Technical Manual on Industrial Pollution Control

(Industrial Waste Landfill Site)

— Based on project cases and investigation research
reports of Japan Environment Corporation (JEC) —

MARCH 1999

JAPAN ENVIRONMENT CORPORATION

Foreword

During the high economic growth period from the late fifties, Japan saw serious industrial pollution and deteriorations in the living environment, but successfully escaped from this critical situation by implementing country-wide remedial measures. Japan's experience and information on antipollution techniques used would be a great help to those countries which now feel it imperative to introduce an antipollution scheme.

Japan Environment Corp., a special national agency for pollution control promotion, has been engaged in project construction-transfer and financing for more than three decades since its foundation in 1965. It has played a major role in assisting small and medium-size companies in particular to take antipollution measures which, despite being strongly called for, would otherwise be both a financial and technological difficulty to those companies.

In response to socioeconomic changes in Japan, we have extended the scope of our activities to cover industrial waste related measures, urban environmental improvements, and the protection of the natural environment. We have committed ourselves on the issue of global environment protection by providing relevant information overseas and creating a global environment fund.

As part of our environmental information service, we offer interested foreign organizations a book entitled "Japan Environment Corp. and its Projects in Brief" describing our functions and experience and containing a case study of our build-transfer projects and data on our financing projects.

The Pollution Prevention Technique Manual Series, a supplementary to this book, is based on a case study of our projects and focuses on the activities of small and medium-size enterprises, which the governments of developing countries may find are the most important and immediate target of their antipollution schemes.

This Volume IV, primarily designed to provide information on pollution prevention measures and environmental protection techniques to be taken and applied at industrial waste landfill sites and delineate applicable statutory requirements, also teaches you how to determine the location of such facilities and best utilize the reclaimed land.

We hope that Japan's experience in environmental protection will furnish a source of useful information to those countries which are tackling environmental problems and thereby make some contribution to the protection of the global environment.

Osamu Watanabe
President

Contents

1. Waste Disposal in Japan

1.1 Basic principle of waste disposal

The basic principle of waste disposal in Japan where it is extremely difficult to secure the land for landfill site due to limited amount of national land is as follows.

① Effort to minimize the amount of waste

② Segregated discharge

③ Promotion of resource recovery and recycling

④ Reduction of volume, creation of harmless waste, stabilization and conversion of waste into resources through intermediate processing such as incineration and shredding

⑤ Final treatment of residue

This can be illustrated as follows.

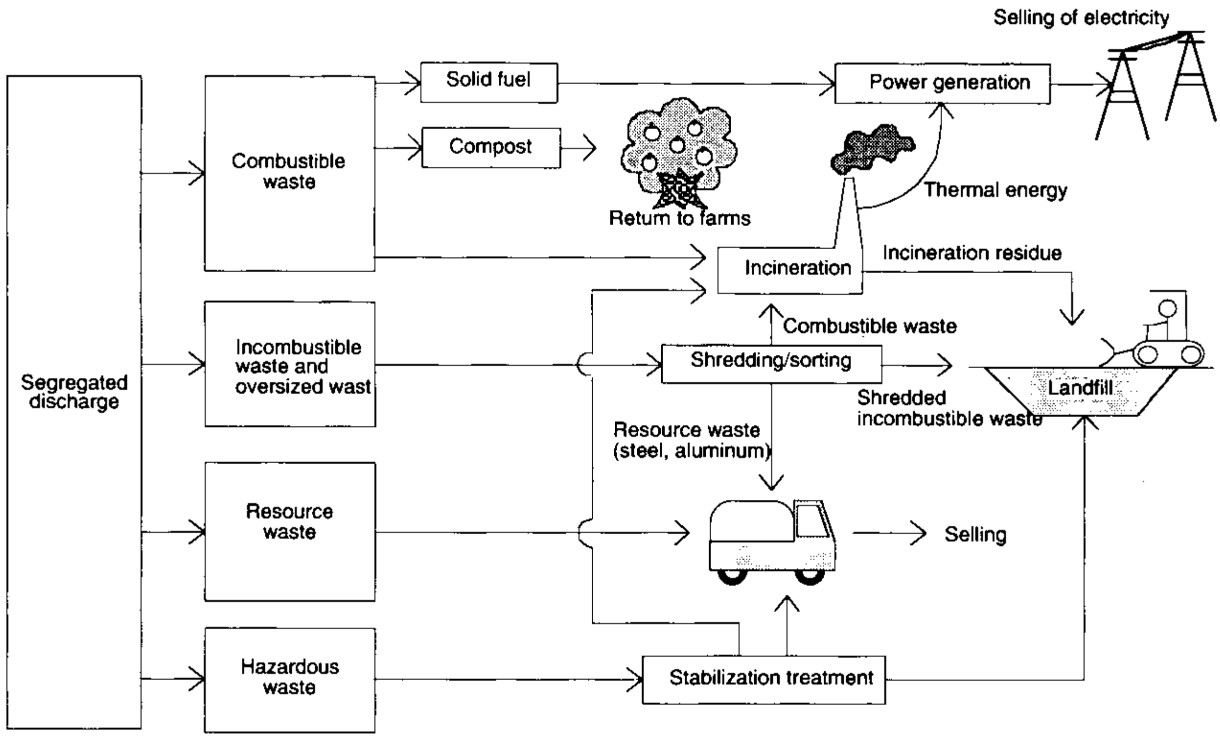


Figure 1-1 Example of treatment/disposal flow for general waste

Method of general waste treatment is shown in Figure 1-2. Rate of incineration is high in Japan and Sweden whereas the majority of Western countries are replying on reclamation for treatment.

Owing to stringent environmental regulations in the Europe and North America, construction of incineration facilities is far more difficult there compared to Japan because of the hazardous substances that are generated by thermal cracking during incineration. Another difference with Japan is the relative ease with which the location for landfill site can be secured due to abundance of land.

While effective reduction or control processes have been developed for dioxin and other hazardous material, carbon dioxide (CO_2) discharged from incineration facilities and methane gas (CH_4) produced as a result of landfilling are said to be chief causes of the global warming. It is thus necessary to identify ways to dispose of them in the best interest of the global environment as well as economy, not to mention their volume reduction.

