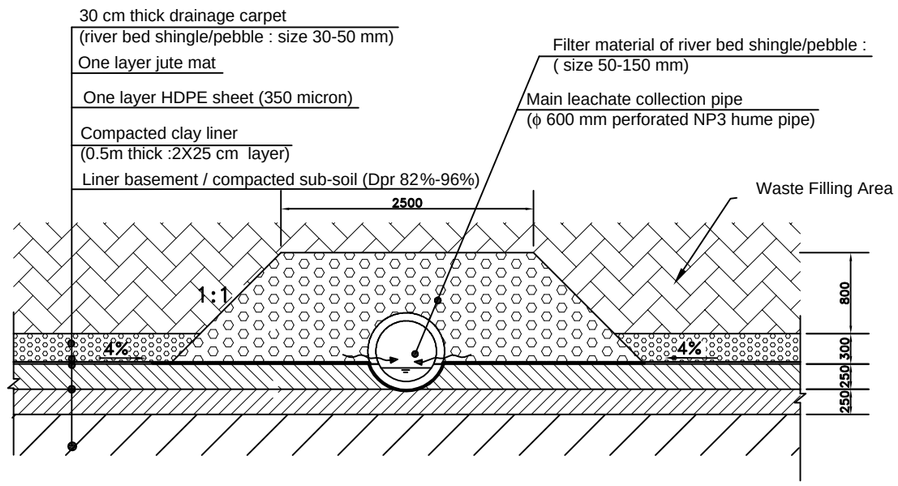
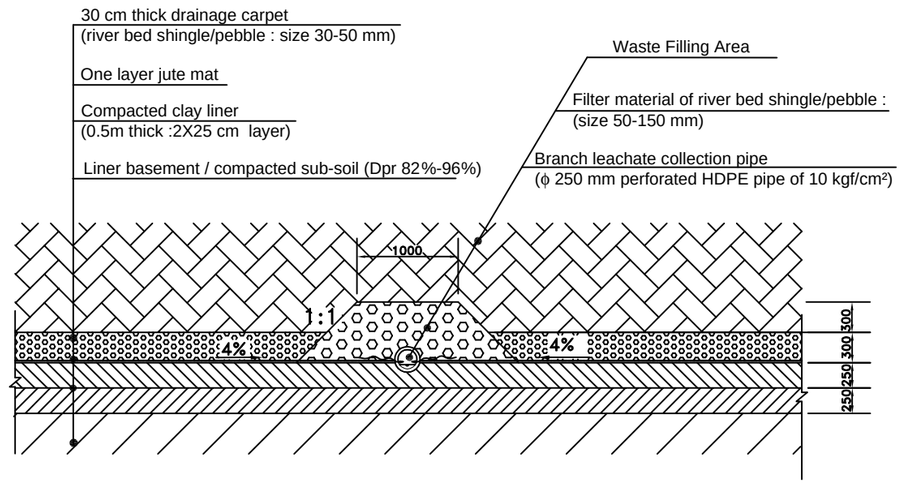
Figure C.5-5
Lrachate Collection Pipe and Gas Vent System



1 TYPICAL CROSS–SECTION: MAIN LEACHATE COLLECTION PIPE

0 500 1000 2000

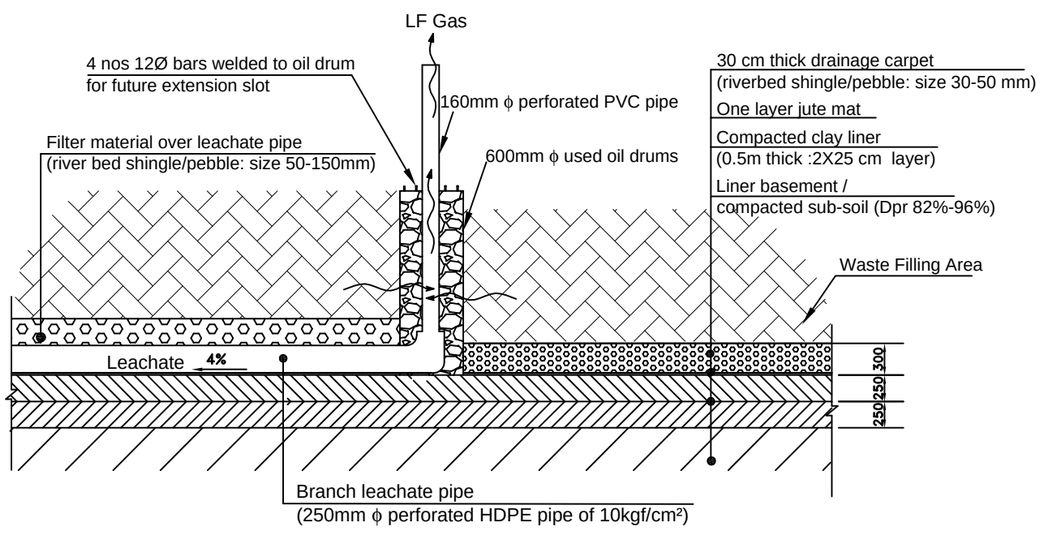
SCALE (mm)



2 TYPICAL CROSS SECTION: BRANCH LEACHATE COLLECTION PIPE

0 500 1000 2000

SCALE (mm)



3 TYPICAL CROSS SECTION OF GAS VENT SYSTEM (OVER BRANCH LEACHATE PIPE)

0 500 1000 2000

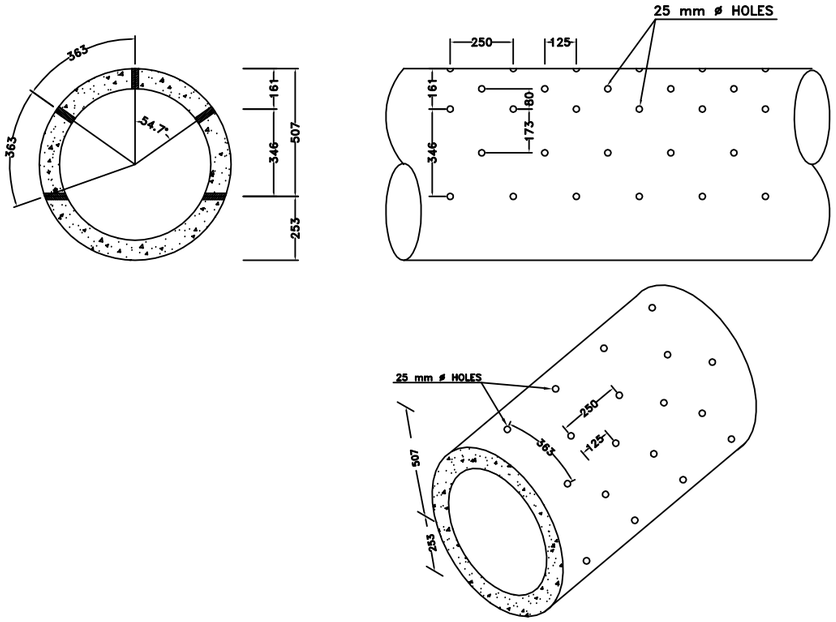
SCALE (mm)

NOTE:
ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE MENTIONED

The Study on the Solid Waste Management for the Kathmandu Valley

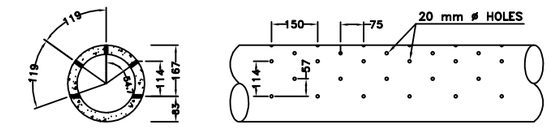
Japan International Cooperation Agency

Figure C.5-6
Detail of Leachate Collection Pipe/ Gas Vent Pipe



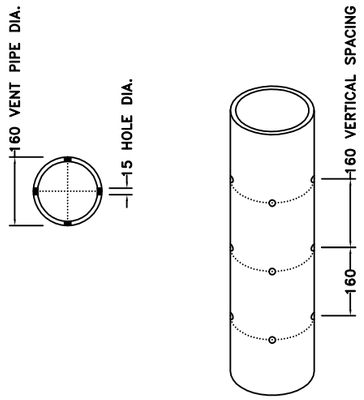
1 PIPE PERFORATION FOR PERFORATED 600mmø NP3 HUME PIPE
(MAIN LEACHATE PIPE)

GRAPHIC SCALE
0 100 200 400mm



2 PIPE PERFORATION FOR PERFORATED 250mmø HDPE PIPE
(BRANCH LEACHATE PIPE)

GRAPHIC SCALE
0 100 200 400mm



3 PIPE PERFORATION FOR GAS VENT PIPE

GRAPHIC SCALE
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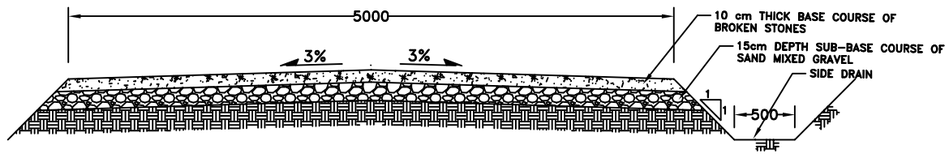


4 TYPICAL DETAIL FOR GRAVELLED INTERNAL SERVICE ROAD

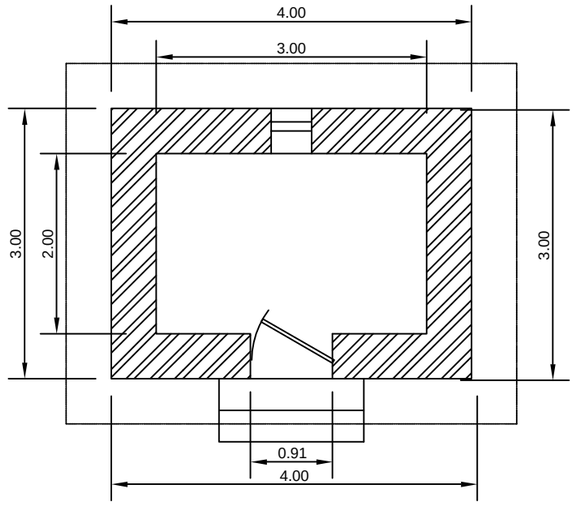
GRAPHIC SCALE
0 20 40 60cm

NOTE:
ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE SPECIFIED.

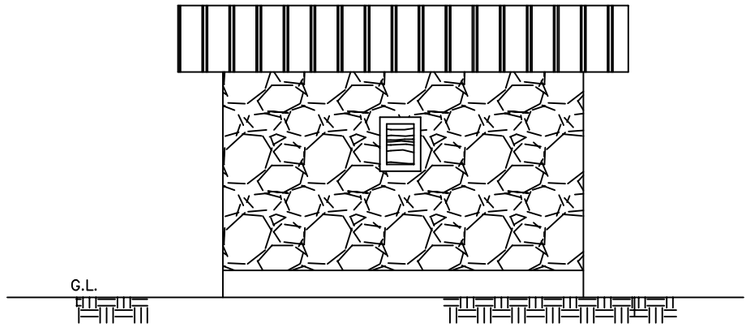
The Study on the Solid Waste Management for the Kathmandu Valley

Japan International Cooperation Agency

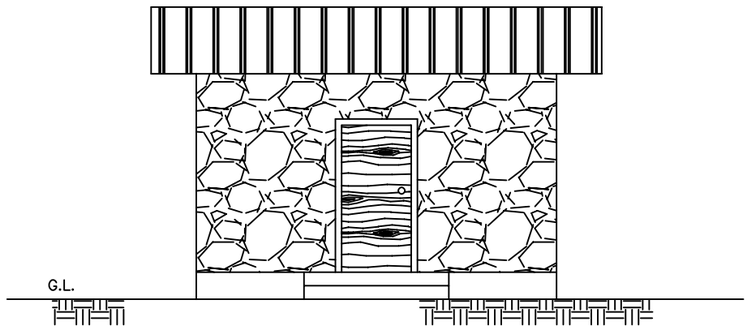
Figure C.5-7
Detail of Leachate pipes, Gas Vent Pipe & Typical Internal Service Road



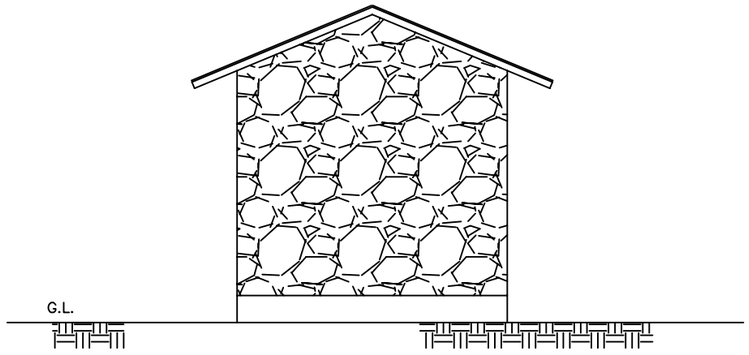
Plan



Back Elevation

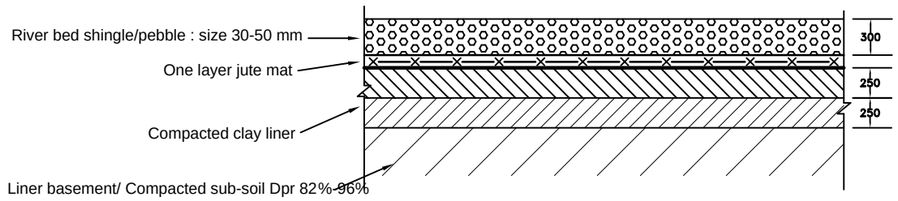


Front Elevation



Side Elevation

The Study on the Solid Waste Management for the Kathmandu Valley	**Figure C.5-8 Construction of Control Room**
Japan International Cooperation Agency	



