in association with

Brisbane City Enterprise Pty Ltd – Australia
Building Design Authority – Nepal
CEMAT Consultants – Nepal

Final Report

Public- Private Partnership (PPP)

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

Dec 2015

Birgunj Sub Metropolitan City, Nepal

AUSTRALIA | ASIA | MIDDLE EAST | AFRICA | PACIFIC

ACRONYMS

3R	Reduce, Reuse and Recycle
ADB	Asian Development Bank
APs	Affected Persons
BoQ	Bill of Quantities
BSMC	Birgunj Sub-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
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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EXECUTIVE SUMMARY

Background

This Final Report is submitted to comply with the contract entered into on 16th January 2012 between the Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Project Implementation Unit, Birgunj Sub-Metropolitan City (BSMC), Birgunj, Nepal (the Borrower) and SMEC International Pty Ltd., Australia, the design and supervision (DSC) consultant for the provision of design and supervision consultancy services for project. The DSC consultancy services contract followed the Agreement dated 26th October 2010 entered into between the Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Project Implementation Unit, Birgunj Sub metropolitan City, Birgunj Nepal (the Borrower) and the Asian Development Bank (ADB) to provide funding for the provision of consulting services and implementation of urban infrastructure, as well as community and institutional development and related activities. The DSC services officially started on 17thFebruary 2012. The Interim Report was submitted on December 31, 2012 and the Draft Final Report was submitted on August 7, 2013. This Final Report submission contains the results of the Detailed Engineering Design Services of the Solid Waste Management component. The Final Report addresses the comments of the Project Coordination Office (PCO)/Project Management Support Consultants (PMSC) on the Draft Final Report (DFR) as well as the changes in the detailed design components of the SWM component as a result of the budgetary constraints of the project. More recently on 14 January 2014 to 4 February 2014, the ADB furthermore sent a consulting mission for the solid waste management component of the STIUEIP, including Birgunj. During the mission and after the technical meetings, it was agreed that the composting component, which had been curtailed because of the budgetary constraints was to be incorporated again as a result of which the other building components had to be reduced in scope and cost where possible, to further accommodate the budget limitations.

The proposed Waste Collection Program previously prepared was revised and designed in detail to put emphasis on the composting component, source separation, reduction, reuse and recycling true to the 3Rs concept, which after all was the basis for the whole project design right from the very beginning of project conceptualization. Whereas the initial submission would have been used as a program guide for the Municipality Sanitation Section's own waste collection planning and programming, the DSC consultant designed the waste collection program in its totality to include the waste storage/container system, the collection system, the transport system, and the operations of the Integrated Solid Waste Management site that included the Waste Resources Processing Center, the Composting Center, and the Sanitary Landfill for residual wastes. The DSC design went further to include not only the detailed design of the waste collection program and the ISWM site components including the sanitary landfill and its ancillary facilities, but also the design of the first year operational system of the proposed waste collection program and sanitary landfilling operations. This Final Report incorporates these changes in respect of the ADB Solid Waste Expert's findings and recommendations, and the respective changes to the original design in view of operations plans for the first year.

Final Report Overview

This Final Report is the result of the detailed engineering design work and the cost estimates performed for tendering and bidding of the project. This report is complemented in scope by the Technical Specifications, Bill of Quantities, and the Bidding and Tender Documents all prepared in separate volumes and submissions. The important results of the Design Criteria Report, Concept Plan, Interim Report and Draft Final Report are integrated into this Final Report. As discussed above, the Detailed Engineering Design Phase involved design changes

that became necessary in response to the client's (BSMC's) budgetary constraints and in order for the project to be realized. The municipal waste collection program and integrated solid waste management facility at the landfill site are the two majoor components of the project for construction and operations for the first year.

Chapter 1 summarizes the background of the project, a brief review of the solid waste sub-sector and an overview of the existing solid waste management system in Birgunj Sub-Metropolitan City (BSMC). It also includes a short account of the Clean Development Mechanism initiatives and projects that are currently pursued in Nepal and how the project can eventually assess its feasibility as a sub-project in the future.

Chapter 2 briefly discusses the salient features of the project and its various components. It will serve as a summary chapter where all of the main project features are described.

Chapter 3 discusses the waste generation, composition and characteristics of wastes in Birgunj and the minimum requirements for a new 3Rs system to be implemented in a city.

Chapter 4 describes the waste collection, storage, and transportation system design, and a discussion of some of the design options that were considered that led to the selected system design. It also includes the design of the operating procedure for the first year of operation.

Chapter 5 describes the design of the composting systems as envisioned for the project starting from backyard composting, ward level composting or other community based composting and the Composting Center at the ISWM site. It includes the operational procedure that can be initiated at the Composting Center during its first year of operation.

Chapter 6 describes the design of the materials recovery system of the project that culminates in the Waste Resources Processing Center (WRPC) in the ISWM site. It also includes a brief discussion of recycling and its market leading to the current design and implementation of the waste resource processing center in the ISWM site for the first year of operation. It includes the discussion of the operational procedure during its first year of operation.

Chapter 7 discusses the sanitary landfill system design for residual wastes resulting from the 3Rs system. It describes the design options and the selection of the specific design and its various components, such as the topographical surveys, hydrological and flood studies, design grade, base liner and its components, residual waste calculation and projections based on the selected waste collection program, leachate (generation, collection, treatment and removal), leachate piping systems, and the leachate treatment and removal system (leachate stabilization ponds).

Chapter 8 describes the proposed institutional arrangements and recommended organizational system and staffing that is required to implement the project successfully. It also describes the current organization of the Sanitation section that will be available for the project. This chapter likewise highlights the need for instituting and enabling the legal mechanisms in BSMC to implement effectively the Nepal Solid Waste Management Act of 2011 at the city and ward level such as in the imposition of fines, penalties and sanctions against individuals or juridical entities that violate the provisions of the laws and ordinances.

Chapter 9 discusses the other components of the municipal waste stream i.e. health care wastes, toxic and hazardous wastes, industrial wastes, construction and demolition wastes, agricultural waste, etc. that need to be addressed and managed by the BSMC but are not in the current scope of this project or its components. The purpose of the discussion is to be aware of the importance of ensuring that these wastes do not end up in the ISWM site or on the streets where they pose hazards to public health and the options that are available to manage these wastes.

Chapter 10 includes the summary of the project cost estimates as finalized for bidding and tendering.

Chapter 11 describes the operational procedures for the major components of the Integrated Solid Waste Management System that will serve as a guide for the BSMC's implementing organization in formulating and developing their systems and procedures and operational manuals for each facility.

Chapter 12 discusses the conclusions and recommendations regarding the future prospects of success in the operations of the Integrated Solid Waste Management from waste collection to the sanitary landfill, post-closure and long term care plan and future use of the ISWM site and its support facilities and buildings after it has outlived its useful life.

Salient Features of the Integrated Solid Waste Management (ISWM) System

The following table summarizes the salient features of the proposed ISWM Sub-Project, Birgunj Sub-Metropolitan City, from waste collection to disposal of residual wastes at the ISWM site:

SYSTEM COMPONENT	AREA (M^2)/ DIMENSIONS	FUNCTION	REMARKS
WASTE COLLECTION AND TRANSPORTATION PROGRAM	BSMC (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 o Paper o Plastic o Glass o Metal • Hazardous Materials room	0.645 ha	Recovery of recyclables and reusable materials in accordance with 3Rs program	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 and • Sales Office	0.945 ha	Resource recovery from organic wastes and reduce disposal costs through compost production in accordance with 3Rs program	Project component with compost average production of at least 2 tonnes per day
LANDFILL CELLS AREA (Residual Wastes)	Total: 4.86 ha Phase I cells: 1.4 ha Phase IIcells:1.38 ha Phase III cells: .76 ha	Engineered disposal area designed to protect groundwater and minimize environmental impact to air, water bodies and land	• Capacity: approximately 400,000cu.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

BASE LINER SYSTEM LEACHATE COLLECTION PIPING SYSTEM	5.72 ha 1,761 m	Protect groundwater from leachate generated from landfill cells	HDPE geo-membrane, geotextile fabric and clay HDPE Perforated Pipes
LEACHATE GAS VENTING (PASSIVE)	21 vent locations	Passive release of landfill gas, for safety and public health	Vertical PVC perforated pipes
LEACHATE STABILIZATION PONDS • Collection Chamber • Anaerobic Pond 1 • Anaerobic Pond 2 • Facultative Pond • Maturation Pond	 20 m^2 1,500 m^2 500 m^2 3,726 m^2 1,795 m^2	Stabilize and treat leachate by natural methods and protect ground water and surrounding surface water	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.
LEACHATE TREATMENT FACILITY	Future area requirement to be determined	Protect groundwater and surrounding water bodies	Future plant after 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	Present
ENTRANCE DRIVEWAY , MAIN AND INTERIOR SERVICE ROADS	Main and interior roads: 1,578 m	Access and internal circulation	Present
WASTE RECEPTION CENTER/WEIGHING STATION	Location as shown in drawings	Waste tracking and control, materials security and quality assurance	Present
ADMINISTRATION BUILDING	185 m^2 floor area	Management, administration and financial/accounting work	Present
WORKSHOP AND EQUIPMENT SERVICE CENTER	390 m^2 floor area	Repair and maintenance, vehicle washings	Present
GENERATOR HOUSE AND ELECTRICAL ROOM	18 m^2	Emergency or alternate power source	Present
WATER SUPPLY PUMPING STATION AND ELEVATED WATER TANK S	6 ea 1,000 liter tank 1 ea 5,000 liter tank	Water supply	Domestic water supply and vehicle washing
FUEL STORAGE STRUCTURE	3,000- 5,000 liter capacity	Storage	Future
MONITORING WELL NO.1	Existing Borehole No.1	Monitoring environmental impact: water quality , ground water and flood level	Present
MONITORING WELL NO. 2	Existing Borehole No.2	Monitoring environmental	Present

		impact: water quality, ground water and flood level	
MONITORING WELL NO.3	New tubewell for development beside Borehole No. 3 for process and domestic water supply	Monitoring environmental impact: water quality, ground water and flood level	Present
OPEN SPACE AND LANDSCAPING	As shown in the drawings	Aesthetics, health and well-being, and long term use plan	Present

Project Cost Estimates

The Total Project cost is estimated at NPR 347.15 Million. The detailed quantity and cost estimates are contained in separate report volumes entitled Bill of Quantities and Quantity and Cost Estimates. The tender package covering this component constitutes Package II, namely: the Solid Waste Component of the Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Birgunj Sub-Metropolitan City. The Tender scope includes the Construction of the entire Integrated Solid Waste Management (ISWM) site, the provision of Waste Collection and Sanitary Landfill vehicles and equipment as shown in the Final Design Drawings, Technical Specifications and Bill of Quantities, as well as the necessary materials, equipment, tools, machines, plant and manpower necessary to implement the First Year Operations of the integrated solid waste management system in BSMC.

Recommendations on Important Issues and Planning Scenario

Important issues and the planning scenario are raised in this Final Report, which will play an important part in the successful implementation of this project over the next 20 years. Among these recommendations are:

- The projected municipal solid waste collection coverage as presented herein should be aligned with present and future plans, verified, and modified as appropriate by the BSMC, considering the 20 year planning period. Most important would be the land use plans, additional road improvement plans, and anticipating the increase in industrial and commercial, demolition, and new construction activities as a result of further urbanization of the Birgunj Sub-metropolitan City.

- The awareness campaign for the 3Rs (Reduce, Re-use and Recycle) should start as soon as possible even before the construction period in order to successfully realize the process plan for the STIUEIP Birgunj SWM component. The massive awareness campaign for the 3Rs is crucial whereas the synchronization of the campaign should be coordinated with the DSC recommended designs, the CDP program and the concerned NGOs/CBOs involved in the awareness campaign. The campaign should include information/education/communication (IEC) to, from and among the concerned NGOs/CBOs, the CDP program and the DSC consultants. In other countries 3R programs takes years – if not decades - to take root in the consciousness of the affected communities. A municipality-wide "Clean and Green Birgunj" contest is just one example of how - with annual awards and prizes to the winners - ward-level management of solid waste can be institutionalized in coordination with the solid waste user committees that have been formed from the grassroots level. With the prime goal of taking care of the environment and protecting public health, a major effort to make the campaign sustainable would to make the

prospect of producing compost from waste and recovering resources from the recyclables attractive for the households and wards. Leadership training in this regard should be developed starting from the ward level as well and the tole lane organizations.

- With the country's renewed mandate to enforce the Solid Waste Management Act in 2013, the Polluters' Pay principle should be institutionalized as soon as possible in Birgunj by passing city ordinances, regulations and the strict enforcement of these by the imposition of sanctions, fines, penalties, or closure of polluting establishments. If these laws and ordinances are not enforced urgently, it is realistic to assume that the unwanted health care wastes from hospitals/health care facilities, and industrial and toxic wastes from the industries will reach the sanitary landfill and endanger public health.

- 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 construction of the Leachate Treatment Plant once the leachate characteristics are determined depending on the 3Rs progress.

- Sourcing and supply of clay materials for the operational daily cover or intermediate cover, if needed, and final cover (cap) of the Landfill Cells should be ensured by continuously monitoring the specific requirements based on cost and operational performance e.g. compaction density tests and laboratory tests.

- 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 BSMC for the ISWM site.

We will be pleased to discuss any aspect of this report in preparation for the Construction Phase and the Initial Operations phase.

CHAPTER 1: INTRODUCTION

1.1 Background

The Department of Urban Development and Building Construction (DUDBC), under the Ministry of Urban Development (MoUD), through the Government of Nepal, has received Loan 2650-NEP: Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP, or the Project), from the Asian Development Bank (ADB). MPPW is the executing agency for the Project, working through DUDBC, and Biratnagar, Butwal and Birgunj and Kavre municipalities are the implementing agencies (IAs).

For the Birgunj Project urban environmental improvements will be implemented on an integrated basis to include sewerage and drainage, solid waste management and urban roads and lanes. Along with and in support of the infrastructure components, equally important to be implemented are the following:

- community development programs such as awareness-raising on health and hygiene;
- 3R (Reduce, Reuse, and Recycle);
- investment in small-scale community facilities in the municipalities; and
- capacity strengthening of the municipalities and central government in the field of project management and operation.

The project will be implemented over a five year period.

The designed outputs of the Solid Waste Management component in Birgunj are as follows:

- Improved solid waste management through the introduction of a 3Rs-based integrated solid waste management system from the management of household and ward-wise reduction of wastes, composting, recycling, waste collection, transportation and final disposal of residual wastes at a sanitary landfill site. Source segregation or separation, segregated collection, and segregated disposal systems (composting, recycling and residual waste management) are the hallmarks of the proposed system.
- Community development program undertaken, including public and environmental health and hygiene education, 3R (reduce, reuse and recycle) of solid waste, promotion, skills training and investment in small scale community facilities.

The following have been submitted for the Solid Waste Management component of the project:

- Design Criteria Report
- Concept Plan Report
- Interim Report
- Draft Final Report

This Final Report is herewith submitted to complete the Detailed Design Phase.

The Final Report for the Solid Waste Management (SWM) Component integrates the results of the Detailed Engineering Design and Tender Documents Phases under the DSC consulting services contract for the SWM component of the STIUEIP. The Inception Report was submitted on April 15,2012 and the Design Criteria Report was submitted on May 25,2012. The Concept Plan for SWM in Birgunj was submitted on July 31, 2012, presented on August 15, 2012 to the STIUEIP Birgunj decision-makers and generally approved and accepted from the

exchange of comments between the PIU/PCO and DSC Consultants on October 10, October 14, November 5 and November 18, 2012. The Interim Report was submitted on December 31, 2012 and a subsequent presentation of the same was made to the PCO/PMSC on January 18, 2013. A meeting with the PCO and PMSC was held on June 21, 2013 to discuss the progress and comments to the scope of the final design in light of the budgetary constraints. Certain design items were reduced in Scope and were addressed in the Draft Final Report. Working meetings were held on June 30, 2013 and towards the end of July with the PMSC/PCO/PIU officials to finalize the buildings and facilities and required reductions in Scope of the Integrated Solid Waste management (ISWM) site and the respective cost implications to suit the allocated budget for the SWM component. The Draft Final Report was subsequently submitted onAugust 5,2012. The Final Report addresses the comments of the PCO/PMSC on the Draft Final Report (DFR) as well as the changes in the detailed design components of the SWM component as a result of the budgetary constraints of the project. More recently on 14 January 2014 to 4 February 2014, the ADB furthermore sent a consulting mission for the solid waste management component of the STIUEIP, including Birgunj. During the mission and after the technical meetings, it was agreed that the composting component, which had been curtailed because of the budgetary constraints was to be incorporated again as a result of which the other building components had to be reduced in scope and cost where possible, to further accommodate the budget limitations.

The proposed Waste Collection Program previously prepared was revised and designed in detail to put emphasis on the composting component, source separation, reduction, reuse and recycling true to the 3Rs concept, which after all was the basis for the whole project design right from the very beginning of project conceptualization. Whereas the initial submission would have been used as a program guide for the Municipality Sanitation Section's own waste collection planning and programming, the DSC consultant designed the waste collection program in its totality to include the waste storage/container system, the collection system, the transport system, and the operations of the Integrated Solid Waste Management site that included the Waste Resources Processing Center, the Composting Center, and the Sanitary Landfill for residual wastes. The DSC design went further to include not only the detailed design of the waste collection program and the ISWM site components including the sanitary landfill and its ancillary facilities, but also the design of the first year operational system of the proposed waste collection program and sanitary landfilling operations. This Final Report incorporates these changes in respect of the ADB Solid Waste Expert's findings and recommendations, and the respective changes to the original design in view of operations plans for the first year.

1.2 Review of Solid Waste Sub-Sector in Birgunj

Location and Area

Birgunj Sub-Metropolitan City (BSMC) is situated in the Narayani zone and the district of Parsa in the central development region of Nepal. It is one of the business economic and industrial zone of central region, covering an area of 23.37 km2. The city lies at 27°02'30" to 26°57'45" North and 84°55'00" to 84°52' 15" East. The eastern part of the city is bordered by another district – Bara whereas the southern and south western part by Bihar State of India.

The Pathlaiya to Birgunj corridor is one of the most important manufacturing centres in Nepal constituting many industries including among others steel, plywood, rice mills, sugar mill, agricultural equipment, tanning etc. Birgunj is one of the major gateway towns to India and more than 50% of total foreign trade is carried out via this town. In the future this will have a bearing on the change in municipal solid waste generation rates as well as the municipal waste characteristics of Birgunj as it starts to progress to being possibly a light industrial center with a progressive population's potential to earn excess disposable income.

It is important to note that the Birgunj landfill site is in the jurisdictional district of Parsa but is actually located in another district called Bara. As the proposed site has been designed and

proposed as a sanitary landfill site, not any potential conflict in social acceptability by the local people of Bara District has been observed in hosting the landfill site. Scoping and public consultations have been made to present the mitigating measures to avert any negative perception by the nearby residents of the district as a result of the landfill site development.

Political Division and Boundaries

Birgunj Sub-metropolitan City is the leading business centre of the central Terai region of Nepal. By virtue of its proximity to the Indo-Nepal border, it functions as an outlet for Nepalese exports and an inlet for imports. The sub-metropolitan city is a primary gateway city as it has developed considerably in transport significance as the break-in bulk point in the Terai region along the Indo-Nepal border. The city borders India, Sirsiya dry port and Bishrampur VDC in the south, the Sirsiya River, Ramgadh VDC in the west, Parwanipur and Bahundangi VDC in the north, Parsauni, Itahari VDC and the Singaha River in the east.

According to the official Nepal Central Business Statistics census, the population of Birgunj Sub-metropolitan City in 2011 was 135,904 with annual growth rate of 1.91%.

Birgunj sub-metropolitan city has a total area of 2,337 ha, divided into 19 wards with their areas in a range from the smallest ward of 6.57 ha (Ward No. 11) to 509.47 ha (Ward No. 19). The ward locations are shown in Figure 1. The city has an elongated shape with a maximum north-south length of 8 km and east-west width of 4 km. The altitude ranges from about Elevation 78m above sea level in the south near the border area to Elevation 87m above sea level in the north.

Population

According to the census of 2001, the population of Birgunj Sub-Metropolitan City was 112,484 with growth rate of 5.04 %. The census of 2011 officially establishes the population of all 19 wards at 135,904 with an annual growth rate of 1.91%.

The population of BSMC in different census years is given in Table No. 1 along with annual growth rates. As per the Central Bureau of Statistics, the population of Birgunj in various decadal years is as follows:

Table 1:Population Growth Trend of Birgunj Sub-metropolitan City, 1971-2011

Census Year	Population	Annual Growth Rate (%)
1971	12,999	-
1981	43,642	-
1991	68,764	4.65
2001	112,484	5.04
2011	135,904	1.91

Source: National Population Census (Central Bureau of Statistics) 2068 and BSMC town profile

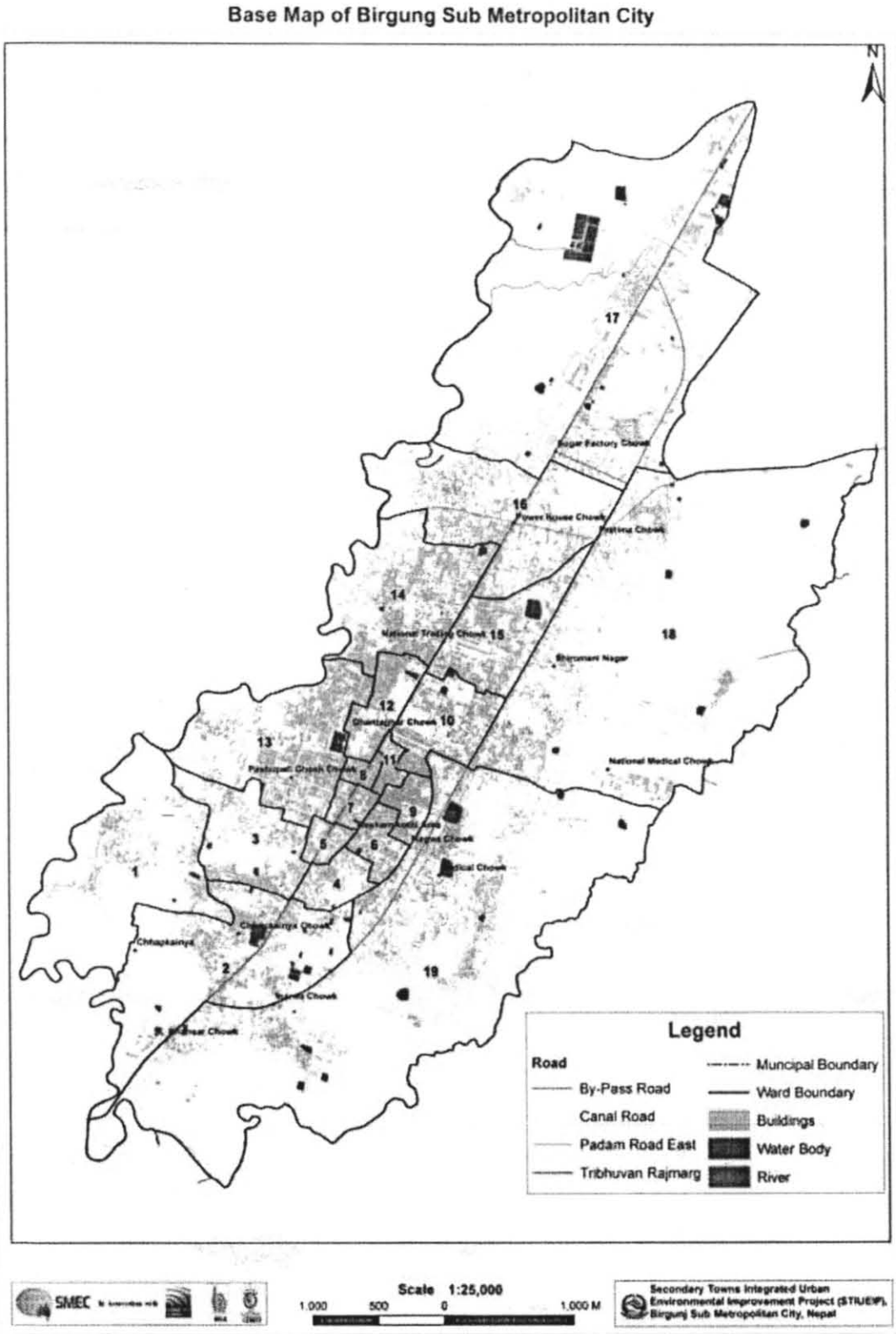


Figure 1:Ward Locations in Birgunj

The Population in Birgunj by ward is presented in Table 2:

Table 2: Ward Population on the Basis of Ward Boundary Areas, 2011

Ward No.	Area in Ha	House hold	Male	Female	Total	Household Size
1	146.46	1,210	4,211	3,794	8,005	6.62
2	149.3	1,377	4,767	4,245	9,012	6.54
3	57.15	1,358	3,873	3,210	7,083	5.22
4	18.92	427	1,170	1,127	2,297	5.38
5	9.48	312	908	899	1,807	5.79
6	15.63	603	1,912	1,773	3,685	6.11
7	9.92	239	875	773	1,648	6.90
8	5.61	171	567	548	1,115	6.52
9	13.43	858	2,429	2,168	4,597	5.36
10	42.91	1,235	3,467	3,068	6,535	5.29
11	6.63	286	871	785	1,656	5.79
12	26.41	621	1,727	1,575	3,302	5.32
13	109.26	2,934	8,237	6,483	14,720	5.02
14	95.6	2,466	6,605	5,767	12,372	5.02
15	56.77	1,560	4,456	4,037	8,493	5.44
16	129.22	2,011	5,977	4,926	10,903	5.42
17	454.33	1,206	4,362	4,188	8,550	7.09
18	482.2	1,699	5,114	4,426	9,540	5.62
19	507.79	3,591	11,052	9,532	20,584	5.73
Total	2,337.02	24,164	72,580	63,324	135,904	5.62

Source: National Population Census (Central Bureau of Statistics) 2011.

The Population growth trend of the urban population as compared to the national population is shown in Table 3.

Table 3: Population Growth Trends of Birgunj (BSMC)

Description	Population Growth Trend	
Year	1991-2001	2001-2011
National annual growth rate	2.25 %	1.35 %
National urban population growth rate	14.2 %	17.7 %
Urban population growth rate	6.65 %	3.4 %
BSMC growth rate	5.04 %	1.91 %

Source: Urban Planning Report, STIUEIP, Birgunj 2013

Climate

The climate in Birgunj is typical in the Terai region of being sub-tropical and characterized by very hot, humid and wet conditions during the summer. The maximum daily temperature recorded is 41.6°C in May and the minimum is 4.5°C in January. The annual rainfall ranges from 1300 mm to 2800 mm with an average of 1800 mm. More than 82% of precipitation occurs during the 4 summer months of June to September. The average sunshine duration ranges from 7.26 hr/day to 7.50 hr/day. Average wind speeds ranges from 1.95 to 2.31 km/hr. Various literature mention the following trends in temperature and climate in Nepal with specific reference to Birgunj on climate trends. Temperature and climate affect the landfill operational capacity and leachate characteristics.

Temperature trends in Nepal

The history of meteorological observation in Nepal has not been historically significant. But an analysis of about 30 years of observed temperature in Nepal has shown that maximum temperatures in Nepal are increasing at an alarming rate. An analysis of 49 stations in Nepal found that the warming was consistent and continuous after the mid-1970's. The average warming in annual temperature between 1977 and 2000 was 0.06°C yr-1. The warming was more pronounced in the higher altitude regions of Nepal such as middle-mountain and the Himalayas, while the warming is significantly lower or even lacking in the Terai and Siwalik regions. Further, warming in the winter is more pronounced compared to other seasons. Analysis of daily temperature data for 36 years from 1971 to 2006 using RClimDex software also shows that days and nights both are becoming warmer and cool days and cool nights are becoming less frequent.[1]

The projections of temperature by the Organization for Economic Co-operation and Development (OECD) show a significant and consistent increase in temperature in Nepal for the years 2030, 2050 and 2100 across the various models. This analysis also shows more warming increases in the winter months than the summer months. The projected change above the baseline average is 1.2° C for 2030, 1.7°C for 2050 and 3.0°C for 2100.

Precipitation trends in Nepal

Analysis of precipitation data from station records all over Nepal does not reveal any significant trends. However, an analysis of daily precipitation data for 46 years from 1961-2006 shows an increasing trend in precipitation extremes. About 73 per cent of the stations (out of 26 total stations selected for the study) exhibited an increase in the annual count of days when precipitation is greater or equal to 50 mm[2]. Table 4 shows rainfall data for the STIUEIP project municipalities.

Table 4: Annual Rainfall in STIUEIP Project Municipalities

Municipality/Station	Average (1971-2000)	2001 (mm)	2002 (mm)	2003 (mm)	2004 (mm)	2005 (mm)	2006 (mm)
Biratnagar (airport)	1881	2279	1923	2108	2144	1596	1300
Birgunj (Simara Airport)	1806	1850	2321	2260	1807	1797	1669
Butwal (Bhairawa Airport)	1673	2016	1269	1953	1524	1768	1214

Source: Central Bureau of Statistics,2009. Environment Statistics of Nepal 2008, Kathmandu

[1] Baidya, S K, Shreshta, M L ,and Sheikh, M M, 2008. Trends in Daily Extremes of Temperature and Precipitation in Nepal. Journal of Hydrology and Meteorology, Vol. 5, No. 1, 38-53.

[2] Ibid.

Topography and Geology

The topography of Birgunj exhibits a gradual slope of about 1:900 from north to southeast resembling Terai plain (northward extension of Indo-Gangetic plain). The altitude ranges from about 78m in the south near border area to 87m in the north. However there is high micro-topographical variation. Two major rivers are features of Birgunj, namely, the Sirsiya River to the west and the Singaha River to the east. In addition to these two rivers there is Gandak Canal in the north. The land is fertile soil with mix of clay, silt and sand.

The geology of the Birgunj area consists mainly of quaternary sediments. It is composed of very fertile soil mixed of clay, silt and sand.

Surface and Ground Water

The area is drained by two rivers – the Sirsiya River in the west and the Singaha River in the east. On the north, there is Gandak Canal running along Gandak Road from the northwest to the southeast. This canal prevents surface runoff from the areas to the north of Gandak Road flowing into Birgunj. The Singaha River originates about 4 km upstream from the northern border of the municipality whereas the Sirsiya River originates from far northern area. These rivers are flooded during the summer monsoon and river bank cutting particularly at the meander bends during flooding is common. The water in the river during dry period is very low. Groundwater table depth is estimated to be between 9-15 m deep with 1-2 m fluctuation during wet and dry season.

Urbanization and Land Use

It is well-known that urbanization and land use affect the quantity and characteristics of municipal solid waste in a fast growing municipality. The per capita waste generation rate tends to increase with urbanization while the characteristics of the wastes in urbanizing communities tend to have more non-biodegradable, recyclable and dry wastes than the more organic fractions of waste in a purely agricultural economy.

Urbanization in Birgunj

Birgunj Sub-Metropolitan City is Nepal's principal trade centre. The city has experienced rapid growth especially in the past decade, due to migration to the city from peripheral districts and VDCs for security reasons, or other reasons such as for seeking better livelihoods. There is consequently environmental deterioration resulting from inadequate sanitation and drainage, uncollected and indiscriminate dumping of solid waste, and increasing traffic congestion mainly in the main roads. These dire environmental conditions consequently lead to the poor air quality in the city. The individual institutional efforts of both the sub-metropolis and sectoral agencies in addressing these issues, have remained uncoordinated and grossly inadequate. Most of the fertile agricultural fields are rapidly converted into residential and commercial areas. There is uncontrolled land use and construction due to the non-implementation of zoning laws to implement land use and zoning plans. The eastern part of the sub-metropolis which lies in the flood-prone area of the Singaha River is also being changed to residential and commercial areas due to the pressure of increasing population in the sub-metropolitan city. Wards 18 and 19 have the highest applications for new housing construction permits. The infrastructural facilities such as roads, sewer and storm-water drains and water supply, need to be developed to match the current rate of other development, which remains a major future concern.

Building permits

Recent studies shows that the majority of building constructions in the last five years are taking place in Ward 19, 18, 16 followed by ward 13, 14 and 15. Few buildings are also constructed in

Ward 4, 5, 6, 7, 8, 9, 11 and 12 as these wards are small and well-developed. The total building construction is around 600 to 700 per year. The analysis of building permits also shows that urban expansion is taking place in the east west direction.

Urban Density

The study of urban density from the census periods of 1991, 2001 and 2011 (ward-wise detail unpublished) showed that the urban density of Birgunj sub-metropolitan has changed from 29.5 0 pph (2001) to 58.15 pph (2011). The urban density is calculated by dividing the total population by the ward area.

The ward-wise structure of population and gross urban density of the year 1991, 2001 and 2011 has been shown in the table below.

Table 5: Urban Population density for the year 1991, 2001 and 2011

Ward No.	Area in Ha	Population 1991	Density 1991 Pph	Population 2001	Density 2001 Pph	Population 2011	Density 2011 pph
1	146.46	2198	15.0	6337	43.3	8,005	54.7
2	149.30	3930	26.3	6694	44.8	9,012	60.4
3	57.15	3300	57.7	5510	96.4	7,083	123.9
4	18.92	2365	125.0	2537	134.1	2,297	121.4
5	9.48	1882	198.5	1940	204.6	1,807	190.6
6	15.63	3865	247.3	5453	348.9	3,685	235.8
7	9.92	2344	236.3	2367	238.6	1,648	166.1
8	5.61	1709	304.6	1721	306.8	1,115	198.8
9	13.43	3208	238.9	4486	334.0	4,597	342.3
10	42.91	3697	86.2	6133	142.9	6,535	152.3
11	6.63	2098	316.4	1913	288.5	1,656	249.8
12	26.41	2525	95.6	3357	127.1	3,302	125.0
13	109.26	6790	62.1	13030	119.3	14,720	134.7
14	95.60	6360	66.5	10647	111.4	12,372	129.4
15	56.77	4999	88.1	7732	136.2	8,493	149.6
16	129.22	3414	26.4	6833	52.9	10,903	84.4
17	454.33	4976	11.0	7684	16.9	8,550	18.8
18	482.20	3224	6.7	5832	12.1	9,540	19.8
19	507.79	6121	12.1	12278	24.2	20,584	40.5
Total	2337.02	69005	29.5	112484	48.1	135904	58.15

The table above shows that urban densities calculated for the census year 2011 have increased in ward no 1, 2, 3, 9,10, 13, 14, 15, 16, 17,18 and 19 whereas the urban densities decreased in ward no. 4, 5, 6, 7, 8,11 and 12 compared with the urban densities of different ward of the year 2001. The decrease in urban densities in ward 4, 5, 7, 8, 11, 12 is the result of decrease in population due to more commercial activities in these wards.

The urban densities in big wards are less than 20.00 pph in ward no 17, 18, and less than 50.00 pph in ward no. 19. The urban densities in most of the main city area are quite high ranging from 121.4 pph in ward 4 to 342.3 pph in ward no 9. Only few wards such as 1, 2, 16, 17, 18 and 19 have low urban density. Since the current densities are low and lots of vacant lands, more densification is possible in these wards through urban expansion. In case of medium ward 1, 2, 13, 14, 15, 17 more people can be accommodated for certain years but whereas in case of densely populated wards such as 4, 5, 6, 8, 11, 12 where negative growth has taken place, there is less chance of further high densification.

Planning Efforts in Birgunj

A number of planning documents have been prepared for the development of BSMC, such as Structure Plan, Integrated Action Plan and concept of Greater Birgunj. The latest development is the Periodic Plan of Birgunj Sub-Metropolitan City.

Development Concepts of Birgunj

Birgunj Sub-metropolitan City has prepared its Periodic Plan to guide the development of Birgunj in the planned way in different sectors and defined its VISION "Birgunj as Main Gate to Nepal, Clean, Prosperous, Progressive is our identity". To achieve its aforementioned vision, a number of programs are put forward in the periodic plan and has adopted the following objectives and strategy for environmental development of physical Infrastructures.

- Development of Birgunj as per land use
- Development of Sewerage and drains
- Proper management of solid waste
- Public awareness building on environmental issues
- Adopt approaches in waste reduction
- Ensure that raw sewerage gets into drains after it passes through septic tanks
- Protection of rivers banks
- Reduce municipal investment in solid waste and encourage private sector

Proposed Land Use Plan

During the preparation of Periodic Plan, a new land use plan has been prepared to guide the future development of Birgunj based on current predominant land use. Besides the existing land use, new areas have been designated for different purposes as follows:

- The industrial area has been extended in the east west side of current industrial area.
- Further new residential and commercial developments have been proposed in between the eastside of Bypass Road and Canal Road in Wards No. 18 and 19.

There is not much change between the existing and proposed land use except the above mentioned two points. Also it is doubtful that the proposed land use map will be implementable unless the municipality passes the land use strategy. At present the municipality does not have any land use policy while continuously issuing building permits.

Existing Scenario of Municipal Solid Waste Management in Birgunj

Despite the passage of the Solid Waste Management Act of 2011, the management of solid waste has not improved and lacks the capacity to meet the demand from rapid urbanization of Birgunj Sub-Metropolitan City. No enforcement of the act or any municipal ordinances or regulations – much less the imposition of fines, penalties and sanctions a required by law and emanating from it have been observed as being implemented. As can be seen in most Nepal cities and developing countries, solid waste is seen scattered in piles and heaps on the roadways and impedes the conveyance capacity of drainage canals bringing about flooding situations especially in the low-lying areas especially during the monsoon season. If not on the streets and empty lots, informal dumps are commonplace and pose public health and environmental risk. The low-lying areas serve as repositories of the wastes that cannot be picked up by the waste collection service because of the lack of vehicles and equipment and the proper receiving system to manage them. Left unattended and uncovered, these empty lots

with rotting waste on them become the breeding grounds of disease vectors, vermin, and animals that carry disease. All collected waste eventually end up in the main disposal site of the Municipality at the river banks of the Sirsiya River near its border with India where it is observed that the surface water quality of the river at those sections are already septic. A couple of the same informal city dumps have been closed due to public complaints.

Although the 3Rs concept is discussed a lot by the government, the NGOs and the concerned citizens at the grassroots, nothing substantial has been accomplished in source separation, recycling or composting even when 51.09% of MSW comprises the organic fraction that can be the source of compost.

There are ongoing efforts by the partnership of the Municipality, the NGO and Wards 10 and 15 in source separation. In 2012-2013, the BSMC Sanitation Section was estimated to be servicing - by the collection of mixed solid waste - approximately 39.1% of the 2012 municipal solid waste generation of Birgunj. The NGO collection is able to service approximately 23.8% of the 1,400 households (2013) for which they have introduced the system of source separation. A system is not in place for recovered materials obtained from source separation to process into composting, recyclables and landfilling of the residual materials. Without such system, the segregated wastes are mixed again when the NGO collection reaches the "transfer station" or temporary dump prior to hauling to the disposal area at the banks of the Sirsiya River. Then there is double handling in dumping from the rickshaw collection and loading again into tractor-trailers for hauling to the disposal area. Such a system is inefficient and unproductive and exposes the workers to health risks since no personal protective equipment are worn such as gloves, boots, or the appropriate masks.

Solid Waste Sub-Sector Objectives

Because of the foregoing situation, the solid waste sub-sector in Birgunj should first ensure that the 3Rs goal is on the top of the list of priority objectives of the sector. The most important enabling mechanism in pursuing this goal is the decision to develop the city's central site for the 3Rs activities and the final disposal area in the proposed ISWM site. Otherwise the 3Rs program would be ineffective. The efforts of the 3Rs collection activities can then be supported by each component in the integrated solid waste management site. As part of Birgunj integrated urban environmental improvement project, it is noteworthy that the Drainage and Sewerage Component, and Roads component of the urban environmental improvement project is synchronized with the solid waste component. The ISWM site has already been acquired and the design has been prepared. This municipal level integrated facility shall be developed with the intention of dealing with the solid waste processing for the whole city. Where the backyard of the households or the wards do not have the space or the capability to pursue the 3Rs and composting themselves, the municipality will be able to provide such proper venue and setting in the Waste Processing Center, the Composting Center, and the Sanitary Landfill in the ISWM site.

In conjunction with the above goal and objectives, the solid waste sub-sector also needs to invoke the law to ensure that industrial wastes, chemical wastes, health care wastes, electronic waste (e-wastes), and other toxic and hazardous wastes and agricultural wastes are managed separately in accordance with anti-pollution laws so that these do not get mixed with the MSW and infringe on the quality of wastes entering the ISWM site.

Legal and Institutional Framework

The development of an integrated solid waste management system for the Sub-metropolitan City of Birgunj as with the other adjacent municipalities in Nepal emanates from the legal basis for establishing these systems. There are several international agreements, national and local legislation and regulations that were considered in the design primarily to ensure the protection

of public health and the environment. In many respects, these international agreements entail more stringent and specific commitments than does national legislation, regulation and policy. This is recognized by the DSC. Some key features of the most recent legislation, the Solid Waste Management Act of 2011, is the enforcement of 3Rs in the municipalities, the participation of the private sector through partnerships, and assessing the feasibility of the establishing inter-municipality or regional sanitary landfills to achieve economies of scale. The concept of joining together several municipalities for regional cooperation through the establishment of a common landfill remains to be seen as the basic solid waste management services evolves from each municipality's system as a first step. There is need to review the most recent, applicable and updated legal and institutional framework within which to enforce and regulate the operating systems of the integrated solid waste management system in the context of the prevailing political system.

1.3 Clean Development Mechanism

The Clean Development Mechanism (CDM) is a mechanism that is defined in the Kyoto Protocol that enables the development of emissions reduction projects by developed or industrialized (Annex 1) countries "recognized" to be principally responsible for the current high levels of greenhouse gas (GHG) emissions in the atmosphere as a result of more than 150 years of industrial activity. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty that sets binding obligations on industrialized countries to reduce these GHG emissions placing a heavier burden on them under the principle of "common but differentiated responsibilities". The UNFCCC is an environmental treaty with the goal of preventing dangerous anthropogenic (i.e., human-induced) interference of the climate system.

As part of the Kyoto Protocol, many developed or industrialized countries have agreed to legally binding limitations/reductions in their emissions of greenhouse gases in two commitment periods: the first, between 2008-2012, and the second, between 2013-2020. The protocol was amended in 2012 to accommodate the second commitment period although this amendment has still to be entered into legal force. International emissions trading allows developed countries to trade their commitments until late 2014 – 2015 to meet their first-round targets by trading emissions quotas among themselves, and to receive credit for financing emissions reductions in developing countries. Developing countries like Nepal do not have binding targets under the Kyoto Protocol, but are still committed under the treaty, to which Nepal is a signatory, to reduce their emissions. Developed and developing countries' actions to reduce emissions include support for renewable energy, improving energy efficiency, and reducing deforestation. Also under the Protocol, emissions of developing countries are allowed to grow in accordance with their development needs.

The CDM is intended to meet two objectives:

(1) to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC), which is to prevent dangerous climate change; and

(2) to assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments (greenhouse gas (GHG) emission caps).

Annex I parties are those countries that are listed in Annex I of the treaty, and are the developed, industrialized countries. Non-Annex I parties are the developing countries which are signatory to the treaty including Nepal. The emissions reduction projects generate Certified Emission Reduction units (CERS) which may be traded in emissions trading scheme through the CDM. The "flexibility" allows Non-Annex 1 countries to meet their emission reduction commitments with reduced impact on their economies.

The CDM addresses the second objective by allowing the Annex I countries to meet part of their emission reduction commitments under the Kyoto Protocol by buying Certified Emission Reduction units from CDM emission reduction projects in developing countries. The CDM is a unique mechanism in that it enables badly-meeded financial flows to developing countries for promoting clean technologies that not only reduce greenhouse gas emissions but also contribute towards the sustainable development of the country. The project design and the issue of CERS are subject to registration and approval to ensure that the emission reductions are real and "additional." "Additionality" means that the project reduces emissions more than what would have occurred in the absence of the project. The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC).

Projects can be registered as capable of producing "Certified Emission Reductions (CERs)" in the carbon market. The CDM allows industrialized countries to buy CERS and to invest in emission reductions where it is cheapest globally. The Kyoto Protocol has been flexible in that the applying countries can develop projects where it is economical to do so. In the case of Nepal, as one among the group of developing Non-Annex I countries (considered to be less or insignificantly pollutive), it can host projects for the Clean Development Mechanism. It has recently deposited the instrument for accession to the Kyoto Protocol and has thus fulfilled the first requirement for participation in the Clean Development Mechanism. It also now has met the second requirement – that of having a Designated National Authority (DNA) that enables it to participate in the regulation of CDM registration. The DNA in Nepal is the Ministry of Science, Technology and Environment.

As of mid-2012, about 13 Nepal projects[3] have been registered with the Executive Board of the CDM with notable projects that include: agricultural biogas projects, hydropower projects, a major railway, large-scale improved cooking stove, clean emissions from transport vehicles, and the Sisdol Landfill Project in Kathmandu although recently, biogas and improved cooking stoves in Nepal have been excluded from this list. The Sisdol project is the only project in waste management that has been registered. The project applied for about 300,000 metric tonnes equivalent of CO^2 emissions, has a crediting period of 20 years, and is still in the process of having their project design documents revised and approved. The Birgunj ISWM project is very small in scale compared to the Kathmandu Project.

With regards to the Birgunj ISWM project, developing a Clean Development Mechanism (CDM) Project from its components such as the Sanitary Landfill, Composting Center and the Waste Resource Processing Center - as designed - is unlikely to be feasible because of the small scale in operations of the project and other barriers that are institutional (global disagreements in the extension of the Kyoto Protocol that ended in 2012) in nature, which have not been resolved. The ISWM is expected to produce at least 2 tonnes of compost everyday while the Waste Resources Processing Center is designed to produce an average of 3 tonnes of reusable and recyclable materials per day. The release of methane gas by means of passive venting becomes appreciable only after 5 to 6 years – that is - if the 3Rs are not successful and gas develops from the landfill cells because of the proportion of organic wastes that is eventually deposited in the cells. The expected amount may not be attractive enough to obtain the calculated Certified Emission Reductions (CERs) that can be traded and necessary to apply for registration as a project. As such, no gas collection for energy recovery in the landfill has been designed.

Although it can be said that projects such as the ISWM project contributes to sustainable development, the experience of Nepal as one of the signatories of the Kyoto Protocol, and the progress of its registration application for projects reveals the difficulties in making a mark in the carbon market. Projects from Nepal are mostly small-scale, aiming to deliver distributed

[3] Clean Development Mechanism, Tiempo Climate Newswatch, June 2012

renewable energy services to rural households. It is challenging to compete in this market. Some proponents in Nepal believe that awareness about CDM has to be heightened to be able to get support from all sectors. A Climate Policy still has to be formalized in Nepal. The Climate Change Support Programme under the Climate Change Management Division of the MoSTE, which serves as the planning and implementing arm of the DNA has to be strengthened and staffed adequately to be able to carry out its task of processing CDM applications and evaluating them for endorsement by the Ministry to the UNFCC CDM process for verification prior to registration.

In the international arena, whether CDM has actually delivered real sustainable development benefits to host countries is being debated upon. The previous and current demand have been to generate a large volume of CDM projects in a short period of time that are possible only with industrial projects emitting a lot of global warming gases, which is not the case in Nepal as a whole. The uncertainty of the CERS values in the future and how these translate to carbon financing leaves the CDM projects' future uncertain as well.

1.4 Overview of Existing Solid Waste Management System in Birgunj

Waste Generation Rates and Waste Volume Projections (Household, Commercial, Institutional, Street Sweepings)

The waste generation rate used in the detailed design is 0.35 kg/cap/day starting in 2011 as the base population year for planning. The bulk density of 0.323 kg/liter or 323 kg/cu.m. was used for projecting the trucked or collected volume of uncompacted wastes generated from Birgunj. These figures were based on the most recent ADB-TA for Institutional Strengthening of Municipalities in Nepal in 2011. It is recommended that these figures be reviewed through the conduct of waste characterization studies at least every two years to monitor changes in the characteristics of MSW as a result of the prevailing urbanization in Birgunj. The same figure was used as the base in projecting waste volumes for the sub-metropolis over a planning period of 20 years. The figure is an average amount for the whole municipality, does not consider pre-collection recycling and composting from the waste stream, and is within the range of values from the experience of the DSC in solid waste projects in developing countries similar to Nepal. The population in 2011 of 135,904 was projected through a 20-year planning period. This average generation rate used includes only the wastes arising from households, business offices, commercial and institutional establishments, and street sweepings. A separate study on hospital and health wastes from health care establishments should be performed by BSMC as it is an important public health and environmental problem when mixed with municipal wastes. A similar study should be prepared for industrial wastes, toxic and hazardous wastes, electronic wastes (e-wastes), construction and demolition wastes, chemical wastes, and agricultural wastes all of which are also not included in the design and are by law the responsibility of the waste generators themselves.

Waste Characterization and Composition

In Birgunj, the waste collection and sweeping services reach only about 30% to 40% of the municipality. There is no organized door-to-door collection system as yet, and 78% of the households still dispose of their waste in public places. Only 10.5% of households used fixed places or containers. From the community surveys, people view solid waste management as both their 1st and 2nd priority.

The existing waste generation and composition obtained from official documents of the Solid Waste Management Resource Management Center (Source: SWMRMC. 2004. Diagnostic Report on Solid Waste Management in Municipalities of Nepal) are the following:

Table 6: Waste Composition in Birgunj (SWMRMC 2004)

Waste Composition	Percent by wet weight (%) [Total 99.7 % ≈ 100 %]
Organic	66
Inert	8.6
Metal	5
Paper	4.4
Glass	1.7
Plastic	5.6
Textile	2.4
Rubber	0
Leather	0
Medical	0
Other	6

These were updated during the year 2011 as follows:

Table 7: Waste Composition in Birgunj (2011)

Waste Composition	Percent by wet weight (%) [Total = 100%]
Organic	51.09
Inert	25.08
Metal	0.16
Paper	6.55
Glass	1.66
Plastic	10.14
Textile	4.65
Leather	0.41
Rubber	0.10
Bones	0.05
Others	0.11

Source: ADB TA 7355 – NEP Institutional Strengthening of Municipalities (2011)

Survey data also from 2011 indicated a per-capita waste generation of 0.35kg/cap/day as municipal average with a bulk density of 0.323kg/l for Birgunj Sub-metropolis (ADB TA 7355-NEP, Institutional Strengthening of Municipalities, Final Report). Therefore, for a projected population of 135,904 in 2011, the total municipal waste generation was estimated at 47.57 tonnes/day.

Field Surveys on Waste Generation and Composition

The waste generation and composition (i.e. quantity and quality) obtained from the recent survey results of 2011 need to be reviewed periodically and updated. Follow-up is recommended on waste characterization and composition surveys covering all 19 wards, including waste density studies and total daily amount of waste to be brought to the Composting and Waste Resources Processing Center for at least 2 seasons during the year, and projections of the figures for a planning period of at least 10 years. The need to change parameters for waste generation and composition surveys will be decided upon by BSMC during the operational phase of the project.The results will be used to verify the figures and adjust technical and operational parameters for running the integrated solid waste management system. The system includes both the Waste Collection and Transportation Program and the Integrated Solid Waste Management site activities.

The data accumulated over a period of time of every 5 years will be sufficient basis for upgrading solid waste facility plans for the future.

The data obtained from the field surveys will be utilized for continuous planning, monitoring and evaluation for:

- the SWM operational system, e.g. for projection of waste generation figures, calculating municipal waste stream flow, equipment replacements, need assessments, etc.; and
- calculating existing and future design capacity of composting facility, recycling facility, landfill capacity and life span of the landfill site, etc.

Mobilizing and organizing the wards and the communities will be crucial in implementing the municipal solid waste collection system for Birgunj. The 3Rs (Reduce, Recycle and Re-use) will only be realized if the population is ready for the required change in behaviour in segregating waste right from the source even before it even enters the municipal solid waste stream. The ward leaders, tole organizations and solid waste user committees will be instrumental in implementing waste reduction at the source by practicing waste minimization methods starting from the household level, and making sure that the ward and tole leaders lend a pro-active stance towards their constituents in the 3R activities. There will be need for champions of these activities. On the other hand, all these activities will only be realized when the legal basis i.e. city ordinances, penalties, fines, sanctions and institutional mechanisms are strictly enforced in accordance with the Solid Waste Management Act of 2011.

Existing Waste Collection Service

The BSMC Sanitation section provided waste collection service in all 19 wards with two tippers (tipper trucks) and 8 tractors-trailers in 2012 (only 4 tractor-trailers are operational for MSW collection as of February 2013). The service is provided at two levels, one is the central-level service and other is the ward-level service. 279 management and staff personnel run waste collection on 2 shifts: 6:00 – 9:00 AM for the 1st or morning shift and 1:00-4:00 PM for the 2nd or afternoon shift. The section deploys around 270 cleaning staffs for street sweepings and drain cleaning.

At the central-level service, the municipality controls the main routes namely: a section of the Tribhuvan Rajpath (TRP) along the "inner core" area, Road No. 1, Road No. 2 and Road No. 3, where the two tippers collect daily from the open dump piles of the different wards following the street sweeping and drain cleaning, and regularly pick-up solid wastes on a pre-determined schedule from establishments such as hotels and restaurants, the Indian consulate, etc. or upon request from the public establishments such as the municipal jail, parks and end of festivals. The existing collection routes are:

Road no. 1: Bhandar Chowk, Rajat Jayanti Chowk/ By- Pass Road junction, Masjid road Chowk, Birta Mandir Chowk, Aakhalia Chowk, Ghantaghar Chowk, National trading chowk, and Power house

Road no. 2: Birta Mandir Chowk, Birta bazaar Chowk, Ganeshman Chowk, Loharpatti Chowk and Ghantaghar Chowk

Road no. 3: Ganeshman Singh Chowk, Reshamkothi Chowk and Link road

The tippers collect from ten open collection points (waste piles) on Road no. 1, six collection points on Road no. 2 and six collection points on Road no. 3. Open waste piles are accumulated and placed for temporary storage at the road side by the street cleaners/drain cleaners and street sweepers.

Photo 1: Tipper with capacity of 6 cu.m

In the ward-level service, with some exceptions where there are overlaps in wards and jurisdictions, each ward office is in charge of the cleaning work within their ward boundaries and under their own management. The tractor-trailers are dispatched by the Sanitation section daily or on alternate days depending on the demand for service to collect and dispose of the municipal solid waste (MSW). Follow-up collection trips are made when the wards inform the Sanitation foremen of such need such as after the end of local festivities.

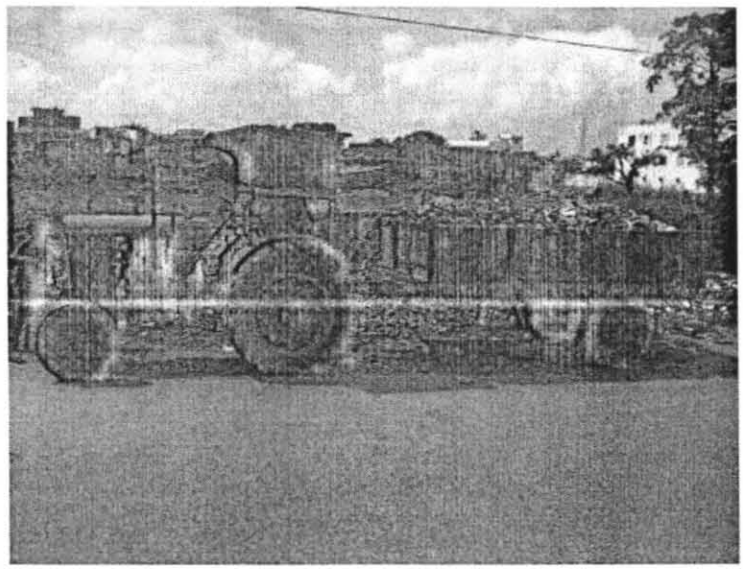


Photo 2: Tractor-trailer with capacity of 3 cu.m.

In general 2 tippers do 10 trips per 2 shifts per day in the core area wards while 8 tractors perform 16 to 20 trips daily in the remaining inner and the outer core area. Wards 10 and 15 are serviced under a PPP program with a local NGO called LIDS including some portion of Wards 12 and 14 that share boundaries with Wards10 and 15. The municipality supplies the NGOs with rickshaws and handcarts, and allocates manpower from the Sanitation section to work with them consisting of about 6 rickshaw pullers, 3 street sweepers and 5 drain cleaners/sweepers.

Existing Collection Points

The collection points (CPs) that were identified in the respective wards of the BSMC during the field survey are enumerated and briefly described by wards as follows. Collection Points as defined for Birgunj are informal sites along the waste collection routes where the residents and other members of the community deposit solid waste from their respective dwellings, stores or other establishments temporarily - usually on the kerbside and extending to the road carriageways - until these are picked up by the BSMC Sanitation section at pre-designated but informal collection points. Waste collection is usually carried out by tractor-trailers. These CPs are shown in Figure 2.

