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OPERATIONS MANUAL

Birgunj Integrated Solid Waste Management

Volume 1 : Integrated Solid Waste Management Site (Sanitary Landfill)

Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Birgunj, Nepal



Birgunj Metropolitan City, Birgunj, Nepal

July 2019

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Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Birgunj, Nepal

OPERATIONS MANUAL
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Volume 1

Integrated Solid Waste Management Site (Sanitary Landfill)

For: Birgunj Metropolitan City, Birgunj, Nepal

JULY 2019

ACRONYMS

3R	Reduce, Reuse and Recycle
ADB	Asian Development Bank
APs	Affected Persons
BoQ	Bill of Quantities
BMC	Birgunj Metropolitan City
cap	Capita
CBS	Central Bureau of Statistics
CBO	Community-based Organization
CDM	Clean Development Mechanism
CDP	Community Development Program
CDTA	Capacity Development Technical Assistance
CERS	Certified Emission Reduction Units
CPs	Waste Collection Points
DDC	District Development Committee
DNA	Designated National Authority
DSC	Design and Supervision Consultant
DUDBC	Department of Urban Development and Building Construction
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GESI	Gender Equality and Social Inclusion
GHG	Greenhouse Gas
GIS	Geographic Information System
GoN	Government of Nepal
HHs	Households
IA	Implementing Agency
IEE	Initial Environmental Examination
IPCC	Intergovernmental Panel on Climate Change
ISWM	Integrated Solid Waste Management
cu.m.	Cubic Meter
kg	Kilogram
km	Kilometer
m	Meter
LIDS	Local Initiative Development Support Program
LSP	Leachate Stabilization Ponds

MIS	Management Information System
MPPW	Ministry of Physical Planning and Works
MoSTE	Ministry of Science, Technology and Environment
MoUD	Ministry of Urban Development
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
NLSS	Nepal Living Standards Survey
NPR	Nepalese Rupee
O&M	Operation and Maintenance
OHS	Occupational Health and Safety
PCO	Project Coordination Office
PMSC	Project Management Support Consultants
PIU	Project Implementation Unit
pph	people per hectare
PPP	Public-Private Partnership
PPPUE	Public Private Partnership for the Urban Environment
PPTA	Project Preparatory Technical Assistance
sq.m.	Square Meter
QA/QC	Quality Assurance and Quality Control
STIUEIP	Secondary Towns Integrated Urban Environmental Improvement Project
SWM	Solid Waste Management
SWMTSC	Solid Waste Management Technical Support Center
TDF	Town Development Fund
TLO	Tole Lane Organization
Tonne	Metric Ton
ToR	Terms of Reference
TRP	Tribhuvan Rajpath
UEIP	Urban Environmental Improvement Project
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VDC	Village Development Committee
WRPC	Waste Resources Processing Center
WWSP	Waste Water Stabilization Ponds

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CHAPTER 1: INTRODUCTION

1.1 Purpose of the Manual

This Operations Manual, Volume 1: Integrated Solid Waste Management Site (Sanitary Landfill) is prepared to implement Package II or the SWM Component of the Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP) in Birgunj Metropolitan City (BMC) and operationalize the newly-constructed engineered sanitary landfill site of BMC.

The SWM Component includes construction of infrastructure to manage Birgunj's municipal solid waste comprised of: the waste storage/container system, the waste collection system, the transport system, and the Integrated Solid Waste Management disposal site composed of the Waste Resources Processing Center, the Composting Center, and the Sanitary Landfill for the disposal of residual wastes. Hereinafter, the foregoing systems are collectively referred to as the Integrated Solid Waste Management (ISWM) System while the sanitary landfill site compound housing the SWM facilities is referred to as the ISWM site. Two (2) other manuals in separate volumes complement the ISWM Site Component. Operations Manual, Volume 2 is for the Composting Center and Operations Manual, Volume 3 is for the Waste Collection and Transportation Program of BMC.

The proper operation of the Integrated Solid Waste Management site and its components is essential for the success of the city's investment in solid waste infrastructure and equipment. Similar facilities in many newly-developing countries fail because of the lack of qualifications and experience and an ineffective regulatory framework for supervising the operational shortcomings of the landfill operator. Thus, it is critical for the BMC or its qualified representatives to provide the operators with operational permits, licenses and guidance on the most fundamental issues associated with managing the ISWM site.

This Manual sets out the basic operational guidance for successfully operating the site facilities. To be successful, this manual cannot be stagnant and should be updated periodically to meet changing conditions in the metropolis due to rapid urban growth. The operators of the city will need a regular and sustained training program under the City's capacity development program, and be engaged in activities at the actual site. The training will need to provide the theoretical basis and reasons behind the prescribed operational approaches.

To ensure sustainable operations, it is recommended that follow-up audits and additional training or revisions be undertaken by external specialists experienced in actual landfill operational requirements over a pre-determined program by the City.

To have a comprehensive understanding of the basic elements of the Integrated Solid Waste Management System, the Operator is referred to the following:

1.2 Overview of the Integrated Solid Waste Management (ISWM) System

The following table summarizes the components of the ISWM Sub-Project, BMC, from waste collection to disposal of residual wastes at the ISWM site:

Table 1: Overview of the Integrated Solid Waste Management (ISWM) System

SYSTEM COMPONENT	AREA (M^2)/ DIMENSIONS	FUNCTION	DESCRIPTION
WASTE COLLECTION AND TRANSPORTATION PROGRAM	BMC (Wards 1 – 19)	Municipal solid waste collection and transportation to disposal site (ISWM) site	Skip container and block collection system, street sweeping and pick-up service

WASTE RESOURCES PROCESSING CENTER (WRPC)
• Office and Sorting Area
• Recyclables Area
  ○ Paper
  ○ Plastic
  ○ Glass
  ○ Metal
• Hazardous Materials room
	0.645 ha	Recovery of recyclables and reusable materials in accordance with 3Rs program, Disposal of hazardous wastes to be determined by BMC	Project component with reusable or recyclable materials average production of at least 3 tonnes per day

COMPOSTING CENTER • Composting Reception Area • Sorting Area • Shredders • Windrow Compost Piles • Compost Maturation Bins • Post-harvest screening and packaging • Final Compost product storage & • Sales Office	0.945 ha	Resource recovery from organic wastes and reduction of disposal costs through compost production in accordance with 3Rs program	Project component with compost average production of at least 2 tonnes per day
ISWM SITE: SANITARY LANDFILL CELLS AREA (Residual Wastes) BASE LINER SYSTEM LEACHATE COLLECTION PIPING SYSTEM	Total: 4.86 ha Phase I cells: 1.4 ha Phase IIcells:1.38 ha Phase III cells: .76 ha 5.72 ha 1,761 m	Engineered disposal area designed to protect groundwater and minimize environmental impact to air, water bodies and land Protect groundwater from leachate generated from landfill cells	• Capacity: approximately 400,000 cu.m.compacted • Average filling rate/day: 1) 59 cu.m./d w 3Rs 2) 107 cu.m./d w/o 3Rs • Average lift height: 1.5 m • Lifespan: 15 years Compacted clay liner, HDPE geo-membrane, HDPE Perforated Pipes, geotextile fabric
LEACHATE GAS VENTING (PASSIVE) LEACHATE STABILIZATION PONDS • Collection Chamber • Anaerobic Pond 1 • Anaerobic Pond 2 • Facultative Pond • Maturation Pond LEACHATE TREATMENT FACILITY	26 vent locations: Phase I cells: 11 Phase II cells: 9 Phase III cells: 6 20 m^2 1,500 m^2 500 m^2 3,726 m^2 1,795 m^2 Future area	Passive release of landfill gas, for safety and public health Stabilize and treat leachate by natural methods and protect ground water and surrounding surface water Protect	Vertical PVC perforated pipes Preliminary biological treatment for 1st year of operation at low cost. Combine with back-up plan for leachate treatment offsite. Ponds used for future leachate stabilization. Future plant after

SYSTEM COMPONENT	AREA (M^2)/ DIMENSIONS	FUNCTION	DESCRIPTION
	requirement to be determined; future area allocated	groundwater and surrounding water bodies	establishing leachate characteristics with 3Rs
BUILDINGS, SUPPORT FACILITIES AND SITE INFRASTRUCTURE			
MAIN ENTRANCE GATE AND GUARD HOUSE PERIMETER WALL	Gate:1.8m height x 8 m width Guard House: 14m^2 Perimeter wall:1778 m	Security and traffic control	Security Gate and Guard House
ENTRANCE DRIVEWAY , MAIN AND INTERIOR SERVICE ROADS	Main and interior roads: 1,578 m	Access and internal circulation	Asphalt Concrete
WASTE RECEPTION CENTER/WEIGHING STATION	Location as shown in drawings	Waste tracking and control, materials security and quality assurance	Control Center attached to Administration Building
ADMINISTRATION BUILDING	185 m^2 floor area	Management, administration and financial/accounting work	Concrete Building
WORKSHOP AND EQUIPMENT SERVICE CENTER	390 m^2 floor area	Repair and maintenance, vehicle washings	Concrete Building with Open Bays
GENERATOR HOUSE AND ELECTRICAL ROOM	18 m^2	Emergency or alternate power source	Concrete Structure
WATER SUPPLY PUMPING STATION AND ELEVATED WATER TANKS	6 ea 1,000 liter tank 1 ea 5,000 liter tank	Domestic water supply and vehicle washing	Structural Steel framing and Extra Heavy Duty HDPE Water Tanks
FUEL STORAGE STRUCTURE	3,000- 5,000 liter capacity	Storage	For future construction as needed during operations
MONITORING WELL NO.1	Existing Borehole No.1	Monitoring environmental impact: water quality , ground water and flood level	Located downstream of site along Singha River. Secured and protected for regular environmental monitoring.
MONITORING WELL NO. 2	Existing Borehole No.2	Monitoring environmental impact: water quality, ground water and flood level	Located upstream of site along Singha River. Secured and protected for regular environmental monitoring.
MONITORING WELL NO.3	New tube well for development beside Borehole No. 3 for process and domestic water supply	Monitoring environmental impact: water quality, ground water and flood level	Located upstream of the landfill cells site at its eastern boundary. For domestic water supply, and regular environmental quality monitoring.
OPEN SPACE AND LANDSCAPING	As shown in the drawings	Aesthetics, health and well-being, and long term use plan	In accordance with BMC's Clean and Green and related environmental program.

1.3 Important Issues in ISWM Site Operations

Important issues in ISWM Operations are raised in this Manual for guidance as these will play an important part in the successful implementation of the ISWM program over the next 15-20 years. These are:

- To maximize the useful life of the ISWM site, the awareness campaign for the 3Rs (Reduce, Re-use and Recycle) in all the wards and generators of solid waste should be sustained as a priority program to successfully realize waste reduction and minimization at the source and segregation to maximize recovery of materials. To this end, the City should coordinate purposefully with the work of NGOs, CBOs, community environmental and pollution control programs and other groups involved in waste management, pollution control and public health, whose work should be encouraged and supported.

- Through existing legislation and new ordinances, the following types of wastes should be strictly prohibited from entering the site:

  1) unwanted health care wastes from hospitals/health care facilities,
  2) industrial and toxic wastes from the industries,
  3) bulky construction and demolition debris

  The generators of the above types of waste should comply with existing environmental laws mandating management and treatment of their own wastes prior to disposal into the municipal waste stream.

- Groundwater sampling and monitoring from the two monitoring wells, as well as from the additional pumping stations and wells developed onsite for domestic water supply should be performed and reports prepared quarterly.

- The flood design level for the proposed Sanitary landfill Site should be monitored throughout the operational years, especially during the monsoon season so operational adjustments can be anticipated for operating the sanitary landfill cells area, and most importantly for future construction of the Leachate Treatment Plant once the leachate characteristics are determined depending on the 3Rs progress.

- The final closure and post-closure long term plan for the sanitary landfill site after its useful life has been reached shall always be considered as a major factor in the regular preparation of the current short term operational plans of the BMC for the ISWM site.

Base Map of Birgung Sub Metropolitan City

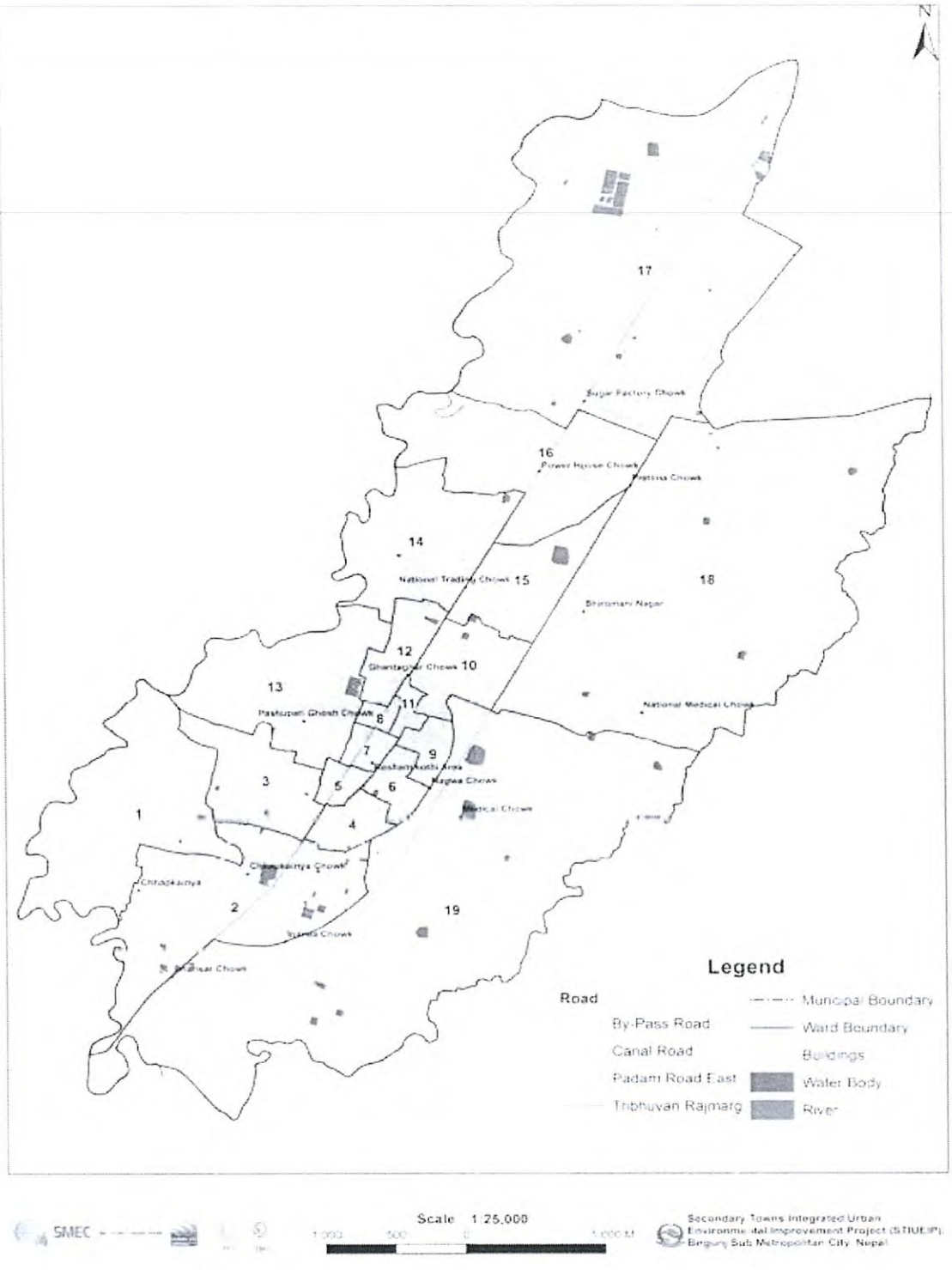


Figure 1: Ward Locations in Birgunj (2016)

CHAPTER 2: THE INTEGRATED SOLID WASTE MANAGEMENT SYSTEM

2.1 Overview of the Integrated Solid Waste Management (Sanitary Landfill) Site

The Integrated Solid Waste Management site includes the Composting Center, Waste Processing Resources Center, the Sanitary Landfill Cells area (Phases 1, 2 and 3), the Administrative Building, Workshop and Service Facility, Leachate Stabilization Ponds, service roads, and the other support buildings and facilities constructed within a 10.76 hectare property owned by the Birgunj Metropolitan City and located at Itiyahi and Bishrampur VDC, Ward Nos. 7 and 9 respectively, of Bara District in the Central Development Region of Nepal. The Singaha River is located on the western side of the proposed sanitary landfill (SLF) site which is at the boundary of Ward No. 19 of Birgunj Sub-metropolitan city. The proposed site is linked with Birgunj via existing 1.0km gravel road from Nagwa Ward No. 19.

The SLF with a total area of 10.76 ha is located in the Terai plain. Geographically it is located at 26°59'47" north latitude and 84°53'20" east longitude with average altitude of 80.5m. The landfill site area consists of plain terrain mainly of quaternary sediments constituting cultivated land. It is composed of very fertile soil mixed of clay, silt and sand.

The Municipality's waste collection vehicles coming from the different wards of Birgunj shall bring the segregated recyclable wastes into the Waste Resources Processing Center (WRPC) and the organic compostable wastes to the Composting Center at the ISWM site for further processing. The recyclables and the compostable materials will be further sorted at both centers and brought to their respective processing centers respectively. The remaining or residual wastes will then be disposed at the sanitary landfill cells area in a sanitary manner with daily cover for each cell and the proper management of leachate and gas.

The sanitary landfill is designed for a life of at least 15 years. With proper management it's life may extend to 20 years. It is the major component of the Integrated Solid Waste Management Site proposed for Birgunj Metropolitan City. The segregation of waste generated at the source from the households (HH), wards, commercial and institutional areas is the key to the successful operation of the sanitary landfill site. The Integrated Solid Waste Master Plan envisions pre-collection HH and ward-level composting and materials recovery to reduce wastes that need to be hauled to the ISWM site. The organic fraction is estimated to be between 50 to 60 % biodegradable while the rest is estimated to be non-biodegradable or recyclable waste, and the rest of residual wastes for proper disposal into the sanitary landfill.

The Integrated Solid Waste Management (Sanitary Landfill) site consists of a complex of the following solid waste management functions:

- Waste reception, business office and clearance for entry into the integrated Solid Waste management (sanitary landfill) site
- Composting Center for a 2-tonne per day pilot compost manufacturing facility
- Waste Resources Processing Center for managing 2 tonnes recyclable waste for storage and linking the products after light processing with buyers, consolidators and junk shops
- Landfill Cells Area for the deposition of residual wastes in a properly engineered manner
- Workshop and Service Center for servicing the landfill equipment and washing/servicing of the collection vehicles and equipment

- Leachate Collection and Treatment System for ensuring that the groundwater table is not contaminated by leachate
- Waste stabilization ponds and Leachate Treatment Plant (future) system for ensuring that the leachate is treated according to Nepalese effluent or stream standards prior to release into the Singha river

2.2 ISWM Site Master Plan

The main facilities in the sanitary landfill site consist of the following (See Figure 2):

- Entrance Gate and Guard House
- Frontage boundary wall
- Property boundary fence
- Interior and Service Roads
- Waste Reception Center (with Truck Axle Weighing Scales)
- Administration building
- Waste Resources Processing Center (WRPC)
- Recyclable storage: Paper, Plastics, Glass, Metal
- Staff office (WRPC)
- Hazardous (Residual) waste room
- Composting Center
- Recyclables (non-compostable storage sheds)
- Composting reception area (Shredders)
- Windrow compost piles
- Compost maturation bins
- Post-harvest screening and packaging
- Final compost product storage & sales office
- Workshop/Office/Equipment depot and Washing Facilities
- Surface water Interception canal and management system
- Daily cover stockpile area
- Landfill Cells Area
- Landfill Base Liner System
- Leachate Piping Collection and Removal System
- Leachate Outlet Chamber
- Leachate Treatment Facility Office (Future)
- Leachate Treatment Holding Tank (Future)
- Leachate Treatment Plant Area (Future)
- Anaerobic Pond – 1
- Anaerobic Pond – 2

- Facultative Pond
- Maturation Pond
- Sludge Drying Bed (Future)
- Generator House and Electrical Room
- Fuel Storage Structure, 3,000-5,000 liters (Future)
- Water supply pumping station and Elevated Water Tank (Vehicle Washing Facility)
- Water supply pumping station and Elevated Water Tank (Domestic)
- Communication Facilities
- Water Distribution Facilities
- Gas Management Facility (Future)
- River Training Works
- Trees and plants along buffer zone
- Monitoring well No. 1
- Monitoring well No. 2
- Monitoring Well No.3 (the water supply tube well beside bore hole 3 will be utilized for monitoring)

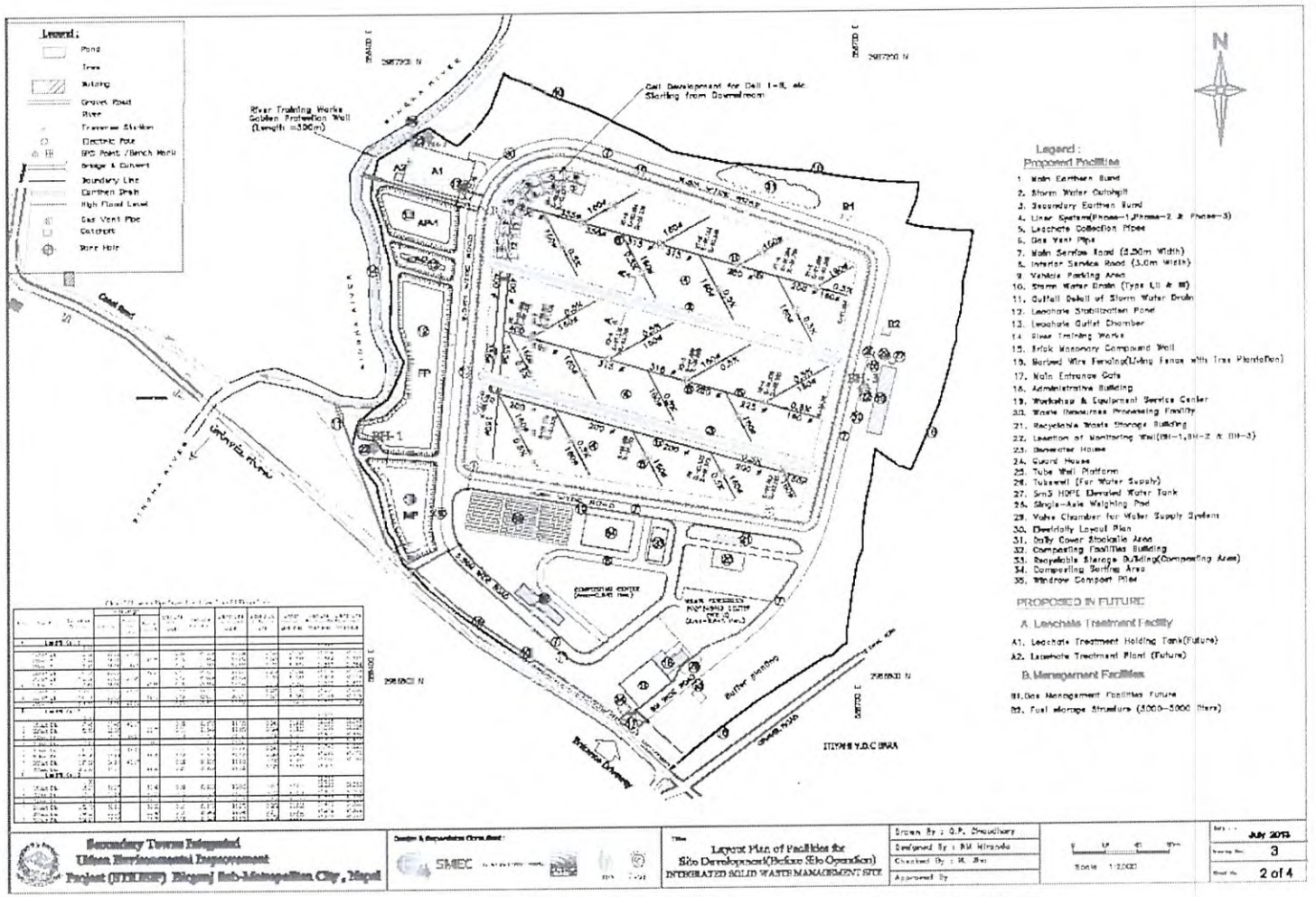


Figure 2: Layout Plan of Facilities for Site Development Plan Dwg. No. 3

2.3 Institutional Arrangements

The existing organization of Birgunj Metropolitan City consists of the Sanitation Department and the Environmental Sanitation Division. The department head has assigned a management position specifically to take charge of waste collection and another position to manage the ISWM site. Several positions for section heads and supervisors are respectively responsible for managing the technical operations of the Composting Center, the Waste Resources Processing Center and the Sanitary Landfill Cells area. These positions are in the organizational charts of the ISWM site chapter of this manual. Approximately 100 additional personnel are necessary for the full operation of the proposed collection and sanitary landfill vehicles and equipment and the additional personnel requirements for primary collection to bring the level of collection service to a higher percentage.

It is important for the present organization to work closely with the new organization running the landfill site. The two organizations need to be attached to the Sanitation and Environmental Department of Birgunj in their present set-up. As mentioned above, a Resident Manager is recommended to be assigned to the ISWM (Sanitary Landfill) Site.

2.4 Fleet of Waste Collection Vehicles and Equipment

The ISWM program utilizes the following waste collection vehicles, managed by the BMC Workshop and under the responsibility of the Mechanical Operation and Maintenance Department:

- Tippers (6 m^3 capacity) : 2 nos.
- Tractor-Trailers (3 m^3 capacity) : 4 nos.

The ISWM program utilizes the following waste collection equipment, managed by the Environmental and Sanitation Department, Sanitation Section:

- Rickshaws : 8 nos.
- Handcarts (Large) : 12 nos.
- Handcarts (Small) : 13 nos.

The fleet of waste collection equipment are dispatched daily from the Workshop/Equipment depot and parking lot provided by the City at the old bus park in Ward 13. Alternatively, depending upon the space allocation and to decrease the distance between the service areas and starting point of the collection fleet, some vehicles and equipment can park at the ISWM site.

A preventive maintenance program for all the vehicles and equipment shall be formulated, implemented and updated regularly.

The following is the list of vehicles and equipment utilized for the ISWM Project. These will need to be updated at the time of operationalization of this Manual:

1. Refuse Collector Skip/Hoist Truck - 2 nos.
2. Backhoe Loader - 1 no.
3. Track Dozer CAT D6 - 1 no.
4. Solid Waste Skip / Container - 28 nos.
5. Tractor with Trailer (3.4 m^3) - 4 nos.
6. Tipper (6 m^3) - 1 no.
7. Tipping Paddle Rickshaw - 38 nos.
8. Rickshaw (50" × 33" × 30") - 4 nos.

9. Rickshaw (39" × 39" × 16") - 36 nos.
10. Hand Cart (60" × 36" × 18") - 25 nos.
11. Hand Cart (48 × 30" × 18") - 15 nos.
12. Shredding Machine - 2 nos.
13. Single Axle Weighing Scale - 1 nos.
14. Platform Weighing Scale (balance) - 1 no.
15. Waste Bins (150-liter capacity - 10 nos.
16. Waste Bins (50-liter capacity) - 152 nos.

