



**MINISTRY OF URBAN DEVELOPMENT**  
**GOVERNMENT OF INDIA**



**Guidance Note**

# Municipal Solid Waste Management on a Regional Basis





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on a Regional Basis**



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*Cover: Large capacity trucks transport waste from the transfer station to the Jones Cross Roads Landfill site, Delaware, USA. The active cell receives approximately 720 TPD of mixed municipal solid waste (FY08).*



# Abbreviations

<b>AUDA</b>	Ahmedabad Urban Development Authority
<b>AWQ</b>	Available Waste Quantity
<b>BISAG</b>	Bhaskararcharya Institute for Space Applications and Geo-informatics
<b>BNMC</b>	Bhiwandi Nizampur Municipal Corporation
<b>BOT</b>	Build Operate Transfer
<b>cm/sec</b>	centimetre/second
<b>CEO</b>	Chief Executive Officer
<b>CMA</b>	Commissionerate of Municipal Administration
<b>CMDA</b>	Chennai Metropolitan Development Area
<b>CPCB</b>	Central Pollution Control Board
<b>CWJSC</b>	Canterbury Waste Joint Standing Committee
<b>CWS</b>	Canterbury Waste Services Limited
<b>DMA</b>	Directorate of Municipal Administration
<b>DSWA</b>	Delaware Solid Waste Authority
<b>GIS</b>	geographic information system
<b>GL</b>	ground level
<b>GSM</b>	grams per square metre
<b>GUDC</b>	Gujarat Urban Development Company
<b>HDPE</b>	High-density polyethylene
<b>IIM</b>	Indian Institute of Management
<b>JNNURM</b>	Jawaharlal Nehru National Urban Renewal Mission
<b>JV</b>	joint venture
<b>KCDC</b>	Karnataka Compost Development Corporation
<b>km</b>	kilometre
<b>m</b>	metre
<b>m<sup>3</sup></b>	cubic metre
<b>mm</b>	millimetre
<b>MT</b>	metric tonne
<b>MBMC</b>	Mira Bhayandar Municipal Corporation
<b>MJP</b>	Maharashtra Jeevan Pradhikaran
<b>mld</b>	million litres per day
<b>MoU</b>	Memorandum of Understanding
<b>MSW</b>	Municipal Solid Waste
<b>NGO</b>	non-governmental organisation
<b>O&amp;M</b>	operation and maintenance
<b>PPP</b>	Public Private Partnership
<b>PSP</b>	private sector participation
<b>RFP</b>	Request for Proposal
<b>RSWM</b>	Regional Solid Waste Management
<b>SLB</b>	Service Level Benchmark
<b>SPV</b>	Special Purpose Vehicle
<b>TCL</b>	Trans-waste Canterbury Limited
<b>TMC</b>	Thane Municipal Corporation
<b>TPD</b>	tonnes per day
<b>ULB</b>	Urban Local Body
<b>USA</b>	United States of America







**Secretary**  
Ministry of Urban Development  
Nirman Bhawan  
New Delhi

## Foreword

The management of solid waste is integral to city sanitation. Over the last decade, larger cities, especially those with financial and managerial capacity, have attempted to improve waste management practices in response to the Municipal Solid Waste (MSW) Rules 2000. In this, the development of disposal infrastructure, i.e., sanitary landfills, has made the least progress due to factors ranging from land scarcity to lack of technical and financial capacity in cities. These challenges are further accentuated in smaller Urban Local Bodies (ULBs).

Recognising these challenges, the Government of India and key stakeholders have been deliberating upon mechanisms and arrangements to facilitate compliance with requirements for treatment and safe disposal of solid waste. In this context, regional arrangements for waste management—whereby a single, relatively large site is developed to serve the waste disposal requirements of a group of ULBs—provide a way forward for pooling of resources to address some of the challenges in MSW management. Regional facilities may incorporate treatment as well as disposal facilities, and generate sufficient scale to enhance technical and financial efficiencies. Furthermore, they facilitate the monitoring of environmental outcomes and performance due to a reduced number of sites. The approach enables smaller ULBs to achieve compliance with minimal financial burden.

Due to the multi-ULB nature of such arrangements, however, state governments are required to play a lead role in planning and initiating a regional approach. At the same time, MSW management is a core and statutory function of ULBs, which remain responsible for service delivery. In this respect, entities entrusted with developing and operating regional facilities will need to remain directly accountable to the ULBs.

The objective of this Guidance Note is to identify and address issues in the implementation of regional arrangements for delivery of MSW management services. While some of these are common to all MSW management initiatives, there are specific issues that need to be addressed in the context of regional arrangements. By focusing on these, it is hoped to facilitate the establishment of regional initiatives to enhance compliance with the MSW Rules 2000.

**Navin Kumar**  
(Secretary)





**Joint Secretary**  
Ministry of Urban Development  
Nirman Bhawan  
New Delhi

## Preface

Solid waste management is one of the most significant functions carried out by ULBs. However, the scarcity of suitable landfill sites is one of the constraints increasingly being faced by ULBs in the discharge of their functions. As a result, even several years after the issuance of the MSW Rules 2000, the state of MSW management systems in the country continues to raise serious public health concerns.

Regional or inter-municipal solutions provide a viable option to redress this situation. Working together can be a practical and cost-effective way to discharge common tasks, share resources, and take advantage of the economies of scale that such arrangements would provide. This is applicable in the case of both large municipal bodies which experience scarcity of land resources, as well as smaller ones which may find technical and financial resources a challenge.

Therefore, in public interest and with the aim of improving standards of public health and sanitation in the states, the Government of India has developed this Guidance Note on regional solid waste management to facilitate the creation of appropriate strategies by the states and ULBs. This note is the result of work done over a period of about 18 months, and aims to support decision making towards the implementation of regional arrangements for safe treatment and disposal of MSW.

Regional approaches to MSW management are common in several countries, and have recently gained momentum in a few states in India. Studies undertaken attest to the importance of two factors in the successful implementation of regional initiatives: (a) an explicit policy, supporting the adoption of regional approaches; and (b) a robust institutional framework, underpinning development and implementation.

In this respect, it is intended that this Guidance Note may form the basis for states to formulate and notify state-level policy directives to recognise regional initiatives, strategies to encourage their adoption, and tools to facilitate implementation. The Note also includes a few case studies illustrating frameworks and implementation strategies adopted in other jurisdictions and sectors. Frameworks observed include legislation supporting municipalities to prioritise regional initiatives to effectively use available resources as well as options for:

- Creation of regional solid waste management authorities or entities empowered by law to undertake waste management activities over a region or state;
- Creation of solid waste management 'regions'; and
- Municipalities jointly constituting a company, or common authority, to implement a regional waste management project.

These can be facilitated by statutory mechanisms for municipalities to work together.

I would like to thank the various state governments and ULBs associated with this initiative; and recognise the inputs of the Water and Sanitation Program, which has partnered with the Ministry in developing this Note. I indeed hope that this Guidance Note will contribute towards a more effective realisation of the objectives of the MSW Rules 2000.

  
**A.K. Mehta**  
(Joint Secretary)



## 1

## Background and Need for the Guidance Note

- The responsibility for solid waste management lies with the respective Urban Local Bodies (ULBs), consisting of municipal corporations, municipalities, nagar panchayats, etc., (collectively referred to as the '**Authorities**'). The Municipal Solid Waste (Management and Handling) Rules, 2000 (the '**MSW Rules**'), issued by the Ministry of Environment and Forests, Government of India, under the Environment (Protection) Act, 1986, prescribe the manner in which the Authorities have to undertake collection, segregation, storage, transportation, processing and disposal of the municipal solid waste (the '**MSW**') generated within their jurisdiction under their respective governing legislation.
- Compliance with the MSW Rules requires that appropriate systems and infrastructure facilities be put in place to undertake scientific collection, management, processing and disposal of MSW. However, it has increasingly come to the attention of the national (and state) government that, individually, the Authorities are unable to implement and sustain separate and independent projects to enable scientific collection, management, processing and disposal of MSW. This is mainly due to lack of financial and technical expertise and scarcity of resources, such as land and manpower, with the Authorities, which makes it difficult for them to discharge their obligations individually in relation to scientific collection, management, and processing and disposal of MSW.
- The Government of India recognises that the existing state of MSW management systems in the country is also raising serious public health concerns and sanitation issues that need to be addressed in the public interest.
- Regional MSW projects/regional infrastructure facilities provide an economically viable, technically and environmentally efficient, and effective alternative for the Authorities to discharge their obligations to provide scientific collection, management, processing and disposal of MSW effectively (Annex 1).
- A '**Regional MSW Facility**' means a waste management facility or system of any kind (whether in relation to collection, transportation, treatment or disposal of MSW or a combination of any or all of them), which collects, manages or receives or disposes (as the case may be) MSW from more than one Authority.
- A '**Regional MSW Project**' means a project to either:
  - (a) develop and/or construct and/or operate, maintain and/or manage any type of new Regional MSW Facility; or
  - (b) convert and/or redevelop an existing MSW facility or system from being a facility used by a single Authority into a Regional MSW Facility. A Regional MSW Project can cover, within its scope, any existing MSW management facilities or systems within the jurisdiction of an Authority.
- Thus Regional MSW Facilities or Regional MSW Projects would help the Authorities to share technical expertise, costs of development and management of infrastructure and scarce natural resources, such as land, and consequently help in provision of scientific collection, management, processing and disposal of MSW in an efficient manner within respective states (Annex 1).
- Nothing in this Regional Solid Waste Management Guidance Note ('**RSWM Guidance Note**') shall be taken to be in conflict with any existing law or legislation.

## 2

## Objective of RSWM Guidance Note

The main objective of this RSWM Guidance Note is to propose an enabling policy framework that would provide guidance and direction in planning, development, implementation and management of such Regional MSW Projects in the country. It is expected that Regional MSW Projects will enable:

- Authorities to aggregate the waste quantities generated across their respective jurisdictions to take advantage of economies of scale in transportation, processing and disposal of MSW;
- Reduce the financial and technical burden on each individual Authority and help the Authorities discharge their obligation for MSW management in a cost-effective manner with better technologies;
- Result in more efficient use of land and other scarce natural resources within the region; and
- Enable better management and easier monitoring, with an optimal number of MSW management projects.



*The first attempt at developing a regional facility in India was by Ahmedabad Urban Development Authority (AUDA), in 2007, to address the SWM requirements of 11 towns in its (then) jurisdiction. Located at Village Fatehwadi, the facility integrated composting facilities for approximately 150 TPD; and the first cell of a scientific landfill site of 50 TPD capacity. The overall strategy included the development of three transfer stations.*

## 3

## Implementation Through Private Participation

- The Government of India recognises the magnitude, scope and nature of: (i) investment; (ii) technical expertise; and (iii) resources required for a viable Regional MSW Project. Most Authorities face shortages of technical and managerial staff and systems. A regional project will enable the Authorities to discharge their statutory municipal waste management functions in a scientific and viable manner in accordance with applicable laws. A regional project can be implemented either through: (a) a government body/utility that may be specifically incorporated for implementing such regional projects in the state (which may thereafter implement through its own staff, or contract out activities); or (b) through a Public Private Partnership (PPP) structure, wherein a concession is granted by the land-owning entity (state or lead ULB).
- A robust PPP framework will be based on the following principles:
  - Provide for a framework that permits private investment and debt financing of Regional MSW Projects;
  - Provide a legal framework for the enforcement of contractual obligations between municipalities, on the one hand, and municipalities and private entities, on the other;
  - Provide a framework for grant of contracts that is clear, transparent and stable to encourage



*Transfer station, Rajkot city, Gujarat, India. Small vehicles climb a ramp to empty waste into larger vehicles stationed at a lower level. Transfer stations enable costs of transportation over longer distances to be optimised.*

- greater private participation and fair sharing of risks between private participants and municipalities; and
- Permit creation of special funds/escrow accounts to enable securing of payment obligations of municipalities to the private developers.
- Furthermore, it is proposed to harmonise the existing institutional structures and evolving legislations to create a robust and transparent framework for the implementation of Regional MSW Projects in the country.

