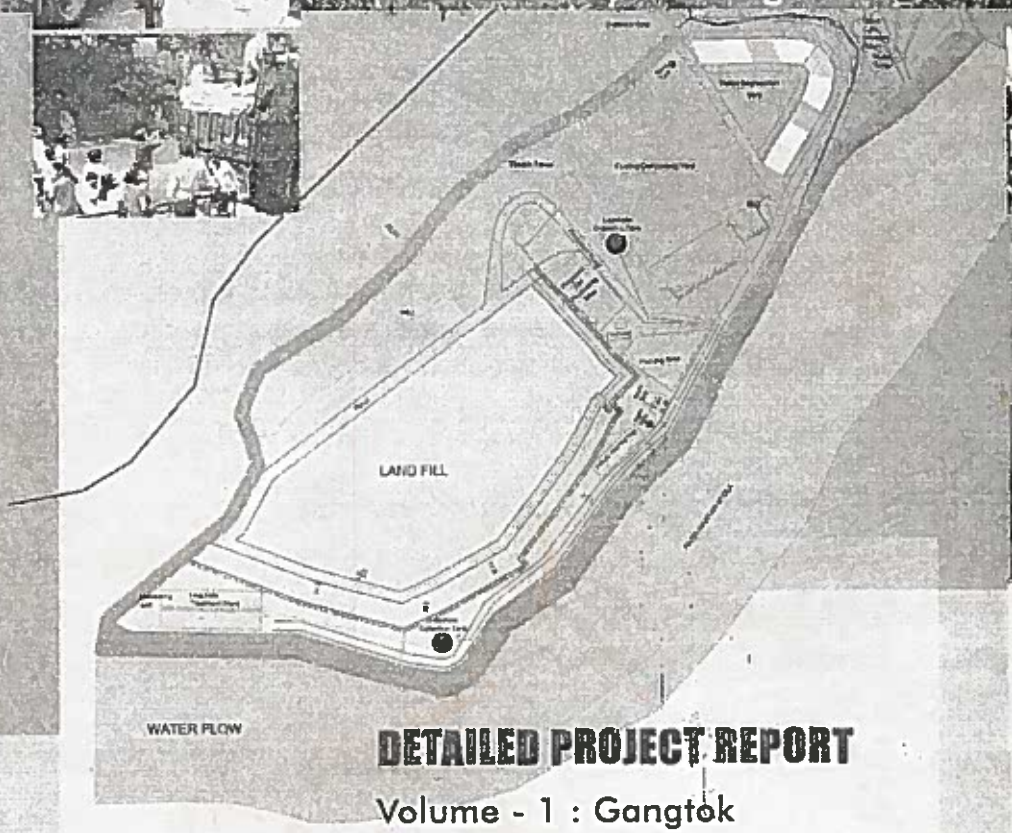
Sept 2011

Government of Sikkim
State Investment Program Management and Implementation Unit (SIPMIU)

ADB - LOAN 2528-IND

North Eastern Region Capital Cities Development Investment Program (NERCCDIP) - Gangtok



DETAILED PROJECT REPORT

Volume - 1 : Gangtok

Solid Waste Management Project

Prepared By:

WilburSmith ASSOCIATES

Design, Supervision and Management Consultant (DSMC) Gangtok

SEPETMBER'2011

State Investment Program Management and Implementation Unit (SIPMIU),
Urban Development and Housing Department, Government of Sikkim
Asian Development Bank

North Eastern Region Capital Cities Development Investment Program (NERCCDIP)

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Design, Supervision and Management Consultant (DSMC)
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SWM Specialist
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J. D. BHUTIA
PROJECT DIRECTOR
SIPMIU (NERCCDIP)
GOVERNMENT OF SIKKIM
GANGTOK

Currency Equivalent

Currency Unit	-	Indian Rupee/s (Re/Rs)
Re. 1.00	=	US$ 0.022
US$ 1.00	=	Rs. 45

Abbreviations

ADB	:	Asian Development Bank
AE	:	Assistant Engineer
BIS	:	Bureau of Indian Standards
BOQ	:	Bill of Quantities
BT	:	Black Topped
C&D	:	Construction and Demolition Waste
C/N Ratio	:	Carbon Nitrogen Ration
CBO	:	Community Based Organization
CDM	:	Clean Development Mechanism
CHO	:	Corporation Health Officer
COD	:	Chemical Oxygen Demand
CPCB	:	Central Pollution Control Board
CPCG	:	Combined Per Capita Generation
CPHEEO	:	Central Public Health &Environmental Engineering Organization
CRZ	:	Coastal Regulatory Zone
DPR	:	Detailed Project Report
EE	:	Environmental Engineer
EPA	:	Environmental Protection Agency
FY	:	Financial Year
GNP	:	Growth National Product
GoI	:	Government of India
GoS	:	Government of Sikkim
HCV	:	Heavy Commercial Vehicle
HD	:	Health Department
HDPE	:	High Density Polyethylene
HIG	:	High Income Group

ISWM	:	Integrated Solid Waste Management
JHI	:	Junior Health Inspector
GMC	:	Gangtok Municipal Corporation
SPCB	:	Sikkim State Pollution Control Board
NERCCDIP	:	North Eastern Region Capital Cities Development Investment Program
LCV	:	Light Commercial Vehicle
LDPE	:	Low Density Polyethylene
LIG	:	Low Income Group
LSGD	:	Local Self Government Department
MC	:	Municipal Corporation
MIG	:	Middle Income Group
MoEF	:	Ministry of Environment and Forests
MSL	:	Mean Sea Level
MSW	:	Municipal Solid Waste
MT	:	Metric Ton
NEERI	:	National Environmental Engineering Research Institute
NGO	:	Non Government Organization
NH	:	National Highway
NMC	:	Natural Moisture Content
O&M	:	Operation and Maintenance
PHE	:	Public Health Engineer
PMMC	:	Project Management & Monitoring Consultant
PWD	:	Public Works Department
RA	:	Rate Analysis
RA's	:	Resident's Association
RCC	:	Reinforced Cement Concrete
RRP	:	Report and Recommendation of the President
SEUF	:	Socio Economic Unit Foundation
SH	:	State Highway
SoW	:	Scope of Work
SPT	:	Standard Penetration Test
SWM	:	Solid Waste Management
TA	:	Technical Assistance
TDS	:	Total Dissolved Solids

ToR	:	Terms of Reference
ToT	:	Time of Turning
TPD	:	Tons Per Day
UDS	:	Un-disturbed Soil Sample
ULB	:	Urban Local Body
USEPA	:	United States Environmental Protection Agency
WBM	:	Water Bound Macadam
WLC	:	Ward Level Committee

Executive Summary

The Government of India (GOI), had obtained a loan from the Asian Development Bank towards the North Eastern Region Capital Cities Development Investment Program (NERCCDIP). This Detailed Project Report (DPR) on Solid Waste Management for Gangtok has been prepared by the Design, Construction Supervision & Management Consultant (DSMC) for the State Investment Program Management Implementation Unit (SIPMIU), Urban Development and Housing Department, Government of Sikkim NERCCDIP – Gangtok.

Gangtok, is the Capital of Sikkim State (East District) and is connected by the National Highway (NH) 31A with Darjeeling, Kalimpong and Siliguri. Gangtok covers an area of 19.06 sq. km. with 15 wards having a population of 82,149, Census 2001. The nearest railway station is at Siliguri and airport at Bagdogra which are about 120 km from Gangtok. The city lies between 27°16' to 27°20' N latitude and 88°37' to 88°39' E longitude and falls in Seismic Zone IV. The altitude varies from 914 m to 1829 m above mean sea level (MSL). The region receives an annual average rainfall of 3494 mm over 164 rainy days.

The approach adopted for preparation of SWM DPR included carrying out survey of waste quantification and characterisation, field visits, discussions with officers, NGOs, Private partners, residents of Gangtok, assessment of existing solid waste collection, transportation and disposal practices followed in Gangtok. Consultations were held with Sikkim State Pollution Control Board, Forest Department, Department of Mines & Geology, Central Public Health and Environmental Engineering Organization (CPHEEO) etc.

The City lacks systematic/scientific approach towards solid waste management viz., primary collection, secondary collection, transportation and safe disposal of the municipal garbage. The present status of the SWM in Gangtok city is about 54 % of solid waste is collected daily and transported for disposal on open areas outside the city at Martam. The rest is dumped into streams and vacant areas on hilly terrain in the city and finds its way into the drains, causing health risk and environmental degradation. There is no scientifically designed landfill and thereby unhygienic disposal of waste in open dumping areas posing threat to public health. Non working of the existing compost plant has resulted in waste dumps without treatment and due to winds, often finds its way into the stream flowing adjoining the dumping area posing threat to the health and environment.

DSMC has engaged M/s Eco-Pro Environmental Services, Indore (M.P.) for carrying out Solid waste Characterization and Quantification study in accordance with SWM (M&H) Rules 2000 and also had incorporated the guidelines suggested in CPHEEO Manual and relevant code of practice. The information on the nature of wastes, its composition, physical and chemical characteristics – and the quantities were generated for the planning of a Solid Waste Management system at Gangtok. To assess the physico-chemical characteristics of solid waste generated in the city physical analysis

and chemical analysis of waste in the lab was carried out by collecting and testing 35 number of samples such as residential, commercial, market, slum, hotel restaurant etc. sampling points are distributed uniformly all over the study area.

Eco Pro team along with DSMC and GMC officials identified and finalized the sampling points and distributed coded polythene bags for waste collection from different sampling points. In order to analyze the waste generation trends for the entire week including the weekends, the sample surveys were carried out for seven consecutive days from 15.11.2010 to 21.11.2010. The collected sample in each bag was weighed and recorded in the standard data format. For collection of waste from the dump site quartering procedure was followed as per CPHEEO manual. The sampled waste was tested at Indore laboratory,

The sample surveys indicate that the average per capita generation in HIG group of households is about 324 gm as against the 274 gm for MIG and 190 gm per capita for LIG households. The total waste generation from residential area is 60% market area is 15%, 10% each from Hotel and Tourist, followed by street sweeping waste of 5%. Therefore a per capita waste generation from Gangtok city was estimated as 377 grams per person. The Standard testing methods for analysis were adopted for chemical contents (Carbon, Nitrogen, Calorific Value and Heavy Metals) and moisture content. The analysis was carried out to make a decision in finalizing the waste processing technology and potential for recovery/recycling. While the C/N ratio is a direct indicator of the suitability of waste for bioconversion of the waste, calorific value is an indicator for assessing the suitability of waste to energy technologies.

As per the studies conducted in November 2010, the per capita waste generation is 377 grams. The population projections have been considered as 129,500 (2012), 180,500 (2027) and 232,000 (2042) and is in line with the other subprojects under NERCCDIP. With this generation rate as a base and projected growth of 1.41 % annual increase in per capita for 2012 (the starting year of design period) is 387 grams (46 TPD). Waste quantification and characterization surveys in Gangtok indicate that the city generates about 46 MT of solid waste every day, which is equivalent to the GMC estimates of 45 MT per day.

Also the study indicated a marginal increase in the organic waste and accounts for about 63.3% against the earlier projection of 58%. The difference of about 5% would reflect a positive signal for the design process wherein the compost plant can run efficiently with more organic waste. At the same time it is advantageous by increasing the landfill life. Therefore it is recommended to consider the positive aspects of the study and accordingly the SWM project for Gangtok is designed.

It is proposed to introduce segregation of waste at source (house level) as wet waste and dry waste. Two separate bins shall be distributed to residents viz., one for Biodegradable waste (Green colour) and the other for Non-bio degradable waste (Blue colour) separation.. In order to familiarize the concept of segregation at source, massive public awareness and one time supply of bins (47,200 nos) were provisioned in

consultation with GMC, local NGOs, & UDHD. The wet waste shall be composted, dry waste shall be recycled/reused to the extent possible and domestic hazardous waste shall be taken to landfill. This would facilitate maintaining hygienic condition and easy handling of the waste for further processing and also to get quality compost. The Bio medical waste is not allowed in Municipal stream and shall be dealt separately as per Bio Medical Waste (Management & Handling) Rules. It is understood that in Gangtok the hospitals are managing the Bio medical waste through incinerators.

The Door-to-door waste collection shall be introduced and the waste shall be collected on a daily basis. Waste collectors shall be provided with small mechanical vehicles to inaccessible areas and waste shall be deposited by the households in container. Litter bins shall be provided along main roads, bus stand, other public places etc. to avoid littering. Door-to-door waste collection system through small mechanical vehicles (Mini Garbage Tipper) are proposed for Gangtok. The garbage will be emptied manually into the vehicle by the households. Once filled upto its full capacity it shall be transported to a near by, waiting Refuse Compactor at Transfer point (4 Nos). While unloading the container, the Mini Garbage Tipper will reverse itself close to the Compactor's tailgate, and the bin will be hydraulically tipped to discharge its contents into the hopper and emptied into the Compactor. These Mini Garbage Tipper of capacity 4.0 cum capacity and 1.5 cum capacity shall make 3 and 4 trips/day respectively. A total of 14 new vehicles are proposed comprising 1.5 cum capacity (11 Nos.) and 4.0 cum capacity (3 Nos.). Also the existing two vehicles are considered for the Door to Door collection system. The GMC had planned Door to Door Collection system in each ward under the supervision of respective elected representative/ Ward Councilor by collecting fees for operational expenditures.

The public awareness programs shall be started only after the procurement of Two Bins, Door to Door Primary collection vehicles. The detailed programmes on public awareness shall be decided in consultation with GMC/UDHD. An amount of Rs. 2.5 Million is earmarked for Public Awareness. The funds provisioned for public awareness is for the period of about 6 months. GMC is expected to get some revenue when private /public operator takes over O & M of Compost Plant. These revenue may be utilized for public awareness promoting waste segregation during extended period.

Presently there are few NGO's who are collecting primary waste from interior areas and the vehicles are provided by UDHD to local NGOs. NGOs were collecting waste and also collected fee (Rs. 30 to Rs. 50 from per Household and Rs. 50 to Rs.100 from Hotel/commercial establishments), paid for drivers and also maintained the vehicles. The GMC vide the 2nd General Body meeting held on 24th January, 2011 under the Chairmanship of Hon'ble Mayor decided to collect fee for primary collection from the rest of the area. The GMC had planned to involve local Ward Councilors/NGOs/Interested persons to manage the primary collection at Ward level by collecting monthly fee from households and commercial establishments at the rates fixed as per the resolution.

It is recommended to sweep all the roads and lanes with dense habitation or commercial activities on a day to day basis, alternate day sweeping in medium density wards and once in three days/once in a week sweeping in the remaining wards. The 102 nos. of Push carts are proposed for road sweeping and drain cleaning. The sweepers shall transfer waste from Push cart to the litter bins located within a reasonable distance and these shall be emptied into the respective Primary collection vehicle. The life of the Push cart is considered as 5 years and thereafter these are to be replaced.

Though litter bins are not recommended as per the SWM Rules, Gangtok being a tourist destination, in order to cater to the needs of Tourist/ floating population in and around M.G. Marg, and other major market areas, Taxi Stand, Bus station, Shopping areas, in city center area, litter bins are proposed at a spacing of 100 meters. These litter bins shall be emptied by respective sweepers attending the designated area and empty into primary collection vehicle. A total of 235 litter bins of 50 ltrs (20 Nos.), 120 ltrs (101 Nos), 360 ltrs (114 Nos.) are provisioned.

Regarding the secondary collection and transportation, the Compactor vehicles are provisioned. These Compactors are located at four Transfer points namely, (1) Near Indira By-pass, (2) Near Baluwakhane Parking Complex, (3) Near LPG Store, and (4) Near Essar Pump. On arrival of the Mini Garbage Tipper of capacity 4.5 cum capacity and 1.5 cum capacity, the dry waste collected in the litter bins/ plastic drums shall be manually emptied into the 1100 ltrs capacity Bins. The Wet waste collected in the Mini Tippers are emptied/unloaded/Tipped off directly into the Hopper of Compactor Vehicle by Hydraulic Tipping arrangement. The hopper would unload the garbage into the compactor body. Accordingly 4 Nos of Compactors are planned at 4 locations for collecting wet waste. The dry waste stored in the 1100 ltrs capacity shall be lifted and emptied by the one dedicated compactor vehicle with Universal Bin lifting arrangements. Therefore 5 nos of compactors are proposed for 2012-2017.

Also, the proposed system shall undertake direct collection of waste from large and medium sized hotels, restaurants, party halls, hospitals (domestic and non-bio medical waste) and from construction sites. Separate vehicles (existing) with adequate crew shall be provided for the purpose and the collection shall be carried out on a fixed daily schedule. The waste may be directly transported to disposal site by the existing waste transport vehicles available.

The above Collection and Transportation system was formulated in consultation with the community stakeholders viz., 26.04.2010, 18.11.2010, 19.11.2010, 17.12.2010, 24.07.2010. The consultation is carried out in two phase viz., (1) At the beginning of the project emphasizing on the existing status of SWM in Gangtok and (2) after formulation of the DPR.

The State Government has declared Sikkim as an "Organic State" demanding for segregated organic (wet) waste for composting. Therefore the segregation of waste in two bins, door to door collection by primary collection vehicles and compactors are introduced.

As per MSW Rules, 2000 waste processing of the organic component through composting was considered mainly because composting is a proven technology, cheapest option, organic fraction of 63% and moreover MoUD's assisted recently constructed plant existed at Martam. The windrow area available was assessed and the capacity of the plant was found to be 50 TPD. Based on the organic waste generation from Gangtok the Compost Plant at Martam would produces a total quantity of about 6-7 tonnes per day. The UDHD had in principle handed over the Compost Plant to GMC. Also, GMC is in the process of engaging Private agency for O & M and the same agency shall be involved for marketing the compost also. GMC may get some revenue when the agency takes over O & M of Compost Plant. These revenue may be utilized for public awareness promoting waste segregation during extended period and support financial assistance for secondary collection and transportation system. The GMC had indicated that SIMFED and MGNREGA had shown interest to purchase the compost.

The rejects from the compost plant and the inert material is proposed to be disposed in a landfill site, fully complied with the requirements of MSW Rules. After series of search for landfill sites the existing area adjoining to Compost plant at Martam was finalized by the State Government for Landfill construction. The site selection process was carried out by DSMC and since there was no other alternatives were suitable, the challenge of utilizing the existing garbage dump yard was explored by the DSMC to develop into scientific landfill facility for accepting rejects from the composting process and also from non recyclable waste stream.

The existing garbage land belongs to UDHD and has an extent of about 4.2 Ha The site has a sloping terrain from NW to SE towards Ranikhola/Martam Khola river with RL 73.00 m to 60.00 m respectively. Due to various constraints like hilly terrain, river flowing adjacent, existing compost plant etc. the effective area available for landfill is about 10,970 sq.m. (1.1 ha.) only.

The Department of Mines, Minerals and Geology, Government of Sikkim, Gangtok was consulted and site visit was made and soil sample were collected and analysed for Moisture content (5.15%), Dry Density (1.43 gms/cc), Value of C (is zero), phi varies from 25 to 35%, Clay (0.09%), Silt (0.5%), Fine to very fine sand (13.68 %), Medium Grained sand (45.05%), Coarse sand (29%), Very Coarse sand (8%), Gravel (3.4%). Based on the Geophysical Positioning System (GPS, and trial pits, natural sloping terrain the elevation difference of 15 m (580m a.m.s.l on landfill site and 565 m a.m.s.l. at river side) was observed and no where the ground water table appeared. The department verified the exposed materials along the river bank is sand, pebbles and gravels and overall geological setup of the area, and indicated that formation of water table appears to be remote. Therefore the present water level of river was taken as permanent water table which in turn indicated that ground water table is 15 m below the ground level.

Further regarding the apprehension of location nearby the river may cause flood was verified and no such records of flood data were available. However, Geologist from

Mines & Geology inspected the site on various rock masses and indicated the flood level varied between 562 and 565 a.m.s.l. Also the local enquiry reveals that the land is not under flood plain. Not sparing the same, as a precautionary measure, an RCC Wall was proposed to avoid any ambiguity.

Earlier based on the site assessment and soil condition, the landfill containment with conventional soil embankment was not feasible because it occupies huge space and together would have reduced the landfill life. Therefore after consultation with specialized, experienced, technical experts from reputed firm, the design for Gabion wall with Reinforced Earth (RE) was proposed wherein the top width of Gabion wall was for 5.5 m for easy vehicle movement and also included the River protection works. But during the approval stage, the intervention by CPHEEO led to RCC Retaining Wall for containment of Landfill.

