



KARAUTEDANDA LANDFILL SITE OPERATIONAL PLAN



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1. BACKGROUND

Ghorahi Municipality is situated in Mid-Western Development Region of Dang district was established in the year 1978. It is located at a distance of 411 kilometers from the capital, Kathmandu. The urban area of 10 km² comprises Wards 10 and 11 and some parts of 6 whereas the rural area covers 64.45 km². Population of the municipality is 65,107 and the population density is 875 per km² as per CBS 2011.

At present municipality is providing regular waste collection services to urban wards 10, 11 and some parts of ward 6 where more than half of the municipality resides. Municipality collects about 14 Tons of waste every day from these three wards and manages at Karautedanda landfill site since 2005.

1.1 Karautedanda Landfill Site

Landfill is the final but most important part of integrated solid waste management where the collected waste after processing will be managed in isolation from the surrounding environment until it becomes harmless through biological, chemical and physical processes of nature to minimize exposure of the detrimental effects of solid waste to humans and environment.

This landfill site could manage non-biodegradable, inert waste and other wastes that are not suitable either for recycling or for biological process. The residue from waste processing facilities and nonhazardous waste from industries could also be managed in site.

This landfill site is owned and operated by municipal government and is located on the western part of the municipality at a distance of 5.4 kilometer from the city center. Landfill site area occupies about 20 hectare land. Initial Environment Examination (IEE) of the landfill completed and landfilling starts from 2005.

Access Road to the landfill is all weathered black top road and landfill is fenced all-around its area with entrance gate in order to control unauthorized entry. For the safe disposal of waste landfill site is equipped with office building, leachate collection pond, gas vents, a waste sorting area and ware house for storage of recyclables and trenches for composting. In order to maintain greenery and sound environment around the landfill site, more than 3,000 trees (fruit trees and other varieties) have been planted.

1.2 Landfill System

This landfill is anaerobic landfill and is the most common type of landfill system. In this type of landfill waste is allowed to degrade in anaerobic environment. Due to anaerobic environment the decomposition process within landfill is very slow. There is high potential of methane gas in this type landfill than other.

1.3 Project Beneficiaries

The beneficiaries of the landfill is Ghorahi Municipality itself as the waste generated in the municipality will be safely managed at the site and contribute to municipality cleanliness and beautification. The infrastructures developed for the landfill site like Access road, electrification, telephone, water supply etc will also expected to have beneficial impacts for improved livelihood and all round development of the surrounding communities of landfill. Employment opportunities will be an added advantage to the local communities.

2. SCOPE OF THE MANUAL

The scope of this Operations Manual is as follows:

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

3. LIMITATIONS

This operational manual is prepared as per municipal capacity that meets basic Nepalese standards. This manual specifically focuses on operation of landfill and it is expected that landfill operators will have wide range of knowledge on landfill operation. This manual is only for the management of municipal solid waste and does not include procedures applied for the management of toxic waste.

4. EXISTING FACILITIES AT THE LANDFILL

This Section of the operational manual describe about the facilities available within landfill. Landfill operator should have to understand purpose of the facilities and its function so landfill facilities and its functions are briefly elaborated in this Section.

4.1. Site Internal Road

Landfill site internal road provide access to the waste transportation vehicles to working face as well as landfill vehicles to leachate control systems, storm water control systems, and landfill gas control equipment.

This road is Black Top road of 3.5 meter width and is extended up to the active landfill cell. Municipality is gradually extending this road towards south with the extension of landfill area.

4.2. Leachate Pond

Leachate pond is constructed at the downstream of landfill for the collection of leachate generated in the landfill. Since leachate contains harmful substances so it needs to be treated and disposed in proper manner. Leachate collection pond is constructed from Random Rubble Masonry (RRM) of capacity 165 m³. This pond is capable to store maximum leachate produced during rainy season. Pretreatment Screening and sedimentation takes place in leachate collection pond.