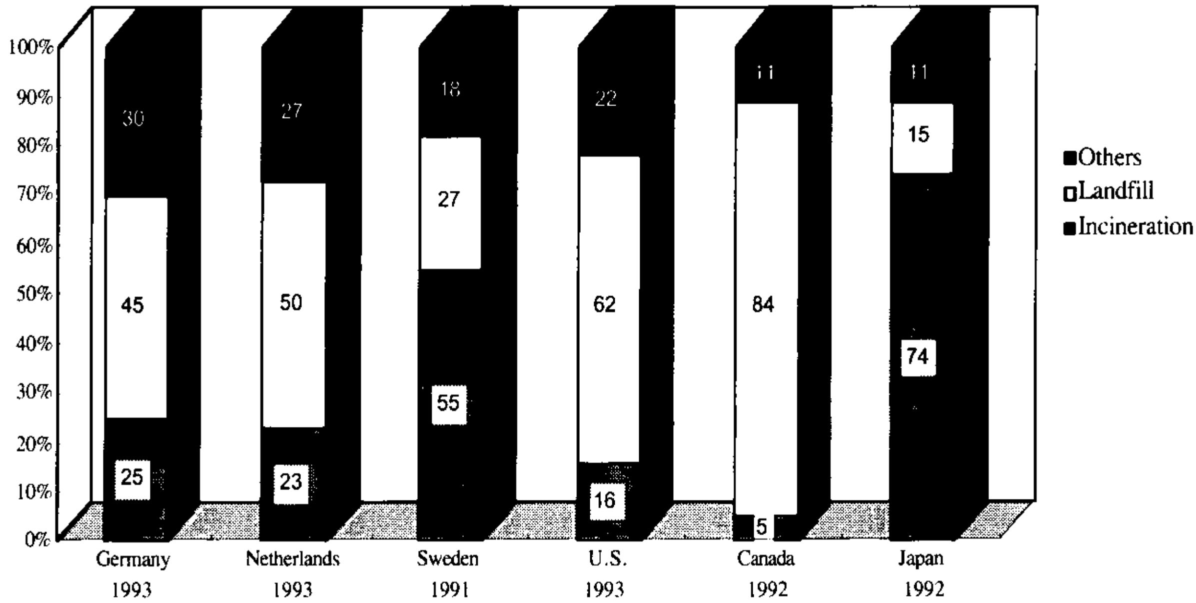


Figure 1-2 Waste treatment methods in various countries

1.2 Laws and regulations

The first law on waste enacted in Japan dates back to the Filth Cleansing Law of 1900 and hygienic landfill disposal of collected waste did not take place until the enactment of the Public Cleansing Law in 1954. The style of today's landfill site emerged after the enactment of the Waste Disposal and Public Cleansing Law (here in after abbreviated as "Waste Disposal Law") in 1970 and the establishment of Technical Standard for Landfill Site in 1977. Since then, the Waste Disposal Law was revised in 1991 and in 1997 and the Technical Standard for Landfill Site was revised in 1998 (see Table 1-1).

Table 1-1 Changes in laws and regulations

Western year	Laws and regulations
1900	Filth Cleansing Law
1954	Public Cleansing Law
1970	Waste Disposal Law
1976	Revision of Waste Disposal Law
1977	Technical Standard for Landfill Site
1979	Guideline for Landfill Site
1988	Revision of Guideline for Landfill Site
1991	Revision of Waste Disposal Law
1997	Revision of Waste Disposal Law
1998	Revision of Technical Standard for Landfill Site

The Waste Disposal Law of 1970 provided for cover soil at landfill sites and measures to prevent offensive odors and insects such as flies. With respect to incidental facilities, landfill sites were required under the Technical Standards for Landfill sites of 1977 to have facilities for leachate collection and treatment, gas collection, littering prevention, etc., which must be designed, including their size, in accordance with the Annotations to the 1979 Guidance on Landfill sites. Instead of specifically providing for seepage control work, however, it assumed that any leachate that has infiltrated into the ground would expected be purified by operation of underground soil's purifying function. In those days the majority of landfilled waste were organic matter, and accordingly antipollution measures to be taken by landfill sites covered organic waste. But as the widespread use of incineration facilities throughout the country resulted in a shift of landfilled waste from organic to inorganic and waste disposal began to draw more public attention, the Annotations were revised in 1988 to set more concrete specifications for the facilities. But yet, no specific guidance was given with respect to seepage control work, except for greater emphasis on the need for liners and so forth (provisions for opaque strata, the material of liners, standards, etc.). In 1998, the Technical Standards for Landfill sites were modified to:

- present in concrete terms the concepts of double-liner facilities and seepage control;
- set more rigorous effluent standards;
- tighten the maintenance/control standards; and
- establish specific requirements for the discontinuation of a landfill site.

These modifications made Japan's technical standards for landfill sites one of the toughest ones in the world.

1.3 Classification of waste

As shown in Figure 1-3, waste is classified into general waste and industrial waste under the Waste Disposal Law. Responsibility for disposal rests with local municipalities for general waste and discharging businesses for industrial waste.

For this reason, industrial waste is being treated and discharged for charge at treatment facilities involving private waste disposal companies and public sector.

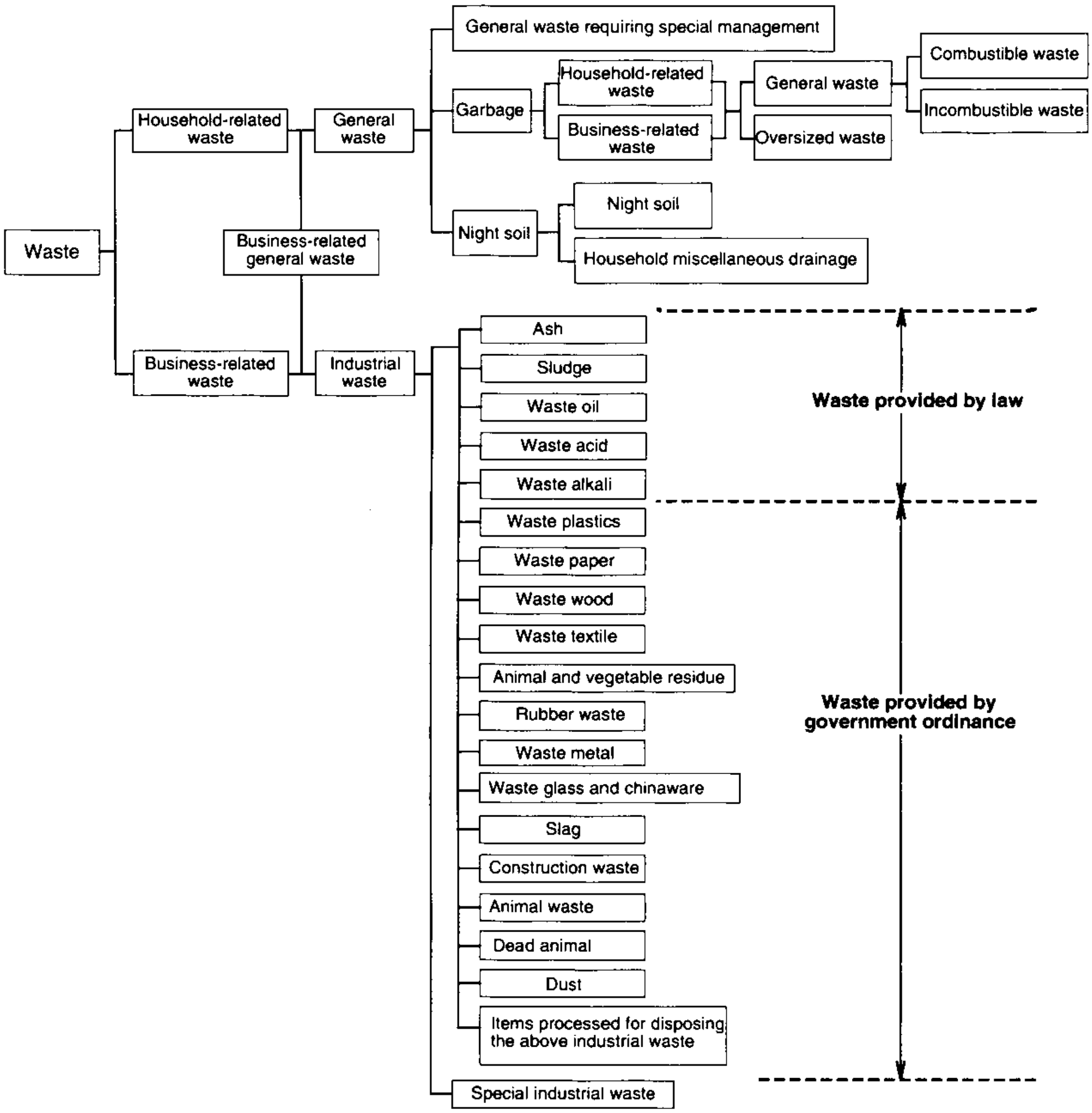


Figure 1-3 Classification of waste

Overseas countries adopt different systems of classification as listed in Table 1-2.
While the Japanese system begins with classification by source (general or industrial), most major Western countries classify waste according to nature, into hazardous and harmless.