## 4

## Scope of the Guidance Note

- This RSWM Guidance Note is intended to facilitate collection, transportation, processing and scientific disposal of MSW generated in the state in a cohesive and comprehensive manner.
- This RSWM Guidance Note may be applicable to all Authorities. Any particular Authority that is able to develop and implement MSW management projects within its jurisdiction on its own may allow access to the MSW treatment and/or disposal facilities, under its jurisdiction, to any other Authority that may request such access in relation to a Regional MSW Project. This RSWM Guidance Note may be used as reference to arrive at an agreement on sharing of costs of development of the relevant infrastructure, and charges applicable for enabling such access between two Authorities.
- The Government of India further recognises that any enabling framework for Regional MSW Projects will have to provide the flexibility to the municipalities to: (i) decide whether to participate in the development and implementation of Regional MSW Projects; and (ii) choose the scope of a Regional MSW Project that can cover any one or a combination of various risk-sharing and mitigation mechanisms to provide a stable framework for private participation. Any one or a combination of the following activities should be taken into account while developing the implementation structure of the Regional MSW Projects:
  - Collection of MSW;
  - Transportation of MSW;
  - Segregation and treatment of MSW;
  - Disposal of MSW; and
  - Any other aspect related to MSW management.
- This Guidance Note may form the basis for states to formulate and notify state-level policy directives on regional waste management. Suitable provisions may also be made under the Municipal Acts in the states for the purpose.
- Under this RSWM Guidance Note, the Government of India also encourages state governments to develop: (i) a state regional solid waste management strategy and plan for identified regions and areas; and (ii) a regional solid waste management guidebook that may provide a detailed step-wise framework to enable private sector participation (PSP) in regional solid waste management. Such a regional solid waste management guidebook can provide an enabling framework for Authorities to cooperate with each other in discharge of their functions.



## 5

## Land for Regional MSW Projects

- Land for Regional MSW Projects shall be identified based on the following criteria:
  - The location should enable optimum number of Authorities to have viable access to the facility developed thereon. In order to determine this, geographic information system (GIS) mapping of regions may be undertaken to identify all suitable lands, in accordance with the criteria and guidelines issued by the Central Pollution Control Board (CPCB) for the location of MSW treatment and disposal facilities. The most viable clusters of ULBs for potential sites for Regional MSW Facilities can then be identified;
  - The area of land being provided should be technically sufficient to enable the type of Regional MSW Facility intended to be developed on the land using the technology that is intended to be used for it;
  - Land that is already within the possession of either the state government or any Authority may be preferred over lands that may require acquisition of private land or from any other entity;
  - Only in the event that no other land is feasible in the light of the above criteria, acquisition of privately owned land may be undertaken. In all cases, requisite environmental clearances should be obtained and stakeholder consultations be held to inform the local community, and address their concerns regarding the proposed Regional SWM Project;
  - Land identified for development/implementation of a Regional MSW Project shall be notified as having been allocated/reserved for the purposes of a Regional MSW Project only. All necessary government notifications, municipal council



*Aerial view of four landfill cells in Jones Cross Roads Site, developed and managed by Delaware Solid Waste Authority (DWSA). The exposed geo-membrane cap (EGC) (greenish in appearance) covers Cells 1 and 2. Cell 3 in the foreground is capped under USEPA rules. Cell 4 is in the right foreground and it is the operating cell. The engineering design for Cell 5 is almost complete. The entire regional landfill site occupies an area of 232 Ha.*

resolutions, government orders, etc., that are needed to ensure that the land is so reserved and will be provided free of encumbrances shall be undertaken and handed over to the Authority at the earliest; and

- It is imperative that the state government undertake to control land use in and around the Regional MSW Facility (minimum 500 metre [m] buffer zone) in accordance with development controls to prevent encroachment or development of habitations, structures, etc.
- Land for a Regional MSW Project can be provided in the following manner:
  - By the state government;
  - By one of the Authorities participating in the Regional MSW Project;
  - Acquired by a particular Authority and allocated by passing appropriate resolutions, without any state government assistance;
  - Acquired by the state government and vested with a particular municipality or a group of municipalities; and
  - Provided by the private sector participant.

If the state government is providing the land, the title of the land shall remain with the state government and the project structure specified in para 9.1 shall be adopted for the implementation of the project.

- If a participating Authority or any other Authority provides the land for the Regional MSW Project, then even though the title of the land may remain with the relevant Authority, the relevant Authority

shall be required to pass such resolutions, orders or notifications, as may be required to ensure that the land has been allocated/reserved/demarcated for use only as a Regional MSW Facility, and not for any other purpose (even a MSW facility for the Authority), for the duration of the concession.

- In the event that a group of Authorities agree on the development of a Regional SWM Facility, state governments may proactively expedite the process through guidance and support to the process, particularly in those cases where the state government is providing land for the purpose.
- If the private participant is providing the land for the project, its title to the said land shall be duly verified from relevant records to ensure that the land can thereafter be used only for the purposes of the Regional MSW Facility/Project, for the duration of the concession. The participant shall remain liable for any environmental problem manifesting during a predetermined time period after the end of the concession period.
- Before the selection of any site for the development of a Regional SWM Facility, it should be ensured that the land use cannot be changed by the competent authority for the duration of the project. This could be needed to ensure bankability and viability of the project, and one of the ways to achieve this is that the terms on which the land is provided mandate its use for the Regional SWM Facility only, for the duration of the project. Therefore, any change in the usage of land whereby it is not used for a Regional MSW Project shall constitute a breach of the terms of the agreement between the developer and the Authorities. This would act as a mitigation factor for any risk that would otherwise result in a change in the nature of the Regional MSW Project itself.

## 6

## Solid Waste Quantity and Tipping Fee

- Each of the Authorities participating in a Regional MSW Project shall undertake to provide a specific minimum quantity of MSW generated within its jurisdiction, to mitigate the risks associated with the operation of the Regional MSW Project. Each Authority will have the right to take a decision to either: (i) retain the primary waste collection activity as a separate activity that such an Authority undertakes independently of the Regional MSW Project and then delivers the MSW collected at identified points for disposal at the Regional Facility; or (ii) merge the primary waste collection activity into the Regional MSW Project and provide it as a mandated activity to be undertaken by the entity implementing the regional project.

It should be noted that it has generally been found that the benefit of economies of scale under regionalisation relate largely to the activities of treatment and disposal of solid wastes. The scope of participation in a regional arrangement is, however, a decision that each Authority would have to make after due consideration of its existing budgetary resources, capabilities, labour issues and the potential benefit, to service levels, of economies of scale that could be obtained.

Depending on the type of waste processing facility intended to be established, each Authority would also have to assure a certain quality of MSW that it supplies to the project.



*Weighbridge at the Jones Cross Roads Landfill site, Delaware, USA. Television cameras provide an image of each truck when it enters the weigh scale. Time of arrival and departure are also recorded.*

- The participating Authorities will all have to share costs of the Regional MSW Project based on their usage. A suitable tipping fee needs to be determined for each project and agreed to by all the participating Authorities. In the event of dispute regarding: (i) determination of the quantum of tipping fee; and/or (ii) payment of tipping fee, the dispute resolution mechanism (such as officers and/or authority) notified by the state government may be resorted to. It should be noted that, generally, the tipping fee for Regional MSW Projects should be structured so as to enable viable implementation of the project in the light of facts and circumstances of each Authority and the location of the project
- In order to provide security for their ability to pay the tipping fee, each Authority participating in a Regional MSW Project may make appropriate arrangements such as: (a) impose and collect a fee from within its jurisdiction relating to the provision of MSW services being provided; and (b) create an escrow and charge structure with respect to the identified revenue streams to provide for security of payment of the tipping fee. If necessary, provisions may be made in the municipal bye-laws to enable this.
- Since MSW functions are a statutory obligation, events of default in payment need to be dealt with in a robust manner. State governments, in order to ensure continuation of basic services to the people, may resort to an intercept mechanism, whereby the state government may provide the required payments directly into the relevant project accounts, for and on behalf of the Authority. Under the proposed structure, the participating Authorities will contractually agree to the state intercept mechanism as a means of providing bankability to the project to facilitate financial closure of the relevant project. This may be executed through a tripartite agreement between the state government, participating Authorities and the developer. The utilisation of revenue (in exercise of a state government payment being undertaken) would only be in the nature of using funds earmarked for the ULB towards enabling the ULB to discharge its statutory function of providing MSW waste management and disposal services.
- Consequently, in such circumstances, the state government may then proceed to set off an equal amount from any fund/grant or other payments made by the state government to the relevant Authority.

## 7

## Inter-ULB Agreements

- An Authority participating in a Regional MSW Project should not terminate its participation in such a project (including the Inter-ULB Agreement) except in accordance with the Inter-ULB Agreement and related documents that it enters into in relation to the Regional MSW Project; and after making payment of any due compensation that may be required to be paid by such an Authority in that regard.
- Furthermore, irrespective of the terms of the Inter-ULB Agreement, no Authority should validly terminate its participation in a Regional MSW Project with respect to which it has entered into an Inter-ULB Agreement, without the prior written approval of the state government. In order to obtain approval from the state government, the relevant Authority will have to submit the reasons, in writing, for such a termination including: (i) the cost benefit of such a termination; and (ii) the alternative method that the Authority is proposing to use to provide the services being provided by the regional project.
- The state government, on receiving such an application, should notify: (i) all the other Authorities that are participating in the Regional MSW Project; (ii) any entity that may be undertaking the development/implementation/operation and management of the said Regional MSW Project; and (iii) any lenders that may have financed the Regional MSW Project. Such a notification shall seek submission of arguments or reasons or objections that they may have in this regard to such a termination. The state government has to take into consideration the replies submitted in response to such notices.
- The state government may provide its approval/consent to the Authority seeking exit from the Regional MSW Project only if the following conditions are fulfilled: (i) the Authority is able to provide reasonable grounds that the exit would not result in an event of default under the various project and financing documents relating to the Regional MSW Project; (ii) the Authority is willing and able to provide compensation that may be required in accordance with the terms of the Inter-ULB Agreement or any other document in relation to the Regional MSW Project; and (iii) the Authority is able to provide, to the satisfaction of the state government, an alternative cost-efficient project for provision of services related to MSW being discontinued through the regional facility.



*Large compactor trucks significantly reduce costs of transportation of waste over longer distances.*

## 8

## Collection and Transportation of MSW

- In order to ensure the continued viability of the operation and maintenance (O&M) of Regional MSW Projects, it would be important for the collection and transportation of MSW that is undertaken within the jurisdiction of each of the participating Authorities to be made more efficient; and for door-to-door collection of MSW to be made available in all wards, to all homes and establishments over a period of time. To ensure financial viability of MSW management services, the participating Authorities should introduce a user charge for door-to-door collection of MSW (and segregation into biodegradable and non-biodegradable portions) within their jurisdiction.
- The Authorities participating in a Regional MSW Project would undertake to augment the efficiency of their MSW collection and transportation systems in a phased, time-bound manner.



*An expanded leachate containment system using glass-lined steel tanks. Each tank has 330,000 gallon (about 1.3 mega litres) capacity. In the foreground are landfill gas headers, connected to landfill gas wells, in a closed landfill cell. Jones Cross Roads Landfill Site, Delaware, USA.*

## 9

## Structures that May Be Adopted for a Regional MSW Project

The following are the structures that may be adopted for Regional MSW Projects (among others):

### 9.1 State Government Concession Agreement

**Structure:** This structure shall be applicable only to projects where the land for the Regional MSW Project is being provided by the state government and is vested with the state government.

- In this structure, the state government shall:
  - (a) manage the bid process for the selection of the private participant and enter into a concession agreement for the development of the Regional MSW Facility on its land; or
  - (b) mandate a specific government body or utility to undertake the

development and construction of the Regional MSW Facility (refer to Section 10). The utility may undertake implementation through its own technical staff, and can be vested with the authority/right to sub-contract various activities relating to the construction and operation of the Regional MSW Facility.