After sedimentation the overflow leachate is transferred to the next leachate treatment pond where sand and aggregate is laid at the bottom of the pond. Physical treatment sedimentation and Evaporation of the leachate is the treatment process applied at this landfill.

4.3. Landfill Gas Vents

Management of landfill gas is important aspect of sanitary landfill operation as it poses threats to health and safety issues to the workers and nearby residents. The landfill gas is the byproduct of decomposition of waste within landfill under anaerobic atmosphere.

Passive gas vents erected from the bottom of landfill and height increases as waste disposal progresses. PVC perforated pipes of 30 cm Ø is being used for gas venting purpose.

4.4. Surface Water Cut-off Drain

Surface water management is considered to be important factor while designing the sanitary landfill site as it contributes to generation of leachate and water logging/ponding problems in landfill. Surface water drainage system should be developed in the landfill to divert the rain water/surface water without entering to the operational area. In this landfill usually during rainy season earthen trench constructed around the active landfill cell in order to divert the rain water entering in to the active landfill cell and conveyed to the downstream of the landfill.

4.5. Fencing

Sanitary landfill site is sensitive area and unauthorized entry to the landfill site needs to be strictly controlled. For the control of unauthorized entry, landfill site area is fenced with barbed wire all around the area occupied by the landfill site.

4.6. Entrance Gate

Entrance gate also have the same function as fencing to control unauthorized entry to the landfill. Entrance gate is located near the administration building and waste inspection and recording of waste takes place at site entrance.

4.7. Plantation Around the Landfill

It is the green belt area within landfill between waste fill area and site boundaries so it acts as a living fence also. It helps to reduce potential off site impacts such as surface runoff, litter, vectors, vermin etc as well as to enhance the aesthetic value of the site.

4.8. Administration Building

Administrative building is constructed for daily office management works. The administrative building comprises of office rooms for the staffs at landfill site including meeting rooms for regular meeting. It also includes office store and rest room.

Currently administration building is being used for landfill site and health post. Incoming Waste inspection and waste record is maintained at the site. Regular health checkup for waste collectors and site staffs also take place at the health post.

4.9. Material Recovery Facility

Although landfill is designed for the final disposal of inert and non-recyclable waste then also due to ineffective segregation of waste at source and its processing, mixed waste is transported to the landfill site for final disposal. Realizing this, Material Recovery Facility at landfill was constructed.

Prior to final disposal the incoming waste unloaded to the tipping yard where biodegradable and recyclables are sorted and rest of the waste transported to the waste disposal cell for landfilling.

Biodegradable waste is buried in compost pit for composting whereas recyclables are stored in the warehouse. Municipality sells the recyclables to the scrap vendors for further recycling. 7 waste collectors are employed by the municipality for MRF.

4.10. Water Supply

Sanitary landfill site should have water supply system designed to fulfill the daily demand of water for the sanitary landfill operation as well as for staffs at landfill. For landfilling purpose water is needed for spraying on the earthen road surface to minimize the dust, washing vehicles etc.

In landfill site water is supplied through boring for daily landfill operation.

4.11. Electricity Power Supply

Sanitary landfill site should have permanent electricity supply system for daily administrative works, landfill operation works and for other utilities. Electricity is required for night work in sanitary landfill as well as for illumination of the landfill area. Three phase electrical line would be appropriate for electricity supply.

5. FACILITIES PROPOSED FOR IMPROVEMENT OF LANDFILL OPERATIONS

5.1. Leachate Collection and Treatment

While developing new landfill cell the base of landfill should be excavated and compacted at 2% slope at downstream towards leachate pond. On the compacted base 30 cm granular filter materials should be laid for the movement of leachate.

For the treatment of collected leachate at present existing treatment system applied ie, sedimentation and evaporation is applicable but in future with increase in waste quantity and wider landfill area more leachate is expected and existing treatment system will not able to treat generated leachate.