Table 1-2 Waste Classification in Major Countries

Country	Classification	Note
Belgium	1. Class-I industrial waste 2. Class-II MSW 3. Class-III least controlled waste Medical waste, hazardous material, radioactive waste, etc., are not acceptable.	A.Bouazza and W.F.Vanimpe Regulatory Aspects of Landfill Liner Design in some countories.(1996)
Denmark	1. Hazardous waste 2. Controlled waste (MSW that is not deleterious) 3. Least controlled waste Any hazardous waste must undergo all pretreatment processes including incineration.	
France	1. Class-I-approved industrial waste 2. Class-II MSW and commercial waste 3. Class-III least controlled waste and construction waste	
Italy	1. General (domestic) waste 2. Class-II least controlled waste IIb & IIc: hazardous waste 3. Toxic and special waste	
Netherlands	1. Waste that is not hazardous 2. Chemical and hazardous waste	
UK	1. Domestic (general) waste 2. Commercial waste 3. Industrial waste 4. Least controlled waste	
Germany	1. MSW 2. Waste requiring special monitoring (corresponds to industrial waste)	
USA	1. Non-hazardous waste MSW, sewage sludge, construction waste, agricultural waste, mining waste, hazardous waste from the small discharger, and non-hazardous industrial waste. 2. Hazardous waste All that falls under the EPA list.	Masaru Tanaka, ed. "Industrial Waste Disposal Practices in Japan, the United States, and Europe" (1996).
Japan	1. General (domestic) waste 2. Industrial waste	

1.4 Output [1), 2), 3)]

The output of general waste and its treatment/disposal condition are shown in Figure 1-4 and the output of industrial waste its treatment/disposal condition are shown in Figure 1-5.

In 1995, the output of general waste (excluding night soil) and industrial waste was 50.69 million tons and 374 million tons, respectively. This means that a total of 424.69 million tons of waste was discharged that year.

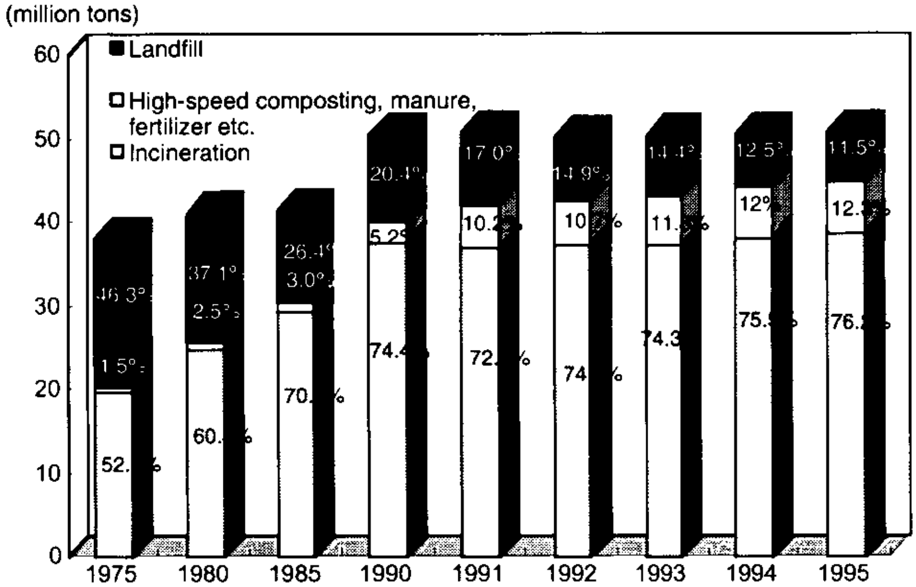


Figure 1-4 Output and treatment/disposal of general waste

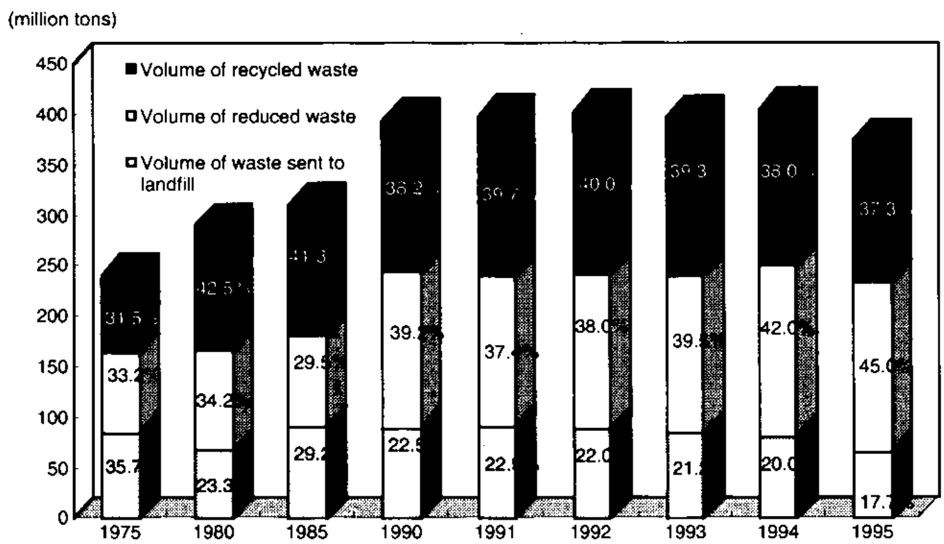


Figure 1-5 Output and treatment/disposal of industrial waste

(1) By Industry

By industry, the construction industry is the largest source of industrial waste (approx. 76.93 million tons or 19.0% of the total), followed by farming (approx. 74.88 million tons or 18.5%), the utility supply industry (approx. 74.61 tons or 18.4%), the mining industry (approx. 30.79 million tons or 7.6%), the steel industry (approx. 30.08 tons or 7.4%), and the paper industry (approx. 24.92 tons or 6.1%). These six sectors altogether account for about 80% of the total industrial waste (see Figure 1-6).

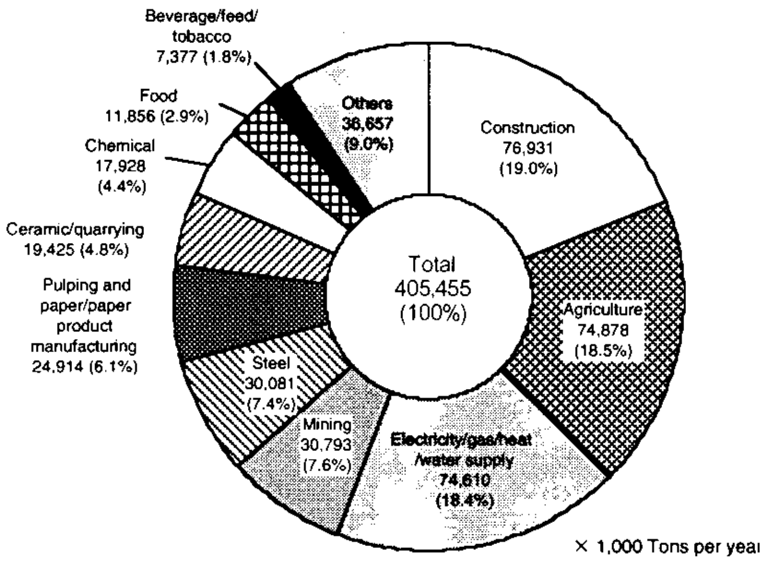


Figure 1-6 Discharge of Industrial Waste by Industry (1994)

(2) By Category

By category, sludge is the type of waste that is discharged most (approx. 184.13 million tons or 45.4% of the total), followed by animal waste (approx. 73.55 million tons) and construction waste (approx. 60.24 million tons). These three altogether account for about 80% of the total (see Figure 1-7).