If a private participant is granted a concession to implement the project, then the said concession agreement will also be executed by the Authorities that have been initially identified for participating in the Regional MSW Project. Any Authority that seeks access to the Regional MSW Facility at a later point of time may enter into a deed of adherence<sup>1</sup>



*Compactor truck carrying waste to the landfill site, Navi Mumbai, Maharashtra, India.*

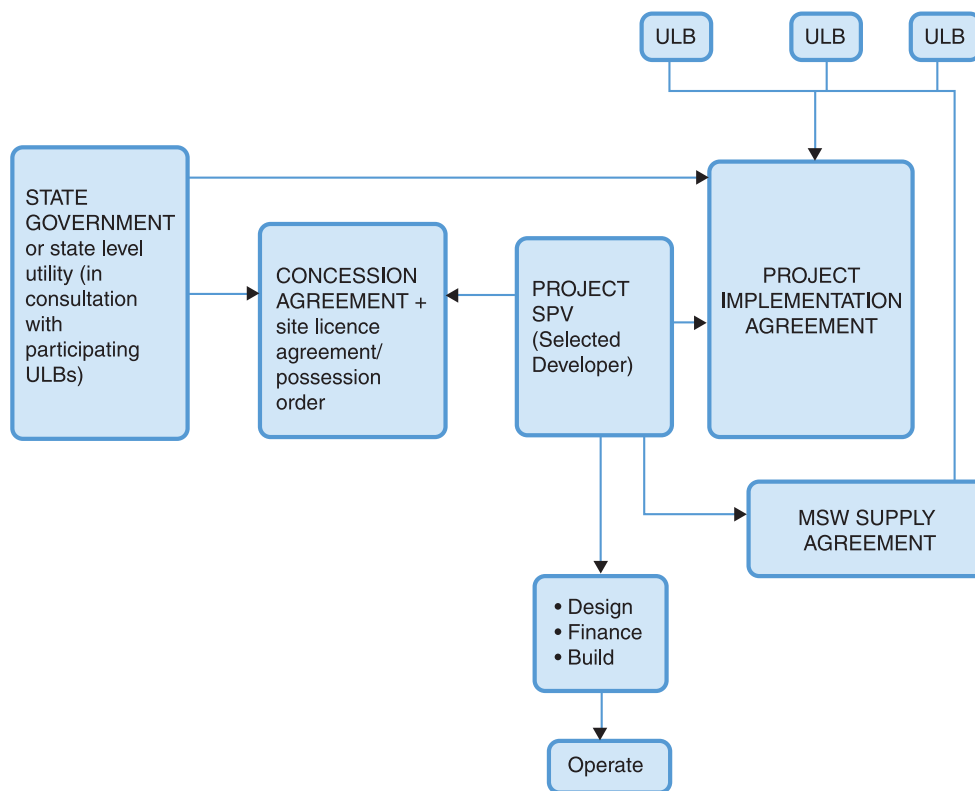
<sup>1</sup> A deed of adherence is a legal agreement, by which a person, who was not originally a party to a contract/agreement, undertakes, by a binding agreement, to abide by the terms and conditions of the relevant contract/agreement as if he were an original party to it.



in relation to the said concession agreement. Each Authority shall enter into a MSW supply agreement with the concessionaire/private party, stipulating that they agree to: (i) supply a minimum quantity of MSW to the regional facility; and (ii) undertake to pay the tipping fee in accordance with the agreement. The standard MSW supply agreement will be drafted by the state government/utility, in consultation with the Authorities; and be part of the Request for Proposal (RFP) documents issued for selecting the concessionaire/private

party. The state government/utility will also enter into a land lease agreement with the concessionaire/private party that shall be co-terminus with the concession agreement and ensure that the land can be used only for the purposes of development, and O&M of the Regional MSW Facility, for the duration of the concession. The private participant will remain liable for any environmental problem for an agreed period after the end of the concession period. Figure 1 provides a diagrammatic representation of this type of structure.

**Figure 1** State Government Concession Agreement Structure



*Note:* As indicated in the Figure, the state government enters into two separate agreements: a) the Project Implementation Agreement which is a tripartite agreement between the state government, the participating ULBs and the Project Special Purpose Vehicle (SPV); and b) the Concession Agreement and the Lease Agreement. Additionally, the participating ULBs enter into the MSW Supply Agreement with the Project SPV.





*Dumped waste being sorted at Cell No. 3, scientific landfill site, Navi Mumbai, Maharashtra, India.*

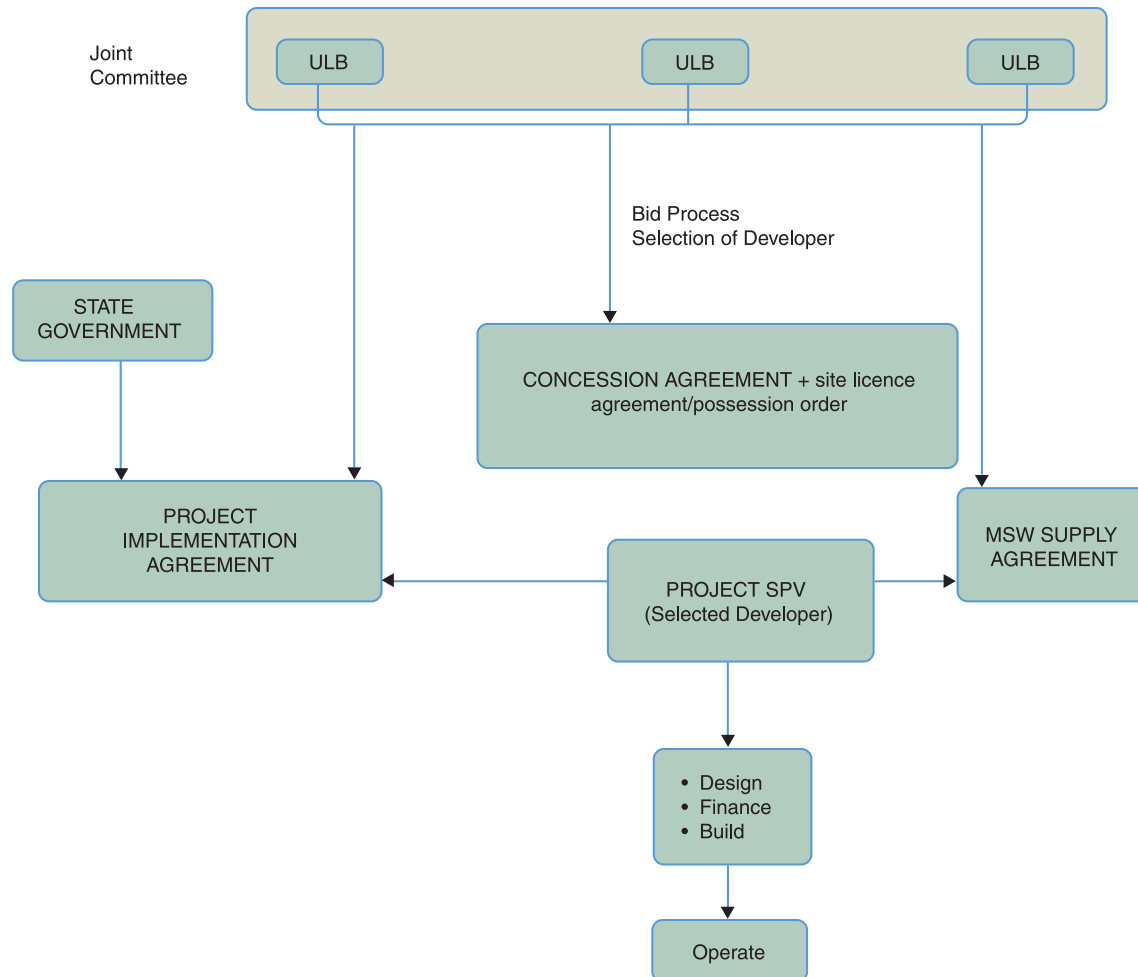
**9.2 Authority Concession Agreement Structure:** This structure shall be applicable only in projects where the land for the Regional MSW Facility is being provided by a particular Authority. The Authority providing the land for the Regional MSW Project/Facility should usually be the ‘Lead Authority’.

The state government should constitute a joint committee of the Authorities to undertake detailing and development of the project in a consultative manner. The joint committee may manage the bid process for the selection of a concessionaire/private party. It may draw upon the support of the state-level utility—if this is established—for this purpose (refer to section 10). The concession agreement will be entered into between the selected concessionaire and each of the participating Authorities. In such cases, the joint committee may also look at an appropriate compensation for the Authority providing the land.

The support of the state government would also be needed to ensure that all participating Authorities support the project on an on-going basis. In this respect, the state government could consider issuance

of relevant government orders/policy directives to the concerned Authorities to ensure participation and continued support to the implementation of the project.

Any Authority that seeks access to the Regional MSW Facility at a later point of time shall enter into a deed of adherence in relation to the concession agreement. Each Authority shall enter into a MSW supply agreement with the concessionaire under which it will agree to supply a minimum quantity of MSW to the Regional MSW Facility and also undertake to pay the agreed tipping fee accordingly. The Lead Authority will also enter into a land lease agreement with the concessionaire/private party that shall be co-terminus with the concession agreement and ensure that the land can be used only for the purposes of development, and O&M of the Regional MSW Facility. At the end of the concession period, the private participant will remain liable for any environmental problem for an agreed period after the end of the concession period. Figure 2 provides a diagrammatic representation of this type of structure.

**Figure 2** Authority Concession Agreement Structure


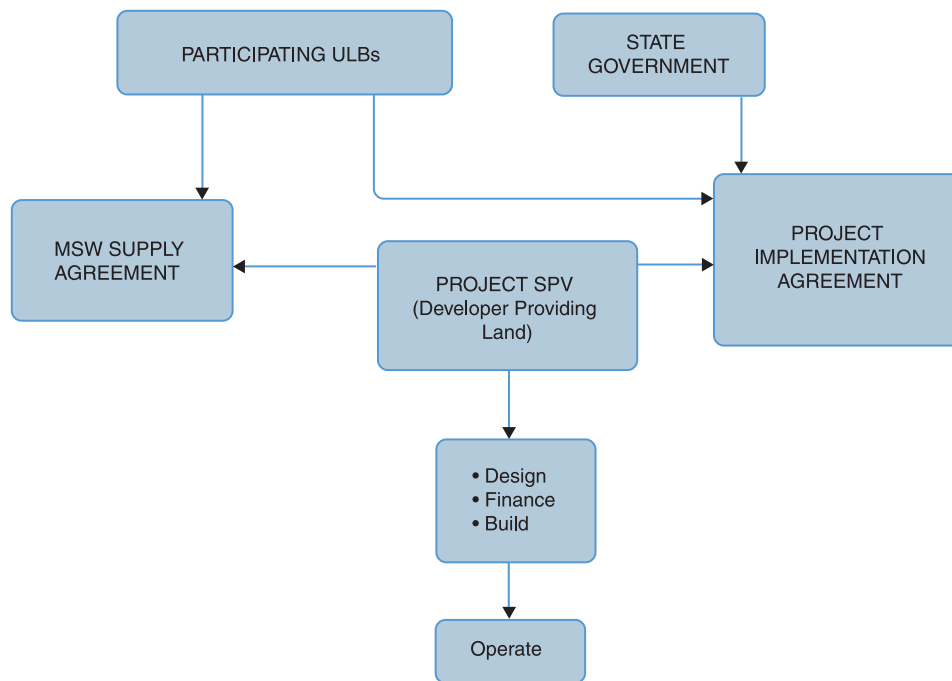
*Note:* As indicated in the above Figure, the ULBs constitute a joint committee to coordinate the various aspects of project implementation, including selection of the developer, who would constitute the Project SPV. Thereafter the ULBs enter into three separate agreements: (1) the Concession Agreement with the Project SPV; (2) the MSW Supply Agreement with the Project SPV; and (3) a Project Implementation Agreement with the state government and Project SPV. State support for the project is integrated into the Project Implementation Agreement.

### 9.3 Structure When Private Party Provides the Land

State governments can provide a framework under which Authorities may invite proposals for the development of Regional MSW Projects from private parties willing to provide land for the facility. Competitive bidding should be followed to enable a

transparent framework for award of such private proposal-based projects. Prior to the bid process, the agreement of all ULBs concerned, for participation in the proposed project, should be obtained. The state government or state-level utility should play a facilitative role in this respect. Figure 3 provides a diagrammatic representation of this type of structure.

**Figure 3** Structure When Private Party Provides the Land



*Note:* As indicated in the above Figure, where the private party is providing the land for the project, the participating ULBs will enter into a MSW Supply Agreement with the Project SPV and, if required, only in order to cover aspects of the project that are not otherwise covered under the MSW Supply Agreement (such as support from state government for the intercept mechanism), a Project Implementation Agreement may be entered into.