For the treatment of leachate in future leachate re-circulation seems appropriate due to climatic as well as investment and operation and maintenance cost point of view. Leachate recirculation treatment system is advantageous in terms promoting early decomposition of waste within landfill as well as for reducing the concentrations of leachate.

5.2. Landfill Gas Management

The landfill gas is the byproduct of decomposition of waste within landfill under anaerobic atmosphere. The landfill gas mainly consists of methane and carbon dioxide along with small amounts of volatile organic compounds. Major constituents of landfill gas Methane is inflammable and explosive in nature as well as potential greenhouse gas contributing to global warming.

Landfill gas collection systems are designed to minimize negative impacts that may result from the uncontrolled accumulation and dispersal of highly inflammable gas in a landfill.

For the control of landfill gas currently applied passive venting system will be applied because of its simplified working procedure and is suitable for small scale landfill where landfill gas generation is not significant. Through passive venting the landfill gas accumulated within the landfill is released to the atmosphere. Passive venting pipes are installed at the base of the landfill and extended to the landfill surface.

5.3. Waste Retaining Structure

Waste retaining structure should be constructed to store the waste and to control the sliding of waste. Apart from above mentioned functions retaining structure should also constructed to control the flow of leachate from landfill area other than leachate collection and treatment facility. The types of structure required for construction of waste retaining structure depends upon geological condition of the site, amount of waste to be landfilled and its pressure, designed height of the landfill etc.

Considering stable geological condition and quantity of waste to be landfilled earthen embankment is appropriate for the site at the downstream of the landfill Earth is readily available at the site and will reduce construction cost significantly.

5.4. Perimeter Drain Around Landfill Area

Surface water drainage system should be developed in the sanitary landfill to divert the rain water/surface water without entering to the operational area, separate collection of rainfall at active tipping area and diversion of rainwater of the completed or partly completed and being used for waste disposal is diverted from active tipping area.

Permanent perimeter drain around landfill area should be constructed to divert the surface waste entering in to landfill area. Apart from permanent drain temporary earthen trenches also should be constructed as per site conditions as landfilling works progresses.

5.5. Landfill Site Service Road

Landfill should have service road around the site boundaries. This service road should be all weathered road where vehicles can move during rainy season for site inspection and other associated works that have to be carried out. Apart from service road, temporary roads should also have to be constructed within landfill area for transferring the incoming waste to the landfill cells. Such temporary roads are filled with waste with the increase of height at the landfill and new such temporary roads are constructed as per site conditions. Usually construction and demolition waste are used for construction of such temporary roads.

5.6. Environmental Monitoring

Environmental monitoring is one of the major task that have to be carried out in landfill to know whether the sanitary landfill is performing as designed as well as to ensure environmental compliance. For this purpose Environmental monitoring should have to be carried in landfill for periodic monitoring of surface water, groundwater, ambient air and soil around landfill site as well as monitoring of incoming waste.

6. LANDFILL SITE PHASING PLAN

The site is depressed area towards south and occupies 20 hectare land. Landfill will be developed in two phases. Based on the quantity of waste generated total landfill capacity will be around 20 years as per study report. For the first phase the maximum height of the landfill will be up to 6 meter from the existing ground level which includes the existing saturated landfill area also. The maximum capacity of landfill is in first phase which is about 14 years. Second phase of the landfill is over the first phase for landscaping purpose and it has about 2-4 years landfill capacity depending upon the closure plan. Landfill has capacity to retain about 144,000 Tons of solid waste.

6.1. Development of Phase-1

The waste will be disposed in newly constructed cell for about 2 years. The waste disposal will start from the north east corner of the site, adjacent to the internal service road and proceed downstream towards the earthen embankment.