The design was based on the waste generation of 50 Tonnes per Day (2012), Design Life of 17 years for 16 m high and 23 years for 19m high, Closure & Post Closure Period of 25 years, Water table of 15 m below ground surface, Average total Precipitation of 3580 mm per year etc. The height of RCC wall would range from a minimum height of 6 meters to maximum of 19 meters. The designs are carried out for 19 m height but CPHEEO has limited the cost of construction by truncating the top 3 meter height. The development of the landfill site is expected to serve the requirement of about 17 years from the infrastructure developed for landfill through NERCCDIP. But the life may be further extended to additional 6 years by taking up the second phase of development by the UDHD/GMC to increase the height for 3 meter fill after completion of fill upto 76.00 RL. Further four years could be utilized based on the waste profile and also by creating additional infrastructures like road, ramp etc from other resources.

The Standard design of landfill is provisioned wherein 90 cm thick of clay liner constructed using wet clay or soil amended with bentonite or other agents, having coefficient of permeability not greater than 1×10^{-7} cm/sec, compacted clay or amended soil (Bentonite amended soil), a HDPE geo-membrane liner of thickness 1.5mm and a drainage layer of 30 cm thick granular material of permeability not greater than 1×10^{-2} cm/sec. Since the RCC wall is a vertical structure the DSMC suggested for HDPE and Geo-synthetic Clay Liner (GCL) of equivalent permeability requirement was proposed for the sides of landfill. However the CPHEEO directed to consider the quantities of HDPE and GCL on hill side only and accordingly deleted for RCC wall side.

Leachate generated from the Landfill shall be collected and removed outside by the Leachate collection and removal system. Since the area receives about 87% of the precipitation in six months of rainfall from April to September and amounts to 3130 mm (95%) with 135 number of rainy days. The quantity of leachate generated from active landfill is estimated by the various models including CPHEEO. The leachate generation from Landfill area works out to 36 m^3/day. Also from compost plant about 4 m^3 /day is generated. Thus the total quantity of leachate generation works out to about 40 m^3/day.

These leachate shall be removed out of landfill through HDPE perforated pipes of 110 mm of feeder pipe and 160 mm dia header pipe. A 200 mm thick graded pebble and 100 mm thick sand layer is provisioned as drainage layer to facilitate the removal of leachate. The leachate collection sump (Size: 5.0 m dia x 2.5m height) to collect leachate from landfill area and compost plant is provisioned. The leachate shall be treated by conventional treatment technology of Facultative aerated lagoon (FAL). The design features are by considering BOD of 2500 mg/l with 60 days of detention period.

The associated infrastructure proposed to facilitate management of long term landfill operation and maintenance period efficiently includes basic infrastructure like, Entrance gate of 5 m wide with two door system, chain link fencing for a length of 1050 m to restrict the entry and also avoid entry of animals, Security Cabin with Toilet, Office cum Workers Room, Toilet Block, provision of new internal access roads for 470m, Rehabilitation of existing approach road (570m), Storm water drainage network of 430 m length all along the access and haul roads, Water supply facilities with a bore well, pump and storage tank, 5 m wide vegetative cover (with three rows of trees) all around the site boundary. In addition to above an open area of about 986 sq.m is earmarked for waste segregation and recycling area, green belt area of 4572 sq.m, vehicle washing area, vehicle parking area, top soil storage area is earmarked. Electrical Works for the street lighting and internal lighting is provisioned.

As per the direction of CPHEEO, the requirements are estimated for five years (Phase I) only and accordingly an estimate for the year 2012- 2017 an amount of Rs 110.98 Million is required for SWM works. The Original allocation for SWM under the NERCCDIP, was Rs. 75.75 Million and further extended to INR 140 million. The DPR cost estimates was presented to the Chief Engineer, UDHD, Government of Sikkim and also the Project Director of SIPMIU who is also the Joint Secretary of UDHD, Govt. of Sikkim had issued a certificate that no duplication of any component of the proposed project with any other project being proposed or sanctioned under any other scheme.

The total contract packages for the SWM project for Gangtok are divided into three by splitting the procurement of goods into two packages viz., SWM-GTK-1 & SWM-GTK-3 and one civil works package (SWM-GTK-2). The details of the same are summarized below;

1. **GTK-SWM-1**: Procurement of Primary Collection Vehicles, Household Bins, Push Carts and Litter Bins of Various sizes for Solid Waste Management – Cost Rs. 16.79 Million

2. **GTK-SWM-2:** Construction of Land fill, Leachate Treatment Plant, and associated Infrastructure, - Cost Rs. 75.17 Mil

3. **GTK-SWM-3:** Procurement of Secondary Collection Vehicles, 1100 ltrs capacity Bins, Landfill Vehicles & Equipments Personal Protection Equipments for Solid Waste Management – Cost Rs.19.01 Million.

The various O & M cost for SWM activity are detailed into four heads viz., Primary Collection of Waste from Household , Secondary Collection & Transportation, SWM facilities Compost Plant and Landfill. The O & M Cost for primary collection system is estimated to be 85.11 lakhs/year. The O & M Cost for Secondary collection and transportation is estimated to be 82.53 lakhs/year. The O & M Cost for Compost plant is estimated to be 79 lakhs/year. The O & M Cost for Landfill is estimated to be 17 lakhs/year. The Environmental Monitoring (EMP) cost for O&M Phase is estimated as Rs. 5.02 lakhs/year.

The final closure/post-closure care of landfill site shall be conducted after twenty three years and long term monitoring to assess; (i) maintaining integrity and effectiveness of final cover and repair required, (ii) efficiency of leachate collection system, (iii) ground water quality and action required to improve, (iv) maintenance and operation of gas collection system to meet the standards. The closed landfill may be used for useful purposes after post-closure care by ensuring gaseous emission and leachate compliance. The final cover system will comprise a 200 mm thick gas venting layer with a 150 mm thick gas vent pipe, 600 mm thick compacted clay barrier layer of permeability $1x10^{-7}$ cm/sec, followed by a drainage layer of 150 mm thick granular material of permeability $1x10^{-2}$ cm/sec and a 600 mm thick vegetative layer.

The Environmental Management Plan to ensure the optimal performance of the landfill site, identify impacts (if any) on environment pollution and comply with the regulatory requirements, the following environmental parameters shall be monitored regularly, at the landfill site. The samples shall be collected as per the sampling plan and monitored as per the standards stipulated in MSW Rules 2000.

The suggestions from Gangtok Municipal Corporation, UDHD, CPHEEO, ADB, PMMC (MoUD), Revenue Department, NGO's on "Concept Report, Feasibility Report, Draft DPR on Solid Waste Management for Gangtok" are addressed suitably in the present Detailed Project Report (DPR). The present DPR had considered the major design aspects suggested by CPHEEO officials, PMMC(MoUD), ADB, SIPMIU and others. DSMC acknowledges the effort of various officials to bring out the present Final DPR.

Contents

SALIENT FEATURES OF THE SWM PROJECT, GANGTOK

1	State	Sikkim
2	City	Gangtok
3	Name of Project	NERCCDIP- Solid Waste Management Project for Gangtok
4	Scheme/Funding	ADB Assisted NERCCDIP Tranche 2
5	Scope	Construction of Scientifically designed Landfill and procurement of waste collection and transportation vehicles for efficient Solid Waste Management for Gangtok City
6	Area/Wards Covered	All 15 Wards
7	Population Covered	Initial (2012): 1,29,000 Design Year – 5 Years (2017): 1,45,510
8	Project Components	• Construction of Landfill Life – 17 years • Construction of RCC Retaining Wall • Construction of Leachate Treatment Plant – 40 Cum/day • Chain link fencing with Entrance Gate • Construction of Office cum Workers room • Construction of Toilet Block • Construction of Security Cabin • Construction of Storm Water Drain • Approach Road • Green Belt etc. • Procurement of Primary Vehicles & Equipments(Household Bins, Litter Bins etc.) • Procurement of Secondary Vehicles & Equipments • Procurement of Landfill Vehicles & Equipments •
9	Project Cost	Rs. 110.98 Million
10	Implementing Agency	SIPMIU, Gangtok assisted by DSMC
11	Operation & Maintenance	Gangtok Municipal Corporation

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GANGTOK

1. INTRODUCTION

1.1 Background

The Government of India (GOI), had obtained a loan from the Asian Development Bank towards the North Eastern Region Capital Cities Development Investment Program (NERCCDIP). The proposed loan is under ADB's Multi Tranche Financing Facility towards financing investment program to improve urban infrastructure conditions in 5 North Eastern Region Capital Cities namely, Agartala, Aizwal, Gangtok, Kohima and Shillong. The program will (i) improve urban infrastructure and services, (ii) strengthen urban institutions for better service delivery, build project management and implementation capacity. The implementing agency of the project in Gangtok is the State Investment Program Management and Implementation Unit (SIPMIU) headed by Program Director.

The NERCCDIP's objective is to improve the urban environment and promote reforms for sustainable, efficient, and responsive urban service delivery. The primary objective of the program is to promote the development of the capital town of Sikkim through improvement of urban services with special emphasis on environmental sanitation. The primary drivers for the initiation of NERCCDIP have been bridging the gaps in urban infrastructure provision, supplementing financial resources and technical capacity and meeting the unmet urban public health and sanitation needs. The goal of the project is to improve the level, quality and sustainability of basic urban services in Gangtok, contributing to improved quality of life among the urban poor. The various Program components are Water supply, Sewerage and Sanitation, Solid Waste Management infrastructure.

The program is estimated to be completed in the span of 6 years. The NERCCDIP envisages an investment of 45.275 Million US $ (INR 2,037.38 Million) in Gangtok in three parts corresponding to three tranches. M/s Wilbur Smith Associates has been selected and engaged as the Design, Construction Supervision & Management Consultant (DSMC) for the NERCCDIP - Gangtok in accordance with ADBs Guidelines on the use of consultants and other arrangements satisfactory to ADB on the engagement of domestic consultants. Out of the total provision of Rs. 2037.38 Million, Rs. 75.75 Million is earmarked for Solid Waste Management. The Solid Waste Management (SWM) sector goal for Gangtok is therefore to improve the quality of life of citizens through environmentally safe and healthy SWM practices.

The present Detailed Project Report (DPR), for Gangtok is the final output under the NERCCDIP (ADB TA) under the SWM detailed engineering design activity. The SWM DPR provides a framework for scientific management of municipal solid waste of Gangtok and details out an implementable solid waste management plan for the city along with detailed designs for the waste disposal facility.

The frame work and the designs are based on the "Municipal Solid Waste (Management and Handling) Rules", 2000. The solid waste management plans and designs for waste disposal facility are based on the analysis of the current SWM situation in Gangtok, and the quantity and quality of waste generated in the city. The designs for preparing solid waste management plan

are based on the recent waste quantification and characterization studies and topographic surveys for landfill site at Martam carried out by the DSMC Team. The SWM plan is also based on consultations of the DSMC Experts/ Team members with elected representatives and officials of Gangtok Municipal Corporation (GMC) and review of successful local-level/community-level initiatives for primary collection of municipal waste. The feasibility study report was also presented to the GMC and the Secretary, Urban Development & Housing Department (UDHD) during November 2010. The observations/comments of GMC are appropriately addressed wherever feasible.

1.2 Assignment Output

The Detailed Project Report for SWM, is the final output envisaged to facilitate implementation of NERCCDIP's Solid Waste Management component. The DPR comprises Solid Waste Management Plan and Detailed Designs for development of Landfill and Leachate Treatment Plant. This DPR incorporates the suggestions made by CPHEEO, GMC, UDHD, NGOs, State Pollution Control Board and stakeholders from time to time.

1.3 Report Structure

The SWM Report is referred as Main Volume (**Volume I**), organized in eight sections. **Section I** provides an overview of the report and a profile of the city focusing mainly on aspects impacting SWM activities. **Section II** analyses the present SWM practices of Gangtok and is based on secondary data collected from UDHD/GMC and other secondary sources; the section identifies key issues to be addressed while preparing the SWM Plan and Landfill design. **Section III** analyzes the quantity and quality of waste generated in Gangtok through various surveys carried out by the DSMC Team – the analysis broadly comprises computation of source wise unit waste generation, combined per capita waste generation, total waste generation and physico-chemical characteristics of waste generated in Gangtok. **Section IV** presents the SWM Plan for Gangtok City which includes all aspects of solid waste management such as storage of waste at source, primary collection of waste, secondary collection and transportation of waste to the disposal site including the options for waste processing and disposal. The SWM Plan, closely analyses, statutory requirements of solid management as per Municipal Solid Waste (Management & Handling) Rules, 2000 by the Ministry of Environment & Forests, GoI and consultations with the officials of UDHD/GMC. **Section V**, Landfill Site Selection Process, detailed design of Landfill **Section VI** presents the Landfill associated infrastructures required at Martam site. **Section VII** Final Closure and EMP, **Section VIII** presents the detailed cost estimates for the SWM Plan and Operation & Maintenance cost, **Section IX** presents the SWM Packages and implementation schedule.

The DPR is further supported by four volumes. **Volume II** presents the drawings for all the components viz., Land fill and other associated infrastructures, Collection and Transportation vehicle and equipments. **Volume III** presents all the Appendices with supporting data that formed the basis for the preparation of the SWM DPR. **Volume IV**, presents the Environmental and Social Assessment of the project components. **Volume V** presents the Economic and Financial Report for SWM sub-component for Gangtok.

2 GANGTOK CITY PROFILE & ASSESSMENT OF EXISTING SOLID WASTE MANAGEMENT PRACTICES IN GANGTOK

2.1 City Profile - General

Gangtok is the capital of Sikkim. It is a hilly town and is gaining popularity as a preferred tourism destination. The ground elevations vary between 750m – 2100m above mean sea level. It is situated in Seismic Zone IV. The average annual rain fall is 3494mm. There has been no Urban Local Body in Gangtok till recently. The Gangtok Municipal Corporation (GMC) has just (May 2010) been established. GMC covers an area of 19.06 sq km (Ward Map 1).

2.1.1 *History and Growth*

Gangtok remained a small hamlet until the construction of the Enchey Monastery in 1840 which made it a pilgrimage center. After the defeat of the Tibetans by the British, Gangtok became a major stopover in the trade between Tibet and British India at the end of the 19th century. Most of the roads and the telegraph in the area were built during this time. In 1894, Thutob Namgyal, the Sikkimese monarch under British rule, shifted the capital from Tumlong to Gangtok, increasing the city's importance. A new grand palace along with other state buildings was built in the new capital. Following India's independence in 1947, Sikkim became a nation-state with Gangtok as its capital. Sikkim became a suzerain of India, with the condition that it would retain its independence, by the treaty signed between the Chogyal and the then Indian Prime Minister Jawaharlal Nehru. Trade between India and Tibet continued to flourish through the Nathula and Jelepla passes, offshoots of the ancient Silk Road near Gangtok. These border passes were sealed after the Sino-Indian War in 1962, which deprived Gangtok of its trading business. The Nathula pass was finally opened for limited trade in 2006. In 1975, the monarchy was abrogated and Sikkim became India's twenty-second state, with Gangtok as its capital.

Gangtok has witnessed annual landslides, resulting in loss of life and damage to property. The largest disaster occurred in June 1997, when 38 were killed and hundreds of buildings were destroyed.

2.1.2 *Regional Setting*

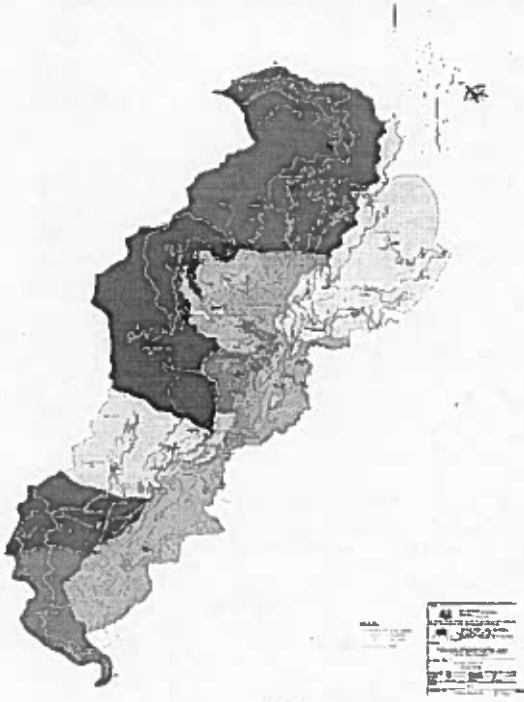
Gangtok is located in the East District and lies between 27° 21' to 27° 16' N latitude and 88° 37' to 88"39' E longitude with an altitude of about 2000 m above mean sea level. January temperatures in Gangtok, range from 4° to 14° C (39° to 57° F); in May the average temperatures range from 14° to 22° C (57° to 72° F). Annual rainfall varies from about 1300

to 5000 mm. Gangtok is connected by National Highway (31-A) to Siliguri, which is a major town in the North of West Bengal. The nearest airport and railhead near Siliguri is 116.97 kms from Gangtok. Apart from being the State capital, Gangtok is the most important town of Sikkim, so all developmental activities in Gangtok are going to be significant for the state. The regional setting of Gangtok is presented in **Drawing No. NERCCDIP-SWM-GANGTOK-LF-LOCATION-001**.

Figure 2.1 shows Location Map of Gangtok City and Figure 2.2 shows the Ward map of Gangtok Municipal Corporation.

Fig 2.1: Location map of Gangtok City

Fig 2.2: Ward Map of Gangtok Municipal Corporation



2.1.3 *Growth trend*

As per the 2001 census the population of the town is only 29,354 within the notified town area but it is very apparent that the reasonable town boundaries which is applicable as per the GOS/4D and HD/6(70)2942 dated 23/11/04 is estimated to currently accommodate about 140,000 to 150,000 people. Some features of the rapid urbanization are as follows:

Untill May 2010 Sikkim was not having municipality or an urban local body that looks into the management of the towns. The UD&HD and the PHED are the primary agencies responsible for the town development and management matters, including the physical planning, growth management and the provision and management of core civic services. There is an inadequate implementation of the building regulations that has led to regional imbalances in terms of civic facilities and infrastructure development. Growth trends are estimated to continue concentrating on the major towns which will lead to the aggravation of the imbalance in the already hard pressed civic facilities

The UDHD was responsible for the civic functions such as garbage disposal, water supply, sewerage & sanitation, tax collection, license allotments, and civic infrastructure. The Sikkim Municipal Act, 2007 has approved the formation of Gangtok Municipal Corporation, which has been just formed with 15 ward councilors. GMC will take over gradually the municipal functions which are being run to date by various state government departments.

2.2 *Existing Status of Solid Waste Management (SWM) services in Gangtok*

Unplanned urban expansion has strained the city's resources. The solid waste management are being maintained by the state Urban Development and Housing Department. It is estimated that about 45 MT of solid waste is generated daily in the Gangtok Municipal Area. In certain areas the Kerb side collection has been introduced. Though GMC is primarily responsible for collection, transportation and disposal of the solid waste, collection and transportation of waste is being handled privately in certain small organized areas. Burning the waste and dumping into the jhoras in peripheral areas is not uncommon.

2.2.1 Staff Position - Sweeping and Drain Cleaning

One of the major activities of the solid waste management is street sweeping, which is time consuming and labor intensive. The GMC has 99 persons for SWM, 80 are Safaikarmacharis, 15 are Garbage Vehicle drivers, 4 Supervisors with 28 permanent workers and rest are on Master Roll basis (**Appendix 4**).

GMC, Gangtok carries out both street sweeping and Jhoras desilting activities. Thirty six sweepers have been engaged for various areas viz., VIP Colony, Rich Road, Zero Point Nehru Park, Zero Point Nehru Park, Baluwakhani, Dev. Area, Hospital point to Zero point, Metro point to Shesha, Arithang, M.G. Marg, Lall Road, Old Super Market, Kazi Road, Tibet Road, Pani House Road, Shyari, Deorali, Amdo Golai Road, Tadong, P.S. Road, Gosh Khan, DPH. Old Children Park, Private Bus Stand, Deorali Taxi Stand, Share Punjab Flyover. Due to disposal in Jhoras, frequent desilting of drains is also necessary and are carried out by six persons.

2.2.2 Disposal System

The Solid Waste dumping ground at Martam about 20 km from the city and adjacent to NH - 31A in unscientific way. It has a hilly terrain/topography and the terrain gradually slopes from North West to South East wherein Ranikhola river a tributary to Theesta river exists. The present waste disposal is non conformity with the prevalent rules and positive threat to the pollution of river Ranikhola from the leachate as also through surface run off during monsoon. The present practice of manual handling is also a health hazard to the workers.