1. Ward No. 1 – No collection point
2. Ward No. 2 – **CP28, CP29, CP30, CP31** (4): three CPs are located along the Tribhuvan Rajpath (TRP): the CP located in front of Shree Ram hall, CP at entry point of road to Doctor's colony and CP located just before TRP's junction with Ghusukpur Main road/railway line. The 4th CP is located along the access road from TRP west of the Chhapkainya pond.
3. Ward No. 3 – **CP33, CP4** (2): CP33 is located in front of the Aadalat Quarter building which is at the opposite roadside of Udyogh Banijya Sangh while CP4 is located beside the foot path of Narayani Hospital Chowk
4. Ward No. 4 - **CP5** (1): CP5 is located at the intersection of the Birta Bazaar Chowk towards Birtha Link road

5. Ward No. 5 - **CP27, CP34** (2): CP34 is located in front of the Kawadi gate between Kanya School and Ganesh man Chowk while CP27 is located along the TRP in front of an apartment complex building
6. Ward No. 6 - **CP6** (1). This CP is located in Ganesh Man Singh Chowk at Ward no 6 and a common collection point for three wards: 4, 5 and 6. Most of the settlements of these wards are not accessible to tractor-trailers and tippers. So waste is collected by hand carts from the inner streets and brought out to the collection point to the awaiting tractor-trailers
7. Ward No. 7 - **CP7, CP26, CP8, CP37** (4): CP37 is located in Chirinjibi Mill Chowk along Road No 3 which is the boundary of four wards (Ward nos. 9, 6, 7 and 11). CP7 is located at the boundary of Wards 7 (North) and Ward 6 (south) demarcated by a drainage canal and CP8 is in Road no.2 opposite a college and secondary school compound. CP26 is located as shown in the map in front of the Resham Kothi Area.
8. Ward No. 8 – **CP9, CP32, CP35** (3): CP9 is located beside a culvert between Kailash road and Jame Masjid, CP32 is in front of Himalayan Bank and CP35 is in front of Maisthan Temple at Road no. 2
9. Ward No. 9 – **CP16** (1): CP16 is located in front of the poverty cluster along the Railway Road
10. Ward No. 10 - **CP13, CP14** and **CP15** (3): The 3 CPs are located in Maanhbeshpu Mandir area. CP14 is located in a cow yard area near Bigunj Ratri Madhyamic School
11. Ward No. 11 – **CP36, CP12** and **CP11** (3): CP 11 is located beside the wall of the Telecom Office and CP12 is at the junction of the vegetable market place where a new market building stall is under construction. CP36 is located on Road no.3 towards the Gahawa Tole
12. Ward No. 12 - **CP17** and **CP19** (2): CP19 is located near CDO office and a School junction area. CP17 (Pvt.) is located beside the gate of Gopal Mandali (Marwadi Sewa Atithi Sadan)
13. Ward No. 13 - **CP10, CP18** (2): CP 18.is located in Ghadiharwa Tole in front of Narayani Boarding school and Kumarimai Chowk and CP10 is beside the wall of the Pond and the Sports Council office
14. Ward No. 14 - **CP20, CP 21** (2): CP20 is located on the road in front of the Agriculture Research Centre office and CP21 opposite the School gate in Shreepur near where a sewer manhole is located
15. Ward No. 15 - **CP2, CP3, CP1** (3): CP1 is located north of Suresh Oil, CP2 near the Department of Medicine Management and CP3 is near the Murli Chowk

Photo 3: Collection Pt. CP-1 at Ward 15

16. Ward No. 16- **CP22** (1) which is located at centre (near the median) of the highway in Trimurti Cinema Hall Chowk
17. Ward No. 17- **CP24, CP23** (2): one CP is located beside a shallow well in Thulo Pipra road where a handcart is parked after the day's work and the other CP is opposite the Sugar mill in Sano Pipra. The sugar mill was closed down 10 years ago and the land is presently occupied by Armed Police Force office
18. Ward No. 18 - **CP25** (1**):** CP25 is located in Laxmanwa Gaon
19. Ward No. 19 – There is no fixed collection point in Ward 19. Being the biggest ward, there is sweeping service

The total number of collection points is **37.**

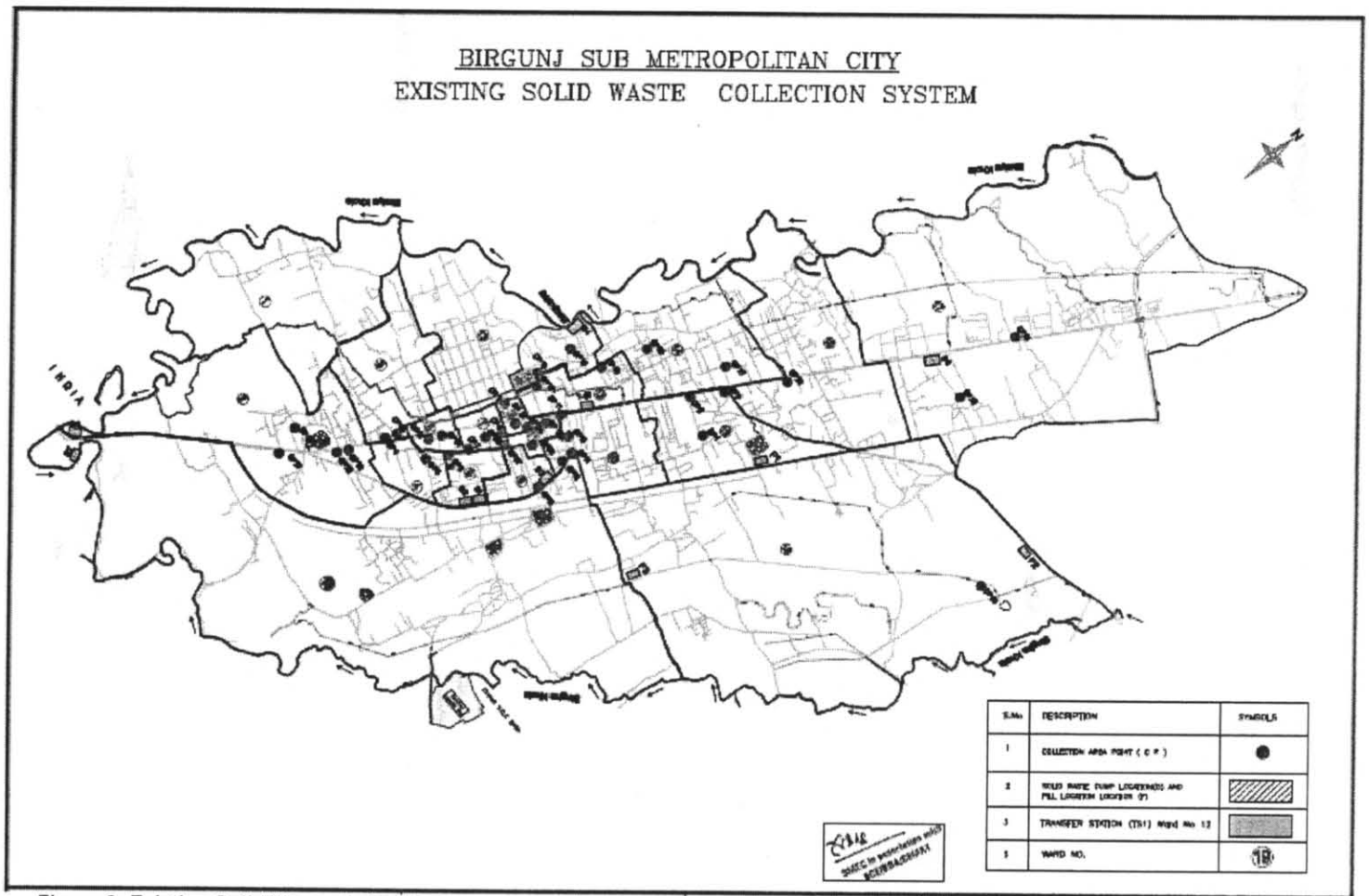


Figure 2: Existing Solid Waste Collection System Drg. No. 36(1)

Temporary Disposal Sites

There are altogether five (5) existing temporary dumpsites (D-1 to D-5) and three (3) existing filling areas (F-1 to F-3) that are being used as disposal sites by the Sanitation Section of BSMC. One of the temporary dumpsites, D-4, does not have its deposited wastes regularly hauled out to the final dumpsites located along the banks of the Sirsiya River near the Customs Office. It can be classified as "semi-permanent" in that respect. There are more unknown and smaller sites that exist in several other unreported disposal areas in the Sub-Metropolitan City including those on vacant lands. Most of these dumpsites have been used for at least 5 years. No permanent solution to the disposal problem has been found prior to the decision to build a sanitary landfill in Birgunj. Except for the "permanent" disposal sites at the Sirsiya River banks, most of the identified dumpsite areas are lowland areas owned by private parties.

Open Dump Sites

D-1 This open dump is in Ward No.6 and is located at the corner of Railway Rd and Kumhal Tole Rd. The dumping area is approximately 6 m wide by 50 m long along Railway Rd with a deposited waste depth of about 2.5 to 3 meters on low lying private land. Ward 6 wastes are brought in by handcarts by BSMC Sanitation street cleaners. Wastes are hauled out by 2 tractor-trailer trips and 1-2 tipper trips daily to the main disposal areas located at the Sirsiya River banks near the Customs Office. This private land is being used by the BSMC as a temporary dumpsite with the owners reportedly agreeing since their property is being filled up closer to the road elevation.

D-2 This open dump is also located in Ward No. 6 along the corner of Railway Rd and the next parallel road south of Kumhal Tole Rd. The area is approximately 20 m long x 15 m wide area with waste piles spread over a 4 m wide strip along the corner of Railway Rd and the parallel road south of the Kumhal Tole Rd. The wastes are collected from Wards 6 and 19 by BSMC Sanitation. Wastes from the households are brought in by handcarts, then hauled to the main disposal areas by 2 tractor-trailers trips and 1-2 tipper trips daily. This open dump is along the same route of collection as D-1. The dump is on private land and is being used by the BSMC as both a collection point and a dumping site. The lot is also low-lying and the property is being filled up to the level of the road.

D-3 This open dump is located in Ward No. 9 along Railway Road. It is an open dumpsite covering an area of about 3 m wide x 100 m long over a fill depth of about 1.5 m. The dump is on a private property with an approximate 50 m x 100 m area along Railway Rd. The roadway has a 1 m wide x 1 m deep dry (at the time of survey), open drainage canal filled with about 0.5 m left from the brim with garbage. The rear area of the lot over the backyard wall of residences on its opposite side is another open dump of about 25 m x 5 m area indiscriminately dumped over the boundary walls onto the low-lying private land. This private land is being used by the BSMC as a temporary dumpsite with the private owner(s) apparently agreeing since their property is being filled up to road-level elevation.

D-4 This open dump is located in Ward No. 13 along the eastern bank of the Sirsirya River westward from the corner of Ashok Bauka Rd and Kumarimaj Rd. This dump is also called the Ranighat dumpsite and is located in Nanyabasti, Ward No. 13. It spans a length of about 150 meters of the river bank length. It is presently used by the BSMC Sanitation as the disposal site for Ward Nos. 12, 13 and 14. Household wastes are brought directly by the residents nearby. MSW from handcarts, tippers and tractor-trailers from BSMC Sanitation (2 trips daily by Tippers/Tractor Trailers) are collected in the respective wards and disposed of in this dump. During the waste survey, there were 4 informal dwellings seen at the dump of families engaged in the "Tanga" transport business who also derive some income from waste picking at the river bank open dumpsite. This site was used as a municipal dumpsite as a precautionary measure by BSMC and upon request by the informal settlers therein when the river cut the bank back 4

or 5 years ago. The dumping is still taking place, and residents nearby are using river water to wash utensils and clothes.

There was another dumpsite along the Sirsiya River bank around 300 meters downstream of the river which is already closed. The BSMC Sanitation stopped dumping at said location 4 to 5 years ago as it was already saturated. It was also reported that the residents living along the riverside were likewise demanding from the Municipality that the river bank be stabilized by filling with solid waste as the river over time had been dangerously eroding and encroaching on their settlements.

Photo 4: Dumpsite D-4 along east side of Sirsiya River

D-5 This open dump is located in Ward No. 17 at the corner of Tibhuvan Rajpath (TRP) and the next road south parallel to the Thulo Pipara Rd. This is a dumping area on the roadside of the TRP and bounded by the corner road. Dumping is done on the fringes of a private lot planted to some vegetables and other urban agricultural crops. The area is also used for cow dung and organic waste processing from which the fertilizer products are reportedly used for the agricultural crops. The BSMC Sanitation also uses this dump as a disposal site although it was not known how often they haul out solid wastes for final disposal to the main disposal sites near the Customs office.

All these open dumps continue to be serious public health and environmental risks. Cows and other domestic animals are often seen feeding on the garbage. The BSMC should formulate and implement a city-wide open dump closure and/or rehabilitation plans (including the fill areas described in the next paragraphs) in coordination with the proposed Integrated Solid Waste Management Program.

Filling Areas/Open Dumpsites

F-1 Murli pond filling area. This 60m x 30 m area is located in Ward No.15. The east edge of the pond next to its outer wall has been filled since February 2013 with municipal solid wastes, construction/demolition debris, and some agricultural wastes collected by BSMC Sanitation. The surrounding community has requested the municipality to raise the adjacent lowland area to a higher level close to the level of the road. The collected wastes are from Ward Nos. 17, 15, 16, 10, 12, and some parts of 18. The earlier fill was covered with clay at a cost of NRs 500 – 600 per tractor-trailer. This site is not a designated dumping site but has become a joint project in developing low-lying lands that has gained support from the respective members of the community who will benefit from the land improvements. BSMC Sanitation is further planning to reclaim a 500-sq.m. water-logged area (about 1.5 meter deep) that forms a corner to two perpendicular walls of two adjacent properties using the mix of collected wastes and various filling materials. During "Mahayagya", a religious festival observed during the months of March/April (Chaitra B.S. 2069), the municipality diverts all of its tractor-trailers to collect wastes and fill water-logged low-lying land with the wastes. The municipality is aware and is being

careful that some members of the community may oppose the dumping in this and similar places after distributing collected wastes from the "Mahayagnya" and similar functions so it is important that they manage the filling properly and in a manner acceptable to the community.

Photo 5: Fill site F-1 at east edge of Murli Pond, Ward 15

F-2 This fill/dumping site is in Ward No.18 and is used by the residents of Ward No. 18 nearest to the site. It is located Along Kailaiya Rd at its boundary with Laxmanwa Park fronting one of the entrance roads into the north side of Ward No.18. Households in the vicinity including those from outside the municipal boundary of Birgunj dump mixed waste (MSW and animal dung) with evidence of burning of garbage. The owners of this private land reportedly sold the property to outsiders (from outside Birgunj). As these were seemingly abandoned by the new owners who are not from Birgunj, the area has been used as an "illegal" dumping area which the BSMC Sanitation does not collect from.

F-3 This fill area is in Ward No.18. It is located along the west side of Canal Rd at its confluence with the National Medical Road. The dump site is about 4 m wide x 20 m long x about 2 m deep and is blocking part of the open road drainage canal along the west north canal road alignment. It is used as a filling site with wastes collected from Ward Nos. 18 and 19. Waste is brought in by handcarts from the nearby residences and the BSMC tractor-trailers from collection points. This is an open dump that is serviced by the BSMC Sanitation primarily for filling. The Owner reportedly demanded that the property be filled as it is flood prone.

Based on the site surveys, more lowland areas in Ward nos. 19 and 18 could serve as potential sites for facility development by way of filling and reclamation. The potential of these areas must be further explored and documented. On the other hand, some dumpsites have been closed intermittently for two reasons: first, because of the mounting public complaints against its continuous use, and second, because they are filled close to capacity and the wastes are not regularly hauled to the final disposal sites near the Customs Office. An example of this is the Adaalat dumpsite. The Adaalat site is a semi-closed dumpsite located just before the bridge westward from Ward No.16 to its border with Ramgadwa VDC. The Sirsiya River separates the

VDC and municipality area. This site is still being used occasionally (reported February 14, 2013) for dumping despite the neighborhood's opposition.

Final Disposal Sites

There are two places in the Inaruwa area which were previously used as dumping sites: one is at the east side of Tribhuvan Rajpath where the old dry pond and the Bisnari Cinema Building are located 200 meters south of the Inaruwa Chowk. The other one is a little further south where the Kedia Dental Hospital building is being built on the west side of TRP. These two sites opposite each other on both sides of the Tribhuvan Rajpath were reportedly used for 20 years. The land where the dental hospital building is being built was said to be also a waste dumping area. At the time of the survey, this site had been closed for about one year.

There are two (2) sites which the BSMC Sanitation is presently using as the final disposal sites of the collected wastes from the different collection points. These are near the Customs Office and are across each other on opposite sides of the Tribhuvan Rajpath. These are:

D-6 This main open dump is located in Ward 2 along the banks of the Sirsiya River on the west side of the Tribhuvan Rajpath approximately 300 meters south of the Customs Office. This dumpsite is located near the Customs office in Ward No.2.

D-7 This main open dump is located in Ward 19 along the banks of the Sirsiya River on the east side of the Tribhuvan Rajpath approximately 300 meters south of the Customs Office. This dump has a clearing where trucks are parked and where some informal settlers are living.

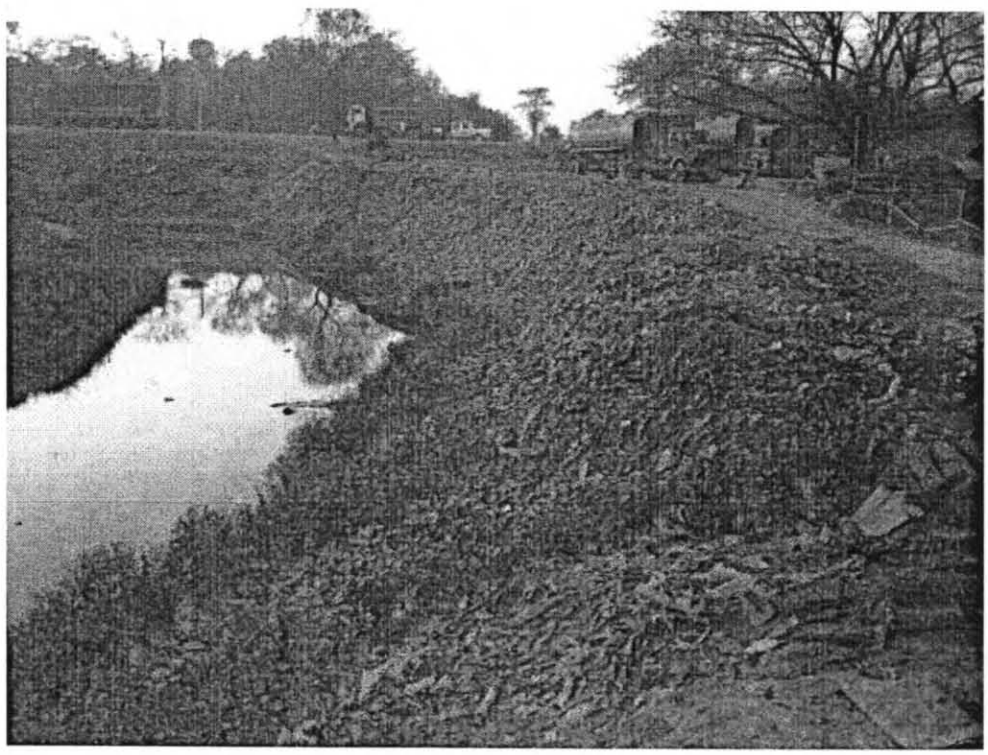


Photo 6: Final Disposal Site D-7 at Sirsiya River bank east of TRP

Public-Private Partnership Model on Solid Waste Management

A local NGO called Local Initiative Development Support Programme (LIDS) started to work on waste collection services in Ward Nos. 10 and 15 under a "pilot" or "model" PPP 5-year contractual arrangement with Birgunj Sub-Metropolitan city, the serviced ward communities, and with initial financial support by PPPUE/UNDP since August/September 2011 (18 Bhadra 2068). UNDP purchased the initial inventory of waste management materials such as dust bins, rickshaws, thela, gloves and first aid medicine, etc. Including support for the awareness raising activities, UNDP contributed a total of 24 % of the initial funding while the municipality 60%, the community 5% and LIDS 11 %. The PPP aims to make the households more aware about proper waste management particularly waste segregation at the source. Another objective is to make the households get accustomed to paying for collection service fees at present and into future, especially when they realize its value to them and its merits.

Solid waste management user committees have been formed to help manage the program with an executive body leading it. The user committees are instrumental in helping with collecting fees and promoting the program. Ward No 13 is being proposed and is under consideration by BSMC to follow the same system with LIDS.

Another privately-run service was reportedly being practiced in Ward No. 6. The service is being carried out by a local club in the Karagar area. The service is provided only in some limited roads of Kumal tole. One rickshaw driver is mobilized for the tole work. They do not carry out drain cleaning work. The Municipality is asked to remove wastes from the drains. The rickshaw is provided by the Municipality, however. They operate the service in the morning and evening. It is not clear what the contractual arrangements are with this private group.

For Ward Nos. 10 and 15, the Municipality presently supplies 14 staff: 6 rickshaw pullers, 3 sweepers and 5 drain cleaners. The salaries of all sweepers and staff are paid for by the Municipality. As an alternate team to do the work when the municipal team is not available such as during public holidays, LIDS uses their staff, namely: 1 Project Coordinator, 1 Administrative/finance staff, 3 social mobilizers and 4 rickshaw pullers.

LIDS is providing the waste collection service in three shifts, namely:

- 1st shift: 5 AM to 9 AM
- 2nd shift: 10 AM to 4 PM
- 3rd shift: 1 PM to 5 PM

1st shift: 5 AM to 9 AM: During this shift 7 rickshaws (2 big and 5 small) are used. Two big rickshaws do 4 trips/day at the rate of 2 trips per rickshaw while 4 small rickshaws do 8 trips per day at the rate 2 trips per rickshaw. The other small rickshaw does 3 trips per day. The waste collected during this shift is brought to the transfer station (TS-1) provided by the Municipality. Besides the waste collected by rickshaws, LIDS uses two handcarts (one big and one small). The big handcart does 3 to 5 trips daily while the small handcart does 4 to 6 trips per day. The big hand cart is used to remove the accumulated wastes from drainage canals. The small handcart is used to collect roadside wastes in areas where roads are too narrow for the big handcarts and rickshaws to access.

2nd shift: 10 AM to 4 PM: This shift operation is carried out once a day with direct management from LIDS staff. The rickshaw pullers use a whistle as a signal to make the houses and other beneficiaries aware of their arrival to collect their wastes. During this shift, LIDS uses one big rickshaw to collect municipal solid wastes from different types of waste generators such as households, small hotels, hospitals (only municipal solid waste, MSW) and wastes not normally

thrown by the individuals or establishments during the routine collection service in the other shifts. During this shift, LIDS is able do 2 to 5 trips per day. The wastes collected are transported to the Transfer station, TS-1 located along the roadside opposite the Post Office in Ward No. 12.

3rd shift: 1 PM to 5 PM: during this shift, MSW is collected from the remaining areas and certain areas missed earlier by the collection crew in Ward Nos. 10 and 15. During this shift, LIDS uses two small rickshaws to collect waste from hotels, households, market shops and remove road - swept waste or street sweepings. During this shift, the collection crew does 3 to 4 trips per day which is also transported to TS-1 (the transfer Station) for subsequent disposal to the final disposal sites.

NGO/ LIDS Service Coverage and Fees

LIDS provides waste collection services to up to 1400 beneficiaries in Ward Nos. 10 and 15. Some 300 others are provided free service in Ward No. 10 and parts of Ward No 15. Among the 1400 beneficiaries, about 50% or 700 pay service fees regularly and the other 50% are not paying or are paying irregularly. Of this remaining 50%, 10% are still not agreeing to pay. Those customers who are receiving free services are mainly marginalized families or the poor and those having reservations or are unable/unwilling to pay. Customers who wish to join this service need to apply for membership with cards issued by LIDS. The LIDS service fees per HH or establishment per month range from NPR30 to 50 per HH per month depending on the income level of the HHs, NPR100-150 for extra-large HHs, NPR20 for students living in rental households, NPR75 for shops and small restaurants, NPR1000 for small hospitals and nursing homes (MSW only and not hospital wastes), NPR250 for doctor's clinics (MSW only), NPR50-150 for medicine stores/pharmacies, NPR 200-250 for banks, schools and campuses, NPR200-1,000 for hotels and 50 NPR for 1-storey buildings and 40 NPR for 2-3 storey buildings. Among the 1400 registered beneficiaries, 200 are shops and hotels and around 1200 are households. While conducting waste collection services, recyclable and reusable materials are recovered by the collection crew of the Municipality.

Cleaning route of NGO/LIDS

The NGOs cleaning service covers the following routes:

1. From Ghantaghar via Ghantaghar link road to Bhanu Chowk
2. From Bhanu Chowk via By- Pass road to Bramha Chowk ward no.15
3. From Bramha Chowk via national Trading Link Road to Suresh Oil ward no.15
4. From Suresh Oil via Tribhuvan Rajpath (highway) to Ghantaghar.

Waste Storage Arrangement

At the beginning of contract implementation, the NGO distributed 12-litre bins (2-bins of two different colors for each household: green for biodegradable waste and red for non-biodegradable waste), 32-litre bins (1-bin) for shops, and also 32-litre bins (2-bins of red and green colors for hotels). The municipality has made land available for composting of organic waste. However, only 30% of the households seemed to have utilized the bins for source separation of their wastes. This effort could not be successful because the municipality failed to make transport facilities available. The affected communities have also opposed this system because they had wanted to develop a Madhesi Park in the same site where a composting site was planned. In the meantime, the LIDS continues to be beset with these challenges of truly providing a system for waste segregation at the source in pursuing the 3Rs goal.

Highlights of LIDS Activities

Some important highlights of the PPP project to date are the following:

- Project Office has been set up in Ward No.15 called Murli Bagaicha Tole.
- One (1) Project Coordinator, One (1) Account Officer and Three (3) Social Mobilizers have been recruited. Basic orientation about SWM and the organizational policies, rules and regulations have been provided.
- 2500 pamphlets on SWM have been distributed to households, shops, hospitals, hotels and other offices. A brief awareness orientation on how to manage household wastes has also been provided by social mobilizers.
- A commitment of support and active participation for the solid waste management program has been obtained from the Toal Sudhar Samiti, a community-based organization.
- Solid waste management user committees (with membership of up to 15 reputable persons from the community), Staff and organizational board meetings are regularly being held for the continuing management and sustainability of the project.
- 25 pieces of drum dust bins, 2,000 pieces dust bins, 5 units of Rickshaw, 1 unit of standard size Thela (wheelbarrow) and 2 units of small Thela have been purchased and distributed to the HHS, shops, hotels, schools, offices and hospitals in the targeted area.
- 5 pieces of Kodalo, 18 pieces of Sabel, 1 piece of Gaicha, 1 piece of Gal and 50 pieces of Jhadu were purchased for solid waste management.
- Installations of the stands of drum dust bins are in process.
- Installations of Hoarding Boards in project location are completed.
- Home visits for awareness of each household and beneficiary establishment is being made by the Social Mobilizers to promote segregation of waste at the source.
- Regular waste collection in Ward Nos. 10, 15 and parts of Ward no. 14 is continuous.
- Awareness activities on solid waste management have been conducted with the schools, especially the students themselves.
- The solid waste management user committees through regular meetings with the involved sweepers and staff have been activated as an organized group to obtain feedback from the households and serviced establishments regarding how to improve solid waste management in the wards and even help with fee collection problems.

Organizational Structure and Staffing

The department in charge of solid waste management in the BSMC organizational structure is the Environmental and Sanitation Department. It is not clear whether Sanitation is a division or section. The Sanitation Section, which is the section in charge of the actual waste collection service is directly under the department with two sub-sections: Solid Waste Collection Sub-section and the Solid Waste Management Sub-section. It is not clear what distinct functions each sub-section is handling. The personnel chart is not clear as it shows the Sanitation Section under a Division Chief. The division is composed of a Sanitation Section and an

Administrative Section. Total staffing of the section (division) is 279, with the following breakdown: Division Chief (Sanitation Section Head) – 1; Administration Section: Administrative Assistants – 2; Junior Administrative Assistant – 1; Drivers – 5; Sanitation Section: Sweeper Head – 35; Sweepers – 129 (Male) and 106 (Female).

Existing Waste Collection Vehicles and Equipment

During the waste equipment survey of the Birgunj Sanitation Section conducted in August 2012, the waste collection vehicles managed by the BSMC Workshop, which were operational at the time and under the responsibility of the Mechanical Operation and Maintenance Department were the following:

- Tippers (6 m^3 capacity) – 2 nos.
- Tractor-Trailers (3 m^3 capacity) – 9 nos.

Of the 9 Tractor-Trailers, only 4 are available for SWM waste collection as of January 2014.

The following waste collection equipment were operational and managed under the responsibility of the Environmental and Sanitation Department, Sanitation Section:

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

Rickshaw and Handcarts are managed, repaired and maintained by the Sanitation Section separately from the Tippers and Tractor-trailers, which are managed by the workshop.

Financial Aspects of Solid Waste Management

The annual expenditure of Birgunj Sub-Metropolitan City for solid waste management services in the fiscal year 2010/11 was reported to be 57.75 million NPR, and the expenditure in the current fiscal year is projected at 59.02 million NPR (2.2% higher compared to the last fiscal year). This expenditure seems to be very high for the coverage and quality of the service being provided. The analysis of the last fiscal year shows that 65.2% of the total amount is expended in salaries, 23.8% in allowances and other benefits, 6.2% in fuel and lubricants, 6.2% in repair and maintenance of equipment and vehicles, 1.3% in clothes/dresses for sweepers and 0.9% in purchasing small equipment and tools (e.g. brooms, shovels, disinfecting materials, etc). It is noted on the other hand that there has been negligible revenue collection from the SWM services rendered by the Sub-metropolis except for that from septic tank cleaning services.

Social Aspects of Solid Waste Management

In Birgunj, the itinerant waste pickers or scavengers and the poverty clusters mostly comprised of ethnic minorities are stakeholders in the present solid waste management system. They constitute potential active participants in SWM activities such as in waste resources processing, composting and recycling activities for their respective communities. The present status of this affected social sector is that although the poor do not generate as much waste as the rest of the population as they are natural recyclers and re-users, are engrossed in making a living and have less time to spend in planning composting and recycling activities in their communities that require in source separation of their own waste, they have the time to perform composting and recycling activities where some livelihood can be derived from the 3Rs activities. The gender issues are also brought to bear when it is mostly women who are sweepers while the handcarts and the mechanized tools are used by men. These issues need to be addressed as

well. The scavengers' income generating activities are also affected as they participate in the formal recycling cycles. The informal, itinerant waste pickers should not be disadvantaged but should be absorbed in the formal system particularly in the collection, processing and sale of recyclables and the livelihood that can be derived from the 3Rs efforts. If they are absorbed by the system, every effort should also be made to protect them from the hazards of exposure to public health risks as a result of solid waste activities such as by the glove, appropriate shoes or boots, masks, and all protective clothing.

Environmental Aspects of Solid Waste Management

The integrated solid waste management project for Birgunj Sub-Metropolis City is a critical environmental project because of the public health and environmental risks that result from the construction and operation of the sanitary landfill site, the composting and waste processing activities of the Integrated Solid Waste Management (ISWM) site that covers an area of more than 10 hectares, and as the extensive exposure of the Sub-Metropolis to the adverse environmental factors from waste collection and transport activities that are to be performed by the Municipality. As such, it has been subjected to a full environmental impact analysis and EIA study with the requisite public hearings and consultations conducted, particularly for the primary communities impacted by the project all in accordance with the regulatory requirements of the Ministry of Science, Technology and the Environment (MoSTE). The project is currently awaiting environmental clearance from the Ministry of Science, Technology and the Environment prior to the implementation of construction and initial operations. The mitigating measures for addressing the adverse potential impacts shall be contained in an Environmental Management Plan approved by the BSMC and the MoSTE. All the positive impacts of the project, on the other hand, shall be highlighted and enhanced as contributing to the improvement of the urban environmental conditions of Birgunj Sub-Metropolitan City as whole.

Hospital Waste Management

There is no proper system of managing hospital waste in Birgunj Municipality. There are four big hospitals in Birgunj, namely: Narayani Sub-Regional Hospital, National Medical College, Maternity Hospital and Krishna Hospital. There are many private clinics. The hospital wastes are getting mixed with municipal waste. It was observed that clinical waste is being dumped regularly in Collection Point No. 4 located beside the footpath of Narayani Sub-Regional Hospital in Ward No.3. The waste comes from the nearby wards and two hospitals, namely: Narayani Sub-Regional Hospital and maternity Hospital.

The hospitals do not have their own system of management of hospital waste but are reportedly dumping them at the collection points where the BSMC tractor-trailers come to remove waste. Recently, it was learned that the Narayani Hospital managed using a small tractor-trailer to dispose of their waste at the Municipality's disposal site near the Customs office in Ward No. 19 near the India Border but this information was not verified.

The NGO LIDS is known to have provided waste collection service to private clinics within Ward Nos. 10 and 15. However, they said they collect only municipal wastes and not hospital wastes.

CHAPTER 2: PROJECT DESCRIPTION

2.1 The Proposed Integrated Solid Waste Management System

The proposed ISWM system is based on the integrated solid waste management principle including the 3Rs (Reduce, Recycle and Re-use) that includes not only the final disposal facility at the sanitary landfill site but the equally important goals of waste minimization and reduction at the source, segregation and separation for waste recovery, storage, transfer, segregated collection, recycling, composting, waste processing and final residual waste disposal. The system design is for the household, all other municipal solid waste generators, and the wards to be involved in the management aspects of the solid waste stream. All elements will be acting as a coordinated and integrated whole with the aim of preventing and mitigating environmental pollution, causing minimum environmental impact and protecting public health. The system design is for a planning period of 20 years.

Massive awareness campaigns and training will be launched for the development of waste minimization and reduction efforts for the households and the wards. The key to its success is the commitment of the Birgunj Sub-Metropolitan City leadership to good governance and exercising the political will to enforce the newly revitalized Solid Waste Management Act of 2011. The NGOs and the social mobilizers of the project such as the tole lane organizations (TLOs) and the SWM user committees at the grassroots will also play a vital role in the success of the integrated system.

2.2 Waste Segregation, Storage and Volume Reduction at Source

The concept of volume reduction at the source shall be the first priority to be promoted by the BSMC solid waste management organization to the wards of Birgunj. Under the leadership of the Sub-metropolis, all wards shall embark on a massive community awareness campaign (information, education and communication) and actively promote the reduction, recycling and reuse (3Rs) and minimization of wastes generated at the source. This can be achieved by backyard composting and recovery of recyclable and reusable materials right from the households and other municipal sources of solid wastes. The sorting and segregation of biodegradable (compostable) and non-biodegradable (inorganic reusable or recyclable) wastes shall be the next equally important priority. The responsibility for the source separation shall rest with the households, businesses, commercial, industrial and institutional centers, and in all other point sources of solid wastes as mandated by the Solid Waste Management Act of 2011.

Primary Storage and Waste Containers

Primary storage will consist of the various containers or bags used by residential, commercial and institutional establishments to deposit segregated wastes prior to primary collection by handcarts and rickshaws. The streets and gutters serviced by street sweeping, the two color-coded waste containers provided to households by NGOs, the containers used by stores, public and privates offices, schools, hotels and restaurants, etc. segregated into two different types of wastes (biodegradable and non-biodegradable) are all classified as primary storage. Segregated storage shall also be used for the block collection service and the pick-up service for establishments availing of waste collection service from the Municipality. The individual waste containers will not be uniform at the early stage of the Integrated Solid Waste Management (ISWM) program but will be owned and be the responsibility of the households, commercial, and institutional establishments disposing of their own segregated wastes. The exceptions to these are the green and red dust bins that are distributed by the NGO LIDS to the beneficiaries of their PPP program. The ward communities shall be given the opportunity to organize their own individual container systems for as long as these are color-coded (green for organic biodegradable; red for inorganic reusable and recyclable) and coordinated with the

Primary Collection work by the Municipality and the Secondary Collection work by the Private Contractor –Operator for Birgunj.

Skip Container System

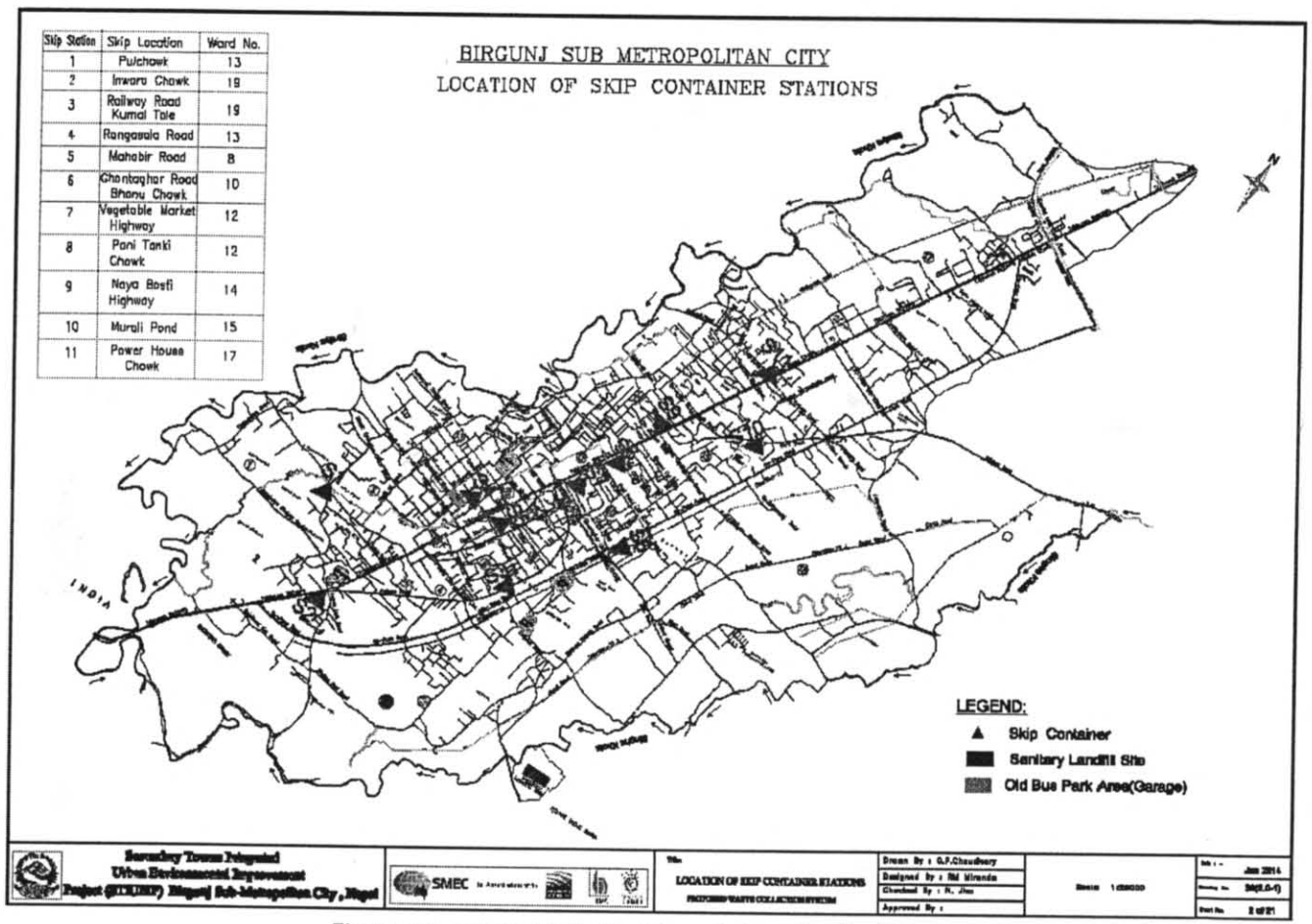
The Skip containers that will be distributed by the BSMC Sanitation Section at their designated locations will consist of 2 color-coded containers (green for organic compostable and red for inorganic recyclable) in one skip container station as shown in the skip operational route plans. Each skip container has a capacity of 3 cubic meters when full. There will be a total of 11 skip container stations or 22 skip containers (11 green and 11 red) for use by the Municipality for all of the 19 wards as shown in the Skip container operational route maps. There will be 4 (2 green and 2 red) empty skip containers to serve as replacement containers after loading by the Skip Loader/Truck hoist. The total number of skip containers at the start of the project will be 26. Depending on the BSMC plans and budget, this number could increase through the years following the implementation of the ISWM program.

2.3 Waste Collection and Transport Program

The design of the waste collection and transport program started with analyzing 37 waste collection points (CPs) that are used by the existing BSMC collection service and determining at which points the maximum volumes of wastes are deposited, which are most accessible to larger collection vehicles, and which are the most appropriate in location as the center of the waste catchment areas of the different wards with respect to the projected waste generation. The CPs are waste piles accumulated by the street cleaning and drain cleaning services using handcarts and rickshaws provided by the BSMC Sanitation Section. The existing collection system consists of route or communal collection, street cleaning and drain cleaning of the inner core roads and the main roads of the sub-Metropolis. The frequency of collection range from 1 to 2 trips per day and are not found to be efficient but are constrained by the present resources of the sub-metropolis in terms of leadership, organizational structure, manpower, the number of vehicles and equipment, and the adequacy of solid waste facilities available for primary collection by the existing BSMC Sanitation staff.

The analysis resulted in organizing the waste catchment areas of the different wards into 11 stations spread across the sub-metropolis. Two skip containers with 3 cu.m capacity each and painted in green and red will be stationed in each of the stations. The present knowledge, attitudes, practices and behavior of the populace with regards to solid waste management were also factored into the selection of the skip station locations. The existing waste collection points were identified as the most appropriate starting locations for the skip containers as the communities have known these areas and have grown accustomed to them as the natural waste repositories for the household and ward waste. The novelty of having containers in some of these locations in two-colors - green for organic, compostable waste and red for organic, reusable or recyclable waste - will command attention in support of the waste segregation program. The regularity of the collection is also achieved by preparing route maps that will be regularly reviewed for efficiency of the skip container collection, block collection, and the collection of street sweepings with specific schedules (See Figures 3, 4 and 5).

The proposed waste collection and transport program includes the skip container collection, block collection, and collection of the BSMC street sweepings and drain cleaning wastes by a private contractor using skip loader/trucks. The private contractor collects the color-coded organic and inorganic wastes separately on a predetermined schedule and transports them for further processing to the ISWM site. The private contractor should be able to collect without



Skip Station	Skip Location	Ward No.
1	Putchowk	13
2	Inwara Chowk	18
3	Railway Road Kumal Tole	19
4	Rangasala Road	13
5	Mahabir Road	8
6	Ghantaghar Road Bhanu Chowk	10
7	Vegetable Market Highway	12
8	Pani Tanki Chowk	12
9	Naya Basti Highway	14
10	Murali Pond	15
11	Power House Chowk	17

Figure 3: Location of Skip Container Stations Drg No. 36(2.0-1)

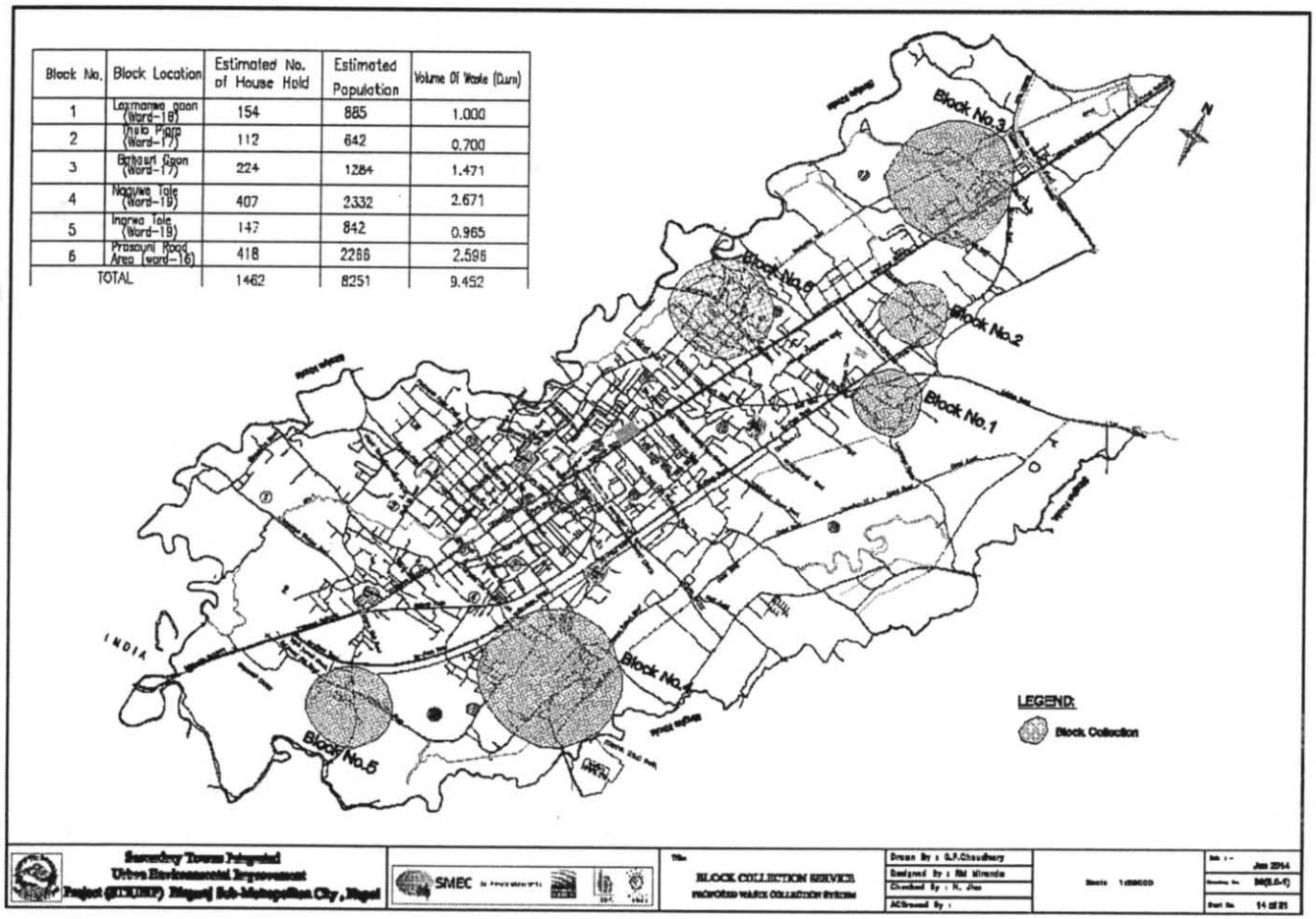


Figure 4: Block Collection Service Drg. No. 36(3.0-1)

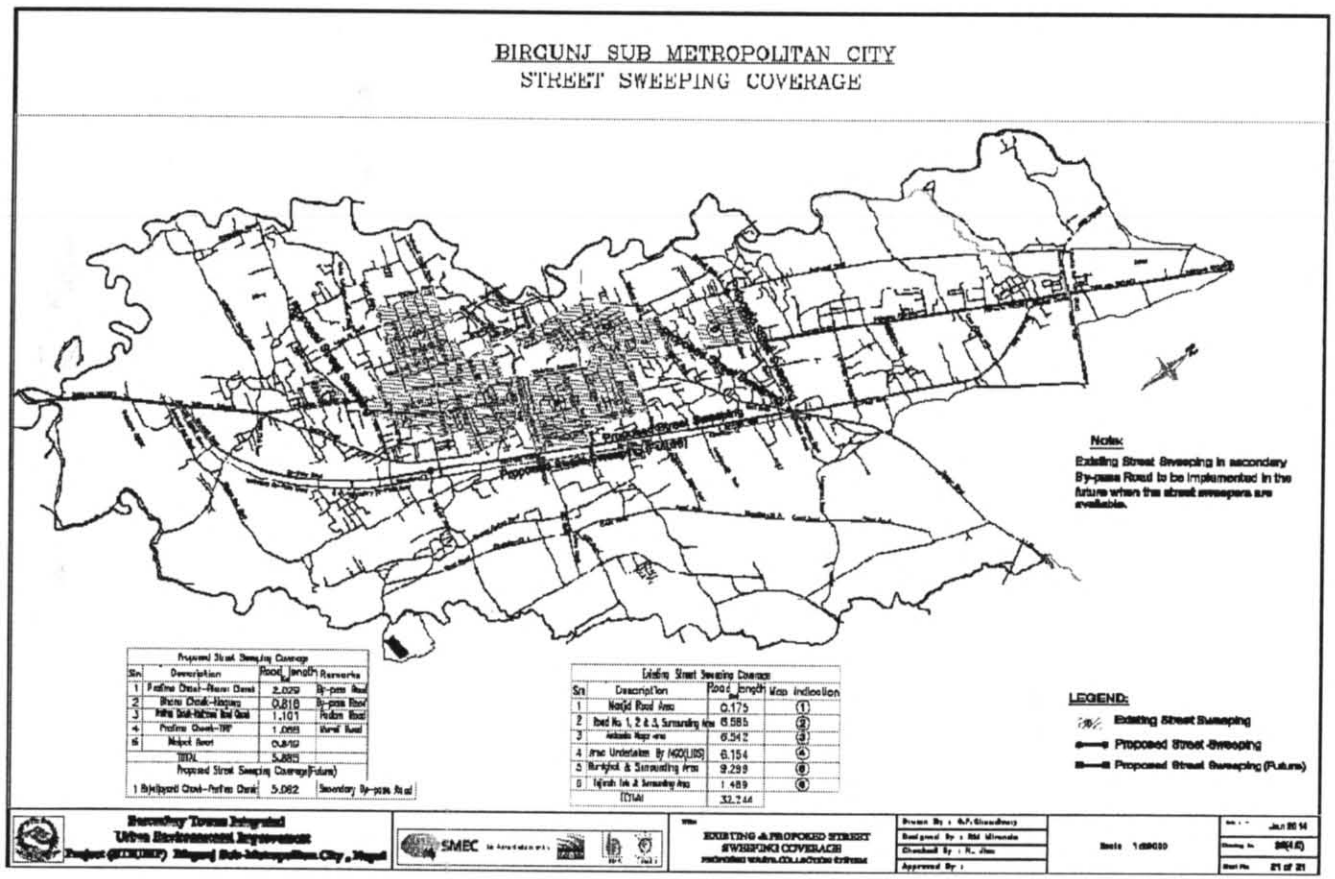


Figure 5: Existing and Proposed Street Sweeping Coverage Drg. No. 36(4.0)

disrupting the work of the Sanitation Section but rather should coordinate to synchronize its work with the primary waste collection performed with the use of handcarts, rickshaws and street sweepings by the Sanitation section. The waste collection and transport is designed such that the BSMC can retain the primary collection functions while the private contractor-operator performs secondary collection. The objective is to organize and prepare a schedule that will collect the biodegradables on different dates more frequently say 3 times a week., the recyclables once or twice a week, and the residual wastes from pre-collection of the households at least once a week.

In summary, the following are the secondary collection services that will be contracted out as discrete work for the private contractor-operator::

- Skip Container Collection – There will be 2 skip loader/truck hoists that will transport the skips on a predetermined schedule to the ISWM Site for further processing and final disposal. The management and care of the skip containers will be the responsibility of the Contractor-Operator.

- Block Collection – The exception to the Primary Collection above that will be under the responsibility of the Contractor-Operator is the proposed Block Collection System. The purpose of this service is to support the skip container system in those areas or blocks of population that are not reached by the Skip container system during the early stage of implementation of the SWM program in Birgunj. There are six blocks of population that will be serviced by the Contractor-Operator. These can be found in the Block Collection operational route plans. The tractor-trailers are dispatched through a route plan to each block wherein stopping points are designated and are made routinely familiar to the community. The collection vehicle then signals the community of their arrival at these stopping points by way of whistles, horns or music. The vehicle waits within an allocated time for response from the community. The households, commercial and institutional establishments then bring their segregated wastes to the tractor-trailers for further sorting. The tractor-trailers which are partitioned for organic and inorganic waste separation and are properly covered proceed to other blocks until full, then proceed to the ISWM site for further processing and final disposal. The service will primarily be provided by tractor-trailers but will be supported with the tippers when required for collection of homogenous wastes, whether organic or inorganic.

- Street Sweepings and Drain Cleaning - In Birgunj, collecting street sweepings from the waste piles on the roadway curbs are classified as secondary collection following the primary collection done by the street sweepers and drain cleaners. Primary Collection will be the prime responsibility of the Municipality (and NGOs under contract) while Secondary Collection will be the prime responsibility of the Contractor-Operator of the Birgunj solid waste project.

- Pick-up Service - The Pick-up service continues the present practice of hotels, embassies, restaurants and other establishments of requesting waste collection services from the Municipality for an agreed fee per collection. In the proposed system, however, the Municipality will provide such a service through the Contractor-Operator "on demand or request", on a pre-determined schedule, and required to be segregated into bio-degradable (organic) and non-biodegradable (inorganic) wastes in their own containers by the establishments. The method of payment of fees will be agreed upon between the Municipality and the Contractor-Operator. Tippers or Tractor Trailers will be used for this purpose.

On a continuing basis, the collection service objective is to organize and prepare schedules that will collect, transport and dispose of solid waste for further processing at the ISWM site as efficiently as possible. As mentioned earlier, the existing 37 waste collection points were used

as starting points for establishing the 11 skip container locations to initialize the system and deciding the designated far-flung areas for block collection. The locations and ward area coverage of the skips should further be improved or revised as the waste collection program progresses. New transport routes should be planned to increase the present collection service of the fleet of vehicles and tractor-trailers to 60% or greater. The assessment of improved road conditions and coordinating new routes with the Municipality will be a priority activity to increase collection service coverage.

The collection efforts will be coordinated with the ward leaders, the households and the NGOs who are working on the 3Rs as this would decrease their load and increase collection efficiency. The concerted efforts are targeted to minimize waste generation and reduce waste at the source or at the points of generation.

Wards shall be organized to be responsible for the collection, segregation, recycling of biodegradable, recyclable, compostable and reusable wastes. The resulting residual wastes shall then be transferred to the waste processing resources center for composting and recycling at the Sanitary Landfill site. Referring to 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 by way of backyard composting and reuse or by the redemption of their own 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.

The transport routes should be reviewed and re-established regularly to increase the present collection service of the fleet of vehicles and trailers. The assessment of the conditions of the roads and coordinating new routes with the municipality should be a priority activity to increase collection service from the present 30-40% to at least 60%. Record keeping should be efficiently performed at all times.

Vehicles used for collection and transport of solid wastes shall have appropriate compartments to facilitate efficient storing of sorted wastes while in transit. The waste compartments shall have covers to ensure the secure containment of solid wastes while in transit.

The following is recommended for the collection, transport and handling of solid waste system:

- All collectors and other personnel directly dealing with collection of solid waste shall be equipped with personal protective equipment and paraphernalia such as, but not limited to gloves, masks and safety boots, to protect them from the hazards of handling solid wastes.

- The City or at the wards level shall provide necessary training to the collectors and personnel to ensure that the solid wastes are handled properly in accordance with the city's solid waste guidelines.

- Collection of solid waste shall be done in a manner that prevents damage to the container and spillage or scattering of solid waste within the collection vicinity. All waste collection equipment should be covered by tarpaulins or similar flexible cover material throughout the duration of the collection and transport routes except when loading and unloading.

- Collection equipment e.g. tractor trailers, trucks, etc. Shall be maintained in good condition and kept clean to prevent the harboring of vectors and the creation of nuisances.

- The use of separate collection schedules and/or separate trucks or haulers shall be required for specific types of wastes. Otherwise, vehicles used for the collection and transport of solid wastes shall have the appropriate compartments to facilitate efficient storing of sorted wastes while in transit. The waste compartment shall have a cover to ensure the secure containment of solid wastes while in transit.

- Vehicles shall be designed to consider road size, condition and capacity to ensure the safe and efficient collection and transport of solid wastes.

- For the purpose of identification, vehicles (tippers, tractor trailers, rickshaws and handcarts) shall bear the identification/body number, the name, and telephone number of the contractor/agency collecting solid wastes.

2.4 The Integrated Solid Waste Management (Sanitary Landfill) Site

The proposed 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 to be developed within an 10.76 hectare property owned by the Birgunj Sub-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 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 proposed 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. It is the major component of the Integrated Solid Waste Management Site proposed for the sub-metropolis of Birgunj. 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 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 residual wastes for proper disposal into the sanitary landfill.

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.