The list of tools, machines and equipment that are needed to operate the ISWM site's different sub-components can be found in the detailed Bill of Quantities volume of the STIUEIP Final Report that will be made available by the BMC upon request.

2.5 Occupational Health and Safety

Working at the ISWM site facility can be dangerous, particularly when precautions are not taken. A landfill safety plan should be prepared by the Contractor/Operator before commencement of any operations at the ISWM site, and updated as required.

Among others, the following frequently reported hazards should be considered in the preparation of a landfill safety plan:

- Accident injury through collisions with heavy vehicles or worker/personnel contact with stationary and mobile vehicles and equipment
- Fires and explosions of gas
- Inadequate maintenance of vehicles and landfill equipment, devises and tools
- Direct exposure/contact with hazardous substances, i.e. leachate, acids, alkalis, dusts, infectious wastes, asbestos etc.
- Accidental contact with sharp or pointed objects
- Physical body stresses imposed by dust, rain, heat, cold, odors and insects
- Vibration from heavy machinery
- Working too close to loud noises without precautions
- Toxic fumes from burning waste as a result of spontaneous combustion
- Over exposure to the sun being a hazard for skin cancer

Constant supervision of the landfill is required, even though the general public should not be allowed access to the landfill cell areas unless they are authorized to do so to transact business with the Administration Building, Waste Resources Processing Center and the Compost Center. The operating managers and supervisors of each ISWM site component area should ensure that vehicles, equipment and tools and other materials are in the correct place to avoid any adverse incidents. At the landfill cells area particularly, the operations staff and equipment operators should make sure that the transport and working crew are able to tip safely and reverse safely within the landfill cells area. It is also vital to know if people are at safe locations when work is ongoing within the active cells of the landfill.

Inhalation of dust and noxious fumes from fresh waste is an important health consideration. A water truck and regular access to dust control water spray should always be available, especially on the main and service roadways.

A fire preparedness, management and prevention (PMP) program should be instituted and maintained at all hazard areas within the ISWM site. As a precaution, fire extinguishers should be provided in accordance with the fire PMP and training on their use should be regularly held for all employees and staff working in the ISWM site.

Personal Protective Equipment should be distributed and mandated for use by the staff and visitors at all times when exposed to the aforementioned hazards. Adequate protection against noise for staff and operators working near or on loud machinery should be ensured.

It is essential that all staff and operators undertake training programs thereby ensuring the safe transfer of responsibility when assigned people are unavailable, such as on leave.

First Aid kits must be provided onsite and be properly maintained. Several staff members must be trained in First Aid, to ensure at least one (preferably a supervisor) is available at all times and a safety officer appointed. In addition, appropriate access for emergency vehicles and directional signage to main facilities should be maintained at all times.

2.6 Basis of Operational Plan

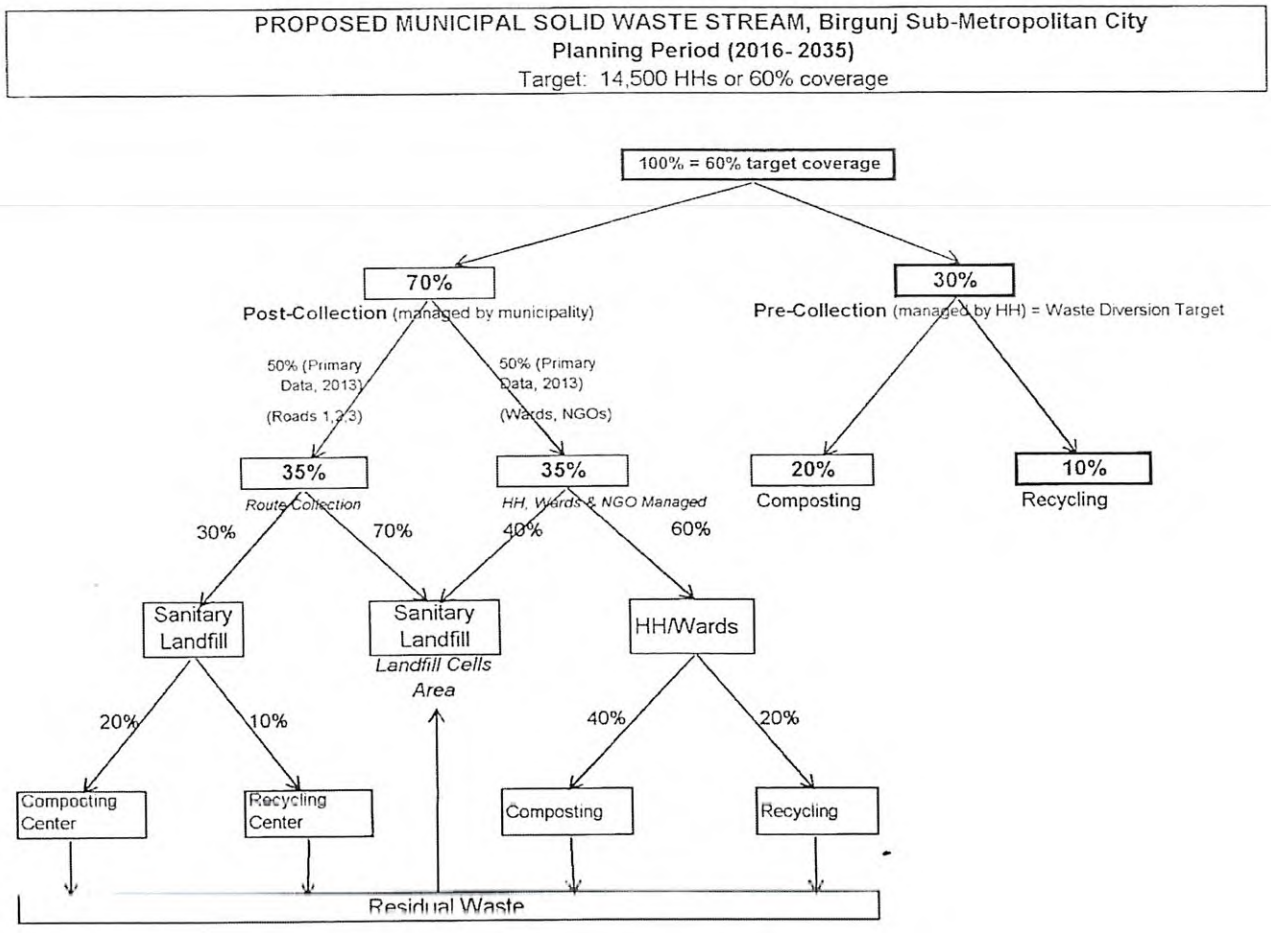


Figure 3: Birgunj Proposed Solid Waste Stream for 3Rs

The level of municipal solid waste collection service in Birgunj is presently around an average of 39.2% or estimated between the range of 35% to 40% of the expected waste generation rate of 0.35 kg/cap/day of Birgunj" total population in early 2013. This is based on 3 months of data gathered from the BMC Sanitation Section and analysed during the first quarter of 2013. Of the total population of Birgunj in early 2013 only 35% to 40% are being serviced by the municipality. The following could be some of the reasons for this:

- There are not enough access roads to reach the outer wards or the roads are too narrow so only handcarts with limited access can reach the households for collection
- The population is sparsely distributed at the outer core of the sub-metropolis so that only the inner core can be efficiently serviced
- There is little demand for solid waste service in the far flung communities particularly on the agricultural areas
- There is a shortage of personnel and equipment to increase the level of service

2.7 3Rs Scenario

Figure 3 above for the Proposed Municipal Solid Waste Stream illustrates the operational framework of the 3Rs envisioned by for Birgunj.

In other developing countries similar to the climate and weather patterns in Birgunj, it is customary to set the level of collection service to at least 60%. In some cities who are aware of and practice 3Rs, the level of collection service is usually in the range of 80% to 90%. Since Birgunj is relatively new to the concept of 3Rs, the level of collection service has been set by the metropolis at 60%. 60% target collection coverage means the proposed management target of the waste collection program based on existing and projected availability of roads and collection routes for service access. This quantity includes the pre-collection, waste reduction target of 30% by the households.The existing waste collection service was at the level of 35% based on the survey of the number of trips by the tippers, tractors and trailers, rickshaws and calculation of volumes.

Referring to Figure 3 above and the 3Rs concept, 30% of the collection service is the targeted waste diversion for the households to practice waste reduction at pre-collection stage. The households are encouraged to reduce their waste and handle their wastes by way of backyard composting and reuse or redemption of recyclables. This amount is allocated to the households for waste reduction by intended waste diversion. Success will be dependent on the cooperation of the households on this activity.

70% of the collection service coverage will be managed by the municipality. Based on past collection data, 35% will be collected by route collection on Roads 1, 2 and 3. For this portion, referring back to Figure 3, 70% of the route collection waste are expected to be mixed waste and will go straight to the sanitary landfill site, specifically in the landfill cells area. 30% of the route collection waste are expected to comprise 20% for composting and will proceed to the Composting Center and 10% for recycling expected to be brought to the Waste Resource Processing Center for further processing.

The other 35% of the collection service coverage will be managed by the inner core wards with the assistance of NGOs. At present Wards 10 and 15 are managed by CBOs on a private-public partnership with the municipality. 60% of this 35% are designed to be managed by other NGOs/Wards themselves on an expanded basis. 40% will be targeted for composting while 20% will be for recycling. The balance of 40 % of the 35% is expected to go straight to the sanitary landfill cells area.

Table 2: Estimated MSW Material Balance from Waste Collection to Residual Sanitary Landfill (First Year of Operation, 2016)

Municipal Waste Stream	tonnes/day	cu.m./day
Total Waste Generation, Organic and Inorganic Fractions, 2016	41.59	128.7
Total Waste Generation, Organic (biodegradable and compostable = 51.09 %)	28.36	87.79
Total Waste Generation, Inorganic (reusables and recyclable = 18.51% + 5.32 %)	13.23	40.95
SKIP CONTAINER input (Compost Center)	17.97	55.63
Compostables recovered (30 % of biodegradable input)	5.39	16.69
Compost Product (50 % of compostables plus 25 % additives)	3.37	10.43
Recyclable recovered move to WRPC (15% of compost center input)	2.70	8.34
Residual waste in composting haul to landfill	12.58	38.94
SKIP CONTAINER input (Waste Resources Processing Center)	8.38	25.95
Recyclable product recovered (range of 50%-90% of WRPC inputs)	5.55	17.17
Residual waste in WRPC haul to landfill	2.84	8.78
BLOCK COLLECTION inputs (Composting Center)	1.56	4.83
Compostables recovered (30 % of biodegradable input)	0.47	1.45
Compost Product (50 % of compostables plus 25 % additives)	0.29	0.91
Recyclable recovered move to WRPC (15% of compost center input)	0.23	0.72
Residual waste in composting haul to landfill	1.09	3.38
BLOCK COLLECTION inputs (WRPC)	0.56	1.75
Recyclable product recovered (range of 50%-90% of WRPC inputs)	0.30	0.94
Residual waste in block collection haul to landfill	0.26	0.81
Residual, other Inorganics from block collection (5.32%) to landfill	0.93	2.87
STREET SWEEPINGS haul to landfill	5.52	17.08
TOTAL ESTIMATED COMPOST PRODUCT	3.66	11.34
TOTAL ESTIMATED RECYCLABLE PRODUCT	8.78	27.18
TOTAL RESIDUAL WASTES TO LANDFILL	23.21	71.85

CHAPTER 3: THE INTEGRATED SOLID WASTE MANAGEMENT (ISWM) SITE

3.1 The Operational Plan of the Integrated Solid Waste Management (ISWM) Site

The ISWM site has a total property area of 10.76 ha located in the Terai plain. Geographically it is located at 26°59'47" north latitude and 84°53'20" east longitude with average altitude of 80.5m. The landfill site area consists of plain terrain mainly of quaternary sediments constituting cultivated land. It is composed of very fertile soil mixed of clay, silt and sand.

The property is located in the Birgunj Sub-metropolitan city and lies in Itiyahi and Bishrampur VDC, Ward No. 7 and 9, respectively of Bara District in the Central Development Region of Nepal. The Singaha River is at the western boundary of the proposed site adjacent to Ward No. 19 of Birgunj. The site is linked with Birgunj via an existing 1.0km gravel road from Nagwa at Ward No. 19.

The sanitary landfill is designed for a life of at least 15 years. It is a major component of the Integrated Solid Waste Management System proposed for the Birgunj metropolis. The sanitary landfill site is composed of several components to promote the concept of pre-collection 3Rs (Reduce, Reuse and Recycle). The segregation of waste generated at the source from the households (HH), wards, commercial and institutional areas is the key to the success of the operation of the sanitary landfill site.

The Integrated Solid Waste Master Plan envisions pre-collection HH and ward-level composting and materials recovery. The metropolis is advised to provide at least 2 types of storage containers for each generator of solid waste in the future: one for the organic or biodegradable and another for non-biodegradable wastes. The organic fraction is estimated to be between 50 to 60 % biodegradable while the rest is estimated to be non-biodegradable or recyclable waste, and residual wastes for proper disposal into the sanitary landfill. It is hoped for the success of the system that the households and wards will develop their respective composting and materials recovery facilities eventually. The residuals from the HHs and those wards with no capability for composting and recycling will be collected also in a segregated manner by the metropolis and hauled to the ISWM site for further processing. The landfill site will host a municipal-level Composting Center and a Waste Resources Processing Center where there will be a recyclable storage area. The final residual wastes shall be disposed of at the sanitary landfill cells area.

The proposed Sanitary landfill site consists of a complex of the following solid waste management functions:

- Waste reception, business office and clearance for entry into the sanitary landfill site
- Composting Center for a 3-tonne per day on average pilot compost manufacturing facility
- Waste Resources Processing Center for managing recyclable waste for storage and linking the products after light processing with buyers, consolidators and junk shops. This is initially estimated to have a capacity of at least 2 tonnes per day.
- Landfill Cells Area for the deposition of residual wastes in a properly engineered manner
- Workshop and Service Center for servicing the landfill equipment and washing/servicing of the collection vehicles and equipment

- Leachate Collection and Treatment System for ensuring that the groundwater table is not contaminated by leachate
- Waste stabilization ponds and Leachate Treatment Plant (future) system for ensuring that the leachate is treated according to Nepalese effluent or stream standards prior to release into the Singaha River

All the construction and working drawings of the above (except for those intended for future development) have been completed and are available from the BMC for reference upon request.

3.2 Components of the Integrated Solid Waste Management Site

The Integrated Solid Waste Management site includes the Waste Reception Control Area, Waste Processing Resources Center, Composting Center, the Sanitary Landfill Cells area (Phases 1, 2 and 3), the Administrative Building, Workshop and Service Facility, Leachate Stabilization Ponds, service roads, and the other support buildings and facilities to be developed within an 10.76 hectare property owned by the Birgunj Metropolitan City.

The Sanitary Landfill Cells area (SLF) has a total area of 10.76 ha is located in the Terai plain. Geographically it is located at 26°59'47" north latitude and 84°53'20" east longitude with average altitude of 80.5 m. The landfill site area consists of plain terrain mainly of quaternary sediments constituting cultivated land. It is composed of very fertile soil mixed of clay, silt and sand.

The Municipality's waste collection vehicles coming from the different wards of Birgunj shall bring the segregated recyclable wastes into the Waste Resources Processing Center (WRPC) and the organic compostable wastes to the Composting Center at the ISWM site for further processing. The recyclables and the compostable materials will be further sorted at both centers and brought to their respective final processing centers respectively. The remaining or residual wastes will then be disposed at the sanitary landfill cells area in a sanitary manner with daily cover for each cell and the proper management of leachate and gas.

In the long term, the sub-metropolis is advised to provide at least 2 types of storage containers for each generator of solid waste: one for the organic or biodegradable and another for non-biodegradable wastes. The cost of these could be offset by the user fees that the beneficiaries of the service would eventually agree to pay.

The main facilities of the site development Master Plan consist of the following (see Figure 2):

- Entrance Gate and Guard House
- Frontage boundary wall
- Property boundary fence
- Interior and Service Roads
- Waste Reception Center (with Truck Axle Weighing Scales)
- Administration building
- Waste Resources Processing Center (WRPC)
- Recyclable storage: Paper, Plastics, Glass, Metal
- Staff office (WRPC)
- Hazardous (Residual) waste room
- Composting Center
- Recyclables (non-compostable storage sheds)
- Composting reception area (Shredders)
- Windrow compost piles

- Compost maturation bins
- Post-harvest screening and packaging
- Final compost product storage & sales office
- Workshop/Office/Equipment depot and Washing Facilities
- Surface water Interception canal and management system
- Daily cover stockpile area
- Landfill Cells Area
- Landfill Base Liner System
- Leachate Piping Collection and Removal System
- Leachate Outlet Chamber
- Leachate Treatment Facility Office (Future)
- Leachate Treatment Holding Tank (Future)
- Leachate Treatment Plant Area (Future)
- Anaerobic Pond – 1
- Anaerobic Pond – 2
- Facultative Pond
- Maturation Pond
- Sludge Drying Bed (Future)
- Generator House and Electrical Room
- Fuel Storage Structure, 3,000-5,000 liters (Future)
- Water supply pumping station and Elevated Water Tank (Vehicle Washing Facility)
- Water supply pumping station and Elevated Water Tank (Domestic)
- Communication Facilities
- Water Distribution Facilities
- Gas Management Facility (Future)
- River Training Works
- Trees and plants along buffer zone
- Monitoring well No. 1
- Monitoring well No. 2
- Monitoring Well No.3 (the water supply tube well beside bore hole 3 will be utilized for monitoring)

The buildings and site infrastructure and all the physical facilities of the Integrated Solid Waste Management Site were designed in accordance with Nepalese design criteria and standards. Where not available in Nepal, global standards for low- to middle-income countries were used.

Based on the detailed site analysis, the site has characteristics that are disadvantageous or are considered limitations of the site for a sanitary landfill. A hydrology report and a Geotechnical Report showing the results of the soils investigations were conducted to verify these conditions. The site limitations include: being a flood prone or inundation area during the monsoon season, high groundwater table observed, need for improvement of access by way of constructing an access road to serve the demands of the population adjacent to the site, and poor sub-surface conditions for natural attenuation of the anticipated leachate from the residual solid waste deposited at the sanitary landfill cells area. On the other hand it is advantageous that the settlement of the ownership of the property has already been achieved. In terms of impact areas, it is also advantageous that there is only sparse human population living adjacent to the site thus the project will have only limited interference to local human habitation or any protected or endangered flora and fauna which the site might have at baseline conditions.

Figures 4 and 5 below show the facilities plan layout and the utilities that are installed at the landfill cells areas prior to site operations for reference in discussing the ISWM site operational procedures.

3.3 Administrative Controls and Procedures

3.3.1 Signage

Adequate signage needs to be in place to inform who has access to the Site (the public is usually prohibited), where key aspects are located, especially the fundamental rules for the operation of the Site, etc. By providing adequate signage, misunderstandings and misuse of the landfill are avoided and directions for vehicle access are enforced in an orderly and safe manner.

A sign at the entrance should include:

- Official name of the facility
- Name of Owner of the waste management facility and regulatory authority
- Who does/who does not have access
- Hours of operation
- Emergency contact phone number.

A sign near the weighbridge should include:

- Official name of facility and city
- Name of Owner of the waste management facility and regulatory authority
- Wastes that are accepted
- Materials that are not accepted
- Speed limit (usually 10kph)
- Details regarding access i.e. public only allowed into recycling area and public tipping face.

A sign near both the public and any commercial tipping face should include:

- Directions to deposit various recyclables or green waste
- Directions on where to tip
- Instructions to follow the operator's directions.

On the Landfill and access roads, temporary signs must clearly mark the roads, direct vehicles to the tipping face and indicate tipping locations as well as the rest of the ISWM centers.

All signs should be removed at the ultimate completion of operations at the Site, except for monitoring locations.

3.3.2 Reporting Procedures

Daily Diary and Miscellaneous Report Sheets

The Daily Diary must be completed each day before the Site Foreman leaves the Site. A typical diary form is provided in Appendix A.

Plant service schedules and records of service and safety start-ups each day will be collected.

If blank forms are running out, the Foreman will arrange for more to be sent to the Site office.

The Incoming Waste Designation Sheets, Load Analysis Sheets and Incident Record Sheets will be collected at the end of each week. Samples are provided in the Appendix. In the initial stages of operation, only the Daily Diary and Incident Reports may be used until waste volumes increase, and greater control and reporting is necessary.

A summary report covering the number of loads, total volume/mass of waste or fill received and the number (if any) of incidents at the Site should be prepared. The individual sheets and the weekly summaries should be filed and copy sent to the Manager.

The Site Foreman will provide a monthly report to the Manager on all aspects of the Environmental Monitoring and Management Plan, including complaints and monitoring results. A summary of the operation of the Site should be included.

Complaints Register

The complaints register serves two purposes:

- It identifies problems unseen or neglected by the Site staff and will ensure that this problem is recognized and action is taken, if appropriate.
- It enables the public to maintain an ongoing relationship with the operation and enable them to have their concerns formally documented and recorded.

The complaints register applies to many aspects of the operation including noise, odor, dust, mud, visual impacts, wind-blown or water borne litter, water quality and so on.

Staff will keep a record of all complaints made about the Site. Generally, it will be the gatekeeper who receives the initial complaint, if it is given by phone or in person direct to the Site, or to the Site Foreman if a written complaint. Telephone complaints made directly to the City offices must be recorded and passed on to the Site Foreman immediately.

The Site Foreman will deal with all complaints and organize the appropriate action to be taken, assess the level of urgency and check if the complaint is valid. The Site Foreman is also responsible for informing the party who complains by letter of the outcome of their complaint, with a copy in his monthly report to the Manager.

Operating License Reporting Requirements

The external reporting requirements will be taken from the Site License where one has been issued. They must be strictly followed or the operator can be fined.

In general, the City will typically be required to report on at least the following issues:

- Annual quantity of different waste types accepted
- Annual quantity of different waste types rejected
- Annual quantity of different waste types recycled
- Annual evaluation of the overall Landfill performance, including air space consumed, monitoring results, complaints handling, etc. The review would involve all Site staff, and include a group section on possible environmental improvements. An external component would include neighbor feedback and discussions with local environmental agencies and departments.
- Possible quarterly audits by external auditor
- Possible yearly comprehensive external audit results
- Environmental improvement plan update, including training requirements, amendments to the policy statement, etc. If considered necessary.

Emergency Phone Numbers

A list of emergency phone numbers should be provided or posted where it is conspicuous and easily accessible and visible to all staff in the local understandable language at the ISWM site.

The numbers would include the General Manager, Site Foreman, Supervisor, Fire Department, Police, Ambulance, nearest Hospital, Environment Department, relevant City Officers, etc.

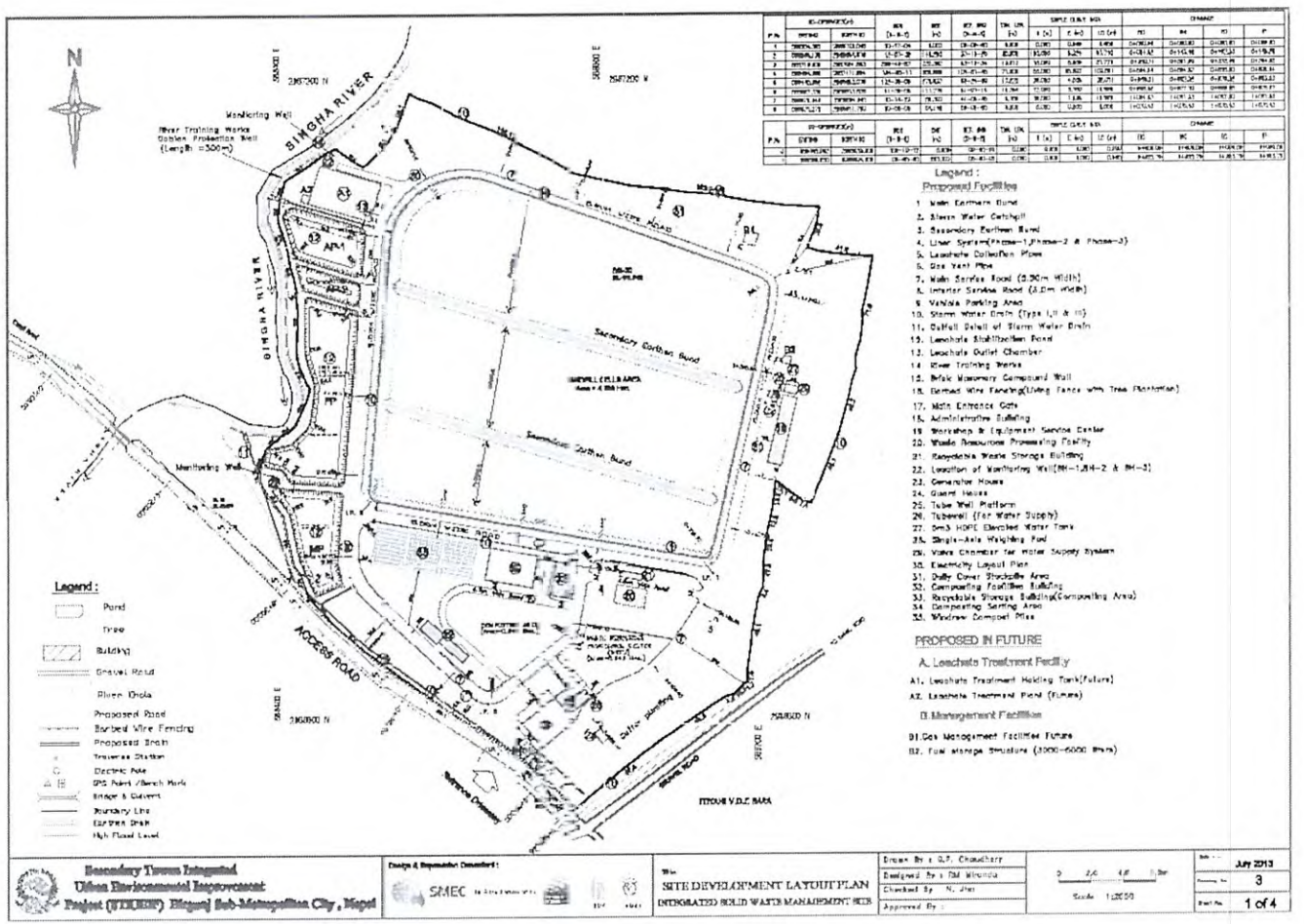


Figure 4: Site Development Layout Plan Drwg. 3 (1 of 4)



Figure 5: Layout Plan of Facilities for Site Development (before site operations) Drwg. 3 (2 of 4)

3.4 Operations of the Waste Reception/Weighbridge Station Control Area

The operational procedures herein were designed and developed to serve as guides for the facility managers and contractor-operators and the respective staff of the Integrated Solid Waste Management (ISWM) Program of Birgunj Metropolitan City in the operationalization of the proposed integrated solid waste management facilities. These procedures should not be considered complete and rigid but should be improved as the solid waste management program evolves and improves throughout the coming years. It is recommended that the procedures be reviewed for revision and updating at least once in 2 years.