At the commencement of operation and for the first 3-4 months all waste will be disposed of at the site daily. The waste shall be disposed of in layers of around 2 m depth within cells assuming a compacted waste density of 0.4 t/m³. There is no any heavy equipment to compact the waste, so compaction of waste by self-weight and by vehicular movement during transporting and covering of the waste is only way to get density increased. The service road of the landfill will serve as an unloading platform. The land adjoining to the new cell is used for storage of cover material gained from construction of new cell landfill and the same land will be excavated for the construction of another cell during operation of existing new cell.

6.2. Development of Phase-2

The phase 2 will only an operation of landfilling over the area covered by Phase 1. The waste will be deposited over previously deposited area in 1:3 slopes until the waste comes to level of service road. In this phase the waste is landfilled for landscaping and closure plan of landfill for future use of landfill. Finally the landfill site covered with clay material of at least 60 cm thickness as final cover to prevent water percolation from above and grow vegetation on it for greenery development.

7. ORGANIZATIONAL STRUCTURE OF THE LANDFILL OPERATION

7.1. Organizational Structure

This landfill site is developed and operated by Ghorahi Municipality. Apart from landfilling facilities for waste processing and recovery as well as treatment of leachate exist within the same site. Municipality will dispose the municipal solid waste in the site and shall be responsible for the site operation. Municipality is expected to take full responsibility for the site further development, operation and post-closure management.

7.2. Landfill Site Management Committee

A Landfill Site Management Committee (LSMC) formed by Ghorah Municipality. This will take overall responsibility for the landfill operation. The LSMC shall have the following specific responsibilities:

- Review the daily landfill 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,
- Review any public complaints or comments on the landfill operation and ensure that effective measures have been taken to deal with these complaints,
- Participate in the environmental monitoring process,
- Participate in meetings with the Local Committee (of people under affected area),
- Review the sanitary LF operation expenditures and prepare the budget,
- Manage issues related to landfill operations within their respective organizations and coordinate with other related departments/sections,
- Provide technical advice and guidance to the permanent landfill staff,
- Hiring of the permanent landfill staff and evaluation of their work performance,
- Others as may be deemed necessary by the LSMC.

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

7.3. Permanent Site Staff

A permanent site staffs shall operate the site. Ghorahi Municipality provide the required personnel although limited, the landfill 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,
- Reporting to the LSMC,
- Prepare the budget and review the expenditures,
- Supervision of landfill activities,
- Develop the disposal plan and waste cell preparation.
- Preparation of drawings and timely completion of all civil works.
- Responsible for environmental monitoring and participation in environmental coordination committee activities,
- Maintain contact with the local community,
- Others as directed by the LSMC.

- (2) **Landfill Supervisor**
- 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,
 - 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 supervisor.
- (3) **MRF Plant Supervisor**
- Direct the waste trucks to the MRF Plant,
 - Maintain record of recyclables collected,
 - Maintain record of compost produced,
 - Spraying of insecticides and odor suppressants,
 - Others as directed by Landfill Manager or supervisor.
- (4) **Public Relations Assistant**
- Compilation and analysis of public complaints or comments,
 - Liaison with surrounding community residents,
 - Prepare and disseminate information on site operation,
 - Arrange site explanatory visits,
 - Maintain 'Public Complaints Analysis Record,
 - Others as directed by Landfill Site Manager or supervisor.
- (5) **Assistants**
- Assist the site supervisor,
 - Collection of recyclables,
 - Production of compost,
 - Assist in mechanical works,
 - Assist in heavy equipment operations,
 - Clear litter scattered away from waste disposal area,
 - Others as directed by Site Manager or supervisor.
- (6) **Guards**
- Landfill access control
 - Protection of landfill facilities and equipment
 - Others as directed by Site Manager or supervisor.

The Ghorahi landfill operation shall commence with 5 permanent staffs and assistants will be hired on daily wages or contract basis. 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 LSMC.

8. OPERATION CONDITIONS

The beneficiaries should have to be familiar with the operating conditions of the site and is elaborated in this Section.

The Ghorahi Municipality may change these operating 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.