2.2.3 Initiatives in SWM from Government of Sikkim

The Government of Sikkim is amongst the first state of the country to successfully enforce a total ban on the use of polythene bags. The State has also (i) passed the Non – biodegradable Garbage (Control) Rules in 1997 to minimize the generation of such waste as also its indiscriminate dumping on roads, streets and in jhoras and (ii) installed a Compost plant at Martam was to dispose the biodegradable waste and thus reducing the waste generation for disposal. However, in spite of the above commitments of the State towards effective solid waste management system the existing situation is far from satisfactory. The compost plant funded by CPHEEO is not in operation at present. The detailed assessment of existing SWM system along with the photographs are presented as **Appendix 1**.

2.3 Key Issues to be addressed in the present DPR:

The key issues in the existing SWM system are detailed below;

- Solid waste quantification and characterization
- Solid waste collection performance is about 54 % only.
- Collection of Waste from interior areas are initiated in few areas (about 16 % only – **Map 2**) by local NGOs viz., The Golden Circle, United Arithang, Watsan Committee covering 4000 households is highly appreciable and needs to be extended to all other areas.
- Throw away garbage into streams (Jhoras)
- Absence of waste segregation
- Unhygienic disposal of waste in open dumping areas posing threat to public health
- Non availability of scientifically designed landfill
- Inadequate number of vehicles and equipment for efficient collection & transportation
- Inadequate manpower
- Waste is collected and loaded on to small vehicles and trucks manually and is not covered during transportation.
- Workers use no safety or protective equipment while handling the waste manually.
- Non working of the existing compost plant
- Waste being dumped without treatment in unscientific manner
- Waste due to winds often finds its way into the stream flowing adjoining the dumping area posing threat to the health and environment.

The current practices are thus unsafe and do not confirm Municipal Solid Waste (Management and Handling) Rules, 2000 (Copy Enclosed as **Appendix 2**).

3 SOLID WASTE QUANTIFICATION AND CHARACTERIZATION STUDY FOR GANGTOK

3.1 Introduction

An accurate assessment of the quantity and characteristics of solid waste generated is crucial for formulating solid waste management plans. Rational decisions on municipal solid waste system are possible only if reliable data of composition and quantity of solid waste are available. The method and capacity of storage, the correct type of collection vehicle, the optimum size of crew and the frequency of collection depend mainly on volume and density of wastes. The treatment and disposal method may be dependent on the type of material recycled, organic content of waste, which could be composted, and the combustible material, which could be a source of energy.

3.2 Earlier Per Capita Assessment Surveys

The Central Pollution Control Board (CPCB) with the assistance of National Environmental Engineering Research Institute (NEERI) has conducted survey of solid waste management in 59 cities (35 metro cities and 24 state Capitals: 2004-05) which included Gangtok city. The report pointed about 440 grams per capita per day of waste generation in Gangtok. As per the "State of Environment 2007" report for Sikkim, the City of Gangtok generates approximately 390 grams/capita/day. The Technical Report titled "Solid Waste Management – Gangtok" Final Report prepared by LEA Associates for North Eastern Region Urban Development Project (Phase -1, TA 4348-IND) estimated about 398 grams per capita per day 40 TPD (2006-07) of waste generation. Correspondingly the waste projections are carried out by considering and projected about 55 TPD for 2012, 67 TPD for 2017, 80 TPD for 2022.

After reviewing the above, DSMC considered the per capita generation as specified in TA report and prepared the Concept Report and Feasibility Report. The Concept Report was presented to Mr. V.K. Chaurasia, Deputy Advisor, CPHEEO on 24 July, 2010 at Gangtok. The CPHEEO pointed out that data considered in the concept report for waste quantification and characterization are old. Therefore suggested to carry out fresh waste samples for seven days from various locations as listed below; The proceedings of the same is presented as **Appendix 3.**

Accordingly, the DSMC in association with Eco-Pro Environmental Services, Indore carried out the waste sampling during 12 – 21st November 2010.

3.3 New Per Capita Waste Generation Survey - Sampling Techniques and Methodology

Sampling points and methodology are primarily influenced by the techniques adopted for quantification of solid waste. Depending on the size of the city and resources available there are varieties of techniques for estimating the quantity of waste generated by a community. Few of the important techniques are:

- Modeling Techniques that apply generic waste generation rates and other community features for predicting waste quantities;
- Physical Sampling Techniques that use statistical methods to predict total waste stream quantity and composition by analyzing small volumes;
- Direct Measurement Techniques through pilot studies to collect type and volume of waste generated by the community; and
- Indirect Methods through assessment and summing up of the quantities of waste (i) collected and transported; (ii) the backlog in collection and transportation; (iii) the waste separated for recycling; and (iv)the quantity disposed at source.

Since the Direct Measurement Techniques provide more reliable information on waste quantity and characteristics, these techniques are adopted for assessing the quantity of waste generated in Gangtok. These surveys involved measurement of per capita waste generated from sample domestic sources and assessing unit generation trends of non-domestic sources.

3.4 Sampling Methodology:

The work has been done in accordance with SWM (M&H) Rules 2000 and according to SWM CPHEEO Manual and relevant code of practice. The information on the nature of wastes, its composition, physical and chemical characteristics and the quantities generated are basic needs for the planning of a Solid Waste Management system. Based on CPHEEO guidelines and in its manual on Municipal Solid Waste Management, about 35 samples are required for getting a representative idea of physico-chemical characteristics. 35 samples per day were collected and analyzed. For collection of samples of municipal solid waste, collection points were identified covering a larger size of population. Based on the type of area such as residential, commercial, market, slum, hotel restaurant etc. sampling points are distributed uniformly all over the study area. The residential sampling points are further classified based on economic status of population such as high, middle and low income group.

A route chart was prepared for collection of waste samples. Data was collected regarding family size and name of head of the family along with their address and filled in the preapproved data sheets. Stake holders were made aware about the purpose of our study and requested for cooperation. The Waste Characterization Report includes Survey/Sampling Methodology, are detailed in **Appendix 23** and the results of the same are discussed in subsequent sub-sections.

3.4.1 *Sampling Period:*

The waste sampling team comprised the officers of GMC, SWM Specialist of DSMC and the Eco Pro Environmental Services team included a Team leader assisted by one supervisor, one driver, one helper along with one vehicle for collection and transportation of samples. The Data sheets, Coded poly bags and spring balance to our team to record and weigh samples. In

order to analyze the waste generation trends for the entire week including the weekends, the sample surveys were carried out for seven consecutive days from 15.11.2010 to 21.11.2010

3.4.1 Sampling Locations

Inorder to assess the physico-chemical characteristics of the MSW, on-site physical analysis and lab testing for chemical parameters was carried out by collecting samples from representative collection points and from dump site. The sampling locations were selected based on consultations held with the Deputy Adviser, CPHEEO, UDHD and GMC officials, Health Inspectors, resident associations, NGO's, merchants and traders, to ensure that the samples are collected from all parts of the city with due consideration to all the wards. List of sample locations with details have been tabulated in Table no 1 and In Table no.2. The total weight collected from each location on all seven days has been tabulated.

Figure 3.1 : Waste Sampling Locations in Gangtok

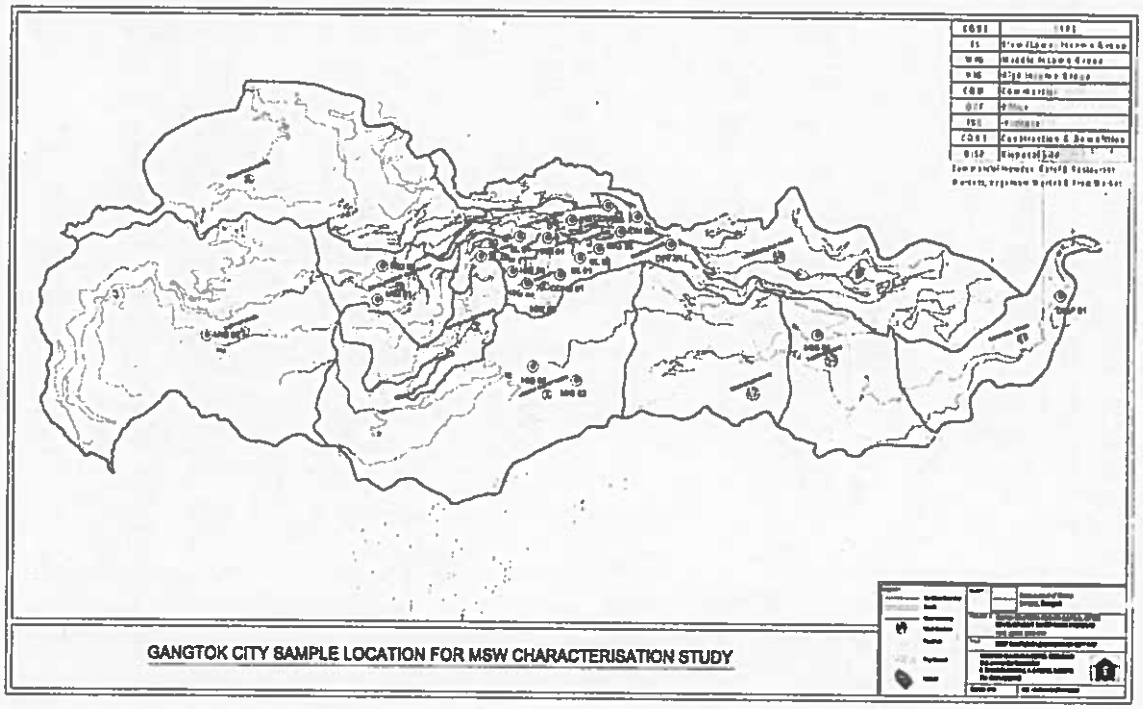


Table 3.1: Details of Waste Sampling from Residential, Commercial & Others

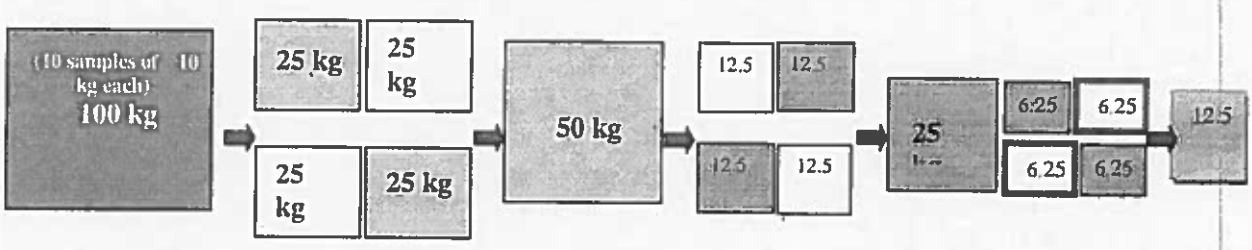
SL	Sample Code	Type	Name & Address
	A	RESIDENTIAL	
1	SL 01	Slum, Vishal Gaon	Mr. Umesh Sharma
2	SL 02	Slum, Vishal Gaon	Mr. M.P.Zameer
3	SL 03	Slum, Bhanu Gram - DPH (Manpari Gaon)	Mr. Moti
4	SL 04	Slum, Bhanu Gram - DPH (Manpari Gaon)	Mrs. Reena Devi
5	MIG 01	Medium Income Group, Development Area	Mr. Jigmee C Bhutia
6	MIG 02	Medium Income Group, Lower Sichey	Mr.G M Ruchal
7	MIG 03	Medium Income Group, Lower Arithang	Mr. T P Sharma
8	MIG 04	Medium Income Group, Tadong	Mr. Bishu Bhagat
9	MIG 05	Medium Income Group, Chuksing	Mr. Passang Narbu Lama
10	MIG 06	Medium Income Group, Brutuk	Mrs. Majeela Gurung
11	HIG 01	High Income Group, Development Area	Mr. G.T.Bhutia
12	HIG 02	High Income Group, Lower Sichey	Mr. L.B. Dikshit
13	HIG 03	High Income Group, Lower Arithang	Mr. P.T. Euthenpa
14	HIG 04	High Income Group, Upper Arithang	Mrs. S M Rai
15	STR 01	Street sweeping waste in same colony,	Development Area
16	STR 02	Street sweeping waste in same colony,	Kazi Road
17	STR 03	Street sweeping waste in same colony,	Lal Bazar
18	STR 04	Street sweeping waste in same colony	
	B	COMMERCIAL	
19	MARKET 01	Market - Textile (Tailoring Waste), Lal Bazaar	Mr. Lok Bahadur Karkijole, No. 4, 3rd Floor, Lal Bazaar
20	MARKET 02	Market - Grossery, Lal Bazaar	Mr. Hari Narayan, No. HP 168, First Floor, Lal Bazaar
21	MARKET 03	Market - Fish Market, Lal Bazaar	Mr. Mahmad Nausad, No. 8, 1st Floor, Meat Market, Lal Bazaar
22	MARKET 04	Market- Meat/Chicken, Lal Bazaar	Mr.Man Bahadur Chettri, No. 2, Meat Market, Lal Bazaar
23	MARKET 05	Market - Mixed Waste with Quartering, Lal Bazaar	Mr. Ram Prasad, Dust Bin Room, Ground Floor, Lal Bazaar
24	VEG 01	Vegetable Market - Mixed veg, Lal Bazaar	Mrs Maya Lama, No. HP 45, First Floor, Lal Bazaar
25	VEG 02	Vegetable Market - Green leaf, Lal Bazaar	Mrs. Yam Kumari, No.HP 6,1st Floor, Lal Bazaar
26	FRUIT 01	Fruit Market, Lal Bazaar	Mr. Udaya Narayan, NoHP151,1st Flr, Lal Bazaar
27	HTL 01	Hotel with upto 10 Rooms, On National Highway near Vishal Gaon	Jyothi Lodge
28	HTL 02	Hotel with 10 to 25 Rooms, MG Marg	Mr. Madhava, Fair View, Kazi Road
29	HTL 03	Hotel with above 25 Rooms, MG Marg	Mr. Motilal Lakhotia, Tashi Delek, MG Marg
30	REST 01	Restaurant with 20 seats, MG Marg	Mr. Sanjok Rai, Masala, MG Marg
31	REST 02	Restaurant with above 20 seats, MG Marg	Mr. Jagjit Singh, Apna Dabha

	C	OFFICES & INSTITUTIIONS	
32	OFF 01	Office, Deorali	Mr. L.C. Lama, Chief Inspector, GMC, Siliguri Taxi Stand, Deorali
33	INS 01	Educational Institute, Mount Deepam, Upper Arithang	Mount Deepam, Upper Arithang
	D	DISPOSAL SITE	
34	DISP 01	Fresh Incoming Waste with Quartering, Martam Disposal site	
	E	CONSTRUCTION & DEMOLITION	
35	CONS 01	Construction & Demolition Waste, Arithang	Mr. Norgey Tsheri Bhutia, Arithang

3.4.2 *Quartering system of waste sampling*

For collection of waste from the dump site quartering procedure was followed as per CPHEEO manual. For quartering of waste about 10 kg of Municipal Solid Waste (MSW) is collected from ten points from outside and inside of the solid waste heap. The total quantity of waste so collected is thoroughly mixed and then reduced by method of quartering till a samples of such a size is obtained which can be handled in the laboratory.

Fig 3.2 : Block diagram of quartering system



The sampled waste was tested at Indore laboratory, first of all accurate weighing of each sample was done on a digital balance. There after density and individual physical components were measured. Proximate and Ultimum analysis of individual samples were carried out. The sample so obtained is subjected to physical analysis, determination of moisture and then the sample is processed for further chemical analysis.

Waste from pre-decided sampling locations was collected on daily basis. A day before the sampling survey each of the selected households were given a labeled sampling bag and were requested to deposit all domestic waste generated on the next day in the bag for collection on the day after in the morning. On the day of sampling, the survey team collected the waste in a collection vehicle from each of the identified sample household in the morning and a fresh sample bag with label was handed over to the household for the next day's sampling. The collected samples in each bag were weighed and weight recorded against the relevant data and entered in the format containing the particulars of the sampling unit. The collected

sample in each bag was weighed and recorded in the standard data format in which the details of sampling unit were recorded.

The same procedure was followed for all the seven consecutive days of sampling. Samples from commercial establishment were collected by using same methodology. Photography of sample collection from each point was done daily by digital camera. Photographs of the sampling have been attached with the report as **Appendix 23**. A spring balance at every waste collection point was used for weighing of waste. The daily collected samples were then packed and send to our Lab for further analysis.

Waste generated by a particular source was measured directly to estimate the quantity of waste generated. Based on the number of members in the family or size of the establishment, the waste generated per capita or per unit was then estimated. Prior to commencement of surveys, both field investigators and sample households were briefed about the purpose of the study and modalities of waste collection. In case of non-domestic generators, information on size of the establishment, number of rooms in hotels, lodges etc., was collected in a standard format.

3.5 Estimation of Per Capita Waste Generation:

The sample surveys indicate that the average per capita generation in HIG group of households is about 324 gm as against the 274 gm for MIG and 190 gm per capita for LIG households.

Table 3.2: Household Per Capita Generation

House Hold Category	No. of persons	Range of Per Capita Generation, gm/day	Average Per Capita Generation, gm/day
LIG	18	43.60 to 343.80	190
MIG	32	33.78 to 600.50	274
HIG	26	113.60 to 901.75	324
Total	**76**		
Per Capita Generation from residetial area (gm/day)			**289**

Source: Field Assessment Surveys and Analysis.

Table 3.3: Per Capita Generation from other sources

Per capita waste generation from residential area	**289 grams/person**
Add 10 % for Municipal Waste from Hotels (Restaurants & Eating Joints)	29 grams/person
Add 15% for Waste from markets and institutions	43 grams/person
Add 5% waste from Street sweeping, inerts	14 grams/person
Per capita waste generation (2010)	**377 grams/person**
With annual 1.4% increase , the Per Capita waste generation for the year 2012	**387 grams/person**

Hence the waste generation from residential area is 70% market area is 15%, 10% from Hotel (Restaurants & Eating Joints), followed by street sweeping waste of 5%. Therefore a per capita waste generation from Gangtok city was estimated as 377 grams per person. The yearly_per capita increase is considered based on the population projection with 1.4% of annual increase, and accordingly waste generation of 387 grams per capita is considered.

3.6 Waste Characteristics:

The samples were analyzed to arrive at bulk density and segregated into constituents for physical composition and were recorded. Components of all the waste sample were segregated in various categories like Food/fruit, Leaves/hay/straw, Paper/cardboard /packaging, Rubber/leather, Plastic/polythene, Textile, wood, Glass and crockery, Tin cans, Stone/brick, Coal ash/fine earth/dust and metals.

Figure 3.3 Composition of Waste

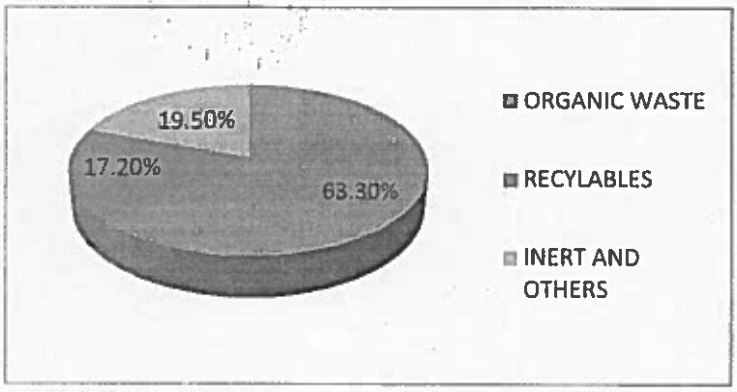


Table 3.4: Physical Characteristics of MSW at Gangtok (Average)

Characteristics	Residential Collection Point Samples	Dump Site Samples
Bulk Density kg/cum	380.24	410.68
Constituents	**Percentage of Total Weight**	
Paper	6.91	6.42
Textile	1.45	3.72
Plastic and Rubber	3.54	3.99
Metals	1.42	1.31
Glass	2.04	1.96
Stone/brick (inert)	0.05	1.78
Ash and Fine Earth	18.87	13.22
Leaves and Wood	2.68	4.11
Food Waste	63.03	63.49
Total	100.0	100

Source: Field Assessment Surveys and Analysis.

3.6.1 *Testing Procedures*

Following test methods were used to analyze the samples:

Table 3.5: Standard Testing Methods for analysis

Sr. No.	Tests/Parameters	Codes/Guidelines/Methods/Protocol
1.	Moisture Content	IS: 9235-1979
2.	Organic Carbon	IS: 228(part 1) / C-H-N-S analyzer
3.	Nitrogen	C-H-N-S analyzer
4.	Phosphorous	IS: 228 (part 3)
5.	Sulphur	IS: 228 (part 9)
6.	Ash content	IS: 1350
7.	Calorific Value	By bomb calorimeter
8.	Heavy Metals (Ar, Se, Zn, Fe, Mg, Ni, Cd, Cu, Hg, Pb, Cr)	By Atomic Absorption Spectrophotometer (AAS)

The heavy metals found in the samples have been tabulated in Table below.