## 10

## Implementation of State Regional Waste Management Solutions

- For the implementation of the Regional MSW Projects, state governments may incorporate a public limited company or state-level utility (which may be called the State MSW Management Company Limited/Utility—the ‘Company/Utility’) for the purposes of identifying and enabling the development of Regional MSW Projects within the state. The Company/Utility may create a body of expertise in the development, implementation and financing of Regional MSW Projects for the benefit of the state. The Utility may be backed by appropriate legislation.
- The Company/Utility would have to be supported by the state government through issuance of adequate administrative instructions/directions/policies. The state government may facilitate the process where Authorities are unable to provide for adequate services in a consultative manner.
- In order to ensure a balanced framework for the implementation of a Regional MSW Project through such a Company/Utility, a framework should be established whereby a Project Coordination Committee for each project is constituted which comprises representatives of each participating Authority and the Company/Utility; and important project decisions during the project development, implementation and operational stages are taken through this committee.
- In the event that the Regional MSW Project is implemented through the PPP route, the Board of the Project Company (SPV) so constituted with a private sector participant, will have

nominees of the participating Authorities, state government as well as the Company/Utility. The Project Coordination Committee, overseeing project implementation, would also have a nominee of the selected private sector participant.

### Functions of the Company/Utility

The Company/Utility shall have the mandate to identify and develop Regional MSW Projects in the state. This Company/Utility would help ensure, among other things:

- Conceptualisation and identification of projects;
- Identification of potential land/sites for Regional MSW Projects in the state;
- Identification of potential clusters of Authorities that can participate in a particular Regional MSW Project;
- Preparation of project feasibility reports and detailed project reports for the intended Regional MSW Projects. In so doing, the Utility must ensure: (a) financial sustainability of the proposed project; (b) compliance with MSW Rules 2000; (c) achievement of Service Level Benchmarks (SLBs); (d) appropriate management of leachate generated in any operation or activity; (e) adequate arrangements for O&M during the entire life cycle of the project; (f) effective mechanisms for addressing events of default arising from any party; and (g) adequate arrangements for the management of the MSW site after termination of the project;



*Waste that is land-dumped (and often set on fire) has an adverse impact on air and ground water quality.*

- Preparation and management of the bid process for the selection of the private party for Regional MSW Projects, and execution of agreements;
  - Effective review and monitoring at the stage of implementation of the Regional MSW Project;
  - Assistance to the Authorities for capacity building support and training of municipal officials, and advice on activities for raising revenues, etc.;
- Formulation of strategies for the development of the Regional MSW Facilities/Projects in the state, and submission of proposals to the state government in this regard; and
  - Development of a team comprising both internal staff and external advisors to develop and implement Regional MSW Projects, consisting of technical, commercial, financial, legal, design, operational and other aspects.

In case the land for the regional facility is being provided by the state government, the Company/Utility may undertake detailed project development and selection of the project implementation partner.

In case the land for the regional facility is being provided by one of the Authorities, the Company/Utility may negotiate the participation of additional Authorities in the facility, and extend support for detailed project development and selection of the project implementation partner to the joint committee of the Authorities.

The state government may also take into account any independent authority with powers to regulate matters relating to Regional MSW Projects, including service levels, tariffs and technical standards.



*Capped landfill site at Navi Mumbai, Maharashtra, India. The site is now an open lung in the city.*



# Case Studies

## 1

## Regional Waste Management Authority— Delaware Solid Waste Authority (State of Delaware, USA)

In the United States of America (USA), ULBs are responsible for solid waste management activities. During the 1960s, compliance in the state of Delaware was low, and there were no specific state regulations for disposal of MSW. As a result, there were over a 100 open dumps where solid waste was disposed.

In 1970, leachate from a closed dump polluted a major groundwater aquifer, jeopardising drinking water supply to a significant number of residents. The state held the three counties (districts) and 52 local governments responsible for cleaning up the mess. Consequently, elected representatives realised that they had to control the disposal of solid wastes. Although new state laws and regulations were enacted in 1973-74 to upgrade solid waste disposal practices, the State Governor realised that local governments were hard-pressed to provide adequate services at reasonable costs, and without further environmental damage and loss of useful resources.

He, with the full consent of the political leadership of both parties in the state, thus created the Delaware Solid Waste Authority (DSWA), an independent agency to manage the state's SWM programme, without monetary support from the federal, state or local governments. Established through an Act, and supported by a state-provided seed grant, DWSA became responsible for planning and implementation of a long range state-wide solid waste management programme. It was vested with appropriate authority to purchase land; engage in design, construction and operation; and grant any licence for, or enter into any contract for the collection, or treatment and disposal of solid wastes. It was further empowered to borrow

money to finance its activities; collect user fees; and support innovation in pursuit of its mandate. DSWA is governed by a seven-member board of directors, drawn from each of the three counties in the state; and one from the largest city in the state.<sup>2</sup>

The state then pursued a programme for closure of all open dump sites, and effectively directed every local government, political sub-division and every department, agency or public body of the state to cooperate and participate in the regional system. Local governments were required to organise primary collection and transportation of solid wastes, and to provide all the waste collected at either a transfer station, or at the regional facility. The quantum of waste to be supplied was based on initial estimates. A database of incoming wastes is maintained at the facility, through a reliable weighing system, to improve upon these estimates.

Each participating ULB is bound by contract to promptly pay for each tonne of MSW disposed. The user fees are set with sufficient public notice, workshops and hearings, to allow ULBs sufficient time to adjust their budgets. Usually 18 months' notice is given for fee increases. The structure is transparent and auditable: the regional authority has to show (via audited balance sheets) how much money it receives in a fiscal year, what its debt obligations are, what its O&M costs are, how much reserve it should maintain, how much it needs for forward planning, etc.

The terms of payment, established in the contract documents, require guaranteed payment on a 30-day

<sup>2</sup> In Western Europe, the governing board of directors of certain regional agencies includes at least one director from each ULB included in the service area.





*Top: Aerial view of the entrance road to Jones Cross Roads Landfill Site, developed by DWSA. Two man-made lagoons were created to provide water storage for fire protection. Migrating birds find the lagoons attractive when they fly south and north. Above: Pine tree transfer station, Delaware, USA, developed and managed by DWSA. Occupying approximately 11 acres, the transfer station has a capacity of 11,000 tonnes per day.*

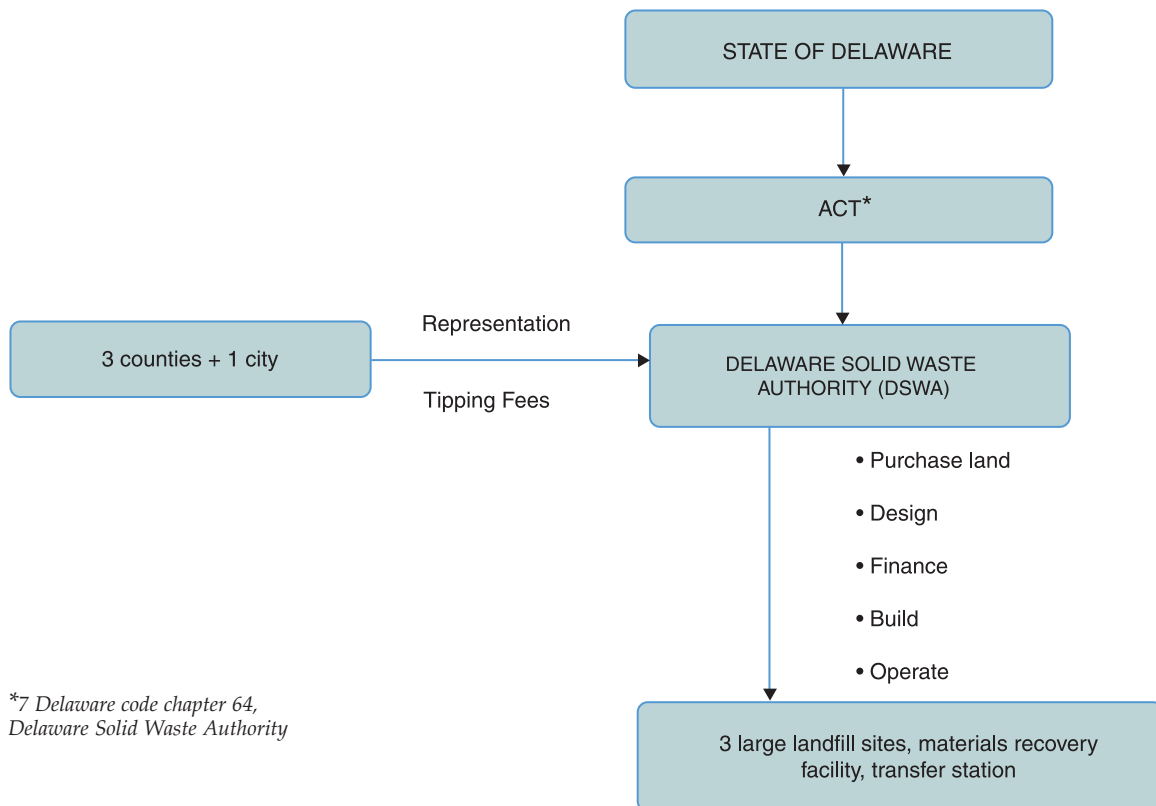
basis. If payments are not timely, the ULB has to pay commercial rates of interest as penalty. After a predetermined cut-off date, the ULBs' (or contractors') trucks are not allowed to dispose the MSW at the facility, and the state regulatory agency is notified. The state environmental agency then acts to enforce its regulations, and ensure that the ULB is adhering to safe disposal standards through the regional facility.

DSWA has so far developed three large landfill sites (sited on 200–300+ hectare) to meet the requirements of ULBs in the state as well as a materials' recycling centre and a transfer station. The Authority is responsible for O&M of all its facilities. It may contract with the private sector for design, construction and operation of the regional system. There could be more than one private sector firm providing services—one or more for transfer

services, one for land filling, one for treatment systems (composting, waste to energy, etc.). However, the Authority is held accountable for the performance of the system (and the activities of the private sector firms).

DWSA is not dependent on the state of Delaware for any financial support. All its systems and facilities are financed through commercial borrowings and the issuance of tax exempt municipal bonds. There is no faith and credit or moral obligation of the state of Delaware to support the bonds, thus forcing DSWA to rely on conservative budgeting and operations. The role of the state government has only been to establish the framework for "Regional Facilities", through specific and aptly tailored legislation to establish the regional agency through an act of law, and grant it appropriate powers to organise regional facilities.

**Figure 4** Management Structure of DWSA



## 2

## Regional Municipal Solid Waste Landfill Site (Canterbury, New Zealand)

Canterbury is New Zealand's largest region, with an approximate area of 42,200 kilometre (km). In 1995, while working on Waste Management Plans, Canterbury City and most of the District Councils found that the final cost per tonne for disposal was significantly higher than their original estimate. They found that the approach to develop individual landfills was not viable and that the regional approach had considerable merit.

The 10 Canterbury local authorities came together to form a Canterbury Waste Joint Standing Committee (CWJSC) to supervise the development of the regional landfill project to serve their waste disposal requirements. This was a long standing committee of each participating Council, with agreed terms of reference to establish and implement solid and hazardous waste strategies. The CWJSC members are elected councillors and each Council is bound by contract to ensure continuation of the CWJSC through the three-yearly election cycle.

When the regional landfill approach was being conceived, there was approximately 300,000 tonnes of solid waste for disposal being generated each year after recycling and other waste reduction activities, within the jurisdiction of the 10 local authorities involved in this venture (translating to an average of approximately 85 tonnes per day (TPD) in each local authority).