8.1. Operation Hours

The landfill shall be operated daily.

- Daily Operation hours: 06:30 to 15:00
- Saturdays and National holidays: 06:30 to 13:00
- These hours will apply to all seasons.

8.2. Permissible Waste

The landfill shall accept all non-hazardous municipal solid waste types including domestic, industrial, commercial, market and public cleansing from the Ghorahi Municipality.

Hazardous waste, infectious waste, radioactive waste, liquid waste and other waste of hazardous nature like healthcare waste, pesticides etc. not considered as municipal waste shall not be accepted at the landfill.

8.3. Non-permitted Practices

Following activities and practices shall be prohibited at the landfill:

- Unauthorized personnel access to the landfill
- Open burning of the waste,
- Waste picking and scavenging activities at active landfill cell but such practices could be done on tipping area.

9. LANDFILL OPERATION PROCEDURES

9.1. Incoming Waste Inspection and Recording

9.1.1. Waste Inspection

Prior to recording of waste it is subject to visual inspection by supervisor. If waste contain unacceptable materials then such waste is rejected and vehicles will be send away from the landfill. Vehicle number, driver name, date and time of arrivals, and reasons for rejection shall be reported to the respective Section Chief of Ghorahi Municipality.

Vehicles allowed unloading waste after initialwaste acceptance may be subject to rejection at the time of waste un-loading at the active waste cell containing un acceptable materials. The rejected waste would then be re-loaded into the vehicle and sent away from the landfill. Vehicle number, driver name, date and time of arrivals, and reasons for rejection shall be reported to the respective Section Chief of Ghorahi Municipality.

9.1.2. Waste Recording

A 'Daily Waste Record shall be maintained and filled at the site for the purpose of keeping the daily record of waste being landfilled at the site. For waste recording purpose date, Vehicle Number, Driver's name, vehicle arrival and departure time and trip origin is recorded. This will help to facilitate management information system as well as for planning proposed infrastructures required for landfilling.

9.2. Waste Unloading

Landfill supervisor will direct the vehicle driver to the active waste disposal area. Operators at the active fill area 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.

9.3. 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 30-50 cm 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.

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 waste shall be pushed up or down the slope with the heavy landfill equipment. In absence of landfill equipment waste could be pushed up or down manually with shovel or appropriate equipment.

9.4. 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 manual compactor 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. If the waste contain large or bulky materials which may not be crushed, these materials should be removed, crushed and then returned to the landfill area.

9.5. Cover Material Source and Placement

Application of the cover material is one of the most important counter measures 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.

The final cover will be placed once waste disposal operation is completed. The final cover will be at least 0.6 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.

The cover material shall be obtained from the site. Materials excavated during the construction are stockpiled and these shall be used for covering. 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.

9.6. Stockpile Requirements

The operator shall at the start of operations identify the stockpiles locations and volume of materials available and already prepared during the site construction /extension / improvement 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 the surrounding area. 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.

9.7. Permanent Drains Maintenance

The permanent perimeter drain will be constructed around the active filling area in order to divert the surface water entering to the landfill. Such drains should be regularly cleared from fill or debris in order to function efficiently.

9.8. Temporary Drains

Temporary drains, in combination with earth bunds, may be constructed during the operation to divert surface 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 treatment tank. Once these drains have served their purpose they should be reclaimed properly. No standing water should be allowed in any part of the landfill.

9.9. Maintenance of Leachate Collection Treatment Pond

Once a year in dry season, it is recommended to clean the leachate collection pond mainly for pumping out the sludge settled down at the bottom by using the leachate re-circulation pump and flexible hose pipe. It helps maintain proper functioning of the tank in pre-treating the leachate and facilitating only liquid leachate over-flow into the treatment pond.

For maintenance of leachate treatment pond, it is recommended to replace bed materials with clean sand and cleaning of inlet and outlet pipes for proper leachate treatment.