1 LINER SYSTEM SECTION

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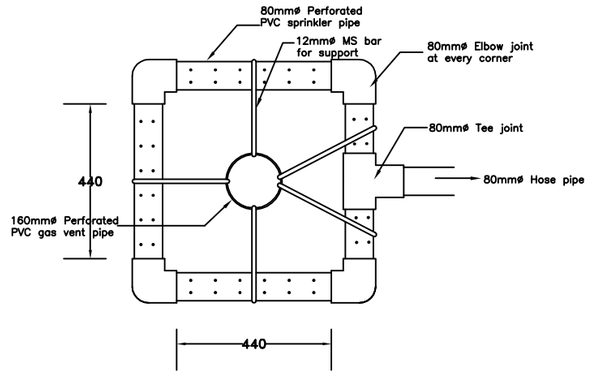
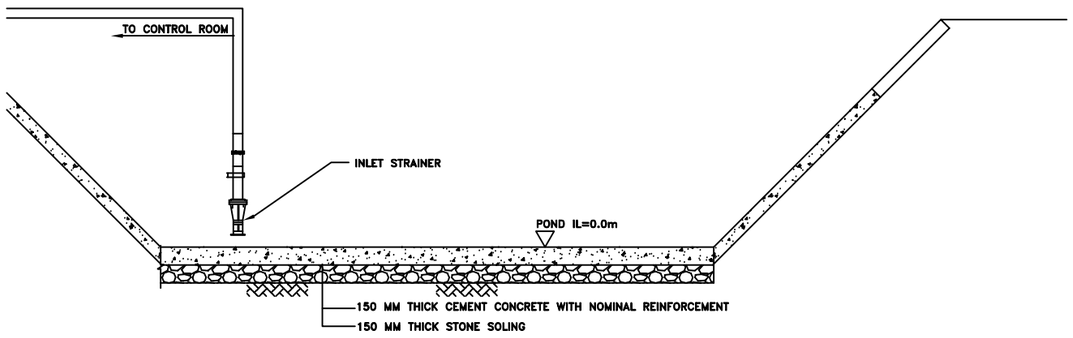
SCALE (mm)



2 PLAN OF LEACHATE SPRINKLER SYSTEM

0 100 200 300

SCALE (mm)



3 FLOOR DETAIL OF LEACHATE POND

0 500 1000

SCALE (mm)

NOTE:
ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE SPECIFIED.

The Study on the Solid Waste Management for the Kathmandu Valley

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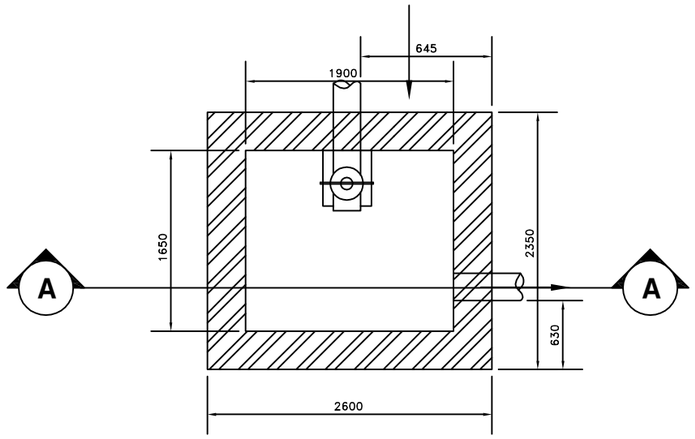
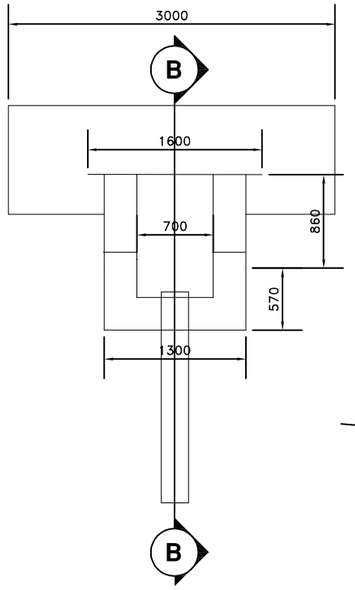
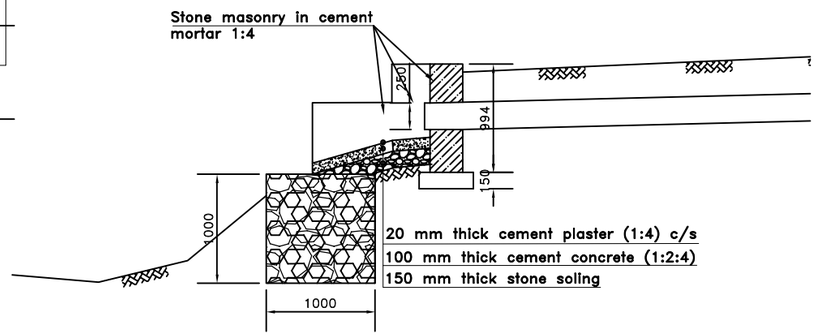
Figure C.5-9
General Detaile



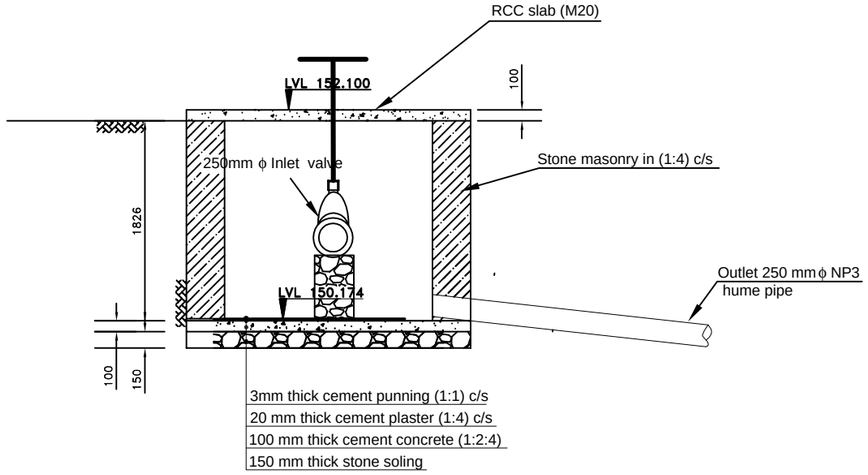
PLAN OF MANHOLE



1 PLAN OF OUTLET STRUCTURE



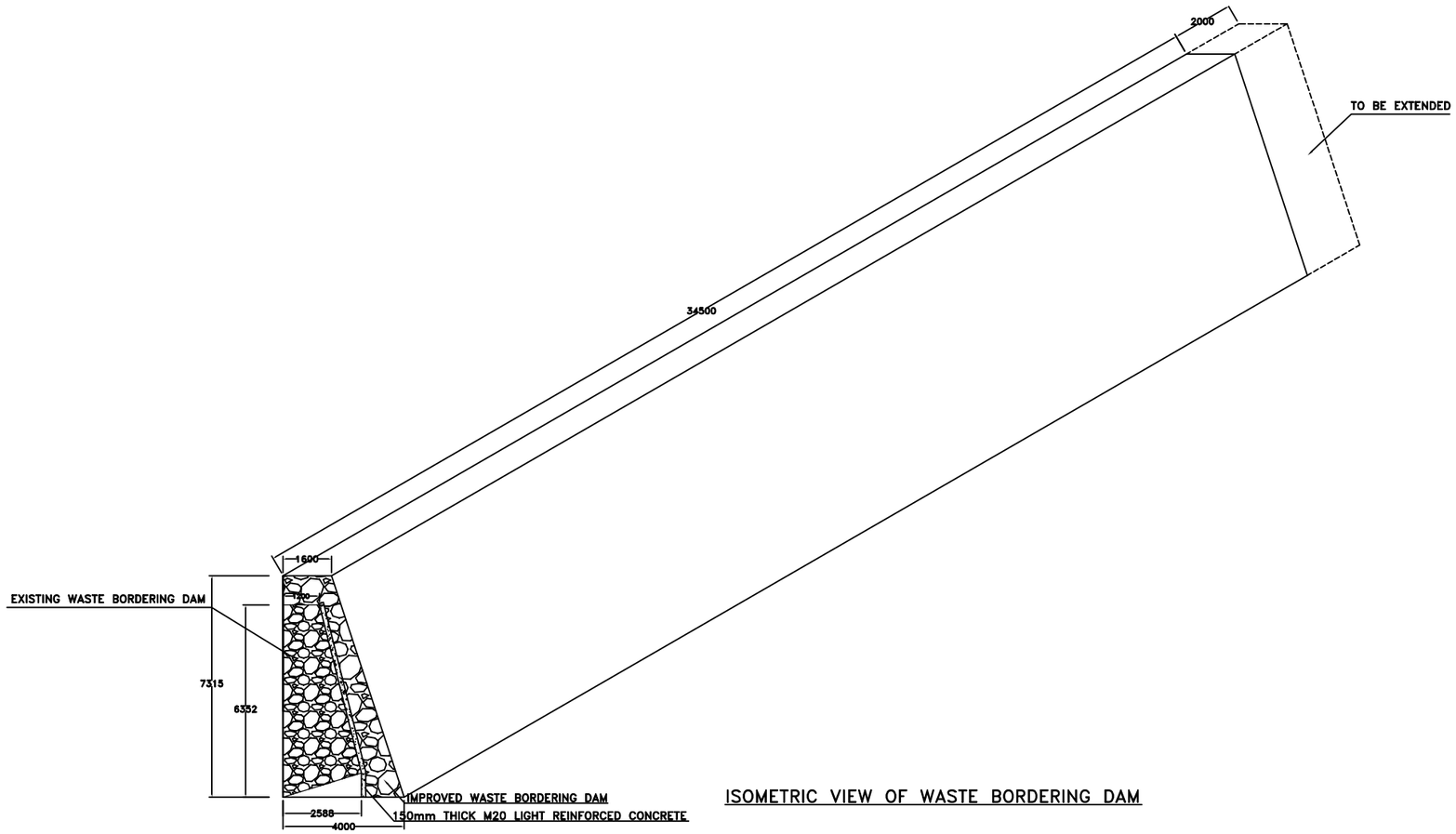
SECTION B–B



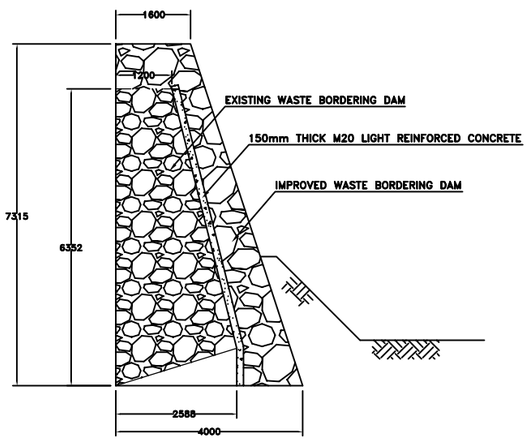
SECTION A–A

NOTE:
- ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE SPECIFIED.
- ELEVATION IS IN METER.

The Study on the Solid Waste Management for the Kathmandu Valley	**Figure C.5-10 Improvement of Existing Manhole & Outlet Structure**
Japan International Cooperation Agency	



ISOMETRIC VIEW OF WASTE BORDERING DAM



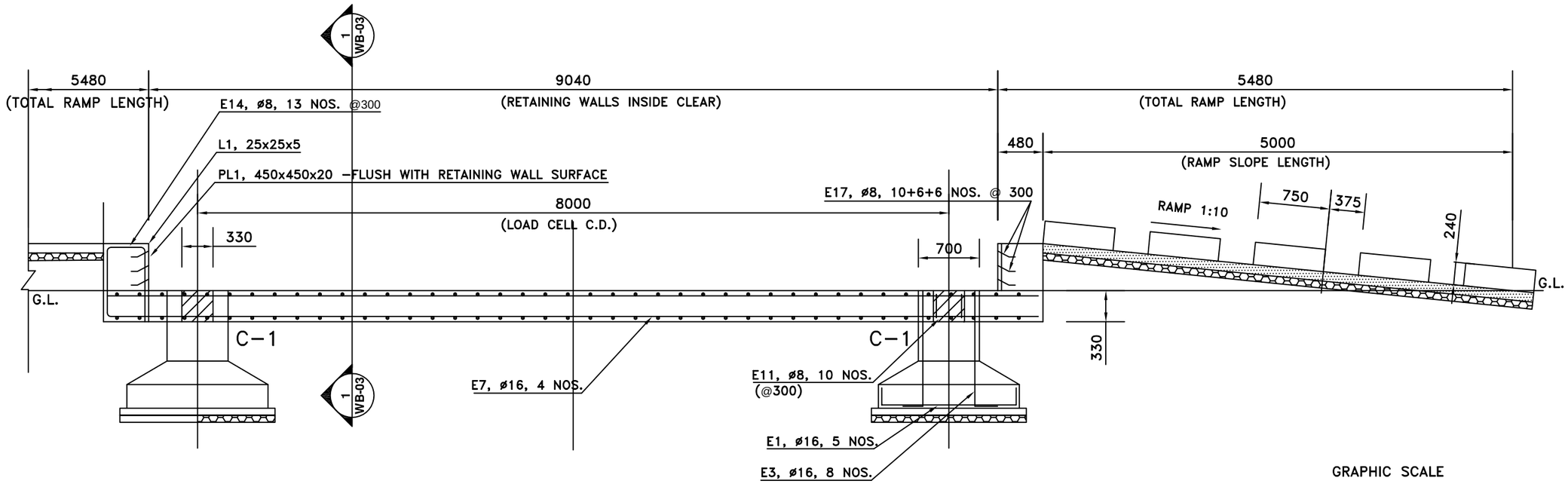
SECTION OF WASTE BORDERING DAM

NOTE:
ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE SPECIFIED.