The following is the operational procedure for the waste reception and weighbridge station:

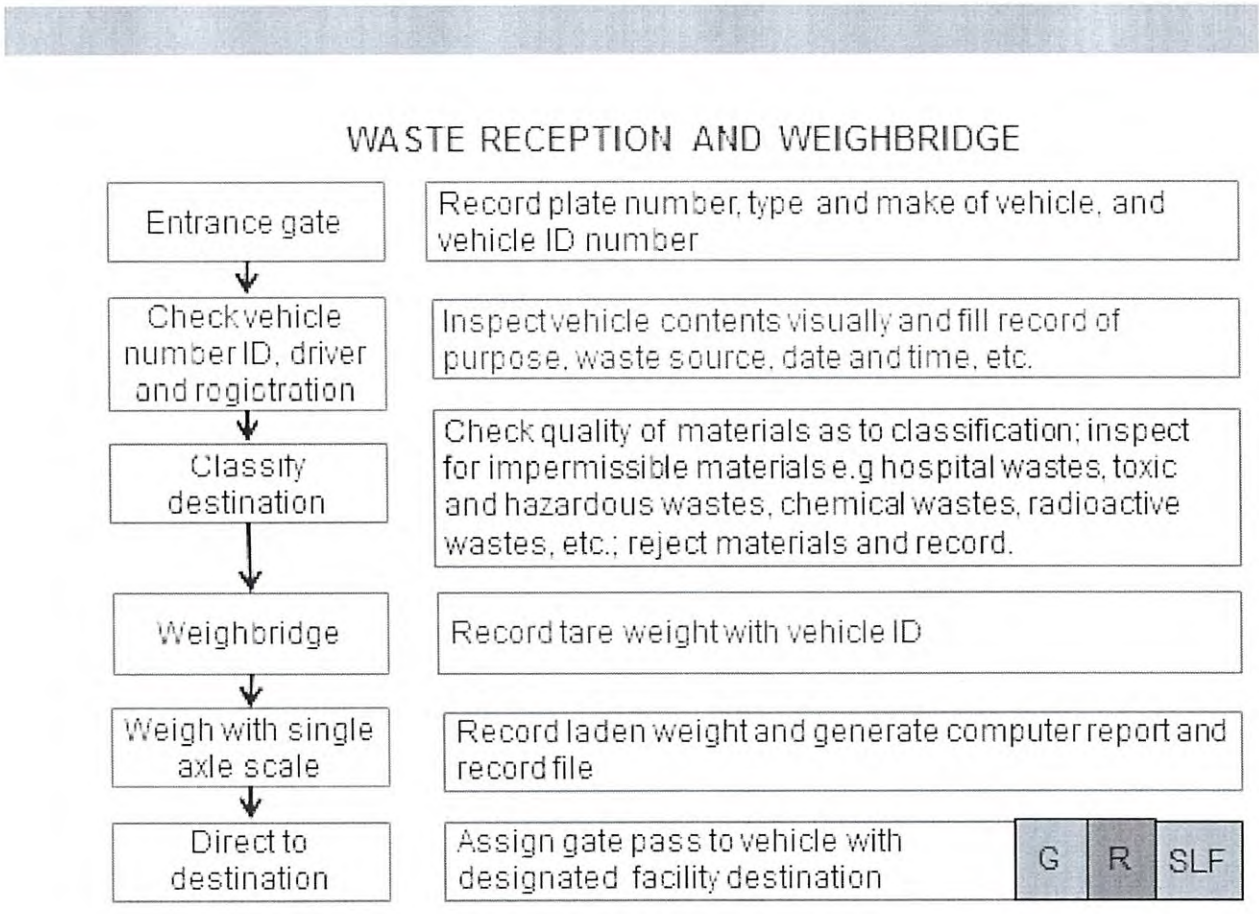


Figure 6: Flow Chart of Waste Reception and Weighbridge Station

The primary function of this entrance facility is to keep and maintain accurate records of the movement of personnel, workmen and staff, vehicles and equipment in the residual Sanitary Landfill facilities in the ISWM site. It shall also keep record of all the solid waste entering the facility, the type, volume and weight, according to the type of vehicle, and origin of the waste.

The classification and condition of waste entering the site is assessed and decided in this station for further assignment to a processing destination i.e. Waste Resources Processing Center, the Composting Center or the Residual Waste Sanitary Landfill cells area. Figure 6 above defines destinations as G for green to the Composting Center, R for red to the Waste Resources Processing (Recycling) Center and SLF in brown for the sanitary landfill cells area.

This record is vital for the payment of fees of the contractor-operator. It is likewise vital for the rejection of impermissible wastes that are brought into the site. Every effort is therefore necessary to ensure that the records are kept and maintained accurate and timely for the efficient operation of the ISWM site.

The weighbridge station is equipped with a computerized single- or double-axle load scale that calculates the laden weight of the vehicle and records the readings automatically with a printout of the complete record of the weighing activity.

One of the most important functions of this facility is to ban the entry of the following into the ISWM site:

- hospital wastes,
- toxic and hazardous wastes
- chemical wastes,
- radioactive wastes,
- construction and demolition waste
- septic and industrial sludge
- agricultural wastes (unless cleared and with municipal permit for Composting Center)
- More detailed guidelines for the assessment of the banned wastes will be issued by the BMC from time to time. Stiff penalties will be imposed on the contractor-operator if it is found by the municipal inspectors or their third party representatives to knowingly receive such banned wastes into the ISWM site.

3.4.1 Incoming Load Inspection Procedure

The following inspection procedure is comprehensive and may be introduced in a staged manner unless required in the operating license/permit to operate the Landfill.

Unless otherwise required by the Landfill approvals permit, it is recommended that the basic recording system be adopted initially, and the more complete docketing system be introduced over time or as legally required.

In any case, the following activities must occur:

1. All vehicles must stop at the gate/weighbridge.

2. The gatekeeper carries out an initial inspection and any vehicles obviously carrying a load containing obvious amounts of 'prohibited material' are rejected from the Site.

3. If the waste load appears acceptable, the following minimal data is recorded by the gatekeeper on the Incoming Waste Designation Sheet:

    - Date and time
    - Name of contractor, carrier or owner of vehicle
    - Registration number and type of vehicle
    - Volume or weight of waste
    - General summary of waste (major constituents such as builders waste or municipal domestic garbage)
    - Load Receipt number – if receipts are to be issued

- The Load Receipt form is the official record of having received the load of waste and a duplicate of this receipt is given to the driver of the vehicle who then proceeds to the tipping area on the Landfill.

4. The tipped load can be broken open and spread by an operator at the tipping face and then inspected by staff who check the description of the contents on the Load Receipt form.

5. If the Site Controller is satisfied with the load, it is spread, compacted and then covered.

3.4.2 Managing Prohibited Substances

The Landfill permit/license may in the future list all the materials that are acceptable for disposal at the Site. All other materials would therefore be considered prohibited from entry into the ISWM site. Unless otherwise specifically addressed in the permit, the above descriptions of acceptable and prohibited waste should be adopted.

Regular customers are to be advised in writing of the prohibited substances.

If prohibited substances are allowed in the Landfill by the operational staff, the following can occur:

- The operator/contractor running the Landfill can be fined or lose their license.
- The health and safety of staff and the public may be affected.
- After some time, the material may leak or change and become a danger to health or the environment.

The gatekeepers will require some education and training on this issue of load rejection and disposal alternatives. They should have a list of specialist disposal facilities in the gatehouse.

The following procedure is recommended:

1. As soon as a prohibited substance is identified, it must not be accepted further.

2. When prohibited substances are brought to the gatehouse, the driver of the vehicle is told that they cannot be accepted at the ISWM site. The driver is asked to return the waste to its source and - if there is such a designated disposal area for such materials authorized by BMC - to direct the driver to such site. In no instance will the waste be allowed into the site especially if the waste loads are found to be toxic and hazardous.

3. When prohibited substances are found on the tipping face, if feasible and safe to do so, the prohibited substances are removed by hand and placed in a nearby bin. When full, the bin is to be disposed of in an approved facility designated by BMC.

4. If it is not feasible to hand pick the dumped load, it may be necessary to use equipment to load the prohibited substances into the bin, for removal as above.

5. If prohibited substances are noticed during tipping, the delivering driver must be told to reload all of the substance and to remove it from the Site. If the driver refuses, write down as much of the following information as possible:

- Name
- Address
- Company
- Vehicle registration/type/color
- Time
- What the material appears to be
- Approximate amount involved

If necessary, call the police or relevant inspectors to come to site. If a prohibited substance is found on the tipping face of the landfill cells area, the material should be left alone and the matter immediately reported to the Site Foreman or the authorized personnel designated by the ISWM Resident Manager.

All staff are responsible for ensuring that prohibited substances are not accepted or allowed to be buried on the Site.

When the Load Checking Procedure reveals the presence of Prohibited Substances, the Site Foreman must fill out an Incident Record Sheet which details the following information:

- Date
- Load Receipt number
- Name of Contractor or Carrier
- Nature and quantity of prohibited substances
- Removal/alternate disposal details

The Load Receipt number will allow a ready cross-reference to the data on the incoming Waste Designation Sheet and the Load Analysis Sheet.

Notice of all "incidents" should be referred to the Contractor or Carrier so that they, in turn, can track down the source of the Prohibited Waste Substances.

For the sake of completeness and possible future reference, it is preferable for the Office Clerk to also fill out an Incident Record sheet for loads rejected during the initial inspection at the Site office. The Incident Details description of "rejected at gate" will explain why there is not a cross-reference to an Incoming Waste Designation or Load Analysis Sheet.

3.4.3 Waste Categories

Summary of Categories

The waste entering the Landfill may be categorized as follows:

1. Acceptable Wastes (General) – these wastes fall under the general classification of MSW or municipal solid wastes consisting primarily of general residential, commercial and institutional wastes that are classified as non-toxic and non-hazardous

2. Acceptable Wastes (Difficult Wastes) – tires, mattresses and other bulky materials that can affect the integrity of operation of the sanitary landfill

3. Special Wastes (Sometimes Acceptable) – asbestos, liquid waste that are non-toxic

4. Prohibited Wastes – radioactive wastes, health care and hospital wastes, other toxic and hazardous wastes from light and heavy industries, and construction and demolition debris over 30 cm in its largest dimension

The first category is always accepted, but the second category requires some special management or conditions for acceptance that may necessitate further processing by the waste contractor/generator.

The third category may be acceptable based on quantities involved, actual waste characteristics etc., and is decided on a case-by-case basis.

Prohibited wastes are never allowed into the Landfill.

It is critical that all loads are inspected when they arrive at the Site entrance gate - or any future skip station and transfer station in the collection system. An elevated floor at the reception gate allows for better inspections of truck loads, with a lower floor at vehicle window level.

Acceptable Wastes (General)

The following general wastes will be accepted at the Landfill:

- Domestic solid waste, as collected by city or private vehicles on a regular basis
- Acceptable commercial and nontoxic, non-hazardous industrial waste regularly collected by contractors or city waste collection vehicles
- Garden refuse (i.e. green waste or yard waste) that may or may not be collected separately to municipal waste
- Inert waste, i.e. non-bulky debris from grounds maintenance, light construction including concrete rubble, masonry, bricks etc. generally less than and not more than 30 cm in its largest dimension

Difficult Wastes (Usually Acceptable with processing)

Difficult wastes are those wastes that are allowed to be tipped at the Landfill but require special treatment to ensure that the best compaction/disposal is achieved. This class does not include hazardous or dangerous wastes, and bulky wastes that are detrimental to the landfill filling operations. These waste types are:

- Tires
- Mattresses
- Whitegoods (refrigerators, freezers or stoves) except e-waste (electronics) such as computers, monitors, mobile phones, tablets, laptops, etc. which contain hazardous wastes, heavy or toxic metals and chemical residues

A comprehensive list of difficult (acceptable and unacceptable) wastes will be provided by the City's solid waste management in-charge from time to time depending on the availability of

alternative secure disposal sites and industrial waste disposal regulations and ordinances enacted and enforced by the City.

Special Wastes (sometimes Acceptable)

These are other wastes that may be accepted on Site but these will have to be decided on a case-by-case basis, and would include some hazardous and dangerous waste. Later sections provide more guidance on how to manage these materials, such as:

- asbestos
- dead animals
- dry sludge, such as sewage treatment plant sludge
- liquid waste, including paints and thinners
- contaminated soil (provided the contamination agent is known)

Prohibited Wastes

Items always unacceptable in the Landfill will include:

- hot loads, greater than 50^{o}C in temperature
- pressure cylinders e.g. condemned gas cylinders, fire extinguishers
- recyclables, except to the recycling area, such as green waste, bulk metals or re-usable demolition waste
- large volumes of liquid waste, particularly if not mixed with an absorbent to a "spadeable" consistency
- radioactive waste
- large containers which cannot be crushed, and
- dangerous goods, such as reactive chemicals, explosives including unexploded bombs and so on. Dangerous goods are those waste that can affect a person's health or the environment. Some wastes appear to be safe when delivered to the Site, but when tipped can react with the air, water or other wastes to form a dangerous material. Typical dangerous goods include:
    - Chemical wastes which can react to form dangerous gasses, liquids or solids, particularly powerful oxidants like chlorine. Chemical wastes can be either liquid or solid.
    - Radioactive wastes. These can come from hospitals, universities, research institutes and private companies
    - Liquid wastes can be dangerous. These include oils, pesticides, solvents, paints, etc.
    - Asbestos (can be safe if correctly packaged, but dangerous if dry and powdery)
    - Medical waste (may be safe if autoclaved or pre-treated in some other manner, but very dangerous if containing infectious material, untreated used sharps and syringes)

There are many dangerous goods that can be delivered to a Landfill, and Landfill staff must exercise extreme caution when dealing with these wastes.

3.4.4 Difficult Wastes

Difficult wastes are those wastes that are usually allowed to be tipped at the Landfill but require special treatment to ensure that the best compaction/disposal is achieved. This class does not include hazardous or dangerous wastes, or Special Wastes.

Tires

Tires are a major problem at Landfills, as they are impossible to compact and provide homes for rats and micro-breeding for mosquitoes. After several weeks or months, tires "float" to the top of the Landfill and pierce through the cover. Tires should be collected in a special area and shredded before they are tipped.

Alternatively, the tires may be useful as scour protection around the external bund of the waste mound, or used to make home composting stacks. A tire wall cutter blade can leave just the tread section which is far less trouble to re-use.

Another option is they can be sold to cement manufacturers as fuel for burning in the cement kiln as RDF (Refuse Derived Fuel).

Mattresses

Mattresses are also hard to compact and are difficult to break up. When found in loads, they should be shredded or cut to pieces then pushed to the toe of the face and covered with soil cover.

Whitegoods

When a fridge, freezer or stove is tipped on the working face, it should degassed, the doors removed and be carefully crushed to ensure that it is as small as possible. These larger items are discouraged and should be stored in the recycling compound and sold to a metal recycler after degassing.

Vehicle Bodies

Car and truck bodies should be collected for sale to metal recyclers. If car parts or bodies are to be tipped, they must be carefully crushed. Operators must take extra care, as there may be petrol left in the tank which could catch fire. If car bodies are collected and stored on Site for later recycling, they must not be stacked more than three high. These are discouraged in the landfill but could be processed in the waste resources processing center.

Drums

Drums of any size must not be accepted if they are sealed or if they contain any liquid. Paint containers with dried paint are acceptable. If a sealed drum is found on the tipping face it must be removed and the Site Foreman notified. He will arrange for the contents to be tested and disposed safely. The illegal disposer should be fined if identified.

Opened drums or large containers of any sort must be crushed before being covered, but should always be recycled if at all possible.

Whitegoods, cars bodies and drums can trap Landfill gas and become an explosion danger unless well compacted. In any case, they should preferentially always be recycled.

3.4.5 Special Wastes

These wastes include materials that may be accepted into the Landfill, but require special consideration on a case-by-case basis.

The management of these of wastes may be covered by Nepal Federal or Birgunj local legislation and ordinances, or the national standards and codes as appropriate. These wastes are allowed into the Landfill on a case-by-case basis:

Asbestos

The area where asbestos is deposited is to be identified with date of deposition, quantity, fibrous or bonded, origin, name of contractor and accurate location (GPS co-ordinates and levels at bottom and top). It is safe - provided that the material is double plastic bagged and not allowed to escape from the bags in a dry state. It is always safer to keep the asbestos material wet as an added safety precaution.

The asbestos will be managed under the regulations of the Ministry of Science, Technology and Environment or any local legislation or suitable international standards recognized by Nepal.

Dead Animals and Obnoxious Waste

Animals and obnoxious wastes will be tipped in front of the Landfill face and covered immediately. Obnoxious waste would include rotting food produce or other condemned foodstuffs.

The animal and obnoxious wastes should not be placed directly on the base/liner of the Landfill.

Non-toxic Liquid Waste

Disposal of large quantities of any liquid wastes and soluble chemical wastes will not be permitted. This may encourage the generation of excessive and contaminated leachate.

It is common to allow up to five percent (5%) of the total Landfill waste stream to be liquid. But in the case of Birgunj refuse has a high moisture content, and is easily saturated. Thus large quantities of liquid should be discouraged especially during the monsoon season.

While this may be currently practiced, liquid wastes should be adsorbed using sawdust or sand to a spadeable consistency to limit their mobility and disposed in discrete sealed areas as a last resort. They can compromise future leachate recirculation, combine to form dangerous substances (chlorine plus any oil based products or ammonia) and are an OHS danger to staff.

In Birgunj, even with the moderately low rainfall conditions during the dry season, liquid waste should not be accepted in large quantities until the Landfill mound is well established and experience is derived on leachate generation rates and waste moisture content. Limiting the liquid waste to a maximum of 5% of the refuse volume would be appropriate for low toxicity waste. Birgunj has a new STP plant so wastewater wastes may be acceptable in the facility.

Toxic Liquid Waste

These wastes must be recorded for type, source and quantity at the front end of the Landfill operation. If there is any doubt about the actual content of the load, it should be emptied into a septic tank, or sealed bund in a separate trench, for subsequent inspection, and if deemed necessary, chemical testing. Since Birgunj has no facility for pre-treating toxic waste, it should not be allowed into the landfill.

Oily Waste Water

The best option is to recycle the oil from its source. Oily waste water except when it comes from household and commercial areas in small quantities will be accepted in the landfill. The landfill does not have the facility for processing oil waste.

Phenolic and Emulsified/Concentrated Oil Waste

This includes wastewaters contaminated with degreasers and decarbonizes, emulsified oils such as machine and cutting oils and other products from the metal fabrication industry and tanker washouts.

Where possible, the phenolic should be oxidized using potassium permanganate. The treatment and disposal method is then the same as for oily wastes. The waste generator should carry this out at its site before delivery to landfill as a disposal condition.

Acid/Alkali/Metal Wastes

These wastes are derived from metal plating works, metal finishers and the paint manufacturing industry.

Wastes should be neutralized where possible by blending acidic and alkaline wastes. This should be done by the waste generator prior to being considered for acceptance in the landfill on a case by case basis depending on the processing conducted.

PPS (Paint/Pesticide/Solvent) Wastes

All pesticide, fungicide and herbicide wastes, plus solvents such as Methyl Ethyl Ketone derivative are not accepted in the landfill. Sources from laboratories and industries should manage the treatment and disposal of such wastes.

The one exception is the Paint/Pesticide/Solvent (PPS) waste, which should be stored for only one month prior to solidifying and burying in small cans or containers.

Pathogenic and Medical Waste

These wastes from medical facilities are dangerous and are not accepted in the landfill.

Various local medical facilities, such a hospitals and medical clinics, often have inadequate or unserviceable facilities to correctly handle all their special waste. This has been confirmed by medical wastes appearing in some waste dumps in the region.

The best solution is to require medical waste incinerators at the various institutions. It would be remote from the public, and ash residual could be safely co-disposed with the refuse. The general requirements for an incinerator should be compliant with the WHO standards for India or Thailand, which should be most applicable for Nepal.

An alternative is autoclaving the hospital waste either at the source after which inert products duly authenticated by the WHO or Ministry of Health can be disposed of as general waste at the SWM site.

The only residual concern is that the collection and handling of the medical waste must be dedicated and safe, and is not co- mingled with other domestic or commercial waste.

The main issue of concern is unsterilized infectious waste, sharps (needles, scalpels). These should only be managed by either:

- placing in a puncture proof container, disinfected and co-disposed with guidelines from the MoSTE at the site of wase generation
- destroying by burning in dedicated cardboard boxes fueled by petrol or in special desk-top electric incinerators, for example. This is usually done at the site of waste generation.

A key issue is that all medical facilities must segregate their waste at source prior to collection. That will ensure that only small quantities of the dangerous wastes are generated for special handling in accordance with the guidelines of the MoSTE, Ministry of Health and the WHO. As a rule medical wastes as classified under the WHO classification is not accepted at the landfill unless after processing and treatment it is certified as inert and equivalent to domestic wastes.

Contaminated Soil

This soil can be from contaminated Sites. The soil should be tested to ascertain the health and environmental risk profiles, such as using the ASTM Standard Methods for Toxicity Characteristic Leaching Procedure.

There are three options for managing contaminated soil coming to the Site, namely;

- Non-acceptance based on laboratory testing, because it is too contaminated for the environmental standard of the Landfill.
- Acceptable into the Landfill, but still too contaminated (or unsuitable for some other reason such as too wet) for use as cover material but suitable for incorporation into the waste mound as waste
- Acceptable into the Landfill for use as daily, but not final, cover material

If the soil is determined as being too hazardous for the environmental capabilities of the particular Landfill, it must not be allowed into the Site based on MoSTE and MoH guidelines and should be directed back to the waste generator for handling their own processing and treatment.

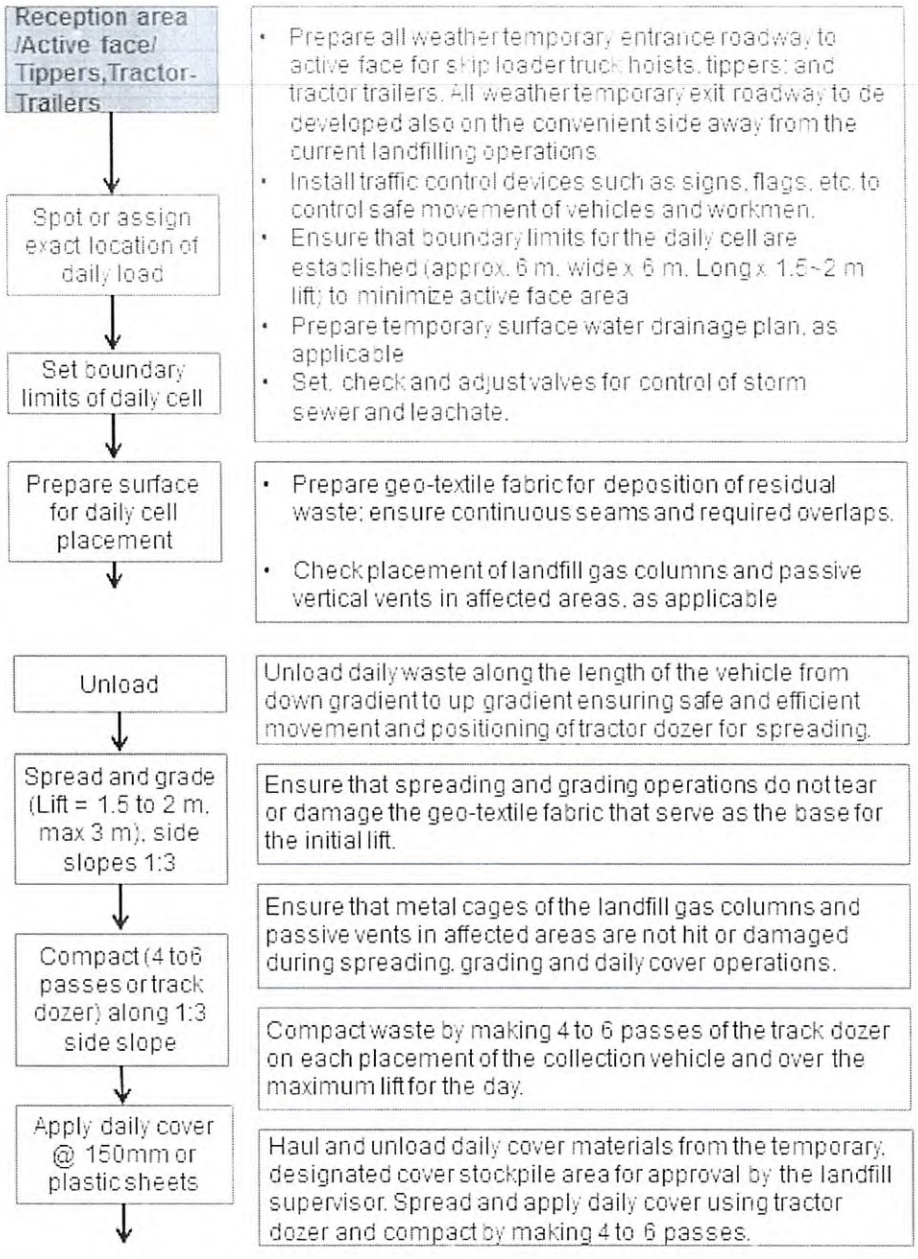
Batteries

Lead-acid batteries are recyclable and should not be allowed into the Landfill.

Only dry cell and household batteries should be accepted without any special precautions being required, unless the quantities become significant.

3.5 Operations of the Sanitary Landfill Cells Area

The following are the operational procedures designed from the Sanitary Landfill cells area from waste reception at the landfill to final cover:



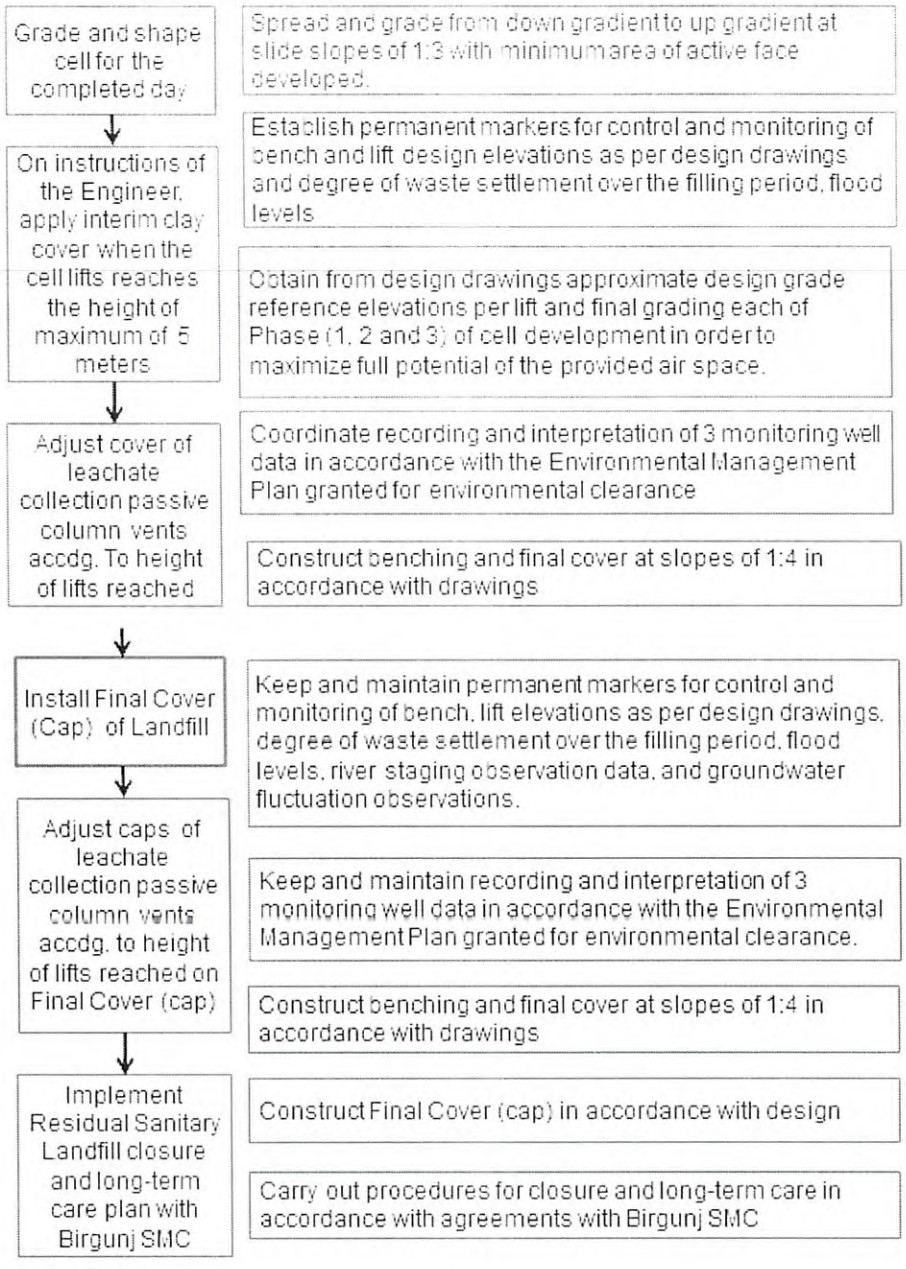


Figure 7: Flow Chart of Sanitary Landfill Cells Area

Unloading of solid wastes shall be confined to a small area as possible to accommodate the number of vehicles using the area without resulting in traffic, personnel, or public safety hazards. Waste materials shall normally be deposited at the toe of the fill. For practical purposes, the working area has been set at 1.5 m high cell lifts with 6 meter widths and a 20 meter length for each working day after which daily cover of clayey material will be applied.