It is hoped that the households and wards will develop their respective composting and materials recovery facilities in the future. The residuals from the HHs and those wards with no capability for composting and recycling will be collected in a segregated manner by the sub-metropolis and hauled to the ISWM site for processing.

The proposed 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 Singaha River

2.5 Site Development Master Plan

The main facilities in the sanitary landfill site consist of the following (See Figure 6):

- 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)

All the design drawings of the above (except for those intended for future development) have been completed and were used in the cost estimating and preparation of the detailed Bill of Quantities that form part of the Bidding Documents.

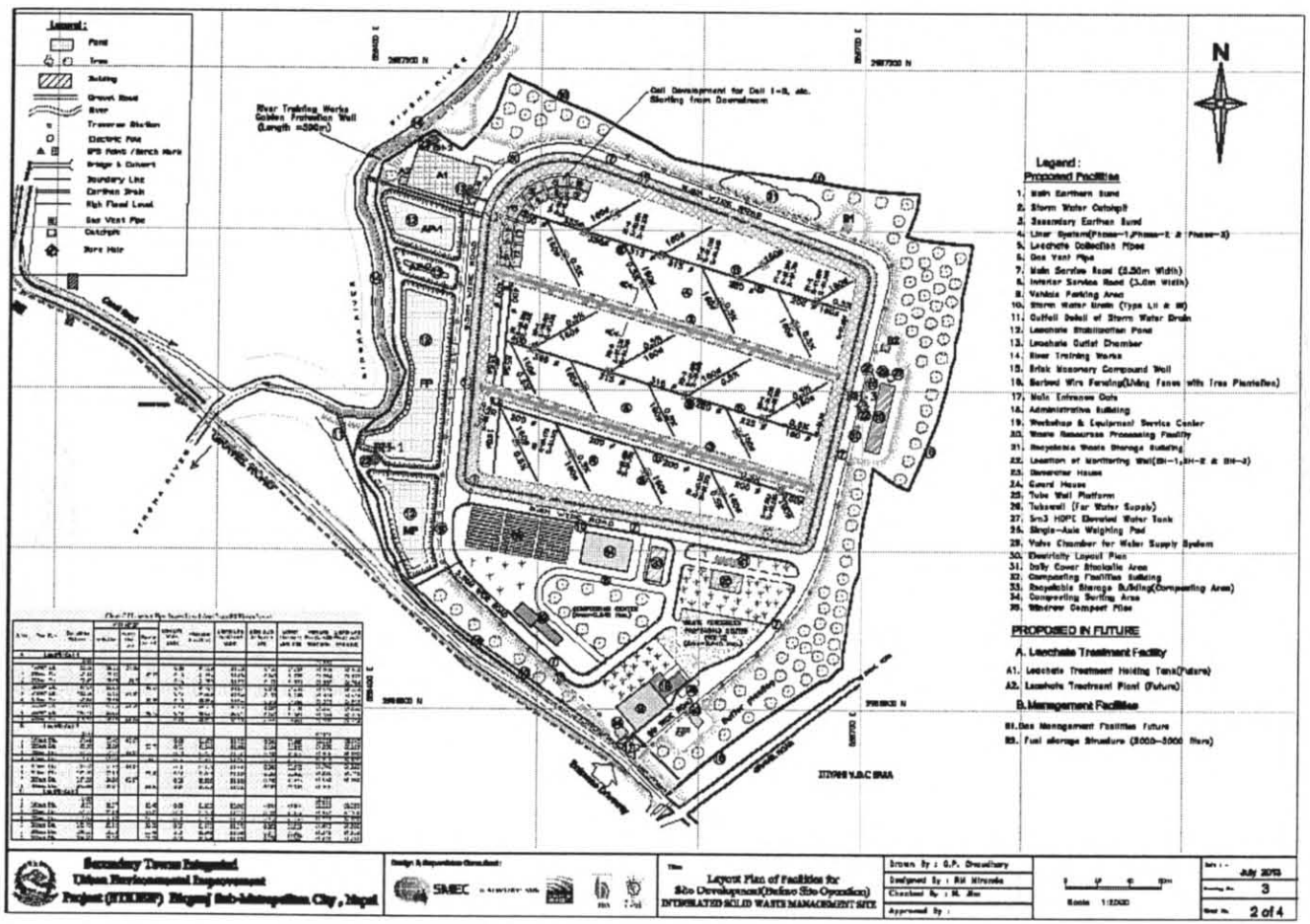


Figure 6: Layout Plan of Facilities for Site Development Plan Drg. No. 3

2.6 Proposed Institutional Arrangements

The existing organization of Birgunj Sub-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.

2.7 Proposed Fleet of Waste Collection Vehicles and Equipment

The following waste collection vehicles presently managed by the BSMC Workshop, which were operational at the time of survey and under the responsibility of the Mechanical Operation and Maintenance Department, shall continue to be used for the ISWM program:

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

The following waste collection equipment which were operational at the time of survey and managed under the responsibility of the Environmental and Sanitation Department, Sanitation Section shall be used:

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

It is proposed that the proposed fleet of waste collection equipment be housed in a new Workshop/Equipment depot and parking lot to be provided by the Municipality. The old bus park in Ward 13 has been identified and proposed for this purpose. Alternatively, depending on the space allocation decided upon and to decrease the distance between the service areas and the 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 should be formulated and implemented.

The following is the proposed list of vehicles and equipment that will be procured for the ISWM Project:

1. Refuse Collector Hoist Truck - 2 nos.
2. Backhoe Loader - 1 no.
3. Track Dozer CAT D6 - 1 no.
4. Solid Waste Skip / Container - 26 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.

These do not include the list of tools, machines and equipment that are needed to operate the ISWM site's different sub-components. These can be found in the detailed Bill of Quantities volume of the Report.

2.8 Project Cost Estimates

The Total Project cost is estimated at NPR 347.15 Million. The detailed quantity and cost estimates are contained in separate report volumes entitled Bill of Quantities and Quantity and Cost Estimates. The tender package covering this component constitutes Package II, namely: the Solid Waste Component of the Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP), Birgunj Sub-Metropolitan City. The Tender scope includes the Construction of the entire Integrated Solid Waste Management (ISWM) site, the provision of Waste Collection and Sanitary Landfill vehicles and equipment as shown in the Final Design Drawings, Technical Specifications and Bill of Quantities, as well as the necessary materials, equipment, tools, machines, plant and manpower necessary to implement the First Year Operations of the integrated solid waste management system in BSMC.

2.9 Social and Environmental Aspects of Solid Waste Management

Those socially impacted by the project are the primary and secondary impact areas of the ISWM (sanitary landfill) site. Consultations have been made with BSMC and a full environmental impact assessment has been prepared that included public consultations and public hearings that were required in accordance with the environmental impact assessment regulations of the Ministry of Science, Technology and the Environment (MoSTE). The Environmental Impact Assessment (EIA) has been prepared and awaiting the issuance of environmental clearance by the MoSTE. Included with the implementing documents is the Environmental Management Plan and Environmental Monitoring Program that will become part of the execution documents to mitigate and monitor the adverse potential impacts of the solid waste component, particularly the ISWM site. All positive impacts will also be highlighted from the point of view of improving the environmental conditions of Birgunj as a whole because of the project.

CHAPTER 3: WASTE GENERATION, COMPOSITION AND CHARACTERISTICS

3.1 Waste Generation Rates and Waste Volume Projections

The municipal solid waste generated in Birgunj is derived from various sources. These are:

a) Household waste
b) Commercial waste including those derived from business such as stores, offices, restaurants, hotels and warehouses
c) Institutional waste including those derived from schools, government offices, and religious buildings, and hospitals or health care establishments
d) Street sweepings including appreciable amounts of household litter, drain cleanings and human and animal faecal matter
e) Construction and demolition debris
f) Industrial waste including toxic and hazardous wastes

Hospital or health care wastes (classified under institutional wastes), construction and demolition debris and industrial wastes, and agricultural wastes from the farm lands in the peri-urban areas, although under the responsibility of the municipality, have to be managed separately because of the way they are generated and required to be managed by law. These waste streams are not addressed in the design of the integrated solid waste management system for Birgunj.

The waste generation rates used for design and waste projections is an average for the whole municipality of 0.35 kg/cap/day based on 2011 data (See Table 8). A bulk density (loose, trucked volume) of 0.323 kg./cu.m. in 2011 is also used throughout the municipality for weight-volume quantity calculations. These figures were used in projecting the generation rates and other characteristics of solid waste for a 20-year solid waste improvement plan with 2016 estimated as the first year of operation. These base rates were likewise used in projecting waste volumes for the sub-metropolis over the 20-year planning period for the waste collection program, the composting and recycling quantities, and the residual wastes ending up in the sanitary landfill located in the ISWM site.

In designing the sanitary landfill's design capacity, the 0.35 kg/cap/d waste generation includes household, commercial, institutional and street sweepings. The pre-collection recycling and composting from the waste stream was estimated to be 10% and 20%, respectively. Although it is well known that the waste composition of municipal solid waste in Birgunj is about 51.09% organic as shown in Table 8, the DSC assumes that only about 20% of the organic fraction would be a realistic estimate based on experience in other countries in regards to how much bio-degradable waste can really be recovered efficiently from a Municipality given the uncertainty in the amount of organic waste recovery from the households. The other reason for the low yield in actual compost produced is because only a smaller fraction of the organic wastes can realistically be part of the fraction of the compost product. Additives constitute a significant fraction. However, for purposes of estimating proposed compost and recyclable plant capacities, the value of 51.09% is used as a starting point. A material balance is estimated to calculate the expected minimum amounts of compost and recyclable products that can result from the 3Rs activities at the ISWM site and the expected residual amounts for landfilling. The population in 2011 of 135,904 was projected through a 20-year planning period. The estimated average generation rate of 0.35/kg/d includes only the wastes arising from households, commercial and institutional establishments, and street sweepings. Industrial wastes that included hazardous wastes are not included and are assumed to be the responsibility of the waste generators themselves. These wastes will be banned from reaching the sanitary landfill. Health care wastes will also be banned from entering the sanitary landfill

site during the present SWM program. The bulk density of 0.323 kg/l or 323 kg/cu.m.is used for projecting the volume of uncompacted wastes generated from Birgunj. The level of collection service of 60% is applied to the waste quantities. This is a good target for a municipality starting an Integrated SWM system. The DSC consultants estimated the present level of collection service at 39.1% after detailed design and survey analysis. Calculations of waste volumes were performed to estimate the indicative quantities of municipal solid waste that need to be collected and disposed of. These quantities are calculated starting from the point of generation and after pre-collection activities at the household and ward levels with 10% and 20% reduction from recycling and composting, respectively. The result is the daily collected, uncompacted MSW volume with 30% reduction from recycling and composting at a level of service target of 60%. These values are shown in Table 10.

Table 8: Average Physical Composition of Municipal Solid Waste in Birgunj in 2011

Particulars	Percentage by Wt (%)	Particulars	Percentage by Wt (%)
Organic	51.09	Leather	0.41
Plastic	10.14	Metal	0.16
Paper	6.55	Rubber	0.10
Textile	4.65	Bones	0.05
Glass	1.66	Inerts	25.08
Others	0.11	Total	100.00

In designing the waste collection program, a different approach was taken. Whereas the landfill capacity estimate is based on an estimate from waste generation rates applied for the whole municipality, the waste collection estimate is based on actual collection data for a certain number of months by the existing collection fleet as shown in Table 9 below, yielding the total average collection of 59.2 cu.m./day and level of collection service at 39.1%.

Table 9: Waste Collection Level of Service (2012) - Sanitation Section, Birgunj

Waste Collection Level of Service (2012) - Sanitation Section, Birgunj									
Data Period	**Mangshir (Nov-Dec 2012)**		**Poush (Dec 2012 - Jan 2013)**		**Magh (Jan - Feb 2013)**		**3-Months average (Nov 2012 -Feb 2013)**		
Type of Collection Vehicle	Tipper (6 cu.m.)	Tractor -Trailer (3 cu.m.)	Tipper (6 cu.m.)	Tractor -Trailer (3 cu.m.)	Tipper (6 cu.m.)	Tractor -Trailer (3 cu.m.)	Tipper (6 cu.m.)	Tractor -Trailer (3 cu.m.)	Calculated Totals
No. of Days	30	30	29	29	29	29	29.33	29.33	
Total Trips/Mo	98	376	62	388	112	428	90.67	397.33	
Waste volume collected per month, cu.m.	588	1,128	372	1,164	672	1,284	544	1,192	
Waste volume collected per day, cu.m.	19.6	37.6	12.8	40.1	23.2	44.3	18.5	40.6	
Total Waste Volume collected per day, cu.m.									59.2
Total Length of Roadway Serviced, km.									30.58
Estimated Volume of MSW collected per km. of ALL serviced roads, cu.m./km									1.94
Estimated Volume of Street Sweepings (25.08%) collected per km. of ALL serviced roads, cu.m./km									0.49
Estimated Waste Generation (population), tonnes/day, 2012									48.7
Estimated Waste Generation (population), cu.m./day, 2012									151.3
Percent Level of Collection Service, 2012									39.1%

Table 10: Projection of Waste Quantities of Municipal Solid Waste in Birgunj in 2011

Projection of Waste Quantities (cu.m.) – Planning Period 20 years from 2015									
Year	Projected end-of-yr population	Waste quantities, kg/cap.day (ave. for entire MSW)	Waste quantities, kg/day	Waste quantities, kg/day assuming 60% service coverage	Waste Quantities, 20% diversion through ward/HH composting (kg/d)	Waste Quantities, 10% diversion through ward/HH recycling (kg/d)	Waste Quantities after 30% diversion by ward/HH composting & recycling (kg/d)	Bulk Density, (kg/cu.m.)	Daily volume, uncompacted, (cu.m.)
2011	135,904	0.35	47,566	28,540	5,707.97	2,853.98	19,977.89	323	88
2012	139,227	0.35	49,217	29,530	5,906.01	2,953.00	20,671.03	322	92
2013	142,680	0.36	50,942	30,565	6,113.01	3,056.51	21,395.54	321	95
2014	146,272	0.36	52,746	31,648	6,329.58	3,164.79	22,153.52	320	99
2015	150,007	0.36	54,634	32,781	6,556.11	3,278.06	22,946.39	319	103
2016	153,890	0.37	56,609	33,965	6,793.08	3,396.54	23,775.77	319	107
2017	157,931	0.37	58,676	35,206	7,041.17	3,520.59	24,644.10	318	111
2018	162,136	0.38	60,841	36,505	7,300.93	3,650.47	25,553.27	317	115
2019	166,513	0.38	63,108	37,865	7,573.01	3,786.50	26,505.53	316	120
2020	171,073	0.38	65,485	39,291	7,858.20	3,929.10	27,503.70	315	125
2021	175,820	0.39	67,975	40,785	8,157.02	4,078.51	28,549.56	314	130
2022	180,765	0.39	70,586	42,351	8,470.30	4,235.15	29,646.05	313	135
2023	185,916	0.39	73,323	43,994	8,798.78	4,399.39	30,795.74	312	141
2024	191,284	0.40	76,195	45,717	9,143.36	4,571.68	32,001.76	311	147
2025	196,879	0.40	79,208	47,525	9,504.91	4,752.45	33,267.18	310	153
2026	202,712	0.41	82,370	49,422	9,884.38	4,942.19	34,595.32	309	160
2027	208,793	0.41	85,689	51,414	10,282.70	5,141.35	35,989.45	308	167
2028	215,134	0.41	89,174	53,505	10,700.93	5,350.47	37,453.27	307	174
2029	221,751	0.42	92,836	55,702	11,140.37	5,570.18	38,991.29	306	182

Projection of Waste Quantities (cu.m.) – Planning Period 20 years from 2015									
Year	Projected end-of-yr population	Waste quantities, kg/cap.day (ave. for entire MSW)	Waste quantities, kg/day	Waste quantities, kg/day assuming 60% service coverage	Waste Quantities, 20% diversion through ward/HH composting (kg/d)	Waste Quantities, 10% diversion through ward/HH recycling (kg/d)	Waste Quantities after 30% diversion by ward/HH composting & recycling (kg/d)	Bulk Density, (kg/cu.m.)	Daily volume, uncompacted, (cu.m.)
2030	228,654	0.42	96,684	58,010	11,602.04	5,801.02	40,607.12	305	190
2031	235,855	0.43	100,726	60,435	12,087.09	6,043.55	42,304.82	304	198
2032	243,369	0.43	104,974	62,984	12,596.89	6,298.45	44,089.12	304	207
2033	251,213	0.44	109,441	65,665	13,132.93	6,566.46	45,965.25	303	217
2034	259,404	0.44	114,140	68,484	13,696.75	6,848.38	47,938.63	302	227
2035	269,140	0.44	119,608	71,765	14,352.93	7,176.46	50,235.25	301	239
Annual population projections provided by Nepal CBS in January 2013									
		Assumptions: *1) 1% increase in waste generation rate per annum (based on experience from developing countries with increasing standards of living of sub-metropolis)* *2) 0.5% decrease in bulk densities per annum (based on experience with sub-metropolitan areas increasing light industrial and high commercial activities, i.e. Birgunj)* *3) Existing (baseline) service coverage of (21.6% from PPTA Report and 47% from Inception Report) proposed to increase to 60%* *4) Sanitary Landfill starts operation in 2016*							

The bulk density of 0.323 kg/l or 323 kg/cu.m. was used for projecting the trucked or collected volume of uncompacted wastes generated from Birgunj. The level of collection service was found to be in the range of 39-40% based on collection data obtained from the Sanitation Department for 3 months. Calculations of waste volumes were performed to estimate the indicative quantities of municipal solid waste that need to be collected and disposed of. These quantities are calculated from the point of generation. Waste collection data for 3 months by the Sanitation Department of BSMC was compiled and analysed to cross-check and verify the volume estimates at the points of collection by the collection vehicles and at the point of disposal at the existing open dumps, temporary dumpsites and fill areas using municipal solid waste.

3.2 Field Surveys on Waste Generation and Composition

The Ministry of Local Development (MLD) / SMWTSC has officially provided survey data from 2011 of a per-capita waste generation of 0.35 kg/cap/day as municipal average with a bulk density of 0.323 kg/l for Birgunj Sub-metropolis (ADB TA 7355-NEP, Institutional Strengthening of Municipalities, Final Report). Using the CBS population of 135,904 in 2011, the total municipal waste generation of Birgunj Sub-metropolis is estimated at 47.57 tonnes/day. This survey on waste generation and composition also gives the average physical composition of municipal solid waste in 2011 as was shown in Table 8 above. The other data used are shown in Table 11 below:

Table 11: Summary of Birgunj SWM Baseline Survey Data and DSC Estimates

Baseline Data/Source	ADB PPTA (April 2010)	SMEC Inception Report, April 16, 2012	Ministry of Local Development (MLD) / SMWTSC (June 2012)	DSC Verified Estimates/ Assumptions
Population	124,032 (2003)	180,624 (2011)	137,976 (2011)	135,904 (2011)
Annual Ave. Growth Rate (AAGR) in %			4.89% (CBS 2011)	1.91%
No. of HHs			19,910	24,164 (2011)
Household Size			5.64	5.62 (ave.)
% Urban area (geographical)			70%	
% Rural area (geographical)			30%	
HH waste generation rate	0.70 kg/cap/d	0.35 kg/cap/d (Averaged total MSW)	0.13 kg/cap/d	0.35 kg/cap/d (Averaged total MSW for Municipality)
Bulk Density		323 kg/cu.m. (loose, uncompacted)		323 kg/cu.m. (loose, uncompacted)
Mun. waste generation rate	0.93 kg/cap/d			
Institutional waste gen. rate			1.6 kg/cap/d	
Commercial waste gen.rate			5.8 kg/cap/d	
Total Household Waste			18 tonnes/d	

Baseline Data/Source	ADB PPTA (April 2010)	SMEC Inception Report, April 16, 2012	Ministry of Local Development (MLD) / SMWTSC (June 2012)	DSC Verified Estimates/ Assumptions
Total Mun. SW generation	115.76 tonnes/d	63.23 tonnes/d	35.5 tonnes/d	47.57 tonnes/d
Total Mun. SW Collection	25 tonnes/d	30 tonnes/d		59.2 cum./d or 19.1 tonnes/d
Percentage City Cleaning (Sweeping) Services Coverage	20%	60%		40 % (ratio of waste volume collected to waste volume generated by total population
Total Mun. SW Collection Quantity at Service Coverage (% by weight)	21.6%	47%		30 to 40% existing collection service
Total Institutional waste			3.2 tonnes/d	
Total Commercial waste			14.2 tonnes/d	
% Total Organic waste to Total Waste			60%	51.09 %
Institutional Facilities (Nos.)				
Higher education			13	
Schools			93	
Hospitals			14	
Hotels			205	4 (large)
Restaurants			42	
Number of Industries within municipality	155			
Disposal methods/practices	Open dumping	open dumping		open dumping/river bank disposal
% of HH dumping in public places	78.0%			94%
% of HH using fixed places or containers for storage	10.5%			6%
SWM organization				
Engineer	1			1
Public Health Inspector	1			
Supervisors	15			35
Sweepers	370			235
SWM Expenses per annum	NRs 50million			
SWM Expenses per month	NRs 4,166,700			
SWM Collection and Disposal Equipment				

Baseline Data/Source	ADB PPTA (April 2010)	SMEC Inception Report, April 16, 2012	Ministry of Local Development (MLD) / SMWTSC (June 2012)	DSC Verified Estimates/ Assumptions
Tippers (3 tonne)	2			2
Tractors with Trailers (2 tonne)	15			4
Rickshaws				8
Hand carts	40			25
Privatized contracted services	None	Ward 10 and 15 (LIDS NGO) for primary collection		Ward 10 and 15 (LIDS NGO) for primary collection
Nepal Composting initiatives				
Teku (1984-1991)	S.P. NRs 10/t			
	Operating cost = 4,000/t			
Teku (2005)	Capacity 6 tpd (actual < 2 tpd)			
Bhaktapur (1978, 1981-84)				
Bhaktapur (1988 w/ SWMTSC tech. assistance)				
Tribhuvannagar Municipality	composting facility at landfill site (trench composting) sold at NRs 300/cu.ft. (280 l): 2008 prices)			

The data obtained from the field surveys above will also be utilized for:

- Re-designing as necessary the SWM operational system, e.g. for projection of waste generation figures, calculating municipal waste stream flow, equipment needs assessments, etc.; and

- Monitoring the design capacity of composting facility, recycling facility, landfill capacity and life span of the landfill site, etc.

3.3 Waste Segregation, Storage and Volume Reduction at Source

The concept of volume reduction at the source shall be the first priority to be promoted by the BSMC solid waste management organization to the wards of Birgunj. Under the leadership of the Sub-metropolis, all wards shall embark on a massive community awareness campaign (information, education and communication) and actively promote the reduction, recycling and reuse (3Rs) and minimization of wastes generated at the source. This can be achieved by backyard composting and recovery of recyclable and reusable materials right from the households and other municipal sources of solid wastes. The sorting and segregation of biodegradable (compostable) and non-biodegradable (inorganic reusable or recyclable) wastes shall be the next equally important priority. The responsibility for the source separation shall rest with the households, businesses, commercial, industrial and institutional centers, and in all other point sources of solid wastes as mandated by the Solid Waste Management Act of 2011.

Primary Storage and Waste Containers

Primary storage will consist of the various containers or bags used by residential, commercial and institutional establishments to deposit segregated wastes prior to primary collection by handcarts and rickshaws. The streets and gutters serviced by street sweeping, the two color-coded waste containers provided to households by NGOs, the containers used by stores, public and privates offices, schools, hotels and restaurants, etc. segregated into two different types of wastes (biodegradable and non-biodegradable) are all classified as primary storage. Segregated storage shall also be used for the block collection service and the pick-up service for establishments availing of waste collection service from the Municipality. The individual waste containers will not be uniform at the early stage of the Integrated Solid Waste Management (ISWM) program but will be owned and be the responsibility of the households, commercial, and institutional establishments disposing of their own segregated wastes. The exceptions to these are the green and red dust bins that are distributed by the NGO LIDS to the beneficiaries of their PPP program. The ward communities shall be given the opportunity to organize their own individual container systems for as long as these are color-coded (green for organic biodegradable; red for inorganic reusable and recyclable) and coordinated with the Primary Collection work by the Municipality and the Secondary Collection work by the Private Contractor –Operator for Birgunj.

Skip Container System

The Skip containers that will be distributed by the BSMC Sanitation Section at their designated locations will consist of 2 color-coded containers (green for organic compostable and red for inorganic recyclable) in one skip container station as shown in the skip operational route plans. Each skip container has a capacity of 3 cubic meters when full. There will be a total of 11 skip container stations or 22 skip containers (11 green and 11 red) for use by the Municipality for all of the 19 wards as shown in the Skip container operational route maps. There will be 4 (2 green and 2 red) empty skip containers to serve as replacement containers after loading by the Skip Loader/Truck hoist. The total number of skip containers at the start of the project will be 26. Depending on the BSMC plans and budget, this number could increase through the years following the implementation of the ISWM program.

The following system shall be used for segregation and storage of solid waste in the Skip containers pending collection by the Skip Loaders/Truck Hoists:

a) The Sanitation section handcart and rickshaw pullers should ensure that no mixing of wastes occur at the skip stations and the covers are properly secured in place. For bulky waste, it will suffice that the same be collected and placed in a separate container clearly distinguishable as either organic or inorganic for the guidance of the waste collector-contractor.

b) The City leadership shall promulgate ordinances and regulations requiring the owner or person in charge of such ward premises where the skips are located to:

- Provide for the residents a designated area and containers in which to accumulate source separated recyclable materials or a Materials Recovery Facility to be collected by the person designated by the wards or the city or private collector; and
- Notify the ward constituencies of the requirements of the rules and regulations that shall be followed at the ward level.
- Work with the NGOs and SWM user committees in disciplining the households in the proper segregation of wastes in Skip containers.

c) For all commercial and institutional establishments, the City shall promulgate ordinances requiring the owner or head of the institutions to:

- Provide a designated area and containers in which to accumulate source separated recyclable materials to be collected by the city or private collector such as in the case of regular picj-up service ;
- Notify all workers, employees, and entities working in the premises of the requirements of the rules and the regulations that need to be followed; and

d) No scavenging or unauthorized collection in designated segregation containers or areas shall be allowed.

Volume Reduction at the Source

The reduction of waste shall be promoted at the households and wards, schools, public offices, and other commercial, business, and institutional establishments. Under the leadership of the BSMC and initiative of the ward leaders, tole lane organizations, NGOs, SWM user committees, and other grassroots and community based organizations. The BSMC leadership should support and enable the development of backyard or ward-level composting, identification of some possible sites within the wards for materials recovery facilities with composting components, and managing their own recyclables properly so these can be sold directly to the itinerant waste pickers or scavengers if a community based effort is not feasible.

CHAPTER 4: WASTE STORAGE, COLLECTION AND TRANSPORTATION SYSTEM

4.1 The 3R's Concept of Waste Storage, Collection and Transportation

During the waste survey, the DSC met with the concerned Sanitation Section head and some ward leaders (ward secretaries) and Sanitation Section foremen to discuss their present collection strategy and estimated quantities of municipal solid waste (MSW) in their jurisdiction. Discussions were held regarding the 3Rs efforts and the results thus far, the willingness to pay and the expectations from the waste collection services by the households (HHs), commercial (hotels, restaurants, variety stores, shops, malls, department stores, bazaars, public markets), and institutional (schools, government and private offices, government hospitals and government clinics) establishments. Whether it is possible to identify areas in each ward or cluster of wards for temporary storage in the form of a material recovery facility (MRF) for ward level composting and recycling initiatives was brought up for further evaluation. It was also discussed that the recyclables should be preferably directly accessible to the vehicles of buyers from junk shops or waste consolidators.

The foregoing discussions confirmed the following general conclusions from the above findings. The waste storage, collection, transportation and disposal of MSW are indeed major tasks of any local body to keep the city clean for the people's welfare. In executing this system, there involves cost which is very expensive and has been difficult to manage for the Municipality. The cost that is incurred in the process of implementation largely depends on the quantity of solid waste that has to be transported to the final disposal site or sanitary landfill which is now called the "Integrated Solid Waste Management site". To transport solid waste in large amounts requires a lot of resources in terms of labor, equipment and fuel, which in turn considerably increases capital and operational costs. For efficient collection service, the goal is reduce operational costs, which is possible only if the municipality reduces the amount of waste that has to be transported at a distance to the disposal site. To reduce overall waste management cost, it is necessary to reduce the volume of waste production for which different waste minimization measures such as composting and recycling (3R's principle) have to be considered. These measures being an important work for municipality have not been paid much attention to because of the daily urgency of spending much of their time in waste collection and disposal activities and not as much of their time in planning for improvements in the methods of collection. No waste minimization work has been done by the local bodies despite some initiatives like making compost in rural wards and selling recyclables to scrap dealers in a disorganized manner. This really does not represent significant waste reduction in the whole waste stream unless action is taken at central level. The typical local body has kept this waste minimization work at second priority knowing that the process implies a lot of efforts in terms of technology, money and people's support. This is what has been seen in practice. Waste minimization work has become a secondary task for the Municipality.

The Municipality has to have a surplus budget to be able to operate waste collection and waste minimization activities in a parallel way. Past experience has shown that the Municipality is not in a position to promote waste minimization work as their primary work without performing city cleansing work first which is their prime duty. These sentiments were voiced out in several meetings with the Sanitation section head and foremen. The same sentiments were expressed by the ward leaders/secretaries.

4.2 Waste Storage

4.2.1 Primary Waste Storage

The stage when waste is lying inside a bin or in private premises and is waiting for another service to come for emptying the waste bin is called primary waste storage. The household generated waste is to be picked up and stored in a bin in order to keep the area of house clean such as room, aagan (outdoor premise), courtyard etc. The area will then look clean and free from waste. The people sometimes ignore to do this in their households. The household may use any kind of receptacle as a storage bin to hold waste for some time. The practice is that household is using different kinds of bins such as utensils, plastic bags and open backyard spaces or onsite burial-pits for storing waste. The next step is to bring this vessel or "Bin" with waste out of the house for disposal. For emptying the waste, the bin is to be taken to a nearby collection point located somewhere in a public place or front premises where they discharge the waste. In these points there may be a place with a public container managed by authority or simply an open traditional receptacle in the road side or vacant land. One member of household carries the waste up to the collection point using his own means while some hire the services of others for removal or practices pit burial and burning. In rural areas, there are open spaces at backyards where they can do on-plot backyard composting and waste management. The process up to this stage of waste handling is called waste storage at source. The practice in which waste is managed on the respective plots by individual is called waste management at the household level.

On-plot waste management can be practiced by anyone who has a small backyard within private premises. In case he does not wish to do this, he can bring the waste out and take a walk to a public collection or container point or to any designated place to dispose of his own waste. Household waste ends up in the streets in most of the towns in Nepal. This practice needs to be discouraged by bringing awareness of such faulty practices among the people.

Use of Container System

In this system every household uses a bin of size suitable for the amount of waste they produce in a day. The size of bins depends on the number of persons living in a family. Usually 1 person generates nearly 1 liter of waste. In Nepal, 1 person generates about 0.35 kg/cap/day. So the household with a family of 5 members requires a bin of size 5 liters. This size of bin needs to be emptied every day to make space for the 2nd day. Usually household waste should not be stored for more than 2 days. If the bin is not emptied within two days, the organic part of waste mass goes rotten and produces foul smell. So the ideal size of waste bin to store waste for 2 days is 12 liter for a family of 5 persons. The type of container can be a plastic bin or any available utensil. The household may use any kind of receptacle as a waste bin to store waste. The purpose of this bin is to hold waste for some time prior to municipal waste collection.

Use of Plastic Sacks for Households

The second alternative to bins for storing waste is the plastic shopping bag or sack. Plastic bags are widely used to carry goods from markets to home in all areas because they are convenient, cheap and easy to use. For bulk waste generators such as hotels, big plastic sacks are an appropriate means to store waste. The disadvantage of using plastic bag is that without a sturdy container to hold or contain them, it cannot remain at a vertical position and wet waste frequently spills out water particles making the bag dirty. However, it is easily available in the market and affordable for people to buy. The plastic bag or sack should be thick enough to withstand waste loads of up to 3 kg so that people can safely carry them up to the designated collection point. In Kathmandu plastic shopping bag and big rubbish bag of 50-liter capacity are widely used. The same may be expected in Birgunj.

The maintenance of established infrastructure and services has been a major problem in a fast-urbanizing municipality such as the Birgunj Sub-metropolitan City. A solid waste management system is in fact a continuous maintenance system. To keep the service running, continuous participation of the community receiving the service is required, for example: to store the garbage in a specific bag or bin, to bring it to an agreed point, to separate it in dry and wet waste, organic or inorganic waste, etc. Making the improvement involves behavioral changes which makes it more difficult.

4.2.2 Secondary Waste Storage

This storage system is a stage of waste collection prior to transporting the waste to either waste processing site or to disposal sites. In this stage, the waste collected from primary sources (household, shops, drainage, vegetable market, bus stop etc.) is brought to a collection point by primary transport vehicle to transfer waste. In Birgunj there are 37 identified open waste piles or collection points currently being used as secondary waste storage sites as they have been collected by tippers without any stopover for direct transport to disposal sites. This practice is a time consuming task as tippers have to stay on site for the time it takes to load waste onto it. The secondary waste storage infrastructures became necessary points to be managed in the service areas to provide transfer facility for residents, sweepers and primary waste collector. These infrastructures can be of different types depending upon the type of service being delivered. These points can be simply open sites or containerized. In Birgunj, the containerized waste collection system has not been in practice. Several options for collection systems were evaluated, but below, however have been found to be the best for Birgunj as a starting point.

Skip Container System

This is a special type of collection system in which a container having a capacity of 3 cu.m. is used and lifted by a special hoist truck and loaded onto it. The containers have a capacity of 3 m3 or more. The containers can be tipped to discharge their contents while in position on the vehicle. This system is being proposed to operate in limited areas of the wards in Birgunj particularly in areas where mixed type of waste is dominantly generated. The proposal is to have it color-coded to green for organic (biodegradable and compostable) wastes and red for inorganic (non-biodegradable, re-usable or recyclable) wastes. Such areas were analyzed for designation into appropriate locations for the 2-colored skip containers and some of them are identified such as existing transfer station in Ward No.12 (Photo 7), backside of Telecom Office in Vegetable market near Ghantaghar (Photo 8), and Tank side in Ward No.12.

Photo 7: Existing transfer station at Ward No. 12

Photo 8: Vegetable Market near Telecom Office

No communal containers will be used for communal use instead skip containers are proposed. The locations will be designated initially and will be revised as necessary depending on the progress of the operational waste container system. The primary waste collectors or roadside sweepers can dispose of collected waste in the skips.

Public Service (markets, parks, temples etc.) Containers

For public service in the places such as markets, parks, no public containers will be proposed instead will make the waste generator manage their own storage system and hire the private or municipality service for waste disposal. However, the municipality provides dust bins in religious places (like temples, mosques and Buddha stupas) for waste management. Presently 39 such places have been identified and 50 dust bins of two sizes 150 liters and 250 liters have been proposed for managing solid waste in those premises which will be emptied by ward level service or privately-run operators.

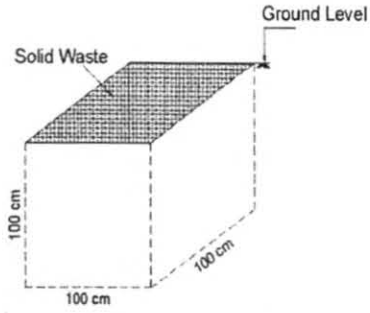
4.3 3R's Household and Ward-Level Waste Processing

When the basic physical infrastructure facilities and regular waste collection services are in place and the system is running well in the sub-metropolitan city, there is a need of a system that operates in an economical way for which different waste minimization programs can be carried out. Example of waste minimization programs are: Composting at household level, waste segregation at source, selling of recyclable goods directly to scrap dealers, etc. Success at this level will reduce waste volumes in the main SWM stream unless the intervention is made at central level. For this separate collection of waste fractions from the households, some kind of technology needs to be developed and established to facilitate the initiated activities. Examples of these are two levels of waste minimization programs: one is at household level and the other at ward level. Implementation of waste minimization programs are usually the task that has to be supported by a second party (formal or informal sector) for successful execution. In this regard, Birgunj Sub-metropolitan City is already implementing a PPP program with an NGO called LIDS. The municipality has also launched a promotional activity by providing 2 Katha of land in Ward No. 12 for a Vermi-composting program to a local waste operator working in Ward No. 6.

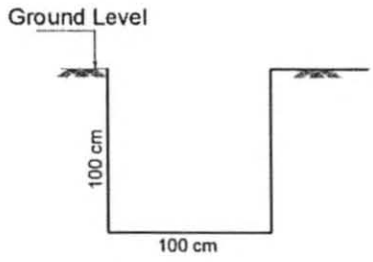
This is a good example of a locally-based, self-help improvement program in solid waste management in Ward No. 6. This is a replication of the PPP program introduced in Ward Nos. 10 and 15 by Birgunj Sub-metropolitan City.

4.3.1 Household Composting

In household-level composting, the pit and bin method of composting will be initiated to make compost from household waste. Waste characterization survey data revealed that Birgunj' municipal waste constitutes around 51.09% organic waste. If only household waste is considered the organic part of the waste would definitely be on the higher side. The Pit method (see Figure 7) is usually carried out in a household with backyard space while the Bin method (See Photo 9) is practiced in areas of dense settlement with no backyard space.



Compost Pit : A Typical View



Compost Pit : A Typical View

Figure 7: Backyard Compost Pit

Photo 9: Compost Bin for HH

The Bin method has been used in making compost from household kitchen waste in five municipalities in Kathmandu Valley. Its capacity is 100 liter. The Kathmandu municipality is providing this compost bin at subsidized rate of NPR 1500. There is emphasis on household composting and segregation at source by the government. The household is required to reduce waste by segregation at source and process the organic part in their own premises. The same system could be adopted in Birgunj Sub-Metropolitan City.

4.3.2 Ward-Level Material Recovery Facilities (MRFs)

Resource recovery means finding a way to use the waste so it becomes a valuable resource, rather than just become a disposal problem. This is a very important part of waste management. Resource recovery includes a range of processes for recycling materials or recovering resources from the waste, including composting. Ward level composting is proposed for making compost from household waste. Dry type of waste is transferred to MRF facility where processing and sorting of recyclable part of dry waste be carried on. The MRF system can be explored in the second stage of the integrated solid waste management system in Birgunj. The key is in finding feasible spaces in the wards for this local facility. This is all part of the 3Rs program.

Materials Recovery Facilities (MRF)

The material recovery facility is a built up station where valuable material are recovered from mixed waste or presorted waste delivered at the site. The locations of the sites for this type of facility have to be identified by the community hosting them. These could be public spaces, abandoned land, previous dump places, etc. with prior approval by the BSMC and the community. Below is a typical design of a facility developed for using as compost storage yards and sorting platform for recyclable goods. It is an enclosure with CGI sheet roof cover. Temporary partition walls may be provided later on depending upon the volume of recovered materials. The size of platform is 12.5 m in length and 6 m in width and 4 m in height. (See Figure 8. Storage shade). The cost of shade is estimated to be NRs. 397119.11.

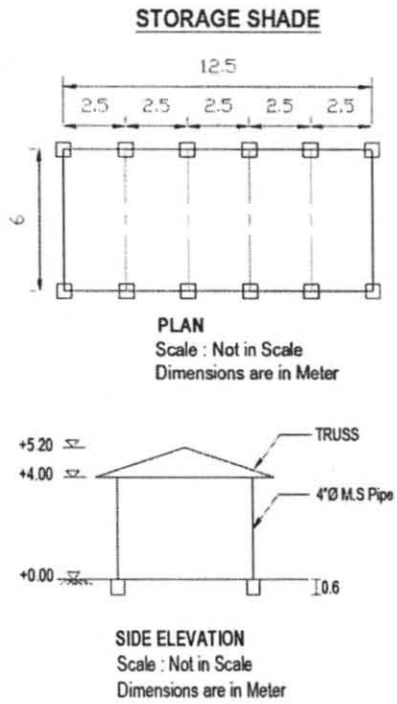


Figure 8: Materials Recovery Facility (Storage Shade: plan and side elevation)

The private sector will be entrusted with operating this collection system within the respective wards. The existing MRF facilities run by private parties will be utilized for managing recyclable waste materials. Two such facilities have been identified: in Birgunj: one is a plastic factory in Ward No. 2 and the other is a carton factory in Ward No.1. The plastic factory has two units, one is material recovery facility and other is production unit. The factory owner will be the potential market for the recyclable materials collected and accumulated by the wards. The wastes, which cannot be composted or recycled, would be sent to the ISWM site for landfilling at the residual sanitary landfill cells area.

Photo 10: Plastic factory in Ward 2 (March 2013)

Photo 11: Plastic Manufacturing Factory in Ward 2

Ward-Level Composting

Aerobic windrow composting is proposed to be used for compost production. The technology is simple as it requires less technology and very flexible. The system can be designed based on the prevailing ground conditions. This is the most popular composting system as it can be set up for variable production capacities and climates. It is the most popular method in many countries. A typical compost facility can be designed for 0.2 ton-capacity of compost per day. It requires 6 windrows for which platform size is calculated to be 24m in length and 15 m in width. The area of the windrow platform is 360 m2. The platform is made of hard impervious surface suitable for movement of a tractor, or a mini-shovel loader over it. The platform is built with RCC concrete of thickness 15 cm to increase its strength. The platform is constructed with 1% slope at both directions to speed up the leachate flow towards the downstream drain side (See Figure 9). This example design can serve 990 households with a population of 6,230. The ward population ranges from 1,115 persons with the least in Ward No.8 and the highest in Ward No. 9 with 22, 824 persons as of the year 2013. The cost of windrow platform is estimated to be NPR 1,240,833.21. It was reported that lot of open space and land is available in Ward Nos. 17, 18 and 19 where this composting facility can be easily established. This can be further studied by BSMC for the future.

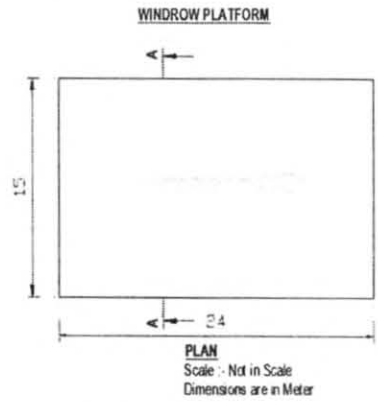


Figure 9: Windrow Platform for Ward-level Composting

4.4 Methods of Waste Collection

From experiences in other developing countries, waste collection methods may be classified under four (4) general categories, as described below:

4.4.1 Communal Collection

Under this system, households discharge their wastes at predetermined locations containing some form of communal storage facility, and refuse collection vehicles visit these sites at frequent intervals, usually once daily to remove accumulated waste. While the advantage of this method is that it reduces considerably the number of sources from which waste has to be collected (not from each household), the economies that result from the reduced number of collection points might in fact be a false one. The responsibility for refuse collection and disposal, where public cooperation is poor, is transferred to the street cleansing service. Waste collection off the streets is more expensive than directly from houses. The frequency with which communal storage facilities should be distributed is often dependent on the extent to which a community is willing to cooperate in its proper use. Accordingly, the containers should be spaced so that the distance between any two containers does not exceed 200 meters. In other countries like those in the African continent, this distance can be as much as 500 meters. For reasons above, portable storage containers should be used, in order to ensure high labor and vehicle productivity.

4.4.2 Block Collection

Under this system, a collection vehicle travels at a predetermined route at prescribed intervals, usually every two to three days, and stops at selected locations, where a bell or some signal such as a whistle is sounded. Upon hearing the signal, the households bring their refuse containers and hand them over to the crew, usually consisting of two men, who empty the containers and return them to the households. No containers are left outside household premises or on communal land. Vehicle and labor productivity lies between low and medium using this method.

4.4.3 Kerbside (Curbside) Collection

Here, the collection crew collects bins, bags and other containers of refuse which are deposited at kerbside at fixed intervals, usually on two specific days in the week, when collection takes place. This system requires a very regular and well-organized collection service, so that households know when to leave out their wastes. Where collection is irregular, it is common to

see the containers placed permanently outside, with increased incidence of the scattering of wastes by scavenging animals. Although kerbside collection has not been used in conjunction with sounding of bell or other signal to invite householders to set out their waste containers, the increased use of this option could reduce some of the disadvantages of the system relating to the scattering of refuse by scavenging animals, theft of containers and traffic accidents caused by rolling bins. Kerbside collection is perhaps the most commonly used method in high income areas of the developing world. In some countries, this system is also called "door-to door" collection. The vehicle and labor productivity of this method of collection is promoted through the use of standardized containers, increased rates of waste generation, and infrequent collection. Unfortunately, climatic conditions dictate that wastes in developing countries should not be stored for periods in excess of three days. Consequently, given the need for a twice weekly collection frequency and the low rates of waste generation, this method is rarely economical for use in low-income to medium-income areas.

4.4.4 Door to Door Collection

In this system, the collection crew enters each premise, takes out the container and sets it back after emptying the waste into collection vehicles. The lack of household involvement in the collection process is, however, offset by increased labor costs in entering all premises. Where labor costs are high, a two-fold increase in cost over the kerbside collection is not uncommon for this method, and door-to-door collection as herein defined, although common in developed countries, is rarely practiced in developing countries. In some communities, the intrusion on privacy and security that the method involves will prevent its consideration as a collection option. Most important the door-to-door collection method only proves productive when collection is infrequent, typically once weekly. Frequent collection intervals, necessary in developing countries, result in poor vehicle productivity, and hence, reduced efficiency and economy.

In the Nepalese context, "door-to-door" collection may actually mean a combination of the above-described door to door collection and kerbside collection whereby the household wastes have to be fetched because of the lack of curbs and access in front of their doorsteps and the lack of appropriate containers to use. In the latter case there may or may not be active participation by the residents themselves in disposing of their solid waste, especially if they have containers to use and are not present when the primary collectors come.

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While the above four (4) methods represent the basic methods of collection, often the most productive and economical method for different communities in urban areas will be a combination of these methods. Criteria for selecting the best combination of equipment and collection methods, such that productivity is maximized and overall costs reduced were considered in the proposed collection program in Birgunj that follows.

4.5 Existing Waste Collection and Transportation System

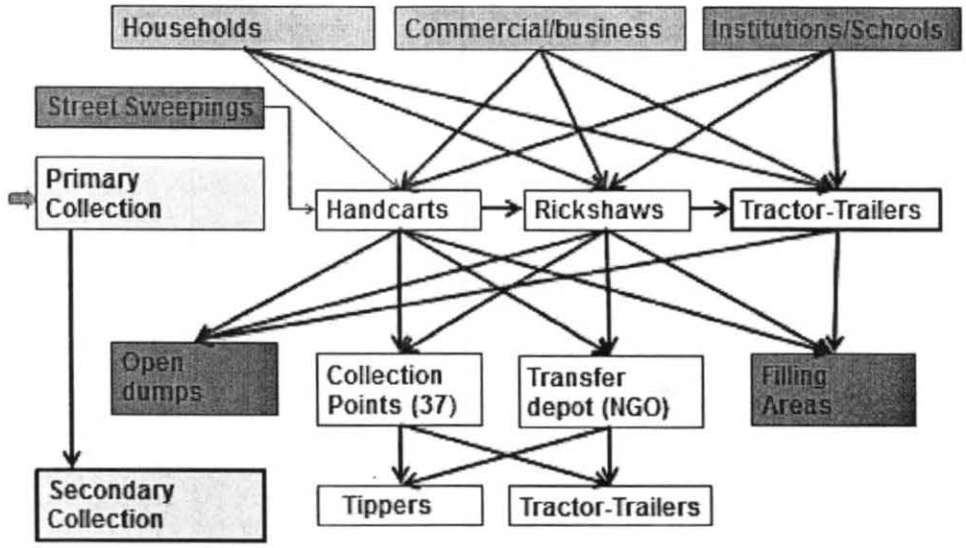

Figure 10: Existing Solid Waste Collection System

4.5.1 Existing Storage and Waste Containers

There is no organized storage or container system in Birgunj at present, except for some 1,400 households in Ward Nos. 10 and 15 who have been provided with 10-liter and 32-liter waste containers respectively by an NGO under contract for waste collection service with the Municipality. Except for these wards, the existing practice is for solid waste to be indiscriminately thrown out into the streets and drainage canals in front of or near their respective premises by residents, stores, commercial establishments, schools, government offices, religious buildings, hospitals and industries. Low-lying vacant lots are also used indiscriminately as disposal sites (open dump sites) for solid wastes with or without permission from the private or public owners. The citizens expect the Municipality to manage the solid waste for them.

4.5.2 Street Sweeping and Drain Cleaning

Street sweeping and drain cleaning are carried out every day by the Sanitation section for almost all of the wards (except for Ward Nos. 10 and 15) with the use of 2 tippers and 4 tractor-trailers (9 tractor trailers were operational in mid-2012), 8 rickshaws (2012) and 25 handcarts (2012). The Sanitation Section is composed of 279 personnel, broken down into: 1 Sanitation Department chief, 3 administrative assistants, 5 drivers, 35 sweeper heads, 129 male sweepers, and 106 female sweepers. Of these, 14 personnel (rickshaw pullers and street sweepers/drain cleaners) are assigned to the NGO waste collection service provider for Ward Nos. 10 and 15. The street sweepers, handcart pullers and rickshaws start their shifts at 6:00 AM and 1:00 PM for the morning and afternoon shifts, respectively, within their areas of assignment while the tractor-trailers and tippers follow with the collection activities most of the time in tandem with the sweepings and drain cleaning and on their own set schedules.

4.5.3 Service Area Coverage

The street cleaning service that is provided by the Sanitation section in 2012 covers approximately 30.58 km. of existing roads that are wide enough for tippers and tractor-trailers to be able to perform the service. The tippers collect from the main roadways (Roads 1, 2 and 3) and support the tractor-trailers, as needed, in the other wards. The tractor-trailers service the rest of the 19 wards. The morning shift begins at 6:00 AM and ends at 9:00 AM and the afternoon shift begins at 1:00 PM and ends at 5:00 PM. The existing waste collection service covers an area of approximately 192.33 hectares. This area comprises the service coverage of the primary collection activities of the Municipality. The Municipality uses the rickshaws and handcarts and the Sanitation section personnel to carry out primary collection. Wards 10 and 15 are being serviced by an NGO under a tri-partite contract agreement among Birgunj Sub-Metropolitan City, the Community (Wards) and the NGO LIDS.

Table 12: Data (3 months) from Waste Collection Service, BSMC Sanitation (2012)

Waste Collection Level of Service (2012) - Sanitation Section, Birgunj									
Data Period	Mangshir (Nov-Dec 2012)		Poush (Dec 2012 - Jan 2013)		Magh (Jan - Feb 2013)		3-Months average (Nov 2012 -Feb 2013)		
Type of Collection Vehicle	Tipper (6 cu.m.)	Tractor -Trailer (3 cu.m.)	Tipper (6 cu.m.)	Tractor -Trailer (3 cu.m.)	Tipper (6 cu.m.)	Tractor -Trailer (3 cu.m.)	Tipper (6 cu.m.)	Tractor -Trailer (3 cu.m.)	Calculated Totals
No. of Days	30	30	29	29	29	29	29.33	29.33	
Total Trips/Mo	98	376	62	388	112	428	90.67	397.33	
Waste volume collected per month, cu.m.	588	1,128	372	1,164	672	1,284	544	1,192	
Waste volume collected per day, cu.m.	19.6	37.6	12.8	40.1	23.2	44.3	18.5	40.6	
Total Waste Volume collected per day, cu.m.									59.2
Total Length of Roadway Serviced, km.									30.58
Estimated Volume of MSW collected per km. of ALL serviced roads, cu.m./km									1.94
Estimated Volume of Street Sweepings (25.08%) collected per km. of ALL serviced roads, cu.m./km									0.49
Estimated Waste Generation (by population), tonnes/day, 2012									48.7
Estimated Waste Generation (by population), cu.m./day, 2012									151.3
Percent Level of Collection Service, 2012									39.1 %

4.5.4 Level of Collection Service

Actual collection data for 3 months were obtained from the logbooks of the Sanitation Section and summarized to calculate the total waste volume collected by the 2 tippers and the 4 tractor-trailers remaining for the street and drainage cleaning work. These include other pick-up services that are requested by some private individuals and establishments such as hotels, offices, restaurants, etc. The total volume, assuming an average waste load of 6 cu.m. for the tippers and 3 cu.m. for the tractor-trailers was found to be 59.2 cu.m. per day. With the length of

roads serviced, the estimated volume of MSW collected per km. of all serviced roads amount to about 1.94 cu.m./km. Of these, street sweepings (25.08%, from Waste Survey data) are estimated to yield about 0.49 cu.m/km of road serviced.

By population projection, the waste generation at 0.35 kg/cap/day of the 2012 population of 139,227 is equal to 48.73 tonnes per day. With a bulk density of 322 kg/cu.m. in 2012, the estimated total waste generation volume in Birgunj is equivalent to 151.3 cu.m. per day. 59.2 cu.m collected over 151.3 cu.m. brings the level of collection service by the existing organization to 39.1%.

It is important to note that the data was taken during relatively dry season. The volume is expected to increase and become more wet and dense during the monsoon season.

4.5.5 Primary and Secondary Collection

There are 37 collection points or open waste piles on the roadways or roadsides throughout the 19 wards of Birgunj serving as temporary disposal areas of waste for residents, businesses and public and private offices.

During primary waste collection, smaller volumes of waste are handled by smaller equipment: brooms, handcarts and rickshaws and accumulate the wastes in the waste piles. The municipality picks up the waste from these points by street sweepings, drain cleaning, sometimes in tandem with handcarts and rickshaws for primary collection.

For secondary collection, the Municipality picks up the wastes from the collection points using tractor-trailers and tippers for disposal to the main dumpsites at the banks of the Sirsiya River. The tippers collect along main roads were the densely populated areas also known as the "inner core" areas. Roads 1, 2 and 3 are the designated daily collection routes of the tippers. The tractor-trailers collect from the different wards and usually coordinate with the wards through their ward leaders or secretaries every time there is a need for follow-up collection in addition to their routine collection schedule. The tractor-trailers make an average of 1 to 2 collection trips per day and consume waiting time during their collection service.

A transfer station/depot is used by the NGO operator as the collection point by the municipality of solid waste and sweepings in the NGO areas of service in Ward Nos. 10 and 15.

Because solid waste collection is un-organized, it is common to see hospital wastes and other hazardous wastes deposited on these collection points.

Table 13: Estimated Street Cleaning Collection Rate of Tipper (6 cu.m.)

Street Cleaning Collection Rate of Tipper (6 cu.m.) from Existing Waste Collection, Road 1 (2012)					
Period	Mangshir (Nov-Dec 2012)	Poush (Dec 2012 - Jan 2013)	Magh (Jan - Feb 2013)	3-Months Total (Nov 2012 -Feb 2013)	
Type of Collection Vehicle	Tipper (6 cu.m.)	Tipper (6 cu.m.)	Tipper (6 cu.m.)	Tipper (6 cu.m.)	Calculated Totals
No. of Days	27	30	29	86	
Total Trips/Mo	42	38	50	130	
Waste volume collected per month, cu.m.	252	228	300	780	
Ave. Waste volume collected per day, cu.m.	9.33	7.60	10.34	9.07	
No. of Km. serviced, Road 1					4.79
6 cu.m. Tipper Existing Waste Collection Rate, cu.m./km.					1.89
6 cu.m.Tipper Existing Street Sweepings (25.08%) Collection Rate, cu.m./km.					0.47

Based on the above table, the productivity of the tippers for collection can be obtained at 1.89 cu.m./km. For street sweepings or 25.08% fraction of the waste, the tipper can collect 0.47 cu.m. .km covered by its route. The primary data generated herein are useful for the integrated waste collection, transportation and disposal program.