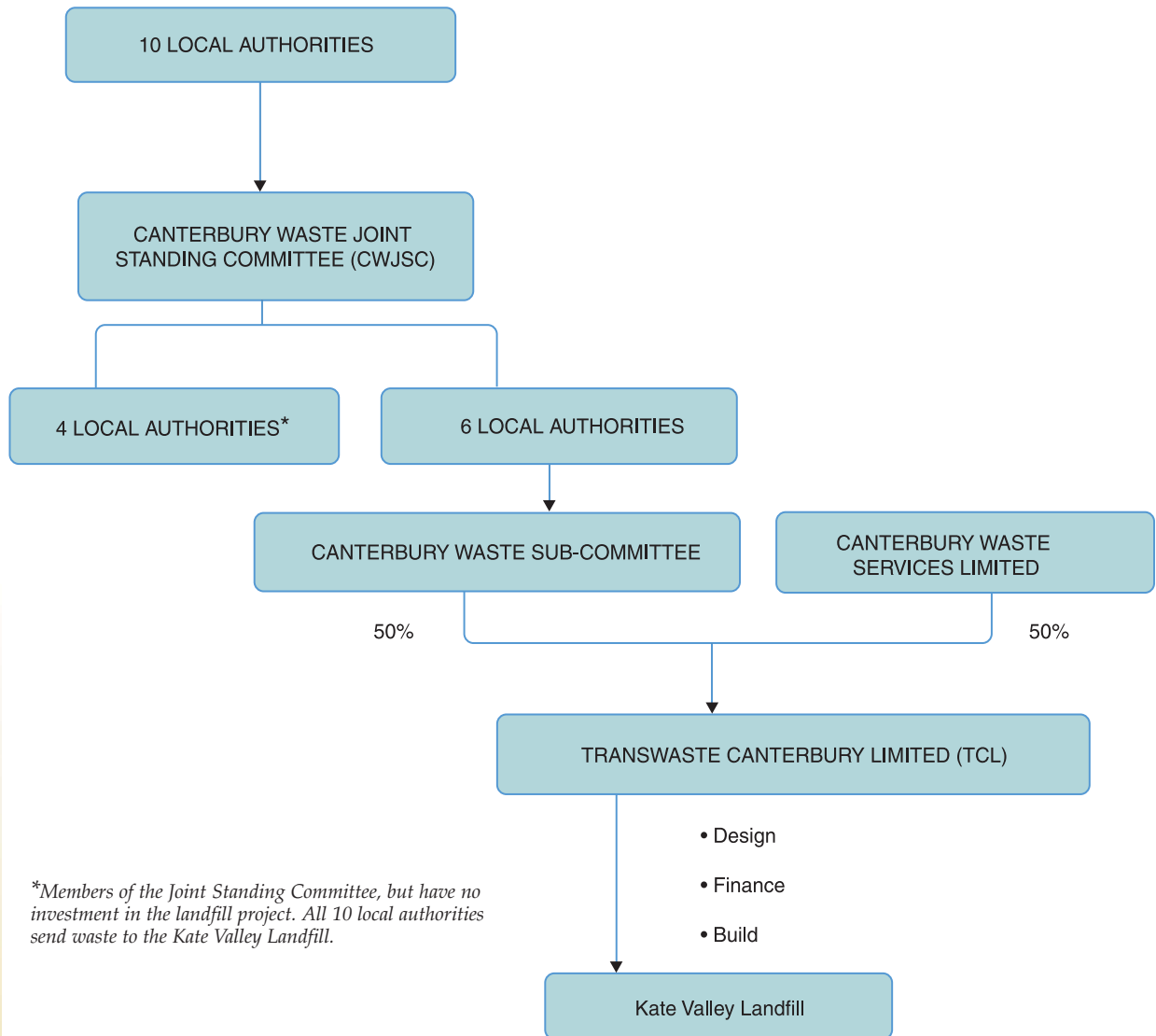
In 1997, the Committee undertook detailed investigations and consultations regarding the development of regional landfills. It also developed criteria for the selection of potential landfill sites. During these investigations, it also became clear that private companies, already actively involved in the collection, recycling and diversion of waste in the

region, were intending to enter the landfill market. Two of them had already secured potential landfill sites in the region. In 1998, six of the original 10 local authorities elected to develop waste management facilities at the regional level through a joint venture (JV) in partnership with the private sector. The partnership would enable the local authorities to benefit from:

- Expertise and experience of the waste companies;
- Potential access to their financial resources;
- Potential access to their landfill sites; and
- Realisation of objectives with the provision that no decision could be made without both the commercial partners and the participating Councils.

Subsequently, private waste management companies were invited through national advertisements to register their interest. After evaluation of the responses, Canterbury Waste Services Limited (CWS) was invited to participate in a JV with the Councils.

A Memorandum of Understanding (MoU) was signed between the six Councils and CWS, and a new JV named Trans-waste Canterbury Limited (TCL) was formulated. The JV has guaranteed adequate disposal capacity for participating authorities for a minimum period of 20 years, which is the term of the JV. Half of the shares in the company were owned by the Councils and the other half by the CWS. The shareholding of the Councils was based on the "proportion of the population as a surrogate of the waste volumes". All coordination

**Figure 5** Management Structure of Regional MSW Landfill Site, Canterbury


between the various Councils was carried out by the Committee, and, in fact, one of the Councils also delegated its shareholders function to the Committee.

The intention to operate TCL as a commercial venture was clear from the inception. One of the main goals as provided in the Mission statement is that the shareholders operate business with sufficient earning to support the companies' growth, while also returning a "fair rate of return".

TCL now owns the Kate Valley Landfill. A 'gate charge' is levied by TCL to ensure a fair rate of return; and in particular, the CWS, as a contractor to build and operate the landfill on TCL's behalf earns a 'proper return'. Furthermore, a landfill management and operation contract was entered into by TCL with CWS under which CWS managed the: (i) design; (ii) landfill operation; and (iii) transportation system from the transfer station to the landfill. The revenue model includes a transportation charge per trip.

The local authorities, as transfer station owners and suppliers of waste to the landfill, have to ensure that the waste: i) meets the TCL's waste acceptance criteria; and (ii) it is loaded in an appropriate manner to meet the efficiency and safety requirements.

Canterbury provides a good illustration of a corporate structure that may be adopted for a regional framework. In simple terms, the structure can be summarised as:

- Participating ULBs form a committee to supervise development of the regional facility;
- Participating ULBs have to execute a contract to join the committee, and are ensured adequate representation on the board of the committee;
- The ULB providing the maximum volume/ quantity of waste and/or land is given a limited casting vote;
- The implementation of the design, construction, O&M of the regional facility (which may include collection and transportation) goes through a competitive bid process;
- The selected bidder executes a JV agreement with the committee for the purpose of the regional facility and both parties have equal shares in the JV;
- The board of the JV has adequate representation of the municipalities/ULBs; and
- The JV is bound to provide adequate disposal capacity for participating municipalities/ULBs for the period for which the JV has been formulated.

## 3

## Regional Strategy through a State Level Nodal Entity (Gujarat, India)

Gujarat recognised the need for an integrated approach to MSW management in 2005, and, in view of the huge lacunae in treatment and disposal facilities, adopted a state-wide, regional (clusterisation) approach to meet requirements for safe disposal. The state-level support was anchored through the Gujarat Urban Development Company (GUDC). GUDC was chosen after the state had tried to approach the planning as a departmental exercise through the Directorate of Municipal Administration (DMA), and realised that the capabilities required were lacking within the department. Subsequently, GUDC was appointed as a nodal agency in 2006, and mandated to develop a state-wide MSW management programme within a five-year period using the available 12th Finance Commission grants. Towards this end, GUDC was empowered with planning, financial and operational autonomy. An Advisory Committee, consisting of government officials and sector experts from related departments, was also constituted to oversee the exercise and provide expert guidance to GUDC.

GUDC began by conducting a series of state-wide workshops to build consensus among ULBs for the approach. It went on to develop a strong scientific planning process, starting with mapping and needs assessments in all urban bodies. Through this, it became clear that GUDC's active support and key interventions should be focused on the last two steps of the waste management chain—treatment and disposal. Operations for primary collection, storage, secondary collection and transportation were to be undertaken by the ULBs, wherein GUDC would only support improved operational and management practices.

GUDC's small in-house team then contracted private planning and technical design companies to provide technical inputs required for the implementation of treatment and disposal facilities. The list and scope of work of the technical groups associated with implementing the strategy is presented in Table 1.



*Waste is received, sorted and sieved through a rough mesh on the concrete pad, before being moved to the vermi-compost sheds. Himmat Nagar, Gujarat, India.*

**Table 1** List and Scope of Work of Technical Groups

Component	Consultant Appointed	Main Scope of Work
ULB level collection and transportation	Institute for Solid Waste Management	Planning and equipment requirements; waste characterisation
Clusterisation, identification of land	Bhaskararcharya Institute for Space Applications and Geo-informatics (BISAG)	Identification of appropriate land parcels using GIS
	Indian Institute of Management (IIM), Ahmedabad	Mathematical model for verification of clustering
Vermi-compost/ Microbial compost plants	Karnataka Compost Development Corporation (KCDC)	Design, procurement and supervision
Sanitary landfill facilities	M/s. Mahindra Acre and M/s. SENES	Design, procurement and third party supervision
PPP transaction advisor	Crisil Advisory Services Ltd.	PPP structuring

The basic model that was arrived at was for initial treatment of wastes, through vermi-composting, to be undertaken individually by each ULB, to reduce volumes to be transported for land filling. Individual ULBs were required to identify sites for vermi-compost facilities on the basis of area and location criteria provided. Each vermi-composting facility was also to serve as a transfer station at the ULB level, for transportation of residual waste for land filling on a regional basis. To date, 77 such facilities have been constructed, and are being operated by non-governmental organisations (NGOs).

Simultaneously, GUDC began the process of clusterisation, land identification and acquisition for regional facilities in a coherent manner. The clustering of ULBs for disposal arrangements was finalised through an iterative process—the final clusterisation, using a maximum travel distance of 50 km, led to the identification of over 20 clusters,<sup>3</sup> each with a regional landfill site. For each of the

clusters of ULBs, alternative sites for a shared landfill were identified using geo-informatics and CPCB recommended criteria. The effort focused on government owned wastelands closest to the largest generator of waste in each cluster. The sites identified were acquired and handed over to GUDC for development. The super-clusters thus demarcate the state into 12 zones for the purposes of solid waste management.

When an estimation of the requirement of funds to implement the ambitious state-wide integrated strategy was undertaken, it showed a gap in capital resources of almost Rs. 169 crore. This large gap was instrumental in the adoption of: (a) prudent technology choices and efficiencies in procurement; and (b) strategies to draw in private sector investment in the programme. Standardisation and centralised procurement of equipment for collection and transportation as well as for contracting of construction of treatment facilities were adopted,

<sup>3</sup> The seven urban agglomerations of Ahmedabad, Surat, Vadodara, Rajkot, Bhavnagar, Jamnagar and Junagadh, consisting of 42 ULBs, were kept on a separate track, and each accounted for a cluster.



leading to significant savings. Complementing this, the following measures are expected to attract private investment:

- Generation of scale, through clusterisation of ULBs into super-clusters; the clusters identified were further grouped into five “super-clusters”. The super-clusters thus demarcate the state into 12 zones for the purposes of solid waste management;
- Clubbing of treatment (remunerative) and landfill activities (non-remunerative) for bidding;
- Provision of unencumbered sites and all required clearances;
- Upfront capital support at various stages, and long-term O&M concessions;
- Inter-ULB agreement, assuring minimum quantity of waste at the treatment site;
- Flexibility to enhance established treatment (vermi-compost) facilities through alternative technologies, and to sell by-products of treatment; and
- Assured tipping fee, to be paid by ULBs through GUDC. ULB default in payment to be made good by GUDC.

Realising the substantial new financial commitment that ULBs would need to make on O&M, GUDC has also provided the following inputs: (a) sensitising the municipalities on the need to increase efficiencies in collection and transportation so as to transfer the saved resources to treatment and disposal; (b) recommending and helping ULBs implement a new waste management surcharge called “*safai karsj*”; (c) clubbing all projects in order to realise CDM (Clean Development Mechanism) revenues, to be shared on a 60:40 basis with the private developer; and (d) creation of an O&M funding subsidy mechanism for specific ULBs unable to raise adequate resources to fund the service.

A new state-level entity, yet to be incorporated, is proposed to be the asset holder for the new investments in treatment and disposal infrastructure. In sum, the overall allocation of roles and responsibilities envisaged is presented in Table 2.

**Table 2** Envisaged Allocation of Roles and Responsibilities

Activity	ULB	Developer	State-level Entity
Primary collection and supply of MSW	✓		
Selection of developer			✓
Financing, development and O&M of treatment and disposal facilities		✓	
Upfront capital support			✓(*)
MWS receipt and processing		✓	
Transportation of inerts		✓	
Land filling		✓	
Tipping fee payment	✓		
Monitoring of design, construction, O&M, quality and post-closure			✓
Contract monitoring and support			✓

(\*) Through funds earmarked for ULBs.



## 4

## Regional Bulk Water Supply Scheme— Shahad-Temghar Water Authority (Maharashtra, India)

On May 1, 1987, the Maharashtra Water Supply and Sewerage Board (Maharashtra Jeevan Pradhikaran—MJP) commissioned a project to supply bulk water to the Thane Municipal Corporation (TMC), Bhiwandi Nizampur Municipal Corporation (BNMC), Mira Bhayandar Municipal Corporation (MBMC) and 34 surrounding villages (outside the urban limits).