Solid waste shall be spread and compacted in layers with repeated passages of the landfill equipment to minimize voids within the cell and maximize compaction. The loose layer shall not exceed a depth approximately 0.60 m before compaction. Spreading and compacting shall be accomplished as rapidly as practicable.

Covered surfaces of the disposal area shall be graded to promote lateral runoff of precipitation and to prevent ponding. Grades shall be established of sufficient slopes to account for future settlement of the fill surface.

Cover material or native material unsuitable for cover, stockpiled on the site for use or removal, shall be placed so as not to cause problems or interfere with unloading, spreading, compacting, access, safety, drainage or other operations.

The following table summarizes of the material throughput and balance that goes through the Integrated Solid Waste Management Site: the Waste Resources Processing Center, the Composting Center, and the Sanitary Landfill for the residual municipal wastes accepted at the site.

Table 3: Estimated MSW Material Balance from Waste Collection to Residual Sanitary Landfill

(First Year of Operation, 2016)

Municipal Waste Stream Description	tonnes/day	cu.m./day
Total Waste Generation, 2016	41.59	128.7
Total Waste Generation, Organic (biodegradable and compostable)	28.36	87.79
Total Waste Generation, Inorganic (reusables and recyclable)	13.23	40.95
SKIP CONTAINER input (Compost Center)	17.97	55.63
Compostables recovered (30 % of biodegradable input)	5.39	16.69
Compost Product (50 % of compostables plus 25 % additives)	3.37	10.43
Recyclable recovered move to WRPC (15% of compost center input)	2.70	8.34
Residual waste in composting haul to landfill	12.58	38.94
SKIP CONTAINER Input (Waste Resources Processing Center)	8.38	25.95
Recyclable product recovered (range of 50%-90% of WRPC inputs)	5.55	17.17
Residual waste in WRPC haul to landfill	2.84	8.78
BLOCK COLLECTION inputs (Composting Center)	1.56	4.83
Compostables recovered (30 % of biodegradable input)	0.47	1.45
Compost Product (50 % of compostables plus 25 % additives)	0.29	0.91
Recyclable recovered move to WRPC (15% of compost center input)	0.23	0.72
Residual waste in composting haul to landfill	1.09	3.38
BLOCK COLLECTION inputs (WRPC)	0.56	1.75
Recyclable product recovered (range of 50%-90% of WRPC inputs)	0.30	0.94
Residual waste in block collection haul to landfill	0.26	0.81
Residual, other Inorganics from block collection (5.32%) to landfill	0.93	2.87
STREET SWEEPINGS haul to landfill	5.52	17.08
TOTAL ESTIMATED COMPOST PRODUCT	4	11.34
TOTAL ESTIMATED RECYCLABLE PRODUCT	8.78	27.18
TOTAL RESIDUAL WASTES TO LANDFILL	23.21	71.85

Each landfill lift shall be limited to 1.5 meter height and not more than 2 meters high. Fixed control elevations starting at an average elevation of 81.50 and every 3 meters going to higher elevations from the top elevation of the main bunds at elevation 84 until elevation 102 and a crest elevation at elevation 103. An elevation column is to be set somewhere in the landfill cells area in order to monitor differential settlements and vertical movement of the lifts. For quick reference but subject to checking for subsidence, the Main bund elevation is Elev. 84.

The base liner section design and the layouts of the leachate collection piping are also shown in the following drawings.

The operator is encouraged to diligently become familiar with the construction drawings of the landfill cells area because the construction and operation of the landfill are sequentially related. The landfill construction above the base of the landfill follows the operation of the landfill.

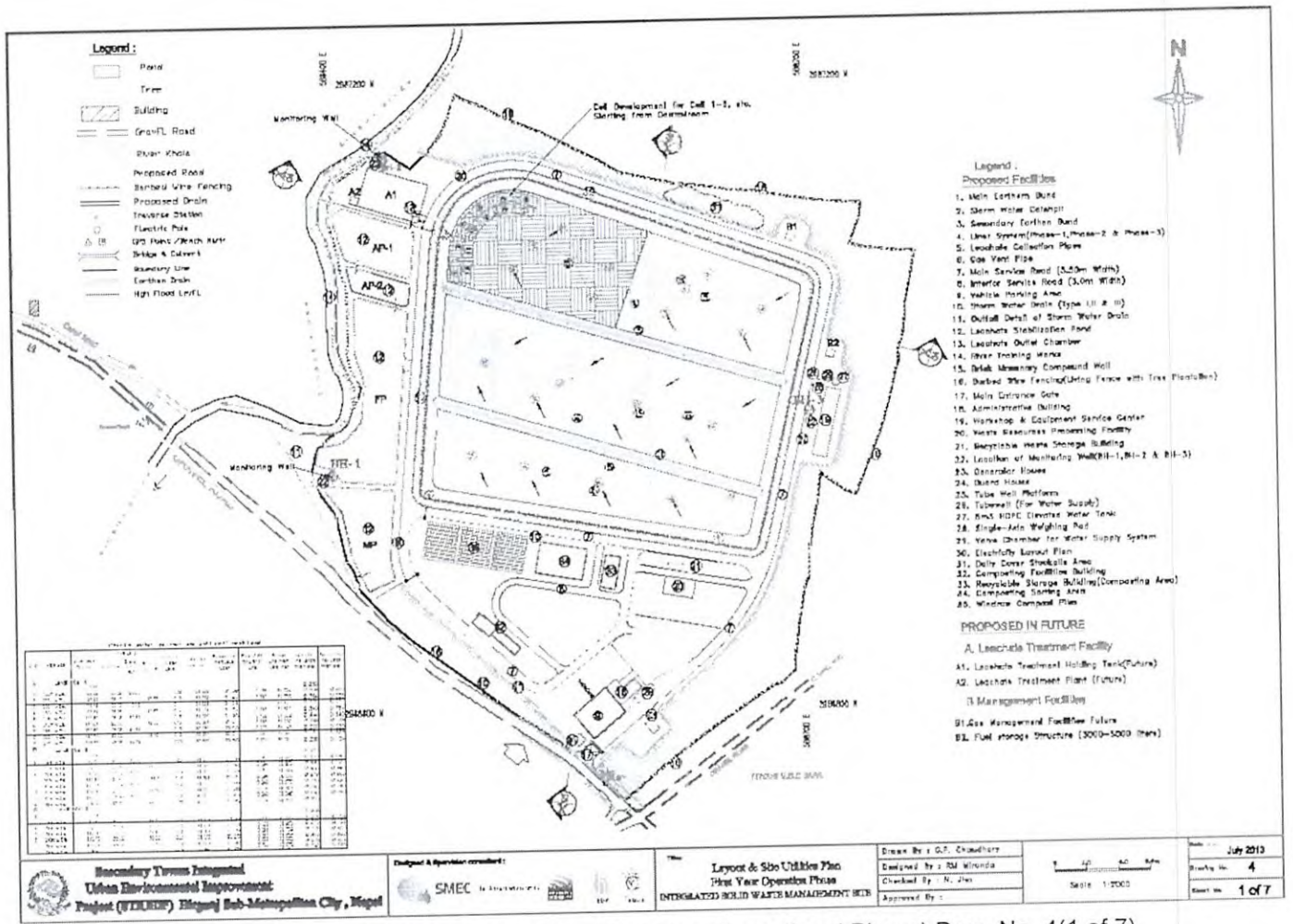


Figure 8: Layout and Site Utilities Plan (First Year Operational Phase) Dwg. No. 4(1 of 7)

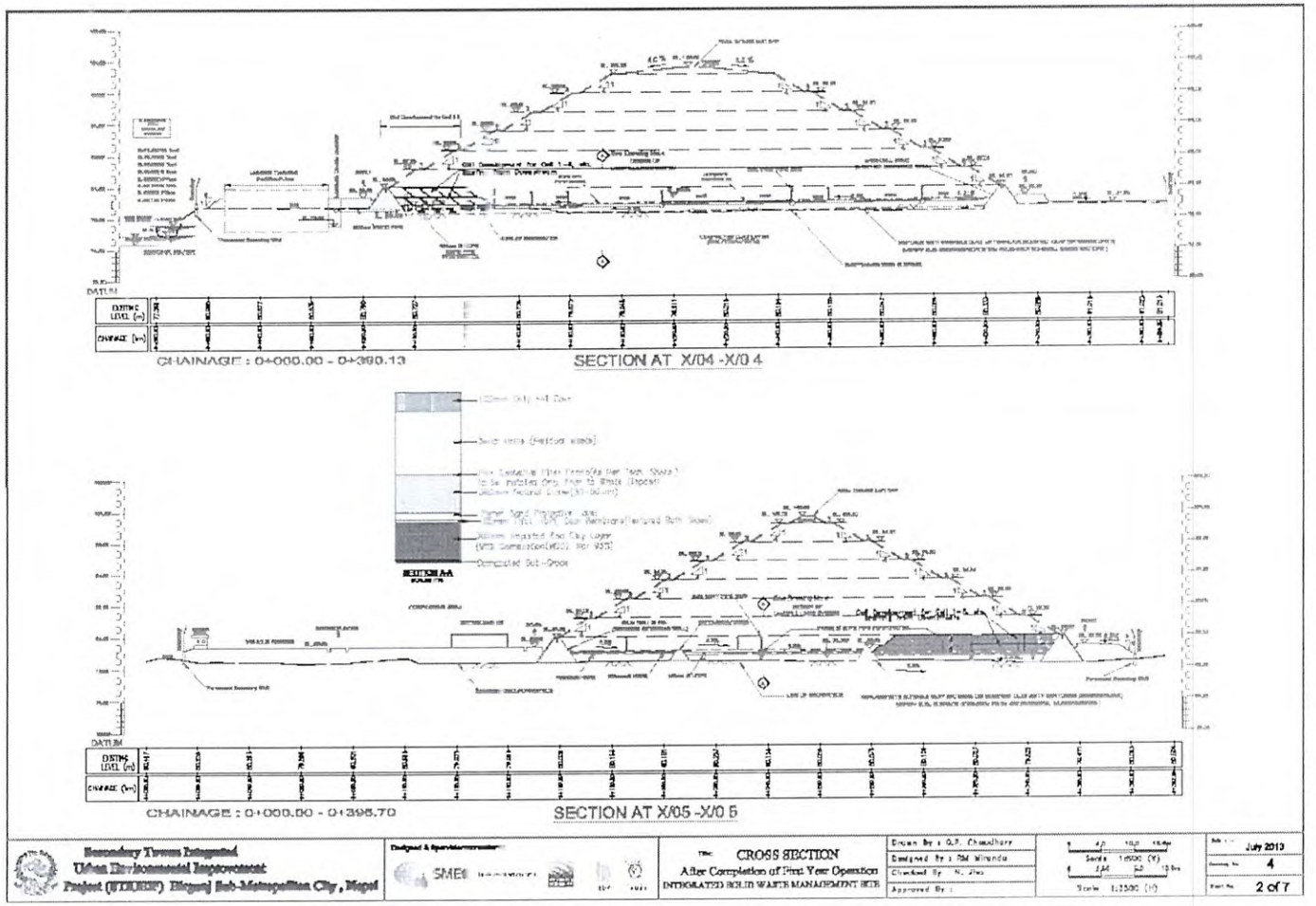


Figure 9: Cross-section (after First Year Operation Phase) Dwg. No. 4 (2 of 7)

3.5.1 Phasing Plans

The Sanitary Landfill Cells area is divided into 3 phases, namely: Phase 1, Phase 2 and Phase 3. The air spaces available for the landfilling for each of the phases are as shown in the tables that are in the drawings that follow. Please see Sections X-X and Y-Y of Figure 10 showing the final development plan of the landfill at maximum utilization including its main closure cover.

Phase 1 starts from its lowest finished grade elevation of the top of gravel layer at the west end of 81.76. The pattern of the first deposition on Phase 1 is shown in the plan view of Figure 11, while the extent of Phase 1 is shown on Section B-B of the same figure. In general, immediately prior to any deposition of waste in Phase 1, the geotextile fabric should be laid on the gravel layer covering the planned landfill operations for the shift or day until the 1st layer and the anticipated waste loads of 1.5m to 2m of the 1st lift is unloaded and spread. During this initial stage, heavy equipment of more than 2,800 kg such as the tractor-dozer for spreading and compaction are not allowed to traverse the landfill cell areas until a minimum of 2 meters is spread over the gravel layer.

At the start of initial operations, the tippers, tractor trailers, skip containers and other authorized waste collection vehicles directed from weighbridge screening towards the landfill cell areas beginning with Phase 1unload their respective wastes from the unloading platform at the north ramp from the main service road. Utmost care is exercised so as not to damage the main bund and drainage trenches along the path of the collection vehicles. Heavy equipment of more than 2,800 kg are not allowed to traverse the landfill cell areas directly on the geotextile fabric and gravel. The waste loads are unloaded slowly from the platform and allowed to spread over through the slope until a heap with a maximum slope of 10% is formed towards the lower west side of Phase 1 where the initial cell formations are to be developed. A pathway about 6 meters wide is constructed by spreading and compacting a maximum of 60 cm of each waste layer with a minimum of 150 mm of soil cover spread over the gravel towards the lower west side of Phase 1. An excavator is used from the platform to spread and shape the unloaded wastes until it forms a 6 meter wide by 1.5 meter high compacted waste over the gravel and geotextile fabric to serve as the access road to the lower end of Phase 1. The cells of Phase 1 are subsequently developed starting from the lowest elevation of the Phase until it reaches the shape as shown in Figure 11.

Placement of wastes is carried out daily starting from the lower elevations at a face slope of 1vertical:3 horizontal. A daily soil cover is applied after the placement of approximately 6 meter x 20 meter area, depending on the waste for the day. It is estimated that the first year operation will reach elevation 84 utilizing approximately one half of the Phase 1 area.

While Phase 1 is being developed by landfilling operations, only the leachate generated from Phase 1 needs to be stabilized and treated at the stabilization ponds. The landfill is designed such that during Phase 1 operations, rainwater received from Phase 2 and Phase 3 need not be treated and is directed away from the main leachate collection and removal leachate pipeline routed through the main exit point from Phase 1. A main storm line is provided parallel to the main leachate pipelines through Phase 2 and Phase 3 as a diversion storm line for storm water directly to a main storm drainage line emptying into the Singha river while Phase 1 is operational. When and while Phase 2 becomes operational, the rainwater from Phase 3 is similarly diverted directly to the main storm line emptying into the Singha river so only the leachate from Phase 1 and Phase 2 are conveyed to the leachate stabilization ponds for treatment. The storm line emptying from Phase 2 is consequently plugged permanently prior to operation of Phase 2 while the main leachate collection pipeline from Phase 2 is unplugged. When and while Phase 3 is operational the storm line from Phase 3 is permanently plugged while the leachate pipeline from Phase 3 is unplugged to allow flow through the main leachate pipeline to join leachate flow from Phase 2 and Phase 1. At this point the whole landfill cells

area is fully operational for leachate collection and removal. The Storm lines within the landfill cells are eventually abandoned when all the rainwater passes over the landfill and leachate is generated from the whole sanitary landfill.

The structures joining the leachate main pipelines at the storm diversion points will be equipped with structural grade plugs to be constructed at different times at their exit towards the main leachate pipelines and the downstream end towards the main storm pipeline. The plugs will be made of approved structural material that can withstand pressure flow and have adequate strength to hold the quantity and velocity of flow into the main leachate and storm lines when operational. See Figure 8 for the layout configuration of the leachate collection pipelines and storm lines parallel to the main leachate pipelines.

The secondary bund between Phase 1 and Phase 2 serves as the boundary and lateral support for Phase 1. Phase 1 is closed eventually on a slope of 1:3 (vertical to horizontal). An intermediate cover to close Phase 1 may be applied upon the judgment of the operator to ensure stability of the landfill cells and reduce rainwater that could cause leachate migration towards the landfill cells. A temporary surface water canal may also be used for the purpose of diverting runoff into the surface water drains and away from the landfill cells. Another secondary bund serves the same purpose between Phase 2 and Phase 3.

The Phase 2 and Phase 3 boundaries are also shown in the in Section Y-Y of Figure 10. Similarly, where the transition of the phases is shown, intermediate covers can be applied on a 1:3 slope and stabilized by the prescribed compaction methods in landfilling as described in the Technical Specifications. At the final cover side there will be 3-meter wide benches that are designed to stabilize the final cover slopes for every 3-meter lift with final cover slopes of 1:4 for greater stability. The Phase Plans are shown in Figures 11, 12 and 13.

In its full development, the landfill cells area has the capacity for approximately 400,000 cu.m. of compacted volume of residual wastes. It is estimated that if properly managed and with continuous 3R activities in BMC, the landfill will be able to accept residual wastes for at least 15 years and up to possibly 20 years.

The last phase of the landfill cells area will be a closure and long term care plan. This will have to be spearheaded by the BMC because of the need for providing funds for the closed facility after 15-20 years. The closed sanitary landfill can be developed as an ecology park with some selected plantings and trees, flowering plants and a continuing center for environmental activities such as recycling and composting, and tree nurseries, and the like.

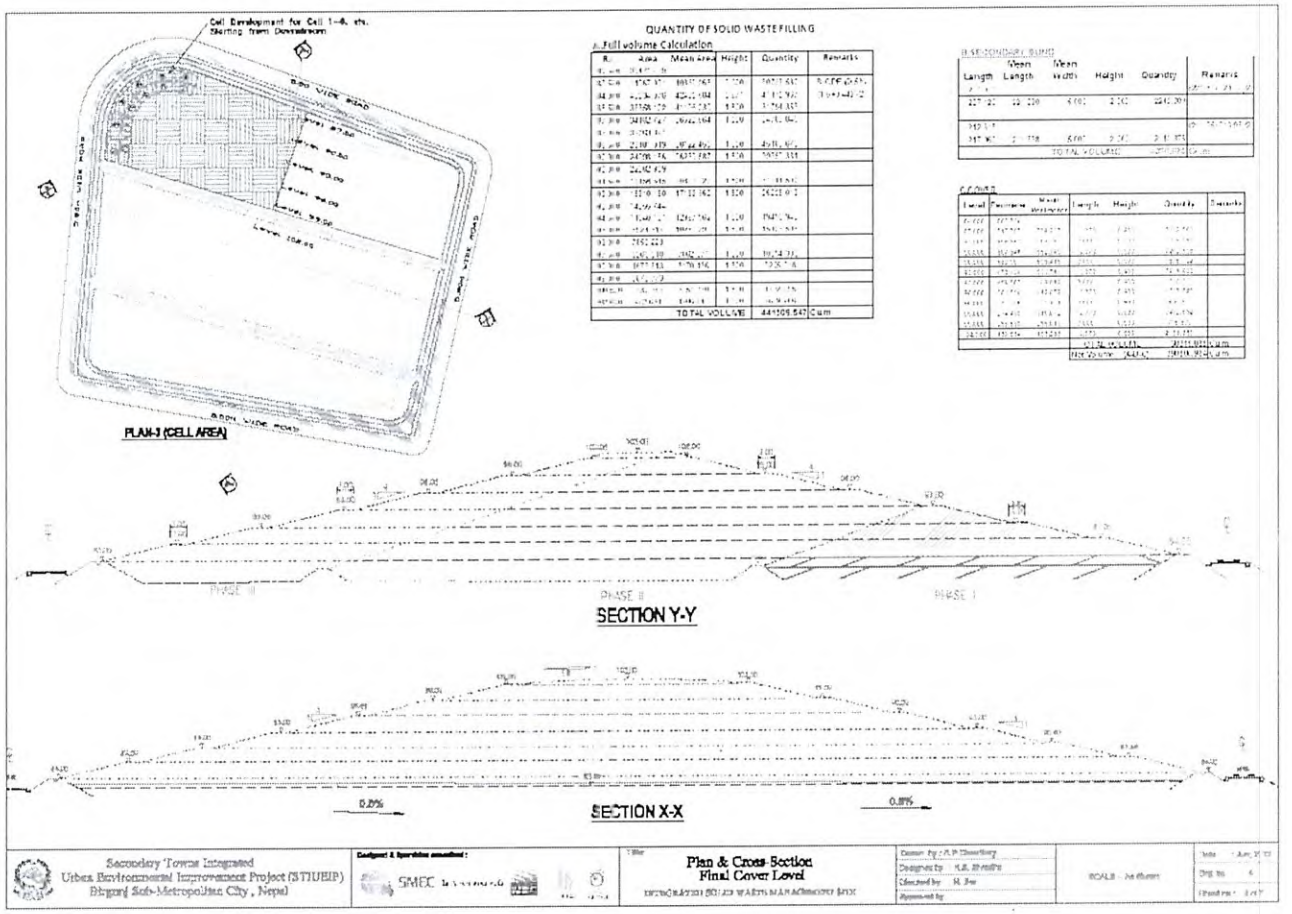


Figure 10: Plan and Cross-section Final Cover Level Dwg. No. 4 (3 of 7)

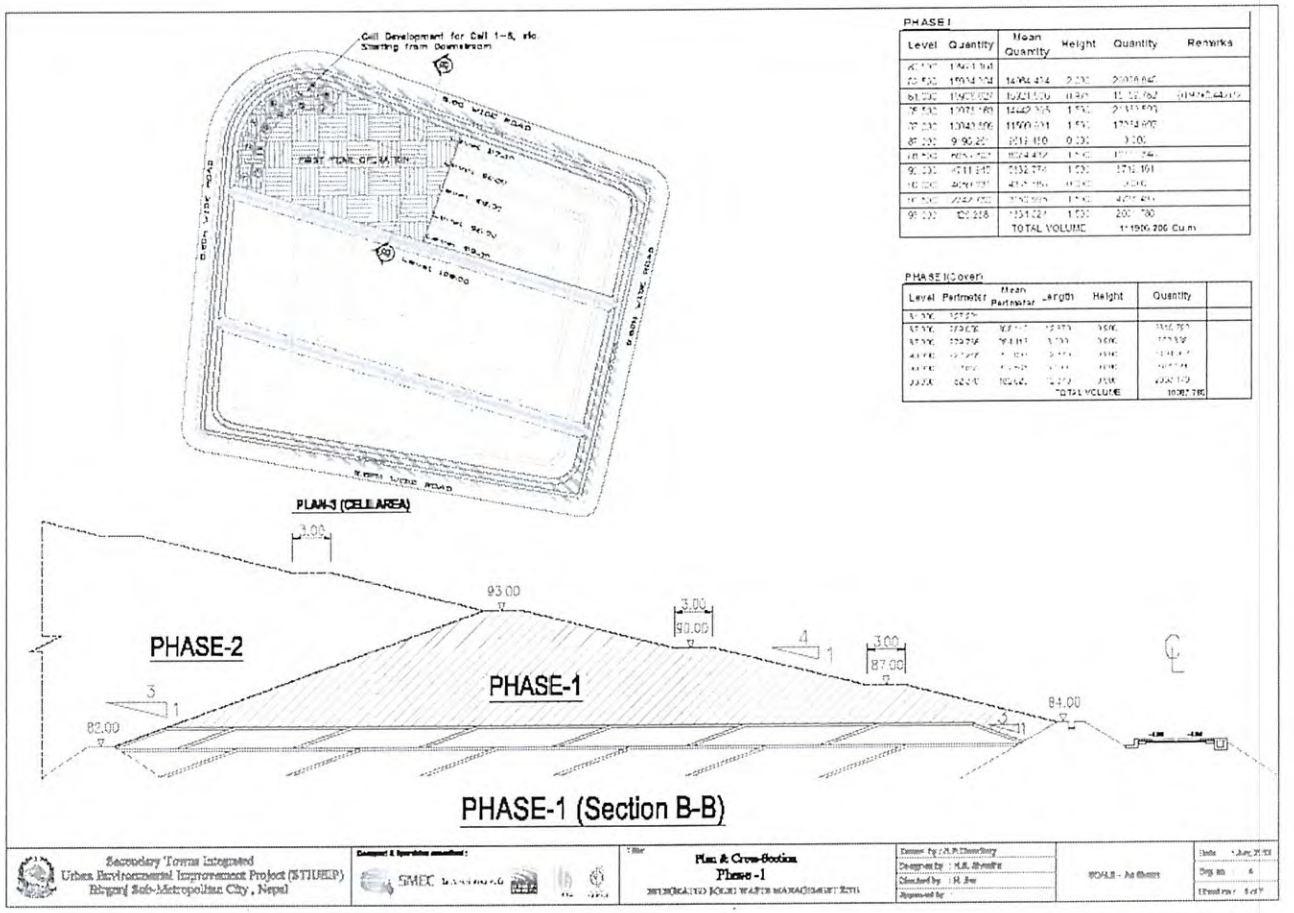


Figure 1: Plan and Cross Section Phase 1 Dwg. No. 4 (5 of 7)