The following data table is the analysis from the present NGO-managed collection activities, which were and will be useful in designing and updating the collection program on a continuing basis with the following findings:

- A minimum of 2 trips and a maximum of 5 trips per day can be achieved by a rickshaw operating within their respective areas of jurisdiction

- From the figures in the table, it appears that the NGO can collect approximately 5.95 cu.m. per day from a population of 1,400 households, which is about 10% (5.95 cu.m. by NGO over 59.2 cu.m. by BSMC Sanitation) of the present level of collection service

4.5.6 Existing Block Collection System Provided by NGO (LIDS)

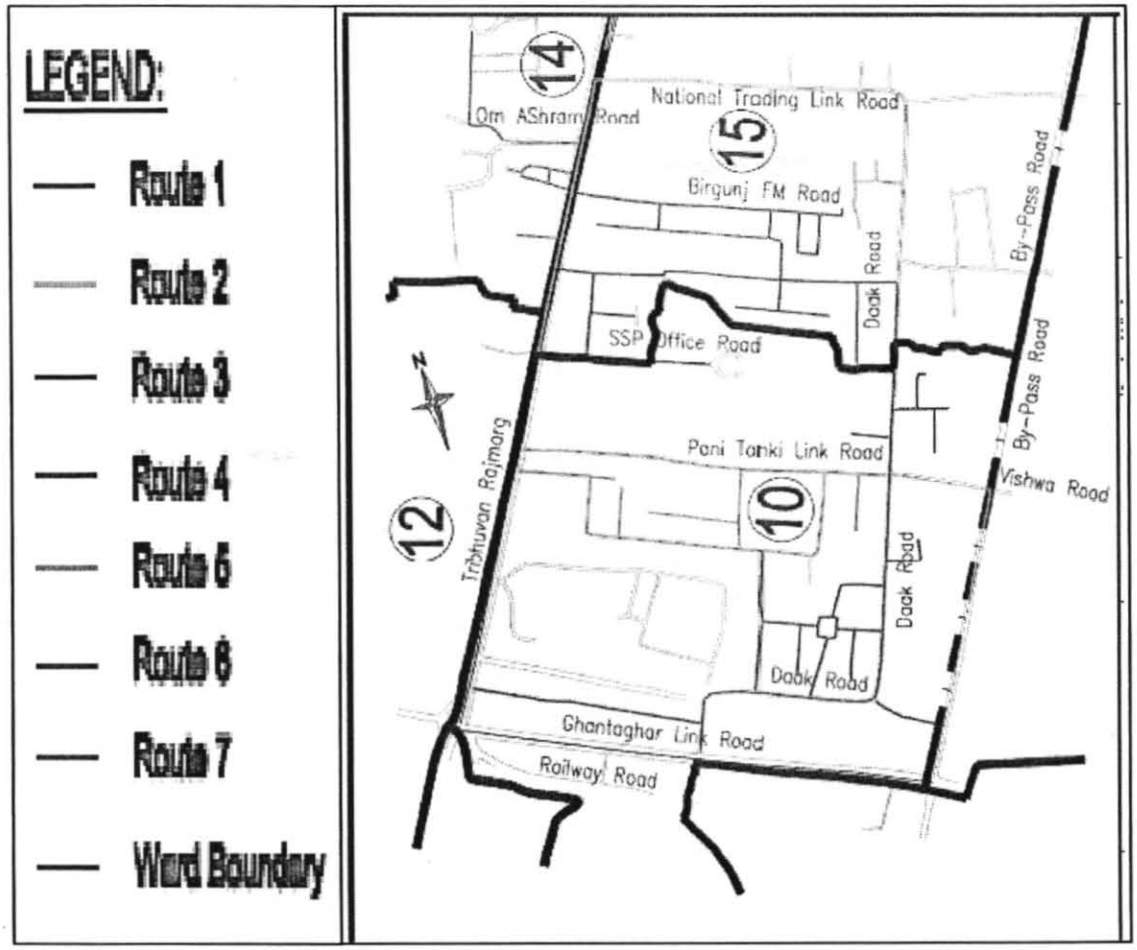

Figure 11: Map of Service Area Coverage of NGO (LIDS)

Table 14: Summary of NGO (LIDS) Waste Collection Coverage

NGO (LIDS) Waste Collection Service at Ward Nos. 10 and 15, Parsa District, Birgunj				
Ward No.	**No. of Households**	**Estimated Population**	**Household Coverage**	**Percent Serviced**
10	1,235	6,535	829	67.1%
12	621	3,302	21	3.4%
14	2,466	12,372	65	2.6%
15	1,560	8,493	485	31.1%
Total	5,882	30,702	1,400	23.8%
Source: LIDS, Parsa District (2013)				

Table 15: Analysis of NGO Waste Collection Service, Wards 10 and 15

NGO (LIDS) Waste Collection Service, Birgunj Ward Nos. 10 & 15 (Rickshaw = 0.35 cu.m.)					
Rickshaw route	Length of roads, km.	Ward Coverage	Time of Collection	Frequency of Collection	No. of Trips
1	1.60	14,15	6:00 - 9:00 AM, 1:00 - 4:00 PM	daily	2
2	1.77	15	6:00 - 9:00 AM, 1:00 - 4:00 PM	daily	2
3	1.23	10,12,15	6:00 - 9:00 AM, 1:00 - 4:00 PM	daily	2
4	0.65	10,12	6:00 AM- 4:00 PM	daily	5
5	1.49	10	6:00 - 9:00 AM, 1:00 - 4:00 PM	daily	2
6	2.02	10	6:00 - 9:00 AM, 1:00 - 4:00 PM	daily	2
7	0.52	14	6:00 - 9:00 AM, 1:00 - 4:00 PM	daily	2
Total	9.27				

Total no. of rickshaw trips	17
Total no. of rickshaw routes	7
Total no. of households serviced	1,400
Volume of rickshaw (50"x33"x13" or 1.27 m x 0.84 m x 0.33 m), cu.m.	0.35
Total volume of solid waste collected, cu.m./day	**5.95**
Estimated total length of roads serviced - ward nos.10 & 15, part 14, km	9.27
Estimated volume of solid waste collected per km of road, cu.m./km.	**0.64**
Bulk density (rickshaw) assumed between 0.275 - 0.37 kg/cu.m., ave 0.32	0.320
Total tonnage of solid waste collected by rickshaw, tonnes/day	**1.9**

Note:

1) Service includes solid waste collection, street sweeping & drain cleaning
2) Some HHs in Wards 12 and 14 are included based upon request for service.
3) Total length of roads includes narrow roads that are only accessible by rickshaws and handcarts.

4.5.7 Quantity of waste collected

The total volume of municipal solid waste collected by the Municipality utilizing the existing fleet of tippers and tractor-trailers in 2012-2013 was approximately 59.2 cu.m. per day inclusive of all the waste components of municipal solid waste (components established by weight). This was based on 3-month data obtained from the Sanitation section between November 2012 and February 2013 (Table 12).

4.5.8 Observation and Evaluation of Waste Collection Methods in Birgunj

In the case of Birgunj, the existing solid waste collection and transport system uses a combination of the different methods of collection. As in any other urbanizing municipality in developing countries, solid waste at the source (e.g. households, institutions, public markets, commercial areas, etc.) or from whatever their storage situation may be (household bin, common container, open dumping area), needs to be collected and removed to keep the surrounding community clean and safe. Different means of transportation are used i.e. motorized (tippers and tractor-trailers) or manually- powered (rickshaws, handcarts and street sweepers), to collect and transport the waste to their respective disposal areas.

In terms of accountability, waste storage and collection are usually classified either as a Shared System or an Individual System. In the Shared system, there is no accountability that can be pinpointed or placed on the individual waste source. The household resident brings out waste at a dumping location or designated common location at any time. In an Individual system, the generators need a suitable container for storing the waste on their property until it is collected. The generators are pinpointed and are accountable for their own wastes. To summarize:

Shared System:
- dumping at designated location
- shared (communal) container

Individual System:
- Kerbside collection
- Block collection
- Door to door collection

In Birgunj, what is practiced is much like the Shared System (dumping at established locations) and a route (pre-designated road route) block collection system characteristic of the Individual System performed by the NGO LIDS waste collection service. The majority of the wards, however, dispose of their wastes in traditionally established collection points which are open waste piles prevalent throughout the roadsides of the wards. Thirty-seven (37) such collection points have been identified in 17 of the 19 wards of the sub-metropolis. In addition to the collection points, solid waste collected by handcarts and rickshaws end up in temporary dumping areas, and fill areas usually supported by agreements between the BSMC and the communities involved.

Route Collection

Route collection service is provided in Ward Nos. 2 to 9, 11 and 19. With this collection system a tractor-trailer goes around house to house on a designated route, where people bring out their waste and hand them over to the collection crew. The tractor-trailer on route will not stay waiting to receive waste for a longer time. The collection crew arrives on a routine schedule at designated times in each of the service areas. This is similar to a block collection system except that access is not the primary consideration for just-in-time collection but maximum waste collection coverage by participation of the waste generators in the collection route along a regular main route established for the Tipper or Tractor-trailer. In this collection service the collection crew is composed of two staffs, one driver and one sweeper. It is proposed that this

service be operated at ward level. The ward offices levy a charge to the beneficiaries for the service.

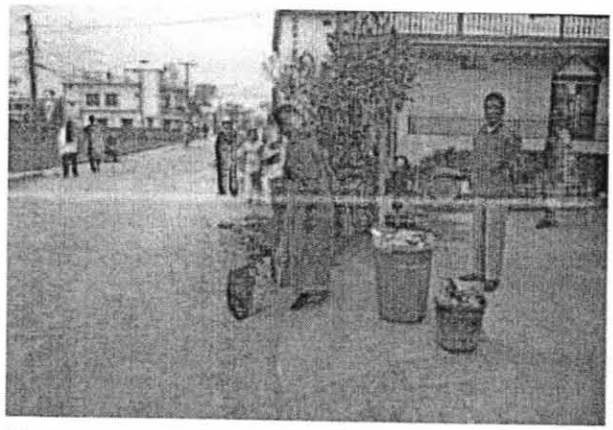

Photo 12: Residents are waiting for municipality's tractor residents are to come for waste disposal

Photo 13: Tractor arrives and give waste to collection crew

Kerbside Collection

In this system of collection, the residents keep waste bins outside of their house at kerbside or roadside corner and the collection crew picks up the waste bin. Here the residents may not be present during collection time hence it is a more flexible system for residents. It has a disadvantage that the waste bins may be turned over by cows, dogs or other domestic animals roaming in search of food. This becomes a problem for the waste collector to be able to pick up all of the waste. It will require extra work from the Waste Collector and because this is not actually his job, the collector may not pick up the waste. This would cause littering in the roadside for the whole day. This is the kind of collection system where the Municipality's regulations or laws need to be strictly enforced and followed by the residents or waste generators.

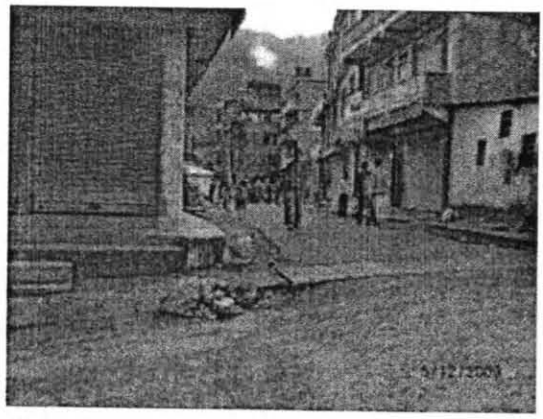

Photo 14: Kerbside Collection: Waste in a plastic bag at roadside corner

Another disadvantage is when a second resident may use the same waste bin for its own wastes at the cost of the first resident. This situation causes confusion as to who are the real subscribers to the collection service. This type of collection was considered in the evaluation of the best system of collection to select given such limitations.

Block Collection

In this system, a waste collection vehicle goes around a neighborhood at a specific time, and alerts the people by whistle that the collection vehicle has arrived. People then bring the waste from their houses and put it directly onto the vehicle. The main disadvantage of the system is that it requires people to be present when the waste collection vehicle arrives. If a municipal-wide tariff cannot be enforced, it is difficult to charge a service fee for this type of collection because the users of the service cannot be easily identified. The tractor trailer is suitable for this collection system as it has lower height compared to the tipper and can move on any type of road, whether earthen, gravel and asphalt. It is similar to a skip except that it is not stationery but mobile. This Block collection service is being considered as one of the collection system options that can be adopted for those areas that are not along the existing waste collection routes but are farther away from the inner core of the sub-metropolis. It has to be managed centrally by the BSMC Sanitation in this case. Similarly tractor-trailers are proposed for waste collection in those residential areas mixed with the Poverty cluster areas. 28 poverty clusters have been identified so far in the different wards of the Municipality with 3,893 persons in 1,238 households. The calculated waste generation in poverty clusters is estimated to be 8.55 m3 per day. The poverty clusters are spread over 13 wards (Ward Nos. 1, 2, 3, 5, 9, 10, 12, 14, 15,16,17,18 and19). These groups were observed to be in highly dense areas of their respective wards. These areas are also highly littered causing pollution in the surrounding neighborhood if they are not provided with collection service.

Door to Door Collection

In this method of waste collection, the primary waste collector goes house to house and collects the waste from the door steps. The generators need a suitable container and store the waste within their property until it is collected. This system is liked by most despite the service fees attached to it. From environment point of view this system is more hygienic and efficient as waste directly goes to the vehicle. However, 100 per cent door-to-door collection is impracticable in the conditions prevailing in Birgunj as there has been a long practice of indiscriminate disposal of waste by residents and businesses in the streets, rivers, roadside drains, vacant lots etc. Door-to-door collection is normally feasible where a once a week collection suffices and the residents are very much aware of the consequences of improper waste management. This system is being considered for the densely-populated core areas in Wards Nos. 12, 13, 14 and 16 at pilot level. This is based on observations from the present work of the NGOs at Ward Nos. 10 and 15.

The private sector and NGOs will be entrusted with door-to-door collection services in the Nepalese context in these highly dense or inner core areas. The private sector and NGOs will be encouraged to use rickshaws and handcarts for the primary collection. Their service will be limited to primary collection - that of collecting wastes from residents, shops, hotels, offices, etc. – then transport these to secondary storage sites (Skips stations and containers that are separated into organic and inorganic wastes). At this stage waste is collected directly from source of generation (e.g. household, institution, markets etc.). Primary collection is followed with transportation by a secondary collection system because once the waste is collected it needs to be disposed of to empty the waste bins. The secondary storage facility and secondary collection such as Skips and transfer station will be managed by the Birgunj Sub-metropolis.

4.6 Existing Transport and Waste Disposal System

In 2012, there were about 4 informal dumpsites scattered throughout the municipality, 1 transfer station/depot (open dumpsite used by NGO waste collection service) and 1 main disposal site (open dumpsite) at the banks of the Sirisiya River on both sides of the Tribhuvan Rajpath south of the Customs Office. Some other vacant lands and low-lying areas are used as open waste dumping and filling areas by the municipality and by private groups.

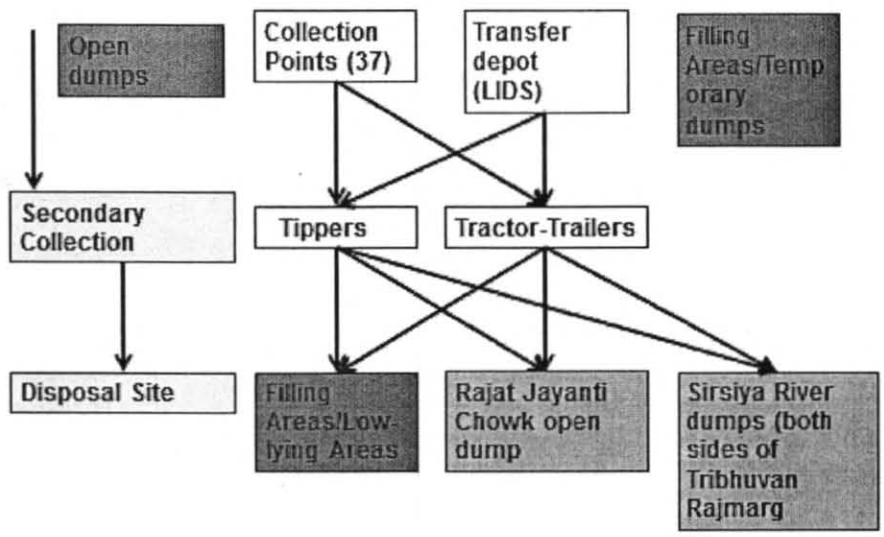

Figure 12: Existing Transport and Disposal System

During the waste survey, the DSC met with Birgunj sub-metropolis in-charge of present and approved (legal) disposal facilities or open dumpsites, and discussed their strategy and the estimate of the actual waste volumes being collected and dumped officially and legally. It was established that waste collection and disposal schedules were planned and set-up but most of the time because of the nature of waste practices of the population, ad hoc practices have to be resorted to, to ensure that the waste collection service keeps running.

The following information regarding the existing final disposal practices were verified:

All the collected solid wastes are finally disposed of at:

- private areas for filling lowlands upon request of the owners
- filling public lands of depressions,
- filling stagnant ponding areas or wetlands,
- along river banks within the municipal area,
- lowlands and several dump sites, after continuing soil cover have been changed into valuable lands for developing squatter settlement areas
- the present final disposal site near custom office in Ward No.2 (close to the border to India)

4.7 Proposed Integrated Solid Waste Management (SWM) System

The proposed ISWM system is based on the integrated solid waste management principle including the 3Rs (Reduce, Recycle and Re-use) that covers not only the final disposal facility at the sanitary landfill site but the equally important aspects of waste minimization and reduction at the source, segregation and separation for waste recovery, storage, transfer, segregated collection, recycling, composting, waste processing and final residual waste disposal. The system design is for the households and the wards to be involved in all the management aspects of the solid waste stream. All elements will be acting as a coordinated and integrated whole with the aim of preventing and mitigating environmental pollution, causing minimum environmental impact and protecting public health. The system design is for a planning period of 20 years.

The development of waste minimization and reduction efforts will need massive awareness campaigns and training not only for the households but also for the wards. The key to its success is the commitment of the Birgunj Sub-Metropolitan City leadership to good governance and exercising the political will to enforce the newly revitalized Solid Waste Management Act of 2011 The NGOs and the social mobilizers of the project such as the "Tole" organizations and the SWM user committees will also play a vital role in the success of the integrated system.

Waste Storage, Collection and Transport

The key strategy for the success of this phase of the integrated solid waste management system is to support the households (HHs) and wards in practicing segregation at the source in line with the principles of 3Rs and in accordance with Nepal's revitalized Solid Waste Management Act of 2011. The collection and transport teams should act as the primary advocates for waste minimization and reduction since they have direct contact at the frontlines with the "waste generators".

To this end, the households and wards should ideally pursue the following action plans:

- ✓ Household- and ward-level composting (with NGOs) – the HHs and wards should be responsible for locating their own composting areas with support from BSMC. Collection will be carried out by handcarts and rickshaws.

- ✓ Ward and Tole organizations (with NGOs) – the HHs, wards and "Tole" organizations should also be responsible for establishing a Materials Recovery Facility (MRF) for recyclables at ward/tole level wherever there is dedicated space to do so. Collection will be carried out by handcarts and rickshaws.

- ✓ Composting (HH backyard and ward-level) using low-technology, natural, labor intensive methods, incorporating vermi-composting whenever possible. Training for HHs and Wards will be provided at the pilot Composting Center located in the Integrated Solid Waste Management (Sanitary Landfill) site.

- ✓ Waste Resources Processing at MRFs using low-technology and labor intensive methods. Training for HHs/Wards will be provided at the Waste Resources Processing Center located in the ISWM (Sanitary Landfill) Site.

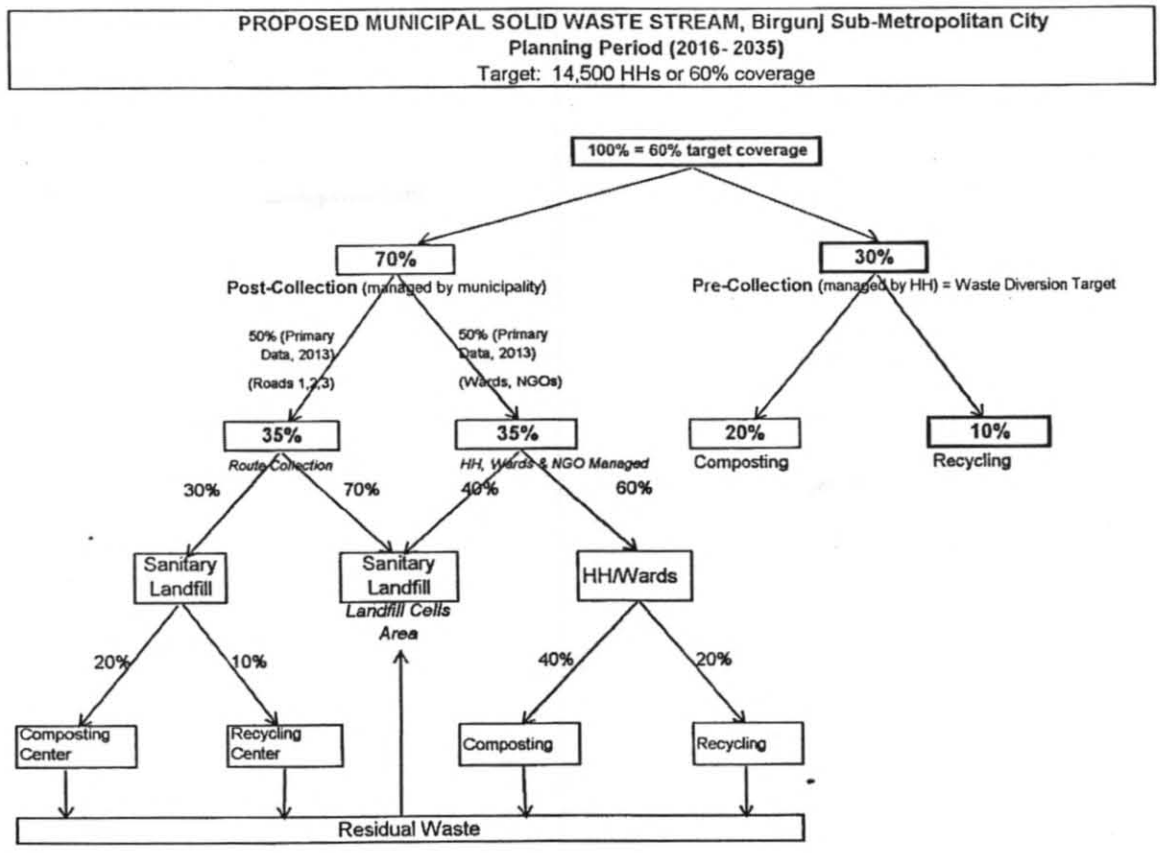

Figure 13: Birgunj Proposed Solid Waste Stream for 3Rs

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 BSMC Sanitation Section and analysed during the first quarter of 2013. This means that out 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

3Rs Scenario

Please refer to Figure 13 above for the Proposed Municipal Solid Waste Stream illustrating the operational framework of the 3Rs envisioned by the DSC 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 DSC in consultation with the PCO/PIU and the PSMC have set the level of collection service by the municipality 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 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 an NGO called LIDS 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.

Worst Case and Phasing Scenarios

In the DSC design, a worst case scenario and a phasing scenario for 3Rs are being planned for. The worst case scenario is when all of the 60% is disposed of straight into the sanitary landfill while the Phasing scenario allows the municipality to gradually adhere from mixed waste towards the 3Rs principle within a period of 3 to 5 years.

It is recommended that BSMC (Birgunj) prepare a collection schedule whereby the compostable and non-biodegradable solid wastes that need to be brought to the sanitary landfill site for further processing are collected separately in assigned tractor-trailers or in tractor-trailers with separate compartments for recyclables and compostables. The modification of the trailers can be done at the workshop. Modifications can also be made to the rickshaws for two compartments.

The compostable fraction of the biodegradable wastes should be collected at least three times a week to prevent rapid decomposition prior to further processing either at the ward composting areas or the sanitary landfill composting center. The non-biodegradable fraction can be accumulated longer for as long as space will permit and the recyclables do not deteriorate in the MRFs. The recyclables: paper, plastic, bottles, metal, bottles, etc. from the wards and households can be sold directly to junk shops or itinerant buyers depending on the attractiveness of the purchase prices.

The concept of volume reduction at the source shall be the first priority to be promoted by the solid waste management organization that is proposed to be established in the wards of Birgunj. Under the leadership of the City, all wards shall embark on a massive community awareness campaign (information, education and communication) and actively promote the reduction, recycling and reuse (3Rs) and minimization of wastes generated at the source; responsibility for sorting and segregation of biodegradable and non-biodegradable wastes shall

be at the household level, business, commercial, industrial and institutional centers, and in all other point sources of solid wastes.

Waste Quantity Calculations for Landfill Cells Capacity Versus for Waste Collection Program

Please note that the above calculations from the two varying scenarios formed the basis for the design of the sanitary landfill cells area (air space available) allocated for the final "residual" wastes after pre-collection recovery, composting at the Composting Center, and recovery of reusable and recyclable materials from the Waste Resources Processing Center. The design calculations for the Waste Collection and Transportation Program were prepared separately and were expected to converge within the same range of quantities expressed in percentage as shown above. BSMS Sanitation is advised that calculations have to be validated once initial operations are implemented. The operational procedures are then streamlined and stabilized and data are documented throughout the years of operation. The data generated will be useful for the continuous MSW planning and design.

Frequency of Collection for 3Rs (Reduce, Recycle and Re-use)

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. The objective is to organize and prepare a schedule that will collect the biodegradables on different dates more frequently say 3 times a week., and the residual wastes from pre-collection of the households say once a week.

The transport routes should be reviewed and re-established to increase the present collection service of the fleet of vehicles and trailers and target a collection service of 60%. The assessment of the conditions and roads and coordinating new routes with the municipality should be a priority activity to increase collection service from the present 30-40% to 60%. Record keeping should be efficiently performed at all times.

The collection efforts should also be coordinated with the ward leaders, the households and the NGOs who are working on the 3Rs as this would decrease their load and increase their efficiency. The concerted efforts are targeted to minimize waste generation and reduce waste at the source or at the points of generation.

The following is recommended for the collection, transport and handling of solid waste system:

a) All collectors and other personnel directly dealing with collection of solid waste shall be equipped with personal protective equipment and paraphernalia such as, but not limited to gloves, masks and safety boots, to protect them from the hazards of handling solid wastes.

b) The City or at the wards level shall provide necessary training to the collectors and personnel to ensure that the solid wastes are handled properly in accordance with the city's solid waste guidelines.

c) Collection of solid waste shall be done in a manner that prevents damage to the container and spillage or scattering of solid waste within the collection vicinity. All waste collection equipment should be covered by tarpaulins or similar flexible cover material throughout the duration of the collection and transport routes except when loading and unloading.

d) Collection equipment e.g. tractor trailers, trucks, etc. Shall be maintained in good condition and kept clean to prevent the harboring of vectors and the creation of nuisances.

e) The use of separate collection schedules and/or separate trucks or haulers shall be required for specific types of wastes. Otherwise, vehicles used for the collection and transport of solid wastes shall have the appropriate compartments to facilitate efficient storing of sorted wastes while in transit. The waste compartment shall have a cover to ensure the secure containment of solid wastes while in transit.

f) Vehicles shall be designed to consider road size, condition and capacity to ensure the safe and efficient collection and transport of solid wastes.

g) For the purpose of identification, vehicles (tippers, tractor trailers, rickshaws and handcarts) shall bear the identification/body number, the name, and telephone number of the contractor/agency collecting solid wastes.

4.8 The Proposed Waste Storage System

As defined above, primary storage will consist of the various containers or bags used by residential, commercial and institutional establishments to deposit segregated wastes prior to primary collection by handcarts and rickshaws; the streets and gutters serviced by street sweeping; the two color-coded waste containers provided to households by NGOs; and the containers used by stores, public and privates offices, schools, hotels and restaurants, etc. segregated into two different types of wastes (biodegradable and non-biodegradable). The segregated storage also applies for the block collection service area and the pick-up service establishments availing of waste collection service from the Municipality. The individual waste containers will not be uniform at the early stage of the SWM program but will be owned and will be the responsibility of the households, commercial, and institutional establishments disposing of their own segregated wastes. The ward communities shall be given the opportunity to organize their own individual container systems for as long as these are color-coded (green and red) and coordinated with the Primary Collection by the Municipality and the Secondary Collection by the Contractor –Operator for Birgunj.

The proposed waste storage system is to use Skip containers will consist of 2 color-coded containers of green (organic compostable) and red (inorganic reusable and recyclable) in one skip container station as shown in the skip operational route plans. Each skip container will have a capacity of 3-cu.m when full. The handcarts and rickshaws bring their waste loads from the households to the station in accordance with a separate schedule for the organic and the inorganic wastes.

4.9 The Proposed Waste Collection System

The proposed secondary collection system does segregated collection using skip loaders/truck hoists and tractor trailers through segregated schedules for organic and inorganic wastes and includes residential, industrial/commercial, public and private offices, and institutional wastes (schools). As much as practicable, color coding of collection vehicles, including their sorting compartments (green for organic compostable and red for inorganic reusable and recyclable) shall be implemented. Secure top covers shall be used at all times.

The proposed city-wide cleaning service shall be harmonized with the total waste collection system through appropriate operational route plans provided herein that shall be updated regularly, so that there is routine operational flow of waste from point of generation up to the final disposal point without bottlenecks in between. For example, the wastes coming to the primary and secondary collection points (through various local activities of communities,

NGOs/CBOs and also of BSMC Sanitation, etc.) shall be properly collected and operationally further managed. The operational route plans with identified location of all collection points in the map shall be used at the start of the program and assessed for improvements depending on the response turnout of the households, commercial and institutional establishments to the 3Rs activities. These considerations became the basis for the design of the Skip Container System, Block Collection System, the Street Sweeping service and the Pic-up Services that are proposed for Birgunj to complement the Integrated solid Waste Management System.

The responsibility for waste collection ultimately rests with the Municipality. However, for efficiency of service the private sector shall be involved by way of the NGO participation, for closer monitoring of the communities engaged in 3Rs and the assignment of a waste collection contract to a private Waste Collector-Operator. This private entity has been determined to perform better if it is also assigned the responsibility for the ISWM site activities particularly in the management of the Composting facility, the Waste Resources Processing Center and the Sanitary Landfill at the ISWM site.

For purposes of clearly defining responsibilities between the private contractor-operator and the Municipality the following definitions are given below:

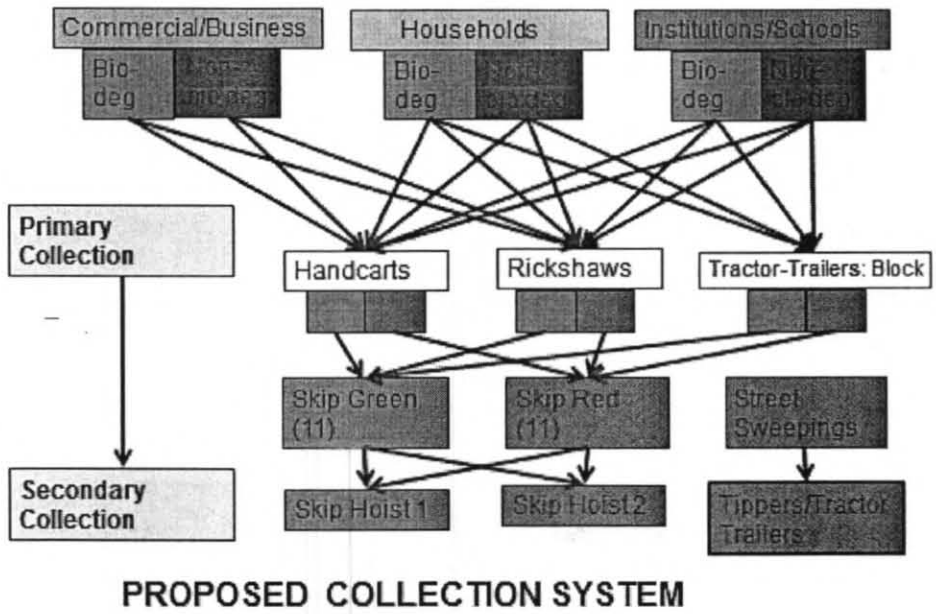

Figure 14: Proposed Collection System

PROPOSED DELINEATION OF RESPONSIBILITIES

PRIMARY COLLECTION (To be performed by the Municipality and NGO)

In the context of the proposed SWM program in Birgunj, Primary Collection will be the prime responsibility of the Municipality. As defined herein, Primary Collection includes the collection by the Municipality's street sweepers and drain cleaners of MSW from households, residential buildings, offices, stores, institutions, government buildings, schools, religious institutions, etc. from all the 19 wards, using handcarts and rickshaws. The segregated MSW are subsequently loaded and transported into two color-coded Skip containers (green for bio-degradable and red for non-biodegradable) located at the Skip container stations closest to their area of operations.

The Primary Collection of two wards, Ward Nos. 10 and 15 is being managed by an NGO, which has an existing contract with the Municipality to provide the waste collection services using drivers, sweepers and drain cleaners, and collection equipment from the Municipality.

BLOCK COLLECTION (To be performed by the Contractor-Operator)

The exception to the Primary Collection above that will be under the responsibility of the Contractor-Operator is the proposed Block Collection System. The purpose of this service is to support the skip container system in those areas or blocks of population that are not reached by the Skip container system at this early stage of the SWM program in Birgunj. There are six blocks of population that will be serviced by the Contractor-Operator. These can be found in the Block Collection operational route plans. The tractor-trailers are dispatched through a route plan to each block wherein stopping points are designated and are made routinely familiar to the community. The collection vehicle then signals the community of their arrival at these stopping points by way of whistles, horns or music. The vehicle waits within an allocated time for response from the community. The households, commercial and institutional establishments then bring their segregated wastes to the tractor-trailers for further sorting. The tractor-trailers which are partitioned for organic and inorganic waste separation then proceed to other blocks until full, then proceed to the ISWM site for further processing and final disposal. The service will primarily be provided by tractor-trailers with support from the tippers when required for collection of homogenous wastes, either organic or inorganic.

SECONDARY COLLECTION (To be performed by the Contractor-Operator)

As defined above, Secondary Collection Secondary Collection will be the prime responsibility of the Contractor-Operator of the Birgunj ISWM project. Solid waste is collected from three sources: Skip containers, Street sweepings and Pick-up service. Skip containers will be loaded onto the Skip Loaders/Truck Hoists in accordance with the skip container operational plan and transported to the ISWM site for further processing and final disposal. Secondary Collection also includes the street sweeping and drain cleaning activities performed by the Municipality's staff using handcarts and rickshaws along the inner core main roads (Roads 1, 2 and 3), along the roads within the service coverage areas of the 19 wards and the service areas covered by the NGO in Ward Nos. 10 and 15. For the street sweepings, it is imperative that the activities are closely coordinated and synchronized between the Street Sweepers and drain cleaners of the Municipality.

4.9.1 Skip Container System

The Skip containers will consist of 2 color-coded containers of green (organic compostable) and red (inorganic recyclable) in one skip container station as shown in the skip operational route plans. There will be a total of 11 skip container stations or 22 skip containers (11 green and 11 red) for use by the Municipality for all of the 19 wards as shown in the Skip container operational route maps. There will be 4 (2 green and 2 red) empty skip containers to serve as replacement containers after loading by the Skip Loader/Truck hoist. The total number of skip containers at this stage of the project will be 26. There will be 2 Skip loader/truck hoists that will transport the skips to the Integrated Solid Waste management Site for further processing and final disposal. The management and care of the Skip containers will be the responsibility of the Contractor-Operator.

The contractual arrangement considered in the design is that the secondary collection will be performed by the Waste Collector/Contractor-Operator under contract with BSMC. There will be a total of 11 skip container stations or 22 skip containers (11 green and 11 red) for use by the Municipality for all of the 19 wards as shown in the Skip container operational route maps. There will be 2 Skip loader/truck hoists that will transport the skips to the Integrated Solid Waste Management site for further processing and final disposal. There will be 4 (2 green and 2 red) empty skip containers to serve as replacement containers after loading by the Skip

Loader/Truck hoist. This brings the total number of skip containers at this stage of the project to 26 units. The management and care of the Skip containers will be the responsibility of the Contractor-Operator.

Table 16 summarizes the expected daily waste loads of each skip station (green for organic and red for inorganic) per day during the first year of operation of the skip container system. The values corresponding to the Skip station and ward numbers indicate the estimated waste contribution of each ward to the skip station referred to, defined by the estimated population percentages contributing to the skip location, its location, and access from the centroid or waste catchment area skip station. The actual catchment areas will be defined in maps when the respective ward communities confirm and accept the assigned skip locations during project consultations prior to the initial operations of the contractor-operator.

The operational schedule of the collection vehicles (two Skip Loaders designated as H1 and H2) are further shown in the following Table 17 based on the estimated waste loads. It is estimated that during the first year the total organic wastes collected would be 55.63 cu.m. per day while the inorganic wastes would be 25.95 cu.m/ per day.

Figure 15 shows the different locations of the skip containers S-1 to S-11.

Figures 16 and 17 show the different operational route maps: Routes 1 to 11 of Skip Loader/Truck Hoist 1 and Skip Loader/Truck Hoist 2.

Table 16: Estimated Skip Container (S-1 to S-11) Daily Collection Volumes by Ward Contribution, cubic meters (2016)

Ward	2016 population (yr beginning)	Skip 1		Skip 2		Skip 3		Skip 4		Skip 5		Skip 6		Skip 7		Skip 8		Skip 9		Skip 10		Skip 11		Totals
		organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	
1	8,788	1.54	0.72	0.26	0.12																			
2	10,151	0.89	0.42	2.97	1.39																			
3	7,831	0.92	0.43	0.92	0.43			1.83	0.86															
4	2,297			0.40	0.19	0.81	0.38																	
5	1,807							0.63	0.30															
6	3,685					1.51	0.70																	
7	1,648									0.58	0.27													
8	1,115									0.33	0.15													
9	4,641					1.63	0.76																	
10	6,691											0.20	0.09			2.94	1.37							
11	1,656									0.29	0.14			0.24	0.11									
12	3,302													1.16	0.54	0.19	0.09							
13	15,458							3.62	1.69					2.71	1.27									
14	13,136																	3.84	1.79			0.77	0.36	
15	8,817															2.58	1.20			1.29	0.60			
16	13,142																	0.38	0.18	0.77	0.36	3.85	1.79	
17	8,922																					2.61	1.22	
18	11,614											2.72	1.27							1.36	0.63			
19	25,307			2.96	1.38	4.44	2.07					1.48	0.69											
Tot	150,008																							81.58
Total Org		3.35		7.51		8.39		6.09		1.20		4.40		4.12		5.71		4.23		3.42		7.23		55.63
Total Inorg			1.56		3.50		3.91		2.84		0.56		2.05		1.92		2.66		1.97		1.59		3.37	25.95

Table 16: Estimated Skip Container (S-1 to S-11) Daily Collection Volumes by Ward Contribution, cubic meters (2016)

Ward	2016 population (yr beginning)	Skip 1		Skip 2		Skip 3		Skip 4		Skip 5		Skip 6		Skip 7		Skip 8		Skip 9		Skip 10		Skip 11		Totals
		organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	organic	inorganic	
1	8,788	1.54	0.72	0.26	0.12																			
2	10,151	0.89	0.42	2.97	1.39																			
3	7,831	0.92	0.43	0.92	0.43			1.83	0.86															
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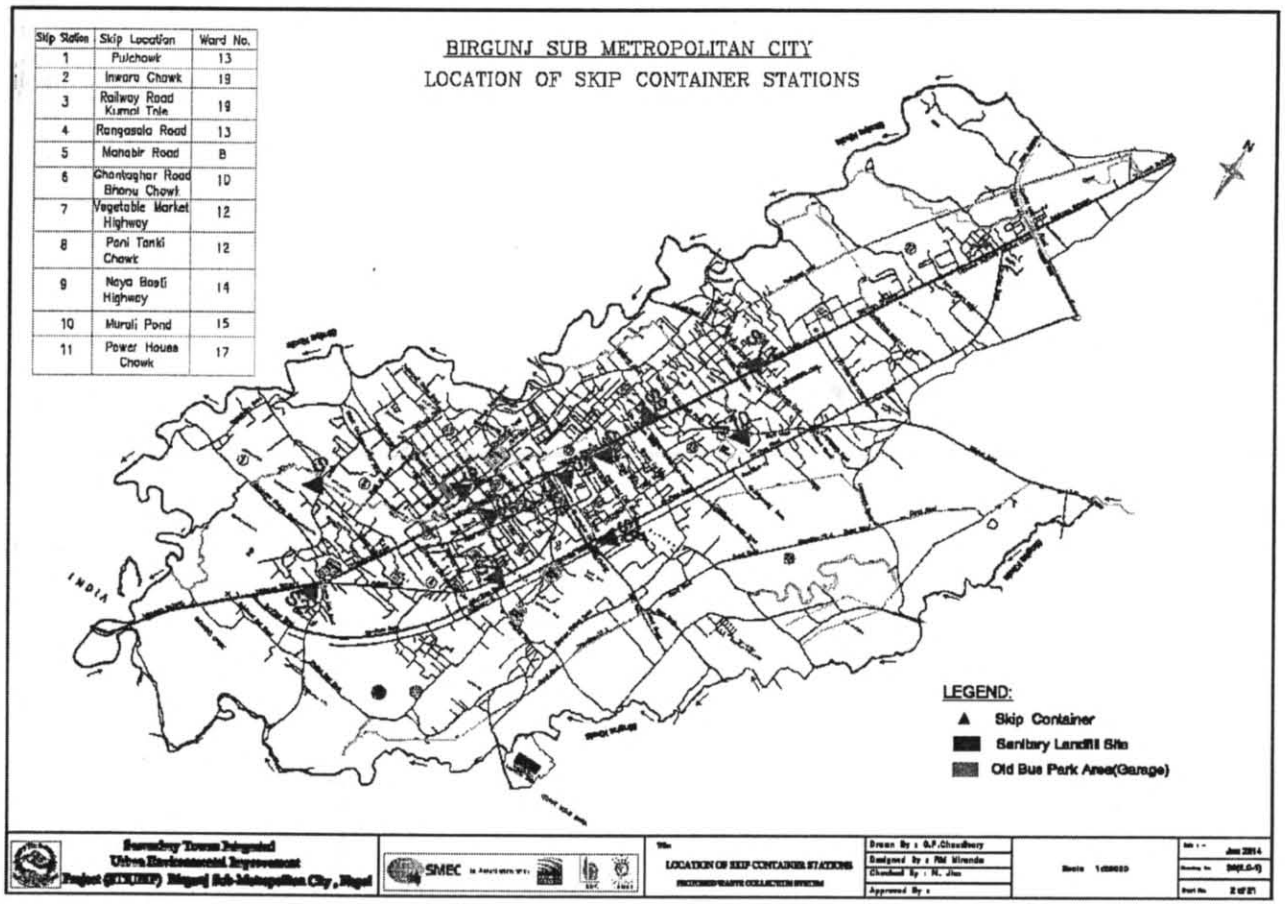
15	8,817															2.58	1.20			1.29	0.60			
16	13,142																	0.38	0.18	0.77	0.36	3.85	1.79	
17	8,922																					2.61	1.22	
18	11,614											2.72	1.27							1.36	0.63			
19	25,307			2.96	1.38	4.44	2.07					1.48	0.69											
Tot	**150,008**																							**81.58**
Total Org		**3.35**		**7.51**		**8.39**		**6.09**		**1.20**		**4.40**		**4.12**		**5.71**		**4.23**		**3.42**		**7.23**		**55.63**
Total Inorg			**1.56**		**3.50**		**3.91**		**2.84**		**0.56**		**2.05**		**1.92**		**2.66**		**1.97**		**1.59**		**3.37**	**25.95**

Table 17: Schedule of Skip Container Collection by Skip Loader H1 and H2

Schedule of Skip Container Collection Operations by Skip Loader H1 and H2													
TIME	Sunday		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday
	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	
5:30 AM	Start from Garage or ISWM site												
6:00 AM	4G1-1	7G-1	4R-1	7R-1	4G1-1	7G-1	4G1-1	7G-1	4R-1	7R-1	4G1-1	7G-1	Preventive Repair and Maintenance
7:30 AM	5G-2	8G1-2	5R-2	8R-2	5G-2	8G1-2	5G-2	8G1-2	5R-2	8R-2	5G-2	8G1-2	
9:00 AM	3G1-3	6G-3	3R-3	6R-3	3G1-3	6G-3	3G1-3	6G-3	3R-3	6R-3	3G1-3	6G-3	
10:30 AM	2G1-4	9G-4	2R-4	9R-4	2G1-4	9G-4	2G1-4	9G-4	2R-4	9R-4	2G1-4	9G-4	
12:00 PM	1G-5	11G1-5	1R-5	11R-5	1G-5	11G1-5	1G-5	11G1-5	1R-5	11R-5	1G-5	11G1-5	
1:30 PM	4G2-6	10G-6	3G3-6	10R-6	4G2-6	10G-6	4G2-6	10G-6	3G3-6	10R-6	4G2-6	10G-6	
3:00 PM	3G2-7	8G2-7	4G3-7	8G3-7	3G2-7	8G2-7	3G2-7	8G2-7	4G3-7	8G3-7	3G2-7	8G2-7	
4:30 PM	2G2-8	11G2-8	2G3-8	11G3-8	2G2-8	11G2-8	2G2-8	11G2-8	2G3-8	11G3-8	2G2-8	11G2-8	
5:00 PM	Back to Garage or ISWM site												
	ID Legend: 1G1-5 = 1(Skip station); G (green skip container for compostables), R (red skip container for inorganics to WPRC);												
	1- (skip count for the day), 5 (Trip 5 for the day)												

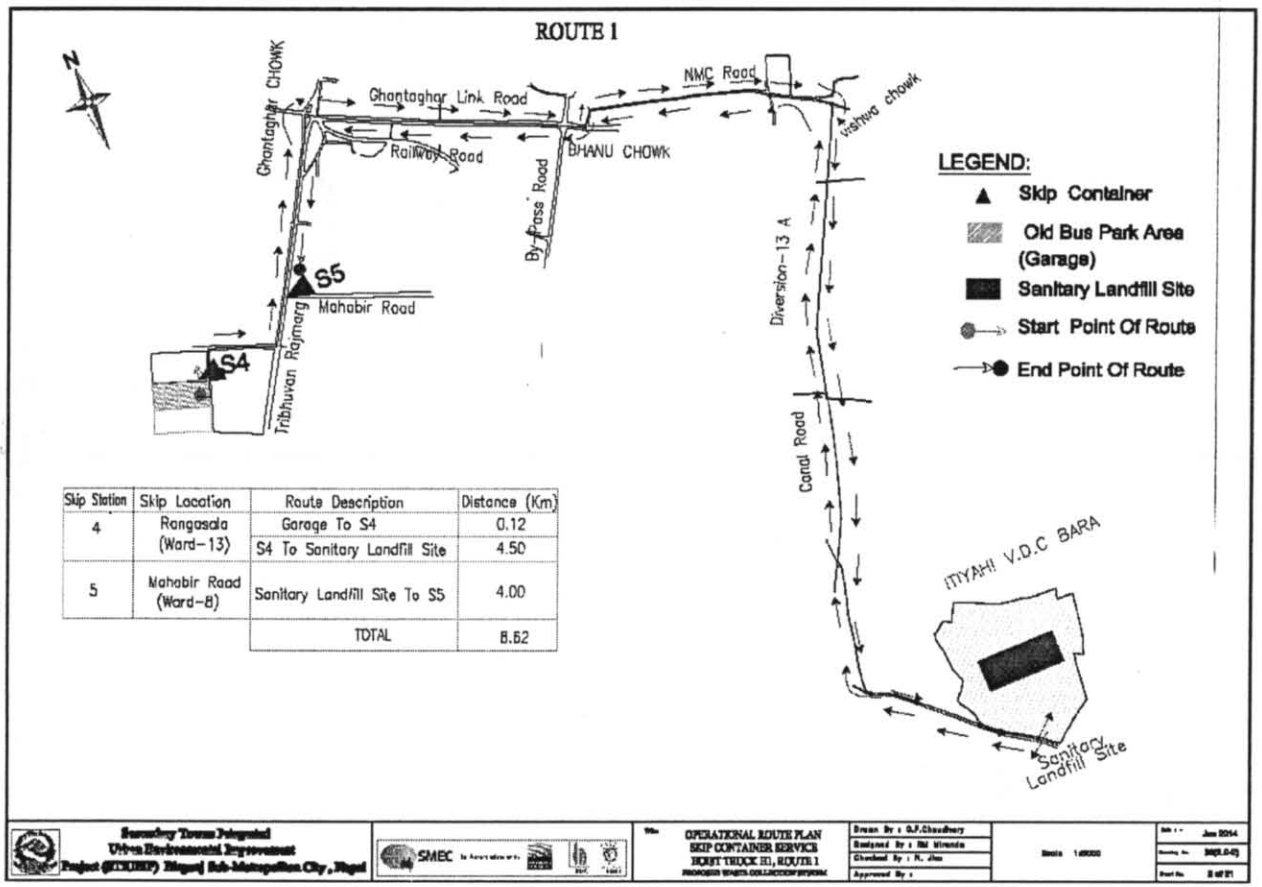
Explanatory note:

As shown in the above legend, the first digit "1" means the skip station name (S-1 to S-11); the second letter "G" means green for organic or "R" means red for inorganic, meaning the color-type of skip container; the number 1 after the letter is the number of collection visits done on the same numbered skip container station for the day (if there is no number, it means that the skip container station is only visited once during the day); the number after the "-" is the "n"th (trip 1 to 8, for example) trip for the day of Skip Loader/Truck Hoist H1 or H2.