The Study on the Solid Waste Management for the Kathmandu Valley

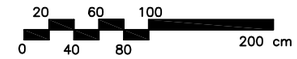
Japan International Cooperation Agency

Figure C.5-11
Section & Isometric View of Waste Bordering Dam



1 SECTION

GRAPHIC SCALE



A) REFERENCE STANDARDS

1) CONCRETE AND ITS CONSTRUCTION	IS:456
2) CEMENT	IS:269
3) AGGREGATES	IS:383
4) REINFORCEMENT BARS	IS:1786
5) ASSEMBLY OF REINFORCEMENT BARS	IS:2502
6) SKIRTING ANGLES	IS:808
7) CONDUIT PIPES	IS:1161

B) NOTES

1) ALL DIMENSIONS ARE IN mm UNLESS MENTIONED OTHERWISE.
2) EL 0.000 DENOTES GROUND LEVEL (REFERENCE LEVEL).
3) CONCRETE TO BE OF GRADE M20 ACCORDING TO IS:456.
4) MINIMUM 7 DAYS CURING FOR CONCRETE AND GROUTING SHOULD BE DONE. CONCRETE SHOULD BE PROTECTED FROM DIRECT SUNLIGHT AND FROM FROST DURING CURING.
5) SOIL BEARING CAPACITY OF 10 TONS/SQ.M. IS ASSUMED AT FOUNDATION LEVEL.
6) GROUND WATER TABLE IS ASSUMED TO BE BELOW FOUNDATION LEVEL.
7) LEVELLING OF SOIL TO BE DONE FOR CIVIL WORK, DEPENDING UPON SITE CONDITIONS.
8) ADEQUATE RUBBLE SOLING TO BE DONE BELOW P.C.C. SKIRTINGS AS REQUIRED.
9) MAXIMUM CONCRETE COVER TO MAIN REINFORCEMENT TO BE AS FOLLOWS:
   RAFTS=25mm, & WALLS=15 mm
10) ADEQUATE CONCRETE TEST CUBES TO BE TAKEN AND TESTED FOR STRENGTH AS PER IS:456.
11) REINFORCEMENT BARS NOT TO BE WELDED TO EACH OTHER FOR RETAINING PURPOSES, BUT TO BE TIED TOGETHER ONLY.
12) CLEAR FOUNDATION BOLT POCKETS TO BE ENSURED WHILE PLACING REINFORCEMENT BARS.
13) FOUNDATION OF 300 mm MINIMUM TO BE PREPARED FOR THE RAMP AND ITS RETAINING WALLS. THE RETAINING WALLS TO BE CONSTRUCTED OF R.C.C. AND BEFORE CONSTRUCTING THE RAMP. THE RAMP TO BE CONSTRUCTED OF RUBBLE SOLING THOROUGHLY COMPACTED WITH A ROLLER. THE TOP 75 mm OF THE RAMP TO BE FINISHED WITH 1:2:4 P.C.C & SMALL AGGREGATES. ADD A SUITABLE CONCRETE HARDENING & WATER PROOFING COMPOUND TO BE ADDED TO THE RAMP CONCRETE SUCH AS 'HARDCRETE' FROM SNOWCEM OR 'DREITOP FH' FROM BAUCHEME IN THE CORRECT QUANTITY, AS SPECIFIED BY THE SUPPLIER.
14) ONLY NON SHRINKING GROUTING MATERIAL TO BE USED, P.C.C. GROUT NOT TO BE USED.

MANUFACTURER: METTLER TOLEDO INDIA PVT. LTD.
RANGE: 20 TONS TO 100 TONS

The Study on the Solid Waste Management for the Kathmandu Valley

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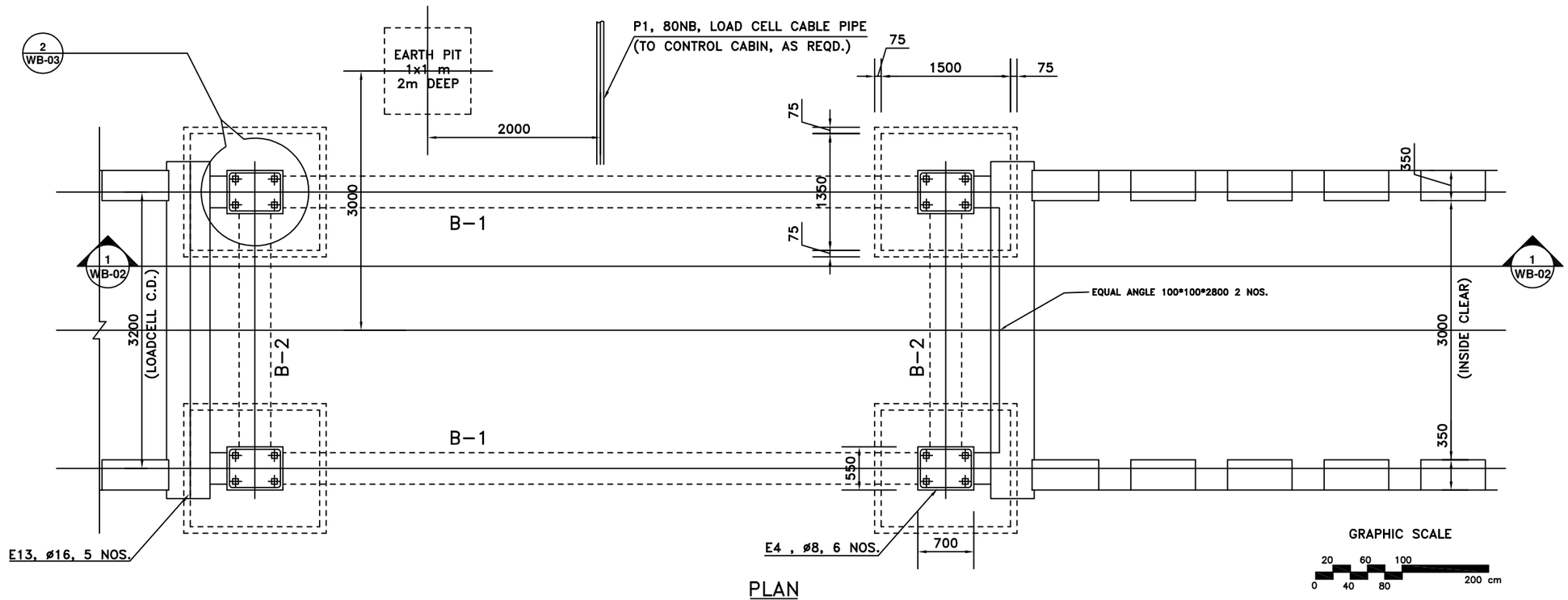
Figure C.5-12
Weighbridge: Foundation Section



PLAN

A) REFERENCE STANDARDS

1) CONCRETE AND ITS CONSTRUCTION	IS:456
2) CEMENT	IS:269
3) AGGREGATES	IS:383
4) REINFORCEMENT BARS	IS:1786
5) ASSEMBLY OF REINFORCEMENT BARS	IS:2502
6) SKIRTING ANGLES	IS:808
7) CONDUIT PIPES	IS:1161

B) NOTES

1) ALL DIMENSIONS ARE IN mm UNLESS MENTIONED OTHERWISE.
2) EL 0.000 DENOTES GROUND LEVEL (REFERENCE LEVEL).
3) CONCRETE TO BE OF GRADE M20 ACCORDING TO IS:456.
4) MINIMUM 7 DAYS CURING FOR CONCRETE AND GROUTING SHOULD BE DONE. CONCRETE SHOULD BE PROTECTED FROM DIRECT SUNLIGHT AND FROM FROST DURING CURING.
5) SOIL BEARING CAPACITY OF 10 TONS/SQ.M. IS ASSUMED AT FOUNDATION LEVEL.
6) GROUND WATER TABLE IS ASSUMED TO BE BELOW FOUNDATION LEVEL.
7) LEVELLING OF SOIL TO BE DONE FOR CIVIL WORK, DEPENDING UPON SITE CONDITIONS.
8) ADEQUATE RUBBLE SOLING TO BE DONE BELOW P.C.C. SKIRTINGS AS REQUIRED.
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14) ONLY NON SHRINKING GROUTING MATERIAL TO BE USED, P.C.C. GROUT NOT TO BE USED.

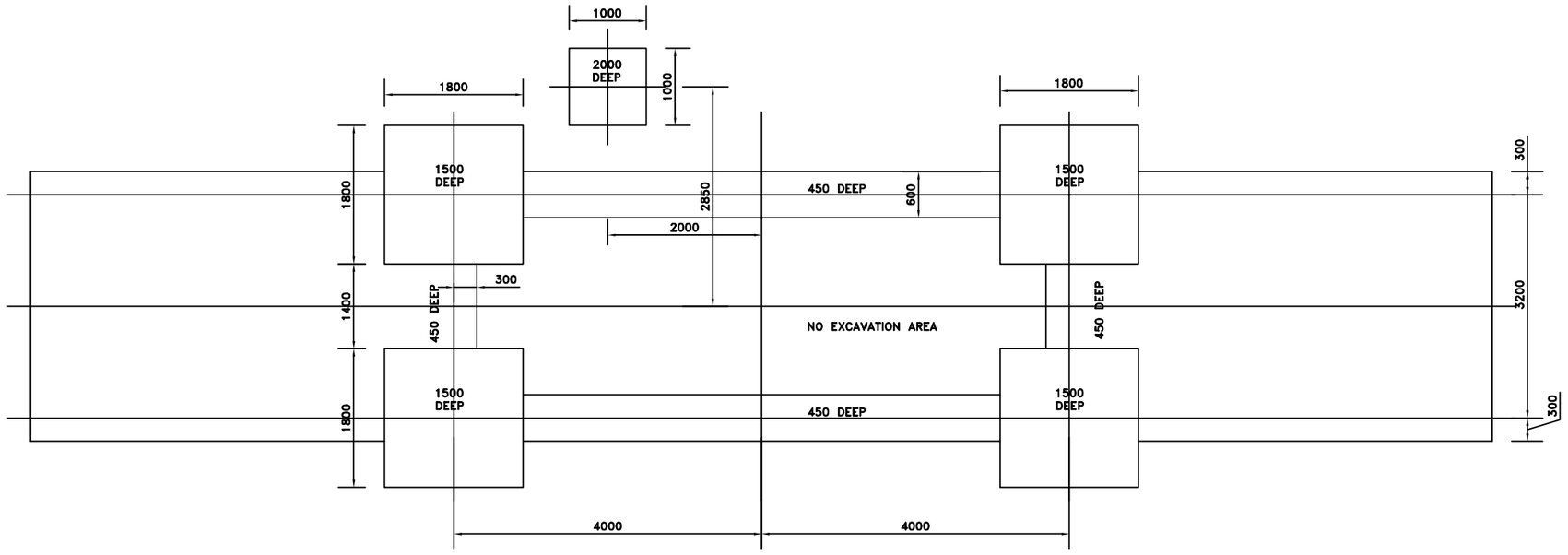
MANUFACTURER: METTLER TOLEDO INDIA PVT. LTD.
RANGE: 20 TONS TO 100 TONS

*= REFER DRAWING WB-04 FOR REINFORCEMENT DETAIL

The Study on the Solid Waste Management for the Kathmandu Valley

Japan International Cooperation Agency

Figure C.5-13
Weighbridge: Foundation Plan



EXCAVATION KEY PLAN
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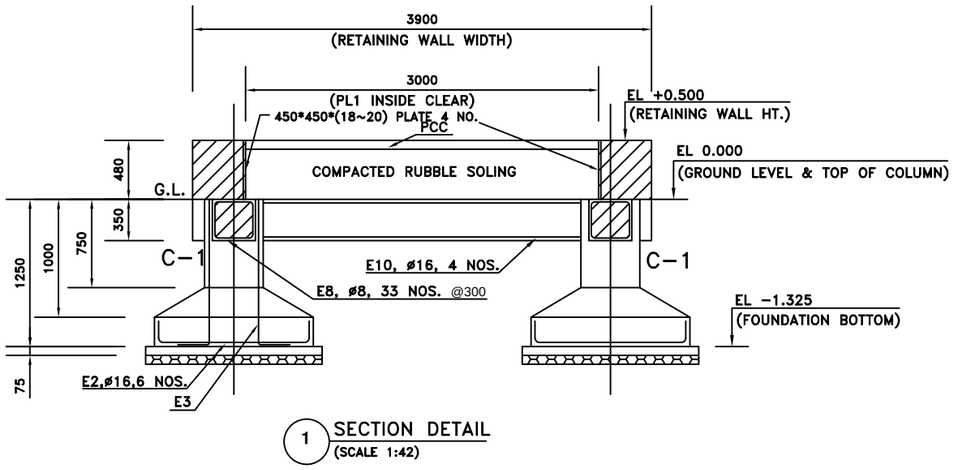