The total estimated cost of the joint project, in 1984, was Rs. 162 crore. Of this, approximately 47 percent (Rs. 75.9 crore) was received as grant-in-aid from the Government of Maharashtra. The loan component incurred for the project was passed on by MJP to the ULBs. The ULBs were required to bear 10 percent of the capital costs.

The project's water source is the Ulhas River and the total sanctioned capacity of the water works, in 1987, was 210 million litres per day (MLD). This water was shared between the ULBs in accordance with the allowed quotas shown in Table 3.

At the time of commissioning, MJP was made responsible for the maintenance and repair works of the scheme up to the bulk supply points, or tapping points, of the ULBs. Distribution within each ULB's jurisdiction was its own responsibility.

Since it was felt that the bulk water rates charged by MJP were significantly higher than the expenditure incurred by it on O&M of the assets, the three municipalities, in 1998, requested the Government of Maharashtra for the water works to be handed over to a consortium of the municipalities for O&M.

The Government of Maharashtra's Water Supply and Sanitation Department, through a resolution passed on February 29, 2000, approved the formation of a Joint Committee and the handing over of the Shahad-Temghar water works to the consortium of the municipalities. Subsequently,

**Table 3** Quotas for ULBs

ULB (Source—Ulhas River)	Quota (MLD)
Thane Municipal Corporation	127
Mira Bhayandar Municipal Corporation	21
Bhiwandi Nizampur Municipal Corporation	48
Surrounding 34 villages	11
Wastage	3
<i>Total capacity of the Shahad-Temghar Water Supply Scheme at the time of commissioning in 1986</i>	210

STEM Water Authority came into effect on March 23, 2000. The authority has been formed on the basis of an MoU between the three ULBs.

According to the MoU, the Joint Committee took over the assets, that is, Shahad-Temghar Water Works, from the custodian MJP, and is responsible for: (a) its O&M to supply water as per their respective shares to the ULBs; (b) managing and administering the water works; and (c) receiving tenders and raising funds for achieving the objectives of STEM Water Authority. All costs of STEM, including employee salary, cost of purchase of raw water and bulk supply are drawn out of the earnings from the sale of bulk water, as metered at the points of supply. The local bodies jointly own the assets of STEM.

The constitution of STEM Water Authority, including a Governing Committee, consists of:

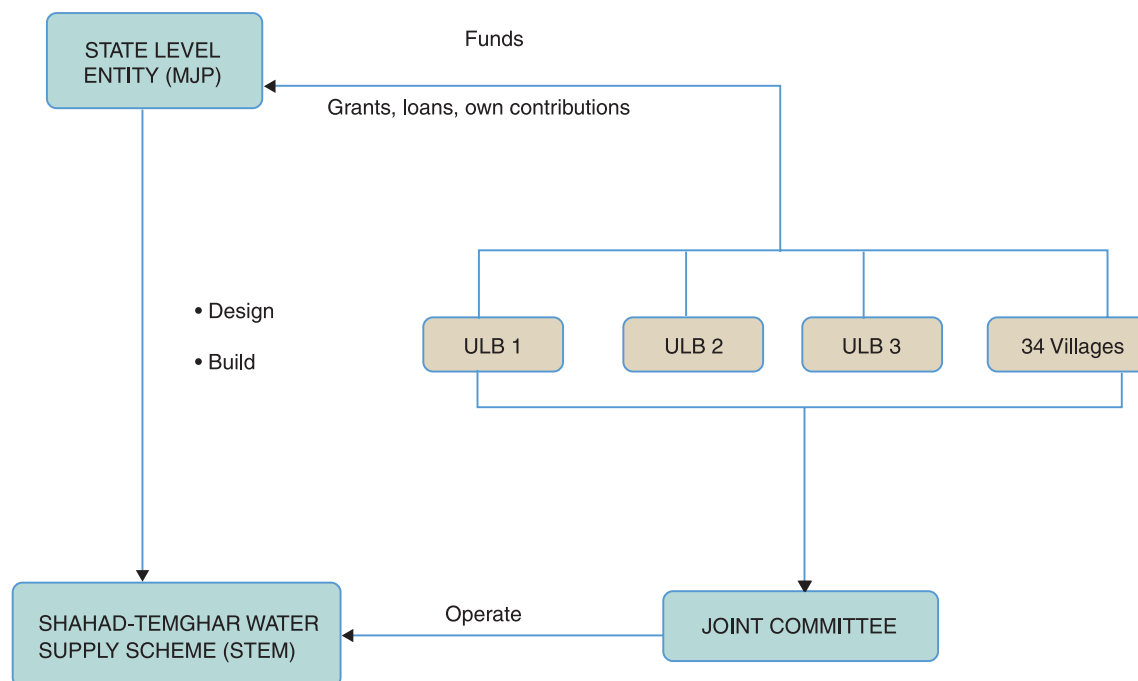
- Mayor of the City of Thane (Chairman);
- Mayors of BNMC and MBMC (Co-Chairmen);
- Commissioners, TMC, BNMC and MBMC; and
- Public Health Engineer/Engineer in charge of Water Supply Departments TMC, BNMC and MBMC.

An Executive Committee consisting of the following was also in place:

- Commissioners, TMC, BNMC and MBMC;
- Public Health Engineer/Engineer in charge of Water Supply Departments TMC, BNMC, MBMC; and
- Ex-engineer, MJP.

The arrangement can schematically be represented as shown in Figure 6.

**Figure 6** Schema of Institutional Arrangement



As a result of prudent and efficient management, STEM Water Authority was able to generate substantial revenues from its operations.<sup>4</sup> From 2003 onwards, the participating ULBs started discussions to further clarify and establish the legal status of STEM, in order to facilitate and enhance its operations. As a result, on February 28, 2009, the Government of Maharashtra approved a Government Resolution to convert STEM into a company under the Indian Companies Act. This will enable STEM to:

- Operate or compete to provide services in other regions, within and outside the state and country;
- Raise funds from financial institutions; and
- Expand its scope of operations to other environmental and infrastructure services.

The Governing Council (apex body) of the company consists of the mayors and commissioners of three cities, the Chief Executive Officer (CEO) of Thane Zila Parishad, and the Executive Director of the company.

The Board of Directors (11-member body) consists of the commissioners of all ULBs and the CEO of Thane Zila Parishad, three city engineers of the ULBs, a technical and financial expert nominated by the Board, a nominee of the state government (Principal Secretary, Water Supply and Sanitation Department, in consultation with the Urban Development Department), and the Executive Director and CEO (appointed by a selection committee constituted for the purpose).

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<sup>4</sup> The accounts of the Authority are audited and presented to the Governing Committee on a yearly basis.

## 5

## Shared Solid Waste Management Facility for Alandur, Pallavaram, Tambaram

(Tamil Nadu, India)

Since 2004, the Government of Tamil Nadu has made significant efforts (through training programmes, capacity building of local bodies, procurement support and financial allocations) to improve solid waste management practices in urban areas of the state. While the focus has been on primary collection and transportation activities, treatment and safe disposal have been a challenge.

Alandur, Pallavaram and Tambaram, three municipalities in the Chennai Metropolitan Development Area (CMDA), each faced the following issues with regard to disposal of MSW:

- Alandur was using marshy lands on the city outskirts to dump its untreated waste, and was facing public interest litigation from environmental groups in the city;
- Tambaram was facing objections to its dumping practices due to proximity to the air force base; and
- Pallavaram could not identify any site for treatment and disposal of its solid waste.

In 2007, the Government of Tamil Nadu, acting through the Commissionerate of Municipal Administration (CMA), urged the three municipalities to work jointly to address their MSW management issues.

As a result, a committee was formed to take forward the initiative, comprising the commissioner, health officer and sanitary engineer from each ULB, the solid waste management specialist from CMA, the regional director<sup>5</sup> of the zone, the regional engineer,

and the manure officer. The regional director is the chairman of the committee.

Pallavaram Municipality (the largest ULB) was designated as the nodal ULB, and assigned the responsibility of preparing a master plan, including the technical and financial details of a facility for treatment and disposal. CMA provided the requisite technical assistance for this. As part of its mandate as the nodal agency, Pallavaram Municipality was authorised to implement a project to develop an integrated MSW Management Project that would comprise development, construction and O&M of three transfer stations and material recovery facilities with a common compost plant, and any other suitable processing facility, and the construction and O&M of a sanitary landfill facility. It was also determined that the project would be implemented in a PPP format.

The ULBs acquired a 50-acre site at Venkatamangalam from the State Revenue Department for the purpose, situated within 10 km (approximately) of each ULB. The cost of the site was met equally by the ULBs and through state funds. The land has been registered in the name of all three ULBs. The integrated Waste Management Project includes components aimed at improving primary collection and transportation practices in the three ULBs, and has been approved for Jawaharlal Nehru National Urban Renewal Mission (JNNURM) funding.

The ULBs have entered into an MoU (vetted and passed by all three councils) agreeing on the quantum of waste to be sent to the facility—

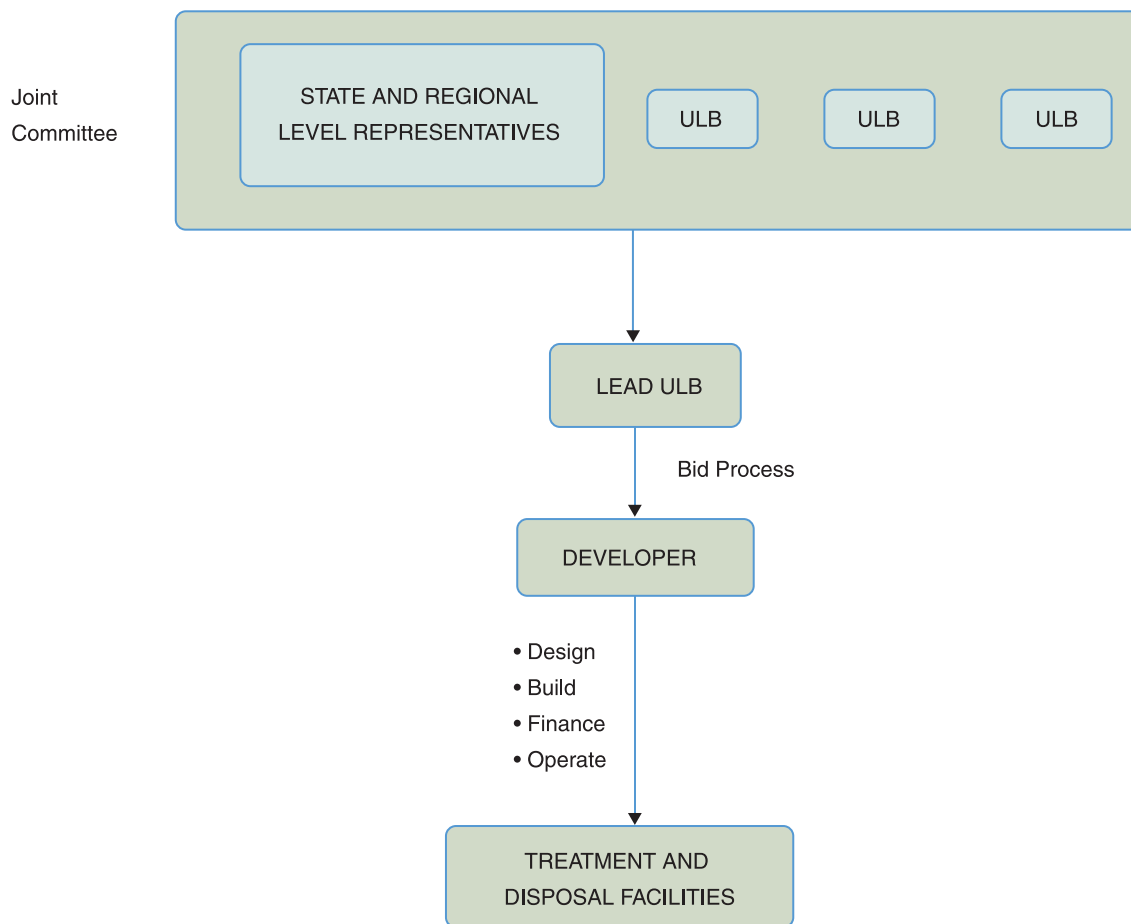
<sup>5</sup> Tamil Nadu is divided into seven “regions” for the purposes of facilitating administration. Each zone is headed by a regional director (reporting to CMA and the Urban Development Department).

estimated at 80 to 90 TPD from each ULB as well as payment of the tipping fee.