Skip Station	Skip Location	Ward No.
1	Pulchowk	13
2	Inwara Chowk	19
3	Railway Road Kumal Tole	19
4	Rangasala Road	13
5	Manabir Road	8
6	Ghantaghar Road Bhanu Chowk	10
7	Vegetable Market Highway	12
8	Pani Tanki Chowk	12
9	Naya Basti Highway	14
10	Murali Pond	15
11	Power House Chowk	17

Figure 15: Location of Skip Container Stations Drg. No. 36(2.0-1)



Skip Station	Skip Location	Route Description	Distance (Km)
4	Rangasala (Ward-13)	Garage To S4	0.12
		S4 To Sanitary Landfill Site	4.50
5	Mahabir Road (Ward-8)	Sanitary Landfill Site To S5	4.00
		TOTAL	8.62

Figure 16: Operational Route Plan(1 to 5) Skip Container Service- Drg. No. 36(2.0-2)

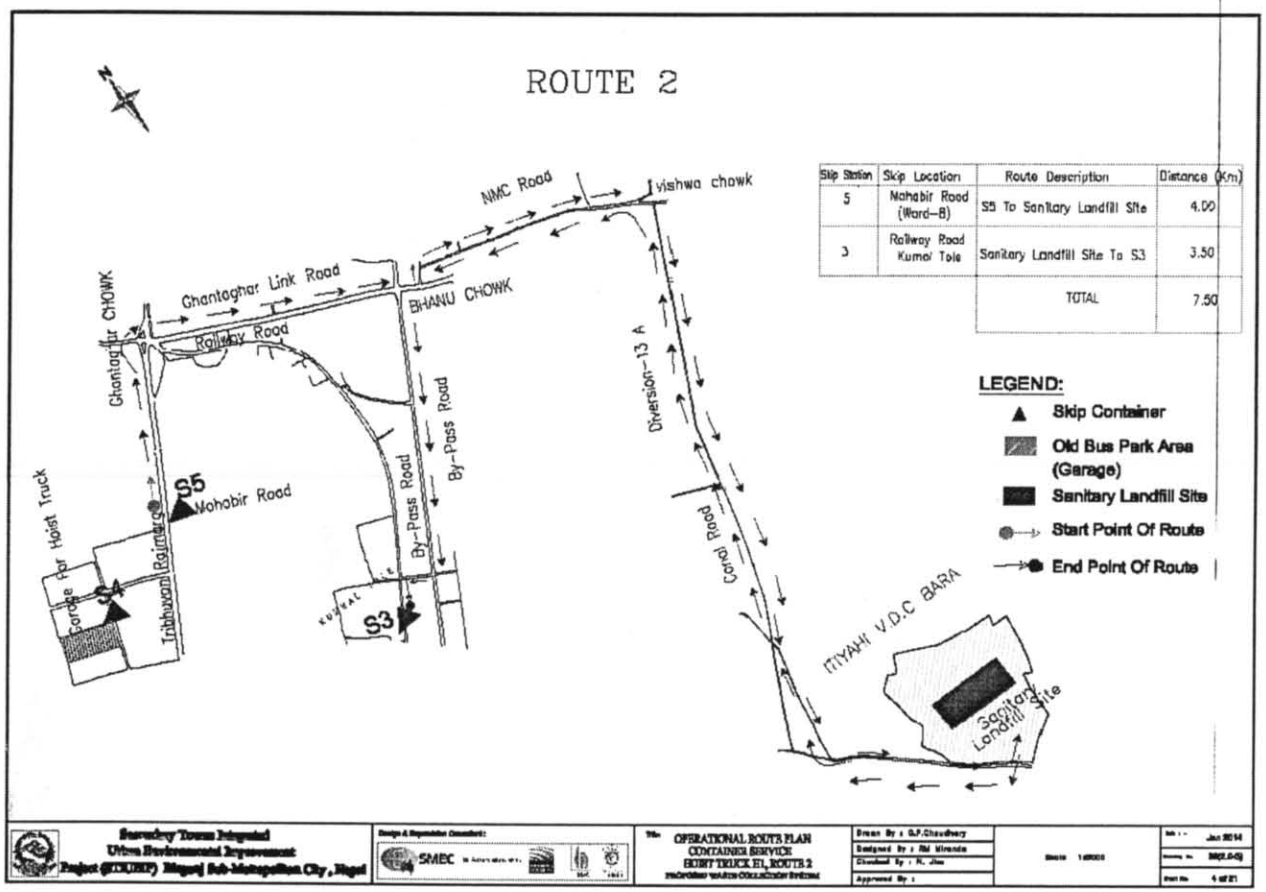
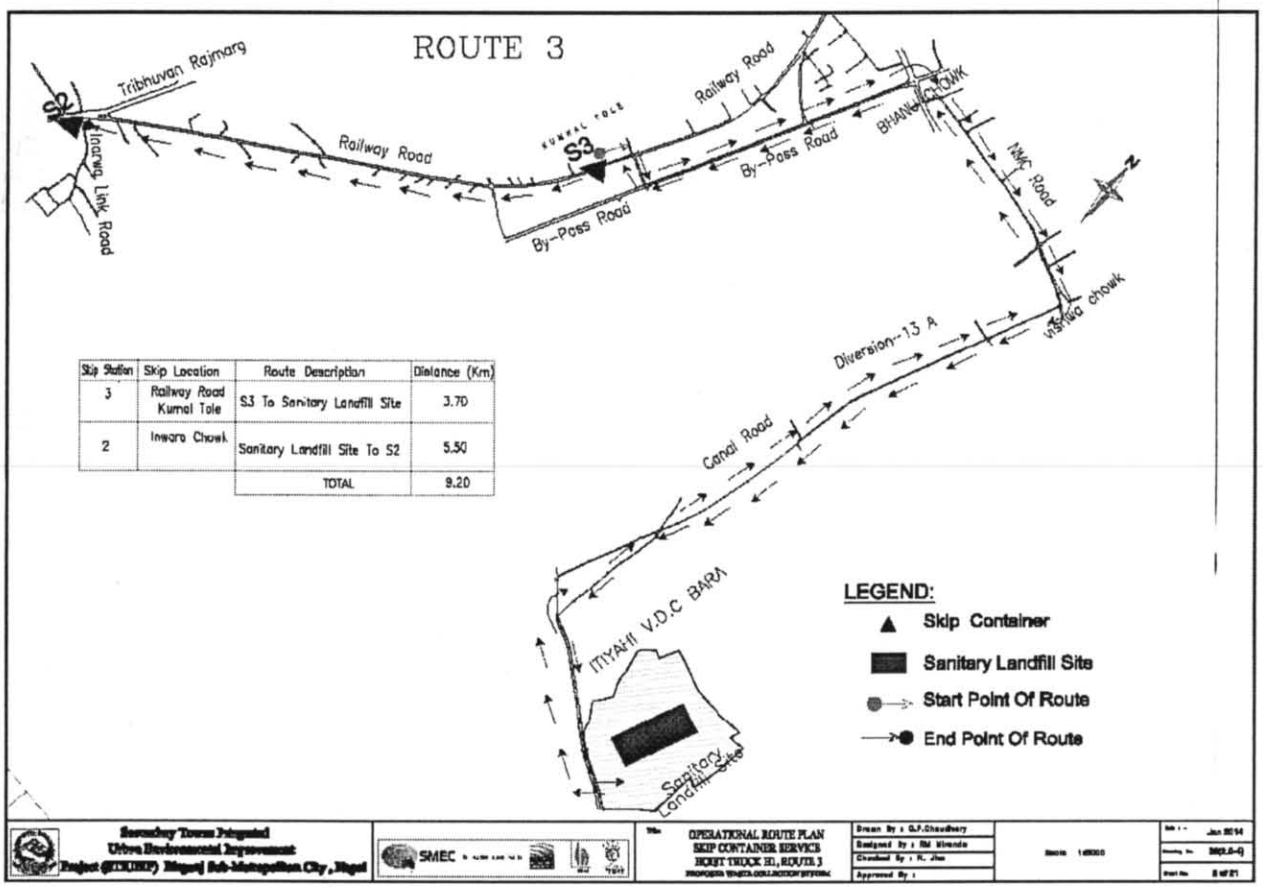


Figure 16-2. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-3)



Skip Station	Skip Location	Route Description	Distance (Km)
3	Railway Road Kumal Tole	S3 To Sanitary Landfill Site	3.70
2	Inarwa Chowk	Sanitary Landfill Site To S2	5.50
		TOTAL	9.20

Figure 16-3. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-4)

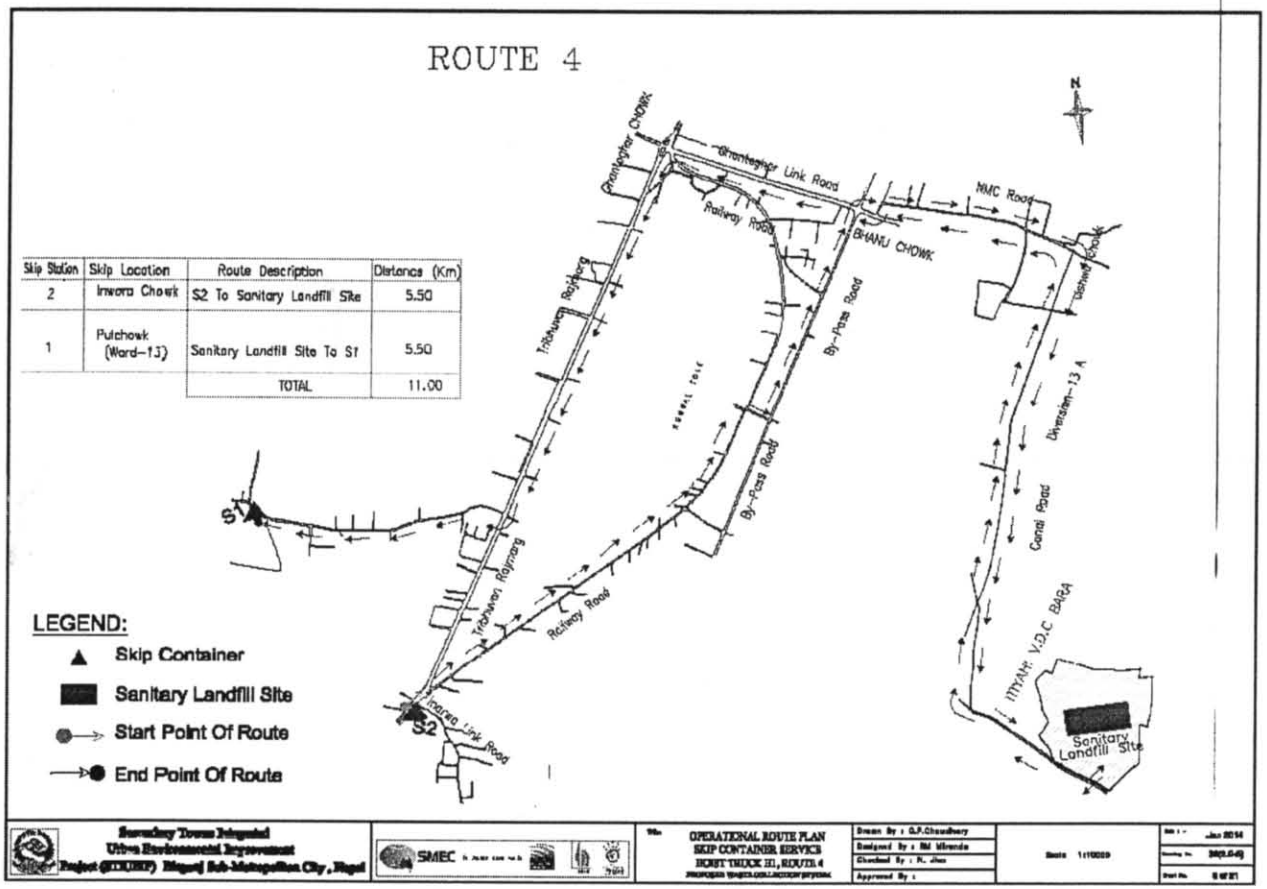
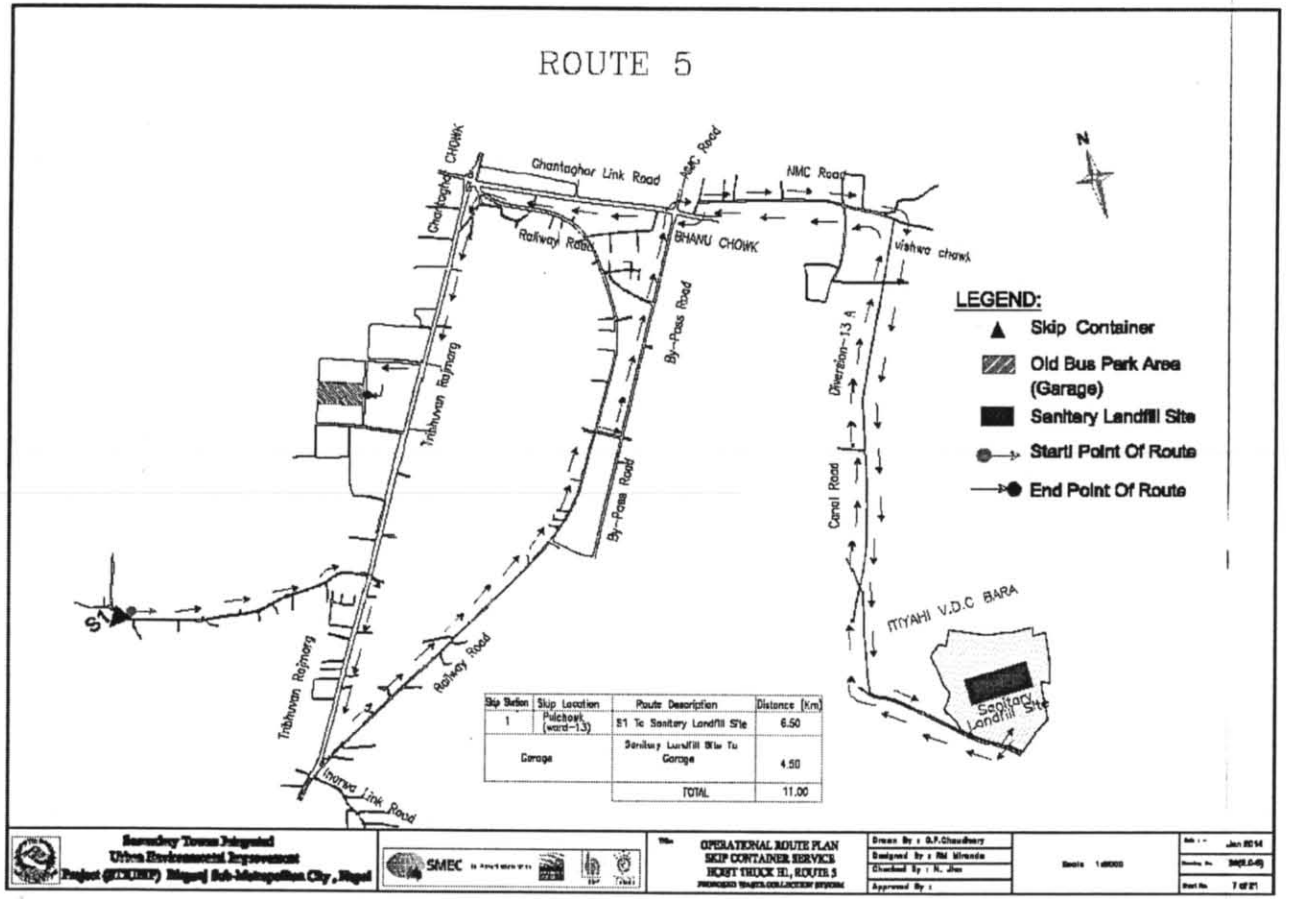


Figure 16-4. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-5)



Skip Station	Skip Location	Route Description	Distance (Km)
1	Pulchowk (ward-13)	S1 To Sanitary Landfill Site	6.50
Garage		Sanitary Landfill Site To Garage	4.50
		TOTAL	11.00

Figure 16-5. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-6)

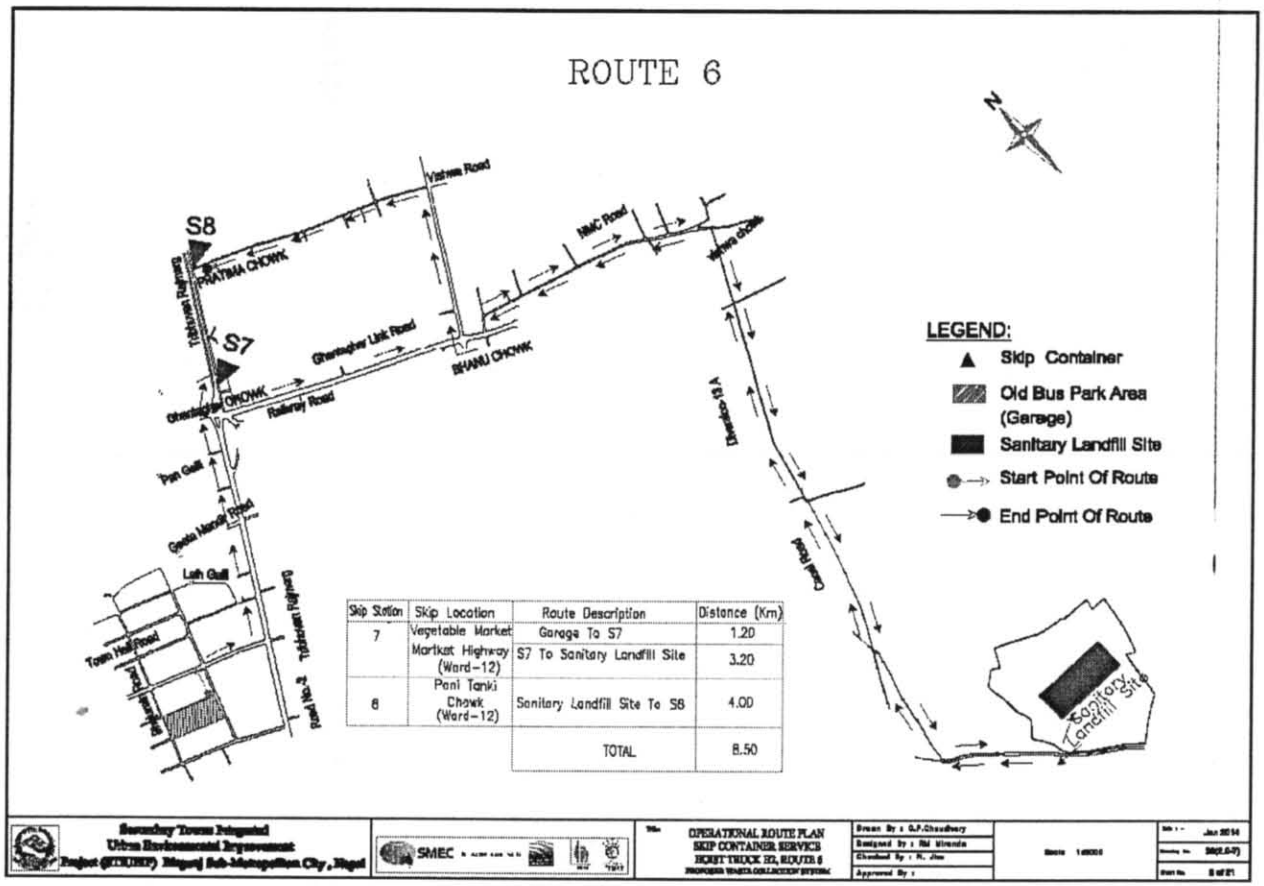
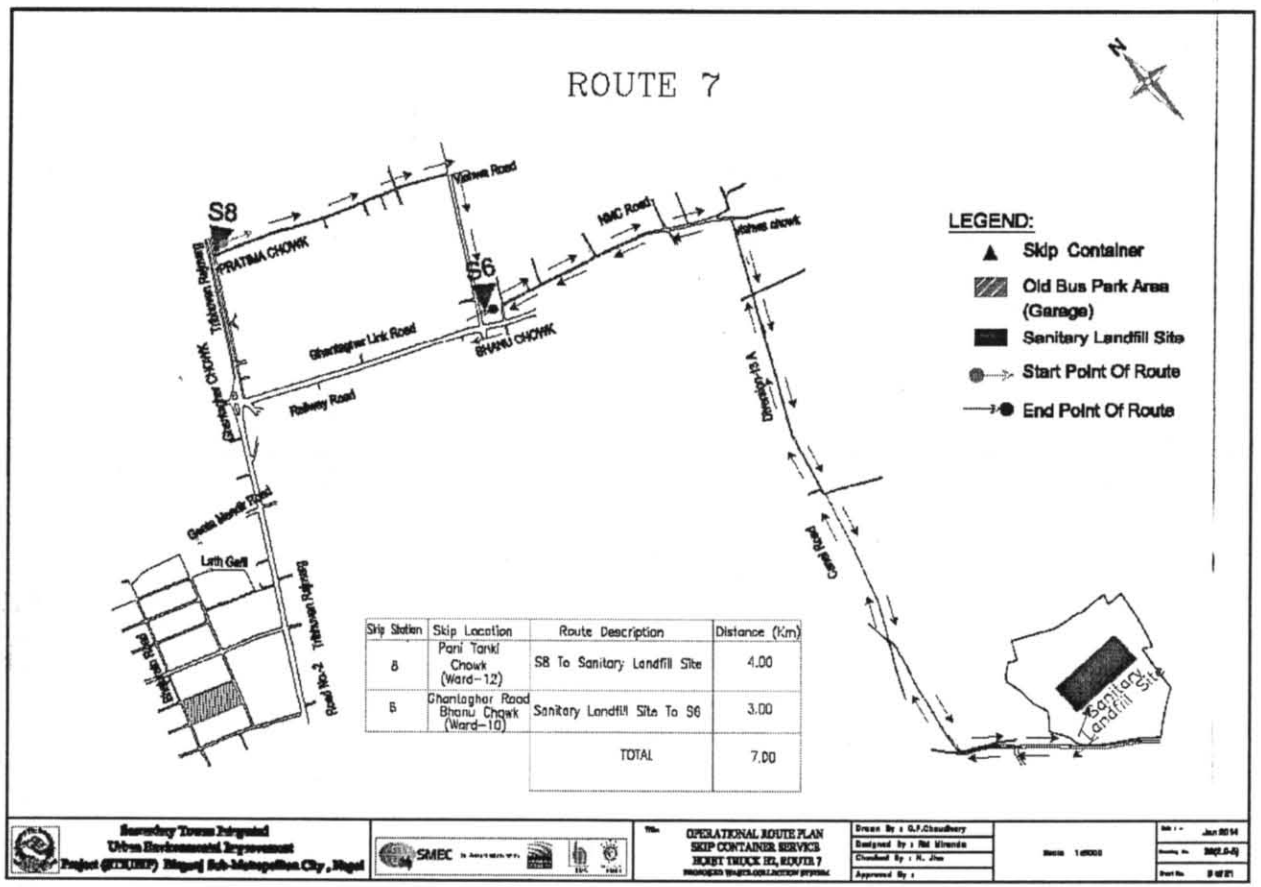


Figure 17: Operational Route (6-11) Plan Skip Container Service- Drg. No. 36(2.0-7)



Skip Station	Skip Location	Route Description	Distance (Km)
8	Pani Tanki Chowk (Ward-12)	S8 To Sanitary Landfill Site	4.00
6	Ghantaghar Road Bhanu Chowk (Ward-10)	Sanitary Landfill Site To S6	3.00
		TOTAL	7.00

Figure 17-2. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-8)

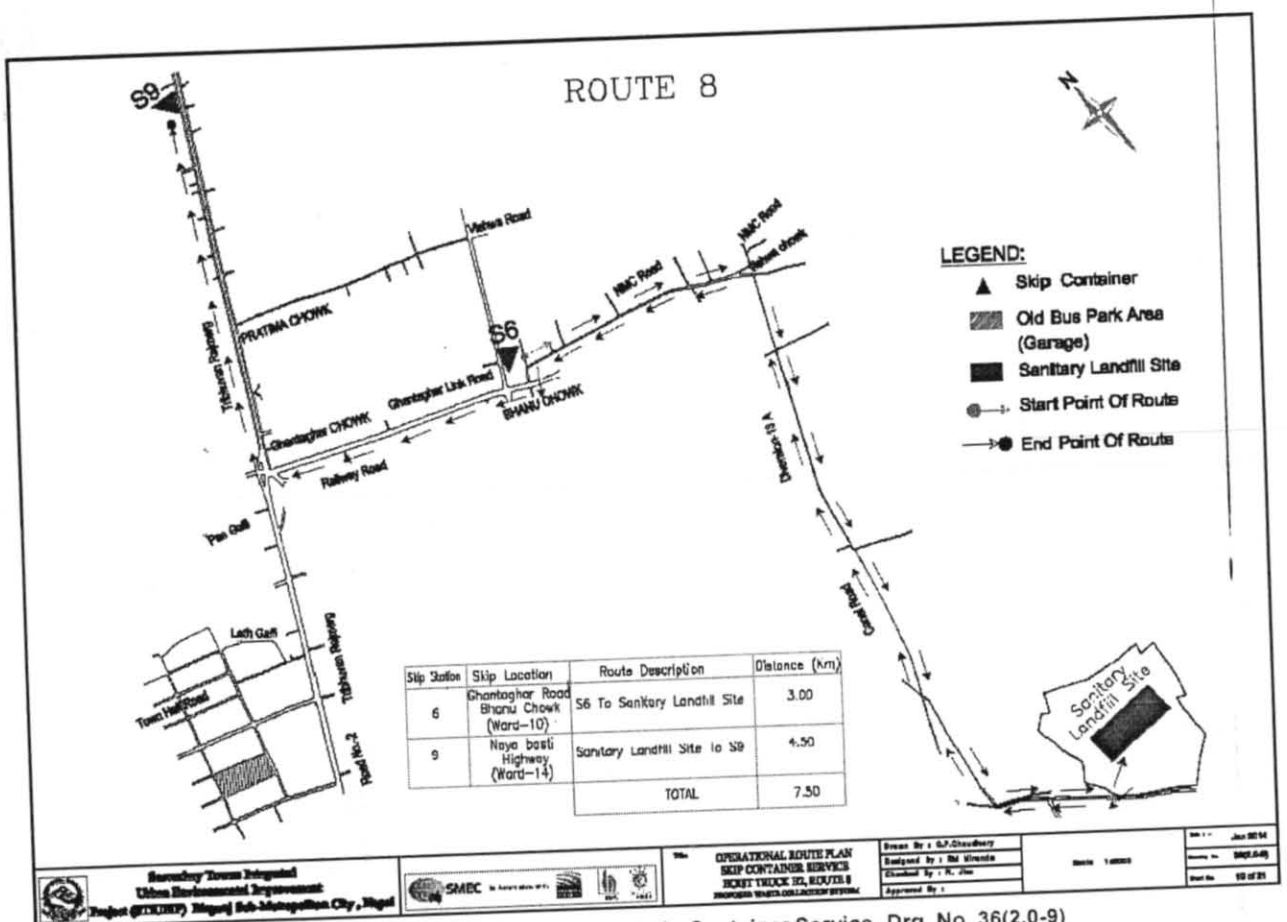


Figure 17-3. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-9)

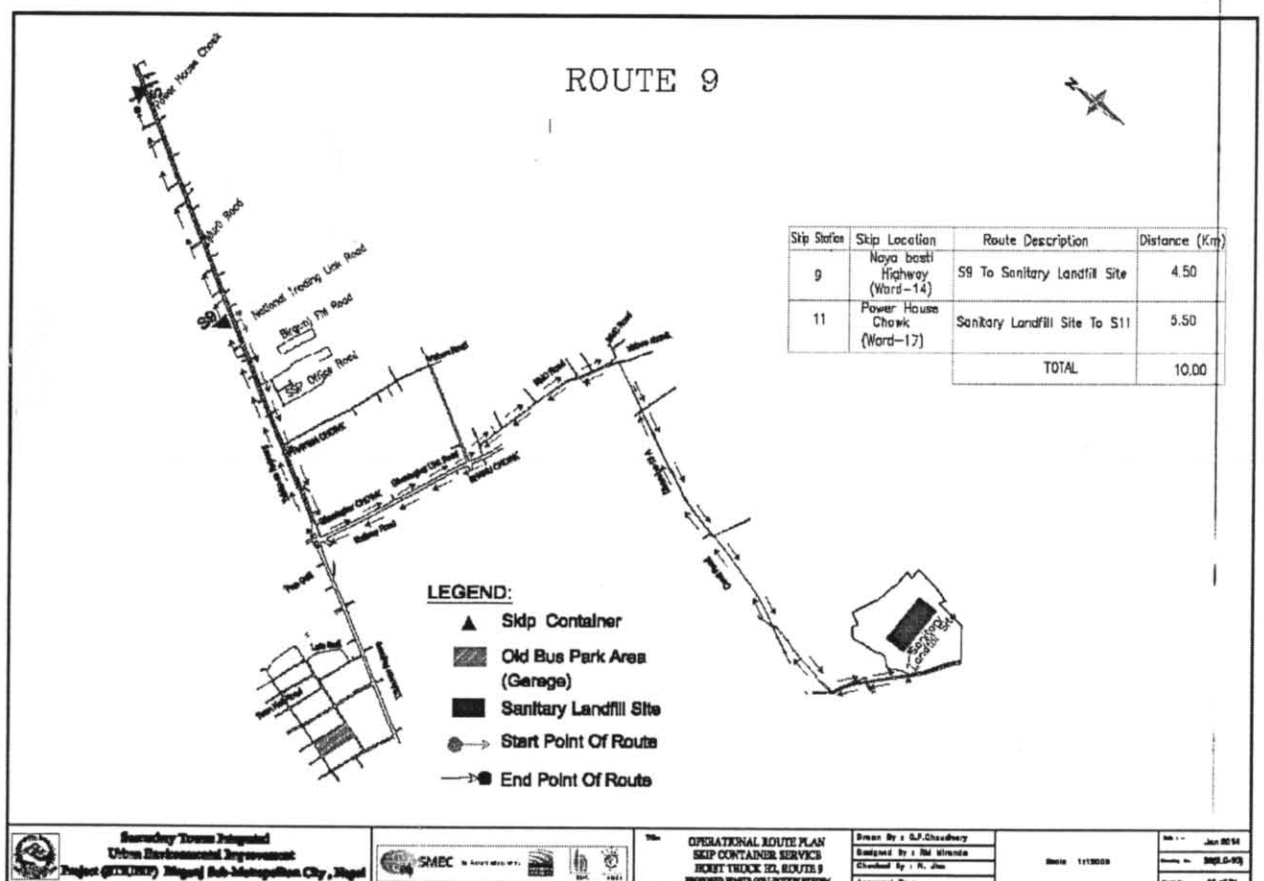
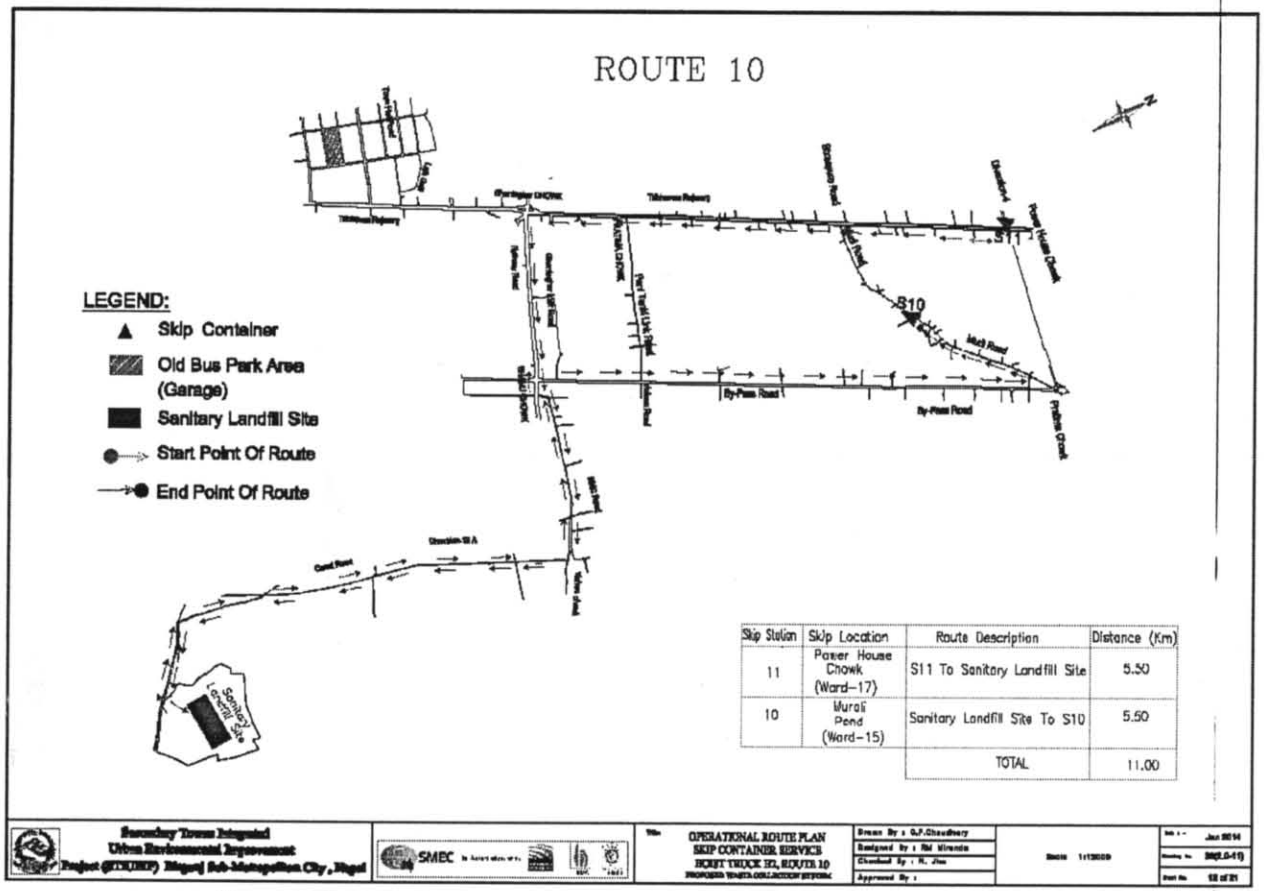
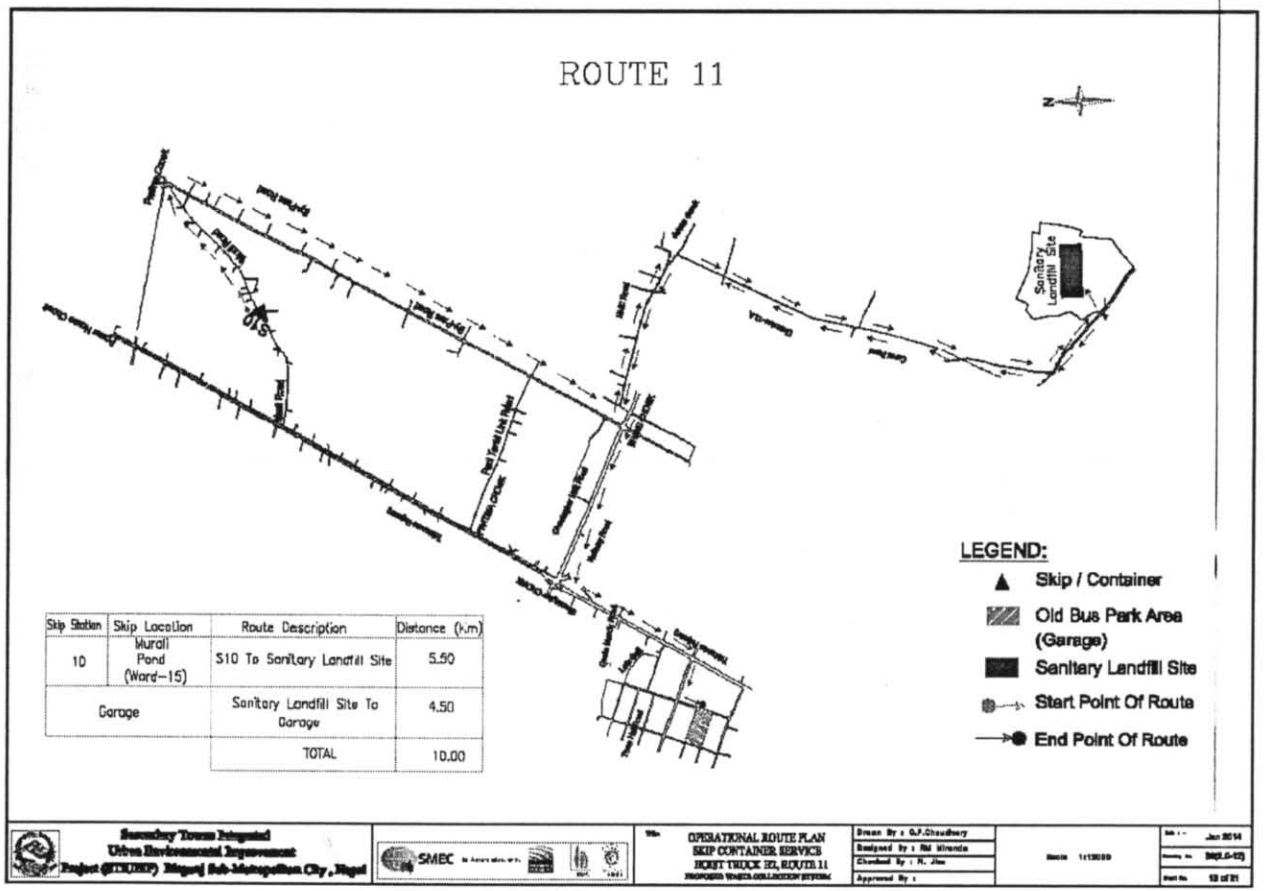


Figure 17-4. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-10)



Skip Station	Skip Location	Route Description	Distance (Km)
11	Power House Chowk (Ward-17)	S11 To Sanitary Landfill Site	5.50
10	Murali Pend (Ward-15)	Sanitary Landfill Site To S10	5.50
		TOTAL	11.00

Figure 17-5. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-11)



Skip Station	Skip Location	Route Description	Distance (km)
10	Murali Pond (Ward-15)	S10 To Sanitary Landfill Site	5.50
Garage		Sanitary Landfill Site To Garage	4.50
		TOTAL	10.00

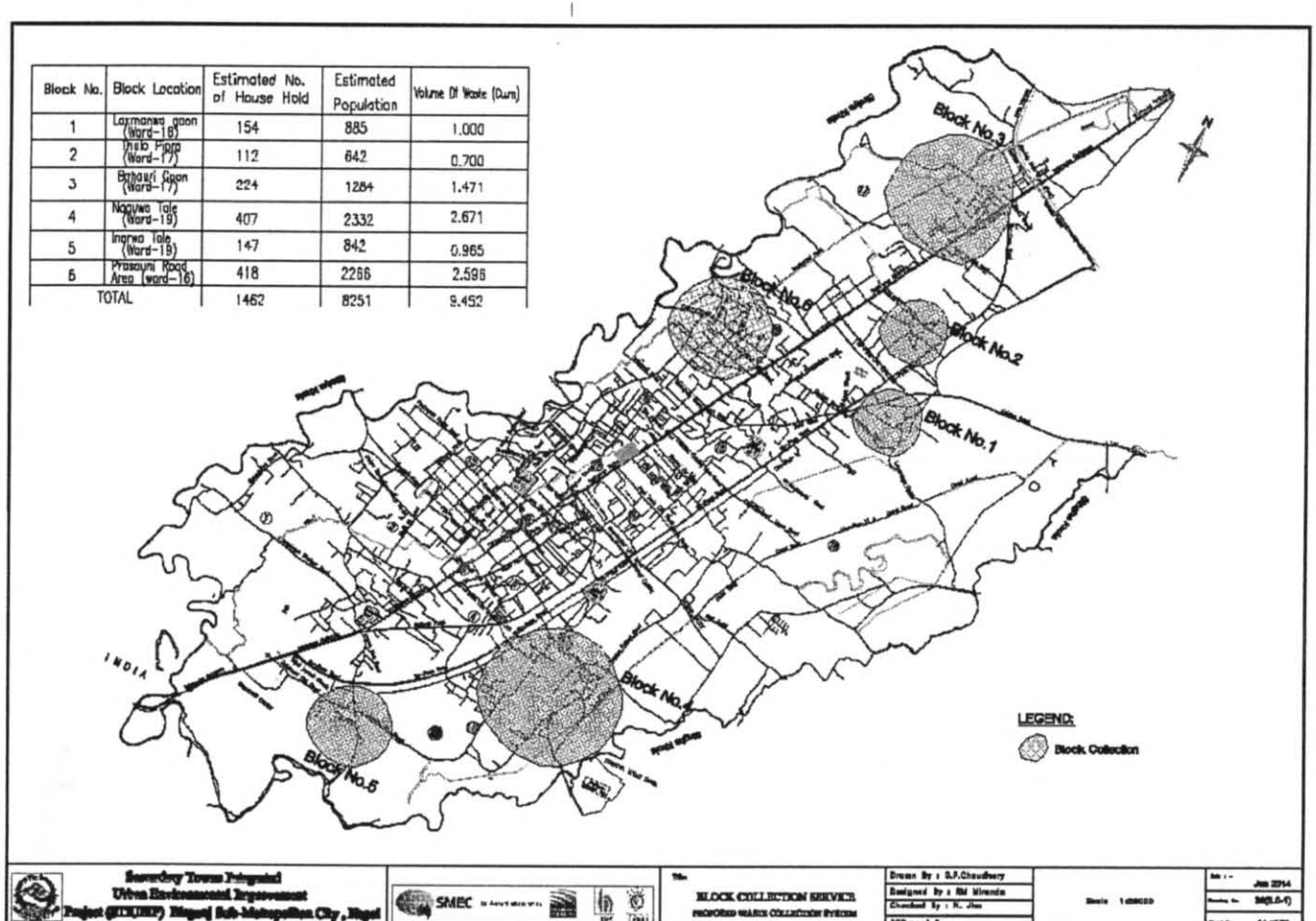
Figure 17-6. Operational Route Plan Skip Container Service- Drg. No. 36(2.0-12)

4.9.2 Block Collection Service

The Block Collection System is the exception to the Primary Collection as defined above that will be under the responsibility of the Contractor-Operator. The purpose of this service is to support the skip container system in those areas or blocks of population that are not reached by the Skip container system during the early stages of implementation of the SWM program in Birgunj.

There are six blocks of population that will be serviced by the Contractor-Operator. These can be found in the Block Collection Service operational route plans (Figure 18). The tractor-trailers, T1 and T2 are each dispatched through individual route plans to their assigned blocks wherein stopping points are designated and are made routinely familiar to the community (Figures 19 & 20). The collection vehicle then signals the community of their arrival at these stopping points by way of whistles, horns or music. The vehicle waits within an allocated time for response from the community. The households, commercial and institutional establishments then bring their segregated wastes to the tractor-trailers for further sorting and proper storage into the collection vehicle compartments. The tractor-trailers which are partitioned for organic and inorganic waste separation (with colored labels: green for compostable organic and red for inorganic reusable and recyclable and are properly covered) proceed to other blocks until full, then proceed to the ISWM site for further processing and final disposal. The service will primarily be provided by tractor-trailers but will be supported with the tippers when required whereby a provisional schedule for collection of homogenous wastes, whether organic or inorganic, needs to be indicated for the schedule.

The following pages illustrate the route plans and contain the pertinent details such as the locations of the different blocks, estimated number of households and population serviced, and estimated waste volumes to be collected. The number of stops within each block and the estimated distances to be travelled within each block are also indicated in the detailed operational route plans.



Block No.	Block Location	Estimated No. of House Hold	Estimated Population	Volume Of Waste (Cum)
1	Laxmanwa gaon (Ward-18)	154	885	1.000
2	Thata Pipra (Ward-17)	112	642	0.700
3	Bhauri Gaon (Ward-17)	224	1284	1.471
4	Naguwa Tole (Ward-19)	407	2332	2.671
5	Ingrwa Tole (Ward-19)	147	842	0.965
6	Prasauni Road Area (ward-16)	418	2266	2.595
TOTAL		1462	8251	9.452

Figure 18: Location of Block Collection Service Drg. No. 36(3.0-1)

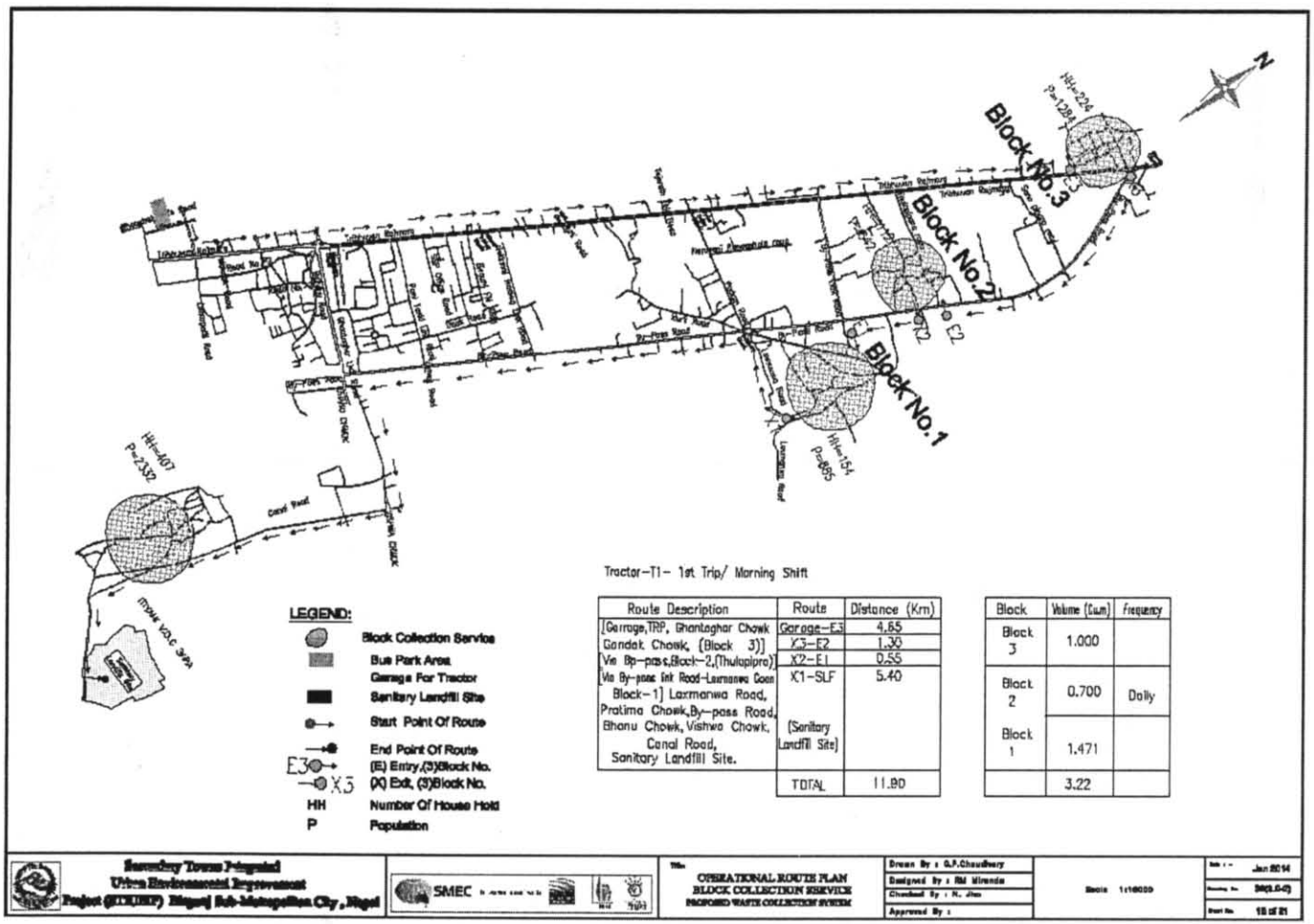


Figure 19(1-4): Operational Route Plan Block Collection Service Drg. No. 36(3.0-2)

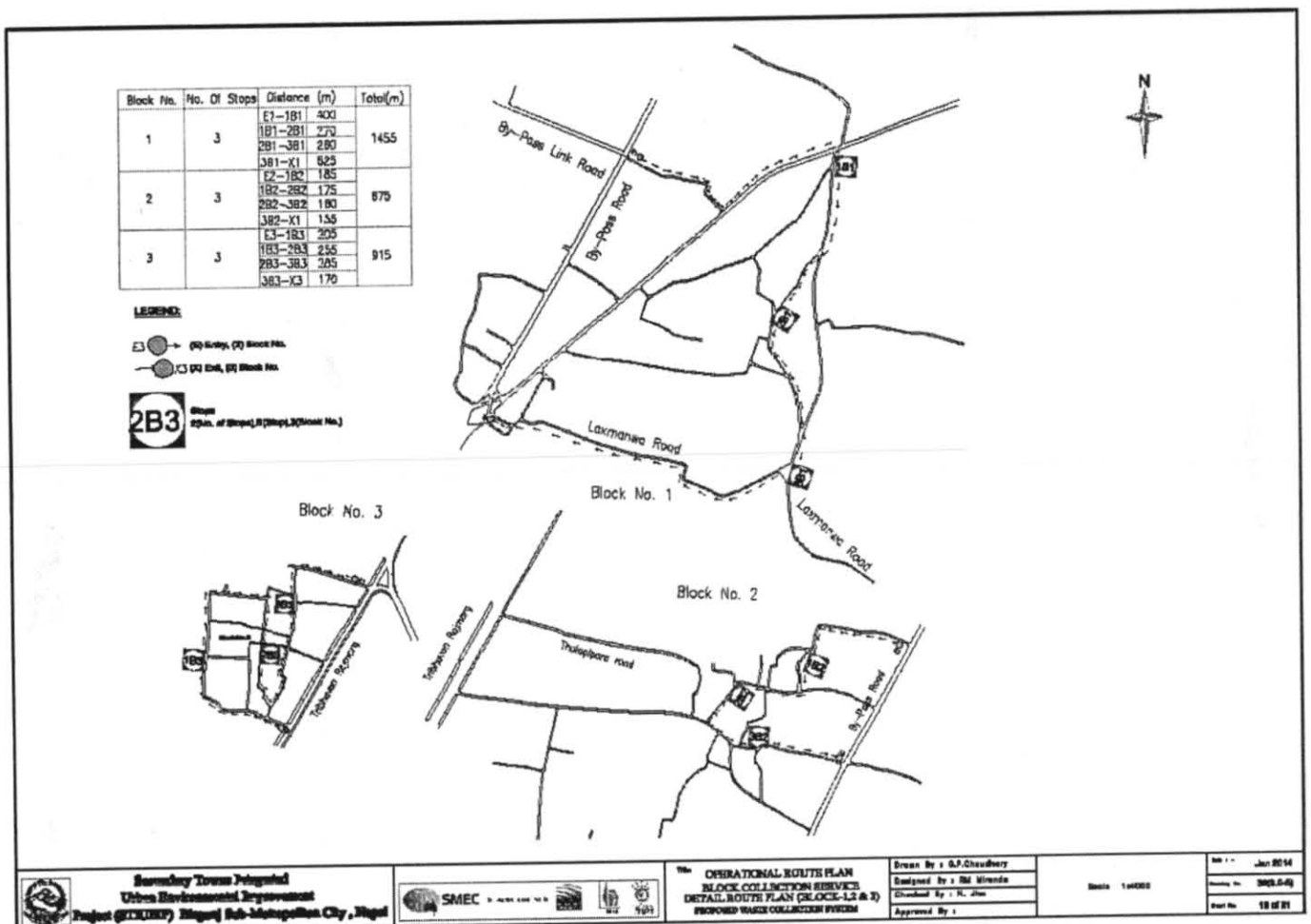


Figure 19-2. Operational Route Plan Block Collection Service Drg. No. 36(3.0-5)

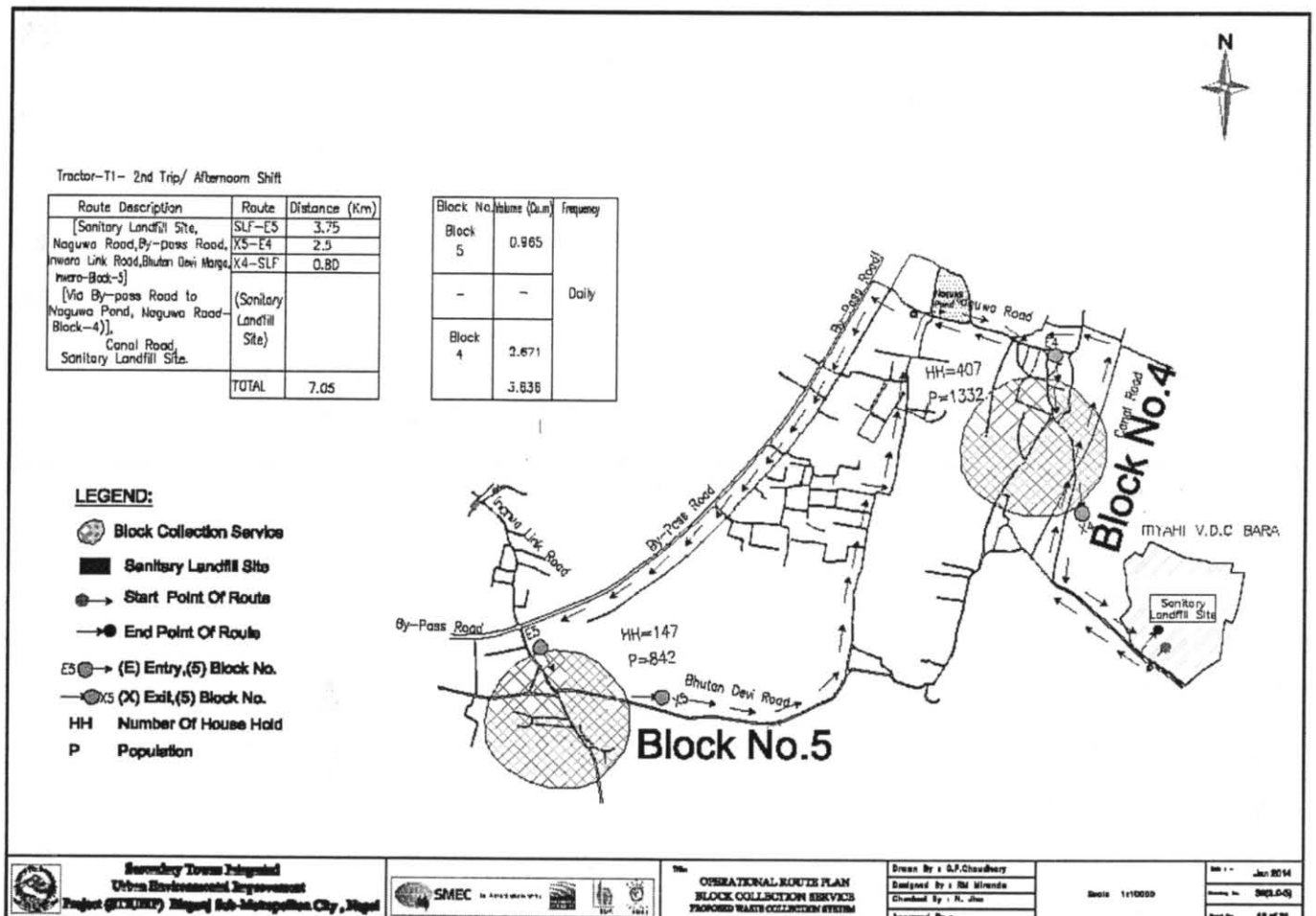


Figure 19-3. Operational Route Plan Block Collection Service Drg. No. 36(3.0-3)

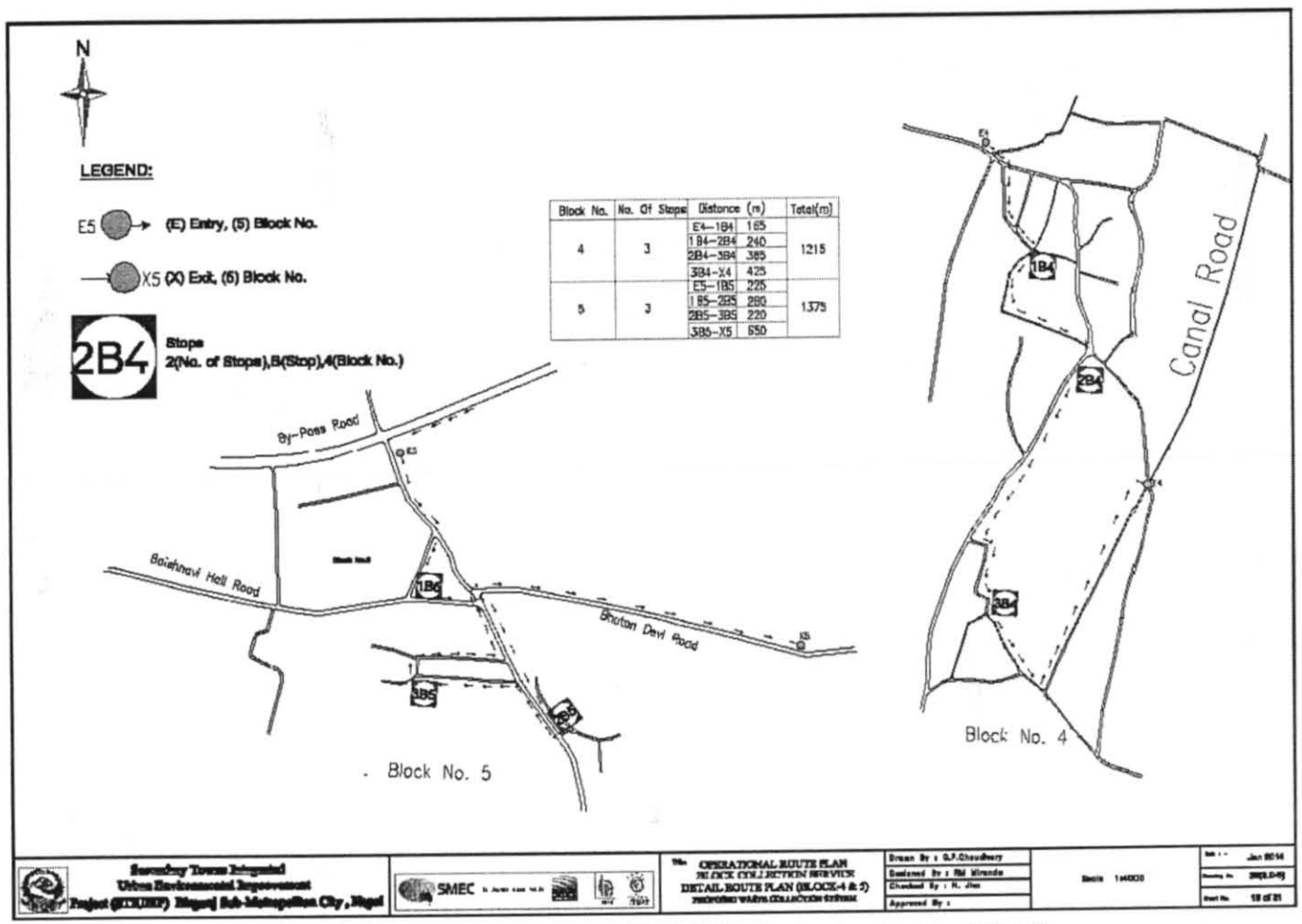


Figure 19-4. Operational Route Plan Block Collection Service Drg. No. 36(3.0-6)

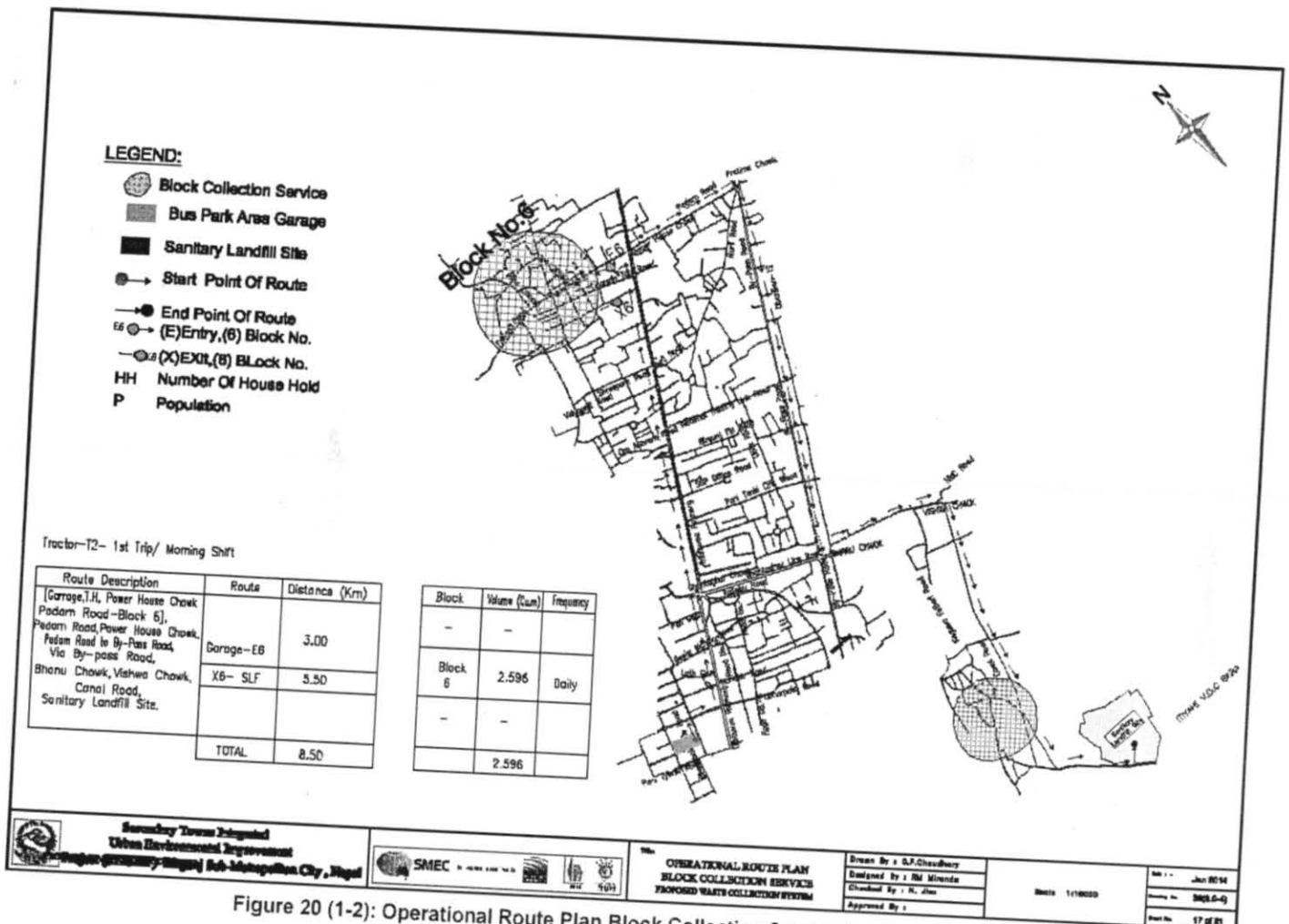
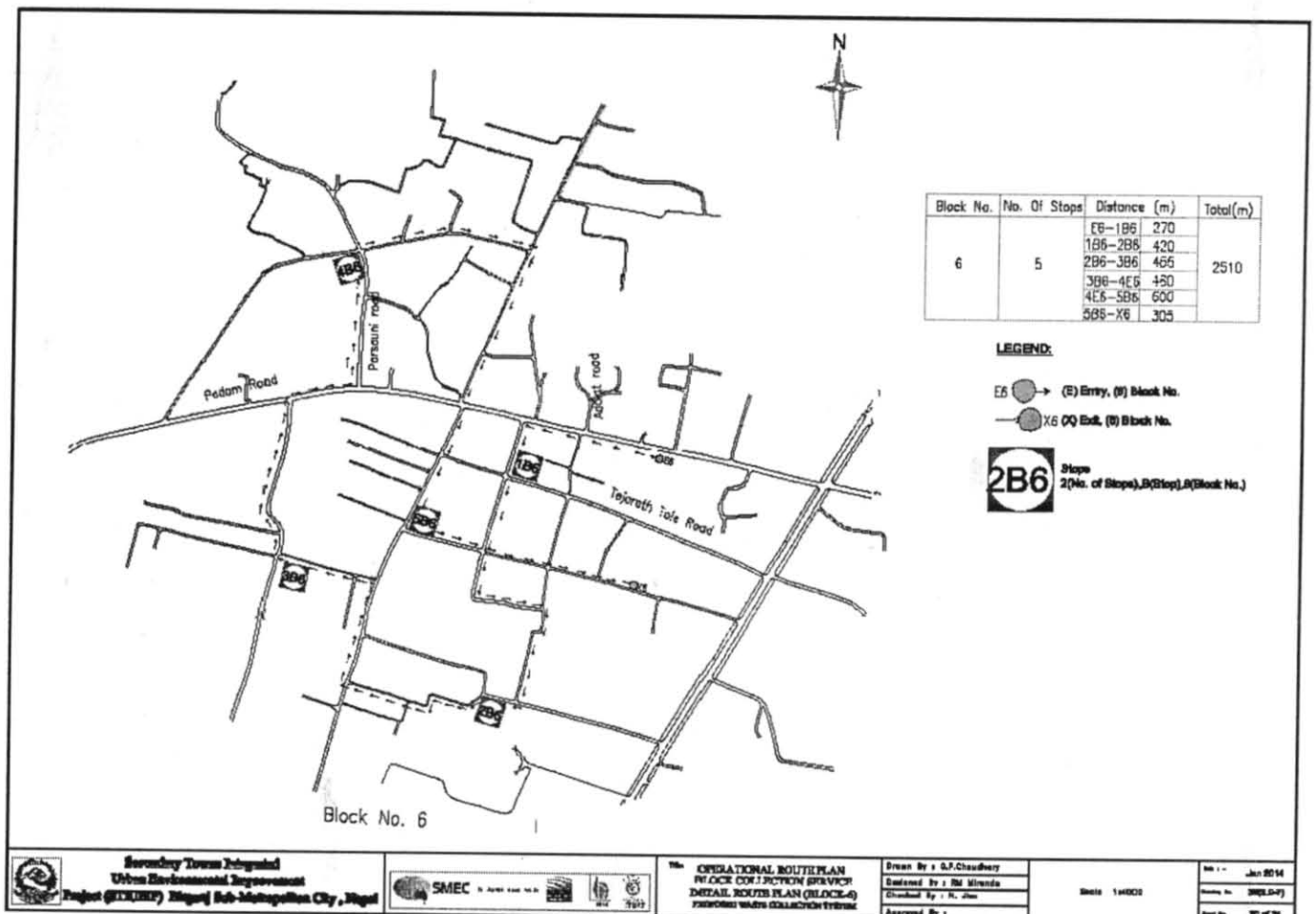


Figure 20 (1-2): Operational Route Plan Block Collection Service Drg. No. 36(3.0-4)



Block No.	No. Of Stops	Distance (m)		Total(m)
6	5	E6–1B6	270	2510
		1B6–2B6	420	
		2B6–3B6	465	
		3B6–4E6	480	
		4E6–5B6	600	
		5B6–X6	305	

Figure 20-2. Operational Route Plan Block Collection Service Drg. No. 36(3.0-7)

Table 18 shows the total block collection service waste projections during the first year of operation (2016) based on the estimated number of households and population to be serviced within the 6 blocks identified. The total estimated daily waste collection by volume is 9.45 cu.m. of which 4.83 cu.m. comprises the organic portion and 1.75 cu.m. comprises the inorganic portion. The plan is for the two fractions to be brought to the Integrated Solid Waste Management site daily for further processing and the final disposal of the residual wastes into the sanitary landfill cells area.