1 SECTION DETAIL
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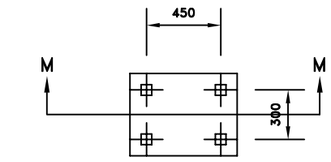
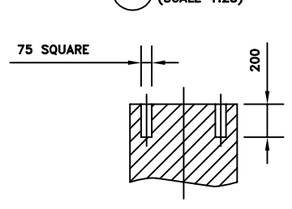


2 PLATE DETAIL
(SCALE 1:28)



SECTION M-M
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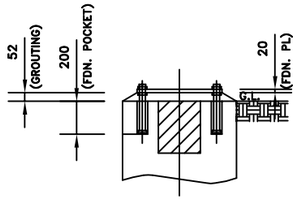
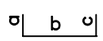
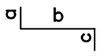
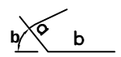
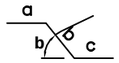
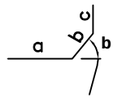
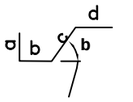
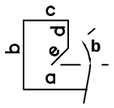
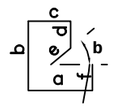
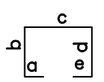


DETAIL OF FOUNDATION PLATE GROUTING
(SCALE 1:28)

NOTE:
ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE SPECIFIED.

The Study on the Solid Waste Management for the Kathmandu Valley	**Figure C.5-14** **Weighbridge: Foundation Details**
Japan International Cooperation Agency	

1 	2 	3 	4 
5 	6 	7 	8 
9 	10 	11 	12 
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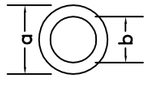
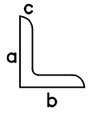
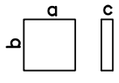
21 	22 	23	24 

FOUNDATION QUATITIES

APPROX. EXCAVATION REQUIRED	36.0 cu.m
APPROX. CONCRETE REQUIRED	12.0 cu.m
APPROX. GROUTING REQUIRED	120.0 kg

The Study on the Solid Waste Management for the Kathmandu Valley

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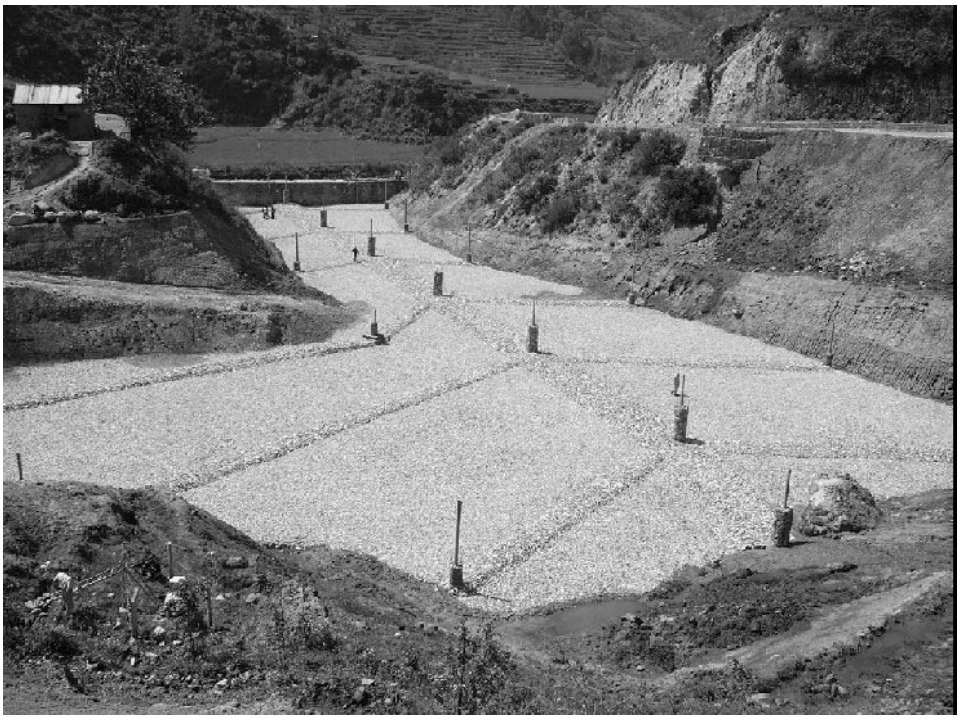
Figure C.5-15
Weighbridge: Reinforcement Details

Pilot Project C-6

Operation Manual
for Sisdol Short-term Landfill

OPERATION MANUAL

SISDOL SHORT-TERM LANDFILL



MAY 2005

Table of Contents

CHAPTER 1 INTRODUCTION

1.1 Semi-aerobic System

The disposal of the waste should be implemented in a sanitary manner in order to protect the public health and mitigate impacts on the environment.

Decomposition of the disposed solid waste, and in particular organic content requires time. Although the organic matter may decompose under either aerobic or anaerobic conditions, in the case of sanitary landfills, decomposition under anaerobic condition is most common.

Anaerobic decomposition of organic matter produces methane and water, decomposition is slow and leachate content is large. On the other hand, under aerobic decomposition organic matter decomposes into carbon dioxide and water and decomposition is rapid. Aerobic decomposition is require a supply of oxygen to be pumped into the landfill. This is a costly system both in terms of construction and maintenance.

At the sanitary landfill, decomposition of the organic matter will increase the temperature in the waste layers. Under semi-aerobic sanitary landfill system, as the collected leachate leaves the outlet pipe (to discharge into the leachate pond), which is suspended above the leachate level and ***not submerged in the leachate***, air is sucked into the sanitary landfill through the gas removal pipes and the leachate collection pipes consequently creating a semi-aerobic system. Specifically the following process is observed:

a. Parts of the landfill in the vicinity of the pipes are under aerobic conditions
b. The differential temperature in the landfill create natural ventilation and the supply of air to the landfill
c. The leachate quality improves within a quick time.

The semi-aerobic system is schematically presented in Figure 1.1.

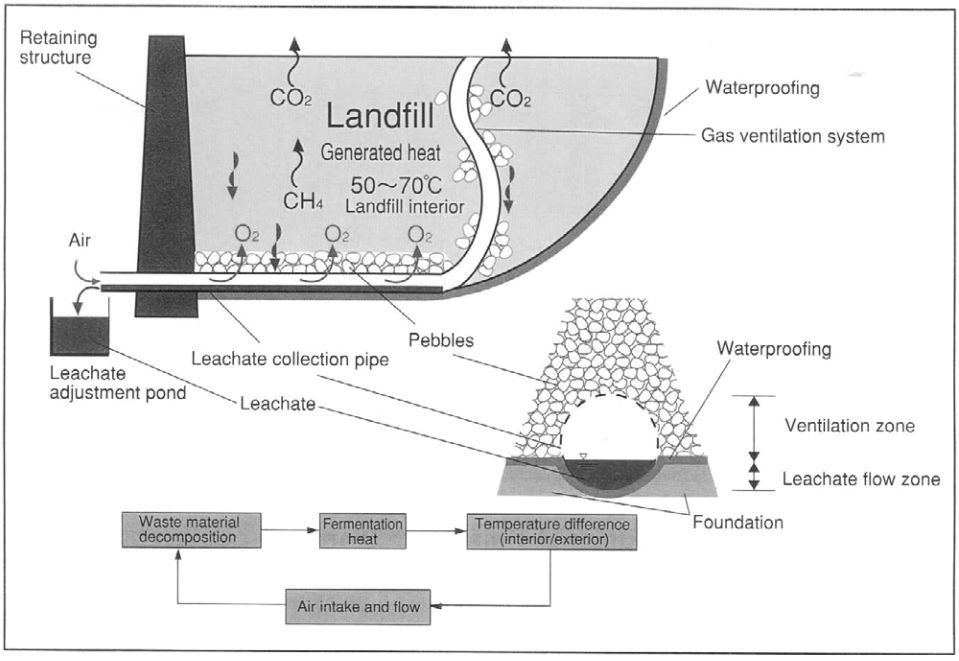


Figure 1.1 Schematic Presentation of Semi-aerobic Landfill System

Source: Hukuoka City

1.2 Landfill Development Levels

In past JICA studies in other developing countries four (4) landfill levels have been identified. These are described in Table 1.1. For long term landfill sites Level 4 offers the best countermeasures for mitigation of impacts on the environment and therefore it is proposed that the Nepal decision makers aim to achieve that level.

Sisdol short term landfill will be operated for only 3-4 years and therefore application of natural liner and leachate re-circulation with aeration treatment is recommended. This level is midway between Levels 3 and 4.

Table 1.1 Proposed Sanitary Landfill Levels

Facility	Level 1	Level 2	Level 3	Level 4
Description	Controlled tipping	Sanitary LF with bund and daily cover	Sanitary LF with leachate re-circulation	Sanitary LF with leachate treatment facilities
Soil cover	O (Periodic)	O	O	O
Embankment		O	O	O
Drainage facility		O	O	O
Gas venting		O	O	O
Leachate collection			O	O
Leachate re-circulation			O	O
Leachate treatment				O
Liners				O

1.3 Project Beneficiaries

The Sisdol Short-term Landfill is used to dispose of the municipal solid waste collected from KMC, LSMC and KRM. In addition solid waste collected from the adjacent VDCs may be disposed of at the site.

The Sisdol Short-term Landfill is expected to assist in determining the suitability of the semi-aerobic landfill system in the context of the Nepali SWM. Therefore SWM stakeholders will also benefit from this site.

In terms of regional development, the sanitary landfill and its associated infrastructures (approach road, electricity supply, water supply, telephone lines, etc.) are expected to benefit the region's development as a whole. The landfill will also provide employment opportunities.

CHAPTER 2 PURPOSE OF THE MANUAL

2.1 Scope of the Manual

The scope of this Operations Manual is as follows:

1) Provide guidance on the sharing of responsibilities amongst the various related stakeholders
2) Provide information on the basic components of the landfill designed and constructed
3) Familiarize the Operator with the various containment units and environmental control/ monitoring systems
4) Familiarize the Operator with the general operational phasing of sequencing of waste filling
5) Provide basic information on the type and purpose of the landfill heavy equipment
6) Provide instructions on daily waste filling operations including load inspection procedures, spreading and compaction of waste and application of cover
7) Provide procedures for operating under inclement or wet weather conditions
8) Provide procedures for emergency response and management
9) Provide detailed description on environmental monitoring and inspections
10) Familiarize the Operator with safety procedures related to landfill operations

2.2 Limitations

This manual was prepared in accordance with basic standard practices in the operation of modern sanitary landfills of this level, specifically practices employed in operation of semi-aerobic landfills in Japan and developing countries.

The operation of landfills in Japan is strictly regulated and therefore standards applicable there were referred to in this manual. However some facilities included in landfills operating in Japan for dealing with waste characteristics of Japan[1] were not included at this site. For that reason the practices adopted and honed in developing countries in south-east Asia[2] were also referred to.

The manual does not provide specific procedures in other areas of SWM such as equipment maintenance and repair, handling of toxic and hazardous waste, detailed safety procedures, and detailed emergency response. It is intended to provide the Operator with the basic knowledge and understanding of landfill operation in general.

[1] Municipal waste disposed of in Japan is mostly ash generated from the incineration of the waste.
[2] Practices in Malaysia where a semi-aerobic system has been introduced on some sites were referred to.

CHAPTER 3 ORGANIZATIONAL STRUCTURE OF THE LANDFILL OPERATION

3.1 Organizational Structure

This site has been developed by SWMRMC and that organization is expected to continue to develop Phase 2 of the landfill as well as the facilities related to the final closure of the site. KMC and LSMC will dispose of their municipal solid waste here and shall be responsible for the site operation. They will be referred to hereafter in this guideline as the "Operator". Therefore these three agencies are expected to fully share responsibility for the site further development, operation and post-closure management. The sharing of responsibilities can be broadly defined as shown in the following table.