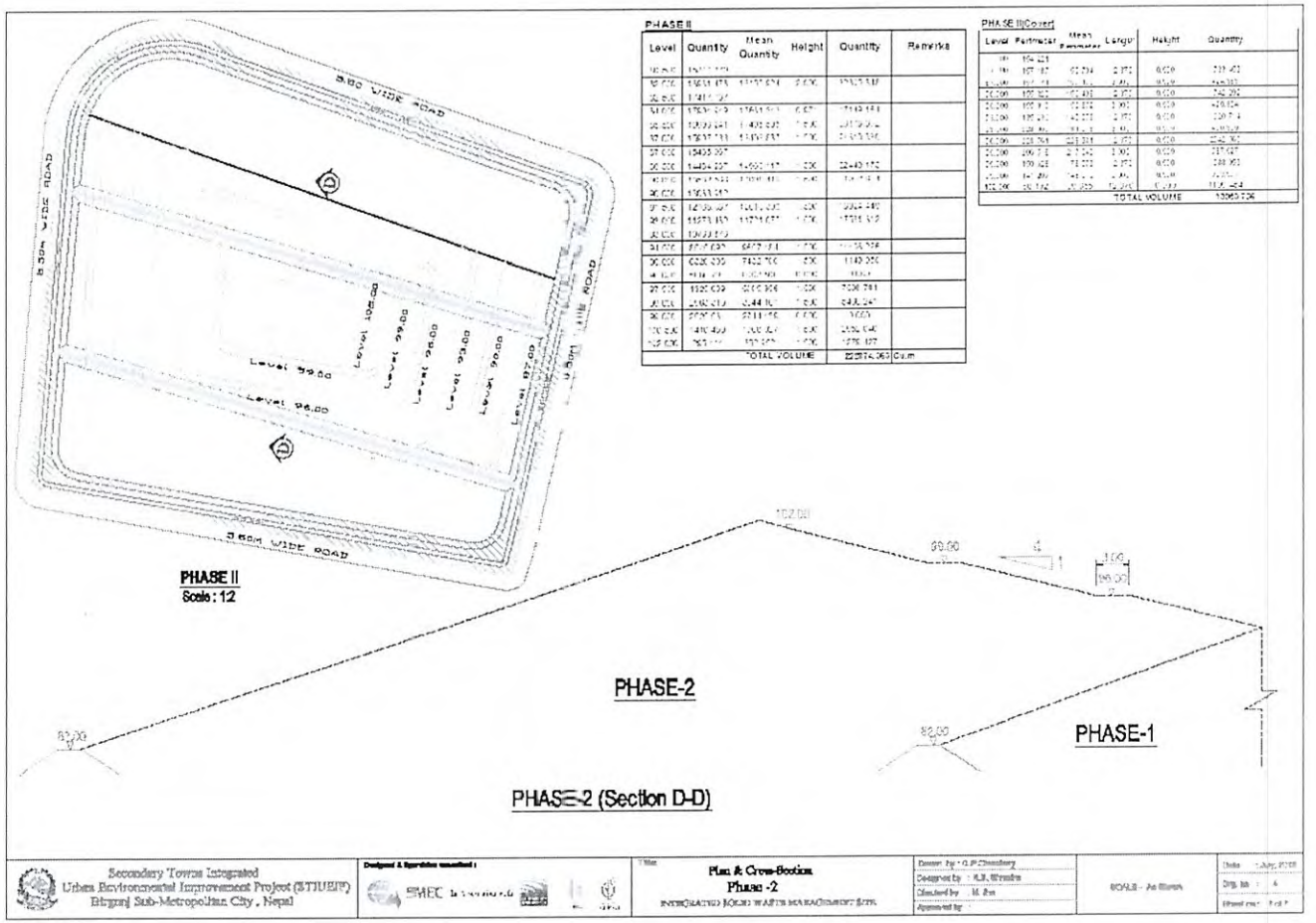


Figure 12: Plan and Cross Section Phase 2 Dwg. No. 4 (6 of 7)

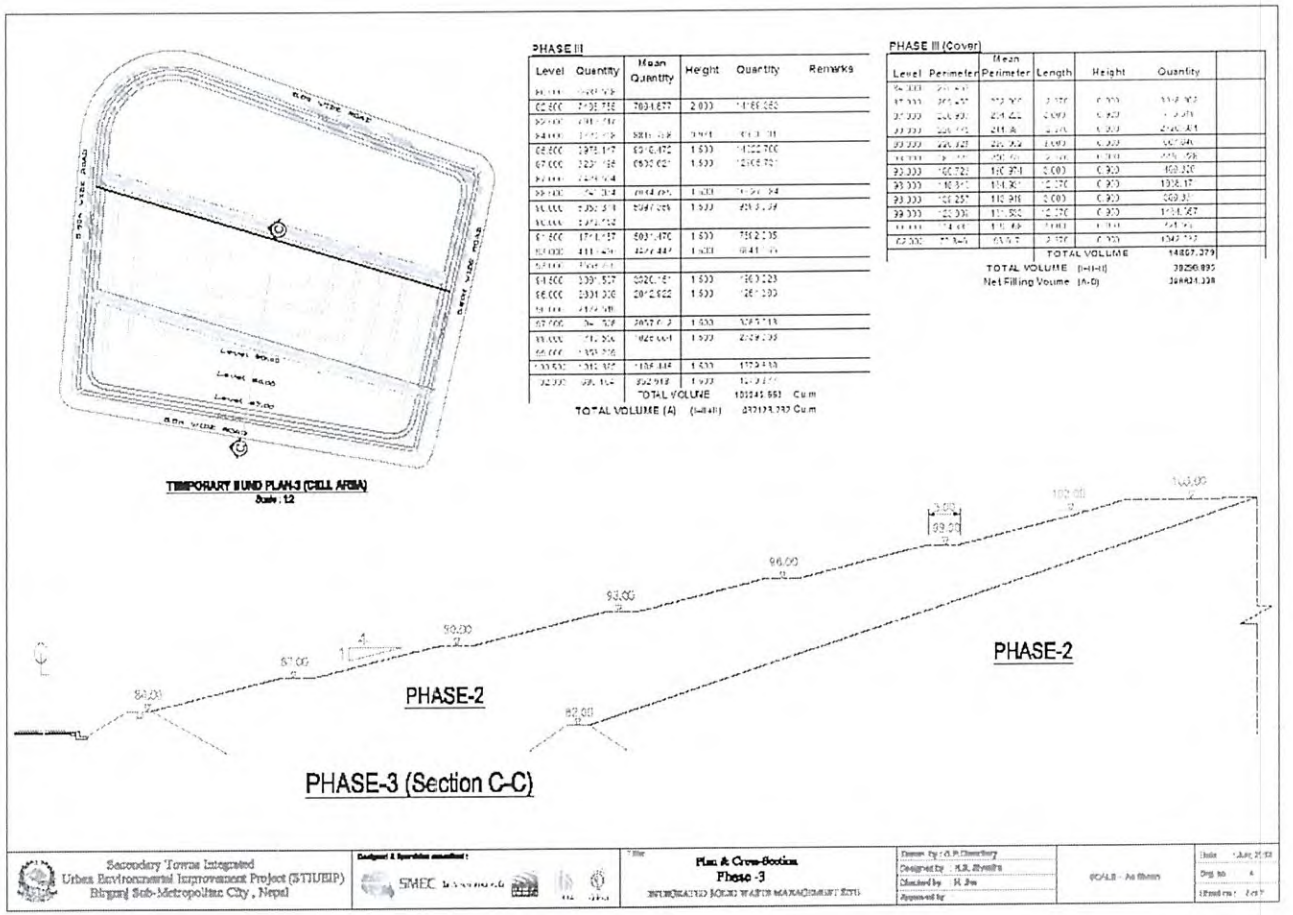


Figure 13: Plan and Cross Section Phase 3 Drg. No. 4 (7 of 7)

3.5.2 Site Preparation

In the Birgunj sanitary landfill, every load must be placed, according to the site development and Phasing plans (Figures 11, 12 and 13) and within the cell area constructed for the day's residual wastes.

Each landfill cell must be set out carefully to optimize the operation of the Landfill. For each cell, several things need to be carefully considered:

- access for the waste collection trucks and skip-hoist trucks - for the particular cell
- access for other private haulers allowed entry to the tipping face of the landfill
- access for the tipping of soil cover material
- utmost care in preventing the disturbance or damage to the gas vent structures
- storm surface water management, to prevent rainwater from entering the active face of the waste and to prevent ponding
- the slope and turnaround area for collection vehicles on the top of the cell
- where the next cell is to be built
- the length and width of the cell for greater control
- haul distances for soil cover material
- the amount of waste to be placed in the cell, and
- functionality of leachate collection.



Photo 1: Landfill cells area at Phase 1

Size of cells

In order to minimize storm water inflow from mixing with the waste at the tipping face, the area required for each cell should be minimized. Customarily a planned area consisting of several cells should allow for one month of tipping. Sub-cells taking one week's waste can be developed within each cell if required to minimize storm water mixing.



Photo 2: Example of preparing a cell area

Stormwater Runoff Management

Storm water runoff management of the active Phase is either, clean or dirty.

Clean storm water is water running over undisturbed areas of the Site, such as

- Areas of the Site still not cleared or areas which have been cleared, prepared and have re-established with daily or intermediate grass cover.
- Previously worked areas that have been covered with soil and compacted as specified and revegetated.

Dirty storm water is rainwater runoff from:

- Active dumping cells excluding any leachate which should be intercepted separately.
- Previously worked areas of the Site that have not been covered and/or revegetated as yet
- Cleared areas of the Site
- Dirt access roads

The aim is to keep all storm water separated from the waste mounds at all times, as storm water should be directed straight off the Site without treatment of any sort.

"Dirty" storm water is often allowed to also flow off the Site untreated, but future permits may require that it should be directed through a settling pond prior to flowing off the Site.

Neither type of storm water should ever be mixed with leachate.

Clean storm water diversion drains or bunds must always be constructed immediately upslope of the active cell to stop rainwater runoff entering the active waste cell. This is to minimize the volume of water contacting the exposed waste prior to covering.



Photo 3: Storm Water Runoff Management along the perimeter of the landfill

The base of that part of the Landfill not in contact with the active waste filling operations is sloped to allow storm water runoff to flow by gravity to a central location from where it either drains away or will be pumped outside the cell to the perimeter storm water drain. Impounded storm water only needs to be pumped out of the cell if the waste, or runoff from the waste, is likely to come in contact with the impounded water. Otherwise the impounded water may be allowed to evaporate or taken to disposal with the use by portable sludge pumps or syphons over the cell bund walls.

When a new cell is to be built on top of the older cells, any areas with excess soil cover should be stripped and stockpiled for use. Stripping off old cover layers should only be performed on areas about to receive waste and not be left exposed. This allows better movement of Landfill gas through the waste mound, and reduces the quantity of cover material required.

Leachate Collection

The leachate collection system should be inspected by the Foreman or Supervisor before placement of any waste in the cell. The gas vent structures should also be inspected to check for movement and stability.

Internal Landfill Access Routes

As discussed during the initial start-up of operations, continue to construct the access routes within the landfill cells area to the start of the new cell. The road should approach the current tipping area by going over previously covered and compacted waste. Vehicles are not allowed to drive over uncompacted and uncovered waste during normal operations.

The access route or passageway for vehicles to newly opened cells should be planned so that as the cell grows, the access can be extended. The access routes should be about 8 meters wide (6 meters for one way traffic) and drainage constructed so that the road does not become unstable. Passing space for a broken down or disabled vehicle should be possible. These access routes should be able to traverse Phases 1, 2 and 3 of the sanitary landfill, ensuring that the secondary bunds between phases are not damaged or made unstable by the movement of vehicles. This is prevented by making sure that the secondary bunds developed as shown in Figures 11, 12 and 13 of the Phasing plans are filled over with stable wastes and soil cover compacted and backfilled with a thickness of at least one (1) meter of compacted wastes and soil cover clear of the shortest dimension in contact with the secondary bunds.



Photo 4: Leachate collection system being developed



Photo 5: Example of internal landfill access route



Photo 6: Example of Unloading waste loads at the lower cell of the landfill

3.5.3 Cell Construction

The "area method" of landfilling is used in the Birgunj Sanitary Landfill. The primary earth bunds enclose 3 phases of the landfill while the secondary bunds are built in between the 3 phases. The earth bunds are constructed, compacted and stabilized to protect the sides of the cell and keep the waste in place.

Builders waste or rubble sent to the Landfill at any time should never just be incorporated into the waste cell, but stockpiled for either road construction, cell bund repair or re-construction as necessary, or use as a possible gas collection blanket under the final cover. The ISWM Resident Manager will decide on where to stockpile these items if they are indeed allowed entry into the landfill.

The Site Foreman will arrange for profiles to be built every 25-35 meters along the cell. The profiles are usually made from timber pegs and show the width and finished height of the lift. Operators should check each day that they are building the cell to the correct levels.

Each lift is 1.5 to 2 meters high and should be not more than 3 meters high.

The top of each cell should drain uniformly to one side at a minimum slope of 5% i.e. 5V:100H. Runoff from the top of the cell is to be drained to the storm water surface control system running on each side of the cell.

Every year, the Site Foreman may arrange for the Site to be surveyed to calculate the amount of airspace used and to provide plans which show the development of the Site.

Before each cell is completed, the next cell must be set out and prepared

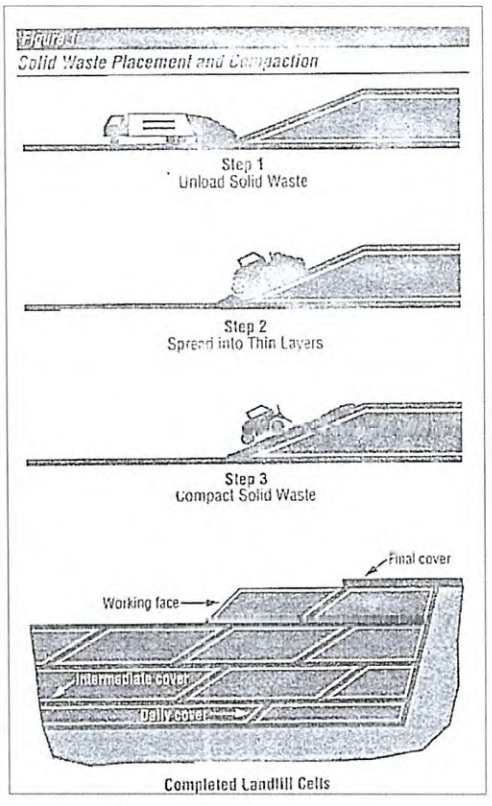


Figure 14: Steps in solid waste placement and compaction by the Area Method of landfilling

3.5.4 Operation of a Cell

Overview of Cell Operation

When waste arrives at the Site it is only lightly compacted. If the waste is dumped in the cell and is not carefully compacted it can take up to two or three times the airspace volume of well compacted waste. Poorly compacted waste causes many other problems including:

- more litter
- more odor
- more vermin problems
- extra leachate
- damage to vehicles because the roads settle and are not as smooth
- drainage problems.

In addition, the Landfill will continue settling for many years making it difficult to keep the final landform. Also, the closed Landfill will be more difficult to develop for other uses.

To achieve the optimum compaction there are a number of things to consider:

1. The most important point for good compaction is the thickness of each layer of waste.

   Each layer must be less than 0.6 meter thick prior to compaction

   If the layers are thicker than 0.6 meter, then it does not matter how many times the waste is compacted, the density will not further increase and fuel is wasted.



Photo 7: Landfill compactor spreading waste controlled at less than 0.6 meters in depth

2. The second most important point for good compaction is the number of passes made over the waste.

   Each layer should receive a minimum of 3 passes. For best compaction, 5 passes are required

   If more than 5 or 6 passes are made, the density will not increase significantly.

3. The type of equipment used will also affect compaction. During initial operations the plan is for a tractor-bulldozer to perform the compaction. In the future, a landfill compactor can be used. If using a tractor-bulldozer, the operator should keep the layers thin and the face steeper than by a compactor to say, 1H:3V.

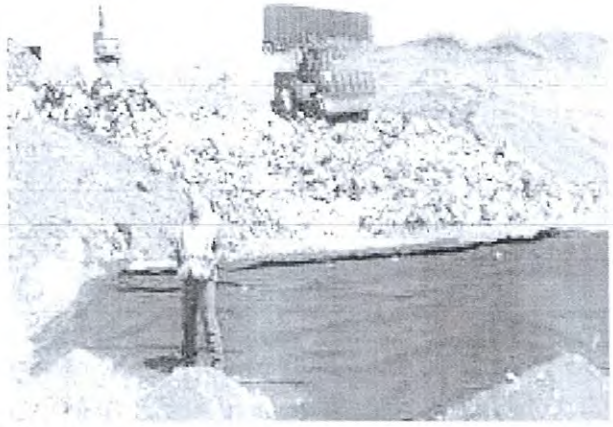


Photo 8: Landfill compactor keeping the width of the face of the active cell to a minimum of less than 25 meters

4. The width of the face should be kept as small as possible. The width required will depend on how many vehicles are at the tipping face. For an efficient operation, vehicles should not be kept waiting to tip. The width of each face for each cell will need to be judged when the Landfill starts, however as a guide, a 25 meter face should be more than adequate.

   Important Reminders:

   - The tipping face should not be wider than 25 Meters.
   - Each lift should be between 2 but not more than 3 meters high.

5. All waste should be tipped at the bottom of the face and pushed up and across. This pushing up hill helps to compact the waste further. Pushing waste down or over the face does not achieve the compaction essential to the efficient running of the operation.

6. If a tractor-bulldozer is being used to compact waste the tipping face should be kept at a slope of 1 in 3. This high slope will help the tracks break up and cut the waste as the dozer climbs up the face.



Photo 9: Tractor-dozer compacting and pushing waste from downgrade to upgrade and spreading

7. Eventually when a landfill compactor is used and the landfill is in an advanced state of development, the tipping face should be kept relatively flat at 1 in 8 or 1 in 10. The compactor does not need the steep slope to break up the waste as the teeth on the wheels are designed to do this. The much heavier weight of the compactor is best at compacting waste if the slope of the face is fairly slight. Compactors should not operate on faces steeper than 1 in 4.



Photo 10: Example of Landfill Compactor operating on a gentle slope

8. The top of each cell should drain away from the tipping face, either to one side or towards the start of the cell (minimum slope1V:20H).



Photo 11: Example of tractor-dozer equipment working on steeper slopes spreading cover from the top of the landfill

Effective Use of Equipment

All equipment must be properly inspected each day and serviced when required. All problems with equipment must be reported to the Site Foreman. Manufacturers' start-up checks and regular maintenance should be recorded in daily sheets and returned to the foremen.

Over-compaction should be avoided as it wastes fuel and people's time.

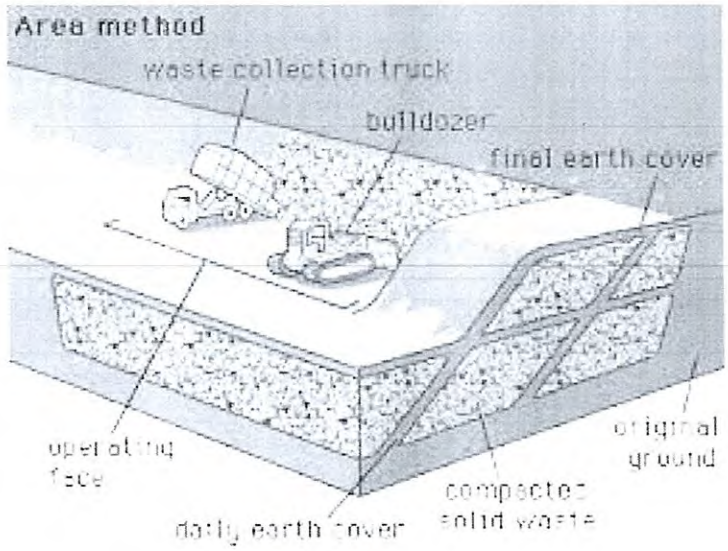


Photo 12: Landfilling by the "Area Method" showing equipment positions minimizing width of face

The most efficient use of equipment will result if the following guidelines are followed:

- WASTE IS SPREAD IN LAYERS LESS THAN 600 MM THICK
- EACH LAYER SHOULD BE GIVEN 3 - 6 PASSES. The best compaction is 5 passes for MSW
- each lift should be between 2 - 3 but not over 3 meters high
- don't try to push big heaps of waste, push around the sides of heaps
- if there is not much waste arriving at the face, park the equipment and do other work, do not continue compaction
- use a bulldozer for spreading soil cover
- keep the width of the face to the minimum necessary to avoid queuing of tipping vehicles
- two faces may be necessary to allow appropriate access for waste pickers
- to get better compaction have waste tipped at the bottom of the face, and push it up and across the face
- have cover material tipped at the top of the face.

Spreading Waste

When truckloads of waste are tipped at the Landfill, the best method of spreading is to push around the sides from the pile, not push front on.

The dozer blade should have waste about half way across and the waste pushed up and across the face in layers less than 600 mm thick.

To try and push the whole of the load will not give good compaction and wastes a lot of fuel.

Soil Cover

At the end of each day, the tipping face must be covered with soil cover. If excess leachate is observed in the landfill, then daily and intermediate cell cover must be applied more frequently.

To make covering easier, the face must be fully compacted and as smooth as possible. Unevenly compacted waste surfaces use extra soil to provide the minimum thickness of cover.

Cover material which is delivered to the cell should be tipped near the top of the tipping face and the dozer should be used to spread out the material as soon as the face reaches final height.

The cover must always contain suitable fines to limit water intrusion and fly breeding..

If the material is to be used for final cover, it must provide a stable, impermeable, permanent barrier to water, odor, pests and vermin and not be easily eroded.

The best material is a sandy or silty clay, with some gravel to provide reasonable trafficability when wet. Too much sand increases the permeability of the cover (allowing landfill gas out and water in). Too much clay increases the chance of cracking in dry weather and makes the surface slippery in wet periods.



Photo 13: Daily soil cover being spread by dozer

The daily cover on the face should be about 150mm thick and must be spread only after the waste face has been well compacted (3 or 4 passes) and graded to a uniform smooth slope close to 1H to 3 V. If the cover layer is too thin, refuse can protrude. If thicker, valuable airspace and cover is being wasted as it does not provide any additional benefits.

If there is going to be a long timeframe involved before the temporary slopes will be amalgamated, these slopes should also be mulched and/or grassed to control erosion and siltation. Tires with sidewalls cut can be roped or bolted together for erosion control and filled with green waste.

The cover depth should be increased to 300 millimeters for intermediate slopes. Intermediate slopes are those slopes which will not covered on a daily basis, for up to 6 months but will eventually be covered with more waste.

The final cover layer must keep the waste in, water out and allow plants to grow. A typical final cover/capping would be:

- 600mm of well compacted, sandy/silty clayey material - to make a waterproof layer to keep out the rainwater. The low permeability of clay or sandy/silty clay soils is essential to minimize percolation of rainwater. Sandy clay is better than a pure clay because it does not develop deep cracks if the layer dries out. This is less important if the cover will be mulched.

- Optional 300mm to 1800m of top soil or mulch - to allow grass and larger plants to grow. If trees are required, it will be necessary to provide the thicker layer of top soil in the immediate area of the tree. When plant roots grow through the capping, the plants are often stunted or killed by the Landfill gas collected under the clay layer. Mulch should be added on top to keep the moisture in and help the grass grow. Chipped or mulched green waste is an ideal medium for mulch and can avoid the need for topsoil if applied over a number of years to build up an organic, rich surface on the cover material.

The total thickness of final cover may be determined by conditions of the city permit.

3.5.5 Sequence of Filling

The sequence of filling chosen must satisfy the following key issues:

- **place waste fill progressively from the top or "head" of the cell and move** towards the eventual final outlet, that is, the lower part of the cell

- **Ensure that the cell is filled such that the waste mound has the smallest practicable footprint and the smallest fraction of slope areas with only 5% fall.**

- **DO NOT INITIALLY COMPLETE ONE FULL LIFT ACROSS THE ENTIRE CELL BASE AND THEN PLACE ANOTHER FULL CELL LIFT ON TOP. RATHER DEVELOP A SERIES OF PARTIAL LIFTS ON TOP OF ONE ANOTHER (starting from the highest area of the cell) TO MINIMISE THE PROGRESSIVE FOOTPRINT SIZE AND MAXIMISE THE FRACTION OF THE MOUND THAT HAS THE FINAL SHAPE AND ASSOCIATED 1:2.5 SLOPE. This is critical to minimise the amount of water that will infiltrate the waste mound and form leachate.**

- allow the progressive shedding of surface water outside the cell as the landforms are built and eventually merge.
- allow diversion of stormwater runoff from previously worked areas around the ongoing stages of filling.

The staged filling sequence are outlined in the Phasing Plans.

The method of construction recommended for the development of primary and secondary bunds up the interior slopes of each stage uses excessive soil, but this will be recovered as fill is eventually placed against them.

Please see Phasing plan drawings to understand the sequencing of filling of the 3 Phases 1, 2 and 3: Figures 11, 12 and 13

3.5.6. Vegetation

On completion of the final cover for each Phase, **the surface should be adequately prepared by placing mulch or some other growing medium**.

A mixture of grasses and small shrubs should be planted. If certain varieties of trees/shrubs are seen to be not performing, then new types should be trialled.

It is critical that all exposed batters are revegetated upon completion of earthworks, as the vegetation:

- assists in screening the Landfill from public viewing.
- softens the general appearance of the operation
- stabilises the batters against erosion, especially if Vetiver grass is used.
- hastens the opportunity to convert the Landfill into the selected end use.

3.5.7 Post Closure

The post closure management plan shall be determined by BMC in coordination with the Parsa district and the adjoining Bara District consultations.

The **ultimate landform and use of the Landfill will be finalized** according to the design drawing, in which a typical proposed rolling/hilly topography will be compatible with most existing areas.

With simple gas control measures, the following uses are possible:

- walkways, playgrounds, cycle paths, passive recreation
- re-pasture and allow grazing
- grass and tree planting



Photo 14: Example of Sanitary Landfill with Final Cover and Park Use

3.6 Monitoring of the Sanitary Landfill Base Liner System

The sanitary landfill is designed for a life of 15 years. It is a major component of the Integrated Solid Waste Management System proposed for the sub-metropolis of Birgunj. The sanitary landfill site is composed of several components to promote the concept of pre-collection 3Rs (Reduce, Reuse and Recycle). The segregation of waste generated at the source from the households (HH), wards, commercial and institutional areas is the key to the success of the operation of the sanitary landfill site. The Integrated Solid Waste Master Plan envisions pre-collection HH and ward-level composting and materials recovery. The sub-metropolis is advised to provide at least 2 types of storage containers for each generator of solid waste: one for the organic or biodegradable and another for the inorganic or non-biodegradable wastes. The cost sharing can be discussed and can be charged back through the user fees eventually. The organic fraction is estimated to be between 50 to 60 % biodegradable while the rest is estimated to be non-biodegradable or recyclable and reusable waste, and residual wastes for proper disposal into the sanitary landfill. Ideally, the households and wards will develop their respective composting and materials recovery facilities. The residuals from the HHs and those wards with no capability for composting and recycling will be collected also in a segregated manner by the sub-metropolis and hauled to the sanitary landfill site for further processing. The Integrated Solid Waste Management site will host a municipal-level composting facility, waste processing resource center, recycling area, and the landfill cells area.

The design of the sanitary landfill base liner depended on the soils and geotechnical investigations, the hydrology study, and interviews with local residents concerning groundwater level fluctuations and flooding frequencies at the site. The bottom sub-grade elevations were designed based on allowing a depth of at least 1 meter to groundwater from the highest flood level observed and established through the hydrology study, The landfill

base stability and structural bearing capacities were also considered based on the design requirements and calculations. The soils and geotechnical investigations confirmed that the subsurface soils are predominantly alluvial silt, sand and silty clay. Because the site is very flat, the DSC designed the bottom liner to be made up of a composite of imported red clay layer (not available in Birgunj and its vicinity), geo-membrane (HDPE sheet liners) and geotextile or natural materials, supported by bunds or embankments at the containment boundaries of the landfill (with temporary secondary bunds to separate the different phases). The base liner design consists from top to bottom of the following liner components (Please see Drawing 9, Sheets 1 and 2, Plan and Section of Landfill Liner of the Detailed Engineering Design Drawings in separate volume).:

- A fine geotextile filter fabric that will be installed and prepared prior to waste deposition;
- A 300 mm thick natural, rounded river gravel drainage blanket;
- A 75 mm sand protective layer (protection for the HDPE from the gravel layer)
- A 1.5 mm textured high density polyethylene (HDPE) sheet liner; and
- A 300 mm compacted red clay (imported) at 95% Compaction, DPr
- Compacted (DPr 95%) low permeability soil subgrade foundation layer.