9.10. Gas Vents Extension

As the waste height increases it will be necessary to extend height of the gas vents and it is to be noted that the gas vents extension in a cell has to be completed timely before starting landfilling in that cell. 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.

9.11. Leachate Pond Aeration

At present there is no aerator at landfill but in future it is recommended to installed aerator for biological treatment of leachate and also as a counter measure 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. The Operation Manual provided by the aerator manufacturer will be referred to for operation and maintenance issues.

9.12. Leachate Re-circulation

For the effective treatment of leachate generated from municipal landfill in tropical and sub-tropical region leachate re-circulation is most widely used treatment system. It is recommended to install in future for better results as Leachate re-circulation accelerate 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 in order to hasten the decomposition process. However during the rainy season the re-circulation shall be done to prevent against overflow of the leachate from the pond.

9.13. 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. 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). Construction and demolition debris could also be used as filling materials for road surface. 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 equipments for transporting waste to the active cell area.

9.14. Special Waste Handling

This landfill is not designed to handle special waste (e.g. liquid waste, chemical waste, hazardous waste, etc.). If such waste be delivered to the site, the truck hauling this waste will be send back.

9.15. Basic Landfill Equipment

At initial stage of landfilling, a back-hoe loader is recommended mainly i) to transfer the un-loaded waste from a designated tipping point to the active cell, ii) to move the cover materials, and iii) to spread the waste and provide some compaction of the fresh waste.

Once the rate of incoming waste reaches its maximum, application of a chain dozer, at least once a week and for every intermediate soil covering shall be necessary for treatment and better compaction of the landfill waste and accordingly longer life span of the site.

9.16. 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. For 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 equipments.

9.17. 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.

The waste 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.

10. ENVIRONMENTAL CONTROLS

10.1. Removal of Sludge from Leachate Pond

Due to the retention of leachate over a long period in the leachate collection tank, thick sludge layer may settle at the bottom, thereby decreasing the effective volume of the leachate collection tank. Periodically, the sludge should be removed from the collection tank and disposed of in the waste active area. The re-circulation pump together with the flexible hose pipe can be good used for this purpose. Manual removal of the sludge from the tank is not advisable.

10.2. Leachate Re-circulation

The leachate re-circulation system in case of excessive leachate generation shall provide the following environmental controls:

- Decrease the amount of leachate to be stored in the collection tank, and to be treated by the simple leachate treatment pond as well.
- Sprinkle leachate into the active waste cell to facilitate the leachate treatment through anaerobic conditions, resulting in reducing ammonia-nitrogen content.

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

10.3. Dust

- On-site dust will be controlled through the following measures:
- Use of water tank for sprinkling on dusty surface,
- 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)

10.4. 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.

10.5. 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.

Application of poison and insecticides should be considered only in case if there is serious problem. 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. It is to be noted that the use of these materials may directly affect the quality of leachate generated.

10.6. 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.

10.7. Noise

Noise emission at the landfill site is generally caused by operation of equipment and collection vehicles that are in bad operating condition. Heavy equipment and collection trucks should be in a good order to avoid excessive noise emission. Regular maintenance of all equipment/vehicles running at the landfill shall be the best control measure against noise pollution.

10.8. Erosion Control

Existing natural condition of the site, particularly with reference to topography and ecology, shows no serious erosion problem.

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 surface water. Such drains may need to be lined. Vegetation shall be planted along the slopes as possible to reduce erosion.

10.9. Odor

The daily soil cover application is the primary control method. If there is 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.

10.10. 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. Tree planting and fencing around the perimeter of the buffer zone should be made as required.

11. ENVIRONMENTAL MONITORING

Environmental monitoring is one of the major task that have to be carried out in sanitary landfill to know whether the landfill is performing as designed as well as to ensure environmental compliance. For this purpose Environmental monitoring facilities should have to be equipped in sanitary landfill for periodic monitoring of surface water, groundwater, ambient air and soil around landfill site.