ACTIVITIES	SWMRMC	KMC	LSMC
Development	- Valley 2 - Closure facilities - Regional development		
Operation	- Environmental monitoring	- Waste disposal operation - Development associated with operation	
Post Closure Management	- Development works associated with final landfill closure (such as final capping, permanent storm water drainage system, etc.) - Operation and maintenance - Environmental monitoring		

Regardless of the waste amounts sent by each of the two cities to Sisdol LF, both cities shall be jointly and equally responsible for the operation of landfill in a sanitary manner. Likewise SWMRMC, as the site developer will have a responsibility for the present and future site facilities in order to ensure that the Operator can with the efficient operation of the site ensure that the sanitary landfill conditions are maintained.

3.2 Sisdol LF Working Group

A Working Group (W/G) shall be formed by KMC, LSMC and SWMRMC and shall assume overall responsibility for the sanitary landfill operation. The W/G shall have the following specific responsibilities:

1) Review the Sanitary LF daily operation records and ensure that they are in order in terms of waste being accepted at the site, and presence of sufficient staff, heavy equipment and budget to effectively operate the site
2) Review any public complaints or comments on the sanitary LF operation and ensure that effective measures have been taken to deal with these complaints
3) Participate in the environmental monitoring process
4) Participate in meetings with the Local Committee, Okharpauwa Sanitary Landfill Site Main Coordination Committee (OSLSMCC) as necessary
5) Review the sanitary LF operation expenditures and prepare the budget
6) Manage issues related to landfill operations within their respective organizations and coordinate with other related departments/sections
7) Provide technical advice and guidance to the permanent landfill staff
8) Hiring of the permanent landfill staff and evaluation of their work performance

9) Others as may be deemed necessary by the W/G

The Working Group shall, in order to discharge their duties as indicated above, hold weekly meetings and members shall visit the site at least once a week.

3.3 Permanent Site Staff

A permanent staff shall operate the site. Although both KMC and LSMC shall provide the required personnel, the sanitary LF permanent staff shall operate as one team under the direct instructions of the site manager.

The minimum required staffing and their duties are outlined as follows:

(1) Landfill Manager

- Manage the landfill staff and assume responsibility for their safety
- Report to the W/G
- Prepare the budget and review the expenditures
- Manage the leachate aeration and re-circulation system and leachate pond
- Responsible for environmental monitoring and participate in environmental coordination committee activities
- Maintain contact with the local community
- Others as directed by the W/G

(2) Asst. Manager/ Weighbridge Operator

- Maintain a daily record of the incoming waste
- Random check of incoming waste
- Develop the disposal plan and waste cell preparation
- Maintain the operations expenditures accounts
- Maintain the daily operation records
- Others as directed by Landfill Manager

(3) Overseer

- Direct the waste trucks to the disposal cell
- Manage the heavy equipment operations
- Daily soil cover application
- Spraying of insecticides and odor suppressants
- Preparation of new waste disposal cell
- Others as directed by Landfill Manager or Assistant Manager

(4) Assistants (4 staff)

- Assist the Overseer
- Assist in mechanical works
- Assist heavy equipment operations
- Clear litter scattered away from waste disposal area
- Others as directed by Site Manager or Assistant Manager

(5) Public Relations Officer

- Compilation and analysis of public complaints or comments
- Liaison with surrounding community residents
- Prepare and disseminate information on site operation
- Arrange site explanatory visits
- Others as directed by Site Manager or Assistant

(6) Mechanic

- Daily inspection of heavy equipment, aerators and pumps and maintain maintenance records
- Simple repair and maintenance works
- Maintain sufficient spare parts on site for simple repairs
- Maintain records of heavy repairs and maintenance works carried out on equipment
- Others as directed by Site Manager or Assistant Manager

(7) Heavy Equipment Operators (3 staff)

- Operation of the heavy equipment under the direction of the Overseer
- Daily inspection of heavy equipment
- Assist in simple repair and maintenance works
- Others as directed by Site Manager, Assistant Manager or Overseer

(8) Guards (2 staff)

- Landfill access control
- Protection of landfill facilities and equipment
- Others as directed by Site Manager or Assistant Manager

The Sisdol LF operation shall commence with 14 permanent staff. As the waste amount disposed at the site increases and based on the experience gained the number, title and job descriptions of the staff may be amended based on request of the Site Manager and agreement of the W/G.

CHAPTER 4 DESCRIPTION OF LANDFILL FACILITIES

The purpose of this chapter is to acquaint the Operator with the facilities available at the site. A description of the facilities and their function are explained hereafter. The As-Built Drawings should be referred to for further understanding.

A. FACILITIES PROVIDED IN THE PILOT PROJECT

4.1 Weighbridge

Function: The weighbridge shall be used to weigh the incoming waste hauling trucks, in order to maintain a record of the incoming waste amounts at the Sisdol LF.

Description: The weighbridge is located at the entrance of the Sisdol LF. It has the following specifications:

- Platform type, installed over RC foundations and with an exit ramp. Approach is flush with the road.
- Material type is steel
- Platform size is 3 m x 9 m
- Weighing capacity is 40t maximum at 5 kg readability
- Four load cells are provided, each 20 t
- Two serial interfaces are provided, 1 RS232 for PC and a second RS232 for the indicator, with 7 segment display

4.2 Site Internal Road

Function: The internal road shall be used by the waste hauling vehicles to access the waste disposal areas in Valley 1.

Description:

- The road has a length of 190 meters and a width of 5 meters.
- Road is formed of two compacted earth layers; a 15cm thick sub-base coarse of sand mixed with gravel overlaid by a 10cm thick base course of broken stones
- Drainage ditch is provided on one side of the road
- Average gradient of the road is 1:10 and the road descends to about 20 meters over 190 meters length

4.3 Basement Structure

Function: The landfill basement is composed of the layers that shall be overlaid by the leachate collection facilities and the disposed waste. The basement shall function to support the leachate collection pipes, waste haulage trucks, heavy equipment operation, and containment of the leachate within the landfill site.

Description:

- After completion of excavation works to the required levels the existing soil (basically blackish clayey silt mixed with overlaying gravelly sandy soil) was compacted to a rate of 82% to 96% (Dpr)
- Above the compacted existing soil layer two layers of clay were placed and compacted in 0.25 m layers to a total thickness of 0.5 m (laboratory tests confirmed a permeability coefficient of k = 9.163 x 10-8 cm/sec)
- A jute mat was laid over the clay liner in order to protect the liner
- Underneath the main collection pipes an HDPE sheet (350 micron) has been laid to offer more protection against seepage of the leachate collected to the pipe to the underground
- Above the jute mat a 30 cm thick drainage carpet (composed of river bed shingle/ pebbles of sizes 30-50 mm) has been laid to facilitate the percolation of the generated leachate towards the leachate collection system

4.4 Leachate Collection System

Function: The leachate collection system shall have two basic functions; to convey the leachate generated during the waste disposal activities to the leachate pond and to allow the air to flow into the disposed waste layers.

Description:

- A main leachate collection pipe line has been constructed and laid in a north-south direction with a total length of 115 m at a gradient of 3%
- The main line is constructed of perforated 600 mm diameter NP3 hume pipe (RC) pre-fabricated and brought to the site (holes of diameter 25mm and intervals 25 cm are provided
- Branch leachate collection pipes made of perforated 250 mm diameter HDPE were laid at a total length of 240 m (in the configuration as shown in the As-build drawings) at gradients of 4%
- The main and branch pipe lines were surrounded by filter materials of river bed shingles/ pebbles (50-150 mm) with the dimensions as shown in the drawings
- Seven (7) manholes were constructed (6 at connections between main and branch pipes, and 1 to connect two branch lines)
- The outlet pipe of the main pipe line is non-perforated RC pipe of 600 mm diameter and is designed that the invert level is 1.25 meters above the design HWL of the pond, the level at which the pond outlet pipe is located

4.5 Leachate Pond

Function: The leachate conveyed through the leachate collection system shall be stored in the leachate pond. An aerator has been installed in the pond to provide biological treatment of the leachate under aerobic conditions. A pump has been installed to re-circulate the leachate to the waste disposal area. The reasons behind this are to further treat the leachate under anaerobic conditions (within the waste) and also to speed up the decomposition of the disposed waste.

Description:

- The pond has a capacity of 315 m^3 (to accommodate estimated maximum leachate quantity for a period of 7 days) under the pond outlet pipe level (the outlet pipe connects the pond to the adjacent manhole)
- The pond dimensions are 10 m width x 20 m length at the bottom with sides sloping 1:1 and the design water depth is 1.25 m
- The height of the pond has been increased by 0.7 m above the outlet pipe level by a perimeter masonry wall. This additional height provides an increased capacity for the pond.
- The pond bed is constructed of a bottom layer of 150 mm thick stone soling overlaid with a layer of 150 mm thick cement concrete with nominal reinforcement
- The walls of the pond are made of 150 mm thick cement concrete with nominal reinforcement
- A RC outlet pipe at a height of 1.25 from the pond bed allows the leachate to flow out into an adjacent manhole if the valve is opened
- The adjacent manhole is 1.9 x 1.65 m clear dimensions and depth of 1.83 m, with walls of stone masonry and a floor of stone masonry and PCC, over a boulder layer.
- A 250 mm diameter inlet valve is installed within the manhole
- The manhole has an outlet Hume pipe of diameter 250 mm which leads to an outfall structure made of stone soling

4.6 Aerator

Function: The aerator has the function to introduce air or oxygen into the leachate. This will provide aerobic conditions for the leachate and assist in biological treatment.

Description:

- Floating Surface Aerator (electrically powered) has been installed
- Capable to transfer atmospheric oxygen at a minimum rate of 1.6 kg O2 per brake horsepower per hour (HP/HR)
- Vertical electric motor 10 HP (7.5 kW) suitable for continuous operation at 1800 RPM 220 volts, 3 phase, 50 cycle, TEFC, minimum Class F insulation system
- Three numbers FRP lined floats with necessary hooks and nylon ropes, with a minimum excess floatation of 130 kg
- Stainless steel anchor cables shall be installed such that the aerator may rise and fall with the water level variations, but have other motions minimized

4.7 Re-circulation System

Function: The leachate re-circulation system will function to pump the leachate stored in the pond back into the disposed waste area. The reason for this is to prevent overflow of the pond, especially during the rainy season and also subject the leachate to anaerobic conditions to effect the nitrification and de-nitrification process. Re-circulation of the leachate to the disposed waste will also speed up the de-composition process of the waste and hasten its stability especially during the dry season.

Description:

- Six (6) sprinklers are temporarily fixed on to the vertical gas vents and connected to the pump by a hose pipe (80 mm diameter)
- Sprinklers may be detached and fixed to other vertical gas vents and their height should be increased as the waste height increases
- A pump of capacity 7.5 kW is installed in the pump house adjacent to the leachate pond and used for pumping leachate out of the pond and into the hose for conveyance to the sprinklers

4.8 Landfill Gas Vents

Function: The installed vertical gas vents shall function to remove the landfill gas generated during the waste decomposition from the disposed waste to the atmosphere (passive gas venting). The vents shall also function to introduce air into the disposed waste to support the semi-aerobic system. It will be necessary to increase the heights of the gas vents as the waste disposal progresses and the disposed waste heights increases.

Description:

- At 20 locations intersecting the leachate collection pipes, perforated PVC gas vents (diameter 160 mm) have been vertically installed
- Vertical gas vents intersecting main leachate pipe mounted within stone boulders surrounded by gabion
- Vertical gas vents intersecting branch pipes mounted within oil drums and surrounded by gravel

4.9 Pump Control Room

Function: This room is constructed adjacent to the leachate pond and the re-circulation pump and electric panel to operate the aerator are stored there.

Description:

- Room of dimensions 4 m by 3 m constructed on stone soling foundation
- Walls made of stone masonry and SWG CGI sheet roofing
- Door and window provided

B. FACILITIES DEVELOPED SEPARATELY BY SWMRMC

4.10 Waste Bordering Dam

Function: The waste dam is located downstream of Valley 1 near to the Kolpu River. The dam functions to retain the waste within the disposal site and to separate the landfill area from the leachate pond and the river.

Description:

- The dam dimensions are 36.5 m long, 1.2 m crown width and has a height of 4.9 m above the landfill ground level, with a total height of 7.3 m
- Dam is constructed of stone masonry
- Outside slope of the dam is 2:1 while waste side dam slope is vertical

4.11 Surface Water Cut-off Drain

Function: The main function of this cut-off drain is to prevent the water from entering into the site from elevated areas above the site. Water is collected into the drain and conveyed to a manhole downstream the site by gravity. It then travels through an RC pipe to an outfall structure and into the river at a point downstream the site.

Description:

- Constructed of stone masonry with a plain concrete bed
- Total length of the drain is 245m
- Drain hydraulic radius is 0.11m

4.12 Fencing

Function: The site is surrounded by a fence to maintain access control. The fence will also function to retain plastics and papers blown by the wind from leaving the site.

Description:

- Two types of fences shall be installed; one is barbed wire fencing with wooden poles and 180 m long
- Second type is GI mesh wire fencing with concrete poles, 2,600 m in length

4.13 Water Supply

Function: Water supply is required at the site for the staff. Water is also needed for land filling purposes, such as extinguishing fires, washing equipment or watering dirt roads.