The leachate collection and recovery layer was designed to drain into perforated HDPE collector drains located at a central point at the down gradient end of the landfill. These will go either to the leachate Collection Chamber (present) or Leachate Treatment Plant (future) and a series of anaerobic, facultative and maturation ponds downstream depending on the leachate characteristics. No penetrations shall be designed into the liner system to minimize the potential for leakage of contaminated leachate from the landfill.

Methane and other gases will be generated as the waste degrades within the landfill mass. During the initial stages of development, the amount of gas generated will be minimal. This minor amount of gas will be controlled by the placement of daily soil cover. The gas management facility will consist of perforated PVC collection columns equipped with vertical passive vents at the junctions of the HDPE main pipelines and portions of branch pipelines that will be distributed over a distance of ideally not more than 60 meters apart. Although it is not expected with the pre-landfilling 3Rs, if it is found that the gas generation increases to a point where the soil can no longer control gas and odors, simple gas collection facilities can be constructed by constructing branch headers and gas collectors in the future. The design would depend on the characteristics of the deposited waste after composting and other waste recovery and processing activities.

The details of the passive vent columns are shown in the Design Drawings volume. As with the leachate management system, the passive gas venting stations would be operated throughout the post-closure period.

For design of the final fill plan, the waste will be placed in multiple, compacted lifts with daily soil cover. When an area reaches its final grade, intermediate cover (300mm thick) would be placed to minimize infiltration of rainfall and to prevent infestation by insects, rodents, or other disease vectors until the final cover is constructed. The top cap of each landfill phase as shown in the drawings shall be graded at an approximate slope of 3- 6% with side slopes constructed at 4 to 1. Surface water drainage benches shall be laid out at vertical intervals on the side slopes up to the final landfill height. Berms shall be provided on the top cap to divert water to collection ditches and down drains to transport water off of the cap. Access to the cap shall be provided from several entry points at various locations around the facility. These are all shown in the Design Drawings volume.

The final fill height for the site shall be established based on the final area allocated for the sanitary landfill cells and landfill stability requirements. This has been set at elevation 103. The cover design shall be based on locally available vegetative/protective cover layer and a drainage layer overlying a low permeability infiltration barrier. The cover will be similar to the bottom liner and be composed of a composite of various manmade and natural materials consisting from top to bottom of the following preliminary liner components:

- A 600 mm thick vegetative/protective cover layer;
- A 300 mm thick sand drainage blanket or geocomposite;
- A 1.0 mm geomembrane; and
- A 300 mm thick intermediate cover and foundation layer.

The thickness of the final cover or cap and the estimates were not included in the detailed design estimates as some local materials equivalent in function may be available. At closure, the cover would be seeded as necessary to promote re-vegetation to minimize erosion and potential damage to the cap.

3.7 Operation and Maintenance of the Leachate Collection Piping and Treatment Facility

The general function of the leachate collection piping and treatment facility is to purify the leachate collected so that the leachate will not pollute the groundwater, Singaha River and affected impact areas and water bodies in Birgunj as a result of the construction and operation of the sanitary landfill at the ISWM site.

The mechanism involved in the analysis of rainfall and leachate production required examining a combination of methods for design purposes. First, for the design of the pipes the amount of expected rainfall was determined from the hydrology study, the materials to be used and the consideration of being perforated drainage collector pipes for drainage buried under 20 meters of waste with soil cover. The delay in the generation of leachate as rainfall does not permeate directly to the collector pipes was also considered. Second, the amount of rainfall averaged over 30 years in Birgunj was considered in determining the total volume of leachate that can be expected in one year's operation. The maximum rainfall was deemed not economical; instead the average was used. The results of the analysis and design of the HDPE perforated piping are shown in Tables 25 and Figure 26. The complete drawings are in the Drawings Volume of the Final Report. The results of the leachate volume calculations are shown in Tables 26, 27 and 28. Indicative gas production values are shown in Table 29 for both slow and fast moving leachate gas for reference. The gas formation is intended to be released through passive vents and expected to be minimal because of the 3Rs program of Birgunj.

The purpose of the leachate collection piping system is the collection and removal of the leachate that is formed and accumulated in the landfill cells during the lifetime of the sanitary landfill. The design of the leachate collection pipes was performed using the Softwell Program for Storm Water Drainage Design and Drawing Package. The HDPE perforated pipes were designed with a discharge calculation using the rational formula on a storm frequency recurrence interval of 5 years as advised by the Hydrologist. Normally in Nepal for underground storm drainage, the frequency interval used is only 2 years. The maximum thickness of the HDPE pipes with perforations was selected to be able to support the pressure of the depth of the landfill that could be as high as 20 meters. There shall be 4

perforations at 60 degrees each at the top and bottom for the ease of infiltration of leachate from wastes deposited the top of the pipes and the allowance of enough surface flow at the bottom to convey leachate through the collection system. .

For leachate treatment, the design for chemical treatment from toxic and hazardous, chemical and other inorganic wastes that may be present in the residual wastes can be determined only after a leachate treatability analysis is performed during the time in landfill operations that leachate begins to form. In the meantime, the DSC decided that the leachate treatment would concentrate on parameters treatable with waste stabilization ponds. DSC also considered a system without using or with minimal use of mechanical equipment that require power. The continuous power outages in Nepal are still prevalent. The sizing of the ponds was finalized during the detailed design stage based on similar ponds in India and Nepal with similar climates. The decision to recirculate leachate back into the landfill to promote rapid degradation of the waste was not made because literature on landfill operations indicate that there is no long term advantage for such a system. This recirculation method of treatment is used to reduce the organic contaminant levels that would normally be present at closure stage of a landfill.

A temporary holding tank may have to augment the adjacent leachate collection chamber if funding for it can be made available in the near future. This will provide an emergency and contingency measure for outsourcing leachate to another wastewater facility should leachate be excessive during certain times of the year. This additional option will also provide more flexibility in the handling and treatment of leachate. Whichever combination of final leachate management system is adopted would remain operational throughout the post-closure period.

Other new technologies for leachate treatment are also worth looking into when leachate characteristics become established during initial operations. These include the EPA-approved blower/spray system for managing contaminants, multi-level solar evaporation ponds that may not require large spaces as long as they receive sunlight, and other effective re-circulation methods.

Table 3: Schedule of Leachate Collection Pipes - Invert Elevations and Landfill Cell Base Surface Finish Elevations (As-Built)

Schedule of Leachate Collection Pipes - Invert Elevations and Landfill Cell Base Surface Finish Elevations												
S.No.	Pipe Size (HDPE perforated), Diameter, mm	Cumulative Distance, meter	Pipe length, meter			Main Line Water Level, (m)	Main Line Invert Elevation. (m)	Branch Line Invert Elevation at Outlet, (m)	Slope of Branch Line, (0.5%)	Branch Line Invert Elevation at Inlet, (m)	Main Line Final Landfill Finish Elevation, (m)	Branch Line Final Landfill Cell Base Finish Elevation, (m)
			Main Line	Branch Line, Right Side	Branch Line, Left Side							
A	PHASE-1											
		0.00									82.350	
1	160	22.32	22.32	27.05		0.08	81.509	81.589	0.135	81.724	82.309	82.350
2	200	47.44	25.12		49.77	0.10	81.384	81.484	0.249	81.733	82.264	82.320
3	280	72.49	25.05	34.3		0.14	81.259	81.399	0.172	81.571	82.157	82.264
4	280	97.54	25.05		49.67	0.14	81.134	81.274	0.248	81.522	82.049	82.254
5	315	122.59	25.05	37.81		0.16	81.009	81.169	0.189	81.358	81.944	82.049
6	315	147.64	25.05		49.56	0.16	80.884	81.044	0.248	81.292	81.839	82.039
7	355	172.69	25.05	41.31		0.18	80.759	80.939	0.207	81.146	81.737	81.839
8	355	197.74	25.05		49.46	0.18	80.634	80.814	0.247	81.061	81.634	81.829
9	400	215.79	18.05	44.24		0.20	80.500	80.700	0.221	80.921	81.700	81.634
B	PHASE-2											
		0.00									82.545	
1	160	37.45	37.45	48.07		0.08	81.675	81.755	0.240	81.995	82.525	82.545
2	225	62.50	25.05		38.77	0.11	81.549	81.659	0.194	81.853	82.490	82.525
3	280	87.22	24.72	48.07		0.14	81.425	81.565	0.240	81.805	82.455	82.490
4	315	112.16	24.94		38.7	0.16	81.301	81.461	0.194	81.655	82.348	82.455
5	315	137.54	25.38	48.07		0.16	81.175	81.335	0.240	81.575	82.240	82.320
6	315	162.69	25.15		38.62	0.16	81.049	81.209	0.193	81.402	82.135	82.240
7	355	187.59	24.90	48.07		0.18	80.925	81.105	0.240	81.345	82.030	82.130
8	400	201.66	14.07		38.55	0.20	80.825	81.025	0.193	81.218	81.825	82.030

Schedule of Leachate Collection Pipes - Invert Elevations and Landfill Cell Base Surface Finish Elevations												
S.No.	Pipe Size (HDPE perforated), Diameter, mm	Cumulative Distance, meter	Pipe length, meter			Main Line Water Level, (m)	Main Line Invert Elevation. (m)	Branch Line Invert Elevation at Outlet, (m)	Slope of Branch Line, (0.5%)	Branch Line Invert Elevation at Inlet, (m)	Main Line Final Landfill Finish Elevation, (m)	Branch Line Final Landfill Cell Base Finish Elevation, (m)
			Main Line	Branch Line, Right Side	Branch Line, Left Side							
C	PHASE-3											
1		0.00									82.753	
2	160	16.37	16.37		18.49	0.08	81.923	82.003	0.092	82.095	82.723	82.753
3	200	62.50	46.13		36.06	0.10	81.673	81.773	0.180	81.953	82.473	82.600
4	200	112.60	50.10		43.19	0.10	81.423	81.523	0.216	81.739	82.223	82.350
5	200	162.70	50.10		50.32	0.10	81.173	81.273	0.252	81.525	81.973	82.100
6	200	199.23	36.53		55.49	0.10	80.948	81.048	0.277	81.325	80.948	81.858
7	200	234.98	35.75		35.75	0.18	80.948	81.128	0.179	81.307	80.948	81.780

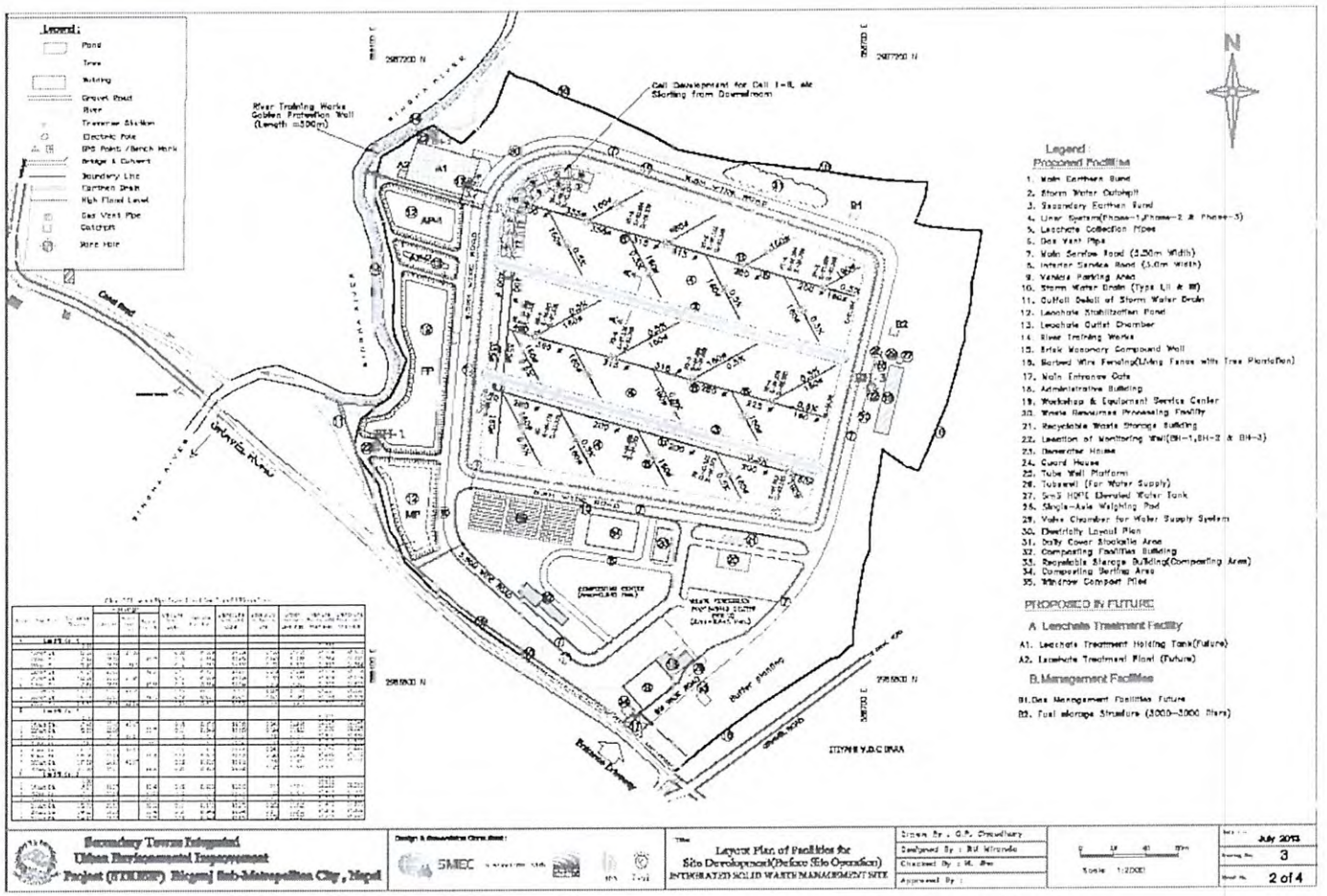


Figure 14: Layout Plan of Facility for Site Development Dwg. No. 3 (2 of 4)

3.8 Leachate Management

3.8.1 Description

As rain water seeps through the landfill cells areas of Phases 1, 2 and 3, it becomes polluted by the waste. When the water finally reaches the bottom of the Landfill, it can be very heavily polluted and is often a dark grey or brown colour, and is then called leachate. During high rainfall or where the waste has not been properly covered, large amounts of leachate can be produced. The landfill is initially aerobic and anaerobic decomposition and formation of full strength leachate can take up to 6 years. Early effluent is weaker and can be acidic, with more slimes formation and odors.

If leachate is allowed to collect in the bottom of the Landfill gravel drainage layer, it could eventually leak into the ground under the Landfill and end up in the ground water or a water supply. After some years, the ground water may permeate a long way from the Landfill and be used by other people.



As leachate contain pollutants which could make the local water unsafe to use, leachate must be collected and safely disposed as quickly as possible from the landfill cells area..

The direct discharge of leachate offsite is environmentally unacceptable, and would generally breach the Landfill operating conditions.

3.8.2 Leachate Control

The overall philosophy of the leachate control system is to minimize leachate production and use the dry waste to absorb any collected leachate and promote rapid biodegradation. (Bio-reactor landfill).

The most effective way to control leachate is a combination of design features and operational practices as follows;



- continuous compaction of incoming waste and provision of daily cover.
- grading of working areas and deposition areas to divert rain water away from the waste working face.
- provision of surface interceptor drains to divert surface water around the filling area.

- progressively developing final grades and shapes to shed surface water off the mound as quickly as possible to reduce infiltration
- prevent leachate escape beneath the Landfill by means of a clay/ synthetic liner or compacted natural clayey subgrade.
- installing leachate drains at the base and the downstream edge of the Landfill to promote leachate drainage to collection points.



Leachate drains are installed in the base of the landfill cell consisting of a slotted pipe inside a gravel drain. This pipe leads to an evaporation pond for very small landfills or a leachate pumping station for larger facilities.

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For smaller landfills, just with leachate lago leachate will be allowed to passively evaporat the leachate lagoon. If the leachate lagoon is fi and is at risk of overtopping, then the portable su pump usually used for pumping out stormwater f the cells could be used to pump out leachate dispose of it by the usual means of evaporatio reinjection.

Disposing **of the leachate in the leachate pumping stations can be by three options**, listed in order of preference below:

- recycling the collected leachate by pumping into the waste mounds by means of "dry wells", located near the top of the filled areas. The Landfill plans may show the design for a reinjection well, or
- irrigation on previously worked areas on stones in prepared future cells, or open pasture to encourage vegetation growth.
- as a last resort, installing and operating a leachate treatment plant and then discharging the treated leachate to irrigate tree farms or coconut plantations or similar non-contact agriculture, or as a last resort discharge into a local canal or watercourse.



The base of the Landfill is graded to a series of low points. Leachate collector pipes are provided which are surrounded with gravel and possibly a woven drainage fabric. The **collector pipes will only be exposed (or connected) just before the slotted leachate pipe (collector pipe) is covered with waste** to stop stormwater entering the leachate system. These main drains are connected to a pumping station, and the leachate is pumped to the dry well injection system on-site, irrigated or treated and discharged.

If the flow of leachate becomes too high for re-injection, it may be irrigated over previously worked areas, over stone on future cells, or treated prior to discharge.

The leachate irrigation system will include a number of flexible hoses such as light gauge HDPE or flexible hoses. These flexible hoses have a number of holes drilled in them to distribute the leachate flows over a large area at the top of the external batters. The **site operators must ensure that the irrigation pipes are regularly relocated to avoid ponding of leachate or run off of leachate from the landfill**.

The leachate pump stations are equipped with pumps that will allow the leachate to be irrigated or injected into the refuse mounds. The pumps should be operated as often as is required to keep the leachate wet wells at suitable level to prevent overflow. The pumps have a low-level electrode cut-out so they cannot run dry and become damaged. The motors must be explosion-proof against methane build up in the well. The Site Foreman will be trained in the disposal of the treated leachate.

All staff are to tell the Site Foreman of any problems with the leachate system. The Site Foreman will also decide whether leachate is to be reinjected or irrigated at **any time,** based on prevailing and expected weather conditions and the need for plant vitality.

3.8.3 Leachate Lagoon

In relatively smaller landfills and especially in drier areas, leachate can be directed to a leachate lagoon for evaporation. In wetter areas, the lagoon may need to balance wet season infiltration until the dry evaporating season arrives in which case they must be covered. The only operational involvement would be to check the lagoon integrity, especially the inside face of the encircling bunds and remove any litter.



If the leachate lagoon is filling and is at risk of overtopping, then the portable sump pump usually used for pumping our stormwater from the cells could be used to pump leachate and dispose of it by the usual means of evaporation or reinjection. Another lagoon may have to be constructed in unusually wet periods.

3.8.4 Leachate Monitoring

Any leachate collected in the deleaching wells will be tested quarterly to assess its quality, or as stated in the site Licence. Ground water will also be tested as this could be affected by leachate. Nitrogen compounds are a common indicator of pollution, but it is important to test the ambient water quality for a year before operations start to avoid false alarms.

It is proposed that the ground water bores/ leachate wells will generally be monitored **on a quarterly basis** or in accordance with the approvals, regulations or guidelines of the time. The **Environmental Monitoring and Management Plan outlines typical water quality parameters and frequency to be tested but the parameters and testing specified in any approvals for the Site should take precedence.**

3.8.5 Emergency Action

The correct operation of the leachate system is extremely important.

If the system has broken down or is in danger of leaking, the Site Foreman must be immediately notified. He will then investigate the problem and immediately notify the Manager.

3.9 Storm Water

3.9.1 Background

If external runoff water is not carefully controlled, many operational problems will arise, including the following;

- extra leachate will be formed,
- pollution can be carried off Site,
- the Landfill will be hard to operate due to bogged vehicles, and
- the operator of the Landfill can be fined for breach of the Landfill Licence.

The storm water on a Landfill can be classified as either clean or dirty. The clean storm water falls on undisturbed land and is not polluted. This water usually drains onto the Landfill from the adjacent catchment. To **stop the clean water from being polluted, diversion drains and bunds will be constructed around the Landfill to divert clean storm water runoff or flood water from entering the working areas** and disturbed areas of the Landfill. All storm-water channels and the entrances into local canals and natural creeks should be checked regularly for signs of erosion and/or instability such as after each major storm event.

Internal stormwater runoff contaminated by soil cover stockpiles and disturbed areas is classified as dirty. This dirty water volume can be minimised by implementing progressive revegetation of completed areas.



In certain locations there is no requirement to treat dirty stormwater before discharge. If tment is ıuired, a / :/geotextile rrier can ɜ constructed across the runoff points within the Site to minimise escape of silt or a settling pond constructed, if required by the Landfill Licence or Permit. The barrier should be inspected after each major storm event. Trapped sediment will be removed for use as cover, and the silt barrier inspected for any damage.

Where storm water is to cross an access track, a piped crossing must be provided. Any **water that ponds against the waste face for a lengthy period, or evenagainst litter, must be treated as leachate,** and must not be directed to the storm water systems.

3.9.2 Storm Water Controls

The **cells will be filled with waste from higher areas to lower areas to avoid stormwater ponding at the base of the working face or previously worked areas**.

The base of the Landfill is sloped to allow stormwater runoff to flow by gravity to a central location from **where it will be pumped outside the cell to the stormwater drain**

Any stormwater runoff from higher areas or previously worked areas will be diverted away from the active face through small drains or bunds as necessary during new sub-cell development.

3.9.3 Surface Water Monitoring

Visual inspection of the water leaving the Site should usually suffice. If obviously turbid or dirty, then treatment will be required, such as silt barriers or settling ponds.



If required by the Landfill Licence in the future, monitoring of surface water as it enters and leaves the Site may be specified on a regular basis, such as during major runoff events to determine the level of any contamination. Parameters analysed could include the following but will be stipulated in the Landfill Licence if required: electrical conductivity, pH, redox potential, temperature, total dissolved solids, suspended solids, turbidity, nitrogen scan, bicarbonate, chemical oxygen demand, standard water analysis, iron total, zinc, chromium, lead and copper. Similar monitoring of the internal storm water above and below the working face should also be carried out.

All staff are responsible for checking that the storm water systems are operating properly. Any problems are to be reported to the Site Foreman.

3.10 Landfill Gas

Landfill gas explosions have occurred infrequently throughout the world, but these are always at poorly run Sites with large voids in the Landfill resulting from old water or fuel tanks, vehicle bodies and so on. These items will not be allowed into the Landfill as they are recyclable materials and also may form these large gas pockets. Without these large voids**, there is no risk of explosion at the Landfill even with only passive gas venting systems. Where domestic housing is allowed too close to a landfill, natural crevices in the soil formation can allow landfill gas to migrate as at Cranbourne in Victoria, Australia where buffer distances were reduced as cover was applied. This resulted in evacuation of houses and significant fines to the operator and approving authorities. Buffers need to be maintained unless a physical barrier is constructed against gas migration.**



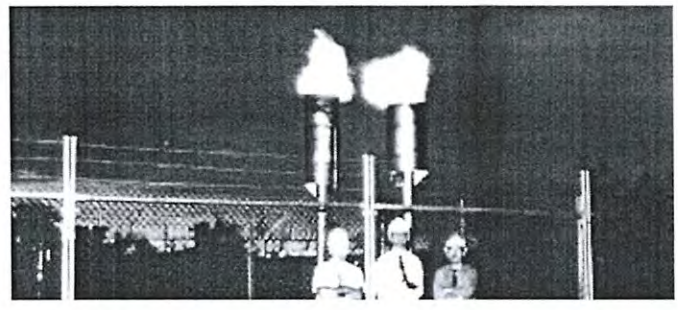
There is no need to have horizontal collection systems and a network of vertical vents and risers for a small Landfill where the gas will not be commercially harvested.

Since the Landfill will provide a relatively low yield of gas, **a simple gas collection blanket could be installed under the final cover with some passive vertical vents.**



The gas collection blanket, consisting of a simple gravel layer, would only be provided under the middle third of the final Landfill footprint.

There are no specific operational requirements. During a temperature inversion, biogas can sink down rather than rise, so attention should be paid to neighbouring terrain if this could be an issue.



In the future if the biodegradable tonnage being landfilled significantly increases, then vertical gas wells can be retrofitted, and a piping network and manifold installed to allow productive reuse or flaring of the gas. The rule of thumb is that landfills receiving less than a few hundred tons a day of waste are unlikely to be commercially successful. The collected gas can still be used for local heating requirements however.

3.11 Litter Control

Litter control is required on all areas of the Site.

3.11.1 Litter Fences

Moveable litter fences should be positioned on the downwind side of the tipping face about 50 metres from the edge of the tipping face. They should form a curve in the horizontal plane, slope inwards and have no gaps.



The length of fence depends on the size of the tipping face but should be wide enough to allow for changes in wind direction.

The litter fence should be cleaned every second day, or daily during windy weather.

3.11.2 Boundary Fence



The boundary fence will help to stop trespassers entering the site and to help keep litter inside the Site.

The boundary fence (or outer litter fence) should be cleaned each week, or more frequently in windy weather.

3.11.3 General Site



Any material found on the access roads should be cleaned up each day before the Site is closed.

Spilled liquid from engine changes or drum spills should be cleaned up with dry powder, such as sawdust or sand, in the first instance.

3.11.4 Access Roads



Litter is often dropped from loads on the way to Landfills and is sometimes dumped near the Site by people arriving when the Site is closed.

The approach roads within 200 metres of the Site should be kept free of litter (or other distance as may be subsequently required by the Landfill Licence). This will require **a hand litter collection to be undertaken each week**.

If a large amount of litter is found on any day, it should be reported to the Site Foreman who will arrange for a special clean up.

All staff should try to "catch" illegal dumpers and get them to pick up their waste and dispose of it legally. If they refuse, obtain as much of the following information as possible and report it to the Site Foreman:

- name
- address
- vehicle registration number plate
- vehicle type
- vehicle colour
- date and time
- type of material
- amount of material.

If possible, take photographs of the vehicle dumping illegally.

3.11.5 Responsibility

The Site Foreman will decide how often to have litter clean ups.

All staff should look out for litter problems and report them to the Site Foreman.

3.12 Pest Control

On a poorly run Site there can be a number of pests including;



- **Birds** such as generic seagulls, ibis and pigeons are common, or local specific species
- **Flies** can be a major problem if the working face is not covered quickly (and mosquitoes in Dengue or malarial areas breeding in micro-containers).
- **Rats** live at nearly all Landfills and can breed into large populations if not controlled
- **Feral cats and dogs, domestic pigs and cattle and goats** are often found on unfenced Landfills and should be controlled, especially as cats and dogs will prey on native animals.

The best method of control of all pests on a Site is to operate the Landfill properly. Fencing keeps out larger animals and it should be kept in good repair. If the waste is properly compacted and quickly covered, the pests find it difficult to feed and will go elsewhere.

Well compacted waste will make it difficult for rats to find homes and tunnels, and access to the waste is difficult if the cover is properly applied.