Table 18: Block Collection Waste Projections (2016)

Block Collection Waste Projections 2016									
Block No. Assignment	Block Location	Estimated No. of HH	Estimated 2016 Population	Waste Estimates, tonnes per day	Waste Estimates, cu.m. per day	Organic portion, by weight (51.09 %) in tonnes per day	Organic portion, by weight (51.09 %) in equiv. cu.m. per day	Inorganic Portion, total by weight (18.51 %)in tonnes	Inorganic Portion, total by weight (18.51 %) in cu.m.
1	Laxmanwa Gaon (Ward 18)	154	885	0.33	1.01	0.17	0.52	0.06	0.19
2	Thulo Pipra (Ward 17)	112	642	0.24	0.74	0.12	0.38	0.04	0.14
3	Bahauri Gaon (Ward 17)	224	1284	0.48	1.47	0.24	0.75	0.09	0.27
4	Nguwa Tole (Ward 19)	407	2332	0.86	2.67	0.44	1.36	0.16	0.49
5	Inarwa Tole (Ward 19)	147	842	0.31	0.96	0.16	0.49	0.06	0.18
6	Prasauni Road (Ward 16)	418	2266	0.84	2.60	0.43	1.33	0.16	0.48
Total		1462	8251	3.05	9.45	1.56	4.83	0.57	1.75

Table 19 below shows the estimated daily material balance for the Block Collection Service. It is estimated that of the 4.83 cu.m. that goes into the Composting Center, about 0.91 cu.m. of compost is produced. Of the 2.47 cu.m. going into the Waste Resources Processing Center (WRPC), about 1.67 cu.m. of mixed recyclable materials are produced in the process of sorting - including the recyclable materials recovered from the Composting Center. Total residual wastes that is estimated to be deposited at the sanitary landfill cells is about 7.06 cu.m. per day.

Table 19: Material Balance from Block Collection Service (2016)

MATERIAL BALANCE FROM BLOCK COLLECTION (First Year)	Total Tonnes	Total Cubic Meters	Estimated compost in tonnes	Estimated compost in cu.m.	Estimated recyclable in tonnes	Estimated recyclable in cu.m.	Estimated residual waste in tonnes	Estimated residual waste in cu.m.
Composting Center input (to be transported to Compost 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**	**0.29**	**0.91**				
to WRPC, Recyclable recovered (15% of composting center input)	0.23	0.72			0.23	0.72		
Residual in composting to landfill	1.09	3.38					1.09	3.38
Recyclable (WRPC) inputs (to be transported to WRPC)	0.57	1.75						
Recyclable product recovered (50 %; 90% of WRPC inputs)	0.31	0.94			0.31	0.94		
Recyclable Product Total	**0.54**	**1.67**			**0.54**	**1.67**		
Residual in recyclable recovery to landfill	0.26	0.81					0.26	0.81
Other inorganics (5.32%)sub-total to landfill	0.93	2.87					0.93	2.87
Residual Waste TOTAL to Landfill	**2.28**	**7.06**					**2.28**	**7.06**

4.9.3 Street Sweepings and Drain Cleaning

In Birgunj, collecting street sweepings from the waste piles on the roadway curbs are classified as secondary collection following the primary collection done by the street sweepers and drain cleaners. Primary Collection will be the prime responsibility of the Municipality (and NGOs under contract) while Secondary Collection will be the prime responsibility of the Contractor-Operator of the Birgunj Integrated Solid Waste Management project.

Table 20: Calculations of Street Sweepings Volume based on Ward Population and Waste Projections (2016)

Calculations of Street Sweepings Volume based on Ward Population and Waste Projections (2016)								
Ward	Population projections for 2016	Waste generation estimates, tonnes/day	Waste generation estimates, cu.m./day	Estimated street sweepings (25.08 %) by weight, tonne/day	Estimated street sweepings (25.08 %) by weight, cu.m./day	Estimated % covered by street sweepings	Estimated weight of street sweepings, tonnes/day	Estimated volume of street sweepings, cu.m./day
1	8,788	3.25	10.1	0.815	2.525	2.0%	0.02	0.05
2	10,151	3.76	11.6	0.942	2.916	20.0%	0.19	0.58
3	7,831	2.90	9.0	0.727	2.250	20.0%	0.15	0.45
4	2,297	0.85	2.6	0.213	0.660	30.0%	0.06	0.20
5	1,807	0.67	2.1	0.168	0.519	60.0%	0.10	0.31
6	3,685	1.36	4.2	0.342	1.059	50.0%	0.17	0.53
7	1,648	0.61	1.9	0.153	0.473	65.0%	0.10	0.31
8	1,115	0.41	1.3	0.103	0.320	60.0%	0.06	0.19
9	4,641	1.72	5.3	0.431	1.333	50.0%	0.22	0.67
10	6,691	2.48	7.7	0.621	1.922	80.0%	0.50	1.54
11	1,656	0.61	1.9	0.154	0.476	65.0%	0.10	0.31
12	3,302	1.22	3.8	0.306	0.949	60.0%	0.18	0.57
13	15,458	5.72	17.7	1.434	4.441	75.0%	1.08	3.33
14	13,136	4.86	15.0	1.219	3.774	70.0%	0.85	2.64
15	8,817	3.26	10.1	0.818	2.533	70.0%	0.57	1.77
16	13,142	4.86	15.1	1.220	3.776	40.0%	0.49	1.51
17	8,922	3.30	10.2	0.828	2.563	0.0%	0.00	0.00
18	11,614	4.30	13.3	1.078	3.337	20.0%	0.22	0.67
19	25,307	9.36	29.0	2.348	7.271	20.0%	0.47	1.45
Total	150,008	55.50	171.8	13.920	43.096	**39.6%**	5.52	**17.08**
Estimated No. of 6 cu.m.-Tipper Trips required								**3**
No. of 6 cu.m.-Tippers required (1.5 trips/day for each Tipper)								**2**
Note: Street sweepings consist of dust (silt and clay), sand stones, bricks, earth, with substantial amount of street litter consisting of organic and inorganic materials.								

Table 20 above shows the calculations of the volume of street sweepings based on ward population and waste projections for the base year 2016. Based on the waste characterization study of 2011, 25.08% by weight of MSW consist of street sweepings. Street sweepings consist of dust (silt and clay), sand stones, bricks, earth, with substantial amount of street litter

consisting of organic and inorganic materials. Estimates were prepared of the percentage contribution of the ward population that is serviced by the street sweeping service. The estimated total volume of street sweeping amounted to about 17.08 cu.m. This requires around 3 6-cu.m. tipper trips per day. Based on the allocation of new and old tippers in BSMC, it means that two tippers will be able to manage the services required. It is also expected that the number of tipper-trips may even decrease as soon as the proper 3Rs program is implemented by the communities themselves and street litter will be considerably reduced. When that time comes, the service will be aptly called street cleansing and sanitation service that will be provide mostly drainage de-clogging and sanitation services.

4.9.4 Pick-Up Service

The Pick-up service continues the present practice of hotels, embassies, restaurants and other establishments of requesting waste collection services from the Municipality for an agreed fee per collection. The BSMC have established fees for each type of pick-up service. In the proposed system, however, the Municipality will provide such a service through the Contractor-Operator "on demand or request", on a pre-determined schedule, and required to be segregated into bio-degradable (organic) and non-biodegradable (inorganic) wastes in their own containers by the establishments. The method of payment of fees will be agreed upon between the Municipality and the Contractor-Operator. Tippers or Tractor Trailers will be used for this purpose.

4.9.5 Kilometers of Road Serviced

The proposed street sweeping collection service will include an additional 5.88 km. of roadway cleaning from the existing 30.58 km covered by the Sanitation Section in 2012. The proposed street cleaning service is expected to be much less in terms of volume when the 3Rs concept is implemented in Birgunj and will be aptly called street sweeping service. Only the inert or residual fraction of municipal solid waste and uncontrolled litter from the streets and sources of waste along the roadway are expected to be significant as the sub-metropolis is promoting 3Rs.

On a continuing basis, the collection service objective is to organize and prepare schedules that will collect, transport and dispose of solid waste for further processing at the ISWM site as efficiently as possible. As mentioned earlier, the existing 37 waste collection points were used as starting points for establishing the 11 skip container locations to initialize the system and deciding the designated far-flung areas for block collection. The locations and ward area coverage of the skips should further be improved or revised as the waste collection program progresses. New transport routes should be planned to increase the present collection service of the fleet of vehicles and tractor-trailers to 60% or greater. The assessment of improved road conditions and coordinating new routes with the Municipality will be a priority activity to increase collection service coverage.

The collection efforts will be coordinated with the ward leaders, the households and the NGOs who are working on the 3Rs as this would decrease their load and increase collection efficiency. The concerted efforts are targeted to minimize waste generation and reduce waste at the source or at the points of generation.

Wards shall be organized to be responsible for the collection, segregation, recycling of biodegradable, recyclable, compostable and reusable wastes. The resulting residual wastes shall then be transferred to the waste processing resources center for composting and recycling at the Sanitary Landfill site. Referring to 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 by way of backyard composting and reuse or by the redemption of their own 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.

The transport routes should be reviewed and re-established regularly to increase the present collection service of the fleet of vehicles and trailers. The assessment of the conditions of the roads and coordinating new routes with the municipality should be a priority activity to increase collection service from the present 30-40% to at least 60%. Record keeping should be efficiently performed at all times.

Vehicles used for collection and transport of solid wastes shall have appropriate compartments to encourage source separation (organic in one compartment and inorganic in the another) and facilitate efficient storing of sorted wastes while in transit. The waste compartments shall have secure covers to ensure the safe containment of solid wastes while in transit.

The following is recommended for the collection, transport and handling of solid waste system:

- All collectors and other personnel directly dealing with collection of solid waste shall be equipped with personal protective equipment and paraphernalia such as, but not limited to gloves, masks and safety boots, to protect them from the hazards of handling solid wastes.

- The City or the wards shall provide necessary training to the collectors and personnel to ensure that the solid wastes are handled properly in accordance with the city's solid waste guidelines.

- Collection of solid waste shall be done in a manner that prevents damage to the container and spillage or scattering of solid waste within the collection vicinity. All waste collection equipment should be covered by tarpaulins or similar flexible and waterproof cover material throughout the duration of the collection and transport routes except when loading and unloading.

- Collection equipment e.g. tractor trailers, trucks, etc. shall be maintained in good condition and kept clean to prevent the harboring of vectors and the creation of nuisances.

- The use of separate collection schedules and/or separate trucks or haulers shall be required for specific types of wastes. Otherwise, vehicles used for the collection and transport of solid wastes shall have the appropriate compartments to facilitate efficient storing of sorted wastes while in transit: 1) organic biodegradable and compostable, 2) inorganic reusable and recyclable, and 3) residual wastes that will go directly to the sanitary landfill cells area. There shall also be a separate container provision for special wastes in the MSW stream deemed hazardous and toxic e.g. aerosols, chemical containers, e-wastes, etc. that shall be disposed of according to the prevailing Nepalese laws regarding toxic and hazardous wastes. The waste compartments shall have secure and weatherproof covers to ensure the secure containment of solid wastes while in transit.

- Vehicles shall be operated to consider road size, current weather and road conditions, and capacity to ensure the safe and efficient collection and transport of solid wastes.

- For the purpose of identification, vehicles (tippers, tractor trailers, rickshaws and handcarts) shall bear the identification/body number, the name, and telephone number of the contractor/agency collecting solid wastes.

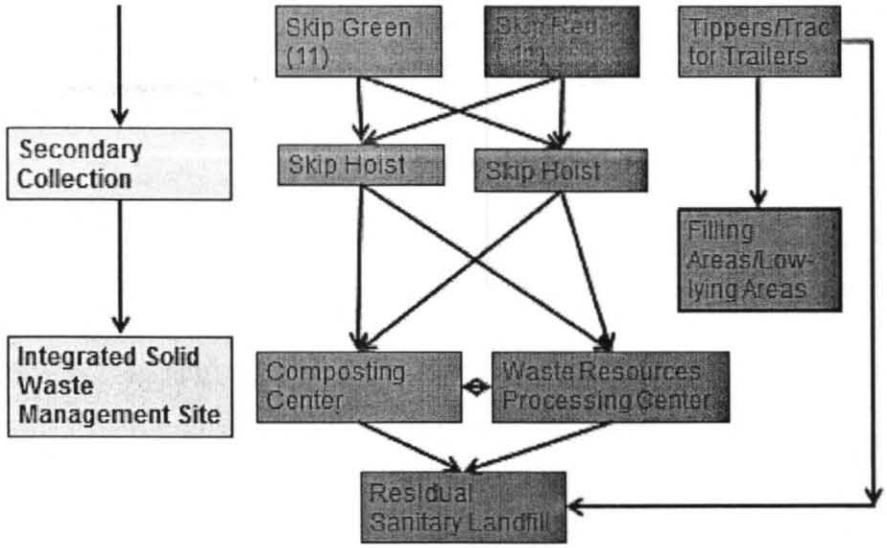


Figure 21: Proposed Transport and Disposal System

4.9.6 Proposed Transport and Disposal System

The secondary collection system will be undertaken by the BSMC through a service contract with a contractor-operator of the waste collection, transport and disposal system. The segregated wastes will then be transported to the Integrated Solid Waste Management Site, specifically to the Composting Center for the bio-degradable, compostable organic wastes; the Waste Resources Processing Center for the non-biodegradable, reusable, recyclable inorganic wastes; and the Sanitary Landfill cells area for the residual wastes.

Table 21 below shows the estimated daily material balance from the municipal waste stream starting in the base year 2016 of the proposed collection program of the wastes ending up at the Integrated Solid Waste Management site for further processing. It is estimated that of the Skip container inputs and Block collection inputs of 19.53 tonnes of compostables to the Composting Center, about 3.66 tonnes of compost is produced. Of the 11.31 tonnes going into the Waste Resources Processing Center (WRPC), about 8.78 tonnes of mixed recyclable materials are produced in the process of sorting - including the recyclable materials recovered from the Skip containers, Composting Center and Block collection service. Total residual wastes that is estimated to be deposited at the sanitary landfill cells is about 23.21 tonnes per day.

Table 21: 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**

4.10 Solid Waste Collection Vehicles and Equipment

4.10.1 Existing Collection Fleet and Equipment

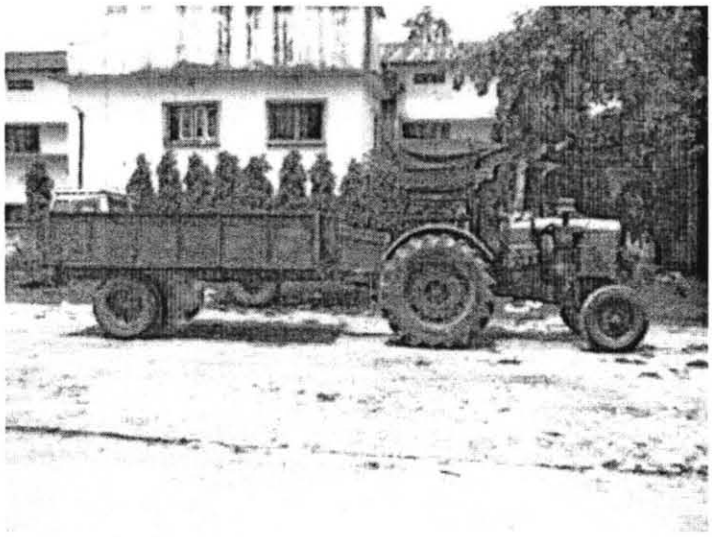
During the DSC solid waste equipment survey, the Birgunj sub-metropolis in-charge of trucks/vehicles (tractors and trailers, etc.) collection equipment and repair and maintenance functions discussed the present strategy and serviceability of collection services, collection cycle times, frequency of collection, vehicle/equipment life, spare parts and replacement costs.

The following were verified in terms of existing serviceability of equipment / vehicles for regular MSW collection and disposal services and other sanitation /construction works:

- Handcarts (40 nos.),
- Tricycle (14 nos.),
- Tractor trailer (14 nos., 3m^3 capacity),
- Tractor trailer (14 nos., 4 m^3 capacity),
- Tipper (6 m^3 capacity),
- Back hoe loader (1 no.) and
- Suction Tanker (2 nos., 3 m^3 cap).
- One Suction tanker not operational.

Tractor-Trailer

The typical Tractor-Trailer used for waste collection from wards and households is shown in Photo 15 below:



Trailer dimension:
Length = 10 ft. (3.0 m)
Width = 6 ft. (1.83 m)
Height = 2 ft. (0.61m)

Photo 15: Tractor-Trailer 1

he following was the inventory of solid waste vehicles and equipment as of August 2012:

Table 22: Inventory of SWM Collection Vehicles and Equipment (August 2012)

Type	Nos.	Capacity in tonnes (t)	Make or Brand	Age (yrs)	Status (operational of non-operational)	Repair/ maintenance requirement	Approx. remaining Life
B.S.M.C. Workshop Office – Mechanical Operations & Maintenance Dept.							
Tippers	2	3	Eicher	12	Operational, well-conditioned	Routine, low repair and maintenance cost	5-10 yrs
Tractor&trailer (Type 1)	5	2	Eicher & Local	8-10	Operational	Conversion of trailer to hydraulic-unloading	10-15 yrs (tractor)
Tractor&trailer (Type 2)	4	1.5	Eicher & Local	8-10	Operational	Conversion of trailer to hydraulic-unloading	10-15 yrs (tractor)
Tractor&trailer	1	2 to 3	Massey	20	Non-operational	No spare parts available	Unknown
Tractor&trailer	3	2 to 3	Hindustan	12	Non-operational	No spare parts available	Unknown
Total	15						

Of the 15 tractor-trailers under the Mechanical Operation and Maintenance Dept. workshop, four (4) tractors are not operational. See Table 22 above. Spare parts are no longer available because the models are old. One (1) "Massey" brand is approximately 20 years old. Three (3) are about 12 to 13 years. The tractors generally incur high repair and maintenance costs.

In terms of remaining life, the tractors are on the average 15 years old and have a potential remaining useful life of 25 years. The trailers, on the other hand, are about 1 to 2 years old and need repair, specifically using channel and metal sheets for repair of the bodies. The useful life of a trailer is about 2 years on average.

The average operating speeds of tractors in the "terai" area is about 20 to 30 kph.

The cost of a new tractor-trailer is between 10 to 11 laks (NPR1,000,000 – 1,100,000),

The Workshop Manager proposes to convert all trailers to hydraulic-unloading trailers. Of those operational, two(2) hydraulic trailers will need to be purchased (approx. cost =NRs 300,000) and the rest can be repaired and converted to hydraulic trailers (approx. cost =
Is NPR 150,000)

Tippers (2 nos.)

- Type I: 2-tonne capacity
- Type II: 1.5-tonne capacity

Note: The tippers are not covered by tarpaulins or other type of cover material to secure loaded wastes and avoid spillage while performing collection or in transit to disposal sites. This was suggested by the DSC during the meeting.

Length = 12 ft
Width = 6.5 ft.
Height = 2.5 ft. (excluding add'l panel height in front and back sides)

Loose Volume =12x6.5x2.5 = 195 cu.ft. (5.53 cu.m.), say **6 cu.m. (heaped)**

Photo 16: Tipper

Logbooks for the collection vehicles and other heavy equipment are kept and maintained in the Workshop Manager's office and was made available for inspection.

Travel Time per collection cycle

Tipper – 1 trip on one route collection travels about 12 km. Birgunj is flat so there are no delaying factors i.e. rolling terrain except for the poor road conditions – muddy or flooded - during the monsoon season. It takes 3 hours on average to complete one collection cycle (departing from the BSMC equipment yard and returning after disposal from respective disposal areas). One tipper spends ½ hour to 1 hour on special collection, i.e. when the Indian Embassy requests tippers from BSMC Sanitation.

Rickshaw and Handcarts are managed, repaired and maintained by the Sanitation Section separately from the Tippers and Tractor-trailers, which are managed by the workshop.

Generally, there is no problem with the repair and maintenance of collection vehicles and equipment. Spare parts are available for the operational vehicles.

Tractors

The tractor repair costs range from NPR 10,000 to 12,000. This is considered a low maintenance cost. The cost of fuel is high, however, at NR 92/liter of diesel at the time of the survey.

New front tires cost NR 3,000 and lasts for 2 years usually, while the rear tires cost NPR 25,000 and lasts for 10 years.

Trailers

The trailer life is between 8 to 10 years. One trailer costs around NPR 20,000 without the hydraulic capability attachment.

Other Equipment

The other equipment maintained by the BSMC Workshop are:

Backhoe and Loader (2 cu.m. capacity, 1 unit) used for excavating and clearing drains and solid wastes. The loads are deposited along the sides of the drainage canals and roadways. These are in turn picked up by tippers after 2 to 3 days. The backhoe is 2 years old and was purchased at NR 3,000,000. Brand is JCB of India and was originally from Germany.

Photo 17: Backhoe and Loader

Suction Machine with 3,000 liters capacity – used on demand from people's request for de-sludging or septic tank de-clogging that would also improve flow in drains or rivers and fill open land. The following charges are charged:

Household – NPR2,000 per trip
Commercial Buildings – NPR 5,000 per trip
Industrial Buildings – NPR 9,000 per trip

Photo 18: Suction Machine

4.10.2 Proposed Waste Collection Fleet and Equipment

It is proposed that the fleet of waste collection equipment should be housed in a new Equipment depot and parking lot to be provided by the Municipality. The old bus park in Ward 13 has been identified and proposed for this purpose. Alternatively, depending on the space allocation decided upon and to decrease the distance between the service areas and the starting point of the collection fleet, some vehicles and equipment can park at the ISWM site parking areas.

Proposed List of Equipment for SWM System

1.	Refuse Collector Hoist Truck	- 2 nos.
2.	Backhoe Loader	- 1 no.
3.	Track Dozer CAT D6	- 1 no.
4.	Solid Waste Skip / Container	- 26 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 (50-liter capacity)	- 152 nos.

1. List of Solid Waste Equipment to be Purchased under Package II

1.	Track Dozer CAT D6	- 1 no.
2.	Backhoe Loader	- 1 no.
3.	Solid Waste Skip / Container	- 8 nos.
4.	Refuse Collector Hoist Truck	- 1 no.
5.	Tractor with Trailer (3.4 m^3)	- 4 nos.
6.	Tipper (6 m^3)	- 1 no.
7.	Rickshaw (50" × 33" × 30")	- 4 nos..
7.	Rickshaw (39" × 39" × 16")	- 36 nos.
8.	Hand Cart (60" × 36" × 18")	- 25 nos.
9.	Hand Cart (48" × 30" × 18")	- 15 nos.
10.	Shredding Machine	- 2 nos.
11.	Single Axle Weighting Scale	- 1 nos.
12.	Platform Weighing Scale (balance)	- 1 no.
13.	Waste Bins (150-liter capacity	- 10 nos.
14.	Waste Bins (50-liter capacity)	- 152 nos.
15.	Portable landfill gas monitoring device	- 1 no.

(electro-mechanical machines and equipment related with workshop not included here)

2. List of Vehicle to be Received from IRDC (NGO)

1.	Refuse Collector Hoist Truck (new imported)	- 1 no.
2.	Tipping Paddle Rickshaw	- 38 nos.
3.	Solid Waste Skip / Container	- 18 nos.

4.10.3 Vehicle Preventive Maintenance and Replacement Program

Birgunj sub-metropolis needs to institute a vehicle preventive maintenance program for both the new and old collection vehicles (tippers and tractor-trailers, etc.) and landfill equipment (track dozers, backhoe, etc.). This is in addition to the manufacturer's recommended preventive maintenance program and schedule. The repair and maintenance of the smaller equipment for solid waste should also be included. Replacement parts that are very fast moving should be kept in stock so as not to disrupt the waste collection functions whenever they are requisitioned.

A replacement program should also be planned so that not all vehicles and equipment go out of service at the same time. This is important because of the critical functions of solid waste management that need to be responsive and timely.

CHAPTER 5: THE INTEGRATED SOLID WASTE MANAGEMENT (ISWM) SITE

5.1 The Proposed Integrated Solid Waste Management (ISWM) Site

The ISWM site has a total property 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 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 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 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 sub-metropolis and hauled to the ISWM site for further processing. The landfill site will host a municipal-level Composting Center, 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 at least a 1-tonne per day 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 design drawings of the above (except for those intended for future development) have been completed and were used in the cost estimating and preparation of the detailed Bill of Quantities that form part of this Final Report.

5.2 Design of the Integrated Solid Waste Management Master Plan

The proposed 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 to be developed within an 10.76 hectare property owned by the Birgunj Sub-Metropolitan City.

The proposed 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 80.5 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 6):

- 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 Detailed Design Drawings highlight all the physical facilities of the Integrated Solid Waste Management Site. The buildings and site infrastructure were designed in accordance with Nepalese design criteria and standards.

The sizing and detailed design and technical specifications of the facilities were finalized during the detailed design stage. The final cost estimates are provided in the separate volume of the report, Quantity and Cost Estimates.

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. Please see Annexes 1 and 2 for the Hydrology Report and the Geotechnical Report respectively. The site limitations that contribute to the high cost of developing the site into a sanitary landfill 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.

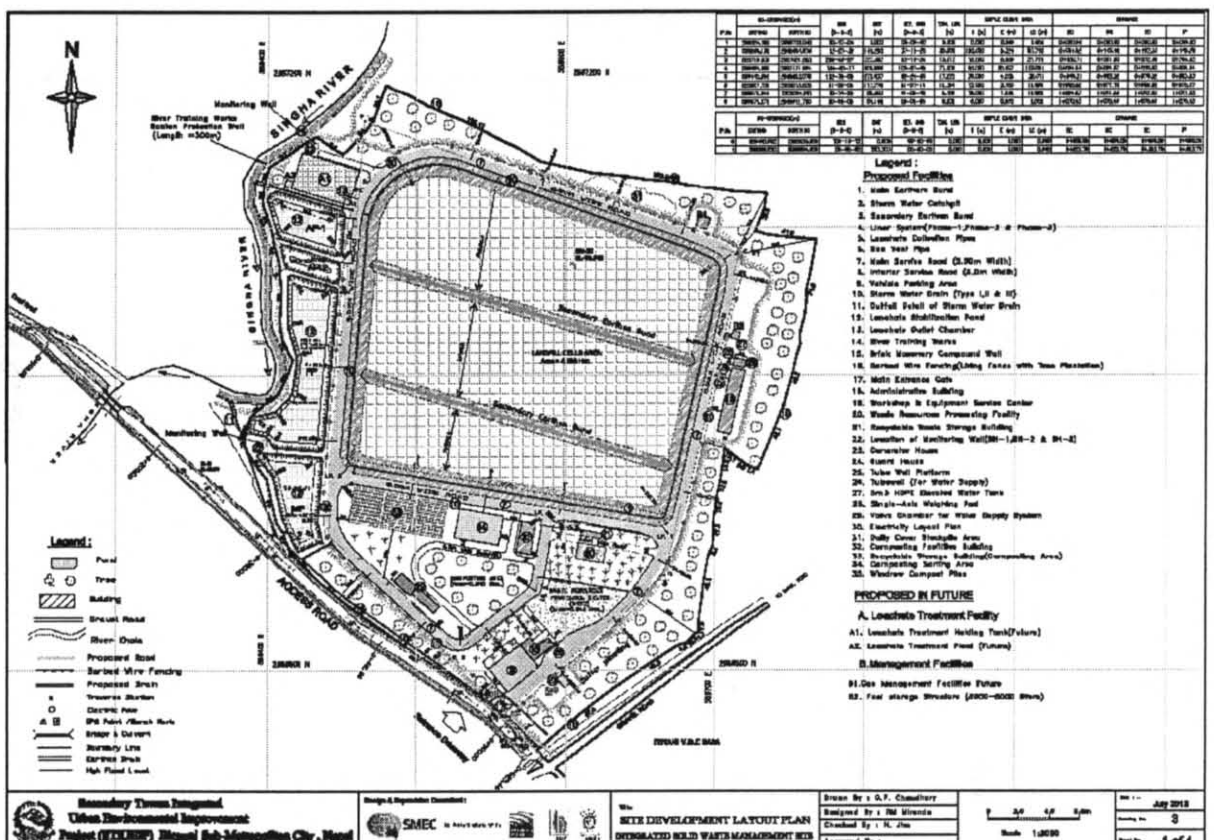


Figure 22(1-2): Site Development Layout Plan Drg. 3(1 of 4)

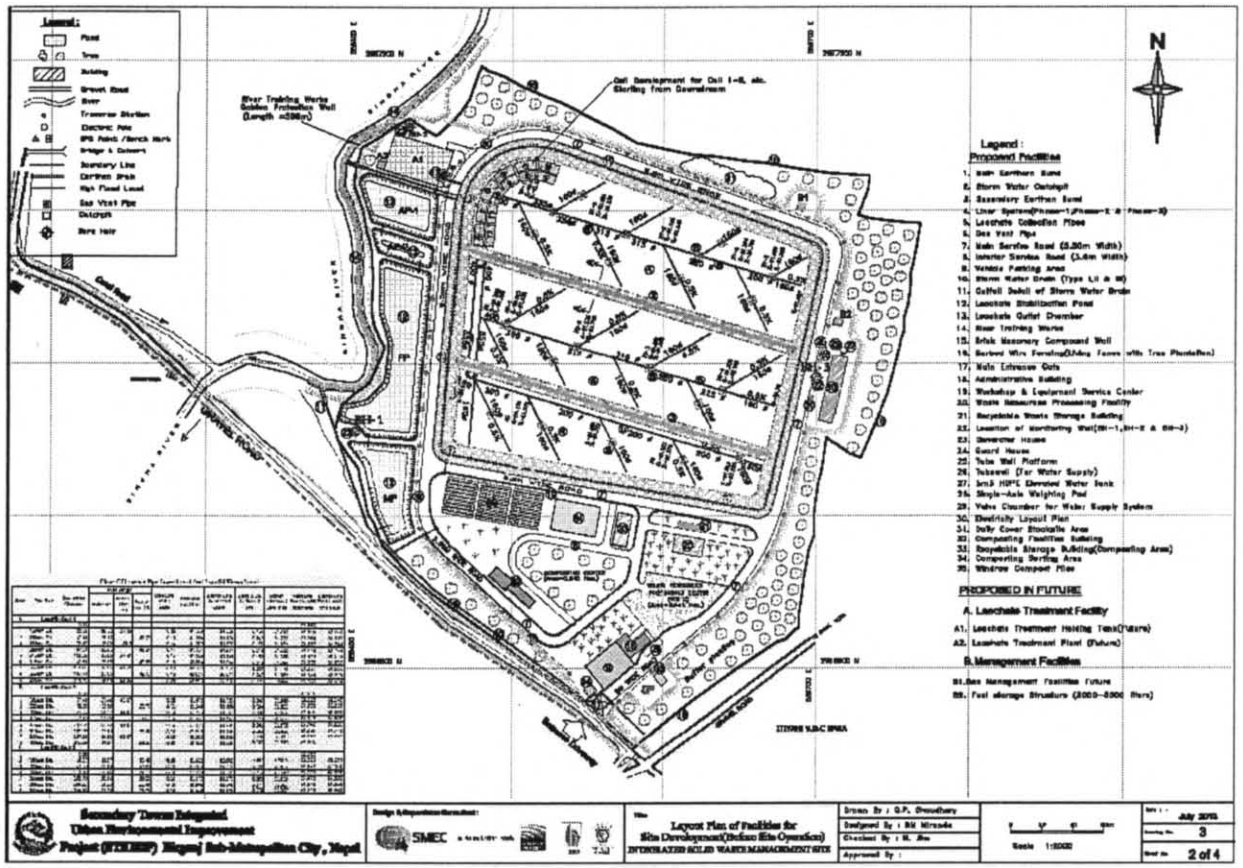


Figure 22-2. Layout Plan of Facilities for Site Development (before site operational) Drg. 3(2 of 4)

5.3 Design of the Sanitary Landfill Cells Area

The findings of the Hydrology Report concluded that the site has the capability to drain during the onset of the monsoon seasons because of the natural flow from the Singaha River regime. Control sections of Singaha River were studied. High flood elevations for different storm return frequencies were plotted and an elevation-discharge curve was developed for the catchment area of the river ending at the site and its vicinity. (See Annex 1: Hydrology Report.)

The Control elevation set for the lowest point of the landfill base liner is elevation 80.5.which was set for the lowest invert elevation of the HDPE perforated leachate collection main pipe downstream of the landfill cells area. Please see Section X-4: X-4 of the site drawings that follow.

The locations of the facilities and the landfill area for the site was based on the flat topography, anticipated traffic patterns, location of existing roads, location of the river channels, etc. Liner excavation and fill side slopes were designed at 3 to 1, horizontal to vertical. Final cover is benched every 3 meters in elevation with slope of 4 to 1, horizontal to vertical. A main bund encloses the perimeter of the landfill cells area while secondary bunds on an east-west orientation are to be built to separate each phase of the landfill. There will be three phases and the daily cells development will start at the lowest grade design elevation near the outlet chamber of the leachate collection piping system.

Each landfill lift was designed for a 1.5 meter height and fixed control elevations where set 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.

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

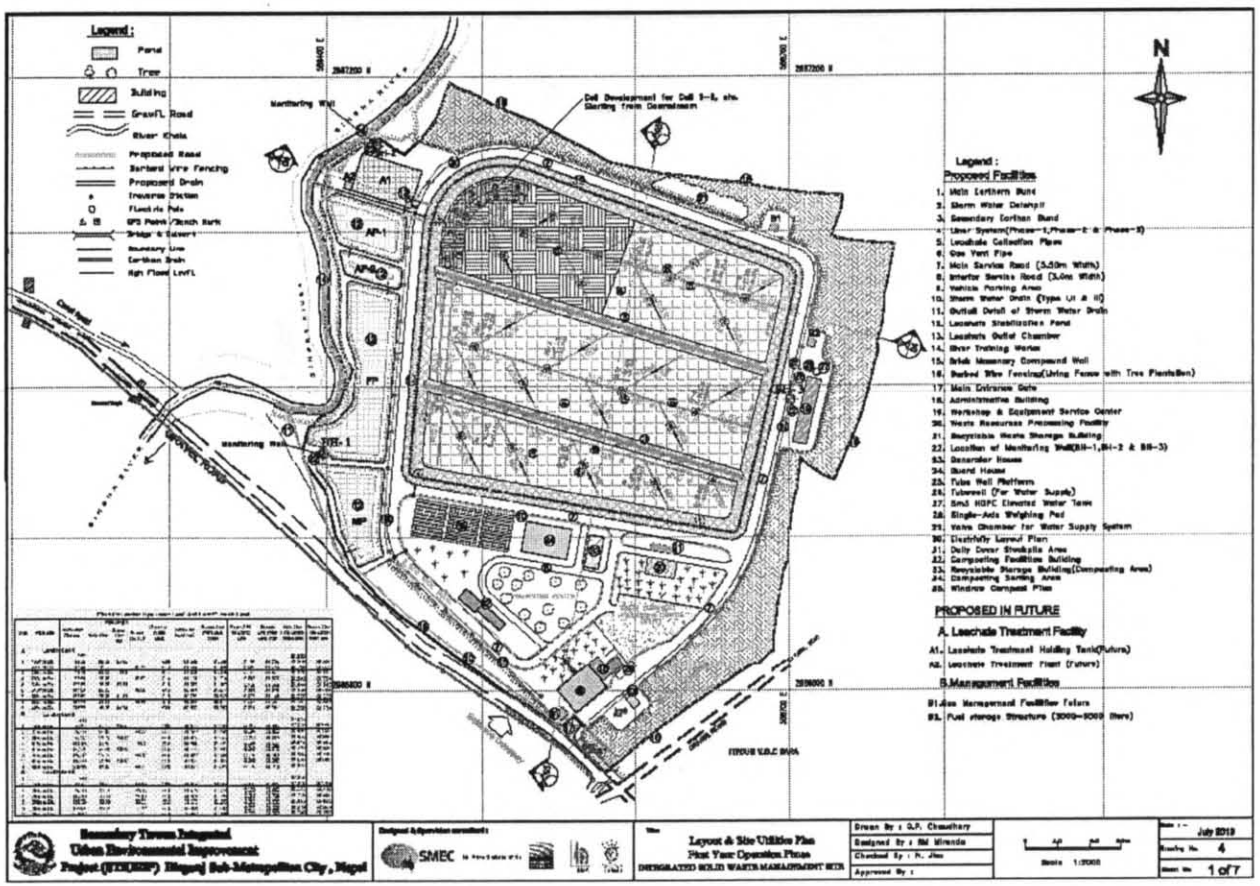


Figure 23 (1-2): Layout and Site Utilities Plan (First Year Operational Phase) Drg. No. 4(1 of 7)

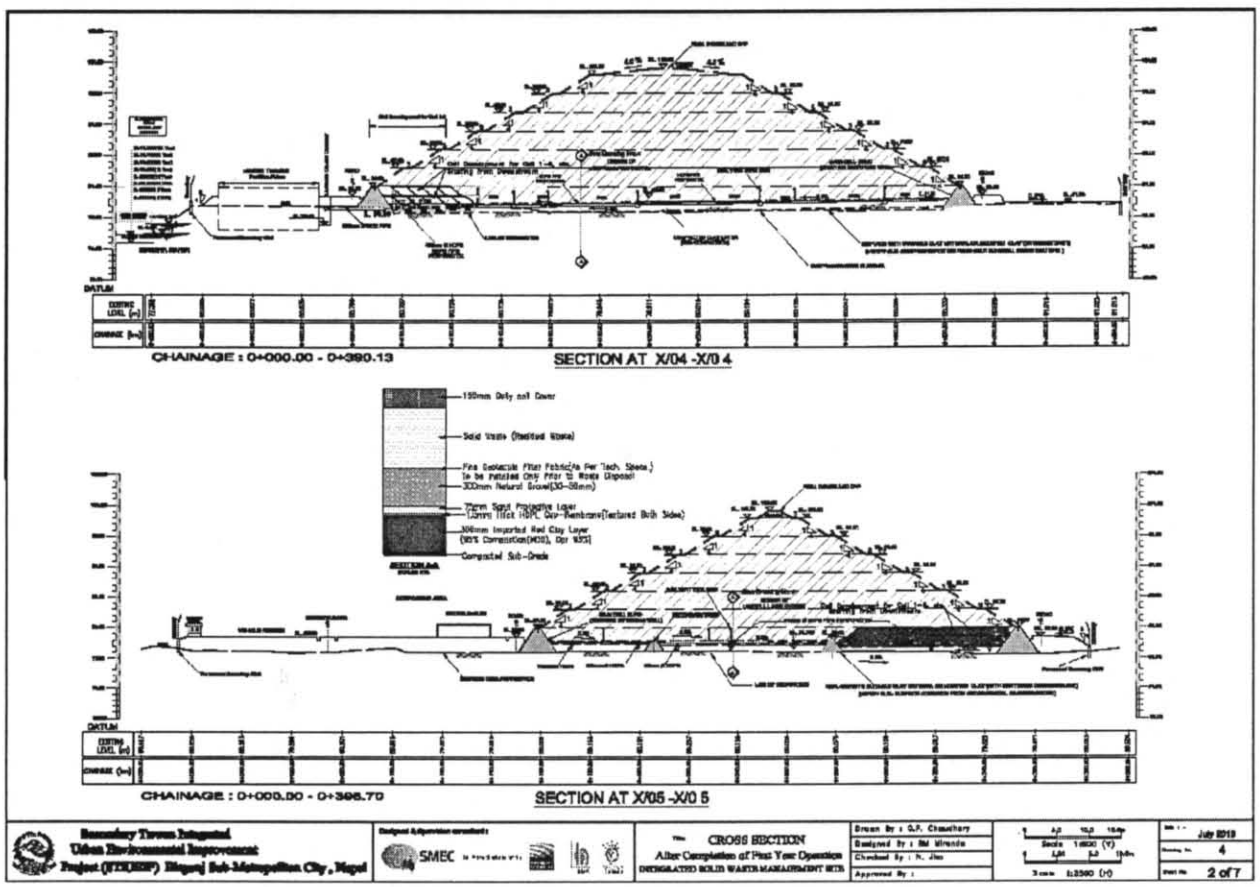


Figure 23-2. Cross-section (after First Year Operation Phase) Drg. No. 4(2 of 7)

5.4 Phasing Plans for the Sanitary Landfill Cells Area

The Sanitary Landfill Cells area is divided into 3 phases, namely: Phase 1, Phase 1 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 in the following drawings.

Phase 1 starts from the lowest elevation of the finished grade of the base liner system at an approximate elevation of 81.2. The first deposition by the contractor-operator is shown in Section Y-Y. Placement of residual 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.

The secondary bund 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. 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.

In its full development, the landfill cells area has the capacity for approximately 398,307 cu.m. of compacted volume of residual wastes. It is estimated that if properly managed and with continuous 3R activities in BSMC, 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 Birgunj sub-metropolitan city because of the need for providing funds for the closed facility after 15-20 years. Some possible uses of the landfill cells eventually will be as an ecology park with some selected plantings and trees, flowering plants and to being a continuing center for environmental activities such as recycling and composting, and tree planting nurseries, and the like.

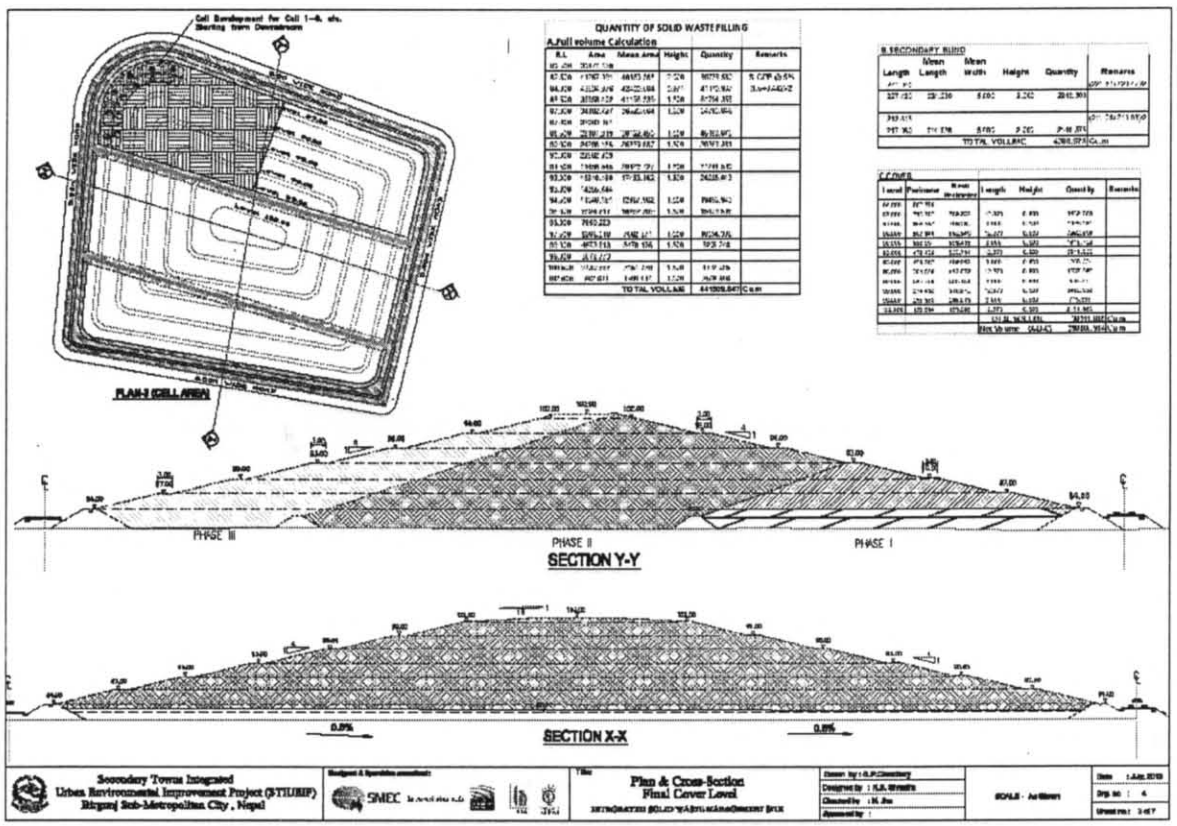


Figure 24 (1-2): Plan and Cross-section Final Cover Level Drg. No. 4(3 of 7)

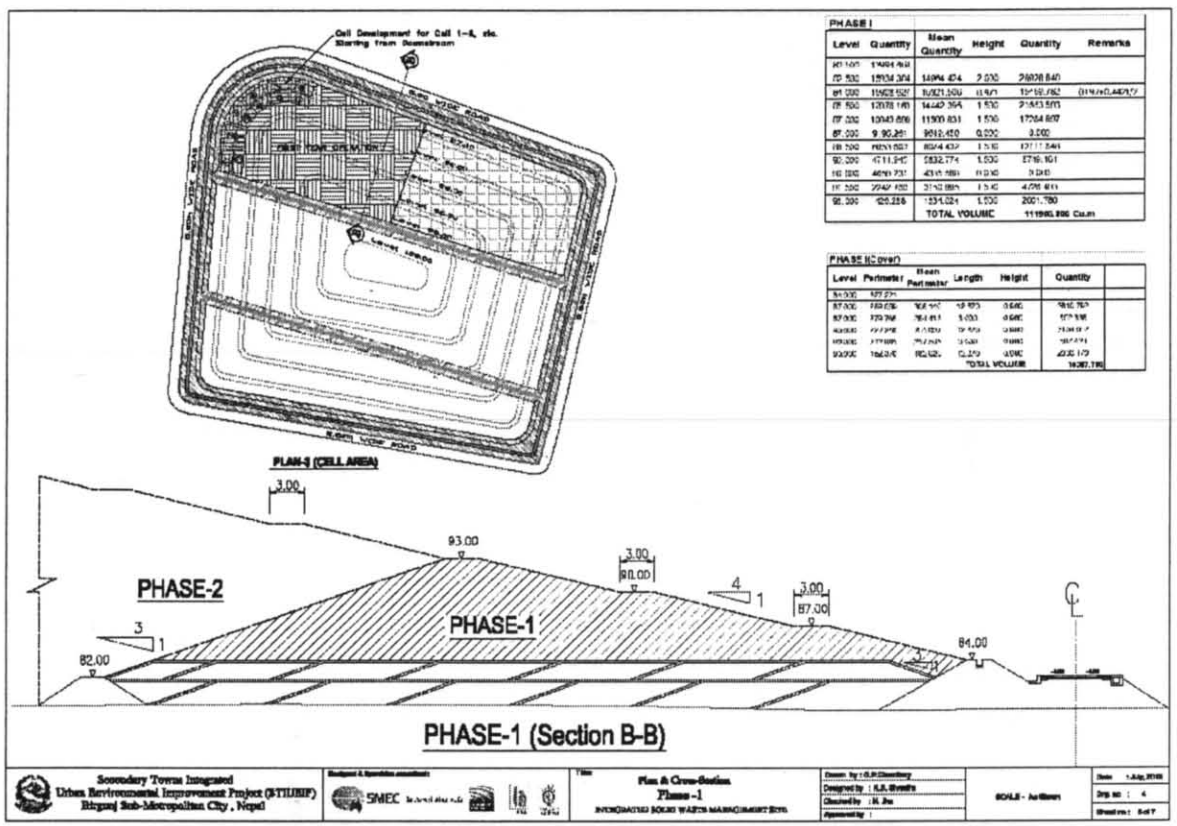


Figure 24-2. Plan and Cross Section Phase 1 Drg. No. 4(5 of 7)

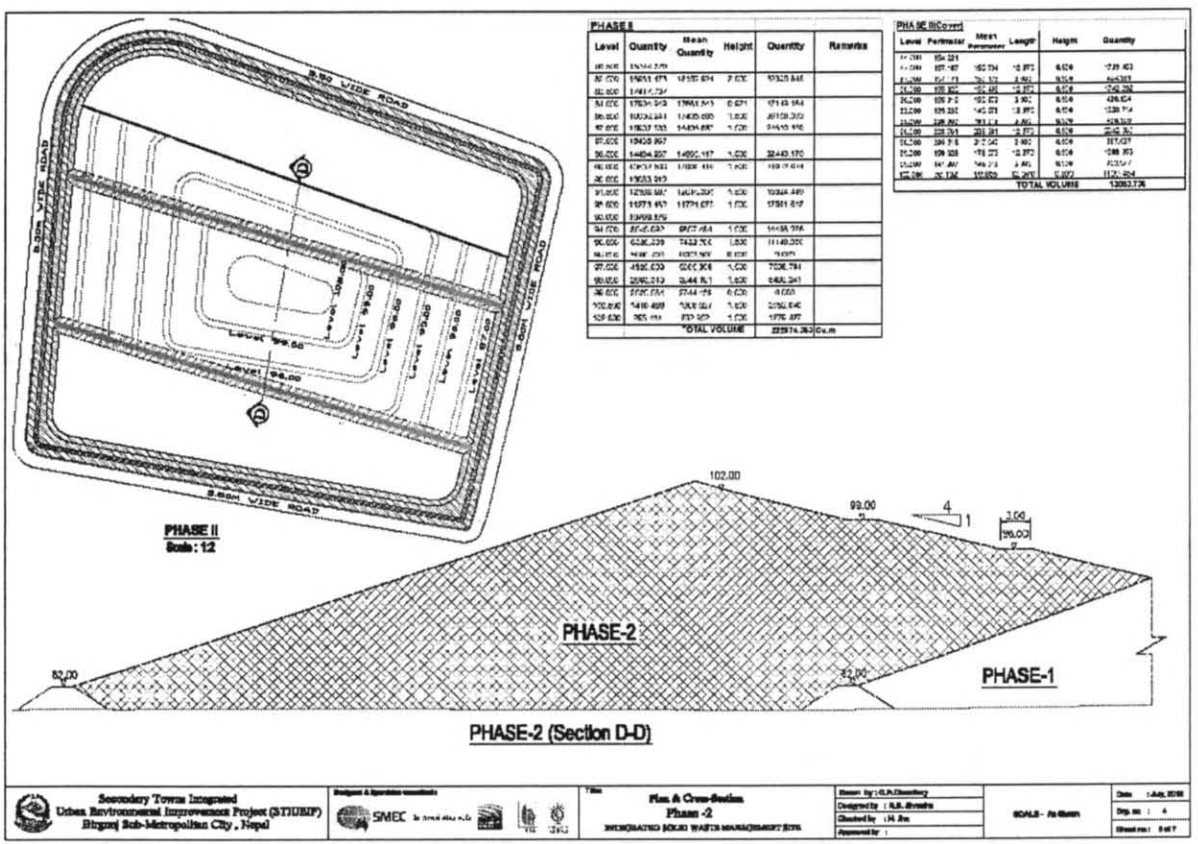


Figure 24-3. Plan and Cross Section Phase 2 Drg. No. 4(6 of 7)

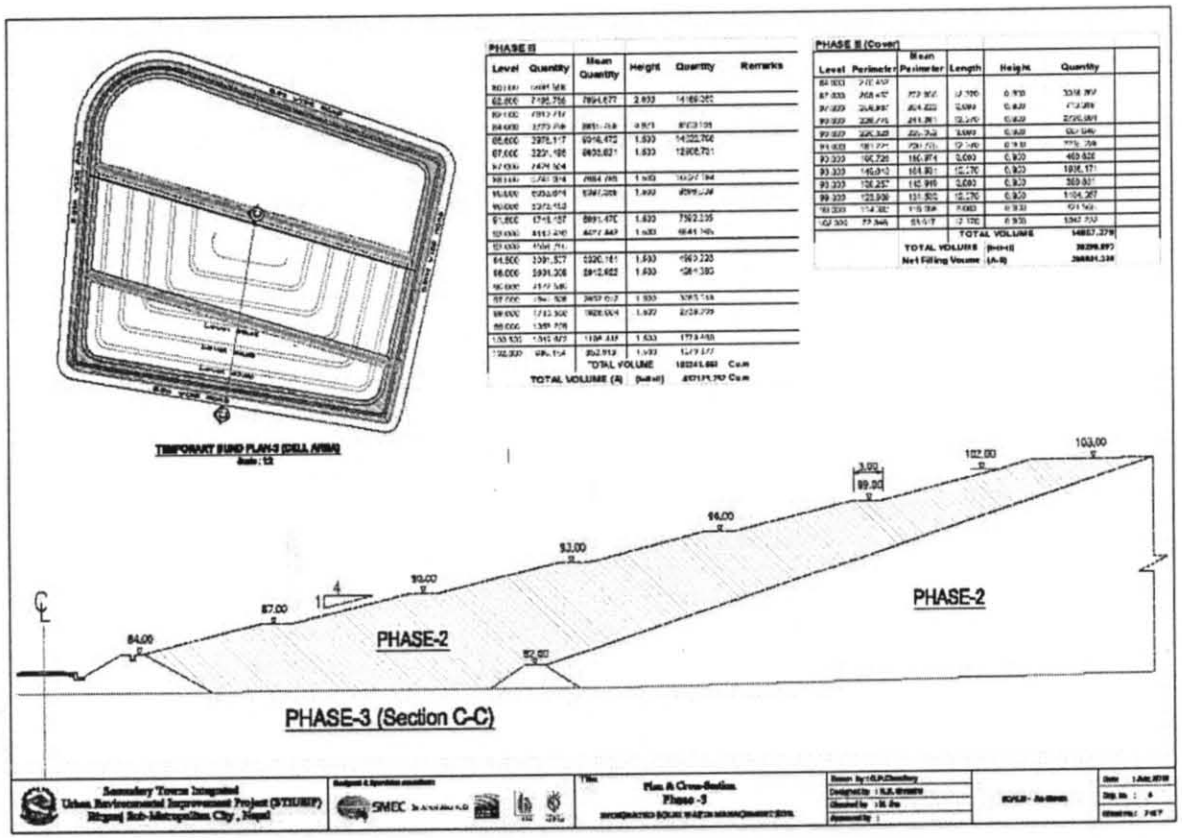


Figure 24-4. Plan and Cross Section Phase 3 Drg. No. 4(7 of 7)

5.5 Variations in Sanitary Landfill Life Based on 3Rs and Worst-case Scenario

The sanitary landfill cells area is expected to be able to accommodate residual wastes from BSMC for at least 15 years. The life of the landfill is highly dependent on the success and sustainability of the 3Rs activities at best and the total non-implementation of the 3Rs as the worst case scenario. Considering the existing situation in BSMC, the actual scenario would probably be somewhere in between where during the early years the waste diversion for 3R targets would be slow and - depending on the sub-metropolitan city's leadership - would improve as the years go by.