Under the proposals, the ULBs will implement source segregation, primary collection and transportation; whereas the treatment and disposal facility will be developed and operated through a private operator.

The contract for this was awarded in early 2009. The Concession Agreement was entered into by Pallavaram Municipality acting as the nodal agency for the project as designated by CMA. The Environmental Impact Assessment and clearances for the site were obtained in 2010, and construction activity is expected to be initiated soon.

**Figure 7** Institutional Arrangements





*Waste being compacted after dumping, Jones Cross Roads Landfill Site, Delaware, USA.*



Annex

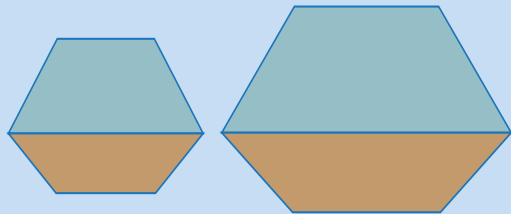
# 1

## Landfills: Economies of Scale

Even when there are effective and reliable systems for processing of waste, there will still be a need for engineered landfills to dispose rejects, residues (from treatment processes) and non-biodegradable waste. Therefore, an engineered landfill is an integral component of a scientific waste management system.

The cost of construction of engineered landfill sites is dependent on many factors including the size of the landfill, site conditions, availability of materials locally, manpower costs, etc. Among various factors affecting the construction costs of landfills, the size of the landfill is observed to be most significant due to the following reasons:

- Cost of construction per unit area/per unit of waste quantity reduces with the increase in the size of the landfill. One single large landfill of a given size would always be less expensive to construct as compared to several smaller sites aggregating to the same area, because the necessary infrastructure that must be provided on all sites (weighbridge, administrative block, site roads, storage area, etc.) can be used more intensively on larger sites. Moreover, the proportional spending on items such as boundary walls and buffer planting is lower for a large site;
- Given a fixed side slope, a greater height can be achieved with a larger base area. Therefore, more waste can be placed per unit area of larger landfill sites, resulting in a lower per tonne cost of land filling; and
- Equipment (such as bulldozers and other specialised machinery) can be used more intensively on a large site. Moreover, more specialised and efficient machinery can be justified at larger sites due to the greater work loads.



Larger landfills can be utilised to a greater height, that is, they contain a greater load per unit area of land.

For example, assume a square land area of ' $x^2$ ' m

Land filling is done up to a height of ' $y$ ' m above ground level (GL) and a depth of 5 m below GL.

Side slopes of 1V:4H (above GL) and 1V:3H (below GL) are maintained.

Then, the area and total air space available for land filling for different values of ' $x$ ' and ' $y$ ' are:

x = (m)	Land area (m <sup>2</sup> )	y = (m)	Air space (m <sup>3</sup> )	Factor increase in	
				Area	Air space
100	10,000	10	82,000	–	–
300	90,000	15	1,302,667	9	17.5
500	250,000	20	4,771,333	25	67.3



## 2

## ULBs: Rationale for Regionalisation

The following factors will influence the decision of a ULB to participate in a regional landfill facility for safe disposal (the facility may include facilities for treatment also):

**A. Land Constraint:** If a ULB does not have a sufficiently large and suitably located site for the development of its own sanitary landfill facility to meet the requirement of the MSW Rules 2000. Requirement of land should be estimated in such a manner that the site is capable of serving the needs of the ULB for a period of at least 20 years, and is located in accordance with the criteria specified by CPCB for the siting of landfill sites.

**B. Travel Distance:** The savings accruing from the development and operations of a regional landfill will compensate for the increased cost of transportation over longer distances (refer to the section on transporting wastes to a regional facility). However, the distance of the proposed regional landfill facility from the participating ULBs should not significantly increase transportation costs for the participating ULBs to such an extent as to marginalise the other benefits of using a regional landfill. On the other hand, in the absence of any other viable alternative, ULBs may consider incurring higher transportation costs in order to meet regulatory requirements for the safe disposal of waste.

**C. Quantum of inerts/rejects to be land filled:** If the quantum of inerts/rejects to be land filled by the ULB is small, the justification for participation in a regional facility is stronger, since the costs incurred by the ULB in developing and operating its own landfill facility will be significantly higher than the costs incurred in a regional facility. For example, as presented in the section on Financial Analysis, the cost of developing a landfill to dispose 75 TPD of rejects is only four times more than the cost of developing a landfill to dispose 10 TPD of rejects, although the waste to be land filled has increased 7.5 times.

# 3

## Financial Analysis: Standalone versus Regional Landfill Facility

The following financial analysis has been carried out to estimate the financial benefits of a regional arrangement as against a standalone landfill. The assumptions for this analysis have been derived from financial details of similar projects in ULBs across the country.

The factors considered for the analysis are:

- Development cost for a standalone landfill and regional landfill; and
- Transportation infrastructure cost in case of a regional landfill.

The facilities are assumed to be developed under a Build Operate Transfer (BOT) concession-based tipping fee structure. The tipping fee is arrived at to achieve a project return of 15 percent. The tipping fee payable by a ULB for development and O&M of a standalone landfill facility has been compared with that payable for development and O&M of a regional landfill facility.

For the purposes of the analysis, it has been assumed that the waste generated is treated at the ULB level, and only rejects are transported to a regional landfill facility, located at an average distance of 40 km from each participating ULB. Since small ULBs would normally not have large trucks for long haul transportation, the private operator could be required to procure and maintain the transportation infrastructure.

### A. Estimated Cost of Development of Landfill

Four typical landfill sizes are considered for the purpose of analysis (Table A1):

Details	Units	LF1	LF2	LF3	LF4
Daily total waste generation rate	TPD	40	80	160	300
Daily inert waste to landfill	TPD	10	20	40	75

*Note:* It is assumed that approximately 25 percent of the waste generated would be land filled.

The assumptions that are considered for the analysis include:

- The landfill is designed for an active landfill life of 20 years (no cells considered);
- The bulk density of waste to be land filled is assumed to be 0.85 tonne/cubic metre (m<sup>3</sup>);
- The height of landfill is assumed as 10 m, depth as 3 m, the slope above ground as 1:4 and slope below ground as 1:3;

- The equipment assumed to be included are weighbridge, JCB, compactor, bulldozer and tractor;
- Base liner, top cover and leachate treatment costs has been included (refer to the list of design components considered in evaluating costs of development and operations); and
- O&M costs include the expenses towards manpower requirement. The cover cost has been included.

**Table A2** Capital and O&M Expense of a Typical Landfill

Details	LF1	LF2	LF3	Rs. crore LF4
<b>Capital Cost</b>				
Landfill and infrastructure	2.70	4.69	8.42	14.58
Site infrastructure (includes roads, water drainage, electricity)	0.97	1.16	1.44	1.78
Equipment (JCB, compactor, bulldozer, tractor, weighbridge)	0.92	0.92	1.17	1.42
Contingency (assumed as 5%)	0.23	0.34	0.55	0.89
<b>Total project cost</b>	<b>4.82</b>	<b>7.11</b>	<b>11.58</b>	<b>18.67</b>
<b>Annual O&amp;M expenses</b>				
O&M cost for landfill operations	0.36	0.37	0.57	0.65

## B. Transportation Infrastructure Cost Assumption

The transportation infrastructure is required to transport the waste to be land filled from the ULB to the regional landfill. The transportation infrastructure assumptions that are considered for the analysis are:

### Capital Cost

- Assuming a 7 metric tonne (MT) truck with max of 3 trips per day—max load per truck (TPD) 20
- Cost per truck (Rs. crore) 0.18
- Replacement of trucks (years) 10

**Table A3** Typical Cost of Transportation Infrastructure

Details	LF1	LF2	LF3	Rs. crore LF4
Daily total waste generation rate (TPD)	40	80	160	300
Daily inert waste to landfill (TPD)	10	20	40	75
No. of trucks required	1	1	2	4
Project cost (Rs. crore)	0.18	0.18	0.36	0.72

## O&M Expense

■ Number of working days (days)	365
■ Vehicle mileage (km per litre)	4.5
■ Vehicle capacity (MT)	7
■ Vehicle speed—including tipping time, stoppages and halts considered (average) (km/hr)	30
■ Number of duty hours (hours)	8
■ Average one-way distance between landfill site and generator (km)	40
■ Max number of trips per truck per day	3.00*
■ Current diesel price (Rs./litre)	42
■ Salary of driver (Rs. per month)	8,000
■ Salary of helper (Rs. per month)	5,000
■ Maintenance of vehicle (% of Capex)	10%

(\*): Round trip time = 3.5 hrs; single shift assumed

The project cost and O&M cost for the transportation infrastructure is provided in Table A4:

Table A4 O&M Cost for Typical Transportation Infrastructure				
Details	LF1	LF2	LF3	Rs. crore LF4
Daily total waste generation rate (TPD)	40	80	160	300
Daily inert waste to landfill (TPD)	10	20	40	75
No. of trucks required	1	1	2	4
No. of drivers	1	1	2	4
No. of helpers	1	1	2	4
O&M cost for transportation infrastructure (per annum)	0.08	0.11	0.21	0.38

## C. Scenario Analysis

A scenario analysis has been carried out to analyse the financial implications on a ULB in case of the development of a standalone landfill facility as against the impact of participating in a regional landfill (assuming that, in both cases, the facility is developed under a BOT concession, and a tipping fee is applicable per tonne of waste disposed).

**Scenario A:** ULB to develop its own treatment and disposal facilities.

**Scenario B:** 4 ULBs have individual treatment facilities but one common regional landfill facility within a 40 km distance of each ULB.

In both cases, the assumptions underlying the tipping fee estimation are:

■ Concession period	20 years
■ Promoters' equity	25%
■ Debt	75%
■ Interest rate	14%
■ Repayment period	10 years
■ Project return	15%
■ Escalation in costs	5–10% (depending upon item)

The above analysis has been carried out for ULBs assumed to be generating 40 TPD and 80 TPD waste. The results are presented below.

#### I. For 10 TPD of landfill waste

The Available Waste Quantity (AWQ) to be land filled by each ULB is 10 TPD, and hence the cost of development of a standalone landfill is Rs. 4.8 crore. In case of a regional landfill facility for all four ULBs, AWQ would be 40 TPD, and hence the cost of development of a regional landfill facility would be Rs. 11.6 crore with an additional cost of Rs. 0.18 crore for the transportation infrastructure for each ULB.

In this analysis, the two scenarios are considered as shown in Table A5.

Scenario	Tipping fee (Rs./tonne)	Rs. crore/Annum/ULB
Scenario A	3,000	0.41
Scenario B	1,950	0.70

It may be seen from Table A5 that in case of four ULBs (each generating 40 TPD of waste) coming together and forming a regional landfill, there are savings of 35 percent, even after paying for the transportation (Scenario B includes transportation costs).

#### II. For 20 TPD of landfill waste

The AWQ to be land filled by each ULB is 20 TPD and hence the cost of development of a standalone landfill is Rs. 7.1 crore. In case of a regional landfill facility for all four ULBs, AWQ would be 80 TPD and hence the cost of development of a regional landfill facility would be Rs. 19.9 crore, with an additional cost of Rs. 0.18 crore for the transportation infrastructure for each ULB.

Scenario	Tipping fee (Rs./tonne)	Rs. crore/Annum/ULB
Scenario A	2,000	1.46
Scenario B	1,425	1.04

There is a significant saving from four ULBs producing 80 TPD of waste coming together and forming a regional landfill, even after paying for the transportation cost. Further, it can be noted that, on larger ULBs coming together, the financial benefits decrease.

## 4

## Regional Facilities: Landfills Only, or Integrated Treatment and Sanitary Landfill Facilities?

MSW 2000 Rules require municipal solid wastes to be treated before rejects/inerts are land filled. The argument is often made that ULBs should receive and treat/process the waste generated at the ULB level (within the jurisdiction of the ULB, or in the vicinity of the ULB), to reduce the quantum of rejects and inerts that is transported over longer distances for land filling at the regional landfill facility, which may be at a distance of over 30 km from each participating ULB. This pre-supposes that the participating ULBs have access to a suitable site to develop and undertake treatment of wastes (through own resources or by contracting PSP).