Table 3.6: Results of Heavy Metals

Sample No.	Arsenic	Lead	Cadmium	Copper	Nickel	Zinc	Mercury	Iron
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SL 01	bdl	bdl	0.122	1.454	0.828	6.998	bdl	15.46
SL 02	bdl	bdl	0.116	1.376	0.907	7.787	bdl	16.63
SL 03	0.326	bdl	bdl	1.505	0.782	6.604	bdl	16.26
SL 04	0.315	bdl	bdl	1.454	bdl	bdl	bdl	15.78
MIG 01	0.987	2.858	0.137	1.634	0.962	bdl	bdl	15.39
MIG 02	0.714	1.333	0.133	1.582	0.91	6.012	bdl	15.33
MIG 03	bdl	bdl	0.146	1.737	0.992	4.83	bdl	28.44
MIG 04	0.885	bdl	0.158	1.878	bdl	7.589	bdl	13.27
MIG 05	0.439	2.935	0.167	bdl	bdl	7.688	bdl	15.63
MIG 06	bdl	bdl	bdl	2.264	0.476	4.041	bdl	12.76
HIG01	0.095	3.097	0.190	2.264	0.941	bdl	bdl	14.96
HIG 02	0.045	3.183	0.160	1.904	bdl	bdl	bdl	14.32
HIG 03	0.061	3.26	0.171	bdl	bdl	8.279	bdl	13.40
HIG 04	0.518	2.772	bdl	2.38	bdl	7.885	bdl	12.46
STR 01	0.360	0.612	0.136	1.621	bdl	10.546	bdl	28.17
STR 02	bdl	bdl	0.167	1.994	1.225	10.448	bdl	28.69
STR 04	0.439	bdl	0.166	1.981	0.782	6.604	bdl	26.85
MKT 01	0.383	2.17	bdl	bdl	0.68	5.815	bdl	13.08
MKT 02	0.315	2.294	0.119	1.415	1.452	bdl	bdl	12.54
MKT 03	0.439	2.658	0.168	2.007	bdl	8.772	bdl	13.23
MKT 04	0.349	3.021	0.133	1.582	0.794	6.702	bdl	13.67
MKT 05	0.360	2.333	0.138	1.647	bdl	7.885	bdl	13.52
VEG 01	bdl	bdl	bdl	1.222	0.839	7.097	bdl	13.67
VEG 02	bdl	bdl	bdl	1.145	0.658	5.618	bdl	15.36
FRT 01	bdl	bdl	bdl	bdl	0.794	6.702	bdl	15.31
HTL 01	0.281	2.61	0.106	1.261	0.794	6.702	bdl	18.90
HTL 02	0.304	2.935	0.118	1.402	bdl	8.477	bdl	18.21
HTL 03	0.259	bdl	0.100	1.196	0.808	7.491	bdl	16.55
REST01	0.349	2.696	bdl	bdl	0.757	7.097	bdl	15.35
REST02	bdl	2.132	0.126	1.505	0.726	8.378	bdl	16.64
OFF 01	0.349	bdl	bdl	bdl	bdl	6.407	bdl	16.01
INS 01	0.360	2.696	0.136	1.621	bdl	7.097	bdl	13.47
CONS01	bdl	bdl	0.130	1.544	bdl	8.378	bdl	13.83
DISP 01	0.461	2.495	0.178	2.123	0.76	6.407	bdl	13.42

The total moisture percentage in individual samples have been shown in Table below;

Table 3.7: Moisture Content (%) and its Variations

Sample Code	15TH	16TH	17TH	18TH	19TH	20TH	21ST	Average %
SL 01	49.39	40.10	57.83	46.07	42.28	47.59	49.39	47.52
SL 02	48.23	59.82	55.17	57.83	39.53	49.40	54.25	52.03
SL 03	48.91	45.07	44.44	47.98	49.94	35.37	37.95	44.24
SL 04	44.96	53.94	46.50	48.21	45.86	43.45	47.53	47.21
MIG 01	46.85	38.19	44.04	34.84	52.61	62.49	42.59	45.94
MIG 02	42.69	38.59	54.97	52.21	54.57	47.14	48.31	48.35
MIG 03	51.80	50.53	44.30	41.60	55.47	44.67	46.45	47.83
MIG 04	51.58	55.94	44.71	52.74	53.43	49.61	50.75	51.25
MIG 05	36.25	43.66	41.72	44.29	42.13	37.93	42.13	41.16
MIG 06	33.31	35.12	36.75	34.34	43.25	49.01	35.67	38.21
HIG 01	45.52	47.95	44.31	42.35	37.99	45.53	54.27	45.42
HIG 02	56.60	52.01	49.84	43.85	42.29	44.62	49.28	48.36
HIG 03	51.60	56.09	46.35	59.57	34.53	36.24	38.19	46.08
HIG 04	38.76	39.22	35.92	44.90	38.59	40.89	49.45	41.10
STR 01	38.97	35.58	45.97	42.63	38.37	50.70	41.07	41.90
STR 02	39.48	35.10	46.04	30.94	54.20	43.65	40.25	41.38
STR 03	37.79	39.32	40.39	42.47	61.40	60.85	42.83	46.44
STR 04	45.40	37.24	51.76	34.63	38.45	50.04	46.38	43.41
MKT 01	26.62	24.93	13.74	0.00	17.54	24.22	22.08	21.02
MKT 02	25.37	24.42	46.63	43.05	43.51	48.16	37.67	38.40
MKT 03	49.85	49.92	47.54	49.47	35.54	47.72	45.10	46.45
MKT 04	56.54	43.67	45.11	47.72	57.23	51.69	60.58	51.79
MKT 05	39.59	45.42	44.78	65.43	42.90	48.27	45.69	47.44
VEG 01	37.73	51.58	47.29	51.34	36.12	51.84	50.58	46.64
VEG 02	41.66	48.01	42.24	51.46	42.55	61.61	40.88	46.92
FRT 01	55.56	42.32	56.15	55.43	53.03	41.21	54.84	51.22
HTL 01	59.09	50.56	61.21	56.40	50.67	51.45	53.86	54.75
HTL 02	58.82	50.62	54.94	53.11	58.29	57.30	45.53	54.09
HTL 03	50.83	53.26	49.37	49.55	42.22	43.97	54.64	49.12
REST01	40.88	40.65	65.32	49.54	40.72	41.89	41.02	45.72
REST02	43.04	73.56	54.58	37.04	46.35	45.61	38.67	48.41
OFF 01	38.73	36.79	44.44	50.44	35.05	21.21	30.34	36.71

INS 01	32.54	35.52	40.68	28.88	32.84	21.85	0.00	32.05
CONS01	22.69	21.95	12.90	21.98	29.46	21.29	22.02	21.76
DISP 01	47.18	36.68	43.22	57.01	49.91	34.62	44.76	44.77
Average Percentage of moisture								44.45

3.6.2 *Chemical Characteristics of MSW*

The solid waste samples were analyzed for chemical contents (Carbon, Nitrogen, Calorific Value and Heavy Metals) and moisture content. The analysis was carried out to make a decision in finalizing the waste processing technology and potential for recovery/recycling. While the C/N ratio is a direct indicator of the suitability of waste for bioconversion of the waste, calorific value is an indicator for assessing the suitability of waste to energy technologies.

Table 3.8: Results of Chemical Characteristics of solid waste in Gangtok

Parameter	Unit	Average Value	
		Residential Collection Point samples	Dump Site Samples
Bulk Density	kg/cum	380.24	410.68
pH (1:10 Aq. Extract)	-	7.11	7.23
Moisture Content	%	46.05	44.77
Carbon as C	%	29.28	35.70
Nitrogen as N	%	1.41	1.65
Phosphorous as P	%	0.75	0.65
Volatile Matter	%	24.05	24.73
Ash Content	%	26.17	23.16
Gross Calorific Value	kcal/kg	1114.79	1043.31
Heavy Metals			
1. Arsenic	mg/kg	0.31	0.46
2. Zinc	mg/kg	4.84	6.40
3. Lead	mg/kg	1.39	2.49
4. Cadmium	mg/kg	0.11	0.18
5. Copper	mg/kg	1.53	2.12
6. Mercury	mg/kg	bdl	bdl
7. Nickel	mg/kg	0.49	0.76
8. Iron	mg/kg	15.72	13.42

Source: Lab Analysis ITL Labs Pvt. Ltd., Delhi.

The laboratory test results are furnished as **Appendix 23**

3.7 Conclusion:

As per the studies conducted in November 2010, the per capita waste generation is 377 grams. With this generation rate as a base and projected growth of 1.41 % annual increase in per capita for 2012 (the starting year of design period) is 387 grams (50 TPD). Also as per the studies conducted by National Environmental Engineering Research Institute (NEERI) in 2004 for the Central Pollution Control Board, the per capita waste generation for cities in the population range of 0.10 to 0.50 million is expected to be in between 190-530 grams/day. The result of quantification study of Gangtok are also in the similar range.

Waste quantification and characterization surveys in Gangtok indicate that the city generates about 50 MT of solid waste every day, as against the GMC estimates of 45 MT per day. These variation is attributed to unaccounted waste generation such as market and institutions, street sweeping activities, hotels and from Tourist population. These four sources are estimated to generate about 15 MT of waste (about 30 percent of the waste generated).

A significant portion of this waste currently finds its way on to storm water drains and Jhoras. These factors are critical in finalizing the Solid Waste Management plan for the city and also the capacities of waste disposal sites.

Also the study indicates a marginal increase in the organic waste and accounts for about 63.3% against the earlier projection of 58%. The difference of about 5% would reflect a positive signal for the design process wherein the compost plant can run efficiently with more organic waste. At the same time it is advantageous by increasing the landfill life. Therefore it is recommended to consider the positive aspects of the study and accordingly the SWM project for Gangtok is designed.

4 SOLID WASTE MANAGEMENT PLAN FOR GANGTOK

4.1 Introduction

In the context of the discussions presented in the earlier section, this section details out the Solid Waste Management Plan for Gangtok city and its implementation modalities. Collection and transportation plan and its infrastructure requirements are detailed out in the first sections, and the waste processing and disposal component with design details are presented in the subsequent sections.

4.2 Growth Projections

The historical trend of population growth in Gangtok are detailed below;

Table 4.1 : Population Growth Trend for Last Five Decades

Year	Population (No)	Decadal Growth Rate (%)
1961	6,848	-
1971	13,308	94.33
1981	36,747	176.13
1991	58,242	58.49
2001	82,149	41.05
Source: WSPHED (SBWAPEPL Consultants Report)		

4.2.1 *Estimation of Future Population*

Varying population projections have been presented by different consultants engaged for augmentation and improvement of city water supply scheme to Gangtok. M/s SMEC India, engaged by ADB for its TA Study 4779-IND had projected the population of Gangtok Municipal Area to be 104,341 (2009), 116,615 (2024) and 147,4475 (2041). M/s Sri Balaji Water and Power Engineers Private Limited (SBWPEPL) engaged by Water Security and Public Health Engineering Department (WSPHED) for preparing Detailed Project Report for JnNURM scheme has projected the resident population as 118,000 (2012), 158,000 (2027) and 198,000 (2042). Finally it was decided to adopt the projections made by M/s SBWPEPL in consultation with SIPMIU and WSPHED Dept and approved for the JnNURM scheme sanctioned for the city. Being a tourist destination, Gangtok receives tourist from all over India and overseas. Considering the same the design population is presented below;

Table 4.2 : Design Population for Base, Intermediate and Ultimate Years

Year	Total Resident Population	Tourist Population (Staying in Hotels)	Design Population
2012 – Base Year	118000	11500	129500
2027 - Intermediate Year	158000	22500	180500
2042 – Ultimate Year	198000	34000	232000

Source: SBWAPEPL Report

Accessories

Table 4.3: Details of Ward wise Population Projection

Ward No.	Name of the ward	Population	Base Year	Inter mediate	Ultimate Year
		2009	2012	2027	2042
1	Burtuk	8356	10371	14455	18580
2	Lower Sichey	9119	11318	15775	20276
3	Upper Sichey	6376	7913	11030	14177
4	Chandmari	5931	7361	10260	13188
5	Development area	9444	11721	16337	20999
6	Diesel Power House	9423	11695	16301	20952
7	Arithang	6137	7617	10617	13646
8	Lower M.G. Marg	8855	10990	15318	19689

Ward No.	Name of the ward	Population	Base Year	Inter mediate	Ultimate Year
		2009	2012	2027	2042
9	Upper M.G. Marg	7060	8762	12213	15698
10	Tibet Road	6768	8400	11708	15049
11	Deorali	7718	9579	13352	17161
12	Daragaon	3421	4246	5918	7607
13	Tadong	5677	7046	9821	12623
14	Ranipool	4321	5363	7475	9608
15	Tathangchen Syari	5734	7117	9919	12750
TOTAL		104,341	129,500	180,500	232,000

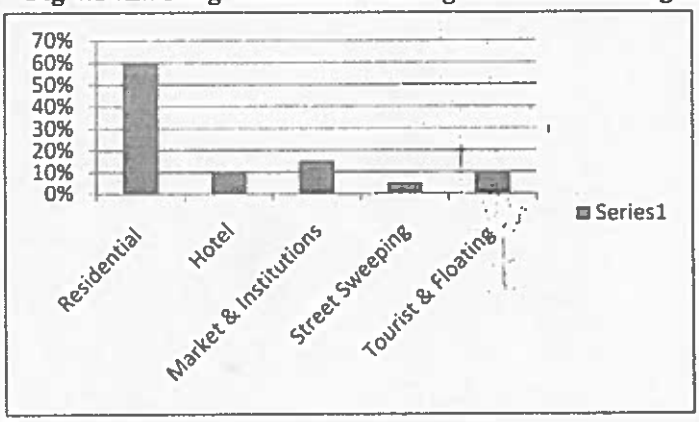
4.3 Waste Quantification

The waste projections are carried out by considering a daily per capita waste generation of 387 (2012) grams and furnished below;

Table 4.4: Waste Projections

Year	Population	Projected Waste Generation
	Nos	*Tonnes/day*
2001	82,149	
2012	129,500	50
2017	145,510	60
2022	163,500	73
2027	179,774	86
2032	197,667	101
2037	214,147	117

Fig 4.1 :Existing sources of Waste generation in Gangtok



Source: Analysis of "Solid Waste Management –DPR preparation, 2010 .

4.4 Solid Waste Collection and Transportation Plan

The existing waste collection and transportation system are detailed out in chapter 2 and the key issues regarding waste collection are poor coverage of Kerb side collection (partly initiated in few areas about 16 % only), inadequate number of vehicles and equipment for efficient collection & transportation resulting in waste clearing performance of about 54 % only. At present the waste is being loaded from the community bins to the truck manually. Manual loading is time consuming and inefficient.

The most important components of the SWM operations namely storage, segregation, collection and transportation of waste require active involvement of the ULB, private operator, community, NGOs, etc. Besides introduction of equipment and vehicles for minimum handling and exposure of waste, awareness creation is the key in developing meaningful partnerships and creating healthy environment. The suggestions in this section focus mainly on the mode of operation, choices of equipment and vehicles, and estimation of the requirements. The following suggestions are mainly based on:

(i) Promotion of the practice of segregation and storage of the waste at the source in two bins-one for biodegradable waste and another for non bio-degradable wastes, so as to facilitate an organized and hierarchical system of waste collection and disposal without letting the waste to reach the ground in the primary and secondary collection stage;
(ii) Organization of door-to-door collection and curb-side collections with community participation on cost recovery basis and minimizing the multiple handling of waste and improvement in the productivity of the labour and equipment;
(iii) Daily transportation of bio-degradable and non biodegradable wastes to the disposal/treatment site;
(iv) Need based transportation of all types of wastes to landfill site;
(v) Transportation of waste using closed/covered vehicles; and
(vi) Community awareness creation of segregation and storage of waste at source.

Also, the **'Hierarchy of Waste Management'** gives a priority listing of the waste management options and indicates important general guidelines on the relative desirability of the different management options. The hierarchy usually adopted is (a) waste minimization/reduction at source, (b) recycling, (c) waste processing – with recovery of resources i.e. material (products) and energy, (d) waste transformation (without recovery of resources). The reduction at source is the first in the hierarchy because it is the most effective way to reduce the quantity of waste, the cost associated with its handling, and its environmental impacts. Thus the proposed Collection and Transportation Plan are detailed below.

The components of waste collection and transportation plan for Gangtok consists of the following;

(i) Segregation and storage of waste at source;
(ii) Primary collection;
(iii) Secondary collection;
(iv) Transportation of waste to processing and disposal site;

4.4.1 *Waste Segregation:*

It is proposed to introduce segregation of waste at source (house level) as wet waste and dry waste. Two separate bins will be distributed to residents viz., one for Biodegradable waste (Green color) and the other for Non-bio degradable waste (Blue color) separation. The details of wet waste and dry waste are detailed below;

4.4.2 *Wet Waste or Bio-degradable Wastes*

- Food wastes of all kinds, cooked and uncooked, including eggshells, bones
- Flower and fruit wastes including fruit peels and house-plant wastes
- House sweepings (not garden sweepings or yard waste: dispose on-site)
- Household Inert (sweepings/ashes)

4.4.3 *Dry Waste or Recyclable and Other Non-Bio-degradable Wastes*

- Paper and plastic, all kinds, Cardboard and cartons
- Containers of all kinds excluding those containing hazardous materials
- Packaging of all kinds
- Glass, all kinds, Metals, all kinds, Rags, rubber, wood
- Foils, wrappings, pouches, sachets and tetrapaks (rinsed)
- Cassettes, computer diskettes, printer cartridges and electronic parts
- Discarded clothing, furniture and equipment.

4.4.4 *List of Some Domestic Hazardous Wastes*

- Aerosol cans, Batteries from flashlights and button cells
- Bleaches and household kitchen and drain cleaning agents
- Car batteries, oil filters and car care products and consumables
- Chemicals and solvents and their empty containers
- Cosmetic items, chemical-based. Insecticides and their empty containers
- Light bulbs, tube-lights and compact fluorescent lamps (CFL)
- Paints, oils, lubricants, glues, thinners, and their empty containers
- Pesticides and herbicides and their empty containers
- Photographic chemicals
- Styrofoam and soft foam packaging from new equipment
- Thermometers, Mercury-containing products
- Injection needles and syringes after destroying them both
- Discarded Medicines, Sanitary towels, Disposable diapers and Incontinence pads

4.4.5 *Bio medical waste:*

The Bio medical waste is not allowed in Municipal stream and shall be dealt separately as per Bio Medical Waste (Management & Handling) Rules. It is understood that in Gangtok the hospitals are managing the Bio medical waste through incinerators.

4.4.6 *Benefits of Segregation of Waste at Source*

The benefits that are likely to be accrued because of segregation of waste at source and door-to-door collection of segregated waste are summarized as under;

(i) Reduction in number of collection points;

(ii) Relief to ULB sweepers as they would be required to handle reduced volume of waste from roads and streets;

(iii) Reduction in waste volume, which will require less space at disposal site as a fair degree of recyclable materials will be sorted out at source;

(iv) Once the segregation of biodegradable and non-biodegradable at source is achieved, composting could become financially viable; and

(v) Optimization of transport vehicles resulting in saving in transportation cost.

The wet waste shall be composted, dry waste shall be recycled/reused to the extent possible and domestic hazardous waste shall be taken to landfill. This would facilitate maintaining hygienic condition and easy handling of the waste for further processing and also to get quality compost. The details on proposed bins for segregation are presented below;

Table 4.5 Requirements of Waste segregation Bins

Waste Segregation Initiatives	Nos	Model
Green colour dust bins for Door-to-Door collection of Biodegradable waste (25 lit. capacity) for 23600 households (Considering only 118000 population)	23600	
Blue colour dust bins for Door-to-Door collection of Non-bio degradable waste (25 lit. capacity) for 23600 households (Considering only 118000 population)	23600	
Total	**47200**	

The SWM plan for entire Gangtok is designed with special focus of waste segregation with two bin system at household level. In order to familiarize the concept of segregation at source, massive public awareness and one time supply of bins are suggested. This may facilitate the household to change their attitude towards two bin system otherwise they may prefer one bin system which is against the proposed segregation programme. Therefore the above provision for Two bin system was made in consultation with GMC, local NGOs, & UDHD.