To illustrate, Tables 23 and 24 are provided to show the waste projections in the best and worst case scenarios starting during the base year of 2016. With 3Rs and assuming a waste diversion of 30% (diverted into pre-collection and post-collection composting and recycling), and a level of collection service of 60% (from the 2013 level of 39.2%), the landfill life will last well over 20 years. The waste projection comes to about 382,639 cu.m. of compacted residual waste while the capacity of the landfill cells area is more with 398,807 cu.m. On the other hand, examining the worst case scenario projections where there will be no 3Rs and all MSW are mixed into the landfill cells, the life of the landfill will only last between 13 to 14 years, These volume projections assume that existing wastes in the present dumpsites and other open dumps on the roadsides and public places are not hauled to the ISWM site and the sanitary landfill cells. Whereas such waste transfer activities to the landfill if decided upon by BSMC in its efforts of cleaning up Birgunj will further even shorten the life of the landfill.

These scenarios can further be analyzed against the variable of when Phases 1, 2 or 3 are activated for use as shown in Figure 25. From examining Figure 25 and after several trials of beginning the use of Phases 2 and 3 at different years, it was found that the most advantageous scenario is for Phase 2 to start during the 8th year of operation and Phase 3 towards the last few years before reaching the 20th year. From the chart this means that the shift from the no 3Rs curve to the with-3Rs curve gradually happens. (See middle concave downward curve). This seems to be the closest to the reality of taking several years before the 3Rs can be effectively popular. Looking at the curves of the figure, the best fit, labeled as Option 3 is when the middle curve originates from the no-3Rs curve and transfers across to the with-3Rs curve and continues on to the 26th year in the graph. This is the most realistic projection. The BSMC should continue with this analysis and modify their strategy of landfilling operations if necessary based on historical data and once they consider starting the use of Phases 2 and 3 of the sanitary landfill.

In order to assess the life of the sanitary landfill, the estimates of landfill airspace was compared with the actual waste estimates and projections through determining demand for air space versus the expected operations from the Waste Collection and Transportation program that was designed for the project. It is necessary to review this program with the Municipality to enable them to adapt to the principles of design that is being addressed here.

Table 23: Projection of Waste Quantities and Sanitary Landfill Volume Capacity (with 3Rs)

		Birgunj Sanitary Landfill																					
		Projection of Waste Quantities (cu.m.)																					
		Planning Period: 20 years from 2015																		DEMAND - Landfill Waste Quantities, cu.m.			
Yr	Landfill Cell/Area Location, Area Method (Ha)	Year	Projected end of year population	Waste quantities, kg/cap.day (ave. for entire MSW)	Waste quantities, kg/day	Waste quantities, kg/day assuming 60% service coverage	Waste Quantities, 20% diversion through ward/HH composting (kg/d)	Waste Quantities, 30% diversion through ward/HH recycling (kg/d)	Waste Quantities after 30% diversion by ward/HH composting & recycling (kg/d)	Bulk Density, kg/cu.m	Daily volume, uncompacted, cu.m.	50% of daily volume collected along Routes 1,2 and 3	20 % to Composting at landfill	10 % to Materials recovery at landfill	70 % for disposal to Landfill cells area	50% of daily volume collected at Wards and by NGOs	60 % to HH and Ward level composting and recycling	40% disposal to Landfill cells area	Daily volume to landfill, uncompacted, cu.m.	Compacted Density, kg/cu.m	Daily Compacted Volume with 3Rs	Yeadly Volume	Cumulative Total	Cumulative Total starting in 2016
		2011	135,901	0.35	47,566	28,540	5,707.99	2,853.99	19,977.89	329	88	44	9	4	31	44	27	18	46	595	29	10,417	10,417	
		2012	139,227	0.35	48,717	29,230	5,906.00	2,953.00	20,671.03	329	92	46	9	5	32	46	27	18	50	595	30	10,800	21,217	
		2013	142,655	0.35	50,942	30,565	6,113.00	3,056.51	21,395.54	329	95	48	10	5	33	48	29	19	52	595	31	11,212	32,429	
		2014	145,237	0.35	52,748	31,648	6,329.59	3,164.79	22,153.52	329	99	49	10	5	35	49	30	20	54	595	32	11,644	44,074	
0	89.5	2015	150,059	0.35	54,634	32,780	6,556.11	3,278.05	22,946.39	329	103	51	10	5	36	51	31	21	56	595	33	12,097	56,171	
1	90.5	2015	153,111	0.37	56,608	33,965	6,793.08	3,396.54	23,775.77	329	107	53	11	5	37	53	32	21	59	595	34	11,572	68,744	12,572
2	91	2017	152,938	0.37	56,675	35,206	7,041.17	3,520.59	24,644.10	329	111	55	11	6	39	55	33	22	60	595	36	13,072	81,814	25,643
3	86.5	2018	162,135	0.37	60,841	36,505	7,300.99	3,650.49	25,553.27	329	115	58	12	6	40	58	35	23	62	595	37	13,594	95,408	39,237
4	87	2019	166,513	0.37	63,108	37,865	7,573.00	3,786.50	26,505.53	329	120	60	12	6	42	60	36	24	66	595	39	14,143	109,551	53,380
5	88.5	2020	171,023	0.37	65,488	39,293	7,858.23	3,929.10	27,503.70	329	125	62	12	6	44	62	37	25	68	595	41	14,730	124,270	68,099
6	90	2021	175,825	0.37	67,975	40,785	8,157.00	4,078.51	28,549.56	329	130	65	13	6	45	65	39	26	71	595	42	15,329	139,596	83,429
7	91.5	2022	180,795	0.37	70,586	42,351	8,470.20	4,235.15	29,646.05	329	135	68	14	7	47	68	41	27	74	595	44	15,965	155,557	99,386
8	93	2023	185,916	0.37	73,329	43,996	8,798.78	4,399.39	30,795.74	329	141	71	14	7	49	71	42	28	78	595	46	16,633	172,188	116,017
9	94.5	2024	191,201	0.47	76,156	45,717	9,143.36	4,571.68	32,031.76	329	147	74	15	7	51	74	44	29	81	595	47	17,334	189,522	133,351
10	96	2025	196,629	0.47	79,206	47,525	9,504.91	4,752.45	33,267.18	329	153	77	15	8	54	77	46	31	84	595	50	18,079	207,596	151,424
11	97.5	2026	202,212	0.47	82,300	49,427	9,884.38	4,942.19	34,595.32	329	160	80	16	8	56	80	48	32	88	595	53	18,852	226,447	170,276
12	99	2027	208,758	0.48	85,588	51,414	10,282.70	5,141.35	35,989.45	329	167	83	17	8	58	83	50	33	92	595	54	19,670	246,117	189,946
13	100.5	2028	215,139	0.48	89,124	53,500	10,700.08	5,350.49	37,453.27	329	174	87	17	9	61	87	52	35	96	595	55	20,532	266,649	210,478
14	102	2029	221,753	0.47	90,836	55,700	11,140.37	5,570.18	38,991.29	329	182	91	18	9	64	91	55	36	101	595	58	21,435	288,085	231,914
15	103	2030	228,597	0.47	96,682	58,010	11,602.04	5,801.02	40,607.12	329	190	95	19	9	66	95	57	38	104	595	61	22,396	310,484	254,313
16		2031	235,656	0.48	100,728	60,435	12,087.09	6,043.55	42,304.82	329	198	99	20	10	69	99	60	40	108	595	64	23,400	333,886	277,715
17		2032	243,357	0.48	104,972	62,984	12,596.85	6,298.43	44,089.12	329	207	104	21	10	73	104	62	41	114	595	67	24,445	358,348	302,177
18		2033	251,213	0.47	109,441	65,665	13,132.98	6,566.48	45,965.25	329	217	108	22	11	76	108	65	43	119	595	70	25,580	383,927	327,756
19		2034	259,489	0.47	114,140	68,484	13,696.75	6,848.38	47,938.63	329	227	113	23	11	79	113	68	45	125	595	73	26,758	410,686	354,514
20		2035	268,148	0.48	119,608	71,765	14,352.98	7,176.46	50,235.25	329	239	119	24	12	83	119	72	48	131	595	77	28,134	438,820	382,639
							201,730.44	115,366.22															

* Annual population projections provided by Nepal CBS in January 2013

Assumptions:

1) 1% increase in waste generation rate per annum (based on experience from developing countries with increasing standards of living of sub-metropolis)

2) 0.5% decrease in bulk densities per annum (based on experience with sub-metropolitan areas increasing light industrial and high commercial activities, i.e. Birgunj)

3) Existing (baseline) service coverage of [71.4% from PPTA Report and 45% from Inception Report] proposed to increase to 60%

4) Sanitary Landfill starts operation in 2016

Table 24: Projection of Waste Quantities and Sanitary Landfill Volume Capacity (no 3Rs)

		Birgunj Sanitary Landfill																						
		Projection of Waste Quantities (cu.m.)																						
		Planning Period: 20 years from 2015																			DEMAND - Landfill Waste Quantities, cu.m.			
Yr	Landfill Cell Area Reactions, Area Method (#8)	Year	Projected end-of-year population	Waste quantities, kg/capita/day (ass. for entire MSDB)	Waste quantities, kg/day	Waste quantities, kg/day assuming 60% service coverage	Waste Quantities, 20% diversion through ward/HH composting (kg/d)	Waste Quantities, 10% diversion through ward/HH recycling (kg/d)	Waste Quantities after 30% diversion by ward/HH composting & recycling (kg/d)	Bulk Density, kg/cu.m.	Daily volume, uncompacted, cu.m.	50% of daily volume collected along Routes 1,2 and 3	20% to Composting at landfill	10% to Materials recovery at landfill	70% for disposal to Landfill cells area	50% of daily volume collected at Wards and by NGOs	60% to HH and Ward level composting and recycling	40% disposal to Landfill cells area	Daily volume to landfill, uncompacted, cu.m.	Compacted Density, kg/cu.m.	Daily Compacted Volume, no 3Rs	Yearly Volume	Cumulative Total	Cumulative Total starting in 2016
		2011	135,994	0.35	47,566	28,540	5,707.97	2,853.98	19,977.89	323	88	44	9	4	31	44	27	18	49	556	52	18,940	18,940	
		2012	138,227	0.35	49,217	29,530	5,906.01	2,953.00	20,671.08	322	92	46	9	5	32	46	27	18	50	556	54	19,683	38,577	
		2013	140,875	0.35	53,942	30,565	6,113.01	3,056.51	21,395.54	321	95	48	10	5	33	48	29	19	52	556	56	20,388	58,965	
		2014	145,272	0.35	50,746	31,649	6,329.53	3,164.79	22,153.52	320	99	49	10	5	35	49	30	20	54	556	58	21,172	80,136	
0	80.5	2015	150,869	0.35	54,834	32,781	6,556.11	3,278.06	22,946.39	319	103	51	10	5	36	51	31	21	56	556	60	21,995	102,129	
1	80.5	2016	153,898	0.37	56,809	33,965	6,793.08	3,396.54	23,775.77	319	107	53	11	5	37	53	32	21	59	556	63	22,859	124,988	22,859
2	84	2017	157,011	0.37	58,676	35,206	7,041.17	3,520.59	24,644.10	318	111	55	11	6	39	55	33	22	61	556	65	23,763	148,752	46,624
3	85.5	2018	160,135	0.37	60,841	36,505	7,300.93	3,650.47	25,553.27	317	115	58	12	6	40	58	35	23	63	556	68	24,716	173,468	71,340
4	87	2019	165,513	0.37	63,108	37,865	7,573.01	3,786.50	26,505.53	316	120	60	12	6	42	60	36	24	66	556	70	25,714	199,183	97,054
5	88.5	2020	171,093	0.37	65,485	39,291	7,858.20	3,929.10	27,508.70	315	125	62	12	6	44	62	37	25	69	556	73	26,763	225,946	123,817
6	90	2021	175,825	0.37	67,975	40,785	8,157.01	4,078.51	28,549.56	314	130	65	13	6	45	65	39	26	71	556	76	27,864	253,810	151,681
7	91.5	2022	180,265	0.37	70,586	42,351	8,470.30	4,235.15	29,646.05	313	135	68	14	7	47	68	41	27	74	556	80	29,003	282,813	180,703
8	93	2023	185,916	0.37	73,303	43,994	8,798.78	4,399.39	30,796.74	312	141	71	14	7	49	71	42	28	78	556	83	30,237	313,049	210,940
9	94.5	2024	191,294	0.41	76,295	46,717	9,343.36	4,671.68	32,001.76	311	147	74	15	7	51	74	44	29	81	556	86	31,516	344,565	242,456
10	96	2025	196,879	0.41	79,206	47,525	9,504.91	4,752.45	33,267.18	310	153	77	15	8	54	77	46	31	84	556	90	32,861	377,446	275,337
11	97.5	2026	202,212	0.41	82,370	49,422	9,884.38	4,942.19	34,595.32	309	160	80	16	8	56	80	48	32	88	556	94	34,276	411,722	309,599
12	99	2027	209,253	0.41	85,884	51,414	10,282.70	5,141.35	35,989.45	307	167	82	17	8	58	83	50	33	92	556	98	35,754	447,485	345,357
13	100.5	2028	215,196	0.41	89,174	53,505	10,700.93	5,350.47	37,453.27	306	174	87	17	9	61	87	52	35	96	556	102	37,331	484,817	382,688
14	102	2029	221,251	0.42	92,826	55,702	11,140.37	5,570.18	38,991.29	305	182	91	18	9	64	91	55	36	100	556	107	38,981	523,798	421,669
15	103	2030	228,894	0.42	96,684	58,010	11,601.04	5,801.02	40,607.12	305	190	95	19	9	66	95	57	38	104	556	112	40,718	564,516	462,387
16		2031	236,765	0.43	101,726	60,435	12,087.09	6,043.55	42,306.82	304	198	99	20	10	69	99	60	40	109	556	117	42,548	607,065	504,935
17		2032	248,369	0.43	106,574	62,984	12,596.89	6,298.45	44,089.12	304	207	104	21	10	73	104	62	41	114	556	122	44,476	651,540	549,412
18		2033	258,213	0.44	103,441	65,665	13,132.93	6,566.46	45,965.25	303	217	108	22	11	76	108	65	43	119	556	127	46,509	698,050	595,920
19		2034	270,494	0.44	114,140	68,484	13,696.75	6,848.38	47,938.63	302	227	113	23	11	79	113	68	45	125	556	133	48,651	746,701	644,572
20		2035	283,148	0.44	119,408	71,765	14,352.93	7,176.46	50,236.25	301	239	119	24	12	83	119	72	48	131	556	140	51,135	797,836	695,707
							230,730.44	115,365.22																
*	Annual population projections provided by Nepal CBS in January 2013																							
	Assumptions:																							
	1) 1% increase in waste generation rate per annum (based on experience from developing countries with increasing standards of living of sub-metropolis)																							
	2) 0.5% decrease in bulk densities per annum (based on experience with sub-metropolitan areas increasing light industrial and high commercial activities, i.e. Birgunj)																							
	3) Existing (baseline) service coverage of (21.6% from PPTA Report and 42% from Inception Report) proposed to increase to 60%																							
	4) Sanitary Landfill starts operation in 2016																							

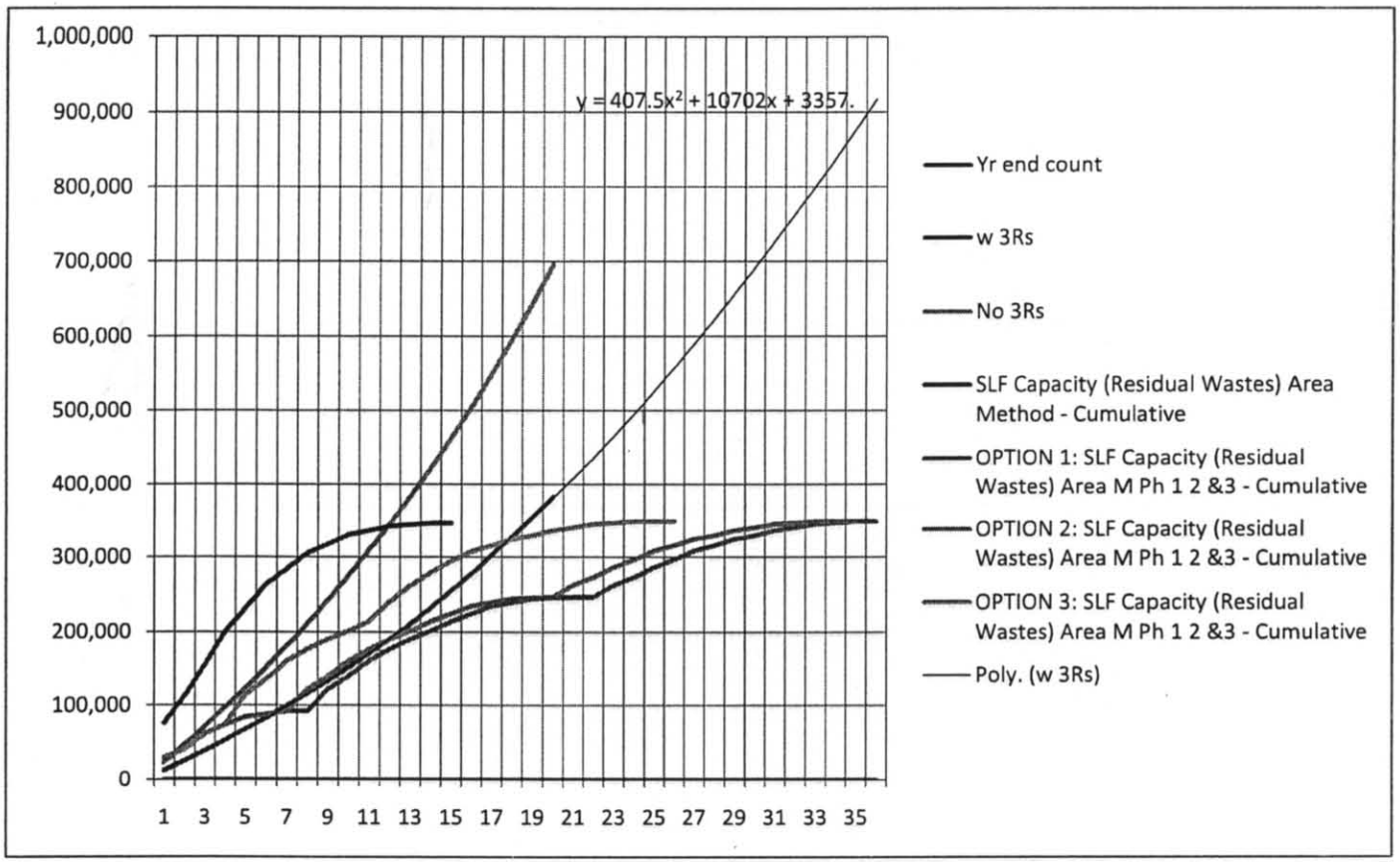


Figure 25: Capacity Analysis of Sanitary Landfill Cells Area

5.6 Design 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 (300 mm 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.

5.7 Design 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 25: Schedule of Leachate Collection Pipes - Invert Elevations and Landfill Cell Base Surface Finish Elevations

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

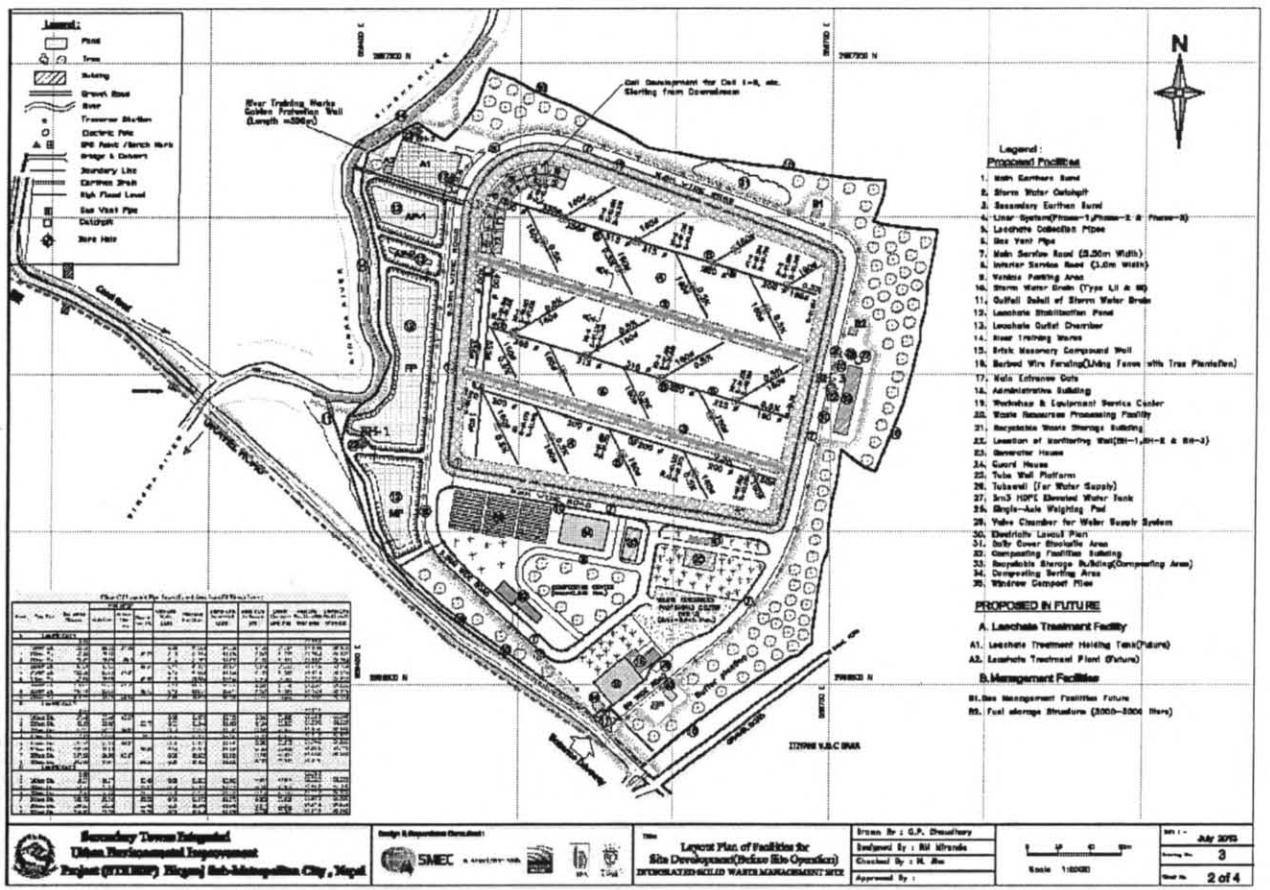


Figure 26: Layout Plan of Facility for Site Development Drg. No. 3(2 of 4)

Table 26: Sanitary Landfill Water Balance Sketch

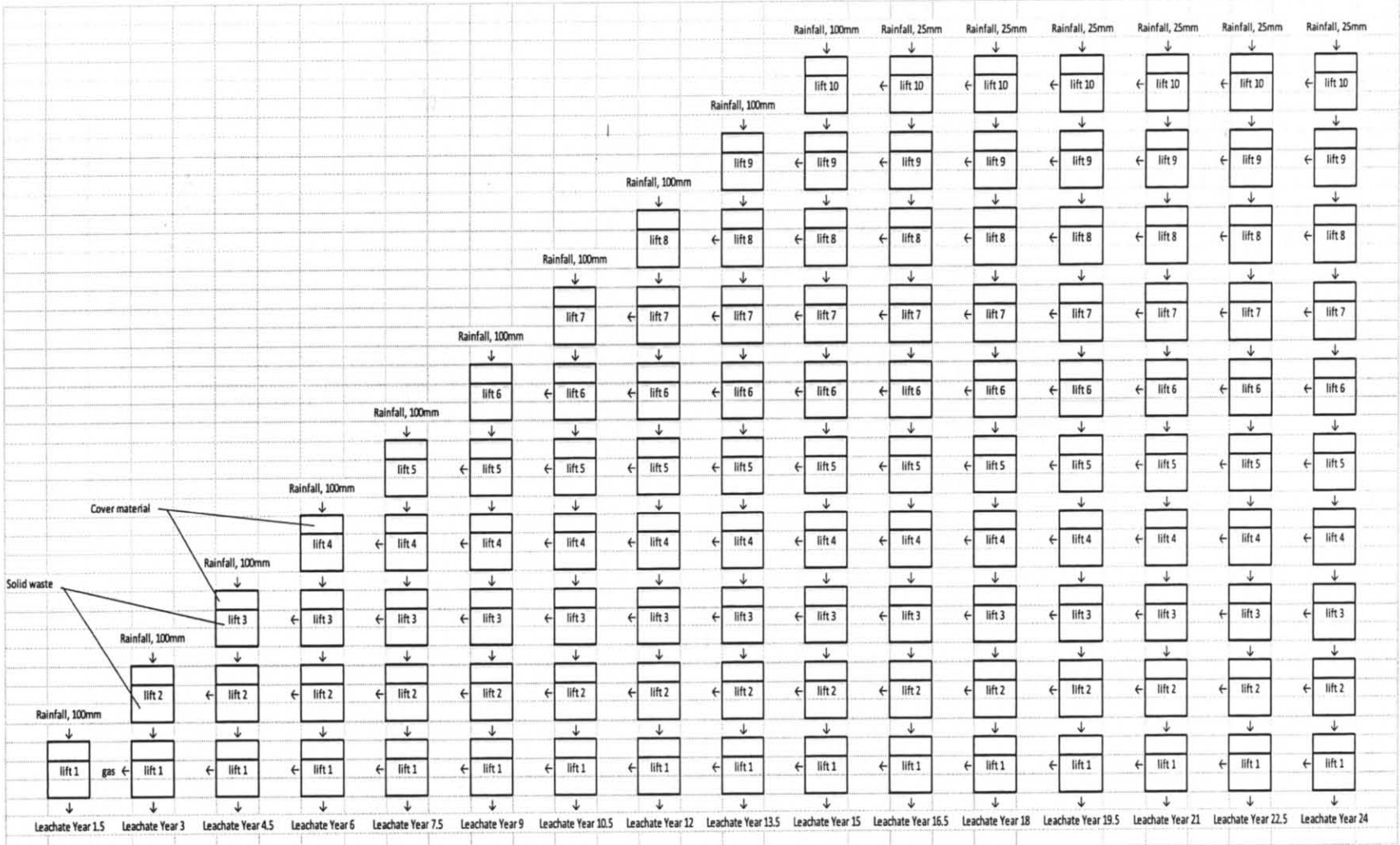


Table 27: Landfill Volume and Leachate Production

LANDFILL VOLUME AND LEACHATE PRODUCTION

End of Year	Lift	Elev	Lift Height	Lift Area, m^2	Volume of Air Space, m^3	Leachate Vol, kg/m^2	Leachate volume, kg	Leachate Vol, Liters	Leachate Vol, cu.m./lift	Leachate Holding Tank (Temporary Storage 80.3 % after the 1st lift to 24.6 % of max. leachate)	Leachate for WSP Treatment (24.5 % capacity on 1st lift to 305.0 % capacity on last lift) of max. leachate)	Percent (%) capacity of max probable leachate volume treated in WSP
0	0	81		46,239.58								
1.5	1	82.5	2.00	46,827.65	93,067.23	162.75	7,620,982.50	7,620,982.50	7,620.98	6,120.98	1,500.00	24.5
3	2	84	1.03	47,027.78	48,100.91	168.50	7,924,093.69	7,924,093.69	7,924.09	6,424.09	1,500.00	23.3
4.5	3	85.5	1.50	41,950.85	66,733.97	175.18	7,348,850.89	7,348,850.89	7,348.85	5,848.85	1,500.00	25.6
6	4	87	1.50	37,468.96	59,564.86	179.56	6,727,810.64	6,727,810.64	6,727.81	5,227.81	1,500.00	28.7
7.5	5	88.5	1.50	30,838.30	49,478.77	182.20	5,618,614.17	5,618,614.17	5,618.61	4,118.61	1,500.00	36.4
9	6	90	1.50	26,958.84	43,347.86	183.47	4,946,219.56	4,946,219.56	4,946.22	3,446.22	1,500.00	43.5
10.5	7	91.5	1.50	21,345.12	34,781.18	184.12	3,930,164.04	3,930,164.04	3,930.16	2,430.16	1,500.00	61.7
12	8	93	1.50	17,964.13	29,481.93	184.69	3,317,793.71	3,317,793.71	3,317.79	1,817.79	1,500.00	82.5
13.5	9	94.5	1.50	13,416.03	22,344.54	185.18	2,484,410.27	2,484,410.27	2,484.41	984.41	1,500.00	152.4
15	10	96	1.50	10,725.56	18,106.19	185.62	1,990,826.76	1,990,826.76	1,990.83	490.83	1,500.00	305.6
16.5	11	97.5	1.50	7,217.77	12534.38							
18	12	99	1.50	5,300.87	9388.98							
19.5	13	100.5	1.50	2,921.34	5517.07							
21	14	102	1.50	1,698.11	3464.59							
22.5	15	103	1.00	144.00	670.54							
24	15	103										
25.5	15	103										
27	15	103										
28.5	15	103										
30	15	103										
31.5				total	496,582.98							

Table 28: Gas Production Table: Values assumed at 1.5 year intervals corresponding to 1 lift

Gas Production Table: Values assumed at 1.5 year intervals corresponding to 1 lift						
	Gas Production, ft^3/lb			Gas Production , cu.m./kg		
End of Year	Rapidly decomposing	Slowly decomposing	Total	Rapidly decomposing	Slowly decomposing	Total
1.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.9410	0.0080	0.9490	0.0587	0.0005	0.0592
4.5	1.6460	0.0230	1.6690	0.1028	0.0014	0.1042
6	1.1760	0.0390	1.2150	0.0734	0.0024	0.0758
7.5	0.7060	0.0550	0.7610	0.0441	0.0034	0.0475
9	0.2350	0.0700	0.3050	0.0147	0.0044	0.0190
10.5	0.0000	0.0740	0.0740	0.0000	0.0046	0.0046
12	0.0000	0.0660	0.0660	0.0000	0.0041	0.0041
13.5	0.0000	0.0580	0.0580	0.0000	0.0036	0.0036
15	0.0000	0.0510	0.0510	0.0000	0.0032	0.0032
16.5	0.0000	0.0430	0.0430	0.0000	0.0027	0.0027
18	0.0000	0.0350	0.0350	0.0000	0.0022	0.0022
19.5	0.0000	0.0270	0.0270	0.0000	0.0017	0.0017
21	0.0000	0.0190	0.0190	0.0000	0.0012	0.0012
22.5	0.0000	0.0120	0.0120	0.0000	0.0007	0.0007
24	0.0000	0.0040	0.0040	0.0000	0.0002	0.0002
25.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
31.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
33	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
34.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
36	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	4.7040	0.5840	5.2880	0.2937	0.0365	0.3301

Reference: Integrated Solid Waste Management, Tchobanoglous,Thiesen and Vigil, McGraw-Hill, 1993

5.8 Design 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).

Anaerobic ponds (in series)

Anaerobic Pond 1

From Table 29 below, the design loading for 25 degC is 350 g BOD/m3 day.

Table 29: Design Values of Permissible volumetric BOD Loadings on and % BOD Removal in Anaerobic Ponds at various temperatures

Design Values of Permissible columetric BOD Loadings on and percentage BOD Removal in Anaerobic Ponds at Variious Temperatures		
Temperature (deg C)	Volumetric Loading (g/m³d)	BOD Removal (%)
< 10	100	40
10-20	20T - 100	2T + 20
20-25	10T + 100	2T + 20
>25	350	70
T = temperature, deg C *Source: Mara and Pearson (1986) and Mara et al. (1997)*		

From Mara's (Mara et al 1997) equation for BOD, for wastewater, BOD may be measured using 24-hour flow-weighted composite samples. If the wastewater exists, its BOD may be measured using 24-hour flow-weighted composite samples. If it does not, it may be estimated from the following equation (Mara's equation 4.1):

$$Li = 1000\ B/q$$

Where Li = wastewater BOD, mg/l
B = BOD contribution, g/cap/d
q = wastewater flow, l/cap.d

Values of B vary between 30 and 70 g/cap/d, with affluent communities producing more BOD than poor communities (Campos and von Sperling, 1996). A suitable design value for India is 45 g/cap/day (Ministry of Urban Development, 1995). The same value is adopted for application in Birgunj.

Mara's equation 4.2 on volumetric BOD loading (λV, g/cu.m.d), without risk of odor nuisance is given by:

$$\lambda V = LiQ/Va$$

where Li = influent BOD, mg/l (= g/cu.m.)
Q = flow, m3/d
Va = anaerobic pond volume, cu.m.

While Mara's equation 4.3 on mean hydraulic retention time in the pond (θ_a, d) is determined from:

$$\theta a = Va/Q$$

Substitution of equation 4.2 into equation 4.3 gives the following alternative expression for the anaerobic pond retention time, θa:

$$\theta a = Li/\lambda v$$
$$= 1{,}000/350$$
$$= 2.86 \text{ say } 3 \text{ days}$$

Thus the anaerobic pond volume (Va) is given by:

$$Va = Q/\theta a$$
$$= 1{,}500 \times 3$$
$$= 4{,}500 \text{ m3}$$

Assuming a depth of 3 m, the anaerobic pond area required is 1,500 m2.

At 25degC the BOD removal (Table 30) i.e.70%, so the BOD of the anaerobic pond effluent is (0.3 × 1,000), i.e. 300 mg/l.

Anaerobic Pond 2

Use the design loading for 25deg C of 300g BOD/m3 day from Pond 1.

Substitution of equation 4.2 into equation 4.3 gives the following alternative expression for the anaerobic pond retention time, θa:

$$\theta a = Li/\lambda v$$
$$= 300/350$$
$$= 0.86 \text{ say } 1 \text{ day}$$

Thus the anaerobic pond volume (Va) is given by:

$$Va = Q/\theta a$$
$$= 1{,}500 \times 1.0$$
$$= 1{,}500 \text{ m}^3$$

Assuming a depth of 3 m, the anaerobic pond area is 500 m2.

At 25degC the BOD removal (Table 30) i.e.70%, so the BOD of the anaerobic pond effluent is (0.3 × 300), i.e. 90 mg/l, say OK for discharge into Singaha River, not considering unrestricted irrigation use.

Facultative Pond

From Table 30, the design loading for 25degC is 350 kg BOD/ha day. Thus the initial facultative pond area is given by equation 4.4 as:

$$Af = 10LiQ/\lambda S$$
$$= 10 \times 90 \times 1{,}500/350$$
$$= 3{,}857 \text{ m2}$$

Calculate the retention time in the facultative pond from equation 4.12:

$$\theta f = 2AfD/(2Qi - 0.001Afe)$$

Taking the depth as 2.0 m:

$$\theta f = 2 \times 3{,}857 \times 2.0/[(2 \times 1{,}500) - (0.001 \times 3{,}857 \times 5)]$$
$$= 2 \times 3{,}857 \times 2.0/[2{,}980.72]$$
$$= 5.17 \text{ say } 5 \text{ days}$$

The following equations of Mara are also used:

Equation 4.12: $\theta_f = 2A_fD/(2Qi - 0.001A_fe)$ where e = net evaporation rate in mm/d

Equation 4.14: $Ne = Ni/[(1+kT\theta a)(1+kT\theta f)(1+kT\theta m)n]$ for a series of anaerobic facultative and maturation ponds,

Where: Ne = number of FC per 100 ml of effluent
Ni = number of FC per 100 ml of influent
kT = first order rate constant for FC removal, d-1
θ = retention time, d

and where Ne and Ni now refer to the numbers of FC per 100 ml of the final effluent and raw wastewater respectively; the sub-scripts a, f and m refer to the anaerobic, facultative and maturation ponds; and n is the number of maturation ponds.

Equation 4.18: $A_m = 2Q_i \theta_m/(2D + 0.001e \theta_m)$

Use 5.0 days and calculate the final area of the facultative pond from a rearrangement of equation 4.12 (i.e. use equation 4.18 with θf in place of θm):

$$Af = 2Qi\theta f/(2D + 0.001e\theta f)$$
$$= 2 \times 1{,}500 \times 5.0/[(2 \times 2.0) + (0.001 \times 5 \times 5.0)]$$
$$= 2 \times 1{,}500 \times 5.0/[4.0 + 0.025]$$
$$= 3{,}726 \text{ m2}$$

The cumulative filtered BOD removal in the anaerobic and facultative ponds is typically 90% for T > 20degC, so the facultative pond effluent has a filtered BOD of (0.1 × 1,000), i.e. 100 mg/l, which is suitable for discharge into the Singaha River.

Maturation pond

For the treatment of faecal coliform present in the leachate and considering that the Singaha River is currently used for unrestricted irrigation purposes, a maturation pond should be constructed downstream of the facultative pond prior to discharge of the effluent to the Singaha River. It is assumed that the wastewater loading contains 240 x 10^4 faecal coliforms per 100 ml (Mara Tables: 1997)).

The anaerobic and facultative ponds are as calculated above. The retention times in the 2 anaerobic ponds and the facultative pond are 1 and 4 days, respectively.

Use the following rearrangement of equation 4.14 to calculate θm:

$$\theta m = \{[Ni/Ne(1 + kT\theta a)(1 + kT\theta f)]1/n - 1\}/kT$$

At 25degC, kT = 6.2 day-1 (Mara: Table 4.6). Therefore the above equation can be solved for the following values of n as follows, with Ne = 1000 for unrestricted irrigation (Mara:Table 10.1):

$$\theta m = \{[270 \times 104/1000\ (1 + 6.2 \times 4)(1 + 6.2 \times 5)]1/n - 1\}/6.2$$
$$= 0.366 \text{ day for } n = 1$$

Choose 1 pond with a retention time of 3 days (=θmin). Check BOD loading on the maturation pond from equation 4.17, assuming 80% cumulative removal in the anaerobic and facultative ponds and a depth of 1.5 m:

$$\lambda S\ (m) = 10 \times (0.2 \times 100) \times 2.5/3$$
$$= 167 \text{ kg/ha day}$$

This is satisfactory as it is less than 75% of the permissible design loading on facultative ponds at 25oC (350 kg/ha day; Mara:Table 4.3).

The area of the maturation pond is given by equation 4.18 as:

$$Am = 2Qi\theta m / (2D + 0.001e\theta m)$$
$$= 2 \times 1{,}500 \times 3/[(2 \times 2.5) + (0.001 \times 5 \times 3)]$$
$$= 1{,}795 \text{ m2}$$

The hydraulic profiles of the leachate stabilization ponds can be found in the following drawing. The detailed design drawings for each of the ponds can be found in the Drawings Volume of the Final Report.

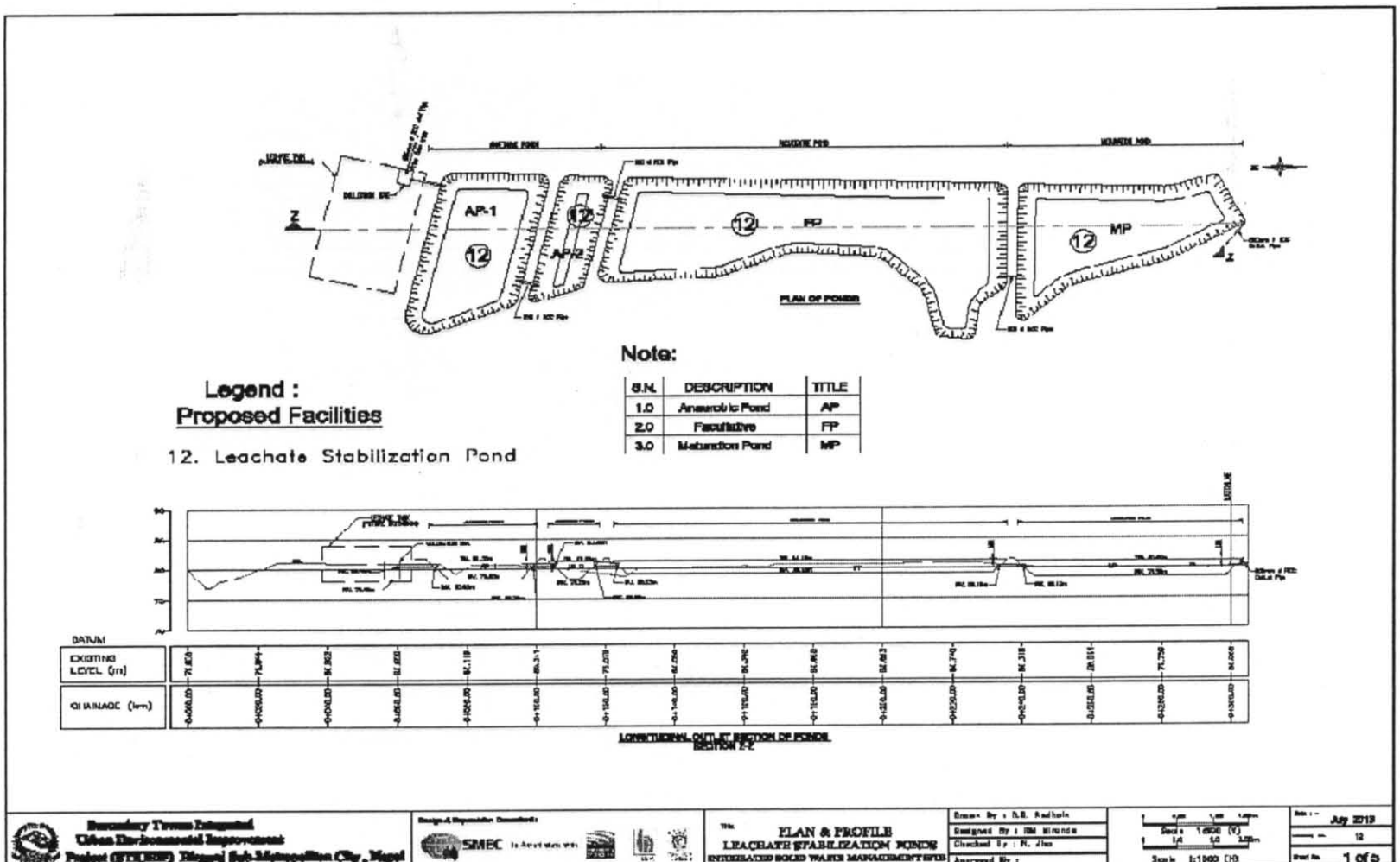


Figure 27: Plan and Profile Leachate Stabilization Ponds Drg. No. 12(1 of 5)

5.9 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.

5.10 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

5.11 Operational Procedures of the Reception/Weighbridge Station and Sanitary Landfill Cells area of the Integrated Solid Waste Management (Sanitary Landfill) Site

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 Sub-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:

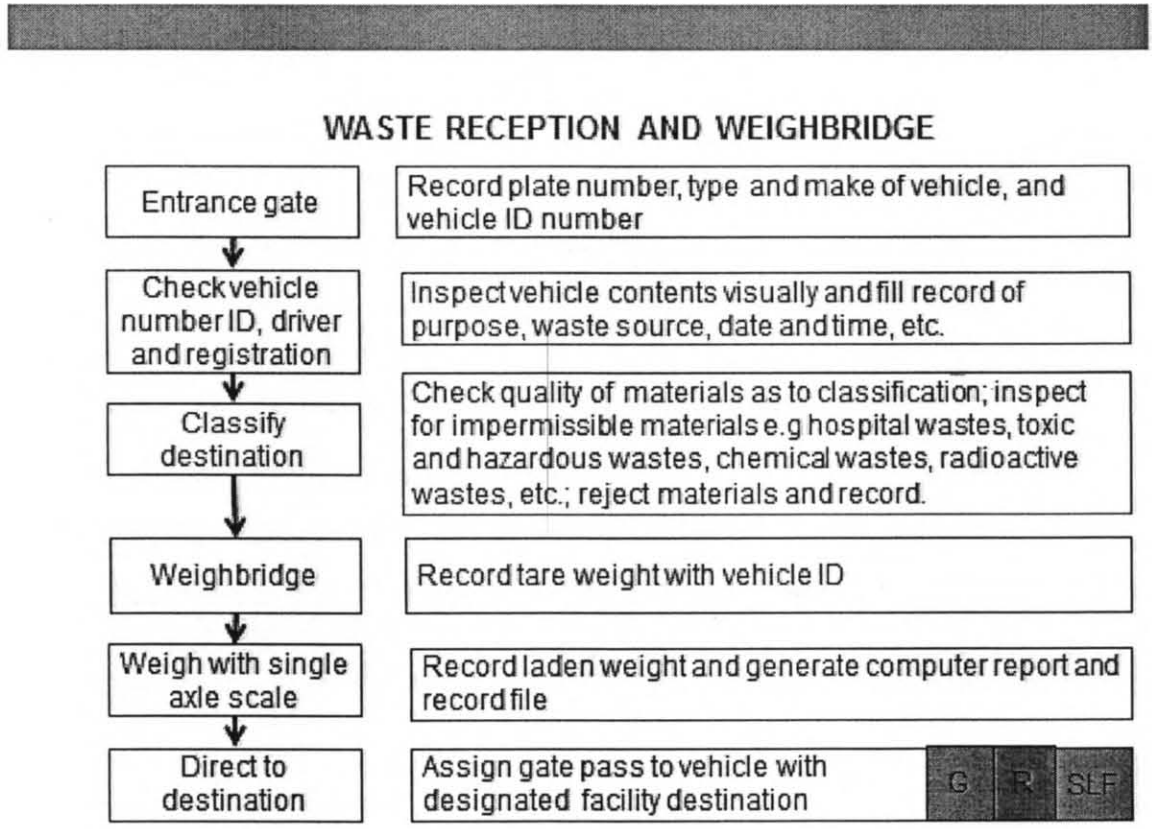


Figure 28: Flow Chart of Waste Reception and Weighbridge Station

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. 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.

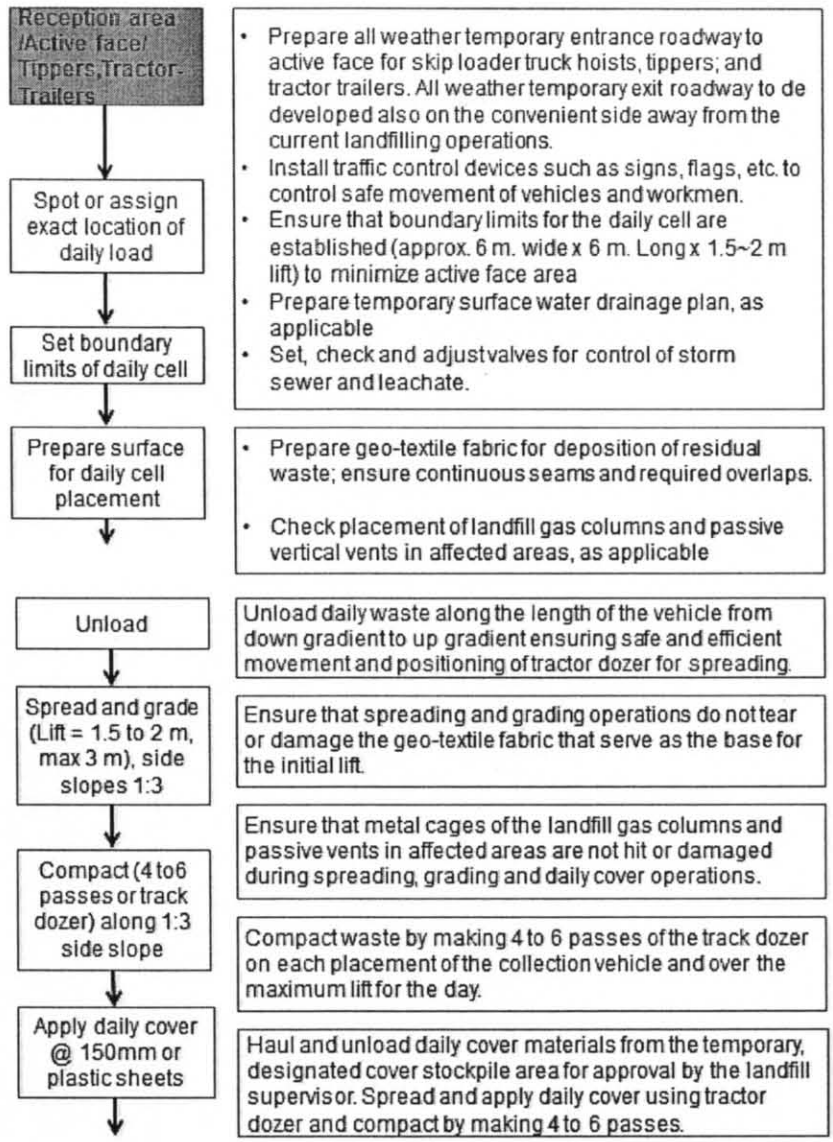
The weighbridge station is equipped with a computerized single-axle load scale that calculates the laden weight of the vehicle and records the readings automatically with a printout of the complete record of the weighing activity.

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 BSMC 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.

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



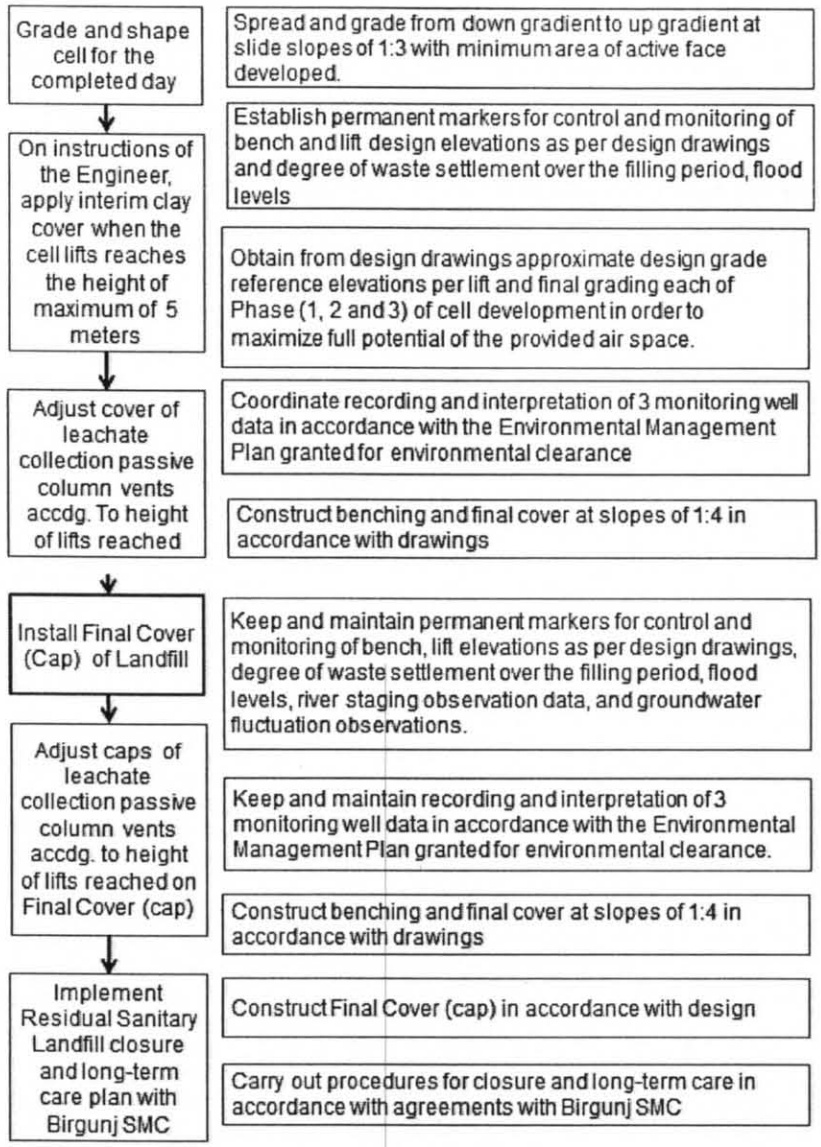


Figure 29: Flow Chart of Sanitary Landfill Cells Area

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 30: 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**

CHAPTER 6: THE COMPOSTING CENTER

6.1 Design of the Composting Center in the Integrated Solid Waste Management Site

The recommended design for composting is for organic fertilizers derived from composting activities and intended to be distributed commercially to be developed that shall conform to the standards for organic fertilizers set by the Birgunj Ministry of Agriculture. Compost products intended for commercial or non-commercial distribution shall be free from hazardous/toxic constituents above permissible levels, and shall be tested for such constituents using internationally accepted testing procedures. Every effort should be done by the wards and the NGOs to promote and cite the benefits of composting by way of massive information, education and communication campaigns. Vermi-composting shall also be promoted alongside simple, household composting methods that have been long practiced in the rural areas.

The Ministry of Agriculture in coordination with the Birgunj Municipal office will be asked to provide an inventory of existing markets and demands for composts. Said inventory shall thereafter be updated and published regularly: Provided that composting of agricultural wastes, and other compostable materials, including but not limited to garden wastes, shall be encouraged.

The main community composting facilities shall be established at the Composting Center at the ISWM site. The Composting Center is open for those wards and households that do not have space or the capability to do their own ward or household composting. This area is also designed as a training ground for composting for the whole Sub-Metropolitan city of Birgunj. The proposed system (See Preliminary Design Plans) shall be composed of a receiving/office area, two composting machines with hammermills or shredders, windrow compost piles and transfer sheds for aeration and maturation into compost. Materials such as enzymes or microbial activators shall be used to hasten the decomposition process. An inventory of these materials should be maintained. After about 15 – 30 days (depending on the quality of the compost) of transferring from one storage shed to another, the compost will then be hammermilled again or shredded, subjected to inspection, fine screened and bagged for production and sale.

It is recommended that a business plan be prepared for the composting component of the Birgunj SWM system in order to derive the benefits of composting as a revenue generator for the municipality. Research in Birgunj yielded a selling price of NR 20 to NR 25 per kg. of compost. The range of NR 20-25/kg is the price of agri-based waste compost in Birgunj from two compost stores that the DSC visited. The price in Nepal Pollution Control and Environmental Management Center (Nepcemac), Chobar, Kathmandu Vallley for MSW waste was lower at NR 15 to NR 20/kg.

Vermi-composting shall also be promoted with training provided to key staff of the composting office. The composting staff assigned to the landfill facility should be trained periodically who in turn will re-train other personnel as well. The training center proposed at the sanitary landfill site shall be used for these activities.