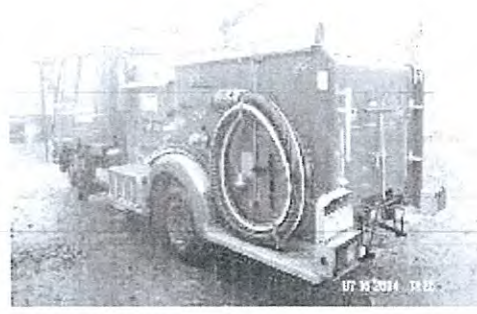
Many methods are used to control birds, including, poison, guns, shotgun blasts (blanks) wires between high poles, nets, noise, hawks and eagles and even whips. None are completely successful but can be of some use if birds are a problem.

Rats are difficult to control and it is usual to employ a contractor to lay poison to keep the population under control if numbers become excessive. Typically, the contractor would come each day that rubbish is delivered to the Landfill. If the Landfill accepts a lot of solid waste and little kitchen/putrescible waste, baiting may only be required twice each week.

Inform the Site Foreman if pests are increasing. The Site Foreman will arrange for extra pest control.

3.13 Fire Control

3.13.1 Notification Procedure



As with any Landfill, purposeful lighting of fires is banned, as is smoking anywhere on the Landfill.

Fires usually occur because of chemical reactions from hazardous chemicals, high piles of composting wastes in the Landfill or someone burns the waste pile to reduce odours or vermin infestations.

When smoke is found coming from the Landfill, the Site Foreman must be immediately notified.

Under no circumstances is the fire to be put out by the bulldozer/excavator operator if no-one else is present.

The Site Foreman/Manager will decide what action is to be taken. If the fire is over a large area, contact the fire brigade.

3.13.2 Fire Fighting Procedure

Do not just flood the waste mound with water hoping to extinguish the fire. This rarely succeeds and will just form large quantities of leachate.



The best method of putting out a fire is to open up the Landfill and spread out the burning waste. Before the Landfill is opened, the Landfill water tanker is brought to the area and checked that it is in operating condition.

Operators must take extreme care when fighting fires with earthmoving equipment. All major plant equipment must have a fire extinguisher. Before starting to fight the fire, make sure the fire extinguisher is ready for use.

Any plant equipment which is in poor condition must not be used, especially if there are any oil leaks or the plant is unreliable and in need of service.

The waste mound is to be opened near the smoking area and the dozer will move towards the smoking area, by pushing the waste well away from the point of fire.

When the burning area is reached, the waste is spread out on the surrounding cover and either put out with the Landfill water tanker or buried with cover material. When the fire is put out, the material should be reworked to ensure there are no hot spots before it is re-buried.

The Site Foreman will note all fires in the Daily Report including the suspected cause, how long the fire went for and what equipment was used to put it out.

3.14 Dust Control



Dust is often caused mainly by vehicles as they drive to and from the tipping face, but large stockpiles of cover material can also be a major dust source in dry periods. Dust control is especially needed when dry and windy.

Dust control is achieved by spraying water or leachate on access roads, open dirt areas and stockpiles to reduce the amount of dust emitted.

Where available, magnesium chloride salts added to the tanker water will settle dust for six or more months, with no adverse environmental problems. Magnesium chloride is a waste product from table salt production.

The Site will be provided with a water tank to be used for dust control and firefighting. This is awater tank that can be fitted to the site tipping truck as required. A motorised pump and hose should also be fitted.

When the Landfill is dry, especially on windy days, all access roads should be watered at the start of the day and watering repeated whenever dust starts affecting visibility. Leachate or stormwater is suitable for this purpose.

When spreading cover material, water needs to be sprayed to control the amount of dust generated.

The waste mound batters must be progressively mulched and revegetated which eliminates dust from the previously worked areas of the Site.

Mulching or other techniques may be required to control dust emissions from cover stockpiles, if this becomes an ongoing problem.

All staff should look for dust problems and report them to the Site Foreman who will log the problem and decide the solution.

3.15 Mud Control

Mud adhering to vehicle wheels could be removed in wheel washes prior to vehicles leaving the Site.

Wheel washes may be classified as static or pressure as described below:

Static

These are shallow drive through basins which remove the dirt from the tyres. The basins are usually made of concrete and can be profiled to enable an excavator or similar to clean out the mud. A sealed road before and after the wheel wash is required. This type of wheel wash does not remove mud from the chassis of the truck.

Pressure

The simplest type of pressure wheel wash consists of a concrete drive through area with spray nozzles on low side walls. As the truck moves slowly through, the wheels and chassis are washed. To help remove the mud before the wheel wash a rough section of sealed/concrete road can be built. This must be cleaned regularly. Access roads should be constructed from sandy/gravel material. If mud is noticed on the public roads near the entrance gate it must be immediately cleaned off by either water trucks and/or shovels. The wheel wash will require regular maintenance.

The City may decide that wheel washes are unnecessary, provided that they are not required in the Landfill permit.

The same facility and treatment can be used for skip bin washing and exchange, with water taken to the landfill or slow sand filter treatment.

3.16 Operation of the Leachate Stabilization Ponds

The general function of a leachate treatment facility is to purify the leachate collected so that the leachate will not pollute the groundwater, the adjacent Singaha River, and the affected impact areas and water bodies in Birgunj as a result of the construction and operation of the sanitary landfill at the site.

The leachate treatment design consists of a leachate holding tank for containing the initial production of leachate from the landfill cells area, and a waste stabilization pond system for managing the biological treatment of leachate consisting of a series of the following:

1) Anaerobic pond
2) Facultative pond
3) Maturation pond

A sludge drying bed can be established in the future in the area near the Composting Center when the parameters for sludge become clear in a few years of operation of the landfill.

The design is for continuous inflow and outflow of leachate from the landfill site for a period of more or less 20 years. Active landfill deposition of residual waste is expected to commence in 2016 up to a design life of about 15 years. If the process of waste recycling at the households, ward and municipal- level is successful, the life of the landfill could extend for another 3 to 5 years, if properly managed.

A leachate treatability analysis will be performed during the first few months of operation of the landfill cells area. For this purpose a leachate holding tank for pre-treating the leachate for trace metals and inorganic compounds will be constructed and utilized prior to the eventual release of leachate into the waste stabilization ponds for reduction of the organic loading. A pilot physicochemical treatment plan needs to be established to determine the prevailing requirement for chemical treatment. This pilot system is to be expected because the landfill cells are designed to only be the final repository of residual wastes or unwanted waste – after 3R activities of the municipality - with compostable waste and recyclable waste considerably removed from the final disposal waste stream. It is not practicable to design the leachate treatment plant based on parameters from other predominantly co-mingled or "mixed waste" landfills hence the design for the combined option of pre-treatment for inorganic compounds and trace metals and biological treatment has been adopted to be a design in progress based on a pre-determined budget that is available.

The pilot physicochemical treatment will involve obtaining samples from jar tests or other applicable sampling and laboratory techniques available in Birgunj and neighboring Nepal cities or districts and determining the optimal dosage and treatment parameters.

The waste stabilization pond system is designed to treat leachate by the natural process of bio-degradation from the activities of both algae and bacteria. The anaerobic ponds are designed to handle the organic loading from leachate and make use of anaerobic digestion to achieve organic removal. The facultative pond will operate with reduced organic loading to enable algae to develop in the surface layer and an oxy-pause to form. In the lower layer the oxy-pause will occur and above the oxy-pause aerobic bacterial oxidation occurs in symbiosis. These anaerobic and aerobic processes are highly temperature dependent and increase logarithmically with the linear increase in temperature. In maturation ponds, faecal indicator bacteria and pathogenic bacteria are removed mainly due to starvation and hostile environment. Detention time is the key factor in these ponds as well as temperature, ultraviolet radiation and oxidation.

The leachate stabilization ponds will be capable of treating a calculated peak flow of Q = 1,500 m3/day of leachate which has an assumed BOD of 1,000 mg/l. The design temperature is 25 degC and the assumed net evaporation rate is 5 mm/day (Data from The Society of Hydrologist and Meteorologist, Nepal).

As a guideline for operations, the hydraulic profiles of the leachate stabilization ponds can be found in the following drawing.

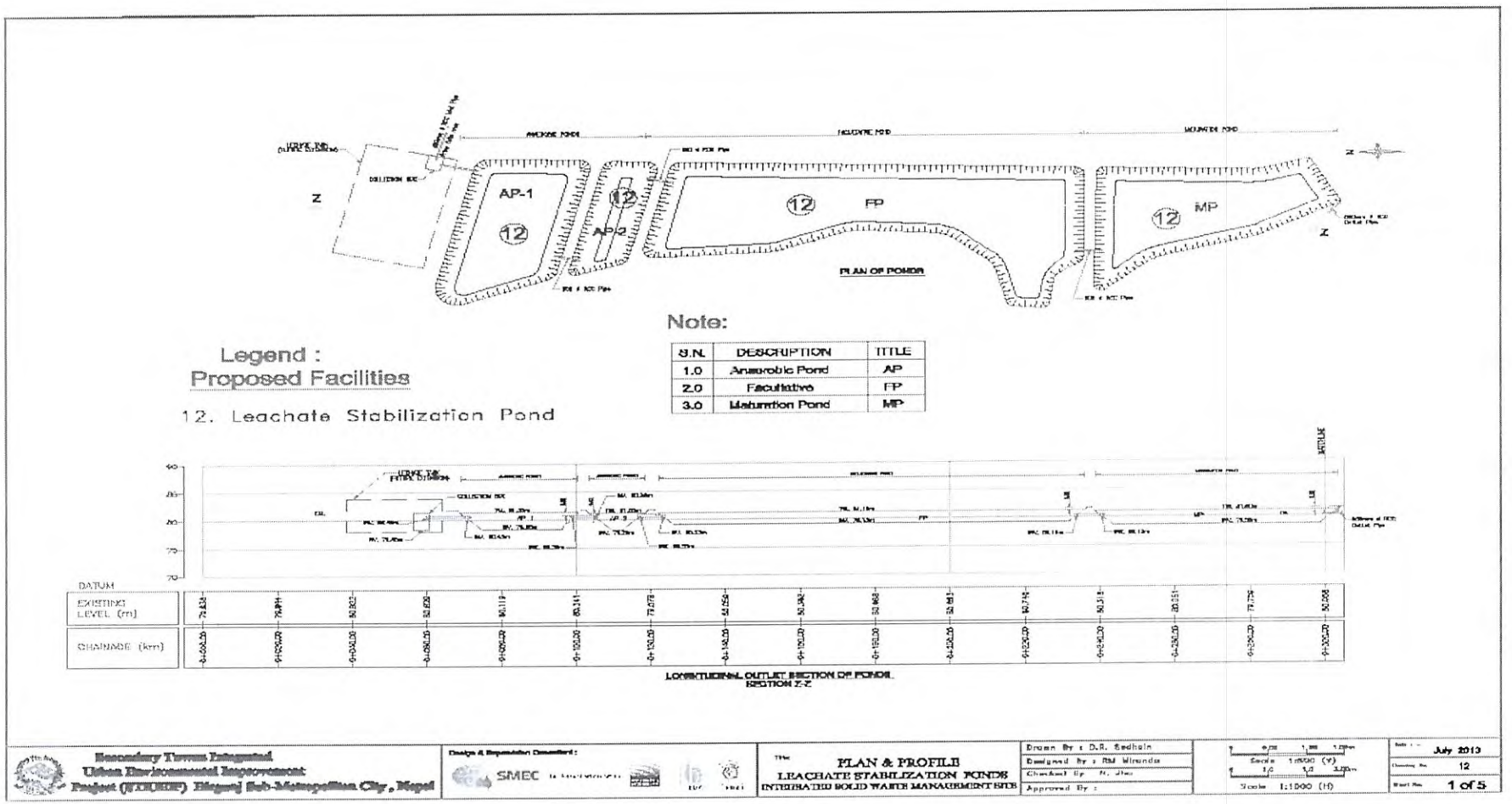


Figure 15: Plan and Profile Leachate Stabilization Ponds Dwg. No. 12 (1 of 5)

3.17 Civil/Structural and Electro-Mechanical Works

The detailed designs of civil, structural and electro-mechanical works are shown on the detailed design drawings. They were designed so that they will have a minimum life of at least 25 years and be able to withstand foreseeable flooding and climatic events. The design drawings are presented so that all construction tasks are clearly illustrated and the respective facilities are drawn with adequate construction details. Quality control measures are identified with the designs.

In the case of structural designs, the critical ones are the main and secondary bunds. Based on the bearing capacities and soil characteristics determined from the Geotechnical Report, all the buildings and structures/facilities have been analyzed and designed in accordance with Nepal design standards (with cost effectiveness and safety as main considerations) and - in the case of the sanitary landfill cells area – the ability to withstand the active and passive pressures exerted by the deposited wastes up to the final elevations and final cover or cap.

3.18 Buildings and Support Infrastructure Facilities

The main buildings and structures/facilities that will support the main operational functions of the ISWM site are:

- Entrance Gate and Guard House – for security, safety and control
- Frontage boundary wall – for security
- Property boundary fence – living fence for security and safety
- Interior and Service Roads – for internal circulation and traffic movement
- Waste Reception Center (with Truck Axle Weighing Scales) – for control of entering and exiting waste materials, and ISWM tracking of activities
- Administration building – for management of personnel and office facilities
- Workshop/Office/Equipment depot and Washing Facilities – for servicing of vehicle and heavy equipment fleet
- Surface water Interception canal and management system – for protection of sanitary landfill build-up of leachate volume
- Daily cover stockpile area – for temporary storage of daily cover material
- Generator House and Electrical Room – for electrical sourcing, transmission and distribution for all buildings and facilities of the ISWM site
- Fuel Storage Structure, 3,000-5,000 liters (Future) – for storage of fuel
- Water supply pumping station and Elevated Water Tank (Vehicle Washing Facility) – for ensuring that vehicles and equipment are washed regularly (with due protection against contamination of site with refuse liquor from operations), and cleansing for the different buildings and facilities, and watering of plants, tress and gardens
- Water supply pumping station and Elevated Water Tank (Domestic) – to ensure adequate and safe water supply
- Communication Facilities – to ensure communication facilities for all personnel at the site
- Water Distribution Facilities – to ensure adequate and safe water supply
- Gas Management Facility (Future) – to provide for future gas management facility when necessary

- River Training Works – to protect the site from river encroachment and the river banks from constricted flow due to ISWM site operations
- Trees and plants along buffer zone – to provide ample space and enhance air quality
- Monitoring well No. 1 – to monitor groundwater quality regularly in compliance with environmental regulations
- Monitoring well No. 2 – to monitor groundwater quality regularly in compliance with environmental regulations
- Monitoring Well No.3 (the water supply tube well beside bore hole 3 will be utilized for monitoring) - to monitor groundwater quality regularly in compliance with environmental regulations

CHAPTER 4: THE WASTE RESOURCES PROCESSING CENTER (WRPC)

4.1 Materials Recovery Facilities (MRFs) in the Wards

It is proposed in the integrated solid waste management design that under the sub-metropolitan city's leadership, wards are organized to be made responsible for the collection, segregation, recycling of biodegradable, recyclable, compostable and reusable wastes at the ward level. Material Recovery Facilities (MRFs) will be established in every ward or cluster of wards. It is proposed that a site will be established and managed by the wards for this purpose.

The MRF shall receive biodegradable wastes for composting and mixed non-biodegradable wastes for final segregation, re-use and recycling, if these have not been done at the household level. Each type of waste is collected from the source and transported to the MRF in separate containers that are color-coded into at least two: green for organic and red for inorganic wastes. A simple ward composting system shall be developed should the wards decide to construct and maintain such facility.

The resulting residual wastes shall then be transferred to the Sanitary Landfill cells area of the ISWM site.

The MRFs shall be designed to receive, sort, process and store compostable and recyclable material efficiently and in an environmentally sound manner. The residual wastes shall be collected at established collection points by the BSMC or its assigned contractor-operator as planned by the BSMC Sanitation.

4.2 Recycling Activities

A quick market survey of recycling activities in Birgunj was conducted to establish that there are three levels of buyers of reusable and recyclable wastes in Birgunj: the itinerant scavengers or waste pickers, the small junk shops and the large junk shops. The 4th level or consolidators are outside Birgunj possibly nearby Northern India. It was however established by interviews with these respondents that recyclable and re-usable materials are sold mostly in Birgunj and in Kathmandu.

A further study should be prepared in the future to look at other potential buyers for recyclables, their buying specifications and prices with the leadership of the BSMC. Another possible market would be the industries within Birgunj who because of their waste management practices and by law could buy back or recover their own recyclable or reusable wastes .

Birgunj NGOs or recycling groups/association would be involved in these activities. For recycling activities to be successful, the principle should be followed that the municipality or its projects should not compete but rather complement or supplement the existing system.

The recommended design for recycling is for Birgunj to formulate recycling plans and strategies. The solid waste sector may undertake a study of existing markets for processing and purchasing recyclable materials, and the potential steps necessary to expand these markets. The NGOs will be very instrumental in promoting the recycling activities in the ward communities under the City's leadership.

When developing the market for recycled goods, an investigation of markets should be made for each recyclable material by the City's solid waste planners. These activities could include:

a) identifying potential purchasers of the recovered material through standard market research techniques;

b) directly contacting buyers and determining the buyers' quality specifications, potential transportation agreements and any minimum quantity criteria.

All information from the investigation of markets, including a list of prospective buyers of recycled products, and a list of procedures, standards and strategies to market recyclable materials and develop local markets, shall be easily accessible to the public and the wards. A database for this could be established by the City.

At the ward and household levels, recycling can be pursued individually or in cooperation with the ward organization. If the Tole organizations or SWM user committees are influential in promoting the 3Rs then by all means their assistance and cooperation should be sought.

4.3 Operation of the Waste Resources Processing Centre (WRPC) in the Integrated Solid Waste Management Site

The city's waste collection vehicles coming from the different wards of Birgunj shall bring the segregated recyclable wastes into the Waste Resources Processing Center in the sanitary landfill site. In terms of solid waste processing facilities and sanitary landfill, the preliminary design for the Center is to undergo a process of further segregation into saleable materials such as paper, cardboards, plastic, metal, bottles and other high value materials. Initially this can be done manually provided that the waste processors or sorters are properly equipped with personal protective equipment such as dust masks, gloves, boots, and protective clothing as required. There will be an office and supervisor to oversee all the activities of the center are functioning smoothly. Depending on the volume of recyclables coming into the center, a mechanical and machine-driven sorter may be procured at a later time if the budget permits. A business plan for the WRPC shall also be prepared by the municipality to monitor sales and expenses, the competition, new outlets and markets as well as the prices of recyclables in the market. The sale of the recyclables shall be promoted by the municipality extensively. It is expected that at least 10% of the post collection load of the collection vehicles will comprise the recyclables that will enter the center for further processing.

Care should be exercise that Electronic waste and other toxic and hazardous wastes, classified as such by the Nepal MoSTE should be handled like toxic and hazardous wastes and should be disposed of in accordance with the environmental and health and safety laws of Nepal

Table 32 below is an estimate of the amount of recyclables that enter the WRPC and the products that it generates after processing.

Table 4: Summary of Inorganic (Reusable and Recyclable) Materials Flow

(Inorganic) Reusable and Recyclable Materials Flow	tonnes/ day	cu.m./ day
Total Waste Generation, 2016	41.59	128.7
Total Waste Generation, Inorganic (reusables and recyclable)	13.23	40.95
Recyclable recovered move to WRPC (15% of compost center input)	2.70	8.34
Recyclable product recovered (range of 50%-90% of WRPC inputs)	5.55	17.17
Recyclable recovered move to WRPC Block Collection to Compost Center (15% of compost center input)	0.23	0.72
Recyclable product recovered Block Collection (range of 50%-90% of WRPC inputs)	0.30	0.94
TOTAL ESTIMATED RECYCLABLE PRODUCT	8.78	27.18

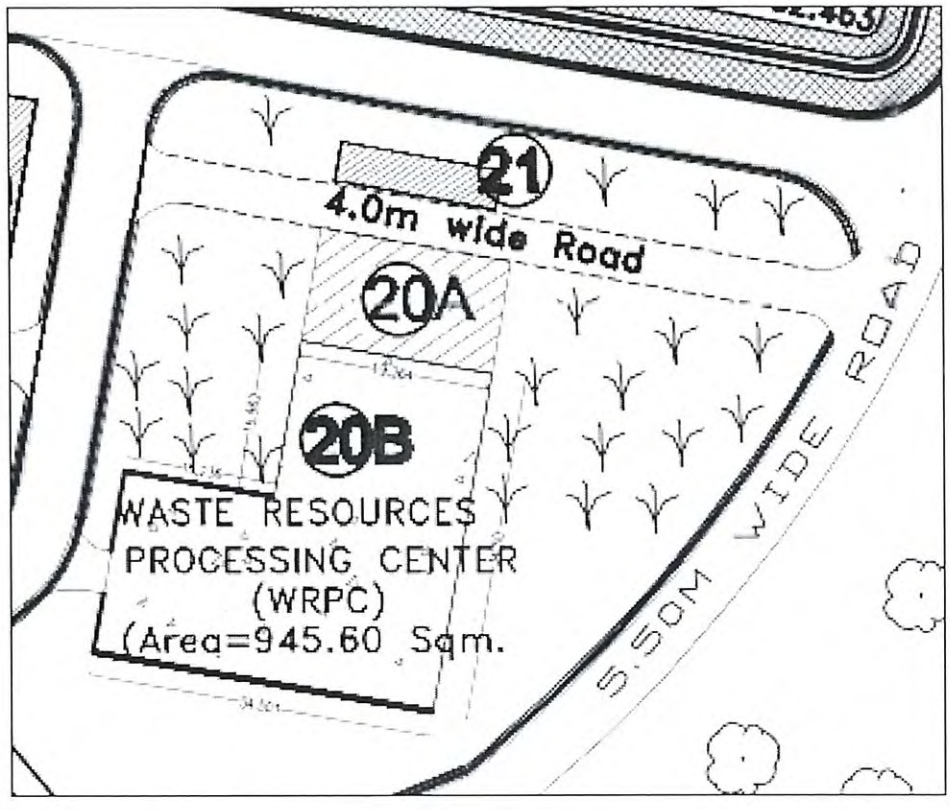


Figure 16: Site Plan of Waste Resources Processing Center

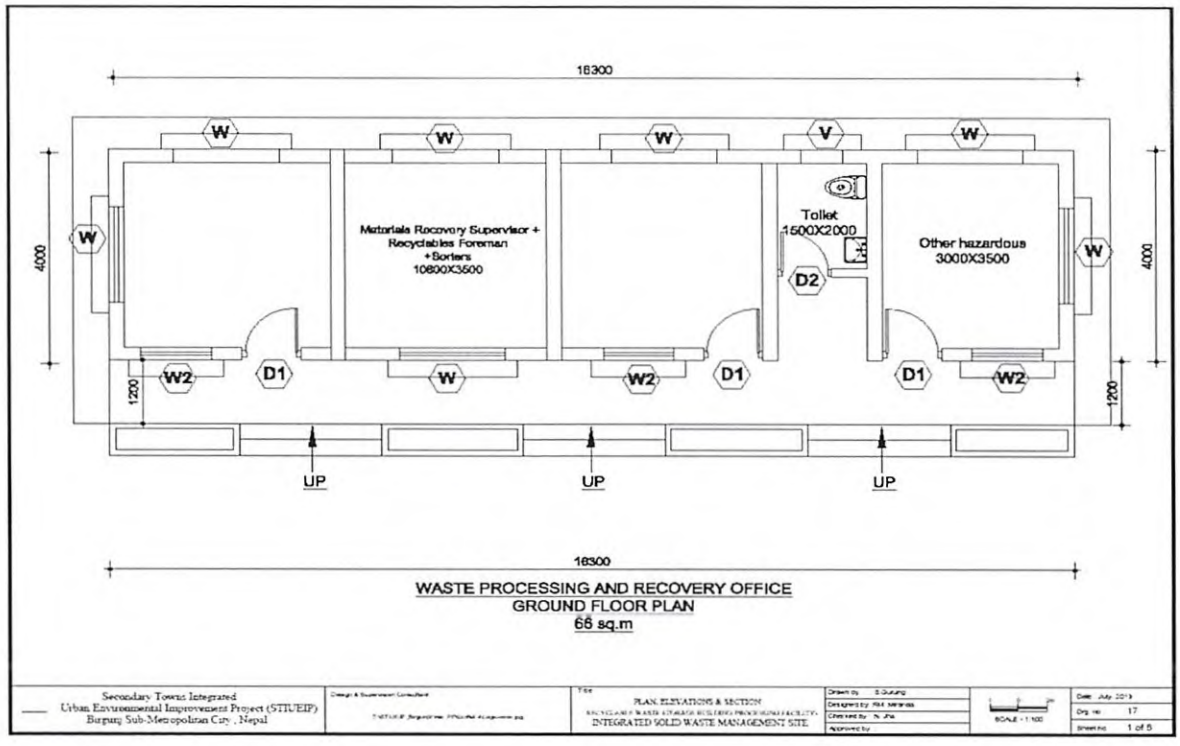


Figure 15: Layout of Waste Processing and Resource Recovery Office

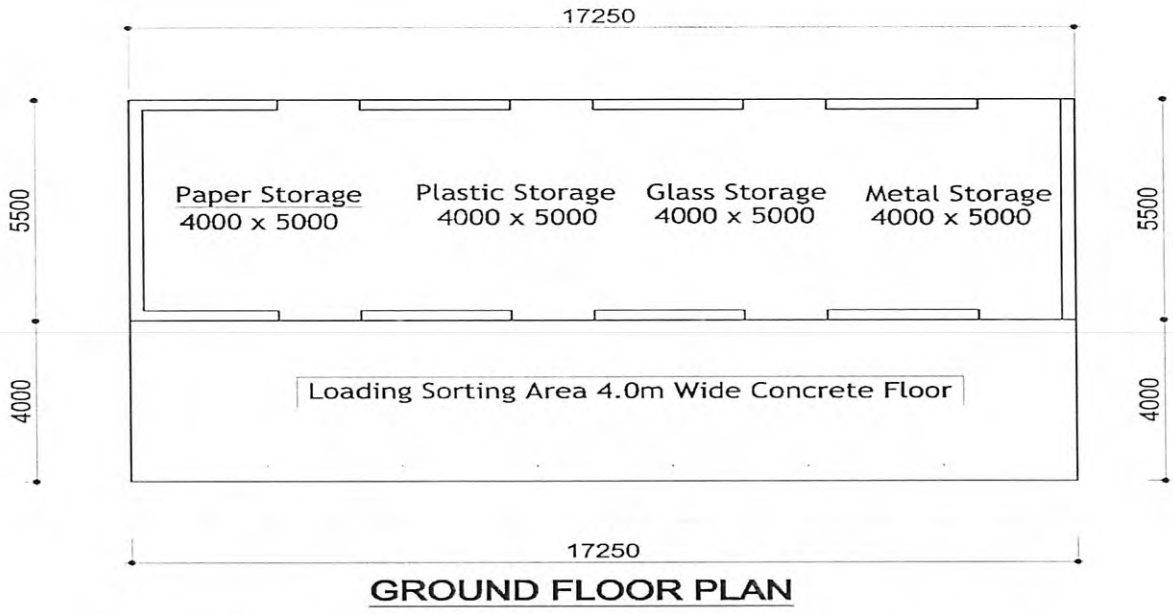


Figure 17: Layout of Waste Resources Processing Center Recyclable Storage Area

4.4 Operational Procedures for the Waste Resources Processing Center

The primary function of the Waste Resources Processing Center (WRPC) is to serve as the main center for the processing of the recyclable and reusable components of the 3Rs activities of the municipality.