Description:

- For the present water shall be supplied by tapping the spring water located near the upper terrace area north of the landfill
- A constructed intake collects the water which is then drained through an underground pipe and conveyed through an overhead 32mm diameter polythene pipe
- This supply may not be sufficient and SWMRMC is considering to develop a system to take water from the nearby Kolpu river

4.14 Gates

Function: The gates, along with the fence will control site access.

Description:

- The main entrance gate is located east of the site at the administration area
- The entrance gate, for vehicles has a width of 5 m and shall be installed between two RCC pillars
- A separate small gate shall be provided for pedestrians

4.15 Electricity Power Supply

Function: The electricity power is required for operation of the weighbridge, aerator and re-circulation pump. Power is also required for the administration area.

Description:

- A three phase electric power supply shall be extended to the site from Kakani, Nuwakot district
- The line shall be overhead at the site and extended to the leachate pond area to power the aerator and re-circulation pump

4.16 Equipment/ Vehicles Shed

Function: The shed shall be used for small repairs, washing and parking for three heavy equipment units.

Description:

- Constructed of stone masonry with truss CGI roofing
- Three compartments of dimensions 7.0m x 3.75m with a total length of 21.75m

4.17 Administration Building

Function: The administration building provides office space for the landfill staff and weighbridge operator room.

Description:

- Constructed of stone masonry with CGI sheet roofing and dimensions of 8.9 x 8.5m
- There is a small veranda in the front

4.18 Toilet Block

Function: To be used by staff and visitors.

Description:

- Two cabins with flush type
- Dimensions of 3.7 x 2.25 m
- It flushes into two pits, the second to be used after the filling of the first
- Water is supplied by an HDPE water tank of 1,500 liter capacity

CHAPTER 5 OPERATION CONDITIONS

The operation conditions that should be understood by the beneficiaries of the site are described in this chapter.

The Operator may change these conditions in order to improve the operation or meet unforeseen circumstances. In such case the modified information should be made available to the landfill beneficiaries.

5.1 Operation Hours

The Sisdol landfill shall be operated daily.

1) Daily Operation hours : 06:30 to 15:00
2) Saturdays and National holidays : 06:30 to 13:00
3) These hours will apply to all seasons

5.2 Permissible Waste

The Sisdol landfill shall accept all non-hazardous municipal solid waste types, including domestic, industrial, commercial, market and public cleansing from the KMC, LSMC, KRM and Nuwakot District. The estimated average daily amount of waste to be disposed of at the site is 350 tons.

Hazardous waste, infectious waste, radioactive waste, liquid waste and other waste not considered as municipal waste shall not be accepted at the Sisdol landfill.

5.3 Non-permitted Practices

The following activities and practices shall be prohibited at the Sisdol landfill.

1) Waste picking and scavenging activities
2) Open burning of the waste
3) Utilization of heavy equipment provided for the landfill operations for other purposes (the Operator may dispatch heavy equipment to support simple repairs that may be required in the access road)
4) Allowance of non-authorized personnel access to the landfill

CHAPTER 6 PHASING PLAN

6.1 Overall Site Development Plan

The Sisdol landfill will be developed in two (2) phases. The total landfill life will be approximately 3 years.

The site is composed of two valleys; Valley 1, the west valley slopes downstream in a north-south direction, and Valley 2, the east valley slopes downstream in a northeast to southwest direct. Assuming a maximum fill height of 27 meters for Valley 1 and 23 meters for Valley 2, the landfill capacity of each is estimated to be 166 thousand m^3 and 109 thousand m^3 respectively.

Two alternatives have been proposed for the development of the Sisdol landfill[3] as described in Table 6.1.

Table 6.1 Development Alternatives

	Alterative 1	Alternative 2
A DEVELOPMENT PHASING		
Phase 1	Valley 1 – Max. disposal height 11m	Valley 1 – Max. disposal height 27m
Phase 2	Valley 2 – Max. disposal height 7m	Valley 2 – Max. disposal height 23m
Phase 3	Valleys 1 and 2 – Max. disposal height 16m	
B COMPARISON OF ALTERNATIVES		
	1. Better slopes stability 2. Gentler slopes for internal service roads 3. Phase 1 will have a capacity of 4-5 months during which Valley 2 has to be developed 4. More leachate will be generated	1. Phase 1 will have a capacity of 12 months thus providing more time for development of Valley 2 2. More rapid stabilization of the waste in Valley 1 3. Lesser leachate generated as final capping is provided for Valley 1 before proceeding to Valley 2

In order to allow more time for the development of Valley 2 and speed up the waste stabilization in Valley 1, Alternative 2 is the preferred one. Final decision should be based on site development and landfill operation progress and should be reached within 2-3 months from the commencement of operations.

6.2 Development within Phase 1

Under Alternative 2, the waste will be disposed in Valley 1 during Phase 1, for about 12 months. The waste disposal will start from the north-east corner of the site, adjacent to the internal service road and proceed downstream towards the waste dam.

At the commencement of operation and for the first 3-4 months about 40-60 tons of waste will be disposed of at the site daily. The waste shall be disposed of in layers of around 0.5 m depth within cells of 10 m x 10 m, assuming a compacted waste density of 0.6 t/m^3. Once a waste platform is prepared, with the compacted waste covering the entire Valley 1 bed, the compaction density shall be increased to around 0.8 t/m^3.

[3] Refer to the detailed design report for the pilot project, JICA Study Team, September 2004

Once the arriving waste reaches the expected full capacity of 350 ton/day it will be necessary to operate two cells, with each cell dimensions being 20 m x 20 m, and with the same depth of 0.5 m.

6.3 Development of Phase 2

Development of Phase 2 will be made under the same principle of the semi-aerobic system. The existing ground level will be deepened through excavation, a waste dam will be constructed downstream Valley 2, soil investigation will be implemented and as required clay liner will be laid, a leachate collection system will be introduced and a leachate collection pond will be constructed downstream the dam.

Implementation of Phase 2 development will proceed in a timely manner in order that there will be no disruption of the waste disposal activities once Phase 1 is completed.

CHAPTER 7 LANDFILL OPERATIONS

7.1 Waste Stream Accounting – Weighbridge Operation

The weighbridge operation shall have two main functions:

- It is the first point of entry to the landfill where the waste transporting vehicle may be inspected to assess the suitability of its load for acceptance at the site, and
- It shall provide the data for recording the arriving waste particulars (Form 1 – Weighbridge Record)

(1) Waste Inspection

a. Each arriving vehicle should show the permit it has from the served municipalities (KMC, LSMC, KRM) to collect and transport *municipal* solid waste (without such permit the vehicle load shall be rejected)

b. The weighbridge operator may demand a visual inspection at which time the vehicle will be directed to a separate location for inspection (subject to vehicle type inspection may be made by looking into the vehicle from the top or dropping some waste at a designated point)

c. Regardless of initial waste acceptance at the weighbridge, at the time of waste un-loading at the active waste cell the waste may be rejected should the load be found to contain un-acceptable materials (the ejected waste would then be re-loaded into the vehicle and sent away from the landfill)

d. Based on the above inspection, should a vehicle not be permitted to discharge its load at the landfill then the vehicle number, driver name, date and time of arrivals, and reasons for rejection shall be reported to the respective municipality and the vehicle in question shall not be allowed at the site in the future until the involved municipality submits an explanatory report to the landfill management on the incident.

(2) Weighbridge Record Information

a. A form shall be prepared for the purpose of storing the recorded information

b. A coding system shall be prepared for inputting the collected information into the computer

c. The final form shall be distributed to the concerned municipalities in ensure that the required information may be obtained

d. The data to be recorded shall be:

(1)	Vehicle number	Weighbridge operator
(2)	Driver name	Driver
(3)	Arrival time	Weighbridge operator
(4)	Vehicle weight (with waste load)	Weighbridge operator (each vehicle shall be weighed once when empty to calculate the waste weight)
(5)	Trip origin	Driver (for transfer haul specify transfer station name, for direct haul specify collection zone)
(6)	Departure time	Weighbridge operator

e. The recorded data shall be input into the computer on a daily basis using the coding format.

7.2 Waste Un-loading

Landfill staff will direct the vehicle driver to the active waste disposal areas. Operators at the active fill areas will direct the vehicle to the appropriate disposal area along the working face as required. No vehicles will be permitted to un-load their waste at any location other than the area designated by the landfill staff.

The Operator will maintain control of the waste unloading within the active disposal area in order to minimize the width of the working face, and decrease the unloading and waiting times. The driver may be instructed to un-load the waste in two or three different places.

7.3 Cell Configuration

A cell shall be prepared to accommodate one day's waste. The cell area should not be too large to limit the leachate production. The cell shall have a height of 1-2 m and the waste deposited in layers of around 30-50cm to allow for more uniform compaction. The width shall be sufficient to allow for 2-3 vehicles to discharge the waste at the same time (i.e. minimum 10 m).

The borders of the cell shall be delineated by soil bunds which shall be used for the cover material source at the end of the working day.

The waste shall not be pushed over a vertical face. It shall be deposited at the top or base of a shallow sloping working face. The bull dozer shall be used to push the waste up or down the slope.

Example for Cell Size Calculation:

(1) First Waste Layer
- It is expected that at the commencement of operation, approximately 40 t/d of waste shall arrive to the landfill.
- The first layer of waste shall not be compacted in order to avoid damage to the basement by the heavy equipment. Therefore the estimated waste placement density is 0.5 t/m^3.
- The waste depth shall be roughly 0.8 m (to allow for waste placement in 2 layers of 0.4 m each).
- Accordingly the cell area = (40 t/d)/(0.5 t/m3 x 0.8 m) = 100 m2.
- With each side roughly 10 m x 10 m.

(2) Cell Size at full operation level
- At full operation the waste amount hauled to the site shall be around 350 t/d.
- The waste shall be compacted and compacted density shall be around 0.8 t/m^3.
- The waste depth shall be kept at a minimum 1.5 m.
- Accordingly the cell area in this case shall be around 300 m2, with dimensions of 15 m x 20 m.

7.4 Spreading and Compacting

In order to protect the basement structure special care will be exercised in the placement of the first waste layer. The waste in that layer will be spread to a depth of around 0.6 m in two layers. This first layer shall be compacted using bull dozer in order to avoid over compaction. No compactor shall be used on the first waste layer which shall be spread over the full face of the basement bed.

For the following layers, uniform compaction levels will be promoted throughout the site by limiting the thickness of each waste layer and using sheep-foot compactor. The landfill staff shall control the spreading of the waste materials along the working faces so that a compacted layer thickness of approximately 0.5 meters will be achieved. This should result in uniformly well-compacted waste layers with little potential for excessive or uneven subsidence.

Should the waste contain large or bulky materials which may not be crushed by the compactor, these materials should be removed, crushed and then returned to the waste fill area.

The most effective compaction occurs when the compactors are operating on levelly spread waste. However the actual waste un-loading and pushing the waste will tend to create sloped waste layers. Therefore these slopes should be mild not in excess of 3 horizontal to 1 vertical.

The number of passes of the compactor is important in order to achieve high densities. Normally 3 to 5 passes should be made for each layer. Passes more than 6 or 7 will not produce significant compaction for the effort expended. As a rule, the passes of the compactor should not be less than 2 passes. The number of passes may be slightly increased in case of spreading and compaction by bull-dozer.

7.5 Cover Material Source and Placement

Application of the cover material is one of the most important countermeasures to mitigate a number of environmental concerns.

At the end of each working day a 15 cm thick layer of soil cover will be placed over all the waste material disposed at the landfill on that working day.

Intermediate cover will be placed over disposed waste in areas where further waste placement will not occur for at least 6 months. The intermediate cover will be spread and compacted to a thickness of at least 30 cm. The intermediate cover will be graded to allow for surface water run-off and reduce ponding and infiltration. This intermediate cover shall be laid over Valley 1 in case the phased development of the site follows Alternative 1 (as explained in Chapter 6).

The final cover will be placed once waste disposal operation is completed. The final cover will be at least 1.0 meter thick and will include layers of soil to reduce infiltration, prevent erosion and support vegetation. The final landfill cover will be re-seeded with native vegetation to minimize the visual impact of the final landfill surface and to provide a natural habitat consistent with the surrounding environment.

Prior to application of the final cover the Operator shall prepare that layer and submit it to the concerned authorities (KMC, LSMC, SWMRMC and Okharpauwa Sanitary Landfill Site Main Coordination Committee (OSLSMCC)) for their approval.

The cover material shall be obtained from the site. Materials excavated during the pilot project construction are stockpiled and these shall be used. In principle care shall be taken to apply materials that will not hamper the passage of heavy equipment on the successive waste layers.

The cover materials shall be brought to the active disposal areas using a wheel loader. Compaction of the cover layer shall be made by the bull dozer of compactor. Compaction shall be of sufficient degree so as not to hamper successive disposal works.

7.6 Stockpile Requirements

The Operator shall at the start of operations identify the stockpiles locations and volume of materials available and already prepared during the pilot project construction, from the excavation works.

During the course of the disposal operations and as the stockpiles become depleted, the Operator shall replenish them from materials excavated from Valley 2. Further as the disposal work progresses the Operator may decide to place stockpiles in new locations to ease the materials transport to the active waste area.