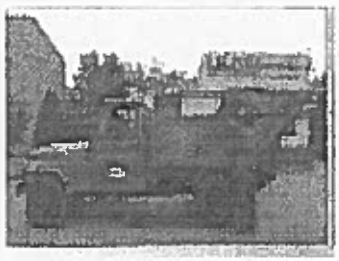
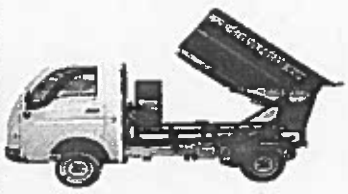
4.4.7 *Strategies for Segregation and Door to Door Collection of Waste*

The following strategies are suggested for which appropriate actions are to be initiated by UDHD;

- To make segregation at source compulsory to all Households, Commercial (Hotels, Shops, Markets), Institutional (School, Colleges, Offices) premises etc.
- All dry and wet waste need to be dumped in separate bins and handed over to the garbage collectors.
- Residents may be asked to deposit segregated waste to Door to Door Collection Vehicle on time
- Wet garbage and Dry garbage shall be cleared for all seven days in a week. Wet Waste is sent to Compost Plant and Dry waste are segregated by Ragpickers and sold to scrap dealers.
- To form local resident welfare associations to promote and regularize the simple practice.
- Rag pickers be organised with the assistance of NGOs for achieving segregation of waste. Borawalas and recycling industries should be encouraged to maximize reuse & recycling of dry waste.
- Publicity campaign for creating community awareness and public participation (CAPP) for segregation of waste should be carried out and continued to achieve segregated biodegradable waste for composting and minimizing the waste for final disposal.

4.4.8 *Primary Collection:*

Door-to-door waste collection shall be introduced along with segregation of waste at household level. At each ward level the Resident Committee/NGO shall be identified to manage Door to Door collection of segregated waste. These waste collectors shall be provided with small 1.5 cum capacity and 4.5 cum capacity container with hydraulically tipped primary collection vehicle (PCV) so as to reach inaccessible areas through narrow streets by ringing the bell. The households shall bring their waste and empty it on to the vehicle container directly. The households shall empty the wet waste on one side of the container and deposit the dry waste into the drums placed on other side of the container.

The PCV moves to next house. Together the PCV also loads the waste stored in the litter bins, street sweepings from pre determined locations viz., nearby the areas where access to houses are only through steps, bus stand, Taxi stand and other public places etc. Once filled upto its full capacity it shall be transported to a near by, waiting Refuse Compactor. While unloading the container, the Mini Tipper (PCV) will reverse itself close to the Compactor's tailgate, and the bin will be hydraulically tipped to discharge its contents into the hopper. The rear end light-sectioned door will open by its self-weight, and the collected waste is emptied into the Compactor.

Table 4.6 : Mini Tipper (Jeep) Requirements for Door Step Collection

Sl	Particulars	Units	PCV 1.5 Cum	PCV 4 cum
1	Capacity of Garbage Mini Hydraulic Tipping vehicle	cum	1.5	4
2	Density of waste	T/Cum	0.4	0.4
3	Quantity per Trip	T/Trip	0.6	1.6
4	HH Waste generation is 2 kg/HH	ton/HH	0.002	0.002
5	Number of house holds covered in one trip at generation rate of 2 kg/day/HH	HH	300	800
6	Average Estimated collection Time (30 seconds/ HH)	Minutes	100	133
7	Average Travel time to container station (average distance 3 km; 3 km x 2way at 20 km.p.h)	Minutes	18	18
8	Unloading time	Minutes	10	10
9	Delay	Minutes	5	5
10	Total time for one trip	Minutes	133	166
11	Number of trips in 480 minutes (8 hours) of working time		3.6	2.9
12		Say	4.0	3.0
13	Coverage/day –No house holds		**1200**	**2400**

Per day household coverage by each vehicle is considered as 1200 and 1800 nos. with 4 and 3

trips/day respectively by the 1.5 cum and 4 cum capacity vehicle. This is considered due to following reasons;

- Gangtok being hilly terrain with limited area, the construction of houses are close by and high population density is observed (Density Map 1). Considering the terrain and topography, Gangtok being hilly terrain consists mostly narrow roads. Therefore house-to-house waste collection are proposed by using smaller vehicles (Mini Garbage Tipper) which can cover majority of the narrow streets (targeted for 80 % collection).

- Also there are houses which are only accessible through steps/pathway (Non motorable) and presently, the NGOs had organized young boys who carry the lighter bins fitted with a rope with cushioning material which can be taken on to back and transfer the load on to their head and back. This can be a locally made container. Percentage of MSW from inaccessible areas - is about 15% to 20%, and therefore waste collection from these areas needs to be addressed separately in a progressive manner.

- Presently, the NGOs at Gangtok are covering about 1500 to 2000 HH per day with one vehicle

- CPHEEO also has reservations in increasing more number of vehicles which increases capital cost together with O & M cost.

Based on the terrain of Gangtok, it is estimated that 11 nos of 1.5 cum capacity Garbage mini tipper (Type 1) and 5 nos of 4 cum capacity Garbage mini tipper (Type 2) are proposed. The requirements are based on the calculation of available volume and required volume as detailed below;

Particulars	Unit	Data for Calulations	Type 1 PCV 1.5 Cum	Type 2 PCV 4 cum
Waste Generation (2015) (T)	T	54		
Density - T /cum	T/Cum	0.5		
Total Waste Volume to be Cleared	Cum	108		
Capacity of Mini Vehicle	Cum		1.5	4
No of Trips	Nos		4	3
Volume of Waste Cleared by 1 Vehicle/Day	Cum		6	12
No of vehicles of 1.5 cum capacity	Nos		10	4
Volume of Waste Cleared by 10 Vehicle/Day	Cum		60	48
Spare / Standby Vehicle	Nos		1	1
Total Vehicles Required			11	5
Existing with GMC			0	2
New Procurement to be made			11	3

However the existing new vehicle, two numbers are proposed to be included into the system. Also a provision for standby vehicle one each is considered to attend for any breakdown. This shall be used as a standby as well as maintenance relieving vehicle. With the above collection efficiency by each vehicle and the life of vehicle (7 years) the projected number of vehicles required are detailed below;

Table 4.7: SWM Door to Door Collection Vehicles/Equipments Requirements

Vehicles/Equipment	Unit	2012-17	2017-22	2022-27
Mini Tippers for Door to Door Collection				
Gross Requirement	Nos	14	16	18
To be Procured	Nos	14	16	1

The life of the vehicle is considered as seven years and thereafter these vehicles are to be replaced and accordingly, the future procurement of vehicles are indicated in Table above for the period upto 2027. A presentation on Feasibility Report was made to Hon'ble Mayor, GMC, on 18th November, 2010, at the Secretary office, UDHD, Gangtok. Hon'ble Mayor had proposed to handle the Door to Door Collection system in each ward under the supervision of each elected representative/ Ward Councilor by collecting nominal fees for operational expenditures. And each ward would get one vehicle and the respective ward councilor would maintain the vehicle with his responsibility. Therefore suggested to increase the Phase 1 requirement to 16 nos (15 nos. at one per ward and one as standby for emergency breakdown etc.). The Note on the proceedings along with photographs, attendance sheet are presented as **Appendix 5**. But based on the discussions held with CPHEEO it was reduced to 14 nos of primary collection vehicles together reducing the capacity from 2 cum to 1.5 cum capacity containers. .

4.5 Waste Collection from Street Sweeping:

It is recommended to sweep all the roads and lanes with dense habitation or commercial activities on a day to day basis, alternate day sweeping in medium density wards and once in three days/once in a week sweeping in the remaining wards.

4.5.1 *Push Carts*

The Push carts are proposed for road sweeping and drain cleaning. The total road network in Gangtok is about 127 km. The sweepers shall transfer waste from Push cart to the containers that are located within a reasonable distance. The life of the Push cart is considered as 5 years and thereafter these are to be replaced. Accordingly, the procurement of vehicles are indicated in Table below for every five years.

Table 4.8 : Requirement of Push Carts for Street Sweeping

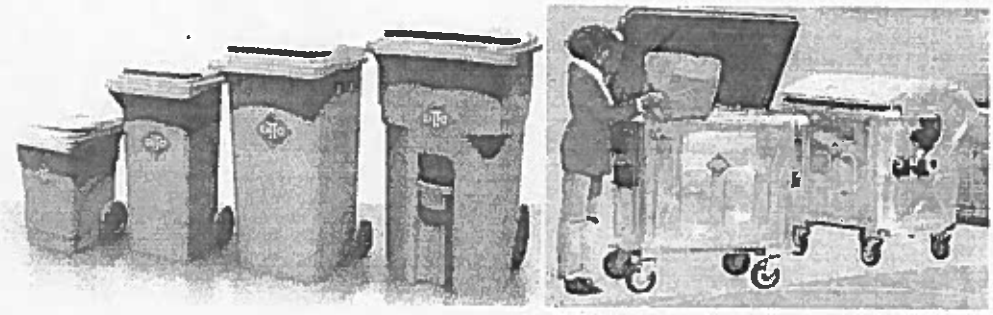
Vehicles/Equipment	Unit	2012-17	2017-22	2022-27	2027-32
Push Carts for Street sweeping					
Gross Requirement	Nos	173	175	177	179
To be Procured	Nos	173	175	177	179

The Number of push carts are calculated based on the road length at Gangtok i.e. About 11.5 kms of market/main roads are considered and with a work norm of 500 m per sweeper about 23 pushcarts are required. The remaining 150 push carts are provisioned for all wards based on road length allocation may be detailed out during preparation of Action Plan. Approximately 10

pushcarts per ward (15 Wards x10 Nos.) These wards may be swept alternatively, weekly or fortnightly based on the schedule either by remaining sweepers or by engaging sweepers on contract basis. The CPHEEO during the discussions considered the existing push carts with GMC reduced the number to 102 nos. This includes two push carts for MG Road.

4.5.2 *Litter Bins:*

In order to cater to the needs of Tourist/ floating population in and around M.G. Marg, and other major market areas, Taxi Stand , Bus station, Shopping areas, in city center area, litter bins are proposed at a spacing of 100 meters. These litter bins will be emptied by sweepers attending primary collection in the respective areas.



The present procurement is limited to five years (2012-2017) requirement. The Hon'ble Mayor had also proposed to provide closed bins of higher capacities and thereby reduce the number of smaller capacity bins together he suggested to procure bins with hooking arrangement to lock the same so that the bins are not displaced by the public. Accordingly the following capacity of liter bins are provisioned;

Table 4.9 : Requirement of Litter Bins for Street Sweeping

Particulars	60 Ltrs. Capacity		120 Ltrs. Capacity		360 Ltrs. Capacity		1100 Ltrs. Capacity	
	G	B	G	B	G	B	G	B
Litter Bins - Permanent Structure Twin Bin Tilting Type - 60 ltrs capacity in Imp. Road	10	10	10	7				
From Steps - Organic waste -17 Cum					58			
From Steps - Inorganic waste - 10 cum				28				
Schools - 17 Nos				17	17			
Govt Department - 39 Nos				39	39			
Transfer points								8
	10	10	10	91	114	0	0	8
		20		101		114		8

The life of Litter bins are considered as 5 years. The 1100 ltrs capacity bins are proposed for collecting dry waste at Transfer points based on the requirements only.

4.6 Secondary Collection, Market areas and Temporary Storage Points:

The proposal of additional new vehicles are made after duly assessing the condition of existing vehicles under use in Gangtok. Accordingly, a discussion was held with the UDHD officials and are detailed below;

Table 4.10 Details on existing Vehicle

Sl	Vehicle No.	Model	Year of Purchase	Condition
1	Sk-03/ 1690	Utility	2003	Crossed 7 years of life
2	Sk-03/ 1686	Tata	2003	Crossed 7 years of life
3	Sk-03/ 1326	Tata	1997	Crossed 7 years of life
4	Sk-03/ 3242	Utility	2005	Proposed to be used at Market
5	Sk-03/ 0853	Tata	1987	Not in Road worthy
6	Sk-03/ 1309	Tata 407	1997	Not in Road worthy
7	Sk-03/1689	Tata	2003	Crossed 7 years of life
8	Sk-03/1687	Pickup/ Utility	2003	Not in Road worthy
9	Sk-03/ 0852	Pickup	2005	Proposed to be used at Market
10	Sk-03/ 2344	Pickup	2006	Proposed to be used at Market
11	SK 03 1688	Utility	2003	Crossed 7 years of life
12	SK-01 DO 400	Tipper	2010	Proposed to be used at Market
	Total			

Further the GMC had procured 2 vehicles and at present, UDHD is having 10 vehicles of which three are pickup vehicles and two are old vehicles 1987 and 1997 models. The balance five vehicles are the only garbage transporting vehicles. The existing vehicle fleet can take up a capacity of about 40 % only. These vehicles are proposed to be used in new system namely, one vehicle at disposal site for carrying compost plant rejects to the landfill and to transfer cover soil to landfill, and four vehicles at four transfer points for collecting dry waste. Keeping in view the above scenario, calculation for acquiring additional collection and transportation vehicles has been prepared to utilize the existing fleet of vehicles with UDHD which are in working conditions. Also, the proposed system shall undertake direct collection of waste from smaller Mini Garbage Tipper from specific locations called Transfer Points.

4.6.1 *Transfer Points :*

Since there was no land available for construction of Transfer Station, the earlier proposal was dropped. Added to this there are objections by the local people for the existing Temporary storage points/ Transfer station located at Arithang area because of unhygienic

practice. Therefore the concerns expressed by the local people are proposed to be addressed by directly transferring the waste to the Compactor vehicle.

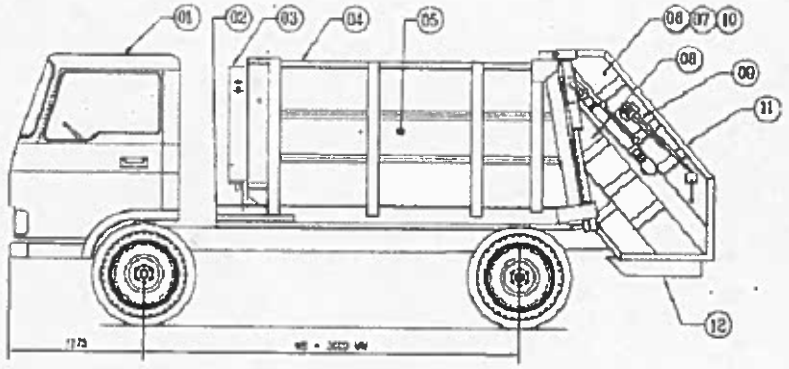
Since there was no land available for Transfer Station, the earlier proposal was dropped and the following four Transfer points are identified.

(1) Indira Bye pass & Road leading to Arithang,
(2) Near Baluwakhani Parking Complex,
(3) Near LPG System,
(4) Ranipool (below Essar Pump.

Location of these transfer points have been marked in (Map 4).

4.6.2 *Solid Waste Transportation by Secondary Collection to Disposal Site:*

The time of Compactor vehicles are synchronized to collect waste from various above four Transfer points and transport the garbage to disposal site at Martam. Since the transportation system will be in synchronization with Transfer points, manual handling of waste is eliminated. Also the smaller litter bins are lifted by the compactors with Universal Bin lifting arrangements. Filled up container bins will be lifted mechanically and emptied inside the compactor vehicles. These compactors have a adjustable hook system and provided with hydraulic lifting arrangements. The waste volume is thus compacted and transported to the disposal site. The life of Compactor Vehicles are considered as seven years. The compactor Vehicle is depicted below.



ELEVATION

About 12 nos of compactors are required for 2012-2032. But Phase I requirement (2012-2017) is 5 Nos (four compactors are for collecting wet waste and one compactor for dry waste collection). Also, the proposed system shall undertake direct collection of waste from large and medium sized hotels, restaurants, party halls, hospitals (domestic and non-bio medical waste) and from construction sites. Separate vehicles (existing) with adequate crew shall be provided for the purpose and the collection shall be carried out on a fixed daily schedule; waste shall be directly transported to disposal site. Existing waste transport vehicles available shall be utilized to the maximum extent.

4.7 Community Stakeholders Consultation

The Primary Collection and Transportation system was formulated in consultation with the community stakeholders. The consultation is carried out in two phase viz., (1) At the beginning of the project emphasizing on the existing status of SWM in Gangtok and (2) after formulation of the DPR. The details of the same are furnished below;

Table 4.12 : Consultations Details

Date	Participants	Topic	Feed Back
26.04.2010	NGO's : The Golden Circle, United Arithang, Gangtok Task Force	Solid Waste generation in Gangtok, Existing practice, Provisions for SWM under NERCCDIP, Details on Wet and dry waste, strategies for segregation at source, door to door collection system, compaction of waste, composting and landfill options	Capacity of transportation vehicle is less Vehicle currentlt used is very old & cannot service all area.
18.11.2010	Mayor, Deputy Mayor, Executive Councillor, Councillors and CMO of Gangtok Municipal Corporation. NGO's : The Golden Circle, United Arithang, Gangtok Task Force	Feasibility Report: Key issues in the existing SWM system Two bin system of waste segregation at source, Primary collection with hydraulic tipping system Secondary collection and transportation by using Compactors Repair of existing Compost plant Landfill facility	To increase the number of primary collection vehicles so that each ward would get one vehicle and one standby To get varied capacity of bins with locking arrangements
19.11.2010	Commissioner Cum Secretary, UD& HD, Gangtok	Feasibility Report: Key issues in the existing SWM system Two bin system of waste segregation at source, Primary collection with hydraulic tipping system Secondary collection and transportation by using Compactors Repair of existing Compost plant Landfill facility	17th December, 2010. The Commissioner cum Secretary of UDHD advised to restart the compost plant at the earliest with their own funds. The Commissioner cum Secretary directed DSMC to delete the provisions made towards repairing the Compost Plant in the DPR
17.12.2010	Commissioner Cum Secretary, UD& HD, Gangtok	DPR Draft Key issues in the existing SWM system Two bin system of waste segregation at source, Primary collection with hydraulic tipping system Secondary collection and transportation by using Compactors	To delete the provisions made towards repairing the Compost Plant in the DPR To restart the compost plant at the earliest with their own funds.

		Repair of existing Compost plant Landfill facility	
24.07.2010	Deputy Advisor, CPHEEO	Concept Report on SWM for Gangtok	To delete decentralized Vermi compost units

4.8 Implementation of Segregation of Waste, Primary & Secondary Collection Vehicles

The State Government has declared Sikkim as an "Organic State" demanding for segregated organic (wet) waste for composting. Therefore the segregation of waste in two bins, door to door collection by primary collection vehicles and compactors are introduced. The public awareness programs shall be started only after the procurement of Two Bins, Door to Door Primary collection vehicles. The detailed programmes on public awareness shall be decided in consultation with GMC/UDHD. An amount of Rs. 2.5 Million is earmarked for Public Awareness. The funds provisioned for public awareness is for the period of about 6 months. GMC may get some revenue when private /public operator takes over O & M of Compost Plant. These revenue may be utilized for public awareness promoting waste segregation during extended period.

4.9 Primary Collection Model

Untill recent, only the NGOs were collecting primary waste and the vehicles are provided by UDHD to local NGOs. NGOs were collecting waste and also collected fee (Rs. 30 to Rs. 50 from per Household and Rs. 50 to Rs.100 from Hotel/commercial establishments), paid for drivers and also maintained the vehicles.

The GMC vide the 2nd General Body meeting held on 24th January, 2011 under the chairmanship of Hon'ble Mayor decided to collect fee for primary collection from the rest of the area. The copy of the resolution is given as **Appendix 10**. The GMC had planned to involve local Ward Councilors/NGOs/Interested persons to manage the primary collection at Ward level by collecting monthly fee from households and commercial establishments at the rates fixed as per the resolution.

4.10 Waste Movement from Household collection to Waste Processing Site:

The SWM plan for entire Gangtok is designed with following approach

Link 1: Waste from Household to Primary Collection Vehicle

(i) Households shall segregate their waste in two bins one comprising biodegradable (Wet) waste and non- biodegradable (Dry) waste at source (i.e. at house level).

(ii) GMC shall identify the Resident Committees in each Ward and shell out the responsibility of managing the Primary Collection Vehicle for Door to Door collection. The Resident Committee shall engage the Collection crew and the Driver for Door to Door collection of waste in their respective wards.

(iii) The primary collection vehicle shall collect the waste by covering the entire ward in a day

(iv) Households shall deposit biodegradable (Wet) waste and non biodegradable (Dry) waste to the Door to Door Collection Vehicle for all seven days in a week at pre determined time.

(v) The primary collection vehicle after it has reached its full capacity shall move towards their respective Transfer Point locations.

Link 2: Movement of Waste from Primary Collection Vehicle (PCV) to Secondary Collection & Transportation Vehicle at Transfer Point

(vi) The fully loaded PCV shall halt at one of the following four pre fixed Transfer Point ;.