The following flow chart, Figure 37, illustrate the operational procedures of the WRPC.

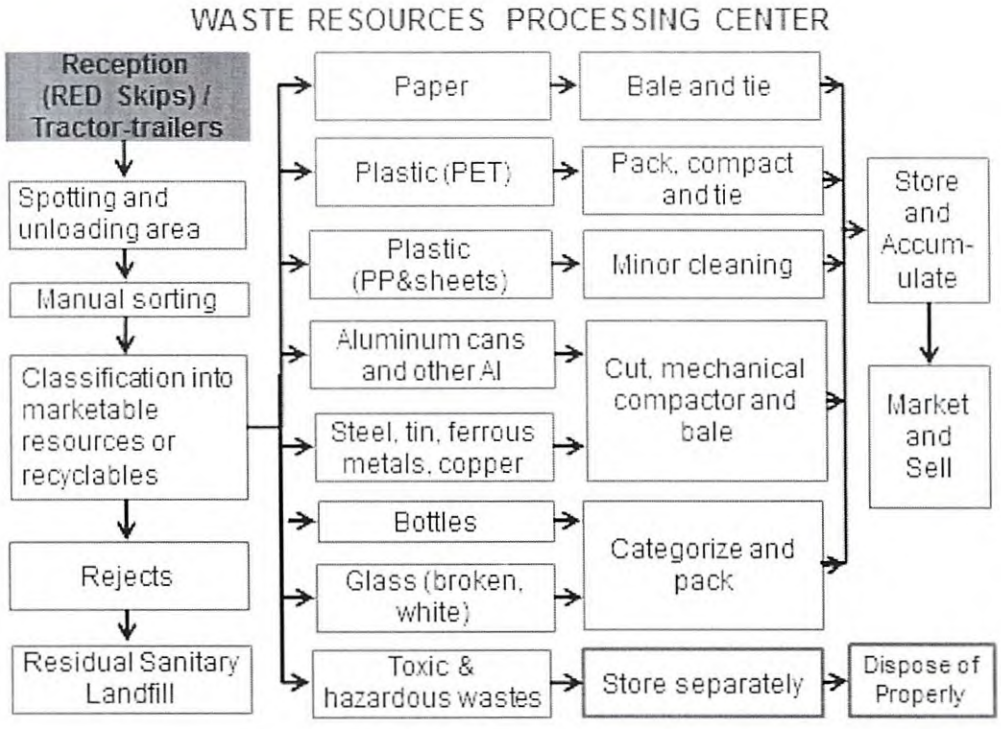


Figure 18: Flow Chart of Waste Resources Processing Center

4.4.1 Recycling Areas

A focus of the Solid Waste Management site is trying to maximise recycling and re- use interventions.

This will be achieved through a number of mechanisms as follows:

- Maximizing segregation, such as for of green waste where processed, to allow it to be chipped and then reused on access roads and daily cover and to protect final cover against erosion.
- Providing set-down areas for other materials that require reprocessing before re-use such as builders' rubble. This will be later crushed and re- used as road



aggregate or for other gravel needs on site, such as leachate drain encasement or landfill gas blanket construction.

- Stockpile areas or concrete bunkers accessible to front loader buckets, for other recyclables such as large metal objects, large volumes of paper or cardboard waste and plastics.
- A separate stockpile area will be provided for any uncontaminated or lightly contaminated soil that can be re-used as cover material.
- Additional areas will be provided for processed recyclables such as chipped green waste, open windrow composting slabs and crushed builders' rubble.



There are few specific operational requirements associated with the recycling facilities.

The main issue will be maintaining litter management throughout the area as well as minimising dust through the application of water or leachate application and erosion control by applying chipped greenwaste or revegetating. Supervision to prevent cross-contamination or incorrect deposition will be required for the public.

CHAPTER 5: INSTITUTIONAL ARRANGEMENTS

5.1 Existing Organization

The present organizational chart and staffing of Environmental Sanitation Division, Sanitation Section and the two sub-sections: Solid Waste Collection Sub-section and Solid Waste Disposal Sub-section are presented in the following chart. The difference between the 2 sub-sections need to be defined and rationalized.

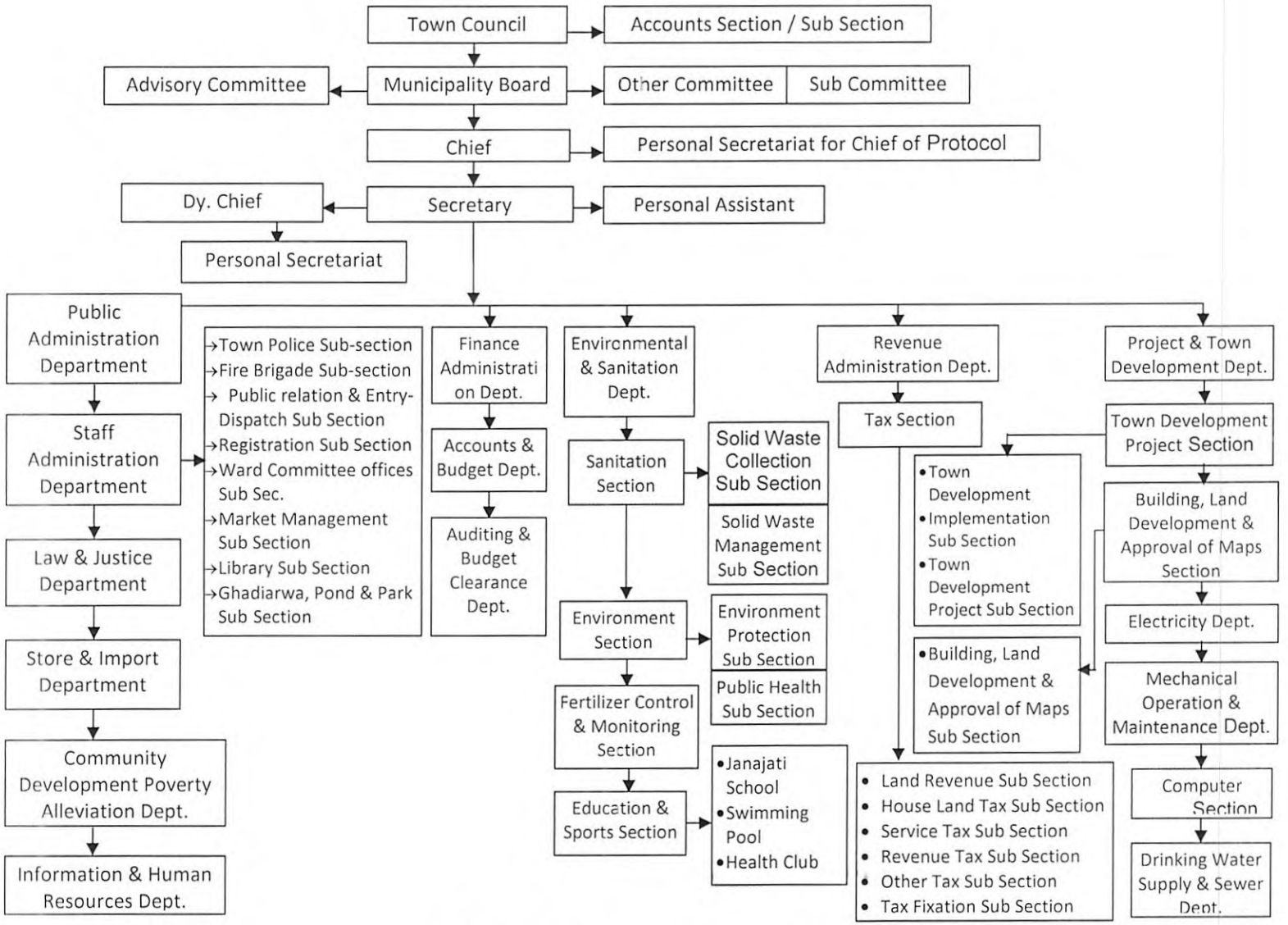


Figure 19: Birgunj Sub-Metropolitan City Existing Organization Chart

5.2 Institutional Arrangements and Organization Structure

The existing organization of Birgunj Metropolitan City consisting of the Sanitation Department and the Environmental Sanitation Division should be rationalized for greater efficiency. It is proposed to create management positions assigned specifically to take charge of waste collection and another position to manage the ISWM site. Several positions are proposed to be filled also to manage the technical operations of the Composting Center, the Waste Resources Processing Center and the Sanitary Landfill Cells area. These are shown in the proposed organizational charts in the ISWM site chapter of this report. About 100 additional personnel are proposed in order to fully operate the proposed collection and sanitary landfill vehicles and equipment and the additional personnel requirements for primary collection to bring the collection service to a higher percentage.

The project awareness campaign has to be started right away and the role of the NGOs will be vital in the campaign for 3Rs. Similar arrangements for PPPs with NGOs should be expanded in other wards that need support. It is also important for the present organization to work closely with the new organization running the landfill site. The two organizations need to be attached to the Sanitation and Environmental Department of Birgunj in their present set-up. As mentioned above, a Resident Manager is recommended to be assigned to the ISWM (Sanitary Landfill) Site.

For the Waste Collection and Transport Program, it is recommended that the Environment and Sanitation Department of BSMC establish a dedicated organization for SWM collection and transport and assess the utilization and serviceability of the tippers, the tractor-trailers and the rickshaws and handcarts.

5.2.1 General Staffing and Responsibilities

The **general staffing and responsibilities will be divided into two; management positions and the remaining operational staff;**

- **Resident Manager - Waste Management**; senior officer to whom the Site supervisor reports. Usually the Head of the Environmental Management Division based in the City offices, t the Cleaning and Greening Department, and responsible for the overview of all operations, including the Environmental Monitoring and Management Plan (EMMP) implementation.

- **Site Foreman**, based on-Site, and responsible for all Site operations on a daily basis and to implement the Operation Manual approach.

The key operational staff will include the following;

- **Site Landfill Compactor operator**
- **Excavator/Payloader and bulldozer operators**
- **Truck drivers**



Other staff will include the following:

- **Water cart operator/leading hand** and backup driver for the heavy equipment
- **Gatekeepers** will be in charge of checking loads and be assisted by the clerks. Much closer inspection of waste streams is an expected requirement in the future to avoid hazardous and dangerous loads entering the landfill. (An elevated platform at the gate house will assist in inspections of truck loads)



- **Weighbridge Supervisor** will be in charge of classifying wastes and direct the wastes collection vehicles to the proper area of the ISWM site. He will be generally in charge of deciding which wastes are allowed entry, the types of wastes and which are prohibited. In case of conflicts, he reports to the Resident Manager for the disposition of the such waste categories in accordance with guidelines form BMC and the MoSTE.
- **Clerks** to maintain load receipts and records. Possibly will be the same person as the Gatekeeper at smaller facilities and may work shifts to allow the Landfill to operate for extended hours.
- **General labourers** for daily litter patrols around the Landfill and buffers, plus traffic direction and tipping control, managing any scavengers on site, picking up litter, clearing drains, moving irrigation pipes, operating the generator, EMMP monitoring, Site safety issues, fire monitoring and control, fence repair and litter fence relocation etc. Will usually need to work shifts to allow the Site to operate for extended hours.

5.2.2 Training

Aspects of the training program will extend to all Site staff to ensure their understanding of the operational methods that would now apply, particularly when compared with the open dumping operations common in the past. Training must also address the Environmental Monitoring and Management Plan (as applies), and how the EMMP affects their day-to-day operations.

In addition to the training required for the key management positions of Manager and Foreman, training should be provided for their temporary replacements for when they are absent.

All key staff should be trained in the relevant issues associated with each other's roles.

Nominees will also be trained to undertake the Site Foreman's role in his/her absence. This training will include all aspects of the day-to-day operational issues, Environmental Monitoring and Management Plan implementation and associated reporting/recording responsibilities. Generally, this would include the Gatekeeper, leading hand and head clerk.

5.2.3 On-Site Facilities

Facilities on Site will vary but may include:

- Gatehouse, including the clerks' offices and record keeping
- Storage compound for equipment, vehicles and fuel
- Amenities building
- Workshop
- Generator building, fuel bund
- Weighbridge
- Wheel wash (future possibly)
- Bins or dedicated areas for recyclables
- Bin wash/ sterilisation
- Container triple wash evaporation pan
- Composting facility



A weather station may also be located near the gatehouse in the future. Its purpose is to keep records of rainfall, temperature, wind direction and speed and evaporation. The weather station can be used to verify odour, dust and even noise complaints to some extent, by interpreting the wind direction recorded at the time of complaint.

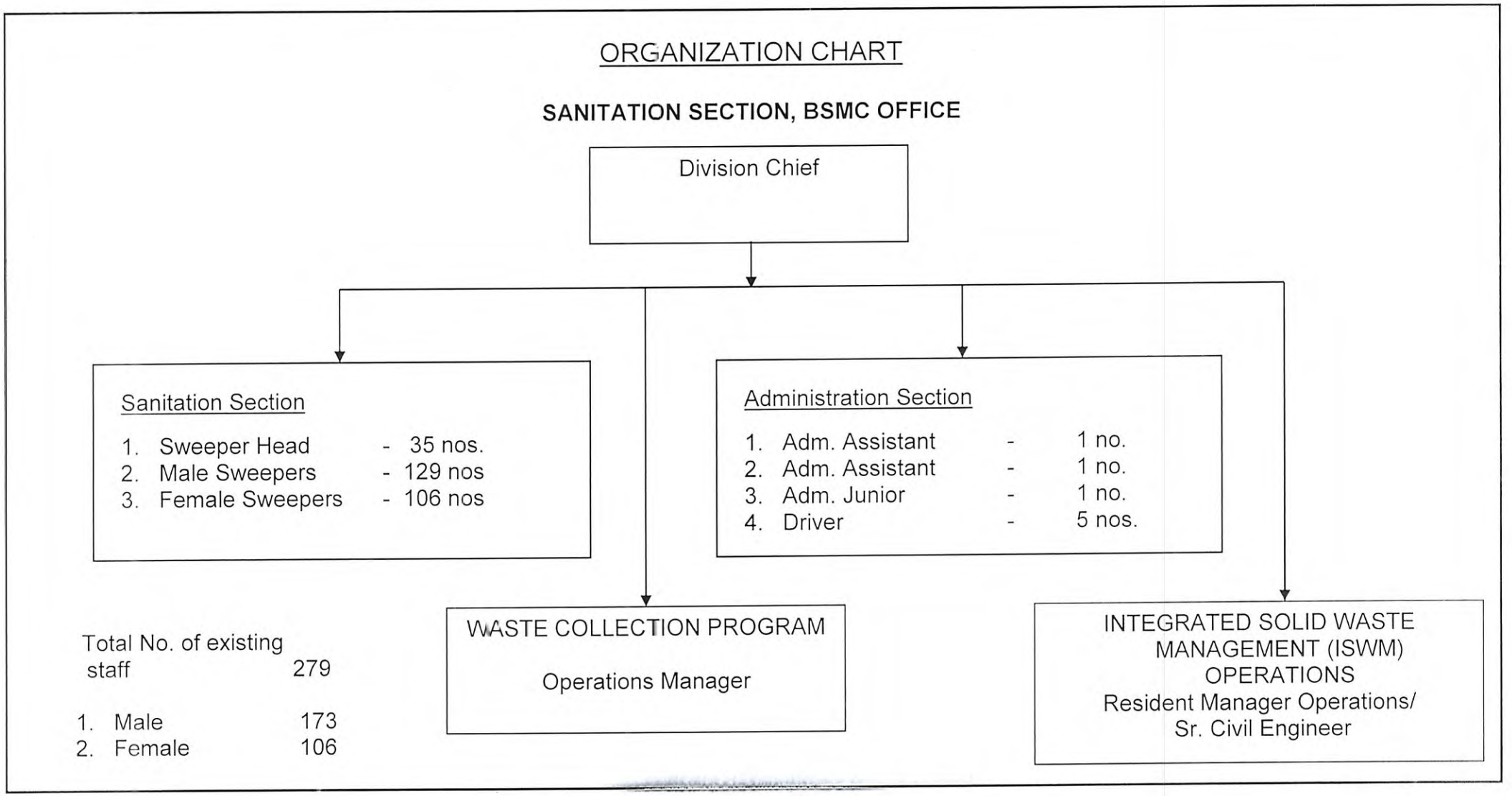


Figure 20: Proposed Organization Chart - Sanitation Section

Table 4: Allocation of SWM Equipment (Mobile) - Waste Collection Service and Integrated Solid Waste Management Site (ISWM)

Allocation of SWM Equipment (Mobile) - Waste Collection Service and Integrated Solid Waste Management Site (ISWM)															
	Waste Collection										ISWM (Sanitary Landfill) Site				
Function/ Service	Skip Containers	Tippers	Tractor-Trailers	Rickshaws (new:39"x39" x16")	Handcarts (Large:60"x36" x18")	Handcarts (Small:48"x30" x18")	Skip Containers (CDP)	Tipping Paddle Rickshaws, 0.3 cu.m cap. (from CDP)	Skip Loader/ Truck Hoists (CDP)	Skip Loader/Truck Hoists	Track Dozer CAT D6	Backhoe Loader	Water Truck	Rickshaws (50"x33"x 30")	Handcarts(Large:60"x36"x18")
OLD (as of Feb 2013)															
Street Cleaning		2		8	12	13									
Other municipal Services:Private,Embassies, Diplomatic miss on		0	3												
Construction & Demolition Waste			1												
SUB-TOTAL, OLD	0	2	4	8	12	13	0	0	0	0	0	0	0	0	0
NEW															
Skip Container Service	8			36	21	15	18	38	1	1					
Block Collection Service			2												
Pick-up Service			1												
Street Sweeping Service		1													
Sanitary Landfill											1	1			
Site Operations													1	4	4
Other municipal Services: parks, religious, festivities			1												
SUB-TOTAL, NEW	8	1	4	36	21	15	18	38	1	1	1	1	1	4	4
TOTAL	8	3	8	44	33	28	18	38	1	1	1	1	1	4	4

Note: CDP = Acquired through the Community Development Program

Allocation of SWM Equipment (Mobile) - Waste Collection Service and Integrated Solid Waste Management Site (ISWM)															
Function/ Service	Waste Collection										ISWM (Sanitary Landfill) Site				
	Skip Containers	Tippers	Tractor-Trailers	Rickshaws (new:39"x39" x16")	Handcarts (Large:60"x36" x18")	Handcarts (Small:48"x30" x18")	Skip Containers (CDP)	Tipping Paddle Rickshaws, 0.3 cu.m cap. (from CDP)	Skip Loader/ Truck Hoists (CDP)	Skip Loader/Truck Hoists	Track Dozer CAT D6	Backhoe Loader	Water Truck	Rickshaws (50"x33"x 30")	Handcarts(Large:60"x36"x18")
SUMMARY OF PRIMARY COLLECTION EQUIPMENT & WASTE BINS															
Rickshaws				36				38						4	
Handcarts TOTAL					21	15									4
Waste Bins (50-liter)				152											
TOTAL CAPACITY															
Volume Capacity (ave.), cu.m.	3	6	3	0.2	0.637	0.425	3	0.3	3	3	per Specs	per Specs	per Specs	0.81	0.637

Table 5: Allocation of Personnel-Waste Collection Service and Integrated Solid Waste Management Site

Allocation of Personnel-Waste Collection Service and Integrated Solid Waste Management Site			
Function/ Service	TOTAL PERSONNEL REQUIRED	TOTAL PERSONNEL AVAILABLE FROM SANITATION SECTION	TOTAL ADDITIONAL PERSONNEL REQUIRED
WASTE COLLECTION			
Drivers	13	5	8
Skip Helpers	2	0	2
Rickshaw pullers	82	76	6
Street Cleaners /Drain Cleaners (Handcarts)	109	77	32
Sweepers	147	103	44
SUB-TOTAL Municipal Waste Collection	353	261	92
WASTE COLLECTION -NGO (LIDS)			
Rickshaw pullers	6	6	0
Street Cleaners /Drain Cleaners (Handcarts)	5	5	0
Sweepers	3	3	0
SUB-TOTAL Municipal staff assigned to NGO	14	14	0
ISWM (SLF) SITE			
Heavy Equipment Optr	3	0	3
Driver	1	0	1
Rickshaw pullers	2	0	2
Street/Drain Cleaners	2	0	2
SUB-TOTAL ISWM Site	8	0	8
TOTAL	375	275	100

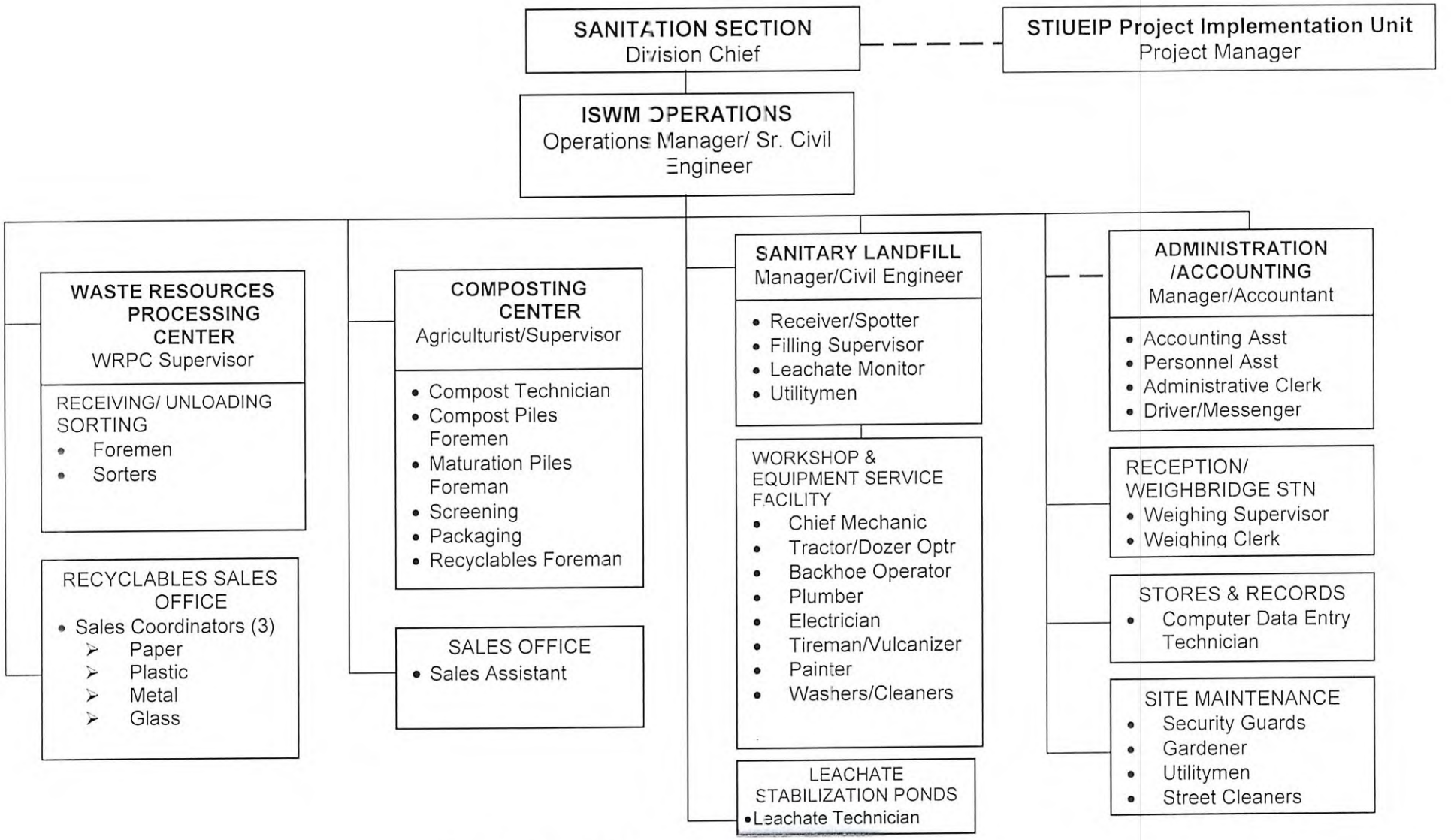


Figure 21: Proposed Organization Chart – ISWM Operations

References: *1. Final Report, STIUEIP Package 2 SWM Component, February 2014* *2. Asian Development Bank (various references), 2017-2018*

APPENDIX A - STANDARD FORMS

The **first three forms are compulsory for all Landfills**, namely:

- **Daily Diary** – summarizes all activities of the day's operations.
- **Waste Designation Sheet** – records all vehicles entering the Landfill and their load types
- **Incident Report Sheet** – used only if an incident occurs, such as detecting prohibited waste or a fire on the Landfill

The Load **Receipt will** only be required if centralized billing of vehicles dumping at the Landfill is adopted.

DAILY DIARY

Date: **Day:** **Shift:**

WEATHER Temperature: Very Hot Hot Warm Cool Cold Rainfall: .....mm ..... Time Wind: Strong Light Still		
RECEIVED: Cubic Meters/Tonnes ..... No. of Skip Trucks ..... No. of Tippers/Others ..... No. of Tractor Trailers	**SAFETY INSPECTIONS:** Morning Afternoon Roads □ □ Work Area □ □ Signs □ □ Staff □ □ Amenities □ □	**DEFECTS REPORTED:**

PLANT AND EQUIPMENT: List all major plant and equipment onsite including sub-contractors

Description	Unit No.	Hours Worked	Hours Idling	Breakdown/ Repairs	Comments
Compactor Dozer Payloader/excavator Truck Chipper/crusher Other (e.g. water truck)					

SUB-CONTRACTORS: List name of sub-contractors, crew size and work area

Name	Hours Worked	Comments/Work Performed

VISITORS: List any visitors

Name and Organization	Purpose of Visit	Sponsor

TRAINING: List employees undertaking training

INDUSTRIAL, SAFETY & ENVIRONMENTAL: List any industrial concerns, accidents, improvement notices issued on safety or environmental grounds. List verbal instructions given to workers.

OTHER COMMENTS: List any EMP Monitoring undertaken, prohibited wastes received, OH&S issues, etc.

....
Name Signature Title

WASTE DESIGNATION SHEET

Date: _____

Load Receipt Number	Contractor/ Carrier	Vehicle Registration Number	Vehicle Type	Waste Type	Volume (m^3)	Weight (Tonnes)

Vehicle Type:

P – Private vehicle/truck
T – Tipper
S – Skip truck
TT – Tractor Trailer
O – Others

Waste Type:

D – Domestic waste
C – Cover (soil, clay, etc)
I – Industrial/commercial waste i.e. packing
R – Rock, concrete, asphalt
G– Green waste i.e. trees, leaves, plants
B –Builders rubble, lumber
L – Sludge
M – Metal
T – Tires
S – Special Wastes

....
Name Signature Title

INCIDENT RECORD SHEET

Site Foreman: _____

Date	Load Receipt Number	Contractor/ Carrier	Incident Details

SMEC

SWM LOAD RECEIPT

Date: _____

Contractor/Carrier: _____ Vehicle Registration No. _____

Volume/Weight of Waste: _____ Waste Type: _____

Signed: _____ Name/Title: _____

Original + 2 copies:

Original - to Head Office for invoicing

1st Copy - to Contractor/Carrier

2nd Copy - retained on Site