Under no circumstances will the Operator endanger the cover materials stockpiles either by neglecting to replenish the materials or locating the stockpiles at in-accessible locations.

7.7 Permanent Drains Maintenance

The landfill is served by a perimeter cut-off drain along the northern border. A second storm water drain is located at the side of the internal service road. Both drains should be regularly cleared from fill or debris in order to function efficiently.

7.8 Temporary Drains

Temporary drains, in combination with earth bunds, may be constructed during the operation to divert storm water from entering into an active waste disposal area. The Operator shall ensure that these drains do not convey the water outside the site. The water collected in these drains should ultimately seep into the disposed waste and enter into the leachate collection system to be conveyed to the leachate pond.

Once these drains have served their purpose they should be reclaimed properly. No standing water should be allowed in any part of the landfill.

7.9 Leachate Pond Aeration

Aerator operation is important to provide biological treatment for the generated leachate and also as a countermeasure against odor emission from the leachate stored in the pond.

During the rainy season and when the pond is full the aerator will in principle be operated on a daily basis, for about 6-8 hours a day. Should there be any electricity power failures; the aerator shall be given priority for connection to the generator.

The Operation Manual provided by the aerator manufacturer will be referred to for operation and maintenance issues.

Should the odor generated from the leachate pond become very serious, additives to depress the odor may be added. However such additives should not be of toxic or hazardous nature.

7.10 Leachate Re-circulation

Leachate re-circulation shall be performed to allow for an increased rate of waste decomposition and provide further treatment to the leachate through exposure to anaerobic conditions.

During the dry seasons the leachate re-circulation shall be done on a regular basis so as to mitigate the build-up of leachate at height of over 30 cm above the basement and subject the disposed of waste to moisture in order to hasten the decomposition process. However during the rainy season the re-circulation shall be done on as required to prevent against overflow of the leachate pond[4].

Any sludge accumulated at the bottom of the pond shall be removed and deposited over the waste.

7.11 Horizontal Leachate Trenches at Intermediate Levels

Horizontal intermediate leachate trenches shall be constructed to strengthen the semi-aerobic function through collection of the leachate and passage of the air.

Maximum waste design height is around 20m. At an intermediate level of 10 m height, the Operator shall construct leachate trenches; using gravel of size 30 to 50 mm (either crushed gravel or river-bed gravel may be used). The trenches shall follow the similar configuration to the main leachate pipe collection system.

7.12 Gas Vents Extensions

As the waste height increases it will be necessary to increase the height of the gas vents. This will be necessary in order that the gas vents continue to passively expel the generated landfill gas and introduce air into the disposed waste layers. The Operator shall use PVC vents and shall surround them with aggregate to protect them. The development works shall be done considering maintaining the vents free of any foreign materials.

7.13 Operation in Rainy Season

There should be no interruption of the disposal operations during the rainy season.

The three major factors of concern during this season are the increased generation of leachate, the difficulty of accessing the internal service road and finally the application of cover materials.

Concerning the increased leachate amount, as discussed in previous sections the re-circulation system shall be used to avoid over flow of the collected leachate in the pond to the adjacent river.

[4] Leachate pond capacity has been designed for one week's storage of maximum 45 m^3.

Concerning the internal service road, the Operator shall in advance of the rainy season strength the road by applying a lime-stabilized sub-grade or other suitable materials (such as cement-stabilized gravel).

The cover soil used during wet weather operation must be granular to allow for ease of placement and compaction. Silt and clay materials will be unworkable when exposed to excessive moisture. The Operator should stockpile such materials well in advance of the rainy season.

The Operator should avoid access of heavy collection trucks directly over the waste areas during the rainy season and instead rely on lighter weight heavy equipment (as bull dozer and wheel loader to transport the waste to the active cell area).

7.14 Special Waste Handling

Sisdol LF is not designed to handle special waste (e.g. liquid waste, chemical waste, hazardous waste, etc.). Should such waste be delivered to the site, the truck hauling these waste shall be refused access, in case of detection at the entrance of the site, or be requested to re-load and remove the waste, should the nature of the waste be detected during the unloading operation.

7.15 Basic Landfill Equipment

Sisdol LF shall commence operation with around 40 t/d of waste arrivals for the first three to four months. During this period the first waste layer shall be constructed. Excessive compaction will be avoided in order to protect the leachate collection system and basement liners.

Accordingly at this initial stage wheel loader, excavator and bulldozer will be required. Wheel loader will mainly transfer the un-loaded waste from a designated tipping point to the active cell, excavator will be used to move the cover materials and bull-dozer will be used to spread the waste and provide some compaction.

Once the landfill reaches its maximum waste arrival acceptance amounts (around 350 t/d) it will be necessary to supply a sheep-foot compactor.

7.16 Landfill Equipment Maintenance

In principle simple repairs and daily inspection for the heavy equipment shall be carried out at the site. For this purpose the Operator shall include a mechanic within his site team. The site shall also have some spare parts, and required equipment for the maintenance.

For larger maintenance work the equipment will be transported to a qualified workshop.

Each equipment will have a maintenance record identifying the dates of inspections, repairs, and maintenance. The contents of each inputted data will be described in detail.

For light equipment, such as aerator, pump and generator there shall be daily maintenance checks for oil and lubricants. The Operator stationed at the site should also be capable to provide simple repairs for these equipment.

7.17 Intermediate and Final Closure Works

Closure works will be implemented gradually as sections of the landfill site reach the waste disposal completion design levels. Such sections shall include when the waste reaches the final waste dam height and the road height.

At these levels (waste dam height and road levels) the waste will be filled to a horizontal level and inwards for a minimum width of 5 m before starting to build the following lift. No further waste disposal activity will be permitted at these sections (Schematic drawings are shown in Figure 7.1).

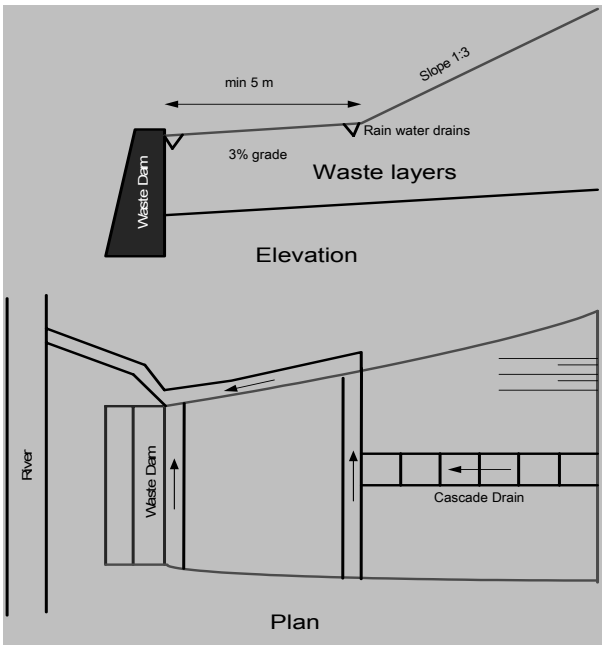


Figure 7.1 Schematic Early Closure of Certain Landfill Sections

The waste slope at the following slope shall be maintained at 1:3 to avoid waste collapse.

The final layer of waste (both horizontal and inclined) shall be topped with a capping soil of thickness around 75 to 100 cm. This capping soil shall be of material supportive to vegetation.

A drainage system shall be designed at the capping soil layer. The drainage system shall have the function to decrease the amount of rain water infiltrating into the waste by collecting and draining the rainwater. The drainage system shall consider appropriate gradients, horizontal and inclined drains, and flow of the collected rain water from the drains (possibly to the outfall structure located west of the site) or to the manhole located adjacent to the leachate pond.

CHAPTER 8 ENVIRONMENTAL CONTROLS

8.1 Leachate Re-circulation and Aeration

The leachate re-circulation system shall provide the following environmental controls:

- Decrease the amount of leachate stored in the pond in order to prevent the overflow of the leachate
- Scatter the leachate into the active waste cell so as to provide leachate treatment through anaerobic conditions

The re-circulated leachate should not be allowed to form ponds in the waste disposal area. If there is difficulty in seepage of the re-circulated leachate to certain parts of the disposal site, other areas should be selected.

The leachate aeration in the leachate pond shall provide environmental control as enhancing decomposition of organic pollutants in retained leachate and decrement of odor emitted from the pond. The operation of aerator shall be in line with the description herein.

8.2 Sludge from Leachate Pond

Not much sludge is expected within the leachate pond. However over a long period the sludge may pile up causing the pond volume to decrease. Periodically an excavator should be employed to remove the sludge from the pond and dispose of in the waste active area. For this purpose a suitable sized excavator should be made available. It is advisable to avoid manual removal of the sludge from the pond.

The road along the pond should be maintained for ease of access at any time by the excavator.

8.3 Dust

On-site dust will be controlled through the following measures:

- Use of water tank
- Cover material will be applied at the active waste disposal areas.
- Continued attention to be given to proper maintenance of internal service roads
- Planting and maintenance of vegetation on closed fill slopes
- Use of leachate re-circulation system in the active waste disposal area or over the daily cover only (sprinkling of leachate over areas closed by intermediate or final cover will be avoided)

8.4 Litter

The Operator will attempt to minimize windblown or dropped materials on site. Portable litter fencing will be installed at active fill areas to catch windblown materials, as required. Both the portable and permanent fencing will be inspected and cleaned daily.

Waste paper materials may require the addition of water to eliminate scattering. The landfill will be inspected daily for waste materials that may have been blown or fallen from trucks. Ditches will be kept clear of litter material.

Haulers will be instructed to cover loads. Access road leading to the site will be inspected regularly for waste materials. The right-of-way of the road will also be inspected, along both sides at least once every week.

8.5 Vectors

By definition, a vector is an insect or animal that can carry disease. Landfills are a potential breeding ground for vectors if control measures are not sufficiently exercised. These vectors commonly include flies, rats, mice and birds.

The first line of defense against vectors is the speedy, regular and proper application of cover materials.

Regular check and inspection to confirm that rats, mice and flies are not thriving in the landfill is necessary. Should there be concern; traps may be set to confirm the presence of rats and mice. Similarly for flies some counting method may be applied to identify the extent of the problem.

Should there be a serious problem then application of poison and insecticides should be considered. A special plan specifying type of insecticides or poison, waste amount, time of use, etc. should be developed by experts. It may be necessary to temporarily close the site to avoid any health danger to the site staff when these materials are used. Finally the effect these materials may have on the generated leachate should be considered.

8.6 Bird Nuisances

A bird control plan shall be developed based on the site conditions. The cover material application is the primary control method. Other methods that may be considered include stretching of strings overhead the site to obstruct the birds glide paths, and acoustical devices that emit noises that scare the birds away.

8.7 Noise

Heavy equipment and collection trucks should be in a good order to avoid excessive noise emission. A serious condition may require the construction of noise berms.

8.8 Erosion Control

In order to prevent slope damage as a result of erosion part of the runoff water on the side slopes of the landfill will be directed to the perimeter cut-off drain. This drain should be maintained in a clear condition.

Waste slopes in the disposal areas shall be formed of grades 1:3 or 1:2. Waste slopes shall be properly covered and served by open drains to collect and divert the storm water. Such drains may need to be lined with rocks. Vegetation shall be planted along the slopes as possible to reduce erosion. Plants should be resistant to waste.

8.9 Odor

The daily soil cover application is the primary control method. Should there be a serious problem on odor then applications of spraying with aroma-masking agents or chemicals should be considered. These agents/chemicals shall be non/less harmful to the site staff, surrounding communities and environment when applied. Attention shall be paid on the possible increment of leachate generation volume from the landfilling area due to the excessive spraying. Odor in post-closure phase will be controlled by the placement of a final capping cover.

8.10 Buffer Zone

Buffer zone will be functioning for avoidance of the undesirable access to the site by the outside people as well as for mitigation of environmental nuisance by site operation such as odor. Tree planting and fencing around the perimeter of the buffer zone should be made as required.

CHAPTER 9 ENVIRONMENTAL MONITORING

9.1 Water Quality Monitoring

9.1.1 Monitoring Location

Water quality monitoring shall be made at the following locations:

- Groundwater: Monitoring wells of Borehole (BH)-1 and BH-2. (*Groundwater of BH-3 should be also monitored as far as the hole will not be under the waste disposed of.)
- Leachate: Leachate outlet pipe and retention pond.
- Surface water: Upstream of Kolpu Khola (1 location), Downstream of Kolpu Khola (2 locations), Thulo Khola (1 location).

9.1.2 Monitoring Parameters and Frequency

The parameters to be monitored are recommended as follows based on the effluent standards of MOEST and the EIA Guidelines by SWMRMC.

A. Field measurement (Twice a year)
Weather, Air temperature, Water temperature, Color, Transparency, Odor, Appearance, River flow*1, Discharge*2, Groundwater level*3, pH, DO, EC
B. Indicators (Twice a year)
TDS, TSS, HCO3-, BOD, COD, Potassium permanganate consumed, Cl-, Ca++, Na+, SO4-, SO3-, S, NH4-N, NO3-N, NO2-N, T-N, PO4-P, Oil and grease, Coliform
C. Metals and others (Annual)
Phenol, F, As, Cd, Cr (total), Cr (hexavalent), Cu, Pb, Hg, Ni, Se, Zn, Fe, Mg

*1: Only for surface water
*2: Only for leachate outlet pipe
*3: Only for groundwater

9.1.3 Sampling and Analysis

Sampling and field measurement shall be carried out by a qualified water quality expert under the supervision of the LF operator. The testing/analysis of samples shall be carried out at a certified laboratory.