(vii) Transfer Point 1 - Near Indira Bye pass and Arithang Area Junction

(viii) Transfer Point 2 - Near Baluwakhani Parking Complex

(ix) Transfer Point 3 - Near LPG Station

(x) Transfer Point 4 - Near Ranipool (below Essar Pump)

(xi) Transfer Point 1 - Near Indira Bye pass and Arithang Area Junction: This is the junction where Refuse Compactor shall stand and wait for the PCV. The various PCVs from Ward No.7 (Arithang), Ward No.3 (Upper Sichey), Ward No. 6 (DPH), Ward No. 9 (Upper MG Marg), Ward No. 10 (Tibet Road), Ward No. 8 (Lower MG Marg), Ward No 11 (Deorali) deposit their waste to Compactor Vehicle by hydraulic tipping arrangement.

(xii) Transfer Point 2 - Near Baluwakhani Parking Complex Area: This is the junction where Refuse Compactor shall stand and wait for the PCV. The various PCVs from Ward No. 4 (Chandmari), Ward No. 1(Burtuk), Ward No. 5 (Development area),

(xiii) Transfer Point 3 - Near LPG Station: This is the junction where Refuse Compactor shall stand and wait for the PCV. The various PCVs from Ward No. 2 (Lower Sichhey), Ward No. 12 (Daragaon), deposit their waste to Compactor Vehicle by hydraulic tipping arrangement.

(xiv) Transfer Point 4 – Near Ranipool (below Essar Pump): This is the junction where Refuse Compactor shall stand and wait for the PCV. The various PCVs from Ward No. 13 (Tadong), Ward No. 14 (Ranipool), Ward No. 15 (Tathangchen), deposit their waste to Compactor Vehicle by hydraulic tipping arrangement.

(xv) The collected refuse in the PCV after its arrival at Transfer station, the dry waste collected in smaller drums are first emptied into the 1100 liter bins manually

(xvi) The collected refuse in the PCV through its hydraulic operations would directly empty/unloaded the wet waste into the hopper of the compactor vehicle.

(xvii) The hopper would unload the garbage into the compactor body. The unloaded garbage inside the hopper is swept and simultaneously pulled into the container body by both the packer plate and slider plate. The ejector plate shall adjust its position automatically depending upon the pressure exerted on it and the garbage is compacted against the ejector plate as the carrier plate ascends.

(xviii) The Compactor vehicle after attaining its full capacity moves towards Waste Processing site at Martam.

(xix) The GMC shall depute Sanitation Supervisors at each of the transfer point to supervise the transfer activity from smaller vehicle to Compactor. Also they shall coordinate and communicate among each other and the drivers of the Compactor vehicle, drivers of primary collection vehicle and the Plant incharge at Martam to know the movement of these vehicles so as to effectively and economically lift and transport the garbage.

(xx) The SWM Action Plan shall be prepared in consultation with GMC/UDHD.

Link 3: Movement of Waste from Compactor (Secondary Collection & Transportation Vehicle) to Waste Processing Site

(xxi) The Compactor vehicle travels from Gangtok to Martam covering a distance of about 10 kms to 18 kms and arrives at the Waste Processing site at Martam

(xxii) To unload the garbage the tailgate assembly is hydraulically lifted to allow the gate to open freely. The ejector block unloads the compressed garbage within the container body, by hydraulically pushing the garbage out. On completion of the unloading cycle, the tailgate is lowered to its closed position. This system facilitates easy and quick unloading of the container without affecting the overall stability of the equipment.

(xxiii) The Compactor vehicle moves out on its next garbage collection trip with the container completely empty, and the ejector panel positioned at the rearmost end of the container.

(xxiv) The above waste movement from Household to waste processing site is depicted in the Waste Movement Diagram No. NERCCDIP-SWM-GANGTOK-SWM 019.

4.11 Hydraulic Mechanism:

The proposed primary collection and secondary collection vehicles are designed with hydraulic system mainly to achieve hygienic and safe garbage handling and avoid any manual handling. The associated benefits of hydraulic operations are easy loading and unloading consuming less time. However care needs to be taken with effective maintenance program for Hydraulic system checking viz., to check oil level of oil tank, check leakage of oil, change oil seal if required, tighten all connections, check hydraulic operations, set pressure, if required etc. It is therefore suggested to strictly adhere to the Hydraulic Inspection Schedule brought out in the CPHEEO Manual (Refer page 639-643, Annexure 13.1).

4.12 Waste Treatment & Disposal Options:

Methods of Treatment and Disposal

The Municipal Solid Waste (MSW), generally, can be treated and disposed off by the following five methods/options:

(1) Bio-methanation /Bio-chemical conversion/Anaerobic digestion
(2) Incineration (Mass burn)
(3) Refuse Derived Fuel (RDF)
(4) Pyrolysis /Gasification – Thermo chemical conversion
(5) Aerobic Composting
(5) Vermi- Composting

The principle of above technologies/ treatment options for solid waste are detailed below;

Table 4.13 : Various Technologies / Treatment options

Sl	SWM Technologies/ Options	Principle
1	Bio methanation	When municipal solid wastes with a large proportion of organic matter is subjected to anaerobic decomposition, a gaseous mixture of Methane & Carbon di-oxide (CH4 & CO2) known as biogas could be produced under favorable conditions. The process is quite stable and upsets do not easily occur. The gas production ranges from 0.29 m3 /kg of Volatile solids added/day to 0.16 cubic metre (m3)/kilogram of Volatile solids added/day in different seasons. The sludge has good manure value of Nitrogen, Phosphorous, Potassium (NPK : 1.6 : 0.85 : 0.93) and is observed to drain easily. The process gives a good performance at detention time of 25 days. Anaerobic digestion to produce biogas (then power) is feasible with food wastes free of plastics & ash
2	Incineration	Incineration is the process wherein the waste is burned at high temperature. Controlling the air pollution to meet the stringent environmental standards are difficult.

Sl	SWM Technologies/ Options	Principle
3	Refuse Derived Fuel (RDF)	The process of conversion of garbage into fuel pellets involves primarily drying, separation of combustibles from garbage, size reduction and pelletisation after mixing with binder and/or additives as required. The MSW collected to be dried if the moisture content is more than 35-40%,until 10-12% moisture content is desirable to be maintained in the garbage for densifying into fuel pellets. By open sun drying and also fed into a rotary drying system i.e. Hot Air Generation burning oversize garbage or other fuel to further bring down the moisture After drying the garbage is passed through a screening equipment to separate sand/grit (below 8mm), heavier combustibles and ferrous materials The dried and screened garbage is then passed through an Air-Classifier (Density Separator) in which the light combustibles and dense fractions (e.g. stones, glass etc.) are separated over an air barrier. At the same time, the garbage is passed over a magnetic separation unit to remove magnetic materials. The light combustibles are ground to 10/15mm particle size. The binder and/or additives are mixed with ground garbage in mixer/ conditioner before pelletising. The pellets coming out of pelletiser are cooled and stored in the pellet storage yard for despatch. The pellets so produced can be used in industrial boilers and thermal power plants as fuel
4	Plasma Arc Technology/ Plasma Pyrolysis Vitrification (PPV)	The system basically uses a Plasma Reactor which houses one or more Plasma Arc Torches which generate, by application of high voltage between two electrodes, a high voltage discharge and consequently an extremely high temperature environment (between 5000-14,000° C) approximating the temperature of the Sun. This hot plasma zone dissociates the molecules in any organic material into the individual elemental atoms while all the inorganic materials are simultaneously melted into a molten lava. The waste material is directly loaded into vacuum in a holding tank, preheated and fed to a furnace where the volatile matter is gasified and fed directly into the plasma arc generator where it is pre-heated electrically and then passed through the plasma arc dissociating it into elemental stages. The gas output after scrubbing comprise mainly of CO and H_2. The liquefied produce is mainly methanol.
5	Composting	Aerobic composting is the process of degradation of biodegradable waste matter into simple organic compound by certain micro-organisms in the presence of air. The main requirements are adequate supplies of air and moisture. Compared to anaerobic process, aerobic conversion process is preferable as it is fast, exothermic and free from odour. Aerobic process also helps to eliminate pathogenic organisms, weed seeds, larva etc. as a result of high temperature developed during the process. Main factors affecting the composting through aerobic process are Moisture Content (50% to 60% optimum), Temperature (50- to 60 degree C (5 to 7 days for pathogens to get killed), C/N Ratio (Between 20 – 40), If C/N Ratio is less – straw, saw dust, paper to be added as carbon Source, If C/N Ratio is more – sewage sludge, slaughter waste to be added as nitrogen source At the end of composting C/N Ratio=20. Adequate oxygen throughout the mass-normally ensured by the turning every 5-7 days.
6	Vermi composting	Vermicomposting involves the stabilisation of organic solid waste through earthworm consumption which converts the material into worm castings. Vermicomposting is the result of combined activity of microorganisms and earthworms. The worm species that are commonly considered are

Sl	SWM Technologies/ Options	Principle
		Pheretima sp, Eisenia sp & Perionyx excavatus sp. These worms are known to survive in the moisture range of 20-80% and the temperature range of 20-40°C. The worms do not survive in pure organic substrates containing more that 40% fermentable organic substances. Hence fresh waste is commonly mixed with partially or fully stabilised waste before it is subjected to vermicomposting. The worms are also known to be adversely affected by high concentrations of heavy metals.

4.13 Evaluation of Waste Treatment Options

The detailed evaluation of various waste treatment options viz., (1) Bio-methanation/Bio-chemical conversion/Anaerobic digestion, (2) Incineration, (3) Refuse Derived Fuel – Thermo chemical conversion, and (4) Pyrolysis /Gasification – Thermo chemical conversion are reviewed. These options are not considered due to following reasons;

- Incineration : Incineration is not suitable for Gangtok because of the waste characteristics indicated low calorific value & high moisture content and inert materials
- Refuse Derived Fuel – Thermo chemical conversion: RDF is not suitable for Gangtok because of the waste characteristics indicate high moisture content and sun drying of waste is difficult due to the low temperature and high cost for artificial drying
- Bio-methanation/Bio-chemical conversion/Anaerobic digestion : Successful solutions to this option will only develop if they are basically self-sustaining and economically viable.
- Pyrolysis /Gasification – Thermo chemical conversion: This is an emerging technology for energy/ resources recovery from organic wastes and high cost.

Based on quality and quantity of garbage generated in Gangtok, the above four options involving waste-to-energy technologies are not suitable for Gangtok. Moreover these technologies are very costly, complex ones and are suitable only where waste generation is in very large quantity. In view of these constraints, high capital cost, complex design and high cost of O&M as mentioned above, these treatment methods are not recommended.

4.14 Composting Technology for Gangtok:

An accurate assessment of the quantity and characteristics of solid waste generated in Gangtok were carried out during November 2010. The results of the solid waste samples analyzed for waste generated in Gangtok are detailed in earlier chapter on Waste quantification and characterization study (Chapter 3). As the MSW Rules, 2000 of Government of India, stipulate waste processing of the organic component either through composting or other useful purposes. Therefore the analysis of the MSW characteristics indicating the option for composting were explored and the results are furnished below;

- High organic content of 63 %,
- Moisture content at Disposal site was 45 % (50% to 60% optimum)
- Carbon as C is 36 %
- Nitrogen as N is 1.65 %
- C/N Ratio is 22:1 (Preferred between 20:1 to 40:1),

The above properties indicated the suitability of waste for Composting. Moreover composting is a proven technology in many locations and also the cheapest available waste-management option today. In view of the above it was decided to go ahead with existing compost plant.

4.15 Status of Existing Compost Plant

The State through MoUD's assistance had installed a Compost plant of 50 TPD capacity at Martam to treat the mixed municipal waste. The technical assistance for the compost plant was from M/s Karnataka Compost Development Corporation (KCDC), Bangalore. However, in spite of the above commitments of the State towards effective solid waste management system the existing situation is far from satisfactory. The compost plant is not in operation at present. The plant was commissioned and worked for a few months. Now the Plant is not in working condition and the plant is shut down since 2009. The reasons attributed mainly are break down of a shaft in the second trammel, poor maintenance of the plant, lack of will, etc. In the feasibility report necessary provisions was made for repairs of machineries, maintenance of mechanical equipments, replacement of electrical wiring/fittings, anti corrosive painting, minor civil works etc was proposed for a cost of Rs. 3.5 millions. A meeting was held on 17th December, 2010. The Commissioner cum Secretary of UDHD advised to restart the compost plant at the earliest with their own funds. The Commissioner cum Secretary directed DSMC to delete the provisions made towards repairing the Compost Plant in the DPR to be funded by ADB for NERCCDIP, Gangtok. Accordingly the same has been deleted.

The existing covered compost plant shed is built up in an area of 3960 sq.m which include 2760 sq.m for windrow area (70%) and 1190 sq.m for machineries (30%) space is provisioned. These area is divided into five bays each measuring 54.5 m length and 14.5 m width. The total windrow length available is 380 m and 5.5 m width with vehicle movement width of 3.5m. There was no detailed information like drawing, detailed project report etc. on the existing compost plant at Martam. Therefore DSMC measured the windrow area available and accordingly the capacity of the plant was assessed as 50 TPD.The details of the existing plant is furnished in the Drawing No. NERCCDIP- SWM-GANGTOK- CP 018. Further a 20 years of design life for compost plant is considered and along with the following criteria's the details are worked out;

Table 4.14: Design Details for Compost Plant

Particulars	Details
Design Period	2012 to 2032
Design Life (Years)	20
Waste Fraction Composted (%)	58%
Ultimate Design Capacity (Tonnes/day)	65
Size of Windrows	12m X 5.5m X 2m
Waste Density (T/cum)	0.5
Initial Composting Period	21 days

The existing plant is designed for 50 TPD but the proposed ultimate design capacity for 20 years is 65 TPD. In order to meet the additional load of 15 TPD, the DSMC had earlier proposed Vermicomposting units of 5 TPD each located in inaccessible areas as decentralized units and suggested for manual operation by local residents. Further the Deputy Advisor, CPHEEO on 24 July, 2010 at Gangtok suggested to utilize the existing 50 TPD compost plant only and additional quantity of waste (15 TPD) generated may be run through introduction of additional shift. Therefore the proposal of three units of decentralized Vermicompost units, as suggested in the Concept report was deleted.

4.16 Compost Marketing Plan

Based on the organic waste generation from Gangtok the Compost Plant at Martam produces a total quantity of about 7 tonnes per day and the details of the calculations are given below;

Table 4.15: Calculation on Compost produced

Particular	Input Data & Calculation		
Bio degradable fraction	63%		
Recyclable	17%		
Others	20%		
Design period of compost plant - years	10		170
Total Waste Generation per day (TPD) - 2012	54.0		
Projected Waste Generation per day (TPD) - 2022	80.0		
Projected Mixed Waste with 80 % organic and 20% others (Improved segregation)			160
Total Waste Generation per day (TPD) - 2011	54.0	54.0	
Collection Efficiency - 2011	90%		
Waste received for composting per day (TPD)	48.6	48.6	
Reduction during Composting Process	100%	TPD	Density (T/Cum)
Windrow 1 - (0 to 7th Day)		48.6	0.5
Windrow 2 - (8th to 14th Day)	15%	41.31	0.5
Windrow 3 - (15th to 21st Day)	20%	33.0	0.6
Windrow 4 - (22nd to 28th Day)	20%	26.4	0.7
Windrow 5 - (29th to 35th Day)	10%	23.8	0.8
Quantity of Compost processing		23.8	
Sieve 1 - 40 mm	50%	11.9	

Sieve 2 - 16 mm	80%	9.5	
Sieve 3 - 4 mm (Passed) : Grade A -Organic Manure	75%	7.1	
4 mm (retained) : Grade B - Organic Manure		2.4	
Inerts from Compost plant		14.3	

Since the State Government has declared Sikkim as an "Organic State" and it is projected that there would be a good demand for Compost. It is understood that presently SIMFED is procuring compost from Kolkatta at high price wherein transportation cost is involved and have also expressed to procure compost produced within the State. GMC vide letter dated 22.06.2011, Memo No. 891/GMC in para 5 had indicated that SIMFED and MGNREGA had shown interest to purchase the same. (**Annexure 12** to revised DPR Volume III) GMC is in the process of engaging Private agency for O & M and the same agency shall be involved for marketing the compost also. GMC may get some revenue when the agency takes over O & M of Compost Plant. These revenue may be utilized for public awareness promoting waste segregation during extended period and support financial assistance for secondary collection and transportation system. The UDHD had in principle handed over the Compost Plant to GMC. (**Appendix 17**).

4.17 Waste Disposal Options

As per the MSW Rules, the organic fraction of 63% of waste generated from Gangtok was planned for composting and the rejects from the compost plant and the inert matter will then be disposed in a landfill site, fully complied with the requirements of MSW Rules.

5 LANDFILL SITE SELECTION & PLANNING

5.1 Landfill Site Identification & Selection

The UDHD had initiated action to search land from Forest department. Accordingly the department had identified a land at Topakhani, Singtam. A visit was made by DSMC team along with the Forest department officials on 22-04.2010 to Topakhani, Singtam. The site was evaluated based on the CPHEEO Locational Criteria and details of the same are furnished below;

Table 5.1: Locational Criteria for Landfill Site

Sl	Particulars	Criteria	Observation made at proposed landfill site at Topakhani, Singtam
1	**Lake or Pond**	No landfill should be constructed within 200 m of any lake or pond. Because of concerns regarding runoff of waste water contact, a surface water monitoring program should be established if a landfill is sited less than 200m from a lake or pond.	No lake or Pond observed during the visit
2	**River:**	No landfill should be constructed within 100 m of a navigable river or stream. The distance may be reduced in some instances for non meandering rivers but a minimum of 30 m should be maintained in all cases.	River is flowing abutting the site
3	**Flood Plain:**	No landfill should be constructed within a 100 year flood plain. A landfill may be built within the flood plains of secondary streams if an embankment is built along the stream side to avoid flooding of the area. However, landfills must not be built within the flood plains of major rivers unless properly designed protection embankments are constructed around the landfills.	Site is in the flood plain. Two small streams are flowing through the site. These streams are normally dry; but totally filled up during heavy rains
4	**Highway:**	No landfill should be constructed within 200 m of the right of way of any state or national highway. This restriction is mainly for aesthetic reasons. A landfill may be built within the restricted distance, but no closer than 50 m, if trees and berms are used to screen the landfill site.	NH 31A Gangtok – Siliguri is just by the side of the site.
5	**Habitation:**	A landfill site should be at least 500 m from a notified habitated area. A zone of 500 m around a landfill boundary should be declared a No-Development Buffer Zone after the landfill location is finalised.	Sumin village (small hamlet) is adjacent to the site and falls in Sumin Lingchey (Gram Panchayat Unit)
6	**Public parks:**	No landfill should be constructed within 300 m of a public park. A landfill may be constructed within the restricted distance if some kind of screening is used with a high fence around the landfill and a secured gate.	No

Sl	Particulars	Criteria	Observation made at proposed landfill site at Topakhani, Singtam
7	**Critical Habitat Area:**	No landfill should be constructed within critical habitat areas. A critical habitat area is defined as the area in which one or more endangered species live. It is sometimes difficult to define a critical habitat area. If there is any doubt then the regulatory agency should be contacted.	No
8	**Wetlands:**	No landfill should be constructed within wetlands. It is often difficult to define a wetland area. Maps may be available for some wetlands, but in many cases such maps are absent or are incorrect. If there is any doubt, then the regulatory agency should be contacted.	No
9	**Ground Water Table :**	A landfill should not be constructed in areas where water table is less than 2m below ground surface. Special design measures be adopted, if this cannot be adhered to.	Needs to be examined
10	**Airports:**	No landfill should be constructed within the limits prescribed by regulatory agencies (MOEF/ CPCB/ Aviation Authorities) from time to time.	Not applicable
11	**Water Supply Well:**	No landfill should be constructed within 500 m of any water supply well. It is strongly suggested that this locational restriction be abided by at least for down gradient wells. Permission from the regulatory agency may be needed if a landfill is to be sited within the restricted area.	No
12	**Coastal Regulation Zone:**	A landfill should not be sited in a coastal regulation zone.	As per the Sikkim Forest, Water Courses and Road reserve Preservation & Protection Act 1988 (Amendments upto 16.05.2009), Chapter 4, Section 29 restricts any development within 60 meters from HFL of the river. ***(Does not pass the restrictions)***
13	**Unstable Zone :**	A landfill should not be located in potentially unstable zones such as landslide prone areas, fault zone etc.	Needs to be examined
14	**Buffer Zone :**	A landfill should have a buffer zone around it, up to a distance prescribed by regulatory agencies.	Needs to be examined

Similarly various sites were visited along with Forest department officials viz., Two sites in Rolep Rolep (1) & Rolep (2), and Anda Bridge near Shiv Gufa. The aerial spread of the sites and comparison of the sites are given below;

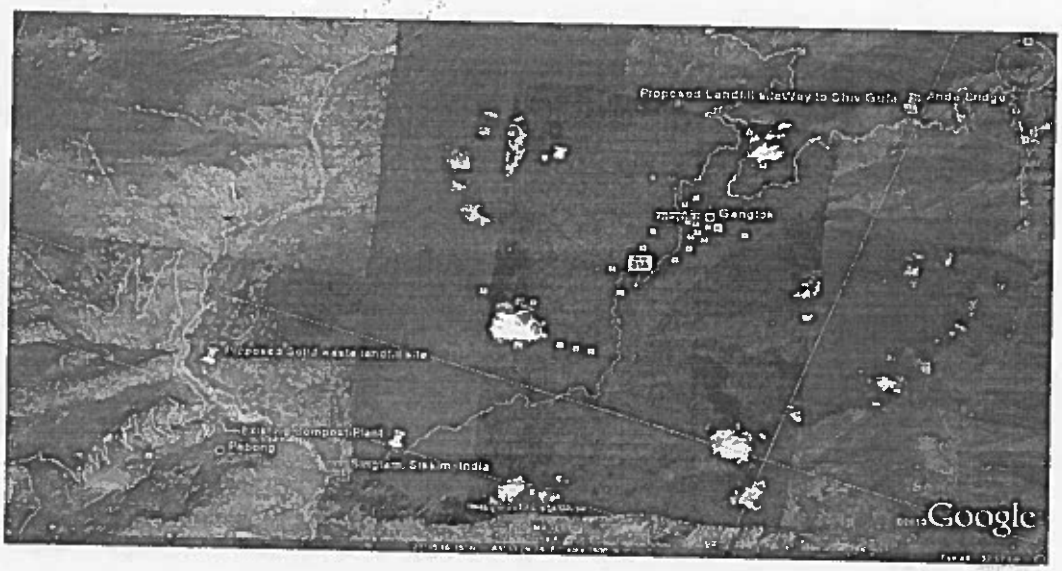


Table 5.2 : Comparison of the sites

SL	DETAILS	SITE	
		Rolep|1	Andha Bridge
1	Ownership of Land	NHPC	Forest land, East District
2	Distance from Gangtok	About 40 kms	About 18 kms
3	Time taken	85 minutes(1 Hr. 25 min)	60 minutes (1 Hr.)
4	Distance from Martam	18 kms	36 kms
5	Time taken	40 minutes	105 minutes (1 Hr. 45 minutes)
6	Site to be large to last 20-25 years	No	Yes
7	Distance within 5 km from city limits	No	No
8	500 m away from habitation, forest, monuments, park, wet lands, cultural/ historic/religious interest	NHPC Guest house, Junior college are within 500 m	Shiv Cave exist at about 500m

In spite of best efforts made by Forest Department/ SIPMIU to find a suitable land by exploring number of sites, unfortunately neither sufficient land was available nor were most of those sites within reasonable distance from the city. Environmentally the site may not qualify as a potential site as per the site selection criteria of MSW Rules/ CPCB/ADB. UDHD/ Forest department. The Site Ranking exercise was carried out and detailed out in the **Appendix 6**.