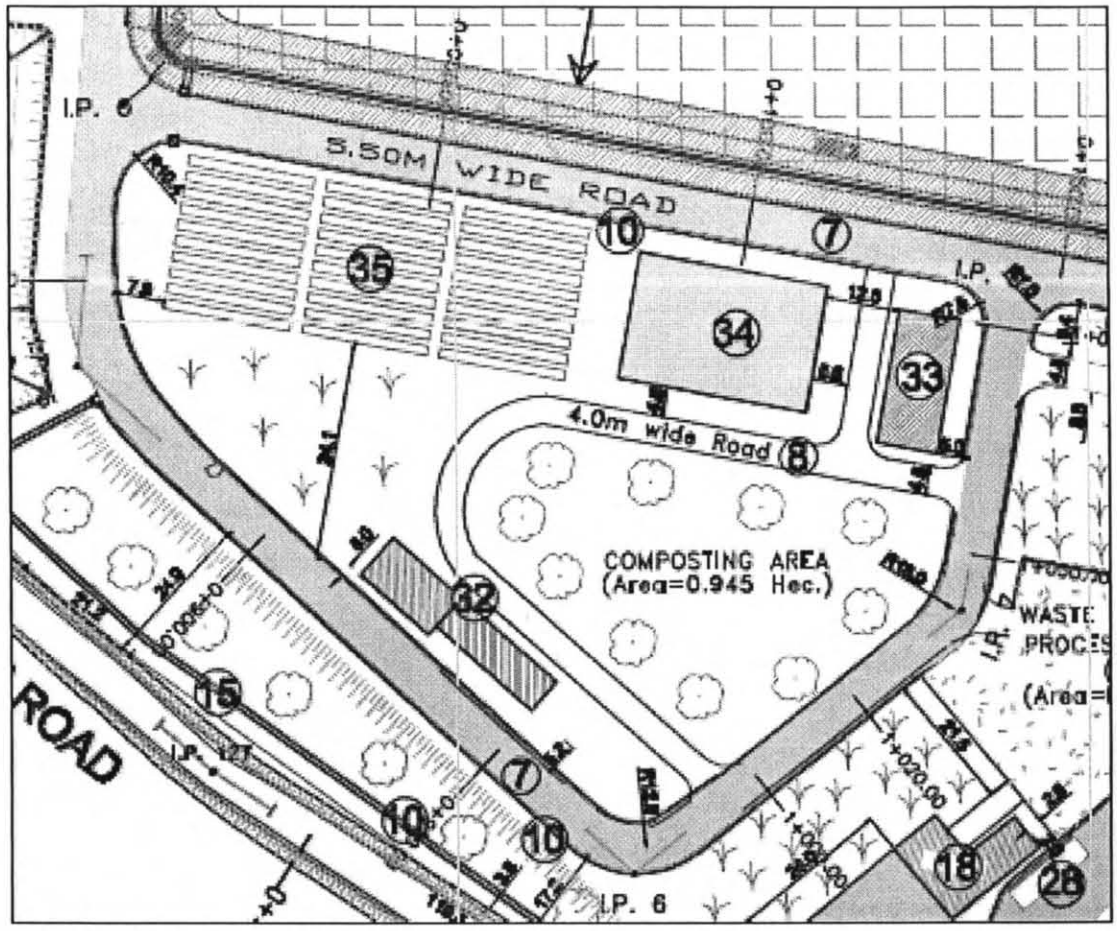


Figure 30: Composting Center Site Plan

Table 31: Summary of Compost Center Materials Flow

Compostables Materials Flow	tonnes/d	cu.m./d
Total Waste Generation, 2016	41.59	128.7
Total Waste Generation, Organic (biodegradable and compostable)	28.36	87.79
SKIP CONTAINER input (Compost Center)	17.97	55.63
Compost Product (50 % of compostables plus 25 % additives)	**3.37**	**10.43**
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**
TOTAL ESTIMATED COMPOST PRODUCT	**4**	**11.34**

Based on the ISWM site's material balance table, the summary table above shows the inputs and outputs to the Composting Center and the layout below illustrates by photo part of the envisioned operations.

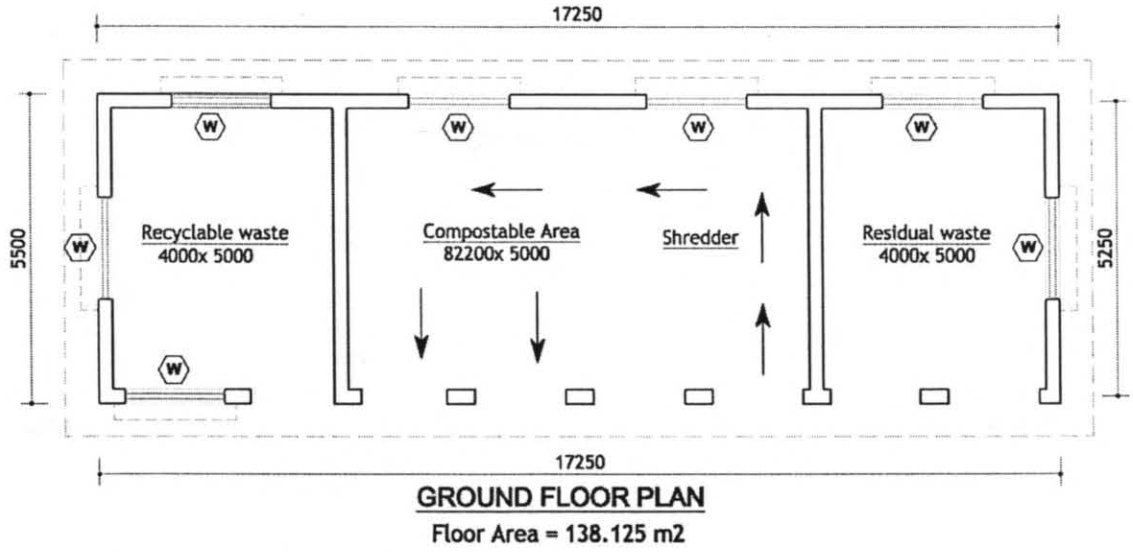


Figure 31: Recyclable Storage Building (Compost Center)

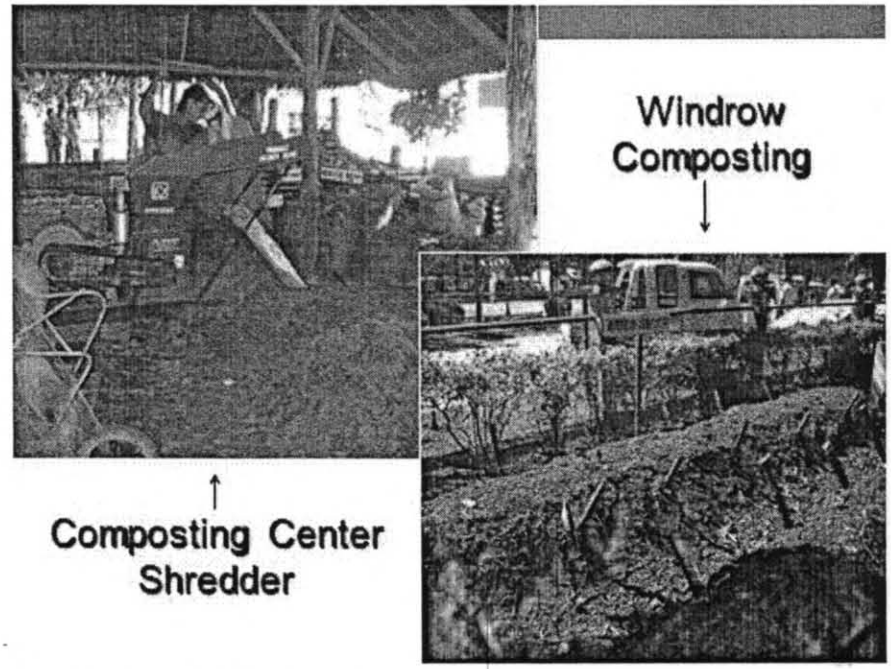


Photo 19: Example of Composting Facility

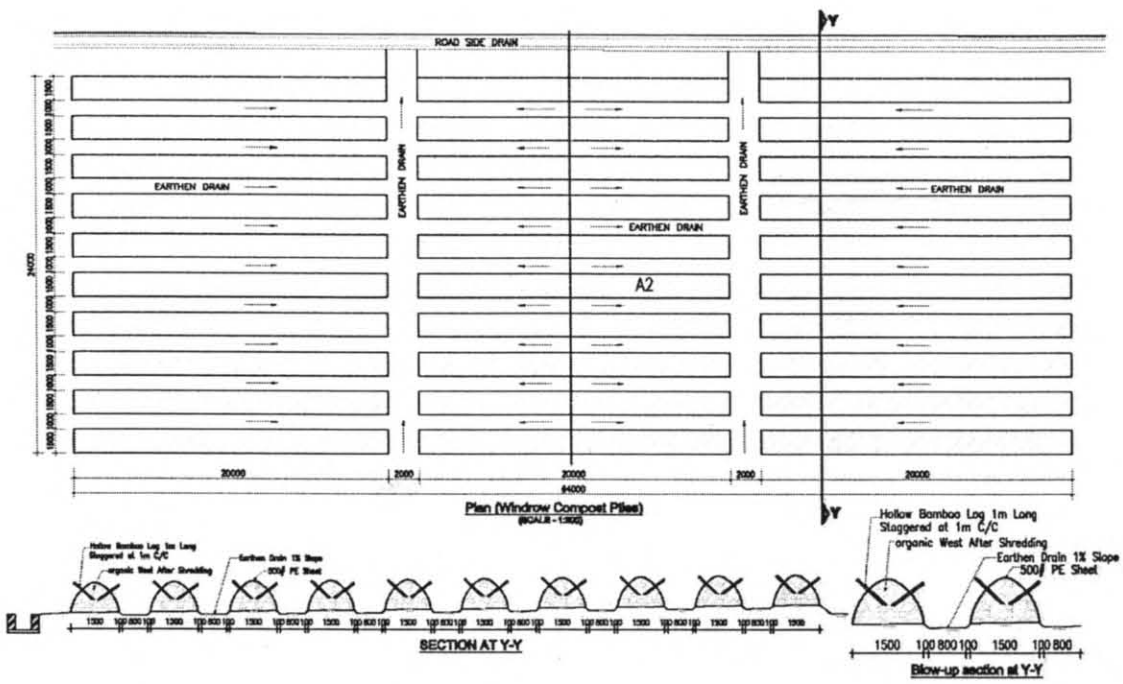


Figure 32: Windrow Compost Piles (Compost Center)

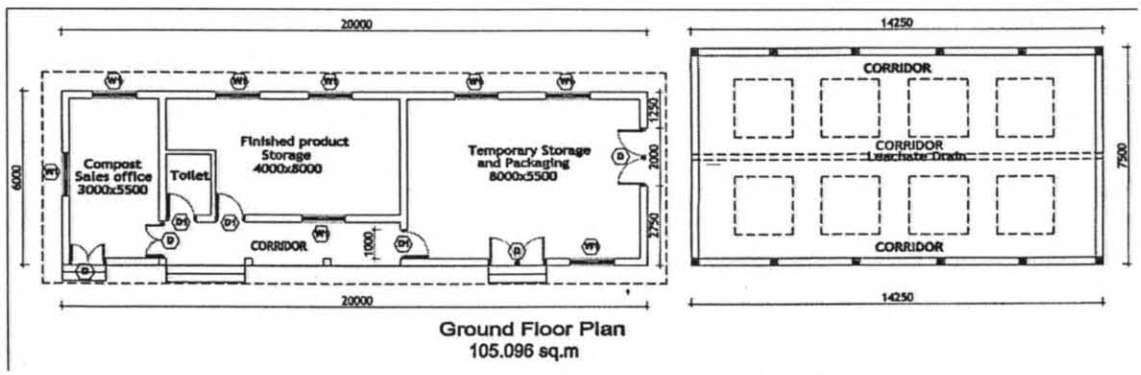


Figure 33: Maturation Bins or Piles (Compost Center)

The Composting area shall conform operationally to the following standards and criteria:

a) The Compost area shall be adequately protected from flooding using engineering controls to be provided in the design to prevent inundation of the facility. Initially the design grade of the proposed site has been designed to be flood free.
b) Leachate and Drainage Control
   - Facilities shall be designed such that compost piles, windrows, residues and processed material will not come in contact with surface storm run-off.
   - Where excess leachate storage is provided, discharge of leachate into the river is prohibited unless it is properly treated by a small leachate treatment Facility. This type of facility can be designed later as the processes become operational.
c) Provisions for vector, odor, litter and dust control shall be included
d) Records keeping shall be maintained at all times

e) Residues shall be managed as residual solid waste and shall be disposed of in the adjoining sanitary landfill.
f) Temperatures of compost piles, curing piles and processed composts shall be maintained in safe levels to prevent spontaneous combustion.
g) Aerobic conditions shall be maintained to prevent creation of dangerous gases such as methane.

In the course of designing the Composting Center components, the following were performed by the DSC:

- Met with compost producers in Kathmandu to determine present and future demand and supply of compost, value compared to organic fertilizers, and plans for organic fertilizers or organic farming, if any.
- Met with NGO leaders to get their views on development of composting market in Birgunj and adjoining districts, VDCs, etc. as reportedly there is no communal composting at present and household composting is negligible.
- Visited wet and dry markets in Birgunj to establish present system of dealing with compostable wastes from the sub-metropolis, and potential for integrated composting projects.

6.2 Operational Procedures for the Composting Center

The primary function of the Composting Center is to process centrally the organic portion of the municipal solid waste of Birgunj resulting from the 3R activities of segregating organic wastes or bi-degradable wastes from the non-biodegradable wastes arising from the households, residential buildings, commercial establishments, stores, schools, government offices, hotels, restaurants, public markets, religious buildings, temples and other waste sources.

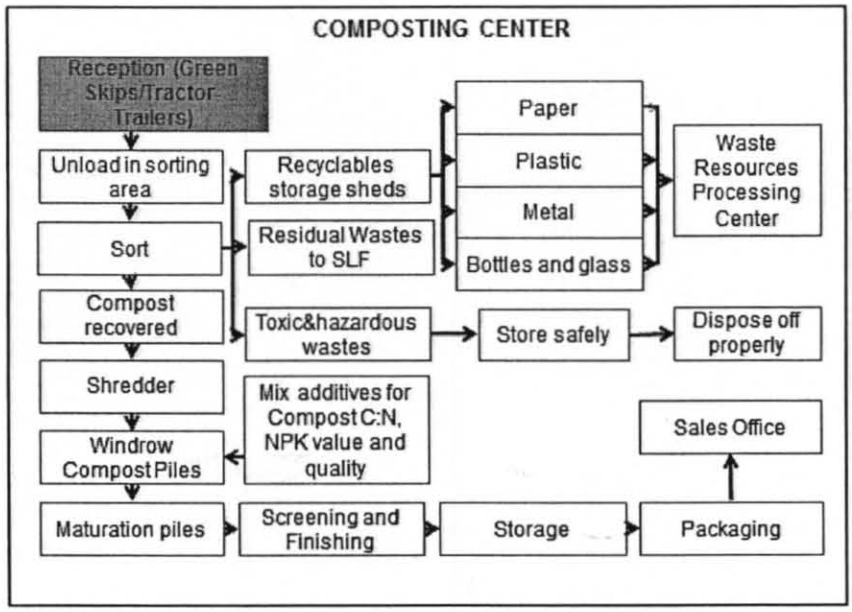


Figure 34: Flow Chart of Composting Center

CHAPTER 7: THE WASTE RESOURCES PROCESSING CENTER (WRPC)

7.1 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.

7.2 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.

7.3 Design 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 32: 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**

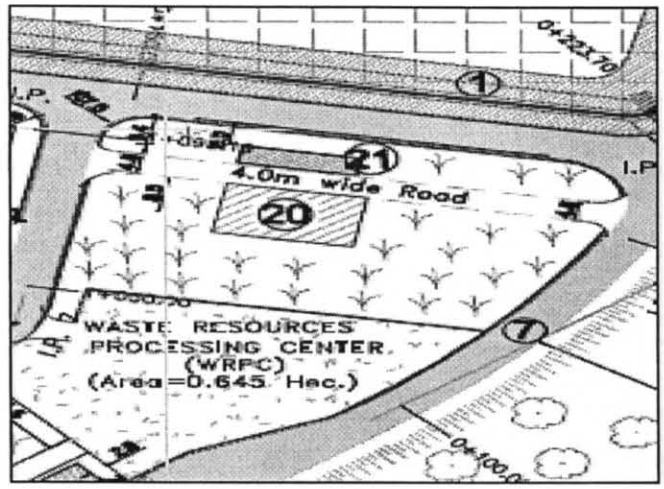


Figure 35: Site Plan of Waste Resources Processing Center

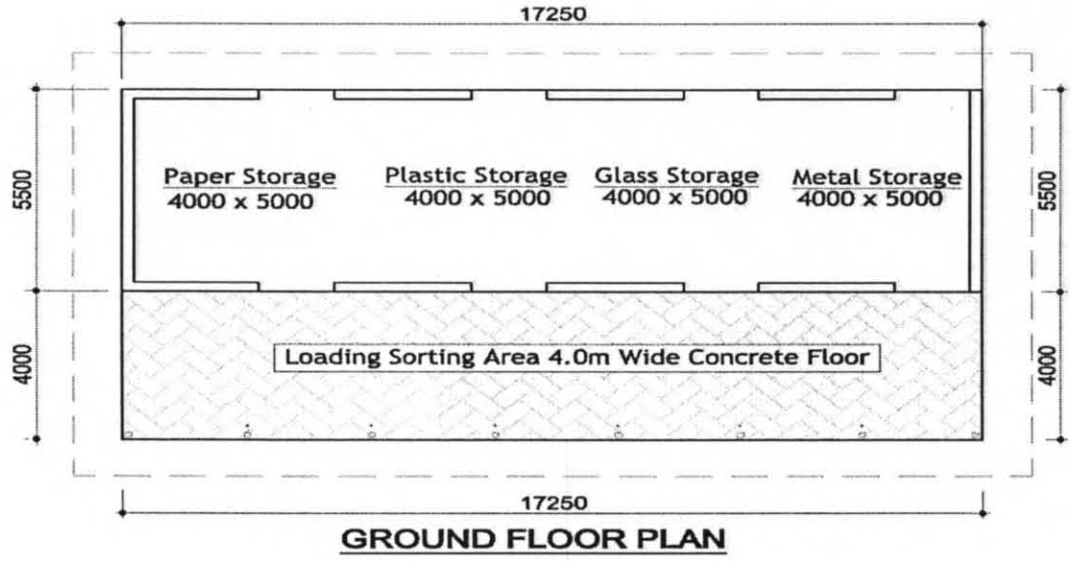


Figure 36: Layout of Waste Resources Processing Center Recyclable Storage Area

7.4 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.

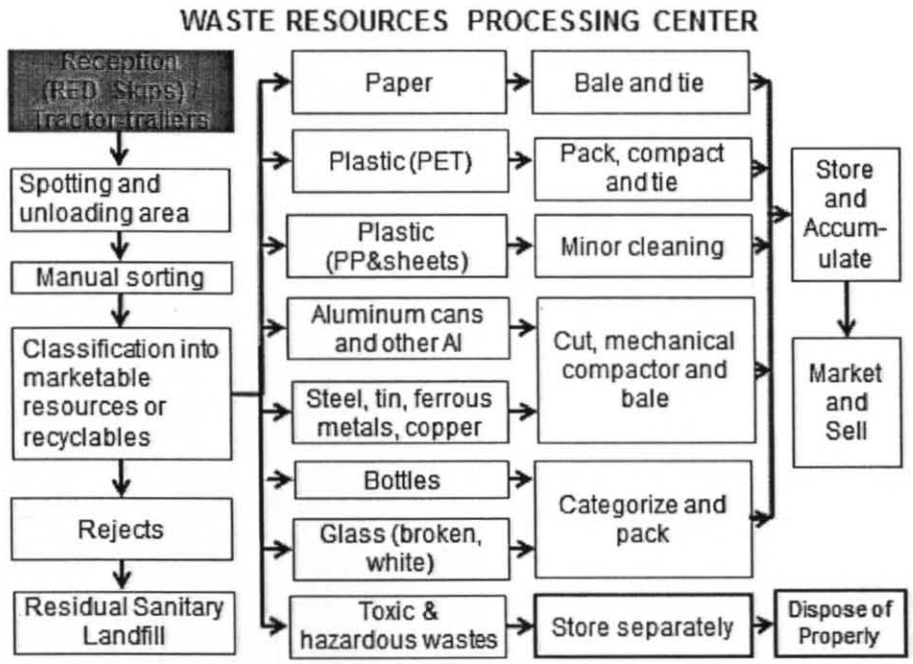


Figure 37: Flow Chart of Waste Resources Processing Center

CHAPTER 8: INSTITUTIONAL ARRANGEMENTS

8.1 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 38: Birgunj Sub-Metropolitan City Existing Organization Chart

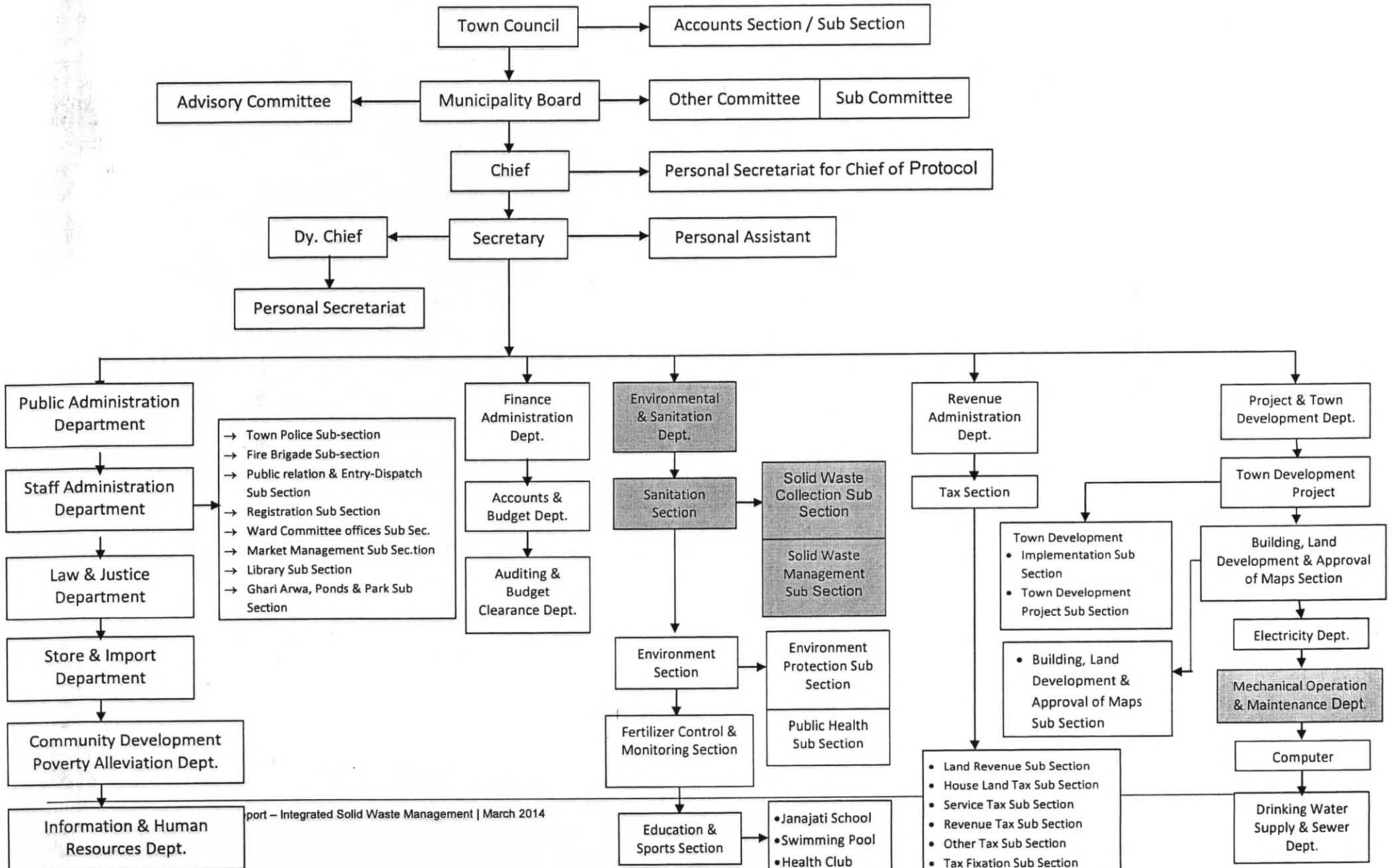
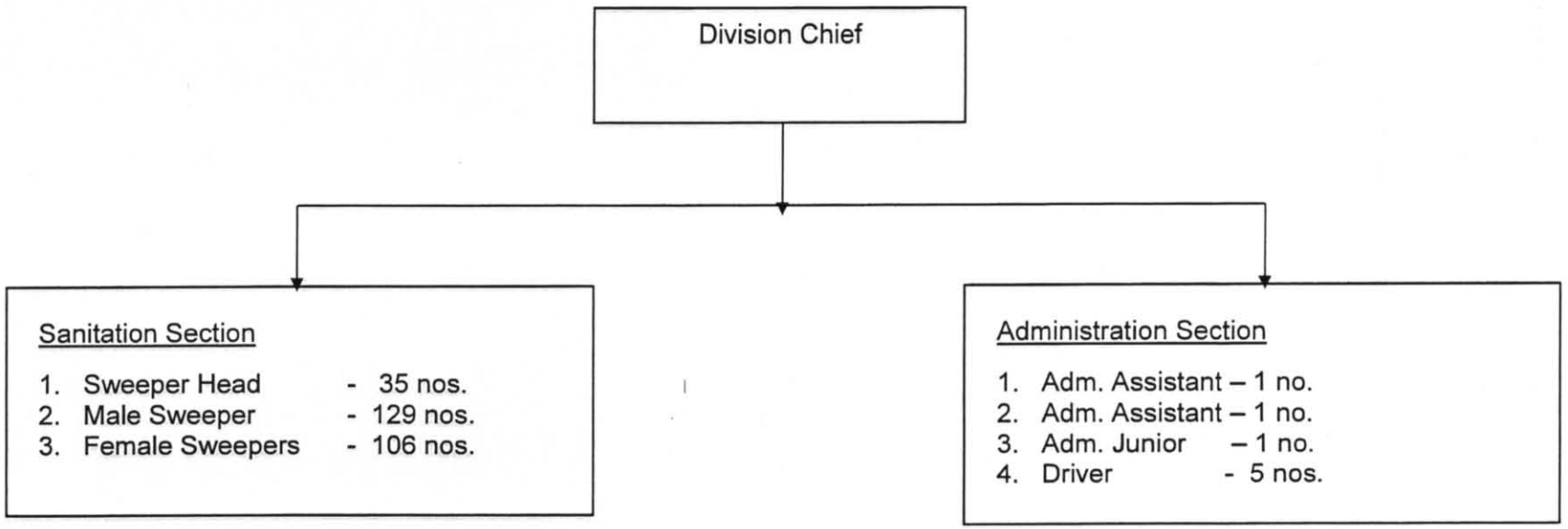


Figure 39: Sanitation Section Existing Organization Chart, BSMC Office



Total No. of staff 279

1. Male 173
2. Female 106

8.2 Proposed Institutional Arrangements

The existing organization of Birgunj Sub-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.

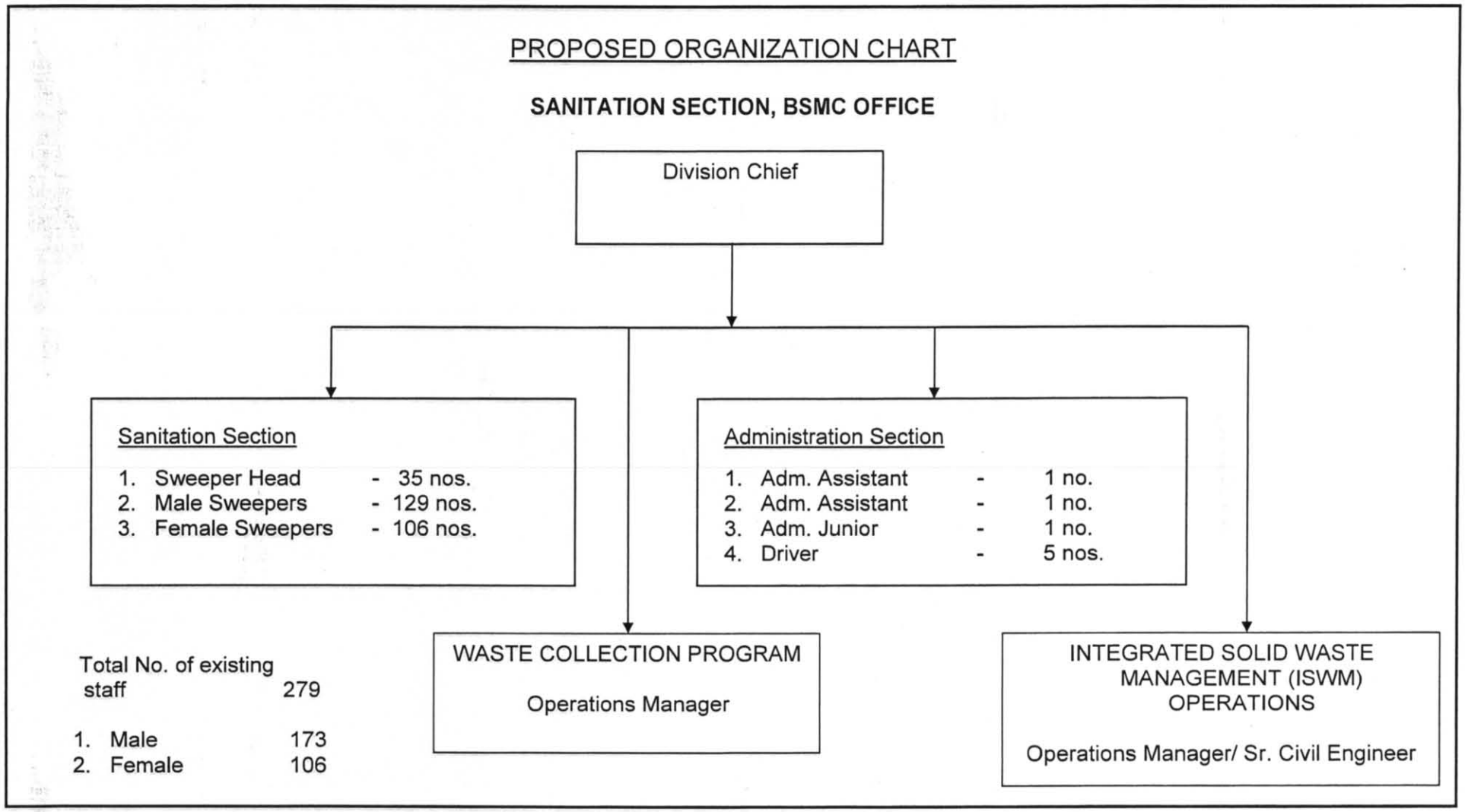


Figure 40: Proposed Organization Chart – Sanitation Section

Table 33: 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)															
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"x30")	Handcarts(Large: 60"x36"x18")
OLD (as of Feb 2013)															
Street Cleaning		2		8	12	13									
Other municipal Services:Private,Embassies, Diplomatic mission		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

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 34: Allocation of Personnel-Waste Collection Service and

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 41: Proposed Organization Chart – Waste Collection Operations

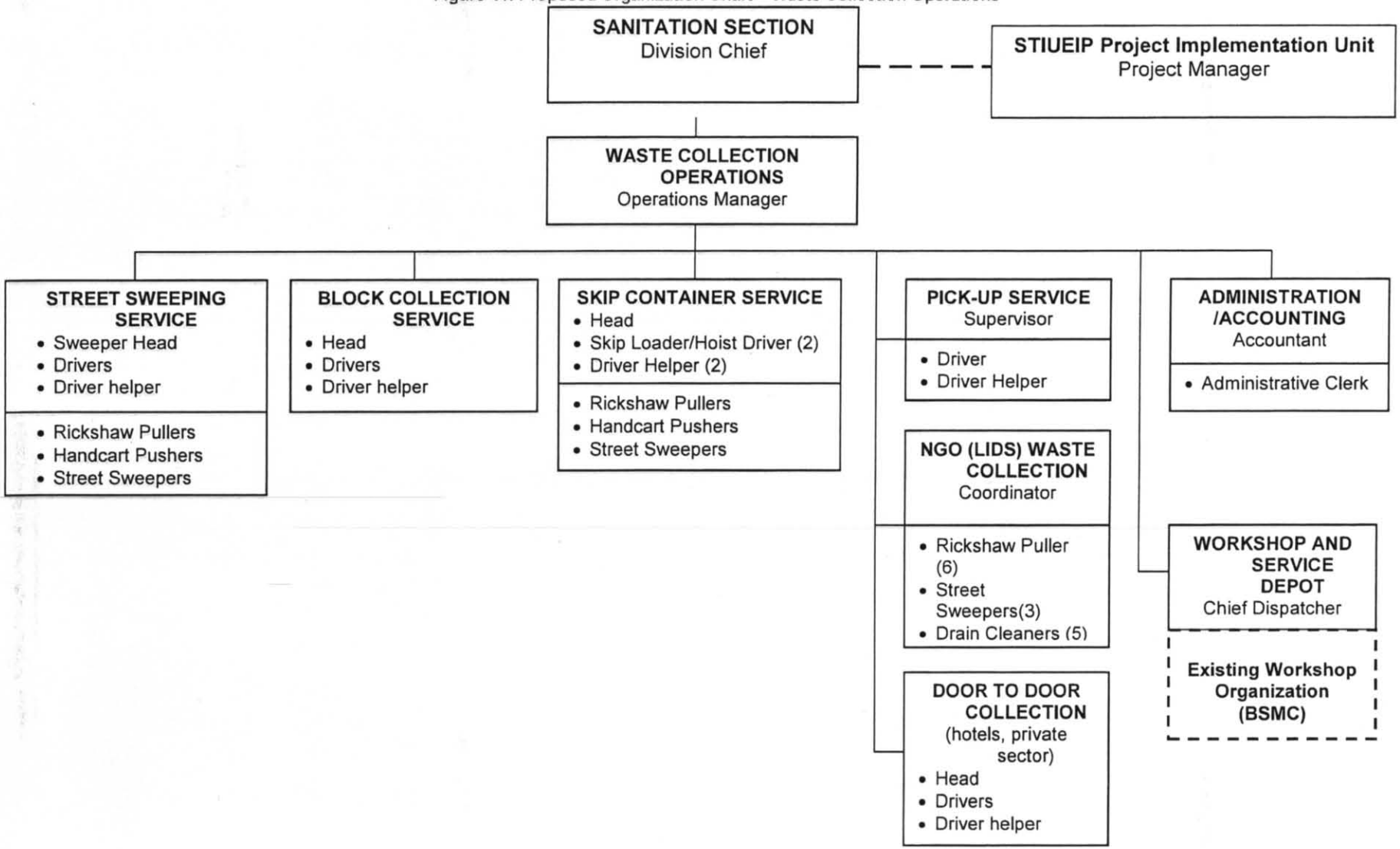
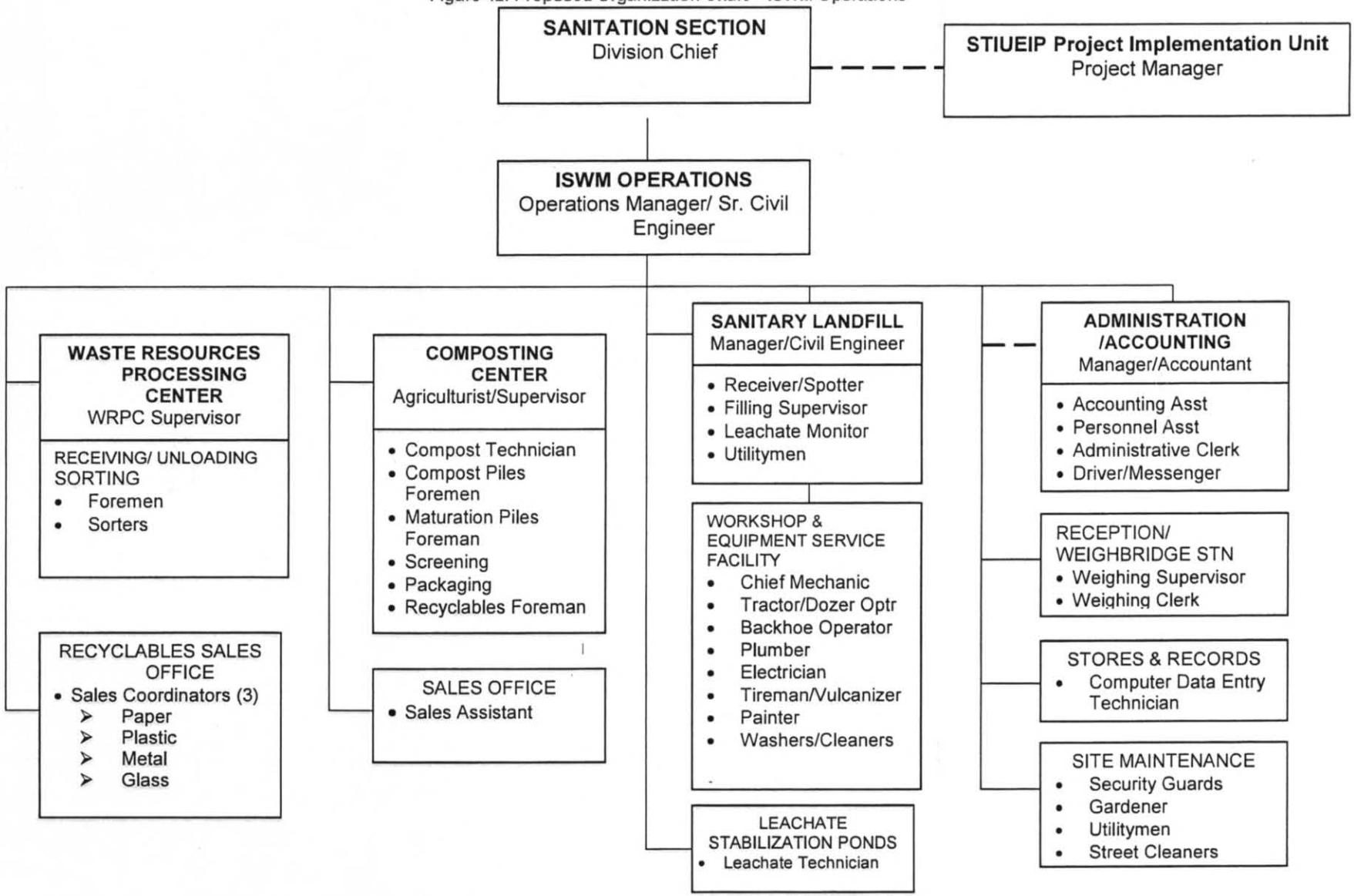


Figure 42: Proposed Organization Chart – ISWM Operations



8.3 Cost Recovery of Mechanisms for Integrated Solid Waste Management

The recommended system for cost recovery of the solid waste investments is to source revenues not only from the existing income from garbage fees and business taxes but most especially from the proceeds of composting activities and proceeds from the sale of recyclable materials.

The wards, if properly organized, may also be able to benefit financially from pre-collection recycling and even ward- or household-level composting.

In the near future, the City should be able to impose the appropriate solid waste fees based on the willingness-to-pay and priority surveys and depending particularly on the initial progress and success of the integrated solid waste system and the participation and cooperation of the public. At certain stages in the implementation of the integrated SWM system these surveys may need to be repeated.

Depending on whether it is within the City's legal jurisdiction to impose SWM service fees, the following factors can be used as basis for determining the service fees:

- types of solid waste to include special waste
- amount/volume of waste
- distance from the catchment areas or ward centers to the waste processing center and sanitary landfill site
- capacity or type of organization performing the services
- cost of construction
- cost of management
- type of technology used
-

Another cost recovery mechanism would be the imposition of fines and penalties to those who violate the solid waste rules and regulations that the City shall have imposed. If fines are to be imposed by the City in the future, the basis of collecting fines may include the following acts:

- Littering, throwing, open dumping of solid waste in public places, such as roads, sidewalks, rivers and streams, parks, and establishments causing or permitting the same;
- The open burning of solid waste;
- Squatting in open dumps and unofficial landfills;
- Open dumping, burying of biodegradable or non-biodegradable materials in flood-prone areas;
- Site preparation, construction, expansion or operation of waste management facilities without an Environmental Compliance Certificate required by the environmental regulatory body of Birgunj City

- The construction or operation of landfills or any waste disposal facility on any aquifer, groundwater reservoir or watershed area and/or any portion thereof.
- Meet with the transporters/haulers of wastes collected either to private disposal sites for filling lowlands upon request of the owners or to the present dump sites near the customs office in ward nos. 2 and 19 close to the border to India.

8.4 Awareness Campaign (information, education and communication)

The project awareness campaign has to be started right away preferably the 3rd quarter of 2013. The NGOs will have a very vital role in the campaign.

8.5 Organizational Development and Training

It is important for the present organization to work 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. A Resident Manager is recommended to be assigned to the Sanitary Landfill Site.

8.6 Social and Environmental Aspects of Solid Waste Management

Those socially impacted by the project are the primary and secondary impact areas of the sanitary landfill site. Consultations have been made with BSMC and a full environmental impact assessment will be prepared that will include public consultation or hearings as necessary in accordance with the environmental regulations of the Ministry of the Environment. The Environmental Impact Assessment will contain the Environmental Management Plan to mitigate the adverse potential impacts of the Sanitary Landfill. All positive impacts will also be highlighted from the point of view of improving the environmental condition of Birgunj as a whole.

CHAPTER 9: HEALTH CARE WASTES

9.1 Health Care Waste Facility at the Landfill Site

A health care waste facility for the future has not been provided in the landfill for public health facilities or clinics that do not have the capability to treat and dispose of their infectious wastes.

Private hospitals will be discouraged to use the facilities. Instead they should be required to install their own treatment disposal facility similar to autoclaves that are preferable non-burn technologies. An autoclave system is recommended as it is not expected to produce any air emissions or wastewater except for sterile steam after the process of autoclaving. Two (2) autoclaves are recommended with a capacity each of around 20 to 50 kg per cycle so that there is a back-up autoclave in case the system breaks down or needs to be repaired or maintained. In addition to the autoclave a shredder is provided to reduce the volume of the sterilized materials that can be recycled and/or sold to established buyers.

CHAPTER 10: PROJECT COST ESTIMATES

The following tables summarize the cost estimates for the STIUEIP Birgunj Solid Waste Management component:

- Master Site Development Plan
- First Year of Operations

The costs as prepared by the DSC Consultants cover the costs for the Overall Master Site Development Plan at the Integrated Solid Waste Management Site and the first year of operations. The detailed cost estimates of all the elements of the landfill and the supporting Bill of Quantities are attached in a separate volume.

The summary of Project Cost is shown in Tables 35 below. The detailed Quantity and Cost Estimates, Bill of Quantities and Unit Rate Analysis are presented in separate volume of the Final Design Report.

Table 35: Summary of Project Cost

S. No.	Description of works	Amount (NPR) in figures
1	Preliminary and General Works	13,499,270.00
2	Civil Works	170,897,664.47
3	Bore Hole Drilling and Installation of 100mm Dia. Deep Tube Well By Rig Machine	821,770.61
4	Water Supply and Sanitation Component	12,389,089.71
5	Electromechanical Works	5,243,123.80
6	Landfill and Waste Collection Equipment and Tools	38,832,500.00
7	Day Works	442,853.00
8	Operation and Maintenance Cost	37,154,810.00
9	Total Cost of 1-8	279,281,081.59
i	Price Contingencies 5% of 9	13,964,054.08
ii	Physical Contingencies 5% of 9	13,964,054.08
10	Sub Total (9+i+ii)	307,209,189.74
iii	VAT 13% of 10	39,937,194.67
11	**Grand Total Cost of the Project (NPR)**	**347,146,384.41**

CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS

The integrated solid waste management system in Birgunj can be successful if the leadership supports it fully with determination and commitment and with the proper appointment of the official-in-charge responsible for solid waste management for BSMC.

Recommendations on Important Issues and Planning Scenario

Important issues and the planning scenario are raised in this Final Report, which will play an important part in the successful implementation of this project over the next 20 years. Among these recommendations are:

- The projected municipal solid waste collection coverage as presented herein should be aligned with present and future plans, verified, and modified as appropriate by the BSMC, considering the 20 year planning period. Most important would be the land use plans, additional road improvement plans, and anticipating the increase in industrial and commercial, demolition, and new construction activities as a result of further urbanization of the Birgunj Sub-metropolitan City.

- The awareness campaign for the 3Rs (Reduce, Re-use and Recycle) should start as soon as possible even before the construction period in order to successfully realize the process plan for the STIUEIP Birgunj SWM component. The massive awareness campaign for the 3Rs is crucial whereas the synchronization of the campaign should be coordinated with the DSC recommended designs, the CDP program and the concerned NGOs/CBOs involved in the awareness campaign. The campaign should include information/education/communication (IEC) to, from and among the concerned NGOs/CBOs, the CDP program and the DSC consultants. In other countries 3R programs takes years – if not decades - to take root in the consciousness of the affected communities. A municipality-wide "Clean and Green Birgunj" contest is just one example of how - with annual awards and prizes to the winners - ward-level management of solid waste can be institutionalized in coordination with the solid waste user committees that have been formed from the grassroots level. With the prime goal of taking care of the environment and protecting public health, a major effort to make the campaign sustainable would to make the prospect of producing compost from waste and recovering resources from the recyclables attractive for the households and wards. Leadership training in this regard should be developed starting from the ward level as well and the tole lane organizations.

- With the country's renewed mandate to enforce the Solid Waste Management Act in 2013, the Polluters' Pay principle should be institutionalized as soon as possible in Birgunj by passing city ordinances, regulations and the strict enforcement of these by the imposition of sanctions, fines, penalties, or closure of polluting establishments. If these laws and ordinances are not enforced urgently, it is realistic to assume that the unwanted health care wastes from hospitals/health care facilities, and industrial and toxic wastes from the industries will reach the sanitary landfill and endanger public health.

- 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 construction of the Leachate Treatment Plant once the leachate characteristics are determined depending on the 3Rs progress.

- Sourcing and supply of clay materials for the operational daily cover or intermediate cover, if needed, and final cover (cap) of the Landfill Cells should be ensured by continuously monitoring the specific requirements based on cost and operational performance e.g. compaction density tests and laboratory tests.

- 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 BSMC for the ISWM site.

ANNEXES

Annex 1: **Hydrology Study of Flood Levels at Proposed Birgunj Landfill Site**

Annex 2: **Geotechnical Report (To be submitted as a Separate Volume with Final Report)**

Annex 3: **Recycling Market Study Forms**

Annex 1: Hydrology Study of Flood Levels at Proposed Birgunj Landfill Site

Introduction

Basin area of Singaha river up to the landfill site located to the eastern side of Birgunj is 12 km2 (Figure 1). The region is flat and maps available does not indicate clear water divide lines, So road boundaries are followed as water divides while delineate the basin area. The channel course i.e. water course is 11 km and the average river gradient is 1 in 1000. Watershed area is flat, cultivated and scattered houses. Landfill area lies at the left bank of the river,

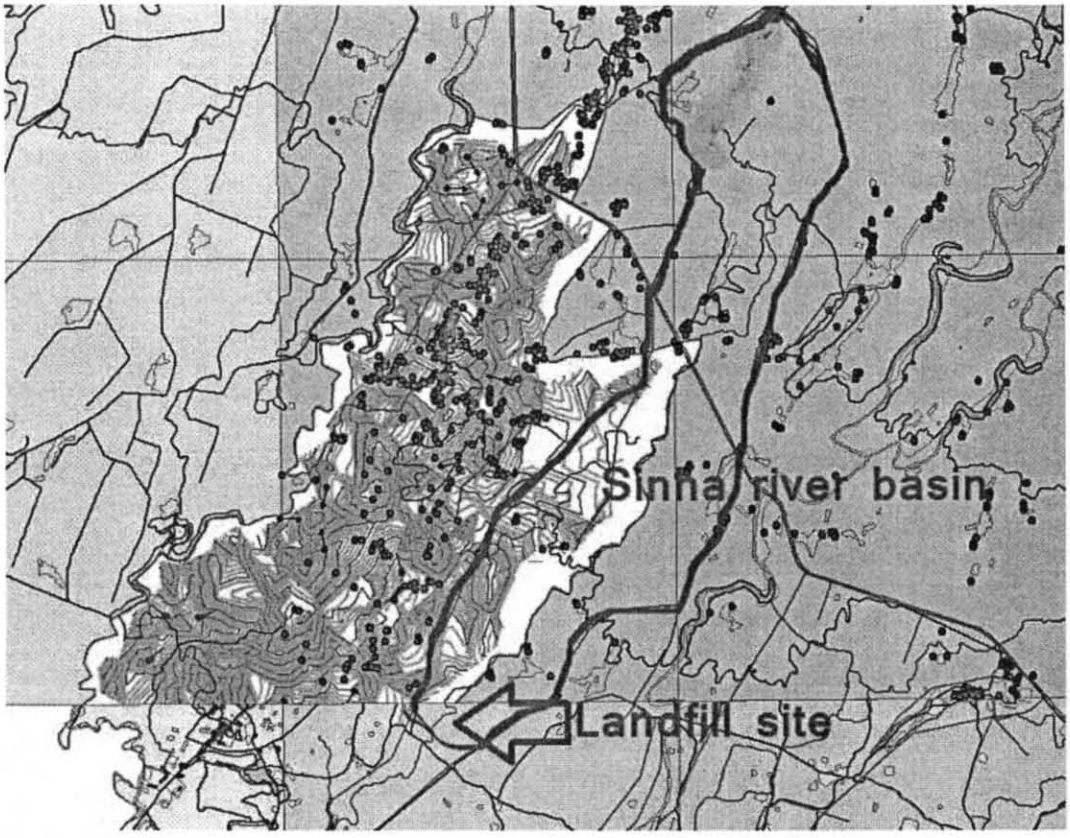


Figure 1: Drainage area of Singaha River

Methodology

Methodology to predict peak flow has been adopted the most appropriate procedures for application to present study. The assessment of methods has been based on the following three critical criteria, i.e. desired objective, available data and watershed characteristics.

- Rainfall intensity duration frequency analysis by WMO's standard method.
- Time of concentration by USGS
- Flood peaks estimate by rational method.

Methods descriptions are given below

Time of concentration

Time of concentration (Tc) is generally determined by Kirpich Equation: The time of concentration of a basin can be estimated as below:

$$Tc = 0.00032L^{0.77} S^{-0.358}$$

Where

Tc = time of concentration (hour)
L = maximum length of travel of water (m)
S = slope equal tp H/L, where H is the difference in evaluation between the remotest point on the basin and the outlet (m)

For the present study, the recommended method is provided from previous study as below.

$Tc = \{0.87*L^3/H)\}^{0.385}$, where

Tc = time of concentration (hour)
L = maximum length of travel of water (Km)
H = Vertical drop of basin outlet to farthest point (m)

Time of Concentration considers sheet flow and shallow concentrated channel flow as well.

Rainfall intensity duration frequency analysis

Intensity duration frequency (IDF) analysis is used to capture the essential characteristics of point rainfall for shorter durations. IDF analysis provides a convenient tool to summarize regional rainfall information, and is used in municipal storm water management practice. The Gumbel probability distribution is used.

This method is used to estimate rainfall frequency for durations of 5, 10, 15 and 30 minutes, as well as for 1, 2, 6, 12 and 24 hours. But the meteorological station at Birgunj do not have data records for durations shorter than 24 hour (Daily), Therefore intensities of shorter rainfall durations are estimated

To develop the Intensity-Duration-Frequency Curves, the annual maximum series of 24hrs rainfall data are required. Probable 24hrs rainfalls and corresponding return periods were calculated by Gumbel method. Monobe's equation which is expressed as follows is used to find rainfall intensity of desired durations.

$$Rt = R24/24(24/t)^{2/3}$$

where Rt : Rainfall intensity in t hours (mm/hr)
R24 = 24 hrs rainfall (mm)
t = Time of concentration (hours)

The Rational Formula

The rational formula relates the runoff from a drainage basin to its area, its physical characteristics, and the rainfall intensity. The limitation of the rational method is as follows:

1) The rate of runoff resulting from any rainfall intensity is at maximum when the duration is equal to or longer than the time of concentration.
2) The frequency of peak discharge is the same as that of the rainfall intensity for the given time of concentration.
3) The relationship between peak discharge and size of drainage area is the same as the relationship between peak the duration and intensity of rainfall.
4) The coefficient of runoff is the same for storms of various frequencies on a given watershed.

In spite of above limitations this formula is particularly applicable to watersheds of the size that can be drained through pipes and small box culverts.

The relationship is expressed by the equation:

$$Q = 2.78\ C\ I A$$

in which

Q = runoff rate (m3/s)

C = runoff coefficient

I = rainfall intensity (cm/hour) of a storm whose duration is equal to the time of concentration of the basin

A = area of watershed (km2)

Results

- 24 hourly point rainfall at a meteorological stations operated by the Department of Hydrology and Meteorology are considered as the representative rainfall over the basin. Rainfall intensities for different return period are determined and are given below (Table 1)
.

- Time of concentration up to the Landfill location is computed and is found approximately to be about 6 hours(Table 2). Therefore intensities of 6-hr duration are used in the rational formula. The area is cultivated, fat and partly residential.

- The runoff coefficient to be used in the rational formula is considered to be 0.5.

- Floods peaks for different return period are estimated and given in Table 3

Table 1: Rainfall Intensity mm/hr

Duration	2yr	5yr	!0 yr	15yr	20yr	25yr	50 yr	100yr
1 hr	50.4	70.6	84.1	91.6	96.9	101.0	113.6	126.0
2 hr	31.8	44.5	53.0	57.7	61.1	63.7	71.6	79.4
3 hr	24.2	34.0	40.4	44.1	46.6	48.6	54.6	60.6
6 hr	15.3	21.4	25.5	27.8	29.4	30.6	34.4	38.2
12 hr	9.6	13.5	16.1	17.5	18.5	19.3	21.7	24.1
1 day	6.1	8.5	10.1	11.0	11.7	12.2	13.7	15.2

Table 2: Time of Concentration

Basin : Sinha River	
Area (sq.km)	12.00
L-max (km)	11
L-mid (km)	5.5
Slope (m/m)	0.001
Level Diff (meter)	10.0
Tc = (0.87*L^3/H)^0.385	6.231
Time of Concentration -adopted	6 hr
Run off Coefficient	0.5

Table 3: Flood peaks for different return period:

Return Period	2yr	5yr	!0 yr	15yr	20yr	25yr	50 yr	100yr
Intensity, mm/hr	15.28	21.42	25.49	27.78	29.39	30.62	34.44	38.22
Flood, m3/s	25.5	35.73	42.51	46.34	49.02	51.08	57.44	63.75

Note : No water flows from Gandak canal breach or road cuts are consider entering the river basin.

Rating curve and flood levels near landfill site:

Two river sections – chainage_0+324 and Chainage_0+353 are taken and cross sectional properties are determined (Table 4 & 5). Manning's equation is used to determine the river flows that can pass through the section at different levels. Based on river profile survey data, channel slope is considered as 1 in 3000 which was used as energy slope at the initial calculation. River flows at different water levels were computed to establish a rating curve (Figure 2). Based on the same curve, flood levels are assessed. (Table 6 and Figure 2)

Table 4: Cross section properties at chainage 0+324

Bed Level(m)	W. L (m)	Area (m^2)	Hyd-R (m)	W-Peri (m)	T-width (m)
80.8	4.6	77.1	2.16	35.6	34.2
80.2	4.0	58.7	2.08	28.3	27.0
79.2	3.0	34.8	1.60	21.7	20.0
78.2	2.0	17.1	1.13	15.1	14.6
77.2	1.0	5.1	0.53	9.6	9.4

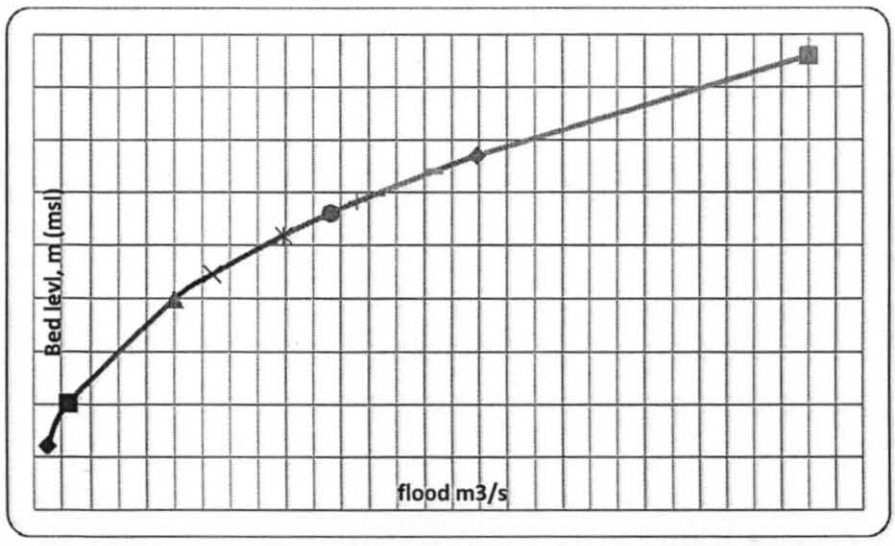
Table 5: Cross section properties at chainage0+353

Bed Level(m)	W. L (m)	Area (m^2)	Hyd-R (m)	W-Peri (m)	T-width (m)
80.8	4.6	88,56	2.46	36.0	34.8
80.2	4.0	68.91	2.17	31.8	30.7
79.2	3.0	41.51	1.67	24.9	24.1
78.2	2.0	20.71	1.15	18.0	17.5
77.2	1.0	6.56	0.60	11.0	10.8

Table 6: Flood levels near landfill site

Return period	Q, m3/s	Level, m
	2.00	77.111
	5.00	77.515
	20.00	78.494
2yr	25.48	78.728
5yr	35.73	79.095
!0 yr	42.51	79.304
15yr	46.34	79.413
20yr	49.02	79.486
50 yr	57.44	79.702
100yr	63.75	79.852

Figure 2: Rating curve near Landfill site



Annex 2: Geotechnical Report

(To be submitted as a Separate Volume with Final Report)

Annex 3: Recycling Market Study Forms