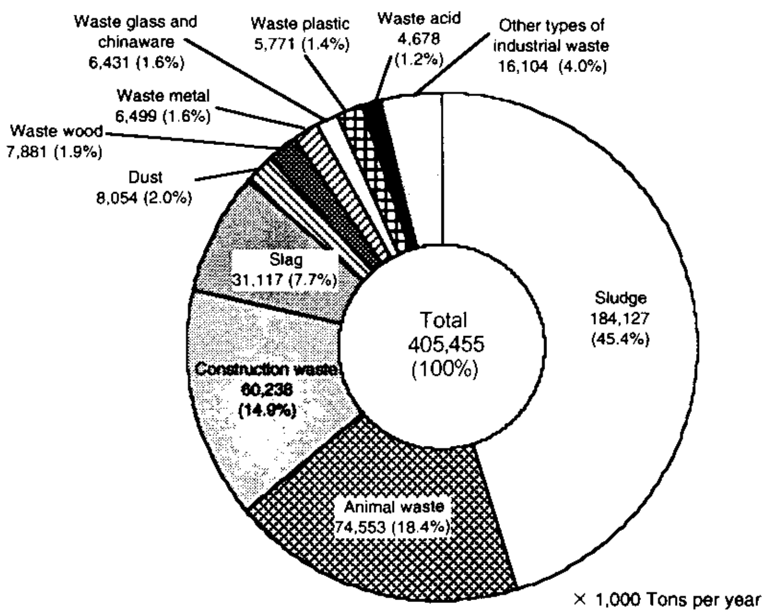


Figure 1-7 Discharge of Industrial Waste by Category (1994)

(3) By Region

By region, the Kanto Region is the largest source of industrial waste (approx. 107.96 million tons or 26.6% of the total), followed by the Chubu Region (approx. 59.69 million tons), the Kinki Region (approx. 58.91 million tons), and the Kyushu Region (approx. 54.64 million tons) (see Figure 1-8).

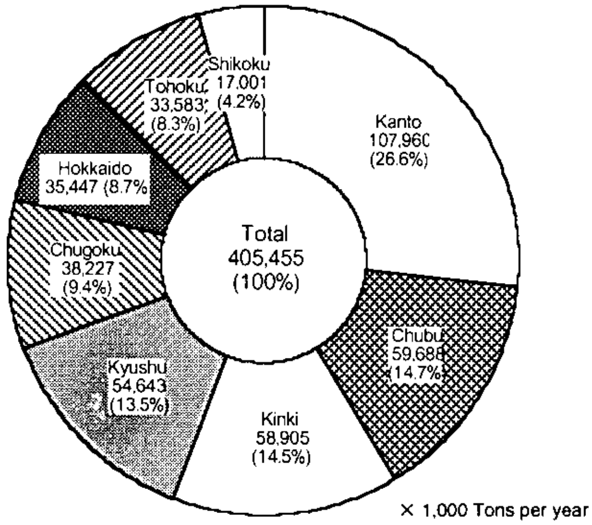


Figure 1-8 Discharge of Industrial Waste by Region (1994)

1.5 Condition of treatment and disposal

In 1994, 75.5% of all general waste discharged was incinerated, with 12% and 12.5% subject to direct landfilling and recycling.

Industrial waste was treated and disposed of as follows.

(1) Disposal Process

In 1994, a total of about 405 million tons of industrial waste was discharged, of which approx. 311 million tons (77% of the total) underwent intermediate processing and approx. 53 million tons (13%) and 41 million tons (10%) were put directly (without intermediate processing) to recycling and final disposal, respectively.

The 311 million tons intermediate-processed waste was reduced in volume to about 142 million tons before put to recycling (approx. 102 million tons) or final disposal (approx. 39 million tons).

The bottom line is that 38% of all discharged industrial waste, or about 156 million tons, was recycled, with 20% or 80 million tons put to final disposal (see Figure 1-9).

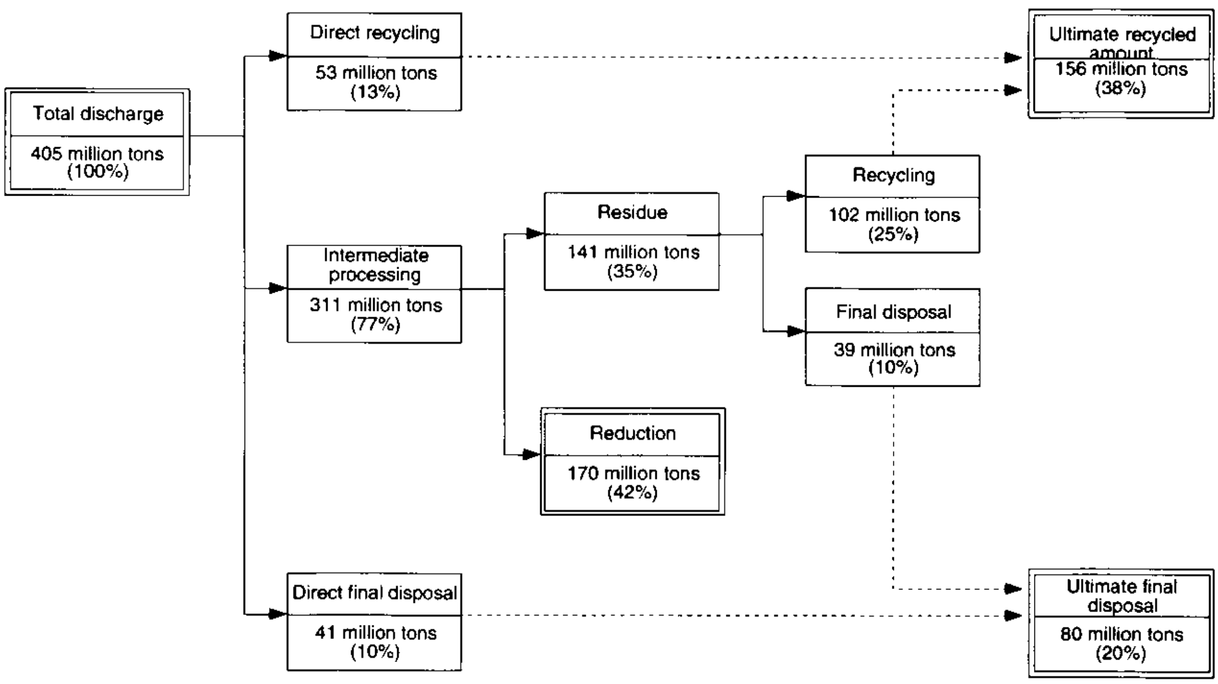


Figure 1-9 Industrial Waste Disposal Process (1994)

(2) Disposal by Category

At the top of the list of recycling rates is animal waste (88%), which is followed by waste metal (70%), slag (70%), and animal/vegetable residue (68%). At the bottom, on the other hand, is waste alkali (3%), which is immediately below sludge (5%), waste rubber (13%), and waste plastics (15%).

Industrial waste that ranks the highest in final disposal rate is waste rubber (78%), which is followed by waste glass/chinaware (74%), waste plastics (59%), and ash (53%).

Figure 1-10 shows, in respect of each category of industrial waste, the recycling rate, the rate of volume reduction by intermediate processing, and the final disposal rate.