5.2 Exploration of Martam site for Landfill

After making several attempts to identify landfill site UDHD concluded that it is difficult to get the required landfill area in hilly terrain. Therefore UDHD suggested to explore the possibility of considering the land adjacent to existing dump yard at Martam as potential site. Earlier the CPHEEO officials visited the Martam Dump yard on 26 July, 2010 and

expressed that compared to other location which are very far and waste transportation cost which is part of O & M would drastically increase and therefore suggested to explore the possibilities of proposed landfill at Martam

Accordingly the DSMC had explored the same and the various advantages/disadvantages of landfill site at Martam are tabulated below;

5.2.1 *Advantages of landfill site at Martam*

- Adequate area for Landfill is available (4.2 Ha.) in Martam
- Comparatively nearer to Gangtok City
- Easy to manage the whole Treatment & Disposal facility in one Complex
- Single Leachate Treatment Plant may be utilized for both Landfill & Compost Plant
- Transportation and O & M cost would be less

5.2.2 *Disadvantages of landfill site at Martam*

- Located adjacent to the River
- Approximate dimension of Site (140m width and 340m length).
- As per SWM Manual distance restriction is minimum 100 m for navigable river/stream. May be reduced for non meandering river. Minimum distance to be maintained is 30m
- Land sloping towards river.
- Location being in high rainfall area, possibility of Runoff, carrying waste being discharged into the river. Proper abatement measures necessary that may increase the cost.

After studying the above environmental requirements and other practical considerations, it was decided by UDHD to use the present dumping site where sufficient land was available in possession of UDHD. Further a joint inspection was made to Martam site by State Pollution Control Board, Sikkim (SPCB), UDHD and DSMC in September 2010. Further the UDHD submitted an application to SPCB with a request for SWM Authorization/Consent to establish Landfill site at Martam on 04.04.2010. Accordingly, the SPCB had issued a Consent for authorization for operation of waste processing facility & setting up and operation of disposal facility at Martam vide Letter No. F75/SPCB/ 1143, Dated 21.10.2010 (Copy enclosed as **Appendix 7**) with certain conditions like development of green belt around the site, to prevent all form of pollution, measures to safeguard the local environment, measure to prevent environmental hazards etc. These suggestions are incorporated in the Environmental Mitigation Plan (EMP) and the cost towards the same is provisioned in the estimates. The Chairman, State Level Environment Impact Assessment Authority (SEIAA), Gangtok vide letter no 85 /FEWMD, dated 25/05/2011 had accorded Environmental Clearance (**Appendix 19**).

5.3 Landfill location at Martam

The proposed site for landfill at Martam is located at 20 km away from Gangtok and is located adjacent to NH 31A. The regional setting and location of SWM Landfill site at Martam is presented in Volume II of DPR for drawings (**Dwg. no. NERCCDIP-SWM-**

GANGTOK-LF-LOCATION-001). The existing garbage dump yard to be developed into scientific landfill facility for accepting rejects from the composting process and also non recyclable waste stream.

5.4 Landfill Design Criteria

The design requirements for sanitary landfill development are primarily guided by the characteristics of the proposed site and the guidelines framed by the Ministry of Environment and Forests, Government of India. Part II, Section 3, Sub-Section (ii), Rule 6 (1), 6 (3) and 7 (2) of these guidelines indicate that the sanitary landfill shall comply with the following:

(i) The minimum bottom liner specifications shall be a composite barrier having 1.5 mm High Density Polyethylene (HDPE) geomembrane overlying 90 cm of soil (clay/amended soil) having permeability coefficient not greater than 1 x 10-7 cm/sec. The highest level of water table shall be 2 m below the clay/amended soil layer;

(ii) Waste shall be compacted adequately and provided with daily cover of minimum 10 cm of soil inert debris;

(iii) Prior to commencement of monsoon intermediate cover of thickness 45 cm has to be provided with proper compaction and grading to prevent infiltration during monsoon. Proper drainage berms shall be provided to divert runoff from the active cell of the landfill;

(iv) The final cover shall have a barrier layer comprising of 60 cm of clay/amended soil with permeability coefficient not greater than 1 x 10^{-7} cm/sec., on the top of the barrier soil layer there shall be a drainage layer of 15 cm and on the top of drainage layer there shall be a vegetative layer of 45 cm thick;

(v) The post closure care of landfill site shall be conducted for at least fifteen years and long-term monitoring plan shall be prepared.

(vi) In order to prevent the pollution problems storm water diversion drains, leachate collection and treatment system and preventive measures for runoff from landfill area entering any stream, lake, river or pond shall be provided;

(vii) Buffer zone around the landfill site and a vegetative cover over the completed site shall be provided; and

(viii) The sanitary landfill shall be provided with fence, security gate, approach and internal roads, waste inspection facility, weigh bridge, equipment and machinery, infrastructure like water supply, lighting, etc., and health inspection facilities;

Considering the above features of the site, the design approach for the development of waste processing and disposal facility for Gangtok comprise the following components.

- Remediation (re-engineering) the already dumped solid waste with final closure;
- Developing a sanitary landfill facility for the future waste disposal;
- Prevention of ground water contamination, more importantly of the Rani Khola (Martam Khola), with adequate containment measures.

5.5 Land availability for Landfill at Martam

DSMC in consultation with the revenue authorities and SIPMIU carried out topographical survey. The existing garbage land belongs to UDHD has an extent of about 4.2 Ha. (Land Possession Certificate furnished as **Appendix 8**) The site has a sloping terrain from NW to SE towards Ranikhola/Martam Khola river with RL 73.000 m to 60.00 m respectively. The site boundary along with the contour map is given in the drawing **(Dwg. no. NERCCDIP-SWM-GANGTOK-LF-CONTOUR-002).**

5.6 Geo technical Investigation and Soil Characteristics at Martam

The Department of Mines, Minerals and Geology, Government of Sikkim, Gangtok was consulted and site visit was made and carried out preliminary geo-technical study and major findings are as detailed below;

5.6.1 ***Location:*** The plot is precisely located at 27 15'30.6" North latitude and 88 33' 04.5" East Longitude

5.6.2 ***Topography :*** The area has a gentle slope facing moderately towards South-East along Rongni chu.

5.6.3 ***Soil :*** The area is composed of sandy soil over burden with high percentage of sand and gravels and least percentage of fines, C value is Zero, Phi value varies from 25 to 35

5.6.4 ***Flood level:*** Flood level varies from 562 to 565 above MSL. And the landfill site is at an elevation of 580 m above MSL.

5.6.5 *Exposed materials along the river bank is sand, pebbles, gravels which are porous*

5.6.6 ***Ground Water Table:*** *Based on the Geophysical Positioning System (GPS, and trial pits, natural sloping terrain the elevation difference of 15 m (580m a.m.s.l on landfill site and 565 m a.m.s.l. at river side) was observed and no where the ground water table appeared. The exposed materials along the river bank is sand, pebbles and gravels and overall geological setup of the area, formation of water table appears to be remote. However present water level of river may be taken as permanent water table.*

The detailed report on geotechnical investigation and soil characteristics for SWM Martam is furnished as **Appendix 14**. However the ground water table by exploring the bore well shall be carried out by SIPMIU before execution of work. A commitment letter in this regard is enclosed as **Appendix 22.**

5.7 Soil Characteristics at Martam

The Department of Mines, Minerals and Geology, Government of Sikkim, Gangtok was consulted and site visit was made and soil sample was collected for soil analysis viz., Moisture content (5.15%), Dry Density (1.43 gms/cc), Value of C (is zero), phi varies from 25 to 35%, Clay (0.09%), Silt (0.5%), Fine to very fine sand (13.68 %), Medium Grained sand (45.05%), Coarse sand (29%), Very Coarse sand (8%), Gravel (3.4%); The

results are given in the **Appendix 14 and 15.**

5.8 Design of Landfill at Martam

5.8.1 *Basic Data:*

Location	:	Martam, Gangtok, Sikkim
Waste Generation	:	50 Tonnes per Day (2012)
Design Life	:	Active Period = 23 years
		Closure & Post Closure Period = 25 years
Topography	:	Sloping ground NW to SE
Sub soil	:	Sandy soil
Water Table	:	15 m below ground surface
Average total Precipitation	:	3580.5 mm per year
Compacted Den sity	:	1.1 T/cu.m
Volume of Liner system	:	12.5%.
Rejects from Compost Plant	:	10%

- Waste Generation (2012) = 50 TPD
- Estimated Waste Generation after 23 years = 111 TPD
- Total Land filling Waste quantity in 23 years = 0.5(7.2 +15.9) x 365 x 23
  = 96,719 Tonnes

- Total Waste Volume (assumed density of 1.1 tonnes/cu.m) = 96,719/1.1 = 87,927 cum
- Volume of Daily Cover = 10% = 0.1 *87,927 cum = 8,793 cum
- Volume of Liner and Cover systems = 12.5% = 0.125 *87,927 cum = 10,991 cum
- Settlement =10 % = 0.1 *87927 cum = 8,793 cum
- First Estimate of Landfill Volume Ci = (87,927+8,793+10,991-8,793) = 98,917 cum
- Likely shape of the Landfill = Rectangular
- Type of Landfill – Above ground Landfill with in the Gabion wall containment and Partly below the ground

5.8.2 *Assessment of Actual Land Requirement for Landfill*

Generally the rejects from the compost plant, and non-biodegradable waste, i.e. construction/ demolition waste silt, rejects from recyclable waste (not collected by rag pickers and scrap dealers) are to be disposed off in the Sanitary landfill. The details of land requirement with lesser height of landfill are presented below;

Table 5.3 : Details of Land requirement

Design Period	2012-2032	2012-2042
A. Landfill Facility		
Design Life (years)	20	30
Waste Fraction Land filled (%)	37%	37%
Quantity of Waste TPD	41	47
Design Capacity (Cum)	311,376	423,709
Land required for landfill (ha)	**3.5**	**4.7**

It is estimated about 3.5 ha. of land is required for the 20 year design period and 4.7 ha. of land is required for 30 years design period for land fill. There are many advantages of having additional area wherein all SWM activities are located in one complex. This would also facilitate lesser Capital and O & M expenditures. Therefore DSMC, in the concept report suggested SIPMIU to procure land of 5.6 ha to meet 2042 requirement. Since no other sites were suitable it was decided to explore the possibility of land availability at Martam for landfill.The land availability at the existing waste dump yard at Martam is about 4.2 hectare. Due to various constraints like hilly terrain, river flowing adjacent, existing compost plant etc. the effective area available for landfill is about 9900 sq.m. (0.99 ha.) only. The area for the landfill and other amenities are brought out in the Layout drawing (**Dwg. no. NERCCDIP-SWM-GANGTOK-LF-LAYOUT-003).**

As per the MSW Rules 2000, Schedule III [see rules 6(1) and (3), 7(2)], Specifications for Landfill Sites, specifies that landfill site shall be large enough to last for 20-25 years. Since the available land is less it was explored to increase the height of landfill to meet the Standard design life of 20-25 years. Also, under par 33 on ***Special provisions for hilly areas state that*** "Cities and towns located on hills shall have location-specific methods evolved for final disposal of solid wastes by the municipal authority with the approval of the concerned State Board or the Committee. The municipal authority shall set up processing facilities for utilization of biodegradable organic wastes. The inert and non-biodegradable waste shall be used for building roads or filling-up of appropriate areas on hills. Because of constraints in finding adequate land in hilly areas, wastes not suitable for road-laying or filling up shall be disposed of in specially designed landfills". Taking this under consideration the strategy for waste management is detailed below;

Table 5.4 : Waste Management Strategy for Gangtok

Characteristics	Average %	Recyclables %	Inert		Biodegradable
Constituents			Land fill	Filling up Muck land	
Paper	6.7	6.7			
Textile	2.6		2.6		
Plastic and Rubber	3.8	3.8			
Metals	1.4	1.4			
Glass	2.0	2.0			
Stone/brick	0.9			0.9	
Ash and Fine Earth	16.0		5.4	10.6	
Leaves and Wood	3.4	3.4			
Food Waste	63.3				63.3
Total	100.0	17.2	8.0	11.5	63.3

With the above hilly area provisions, the life of landfill would increase with following considerations;

1. Percentage of inert material is reduced from 19.5% to 8% which goes for landfill. Therefore waste like Stone/bricks. Ash and Fine Earth amounting to 11.5% may go for filling up the muck land.

2. An area of about 3181 sq.m was identified on the hilly side wherein an excavation

upto 4.2 m (3m effective volume and 1.2 m for liner system) was considered (Below RL 73.00) providing an additional volume.

3. To increase the life of landfill care should be taken by the UDHD/GMC to speed up the process of operating the existing Compost plant immediately and thereby retain more volume for future, otherwise the volume of garbage may increase day by day

4. The UDHD/GMC to utilize the existing dumped garbage for producing Compost by sieving the material in additional shift if required and thereby reduce the volume of already dumped material and increase the life of landfill.

5. To facilitate the above process the earth moving vehicle and equipments proposed for procurement at the end would be advanced to carryout the task of creating more volume and thereby increase the life.

6. The inert waste/residues left out after sieving mechanism may be stacked for final closure or otherwise these volume may be accommodated either in the area mentioned at Sl No 2 above after construction of landfill liners or elsewhere within the landfill.

5.8.3 *Height of Landfill*

Regarding the landfill capacity, it is estimated that the final waste that reaches landfill is about 37 percent (including composting rejects of 28%) of total waste generation. But during the discussions held with CPHEEO the rejects from compost plant is considered as 10% and inert material; for landfilling is only 8%. As the bottom land area is limited and there exists a hilly slope on western side facilitating the waste cell to rest on the hilly slope. It is proposed to construct vertical walls on the other three sides to contain the waste. Since the general terrain of the site is sloping, the height of retaining wall would range from a minimum height of 6 meters to maximum of 19 meters.

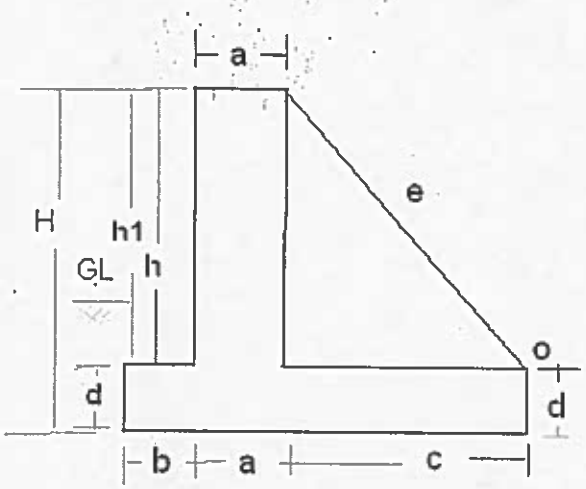
5.8.4 *Formation of Retaining Wall*

Gabion Wall: The Senior Structural Engineer of DSMC visited the Martam site for detailed investigation to explore various options for landfill containment wall namely, RCC retaining wall, soil embankment and Gabion wall. Based on the site assessment, soil condition, seismic zone etc. it was observed that neither RCC retaining wall nor soil embankment was feasible. Therefore as a final option, construction of Gabion wall with special reinforcement earth arrangement to suit garbage and leachate environment was proposed. This would utilize the local heritage of Gabion wall which is a common and accepted practice in these hilly areas wherein landslides are common phenomenon. The height of Gabion wall varies over the length based on the topography of the site. At northern side of landfill 6 m of Gabion wall is proposed and further towards eastern side, Gabion wall upto 19 meters is proposed (RL 60.00 m to 79,00 m). The top RL of the Gabion wall is retained as 79.00 m throughout. The top width of Gabion wall was designed for 5.5 m so as to facilitate movement of vehicles. During the discussions with CPHEEO it was suggested to consider the RCC wall as containment for Landfill.