Especially regarding the monitoring of the leachate, a timing and location of the sampling and field measurement works shall be regularized as follows in order to have an effective accumulation of monitoring results.

- Sampling/measurement shall be made after operating daily aeration.
- Location of sampling/measurement in the leachate retention pond shall be fixed.

9.1.4 Relevant Data/Information

The following data/information shall be obtained and recorded by the qualified water quality expert simultaneously with the sampling and field measurement works, in order to support the interpretation of the monitoring results.

- Rainfall intensity and weather condition during the three days before the date of sampling and field measurement.
- Track of the aerator operation i) on the date of sampling and field measurement, and ii) during the three days before the date of sampling and field measurement.
- Sampling point especially in the leachate retention pond.
- Track of the valve operation of leachate retention pond in an emergency case before the date of sampling and field measurement.
- Photos of each of the monitoring locations at the time of sampling and field measurement works.

9.1.5 Maintenance of Wells

The groundwater wells will be inspected on a regular basis (minimum every 3 months) for signs of damage. Damaged wells will be repaired or replaced as necessary. Replacement wells will be constructed adjacent to the damaged well and with the same depth.

9.1.6 Ad Hoc Monitoring

- Precedent indicators monitoring will be carried out by the LF operator in ad hoc base in order to detect the precedent implication of probable water pollution by using portable equipment for on-site measurement. The precedent indicators will include pH, EC, and DO. Cl- is also preferable to be included in the indicators when the portable equipment has its function.
- The effect of the aerator on the leachate will be monitored to assess its performance. An indicator of adequate aeration is the presence of Dissolved Oxygen (DO) near the surface of the pond at a concentration greater than 6.0 mg/l. This should be checked at least once a week to ensure the pond has adequate aeration and to prevent emission of odor.

9.1.7 Monitoring Results Interpretation and Trouble Shooting

Should certain parameters show worse then the necessary actions should be planned and performed considering the following strategies:

- The analytical value sampled/measured at the downstream of Kolpu Khola can be said as a reference point by which implying whether an environmental damage on water quality would be acceptable or unacceptable. If unacceptable, the causality between the site operation and environmental damage should be examined by reading the accumulated monitoring results and site operation records. Supplementary sampling, measurement and analysis should be carried out as required for clarification of the bygone monitored data.
- Should the unacceptable environmental damage on water quality be identified as being caused by the site operation, then a cause should be clarified. One of the most probable causes would be related to the leachate retention pond, such as non-functioning of the valve, damage on watertight mortar lining on the bottom/sidewall of the pond, etc. Such trouble on the pond should be recovered when identified.
- Leachate percolation through the clay liner system in the landfill area would be also conceivable. If feasible and practical, such countermeasures are applicable as i) placing intermediate capping on the landfill area to avoid the accumulation of leachate

percolation from the new waste, or ii) grouting or cutoff sheet pile works at the toe of the waste dam. Temporary peripheral drainage around the landfilling area would be also effective to reduce the leachate generation.

The Environmental Coordination Committee shall be involved in the course of the above process for interpretation and trouble shooting.

9.2 Odor, Littering, and Settlement

The LF operator shall carry out the observation regarding the odor, littering of waste and settlement of landfill area in ad hoc basis. Should a serious problem be found then the countermeasures described herein should be considered and adopted. The observation results shall be recorded and accumulated in order to facilitate a future trouble shooting including the complaints from the local communities/people.

9.3 Landfill Gas Monitoring

Landfill gas vents will be monitored every three months using an appropriate gas analyzer unit. Records will be maintained regarding the time and date of monitoring and observed methane concentrations over the Lower Explosive Limit (LEL).

Periodic monitoring of the landfill gas shall be also performed at the administration buildings of the site in order to avoid the human health hazard on the site staff and workers.

9.4 Incoming Waste Monitoring

Incoming waste will be monitored for the presence of hazardous materials or liquid waste. Monitoring shall be by visual inspection. If it is realized that there is a serious problem in the detection of such waste than a more sophisticated monitoring plan may need to be developed.

9.5 Public Complaints Analysis

The landfill staff member responsible for public relations shall maintain a record of all complaints arriving to the site. The record should classify the complaints by type, number, frequency and the actions taken concerning each.

While the following complaint types are expected, there may be more.

- Water contamination
- Foul smell
- Waste scattering
- Odor
- Vectors
- Noise
- Health problems
- Birds

etc.

CHAPTER 10 EMERGENCY MANAGEMENT

10.1 Types of Emergencies

Crises at the landfill that require the need for an emergency management and contingency plan include fires, release of methane or other noxious fumes, chemicals or fuel spills, earthquakes and heavy rains.

Other emergencies may include blockade of access road to the site by the surrounding residents, injuries or the operating staff, utilities failure or shortages, collapse of parts of the access road to the site, unauthorized scavenging and waste picking activities in and around the landfill, etc.

10.2 Emergency Management and Contingency Plan

The intent of this manual it to provide a guideline for operation and identify the potential emergencies. A separate Emergency Management and Contingency Plan (EMCP) needs to be prepared and distributed to the staff at the site in order to be aware and trained on the emergency response procedures.

10.3 Emergency Response

The response suitable to some emergency types is described hereafter.

(1) Unauthorized Load

Incoming load that could possible contain hazardous, toxic or infectious waste shall be inspected. Any load containing unauthorized waste will be rejected and proper reporting taken.

(2) Hazardous, Toxic, and Infectious Waste

In the event of any hazardous, toxic or infectious waste discovered at the active waste disposal area, site personnel will not attempt to cleanup such materials. A specialized company will be immediately contacted to identify and clean-up the spill.

In the meantime the following actions should be taken:

- Immediately cordon off area where suspected materials are found
- Relocate the working force as required
- If possible, identify the materials
- Contact a company specializing in hazardous and toxic materials to identify and assist to remove the suspected materials, as required
- Prepare full report with supporting documentation for submission to the relevant authorities

(3) Fire

Fires that may occur in the landfill waste will be controlled by the use of fire extinguishers, covering the burning materials with additional soil, or by spraying with water using the site

water truck. Once the fire is extinguished, the cell containing the burning materials will be excavated and the contents spread out in an isolated area of the site. Following confirmation that all burning materials have been extinguished, the waste will be covered with a minimum of 15 cm of soil.

The following actions will be taken if a fire occurs in the refuse fill area:

- Burning refuse will be buried immediately with cover soil
- The Fire Department will be summoned if site personnel and equipment cannot extinguish the fire. The contact information of the closest fire department should be available at the site.
- If the fire occurs at areas outside the active waste disposal areas, maximum effort shall be made to prevent the fire from spreading to the waste areas. One method may be to excavate a fire break between the active waste disposal areas and the oncoming fire.

(4) Earthquake

Should a strong earthquake occur, it is advisable to suspend the landfill operation in order to conduct a damage assessment of the site facilities. These facilities include, but are not limited to the waste dam, roads, administration buildings, gas vents, leachate pond, and utilities supply networks.

(5) Severe Wet Weather Conditions

In countries such as Nepal, where there is the Monsoon season, areas should be provided within the site for wet weather operations. These areas should have all-weather access roads and smaller active areas for the operation of heavy equipment. However, the Sisdol Landfill is very small and it is not possible to provide such an area. Under this condition actions as outlined in Chapter 7 should be considered.

If there is severe rainfall and fear of collapse of the landfill slopes or the disposed waste then it is necessary to suspend operation and take necessary actions such as application of cover materials and compaction of the effected areas, once the storm has abated.

(6) Waste Picking Activities

No waste picking activities will be allowed within the site or nearby.

Any illegal entrant to the site for waste picking activity or others shall be apprehended and as necessary handed over to the authorities.

The waste collection trucks shall be strongly monitored by the respective municipalities in order to prevent the drivers from cooperating with any un-authorized scavenging centers that may be established in the vicinity of the site.

(7) Access Road Problems

Should there be any disruption of transport to and from the site due to collapse of part or parts of the access road, the landfill operator should notify the Department of Roads for prompt action.

Depending on the extent of the road damage, the Operator may attempt to use the landfill heavy equipment to clear the damaged area. However even under such a condition, the operator should report to the Department of Road later on the damage that occurred and the remedial works done.

Should the access road problem remain un-resolved then it would be necessary to suspend operation at the landfill (even though the collection trucks can access the site, other vehicles transporting workers or carrying site provisions may not be in a provision to access the site).

(8) Residents Site Blockade

All problems related to residents in the surrounding areas should be dealt with through discussions with OSLSMCC. The OSLSMCC representative should be informed immediately of the occurrence of such problems and take the necessary action to remedy them.

CHAPTER 11 LOCAL INTERACTION

11.1 Local Committee

Okharpauwa Sanitary Landfill Site Main Coordination Committee (OSLSMCC) has been established and legally registered to act on behalf of the surrounding residents in all actions pertaining to the sanitary landfill development and operation.

An agreement has been signed between the OSLSMCC, the SWMRMC as the site developer and the two municipalities of KMC and LSMC as the site beneficiaries. This agreement, in conjunction with a second agreement on the site operation signed between SWMRMC, KMC and LSMC, set out the obligations and rights accorded to all the signatories.

11.2 Environmental Coordination Committee

In line with the environmental monitoring requirements, and as described herein and in the agreements, an environmental coordination committee has been set up. The Operator shall assist this committee in its tasks.

11.3 Local Development Schemes

The OSLSMCC shall be responsible for formulating plans for local development which shall be discussed with the SWMRMC and the budget obtained as agreed upon.

The Operator shall be independent of these discussions and the Operator's sole concern shall be the technically sound and environmentally safe operation of the sanitary landfill. The Operator shall in no way neglect this main concern on the pretext of diverting manpower, equipment, or money from the operation of the site to such development schemes surrounding the site.

11.4 Site Public Visits

The Operator shall operate the site in a transparent manner and site visits by local resident groups, NGOs, academics and the media shall be sanctioned. However in order to protect the safety of the visitors, an official request for visits and permission given are required.

In principle the Operator should establish a schedule for holding monthly site visits and inform the OSLSMCC.

CHAPTER 12 POST CLOSURE PLAN

12.1 Introduction

Closure of the site will be accompanied by restoration to prepare the final landform through spreading of the soil and site maintenance during a post closure period.

The aftercare will include taking steps during and after restoration to bring the land up to the required standard for after use by cultivating, fertilizing, and draining the land to sustain vegetative growth.

The potential for environmental problems such as water supply contamination by leachate, waste washout due to flooding, slope failures and landslides, landfill gas migration, odor problems and uncontrolled fires can still exist after site closure. Thus in general, upon cessation of activities (i.e. waste acceptance) the necessary measures are to be taken to avoid any pollution risk and to return the site to a satisfactory state.

12.2 Capping of the Site

The capping system is the final component in the construction of the landform, and it comprises the engineering and restoration (or surface) layers. The restoration layer is to comprise of earthen material at least 1.0 meter thick which will support native plant growth and thus enable the planned after use to be achieved.

The engineered layers of the cap will comprise, as a minimum the following:

a) A protection layer – comprising of subsoil, to safeguard against intrusion by plants, animals, etc.
b) A barrier layer – may be compacted clay, geo-membranes or geo-synthetic clay to reduce infiltration of water into the waste and escape of gas from the waste
c) A gas collection layer – sand, geo-textiles or geo-nets to transmit gas to collection points.

12.3 Management of Leachate and Gas

The equipment used for leachate collection and gas venting and control is to be maintained in good condition in the post- closure period.

12.4 Settlement Monitoring and Maintenance of Final Soil Cover

During the aftercare period there are two aspects of settlement for the site operator to consider in relation to monitoring namely:

- Any further settlement of the waste due to consolidation
- Stability of other parts of the site, including slopes and associated structures

Investigation of the settlement potential and physical stability of the site is to be undertaken using theoretical and practical investigations, taking account of the composition and density of the waste deposited, an assessment of the magnitude of settlement and settlement trends, and identification and stability assessment of slopes and structures.

The soil cover which constitutes the final cap must remain stable and checks must be made to identify cracking of the capping layer. Regular maintenance is required to repair the effects of settlement, subsidence or erosion.

12.5 Surface and Groundwater Control

As outlined above, in order to ensure effective surface water and groundwater control and to maintain effective run-off and run-on, the integrity of the final cover must be maintained. The monitoring for ground water and surface water is to be continued during post closure.

Where pipes or drainage systems have been laid during the life of the site they are to be checked and repaired if necessary. In the event that modifications are necessary in order to maintain effective surface or ground water controls such changes are to be undertaken as soon as practicable.

12.6 Other Facilities

Roads and other site infrastructure are to be maintained in accordance with a post-closure plan. It will also be necessary to maintain site security and keep the site free from vectors.