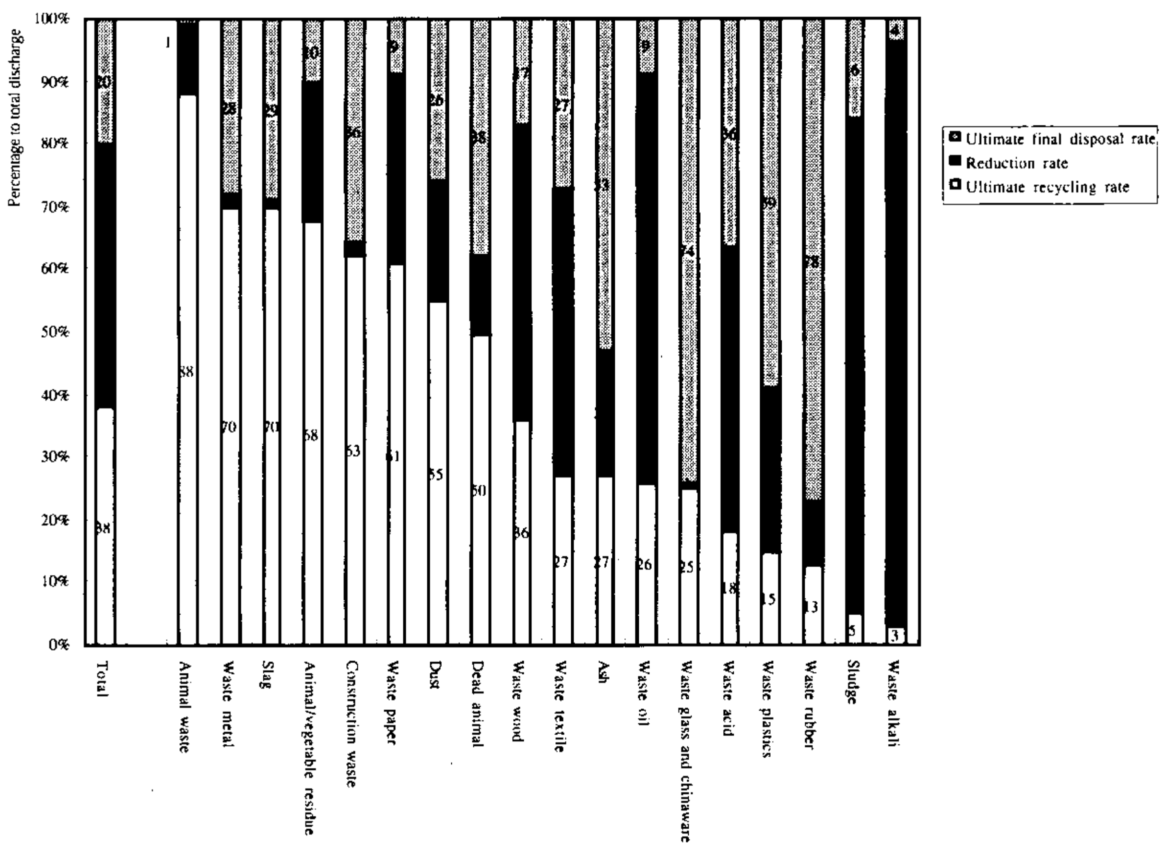


Figure 1-10 Recycling, Intermediate-Processing Reduction, and Final Disposal Rates

1.6 Landfill waste substance

As shown in Figure 1-4, the direct landfill rate for general waste dropped from 46.3% in 1975 to 26.4% in 1985 and further to 11.5% in 1995, while the direct incineration rate constantly increased, from 52.2% in 1975 to 70.6% in 1985 and 76.2% in 1995. This points to an increasing share of incineration residues and incombustibles in total landfilled waste. Figure 1-11 shows the shares by weight of combustibles, incombustibles, and incineration residues in all waste disposed of in landfills in selected years. [6] In 1967 combustibles accounted for 47.8% of all landfilled waste, but the proportion had changed dramatically by 1994, when 93.9% was either incombustibles or incineration residues. This is a result of government effort to have ever increasing waste reduced in volume or stabilized through incineration and other intermediate processes, meaning that landfilled waste is increasingly inorganic.

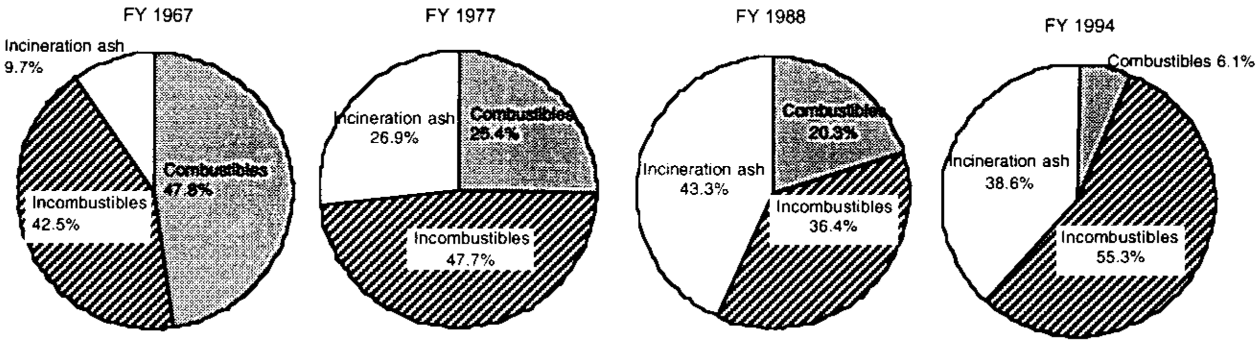
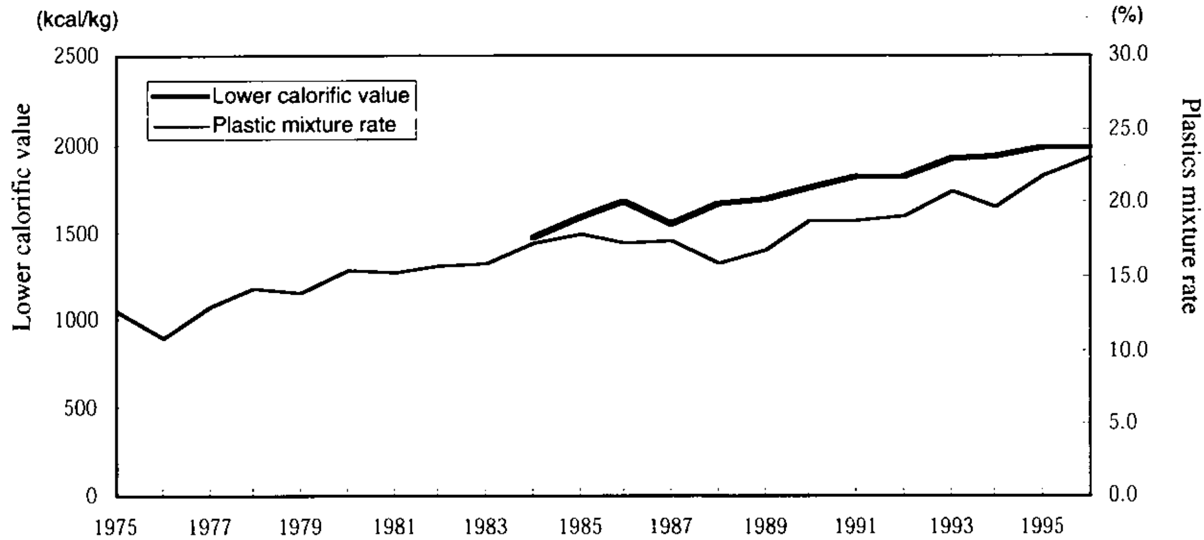


Figure 1-11 Landfilled General waste

Figure 1-12 shows the calorific value of combustible waste and the proportion of plastics therein. From the seventies to the late nineties, the plastics mixture rate rose from 10% - 14% to 20% - 23%, with a commensurate increase in the lower calorific value of combustibles from 1,240 - 1,500 kcal/kg to 1,810 - 1,990 kcal/kg. [5] When waste with a high chlorinated-plastic content is incinerated, hydrogen chloride (HCl) and other toxic gases are generated, which must be neutralized with lime or other agents.

$$2\,HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$$

For this result, fly ashes containing calcium chloride ($CaCl_2$) or unreacted lime ($Ca(OH)_2$) are brought in to landfill sites.



* The total number of samples ranges from 67 to 414 and differs from year to year.