5.8.5 *RCC Retaining Wall*

The CPHEEO advised to explore the possibility of RCC retaining wall against the Gabion wall so as to increase in the life by increasing the volume. Accordingly the design of RCC wall was carried out and detailed below. The cross section details along with height are detailed out in the drawing (**Dwg. no. NERCCDIP-SWM-GANGTOK-LF-RCC- 4, 4A, 4B, 4C, 4D).**

1. Design of Counter fort retaining wall for 6M



Values to be assumed

h1	height of the wall above ground level	6	
SBC	SBC of the soil	200	
Ø	Angle of the internal friction	0.52	Angle in radians
Ys	Desnsity of the soil	16	
μ	Co.eff of friciton	0.55	
Þ	Density of concrete	25	
Yr	Density of the waste materials	10.22	
Ør	Angle of the internal friction for waste material	0.59	Angle in radians
S	Spacing of the counterforts c/c in m	4	
	1/S	0.25	

$$Ka = \frac{1-\sin Ø}{1+\sin Ø} = 0.33$$

$$Kar = \frac{1-\sin Ør}{1+\sin Ør} = 0.28$$

$df = \frac{Ka^2 \times SBC}{Ys} =$

Provide df_{min} = 1.5 m for h1 < 10m — df_{min} 1.5

Provide df_{min} = 2 m for h1 > 10m — df_{min} 2

df_{min} 1.5

H= h1 + df 7.5

Dimension of the wall

Base width (Assume 0.5 H to 0.6 H)	B	3.5
Toe projection (Assume 0.4 B)	b	1.7
Thickness of counter fort Assume 0.03H to 0.06H)	e	0.3
Thickness of stem (assume H/25)	a	0.3
Thickness of the base slab (assume H/20)	d	0.35

h= H-d 7.15

C = B-a-b 1.5

Stability of the wall

Moments about "O"

Sl No.	Force	Magnitude	Cg distance	MR
1	W1=h*b*Yr*S	496.90	2.65	1316.78
2	W2=a*h*b*S	214.50	1.65	353.93
3	w3 = B*d*b*S	122.50	1.75	214.38
4	w4 = 0.5*c*(h-3)*e*b	23.34	1.00	23.34
	Total	857.24		1908.42

Overturning moment due to backfill

Mo = Kar X Yr / h^3 704.08727

Factor of safety against over turnig

FS1 = 0.9 X MR/Mo 2.44

If FS1 ≥ 1.4 , safe — **safe**

If FS1 < 1.4 , unsafe revise the section

Sliding force

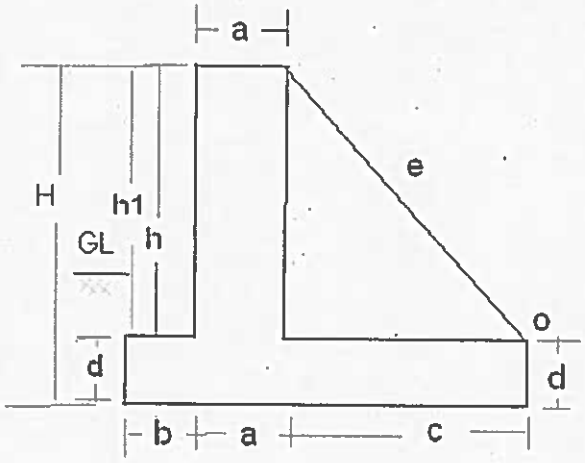
P_H=0.5 X ka X Ys X h^2 73.855308

Resisting force

Pr = μ X (0.9*W1+W2+W3+W4) 111.04

Factor of safety against safety	
Fs2 = Pr / Ph	1.50
If FS2 ≥ 1.4 , safe	
	safe
If FS2 < 1.4 , provide shear key	
Pressure from soil	
Net movement about "O" , M=MR-Mo	1204.3319
Horizontal distance at which resultant intercepts base	
X' = M/∑W	1.40
Eccentricity e1 =(B/2) - X'	0.35
If e1 = ≤ B/6 then safe or unsafe	safe
p1 = (∑W / B) * {1+(6 X e1/B)}	97.46
p2 = (∑W / B) * {1-(6 X e1/B)}	25.01
	Safe
Design of the shear key	
Presure @ the face of the shear key = pb	
pb = (p2)+((p1-p2)/B)*(a+b))	66.41
Co efficient of passive earth pressure = kp = 1/ka	3
Let " Y " is the projection of shear key	
Y = ((1.4 X Ph) - (0.9* μ * ∑W))/ (kp X pb)	-0.013

2. *Design of Counter fort retaining wall – 10 M*



Values to be assumed

h1	height of the wall above ground level	10	
SBC	SBC of the soil	200	
Ø	Angle of the internal friction	0.52	Angle in radians
Ys	Desnsity of the soil	16	
μ	Co.eff of friciton	0.55	
Þ	Density of concrete	25	
Yr	Density of the waste materials	10.22	
Ør	Angle of the internal friction for waste material	0.59	Angle in radians
S	Spacing of the counterforts c/c in m	4	
	1/S	0.25	

$$Ka = \frac{1-\sin Ø}{1+\sin Ø} = 0.33$$

$$Kar = \frac{1-\sin Ør}{1+\sin Ør} = 0.28$$

$$df = \frac{Ka^2 \times SBC}{Ys} =$$

Provide df_{min} = 1.5 m for h1 < 10m — df_{min} 1.5

Provide df_{min} = 2 m for h1 > 10m — df_{min} 2

df'_{min} 2

H= h1 + df 12

Dimension of the wall

Base width (Assume 0.5 H to 0.6 H)	B	5.75
Toe projection (Assume 0.4 B)	b	3
Thickness of counter fort Assume 0.03H to 0.06H)	e	0.4
Thickness of stem (assume H/25)	a	0.3
Thickness of the base slab (assume H/20)	d	0.5

h= H-d 11.5
C = B-a-b 2.45

Stability of the wall
Moments about "O"

Sl No.	Force	Magnitude	Cg distance	MR
1	W1=h*b*Yr*S	1410.36	4.25	5994.03
2	W2=a*h*þ*S	345.00	2.60	897.00
3	w3 = B*d*þ*S	287.50	2.88	826.56
4	w4 = 0.5*c*(h-3)*e*þ	104.13	1.63	170.07
	Total	2146.99		7887.66

Overturning moment due to backfill
Mo = Kar X Yr / h^3 2929.5566

Factor of safety against over turnig
FS1 = 0.9 X MR/Mo 2.42

If FS1 ≥ 1.4 , safe
If FS1 < 1.4 , unsafe revise the section **safe**

Sliding force
P_H=0.5 X ka X Ys X h^2 191.05804

Resisting force
Pr = μ X (0.9*W1+W2+W3+W4) 275.82

Factor of safety against safety
Fs2 = Pr / Ph 1.44

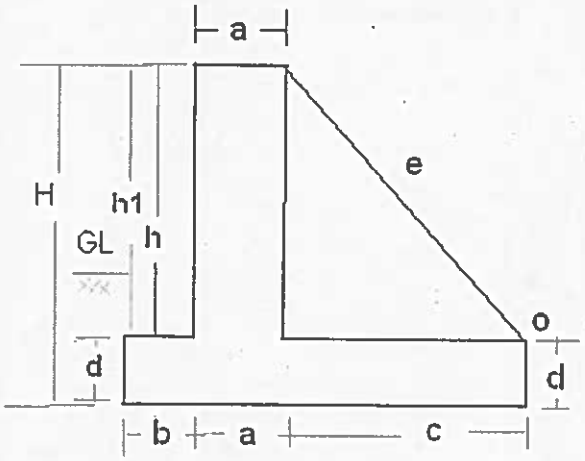
If FS2 ≥ 1.4 , safe

safe

If FS2 < 1.4 , provide shear key

Pressure from soil	
Net movement about "O" , M=MR-Mo	4958.1068
Horizontal distance at which resultant intercepts base	
X' = M/∑W	2.31
Eccentricity e1 =(B/2) - X'	0.57
If e1 = ≤ B/6 then safe or unsafe	safe
p1 = (∑W / B) * {1+(6 X e1/B)}	148.45
p2 = (∑W / B) * {1-(6 X e1/B)}	38.25
	Safe
Design of the shear key	
Presure @ the face of the shear key = pb	
pb = (p2)+((p1-p2)/B)*(a+b))	101.49
Co efficient of passive earth pressure = kp = 1/ka	3
Let " Y " is the projection of shear key	
Y = ((1.4 X Ph) - (0.9* μ * ∑W))/ (kp X pb)	0.006

3. *Design of Counter fort retaining wall – 13 M*



Values to be assumed

h1	height of the wall above ground level	13	
SBC	SBC of the soil	200	
Ø	Angle of the internal friction	0.52	Angle in radians
Ys	Desnsity of the soil	16	
μ	Co.eff of friciton	0.55	
þ	Density of concrete	25	
Yr	Density of the waste materials	10.22	
Ør	Angle of the internal friction for waste material	0.59	Angle in radians
S	Spacing of the counterforts c/c in m	4	
	1/S	0.25	

$$Ka = \frac{1-\sin Ø}{1+\sin Ø} = 0.33$$

$$Kar = \frac{1-\sin Ør}{1+\sin Ør} = 0.28$$

$$df = \frac{Ka^2 \times SBC}{Ys} =$$

Provide df_{min} = 1.5 m for h1 < 10m — df_{min} 1.5

Provide df_{min} = 2 m for h1 > 10m — df_{min} 2

df_{min} 2

H= h1 + df 15

Dimension of the wall

Base width (Assume 0.5 H to 0.6 H)	B	7.25
Toe projection (Assume 0.4 B)	b	3.3
Thickness of counter fort Assume 0.03H to 0.06H)	e	0.5
Thickness of stem (assume H/25)	a	0.5
Thickness of the base slab (assume H/20)	d	0.65

h= H-d	14.35
C = B-a-b	3.45

Stability of the wall

Moments about "O"

Sl No.	Force	Magnitude	Cg distance	MR
1	W1=h*b*Yr*S	1935.87	5.60	10840.89
2	W2=a*h*ᵽ*S	717.50	3.70	2654.75
3	w3 = B*d*ᵽ*S	471.25	3.63	1708.28
4	w4 = 0.5*c*(h-3)*e*ᵽ	244.73	2.30	562.89
	Total	3369.36		15766.81

Overturning moment due to backfill

Mo = Kar X Yr / h^3 5691.9892

Factor of safety against over turnig

FS1 = 0.9 X MR/Mo 2.49

If FS1 ≥ 1.4 , safe **safe**

If FS1 < 1.4 , unsafe revise the section

Sliding force

P_H=0.5 X ka X Ys X h^2 297.49073

Resisting force

Pr = μ X (0.9*W1+W2+W3+W4) 436.67

Factor of safety against safety

Fs2 = Pr / Ph 1.47

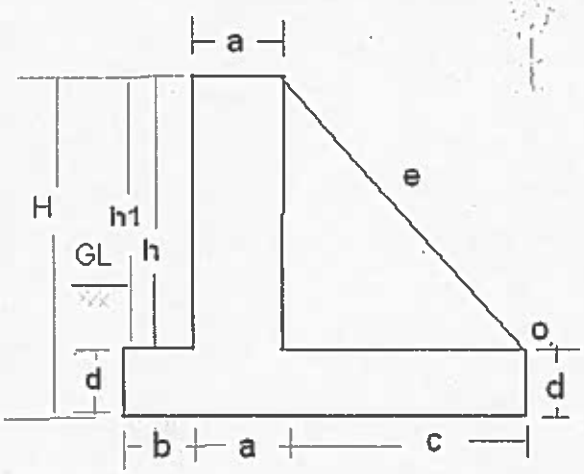
If FS2 ≥ 1.4 , safe

safe

If FS2 < 1.4 , provide shear key

Pressure from soil	
Net movement about "O" , M=MR-Mo	10074.817
Horizontal distance at which resultant intercepts base	
X' = M/∑W	2.99
Eccentricity e1 =(B/2) - X'	0.63
If e1 = ≤ B/6 then safe or unsafe	safe
p1 = (∑W / B) * {1+(6 X e1/B)}	177.23
p2 = (∑W / B) * {1-(6 X e1/B)}	55.14
	Safe
Design of the shear key	
Presure @ the face of the shear key = pb	
pb = (p2)+((p1-p2)/B)*(a+b))	119.13
Co efficient of passive earth pressure = kp = 1/ka	3
Let " Y " is the projection of shear key	
Y = ((1.4 X Ph) - (0.9* μ * ∑W))/ (kp X pb)	-0.001

4. *Design of Counter fort retaining wall -16 M*



Values to be assumed

h1	height of the wall above ground level	16	
SBC	SBC of the soil	200	
Ø	Angle of the internal friction	0.5236	Angle in radians
Ys	Desnsity of the soil	16	
μ	Co.eff of friciton	0.55	
þ	Density of concrete	25	
Yr	Density of the waste materials	10.22	
Ør	Angle of the internal friction for waste material	0.59	Angle in radians
S	Spacing of the counterforts c/c in m	4	
	1/S	0.25	

$$Ka = \frac{1-\sin Ø}{1+\sin Ø} = 0.33$$

$$Kar = \frac{1-\sin Ør}{1+\sin Ør} = 0.28$$

$$df = \frac{Ka^2 \times SBC}{Ys} =$$

Provide df_{min} = 1.5 m for h1 < 10m — df_{min} 1.5

Provide df_{min} = 2 m for h1 > 10m — df_{min} 2

df_{min} 2

H= h1 + df 18

Dimension of the wall

Base width (Assume 0.5 H to 0.6 H)	B	9.5
Toe projection (Assume 0.4 B)	b	3.8
Thickness of counter fort Assume 0.03H to 0.06H)	e	0.6
Thickness of stem (assume H/25)	a	0.5
Thickness of the base slab (assume H/20)	d	0.8

h= H-d 17.2
C = B-a-b 5.2

Stability of the wall
Moments about "O"

Sl No.	Force	Magnitude	Cg distance	MR
1	W1=h*b*Yr*S	2671.92	7.60	20306.57
2	W2=a*h*P*S	860.00	5.45	4687.00
3	w3 = B*d*P*S	760.00	4.75	3610.00
4	w4 = 0.5*c*(h-3)*e*P	553.80	3.47	1919.84
	Total	4845.72		30523.41

Overturning moment due to backfill
Mo = Kar X Yr / h^3 9801.5262

Factor of safety against over turnig
FS1 = 0.9 X MR/Mo 2.80

If FS1 ≥ 1.4 , safe
If FS1 < 1.4 , unsafe revise the section safe

Sliding force
P_H=0.5 X ka X Ys X h^2 427.39213

Resisting force
Pr = μ X (0.9*W1+W2+W3+W4) 629.55

Factor of safety against safety
Fs2 = Pr / Ph 1.47

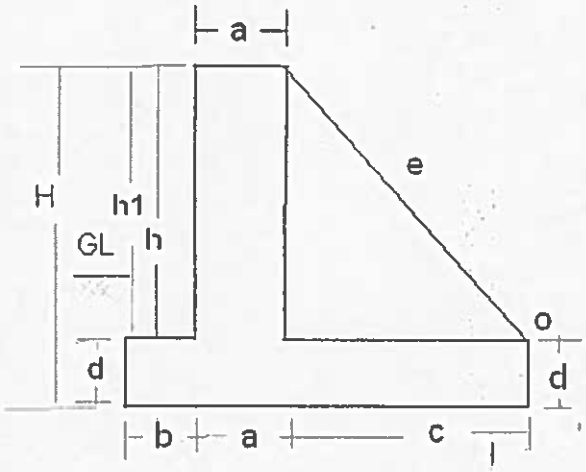
If FS2 ≥ 1.4 , safe

safe

If FS2 < 1.4 , provide shear key

Pressure from soil	
Net movement about "O" , M=MR-Mo	20721.881
Horizontal distance at which resultant intercepts base	
X' = M/∑W	4.28
Eccentricity e1 =(B/2) - X'	0.47
If e1 = ≤ B/6 then safe or unsafe	safe
p1 = (∑W / B) * {1+(6 X e1/B)}	165.67
p2 = (∑W / B) * {1-(6 X e1/B)}	89.37
	Safe
Design of the shear key	
Presure @ the face of the shear key = pb	
pb = (p2)+((p1-p2)/B)*(a+b))	123.90
Co efficient of passive earth pressure = kp = 1/ka	3.0000085
Let " Y " is the projection of shear key	
Y = ((1.4 X Ph) - (0.9* μ * ∑W))/ (kp X pb)	-0.004

5. *Design of Counter fort retaining wall – 19 M*



Values to be assumed

h1	height of the wall above ground level	19	
SBC	SBC of the soil	200	
Ø	Angle of the internal friction	0.52	Angle in radians
Ys	Desnsity of the soil	16	
μ	Co.eff of friciton	0.55	
Þ	Density of concrete	25	
Yr	Density of the waste materials	10.22	
Ør	Angle of the internal friction for waste material	0.59	Angle in radians
S	Spacing of the counterforts c/c in m	4	
	1/S	0.25	

$$Ka = \frac{1-\sin Ø}{1+\sin Ø} = 0.33$$

$$Kar = \frac{1-\sin Ør}{1+\sin Ør} = 0.28$$

$$df = \frac{Ka^2 \times SBC}{Ys} =$$

Provide df_{min} = 1.5 m for h1 < 10m — df_{min} 1.5

Provide df_{min} = 2 m for h1 > 10m — df_{min} 2

df_{min} 2

H= h1 + df 21

Dimension of the wall

Base width (Assume 0.5 H to 0.6 H)	B	11.75
Toe projection (Assume 0.4 B)	b	5
Thickness of counter fort Assume 0.03H to 0.06H)	e	0.6
Thickness of stem (assume H/25)	a	0.5
Thickness of the base slab (assume H/20)	d	0.8

h= H-d 20.2
C = B-a-b 6.25

Stability of the wall
Moments about "O"

Sl No.	Force	Magnitude	Cg distance	MR
1	W1=h*b*Yr*S	4128.88	9.25	38192.14
2	W2=a*h*Þ*S	1010.00	6.50	6565.00
3	w3 = B*d*Þ*S	940.00	5.88	5522.50
4	w4 = 0.5*c*(h-3)*e*Þ	806.25	4.17	3359.38
	Total	6885.13		53639.02

Overturning moment due to backfill
Mo = Kar X Yr / h^3 15876.782

Factor of safety against over turnig
FS1 = 0.9 X MR/Mo 3.04

If FS1 ≥ 1.4 , safe **safe**
If FS1 < 1.4 , unsafe revise the section

Sliding force
P_H=0.5 X ka X Ys X h^2 589.48447

Resisting force
Pr = μ X (0.9*W1+W2+W3+W4) 889.93

Factor of safety against safety
Fs2 = Pr / Ph 1.51

If FS2 ≥ 1.4 , safe

safe

If FS2 < 1.4 , provide shear key

Pressure from soil	
Net movement about "O" , M=MR-Mo	37762.233
Horizontal distance at which resultant intercepts base	
X' = M/∑W	5.48
Eccentricity e1 =(B/2) - X'	0.39
If e1 = ≤ B/6 then safe or unsafe	safe
p1 = (∑W / B) * {1+(6 X e1/B)}	175.70
p2 = (∑W / B) * {1-(6 X e1/B)}	117.29
	Safe
Design of the shear key	
Presure @ the face of the shear key = pb	
pb = (p2)+((p1-p2)/B)*(a+b))	144.63
Co efficient of passive earth pressure = kp = 1/ka	3
Let " Y " is the projection of shear key	
Y = ((1.4 X Ph) - (0.9* μ * ∑W))/ (kp X pb)	-0.062

5.8.6 *Life of Landfill*

Based on above consideration the life of landfill is detailed below;

Table 5.5 : Life of Landfill

RL		Height	AREA		Average Area	Volume Available in Landfill	Waste Generation Volume		Life of Landfill
From	To	m	Bottom	Top		Cum	Cum	Year	Years
65.50	67.00	1.5		3111	1555.5	2333			
67.00	70.00	3.00	3111	5069	4090	12270			
70.00	73.00	3.00	5069	9068	7068.5	21206			
73.00	76.00	3.00	9068	11994	10531	31593			
Total		**10.5**				**67402**	**65000**	**2029**	**17**
76.00	79	3	11994	12300	12147	36441			
Total						**103843**	**100000**	**2035**	**23**

From the above, it is observed that the life of landfill is enhanced to 23 years and is sufficient upto 2035. The detailed calculation for waste generation and volume for various years are projected and presented in **Appendix 9.**

5.8.7 *Design life of existing facility*

The above designs are carried out for 19 m height but CPHEEO has limited the cost of construction by truncating the top 3 meter height. The development of the landfill site is expected to serve the requirement of about 17 years from the infrastructure developed for landfill through NERCCDIP. But the life may be further extended to additional 6 years by taking up the second phase of development by the UDHD/GMC to increase the height for 3 meter fill after completion of fill upto 76.00 RL. Further four years could be utilized based on the waste profile and also by creating additional infrastructures like road, ramp etc from other resources.

5.9 Design of Various works proposed for Landfill at Martam

5.9.1 *Up-gradation of the surface for new landfill*

Up gradating the present uneven waste landfill surface is proposed for the existing waste dump. The task includes preparation of subgrade by excavating earth, dressing and consolidating with 8/10 ton road roller including making good the undulations etc. in the existing landfill site (5069 sq.m. is identified) and forming the landform from the wastes at the landfill site as per plan from RL of 61.20 m to a height of up to a RL 63.80 m is proposed. Waste will be deposited in layers not exceeding 50 cm and compacted to attain a placed waste density of 0.8 tons/ cum. Over this landform a soil layer of 50 cms. is compacted and this RL 64.20 m would act as a bottom of Landfill. The plan and cross section of the same is presented in the drawing **(Dwg. no. NERCCDIP-SWM-GANGTOK-LF-FINCLOS-005).**

Alternatively the UDHD/GMC may explore the possibility of utilizing the existing dumped garbage for producing Compost by sieving the material in additional shift if required and thereby reduce the volume. The inert waste/residues left out after sieving mechanism may be staked for final closure and may be accommodated in the area of about 3181 sq.m identified on the hilly side wherein an excavation upto 4.2 m (3m effective volume and 1.2 m for liner system) was considered (Below RL 73.00). This activity would result in reducing the garbage and also increases the life. It was recommended to take initiatives to reduce the existing dumped/proposed volume by operating the compost plant.

5.9.2 *Design of Liner System*

According to the Municipal Solid Waste (Management & Handling) Rules, 2000 of MoEF, the base of landfill facility, to avoid contamination of ground water resources should be at least 2.0 m above the shallowest ground water table. The landfill is a sloping terrain and exposed surfaces with open ditches with various depths and ground water is not observed. However the RL of bottom of land fill is 65.8 m. which is about 3.2m above the ground and High Flood Level (HFL).