The decision whether to undertake treatment at the ULB level or to integrate treatment and disposal facilities at the regional level lies with each participating ULB. Several factors will influence the ULB's decision. Each of these factors assumes a different priority, depending upon the ULB's particular context. It is thus proposed that each ULB consider each factor or criteria, and accord a weightage to each factor in accordance to its situation, followed by a rating of each factor. The comparison of cumulative marks of each option would enable the ULB to make an informed and logical decision.



*New Cell under development at the landfill site, Navi Mumbai, Maharashtra, India.*

The factors are tabulated in Table A7.

<b>Table A7</b> Factors to be Considered by Each ULB				
Option 1: Treatment at ULB, disposal at regional landfill facility. Option 2: Treatment and disposal at integrated regional facility.				
Criteria	Remarks	Proposed Weightage (Wi)	Option 1 Marks (Mi)	Option 2 Marks (Mi)
		<b>(Scale: 0-5)</b>		
Tipping fee (based on treatment at ULB and at regional site)	Total outflow of tipping fees (for treatment, transportation of wastes/rejects and disposal)	30%		
Land requirement and acquisition process and clearances and approvals	<ul style="list-style-type: none"> <li>■ Extent of land required; number of sites required and acquisition process</li> <li>■ Number of clearances and approvals required and the complexity of securing these approvals</li> </ul>	30%		
Design/ construction/ operational risk	<ul style="list-style-type: none"> <li>■ Impact on city/town</li> <li>■ Complexity in design and engineering</li> <li>■ Ease of operation</li> <li>■ Chances of default by PSP/ULBs</li> </ul>	5%		
Alignment of roles with expertise	ULBs role is in line with their capacity	10%		
Monitoring and management of project	Manpower requirement and complexity involved in monitoring operator(s) and ensuring adherence to agreed performance parameters	10%		
Efficiency of system/operations	Determined by % of rejects transferred to landfill	10%		
Concessionaire profile	Likely profile (experience and expertise) of concessionaire who would be attracted to bid for this project	5%		
<b>Total</b>		<b>100%</b>	<b>ΣWiMi/100</b>	<b>ΣWiMi/100</b>

*Note:* Weightages are suggested only. ULBs may change the suggested weightages in accordance with their particular situations. For example, a ULB that has access to suitably sited land for establishing treatment facilities, and can hence obtain clearances easily, may want to reduce the weightage suggested for this particular criterion.

This assessment will enable the ULB to make a sound decision on the extent of its participation in the regional facility. It should be borne in mind, however, that a minimum quantum of waste must be ensured in order to ensure the viability of treatment processes also. If treatment facilities are to be integrated with the sanitary landfill in the regional facility, the sum of the waste committed by various participating ULBs must be adequate to justify the technology proposed to be deployed and operations.


 5

## Transporting Wastes to a Regional Facility: Estimating the Costs

Sending wastes to regional facilities for treatment and/or land filling will entail an increase in transportation costs for the participating ULBs. This may be offset, to a certain extent, by the lower cost (value) of land at a greater distance from the ULB as well as savings in costs of development and operation of landfill facilities due to economies of scale.

Each participating ULB can estimate the transportation cost involved by undertaking the following assessment. Increase (or savings) in costs can thus be estimated to inform the decision of whether to transport the entire mixed waste generated<sup>6</sup> to the regional facility or treat the waste at the ULB level, prior to transportation.

### A: Estimation of the Number of Vehicles Required

Assumptions:

Quantum of waste generated/collected (TPD): 300

Rejects from composting facility (@35%) (TPD): 105

Vehicle capacity—long haul compactor truck (MT): 12

Average one-way distance to regional facility (km): 40

Maximum number of trips per truck per day: 3

Vehicle speed—including tipping time, stoppages and halts considered (average) (km/hr): 25

Vehicle mileage (km per litre): 4.5

Cost of vehicle (Rs.): 2,500,000

Maintenance of vehicle (% of Capex): 6%

Current diesel price (Rs./litre): 42

Salary of driver (Rs. per month): 8,000

Salary of helper (Rs. per month): 5,000

<sup>6</sup> It is assumed that street sweepings and inert waste shall be transported separately and directly to the landfill facility.



**A** Number of Vehicles Required

	Waste to be transported (TPD)	Waste transported per vehicle/day (TPD)	No. of vehicles reqd.	No of drivers reqd.*	Total cost of vehicles (Rs. crore)
Total waste to be transported	300	36	9	18	2.25
Only rejects to be transported	105	36	3	6	0.75

\*Note: Assuming work in two shifts.

**B** Cost of Fuel

	No. of vehicles	Distance covered by each vehicle/day (km)	Total distance covered/day (km)	Diesel reqd./day (litre)	Cost of diesel/day (Rs.)	Cost of diesel/month (Rs.)	Cost of diesel/annum (Rs. lakh)
Total waste to be transported	9	240	2,160	480	20,160	604,800	72.6
Only rejects to be transported	3	240	720	160	6,720	201,600	24.2

**C** Salaries

	No. of drivers reqd.	Salary/month (Rs.)	No. of helpers reqd.	Salary/month (Rs.)	Total salary outgo/month (Rs.)	Total cost of vehicles (Rs. crore)
Total waste to be transported	18	8,000	18	5,000	234,000	28.08
Only rejects to be transported	6	8,000	6	5,000	78,000	9.36

**D** O&M of Vehicles

	No of vehicles deployed	Total cost of vehicles (Rs. crore)	Cost of maintenance (Rs. lakh)
Total waste to be transported	9	2.25	13.5
Only rejects to be transported	3	0.75	4.5

E Total O&M (per annum)				
	Cost of fuel (Rs. lakh)	Salaries (Rs. lakh)	Maintenance (Rs. lakh)	Total (Rs. lakh)
Total waste to be transported	72.6	28.08	13.5	114.18
Only rejects to be transported	24.2	9.36	4.5	38.06

Thus a ULB generating 300 TPD will incur an additional expenditure of approximately Rs. 76.1 lakh/annum in transporting the entire waste collected to a regional facility, as against transporting rejects/inerts alone. This needs to be viewed *vis-a-vis* the expenditure that would be incurred in establishing and operating a treatment facility at the ULB level.

## 6

## Transporting Wastes to a Regional Facility: Estimating the Optimum Travel Distance

In order to estimate the maximum distance beyond which transportation cost for rejects to the landfill become unviable, the annual O&M cost for regional landfill operations added with the cost for waste transportation for the given distance should be compared with the O&M cost for the standalone landfill. For better understanding, one set of calculations is provided below as a sample:

- Typical cost estimate for various quantity of waste for landfill operations has been provided in Table A8.

**Table A8** Typical Cost Estimate for Development of Landfill for Varying Waste Quantities

Details	10 TPD	20 TPD	40 TPD	75 TPD
Capital cost (in Rs. crore)	4.82	7.11	11.58	18.67
Annual O&M cost (in Rs. crore)	0.36	0.37	0.57	0.65

- A typical cost estimate for transportation of waste through varying distances has been provided in Table A9.
- The capital cost for the regional landfill option along with the capital cost for transportation infrastructure would always be lower than in the case of the standalone landfill option for handling of waste quantities up to 75 TPD, for the transportation distances considered below. However, it may be noted that in calculations provided, the capital cost for the development of a transfer station has not been considered, which may be required (for improved cost efficiency) beyond a distance of 40 km.
- In order to compare O&M costs for a regional arrangement against a standalone option, the calculation of O&M cost for both options have been considered for a 20 TPD (standalone facility) and a 75 TPD regional landfill. The calculations indicate that the O&M cost for a regional landfill would exceed the standalone option beyond approximately 65 km distance.

Annual O&M cost (20 TPD landfill)—Rs. lakh: 37

Annual O&M cost (75 TPD landfill)—Rs. lakh: 65

Annual O&M cost for ULB contributing 20 TPD to the 75 TPD landfill—Rs. lakh: 17.33

Effective savings for ULB generating 20 TPD rejects—Rs. lakh: 19.67

Referring to Table A9, it can be seen that the annual O&M cost for transporting 20 TPD over a distance of 70 km is Rs. 21.10 lakh. Thus the savings in landfill operations may be used for transporting the waste up to an optimal distance of approximately 65–68 km. Beyond this, the option of participating in a regional landfill arrangement will become more expensive for a ULB generating 20 TPD of rejects.

*While this is an illustration of the argument, it is recommended that every ULB undertake an estimation of costs in its specific context to arrive at a financially viable distance for transporting waste.*

**Table A9** Cost Estimate for Transportation of Rejects for the Distances Varying from 40 km to 70 km

Waste quantity (TDP)----->	10				20				40				75			
	40	50	60	70	40	50	60	70	40	50	60	70	40	50	60	70
One-way travel distance (between source and disposal site) in km																
C&T cost																
Capex (Rs. crore)	0.18	0.18	0.18	0.18	0.18	0.36	0.36	0.54	0.36	0.54	0.54	1.08	0.72	1.08	1.08	1.98
Unit Capex (Rs./tonne)	49.32	49.32	49.32	49.32	24.66	49.32	49.32	73.97	24.66	36.99	36.99	73.97	26.30	39.45	39.45	135.62
O&M cost (Rs. lakh)	8.740	10.10	11.42	14.57	11.42	15.24	17.30	21.10	21.29	27.12	31.20	40.58	38.33	49.32	56.71	73.11
Unit O&M cost for transport (Rs./tonne)	239.4	276.7	312.9	399.2	156.4	208.8	237.0	289.0	145.8	185.8	213.7	277.9	140.0	180.2	207.2	267.1

## Design Components Considered in Evaluating Cost of Landfill Development and Operations

### 1. Development

**Life of the landfill:** 20 years

**Size:** Area considered for varying quantities of waste is indicated in Table A10. The site is assumed to be developed in a single phase.

Type	Waste quantity of rejects (TPD)	Area considered (hectare)
LF1	10	1.5
LF2	20	2.6
LF3	40	4.7
LF4	75	8.2

#### Baseliner (from top to bottom)

- Drainage layer (permeability not less than  $10^{-2}$  centimetre/second [cm/sec]): 300 millimetre (mm) thick
- Geo-textile layer (500 grams per square metre [GSM])
- High-density polyethylene (HDPE) liner (1.5 mm thick)
- Base preparation (clay or amended soil having permeability  $1 \times 10^{-7}$  cm/sec): 900 mm

#### Top Cover (from top to bottom)

- Top soil—suitable for vegetative growth: 450 mm
- Compact clay layer (clay or amended soil having permeability  $1 \times 10^{-7}$  cm/sec): 450 mm
- Gas collection layer: 300 mm

#### Leachate Treatment Unit

The leachate treatment unit comprises a leachate sump and solar evaporation pond. Leachate recycling has been assumed as a back-up option, with provision of a reciprocating pump and necessary piping arrangements to recycle excess leachate from the leachate sump to the landfill.

### Site Infrastructure

- Storm water management system
- Internal roads (5 m wide)
- Green belt—5 m width along periphery
- Boundary wall, 3 m high
- Street lighting

### Machinery and Equipment

- Weighbridges at entry and exit
- JCB Excavator(s)
- Compactor
- Bulldozer(s)
- Tractor trailer(s) with water tanker

## 2. Operations

- **Salaries and wages of staff** (superintendent engineer, junior engineer, foreman and technician, workers, drivers)
- **Fuel consumption in vehicle operations**
- **Vehicle maintenance**
- **Landfill operations** (soil cover, maintenance—roads and landfill, monitoring and periodic tests—pore fluid and pore gas, ground water, air quality)
- **Electricity and water costs**

# Acknowledgements

The Water and Sanitation Program (WSP) assisted the Ministry of Urban Development (Government of India) to formulate this Guidance Note.

The following state governments and organisations generously contributed towards this: Government of Gujarat; Gujarat Urban Development Company; Government of Tamil Nadu; Tamil Nadu Urban Development Fund; Tamil Nadu Water Supply and Drainage Board; Government of Maharashtra; United States Agency for International Development.

Suneetha Dasappa Kacker coordinated and compiled this Guidance Note. N.C. Vasuki generously contributed information on the Delaware Solid Waste Authority. Technical support was provided by Claruslaw Associates, iDeCK and SENES Consultants.

The Note was reviewed by N.C. Vasuki and Vikram Kapoor.

Editing by Ananda Swaroop.

Photographs by WSP, N.C. Vasuki and Ahmedabad Urban Development Authority.



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