Figure 1-12 Calorific Value of General Waste and Plastics Mixture Rate (National Average) [5]

1.7 Disposal Cost

In 1995, the disposal of general waste (including collection, transport, final disposal and all other associated steps) required a total of US$18.4 billion (120 yen to the dollar), equivalent to US$147 per citizen per year or US$436 per ton (see Figure 1-13).

Although the amount of actual spending on the disposal of industrial waste is not available, supposing that every ton of industrial waste required US$125 for disposal, the total cost should have been around US$50 billion in 1995.

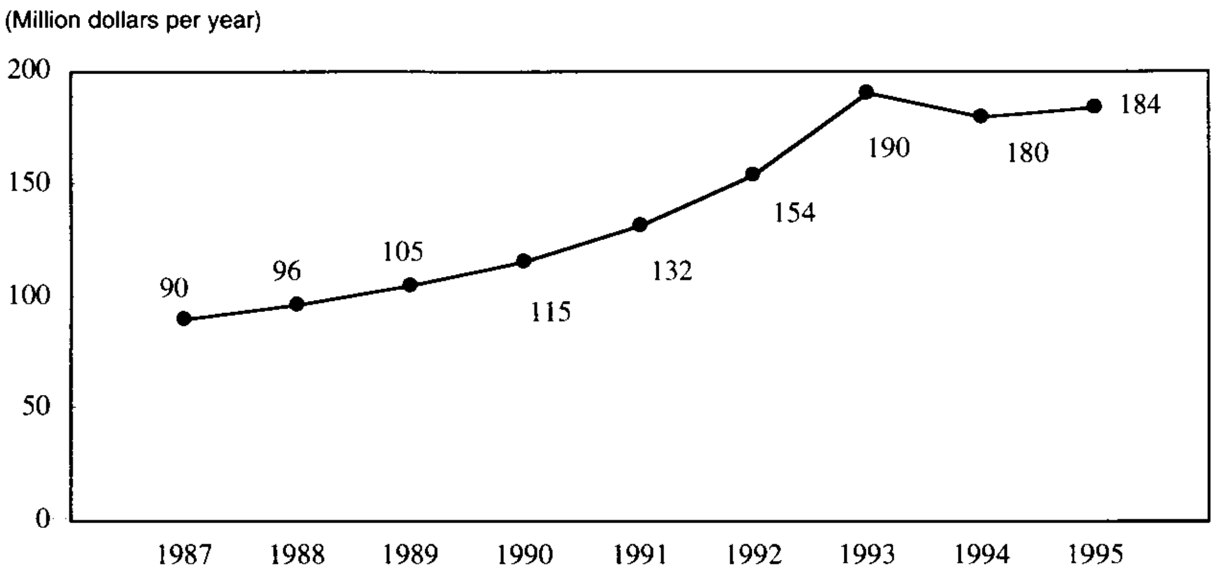


Figure 1-13 General Waste Disposal Cost [3]

2. Types and Structure of Landfill sites

2-1. Types and Structure

Landfill sites are classified according to use, i.e., whether they are for general or industrial waste, and the latter category can in turn be divided into three types, controlled, least controlled, and strictly controlled, as shown in Figure 2-1. There is no remarkable difference in structure between landfill sites for general and controlled landfill site for industrial waste.

2-2. Location and Number

The number of existing landfill sites and the location of those for general waste are shown in Table 2-1 and Figure 2-2, respectively. The latter figure shows that approximately 70 percent of all such facilities are located in mountainous areas, with 2.4 percent on inland waters or sea areas. This reflects the fact that Japan is a small country.

Table 2-1 Number of Landfill sites (1994) [3][4]

Type		Number
General waste landfill site		2,392
Industrial waste landfill site	Controlled	988
	Least controlled	1,653
	Strictly controlled	40
	Subtotal	2,681
Total		5,073

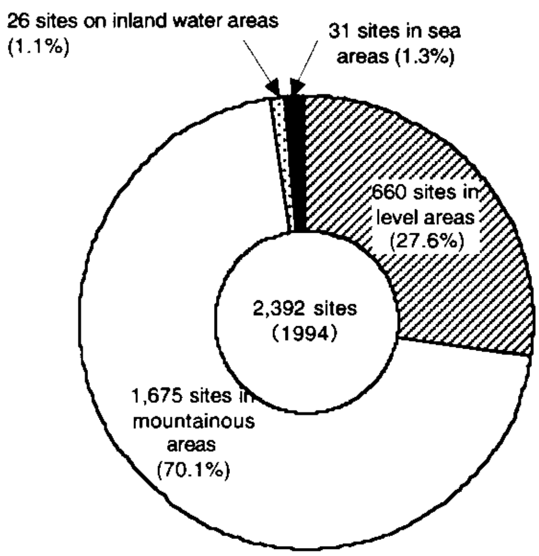


Figure 2-2 Location of General Landfill sites

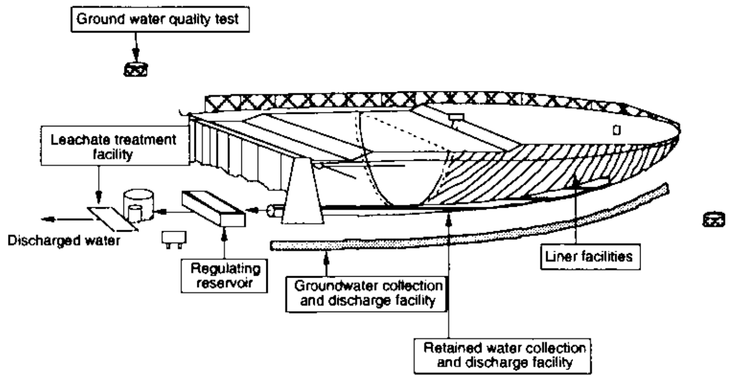
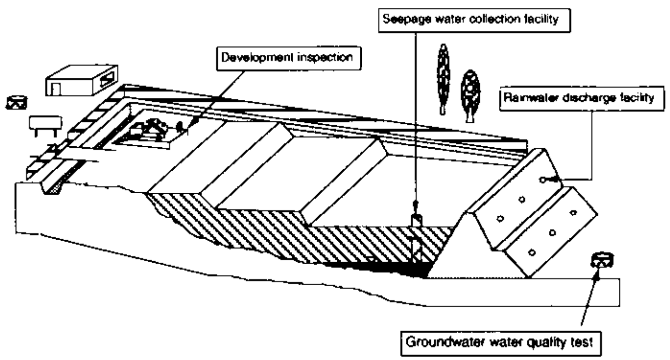
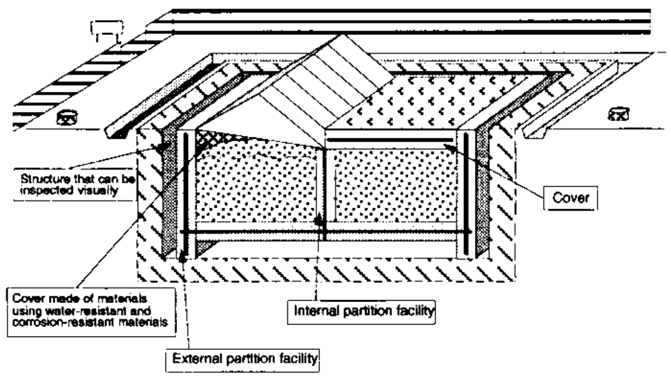
Type	Diagram	Outline
Controlled landfill site **General waste landfill site**		Refers to sites that dispose waste oil (only tar and pitch), waste paper, waste wood, waste textile, animal and vegetable residue, animal waste, dead animal, harmless ash, dust, sludge and slag through reclamation.
Least-controlled landfill site		Refers to sites that dispose waste plastics, rubber waste, metal waste, glass and chinaware waste, asphalt concrete and inorganic solid matters (excluding shredded automobile waste, waste printed circuit board, waste containers and packaging, lead battery electrodes, lead pipes and boards, waste cathode-ray tubes, waste gypsum boards) through reclamation. Least-controlled landfill site reclaims wastes that do not cause any problems in terms of environmental conservation when disposed directly by land disposal. , Installation of retaining wall, dam, enclosure and sign is sufficient to meet the structural standard. Some prefectures, however, instruct the installation of collecting pipes and leachate treatment facility.