For environmentally sound operation of the landfill site, following monitoring system shall be adopted in the operation and post-closure phases. In case of surface- and groundwater, testing of samples from respective locations for parameters as described below should be carried out in 3 phases, 1) just before operating the site as baseline monitoring, 2) during site operation period, and 3) in post-closure phase. All test results have to be kept well recorded at the site for documentation and use as and when required for planning purposes.

11.1. Groundwater Monitoring

For monitoring of groundwater, monitoring well should have to be constructed. Depending upon the size of landfill number of monitoring well should be determined. Usually one monitoring well at upstream, one in between upstream and downstream but apart from waste deposit area and two monitoring wells at the downstream of landfill site for small scale landfill site is preferable. The quality of groundwater should comply with the Nepal Drinking Water Quality Standard if wells are being used as drinking water sources by the settlements at the downstream.

11.2. Surface Water Monitoring

Surface water of the river/stream nearby landfill should be monitored at upstream and downstream of the landfill. If landfill is near to the confluence of two rivers/streams then surface water samples should be taken immediate upstream of confluence points to know the water quality of river/stream that mixes.

For water quality monitoring parameter like pH, DO, temperature, color, odor and electric conductivity, TDS, TSS, BOD, COD, Ammonia Nitrogen, oil and grease, coliform, lead, arsenic etc are required to be monitored.

11.3. Leachate Monitoring

For monitoring quality of leachate, the leachate from the leachate outlet pipe and in leachate collection/retention pond should be monitored.

11.4. Effluent Monitoring

Effluent monitoring should be conducted by taking the sample of treated effluent before discharging from leachate treatment facility into the nearby river/stream.

11.5. Landfill Gas Monitoring

Landfill gas should be monitored by appropriate landfill gas analyzer unit. Records of methane concentration over the Lower Explosive Limit (LEL) shall be recorded. Monitoring at administrative building and surrounding settlements also carried out to know the landfill gas concentration.

11.6. Incoming Waste Monitoring

In coming waste monitoring should be done daily for the waste brought to the sanitary landfill for final disposal. It should be done through visual inspection by responsible site supervisor. This monitoring is done to control entry of hazardous and liquid waste.

LSMC should take lead role for periodic monitoring of the landfill.

11.7. 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. If 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.

11.8. 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.

12. EMERGENCY MANAGEMENT

12.1. 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.

12.2. Emergency Management and Contingency Plan

The intent of this manual is 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.

12.3. Emergency Response

The response suitable to some emergency types is described hereafter. The operator shall maintain a monthly Emergency Response Record of all emergency cases happening at the site.

12.3.1. Unauthorized Load

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

12.3.2. 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

In such situation contact a company specializing in hazardous and toxic materials to identify and assist to remove the suspected materials, as required. Also prepare full report with supporting documentation for submission to the relevant authorities.

12.3.3. 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 landfill 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.

12.3.4. Earthquake

If 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.

12.3.5. 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 landfill is small and it is not possible to provide such an area. Under this condition actions as outlined above 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 affected areas, once the storm has abated.

12.3.6. Access Road Problems

If there is 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.

If 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.

12.3.7. Residents Site Blockade

All problems related to residents in the surrounding areas should be dealt with through discussions with coordination committee by LMSC. The Committee representative should be informed immediately of the occurrence of such problems and take the necessary action to resolve the problem.

13. LANDFILL CLOSURE PLAN

13.1. 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, after completion of landfill activities necessary measures are to be taken to avoid any pollution risk and to return the site to a satisfactory state.

13.2. 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 at the minimum will comprise of following:

- A protection layer – comprising of subsoil, to safeguard against intrusion by plants, animals, etc.
- 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
- A gas collection layer – sand, geo-textiles or geo-nets to transmit gas to collection points.

13.3. 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.

13.4. 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.

13.5. 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.

13.6. 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.