Figure 2-1 Types of landfill sites (1/2)

Type	Diagram	Outline
Strictly controlled landfill site		Refers to sites that dispose specified toxic industrial waste such as hazardous ash, dust, sludge and slag. Criteria are as shown below and waste exceeding these criteria are send to land disposal at strictly controlled landfill site.

Criteria concerning industrial waste including metal

	Criteria	Type of industrial waste
Alkyl mercury compound	Not detected	Cinder, dust, sludge, slag
Mercury and its compounds	0.005mg/L or less	Cinder, dust, sludge, slag
Cadmium and its compounds	0.3mg/L or less	Cinder, dust, sludge, slag
Organophosphorus compounds	1mg/L or less	Sludge
Hexavalent chromium compounds	1.5mg/L or less	Cinder, dust, sludge, slag
Cyanide	1mg/L or less	Sludge
PCB	0.003mg/L or less	Cinder, dust, sludge
Dichloromethane	0.2mg/L or less	Sludge
Carbon tetrachloride	0.02mg/L or less	Sludge
1.2-dichloroethane	0.04mg/L or less	Sludge
1.1-dichloroethane	0.2mg/L or less	Sludge
Cis 1.2-dichloroethylene	0.4mg/L or less	Sludge
1.1.1-trichloroethane	3mg/L or less	Sludge
1.1.2-trichloroethane	0.06mg/L or less	Sludge
1.3-dichrolopropane (D-D)	0.0.2mg/L or less	Sludge
Thiuram	0.06mg/L or less	Sludge
Simazine (CAT)	0.03mg/L or less	Sludge
Benthiocarb	0.2mg/L or less	Sludge
Benzene	0.1mg/L or less	Sludge
Selenium and its compounds	0.3mg/L or less	Cinder, dust, sludge, slag
Lead and its compounds	0.3mg/L or less	Cinder, dust, sludge, slag
Arsenic and its compounds	0.3mg/L or less	Cinder, dust, sludge, slag

Figure 2-1 Types of landfill sites (2/2)

2.3 Landfill site's Functions and Leachate Control System

A landfill site is expected not only to function as a waste storage place, but to decompose and stabilize waste. Landfilling is thus defined as "the making the most use of the natural cycle and decomposition mechanism", which forms the basis of one of the landfill techniques, semi-aerobic sanitary landfill.

This type of structure is designed to let air go naturally into the landfill layer through an end-opened leachate collection pipe (see Figure 2-3).

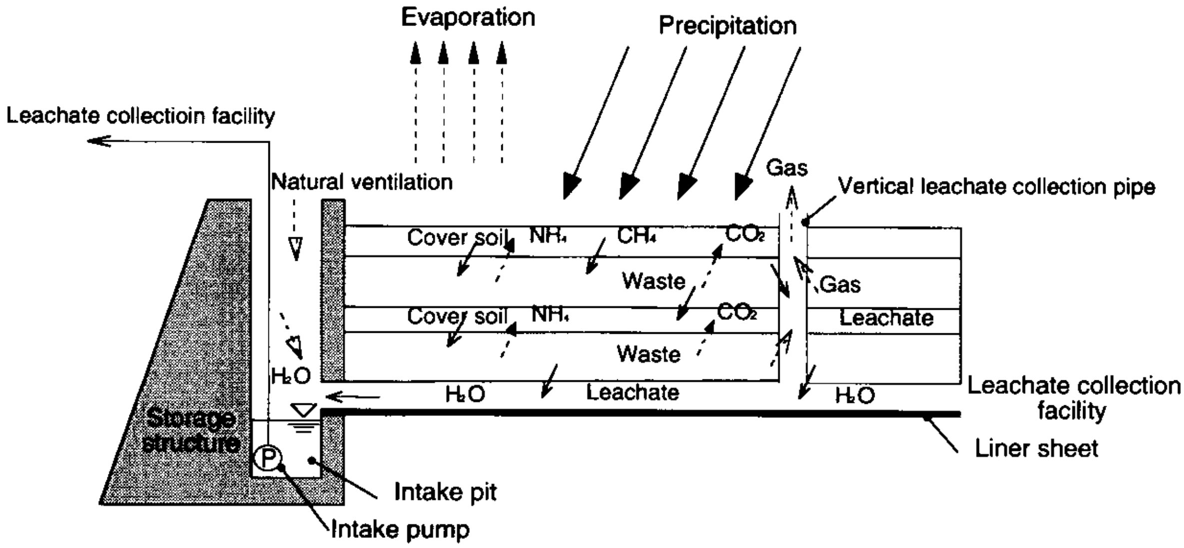


Figure 2-3 Structure of Semi-Aerobic Landfill

Waste containing organic matter, when put in a landfill, decomposes to generate gases, which in turn are discharged through gas collection facilities. At the same time, negative pressure commensurate with the volume of the discharged gases is generated within the landfill layer and draws in air through the leachate collection pipe, which results in the expansion of aerobic areas and facilitates decomposition of waste.

The center of the landfill layer, a hardly aerated area, is supplied with air through a vertical leachate collection pipe or gas collection equipment and therefore forms a mixed aerobic-anaerobic area.

The semi-aerobic landfill structure thus has the following features.

- Organic matter decomposes in an aerobic area.
- Heavy metals are fixed in an anaerobic area.

The decomposition of organic matter will result in an early stabilization of landfill and an early purification of the quality of leachate, with insolubilized heavy metals confined within the landfill.

Because of these advantages, the majority of landfill sites built in recent years are of a semi-aerobic type. Figures 2-4 and 2-5 show the classification of landfill structures and the change in the quality of leachate. It is verified that this type of structure enables earlier stabilization.

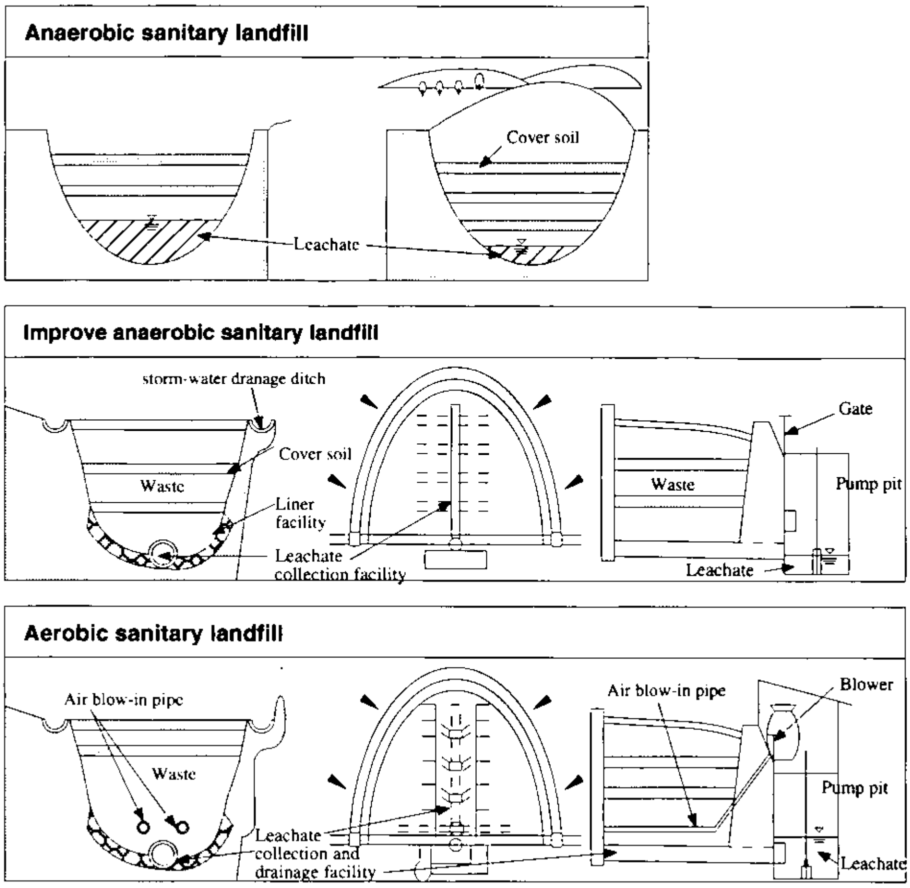


Figure 2-4 Structural Classification of Landfills

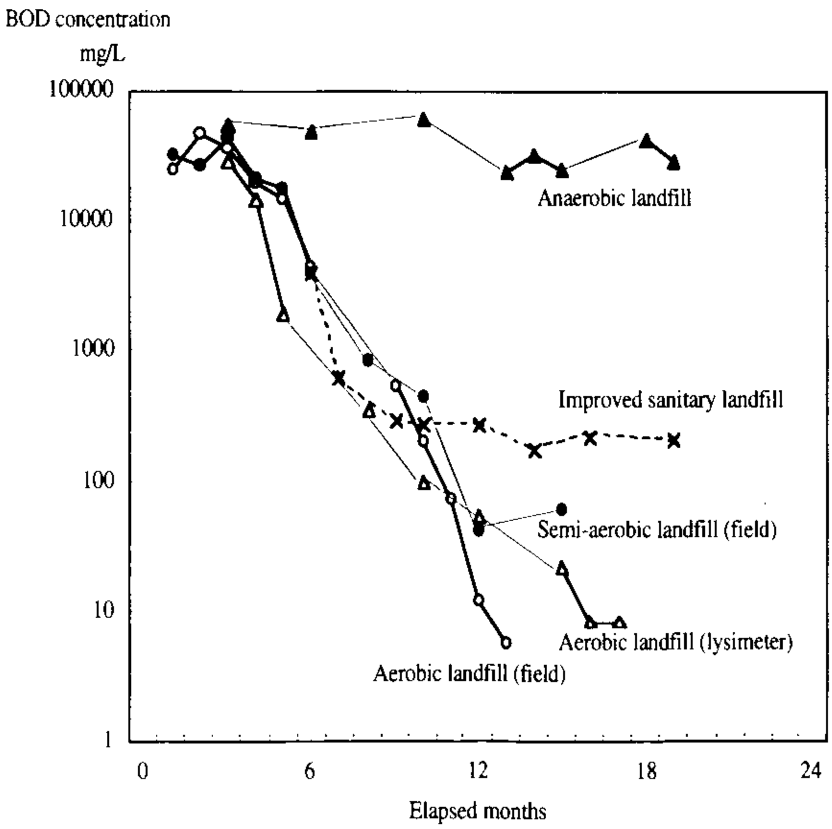


Figure 2-5 Change in Leachate Quality over Time by Landfill Type

As a result of recent spread and advance of incineration and size reduction facilities, most of the landfill sites in Japan mainly handle incineration residues and incombustibles. It is verified, however, that even the landfilling of incineration residues and incombustibles, if in an anaerobic atmosphere, causes a rise in the BOD or COD of leachate. Advance incineration processes also may result in the accumulation of inorganic salts in the landfill. Among others, the chloric ion elutes into leachate in high concentrations in an anaerobic atmosphere (that is, under humid conditions) because of its high solubility in water, nitrification damage and corrosion of water treatment facilities.

In addition, there is an increasing need for immediate removal of leachate as one of the measures to prevent damage of liner facility. In this context, the semi-aerobic landfill structure, which aerates the landfill layer, is viewed as increasingly effective.

To maintain this structure, a landfill site is composed of liner facility, a leachate collection facility, a solid waste retaining structure, a leachate treatment facility, and so forth.

These facilities do not function independently of one another, but form an organic whole altogether as delineated in Figure 2-6. They function in a well-coordinated manner during the entire process, from leachate collection and storage to treatment, constituting what may be referred to as a leachate control system.

Therefore, the planning, design, construction, or management of any landfill site should ensure the proper operation of this control system.

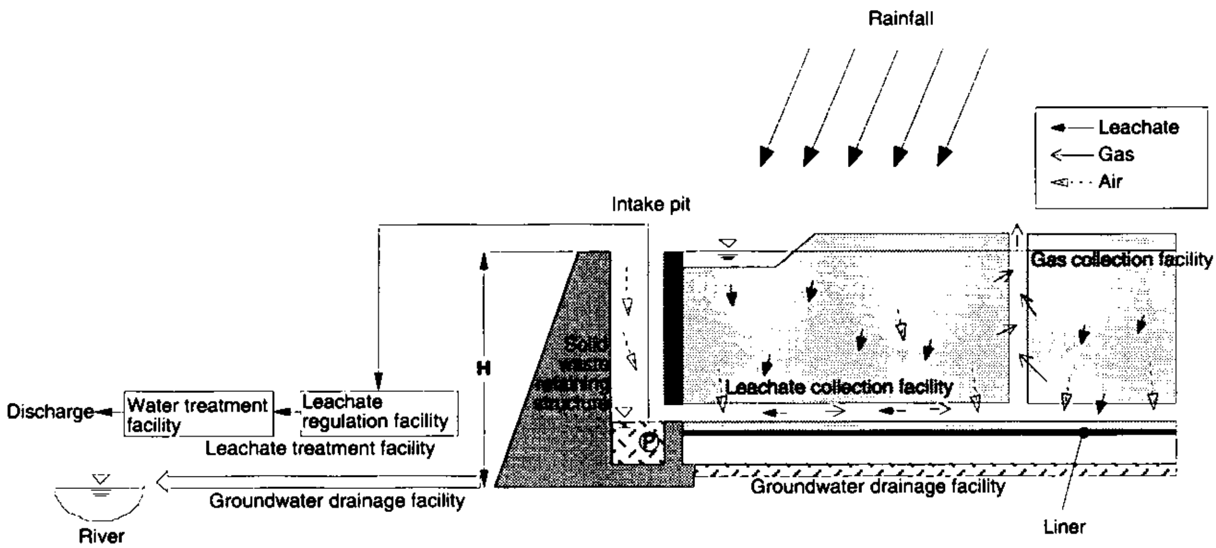


Figure 2-6 Semi-Aerobic Landfill and Leachate Control System

2.4 Present Problem

As Japan is a small country and finding appropriate sites for final disposal plants is an extremely difficult task, approximately 70 percent of all landfill sites are located in mountainous areas and are mostly small in size. [8] (The average landfill is 22,400 square meters in area and 190,000 cubic meters in volume.) Landfill sites in the sea areas also are a feature peculiar to Japan.

Downstream from proposed landfill sites in the mountains are often sources of drinking or agricultural water, and many such plants have met with objections from residents in the downstream or water rights holders demanding the protection of the living and natural environments. Accordingly this has caused a shortage of landfill sites, with the average remaining lifetime as of 1995 as short as 8.5 years for landfill sites for general waste and 2.7 years for those for industrial waste, which is critically short especially in the Tokyo metropolitan area. [3)4)] Under the circumstances, the effort is called for to propose landfill sites that are both safe and acceptable to the local community.

3. Location and Construction Process

3.1 Selection of location

(1) Site Selection Process

There are several approaches for selecting a suitable location for a landfill site depending upon its objective. This paper describes one of relatively general approaches. Figure 3-1 shows the procedure for selecting a suitable location.

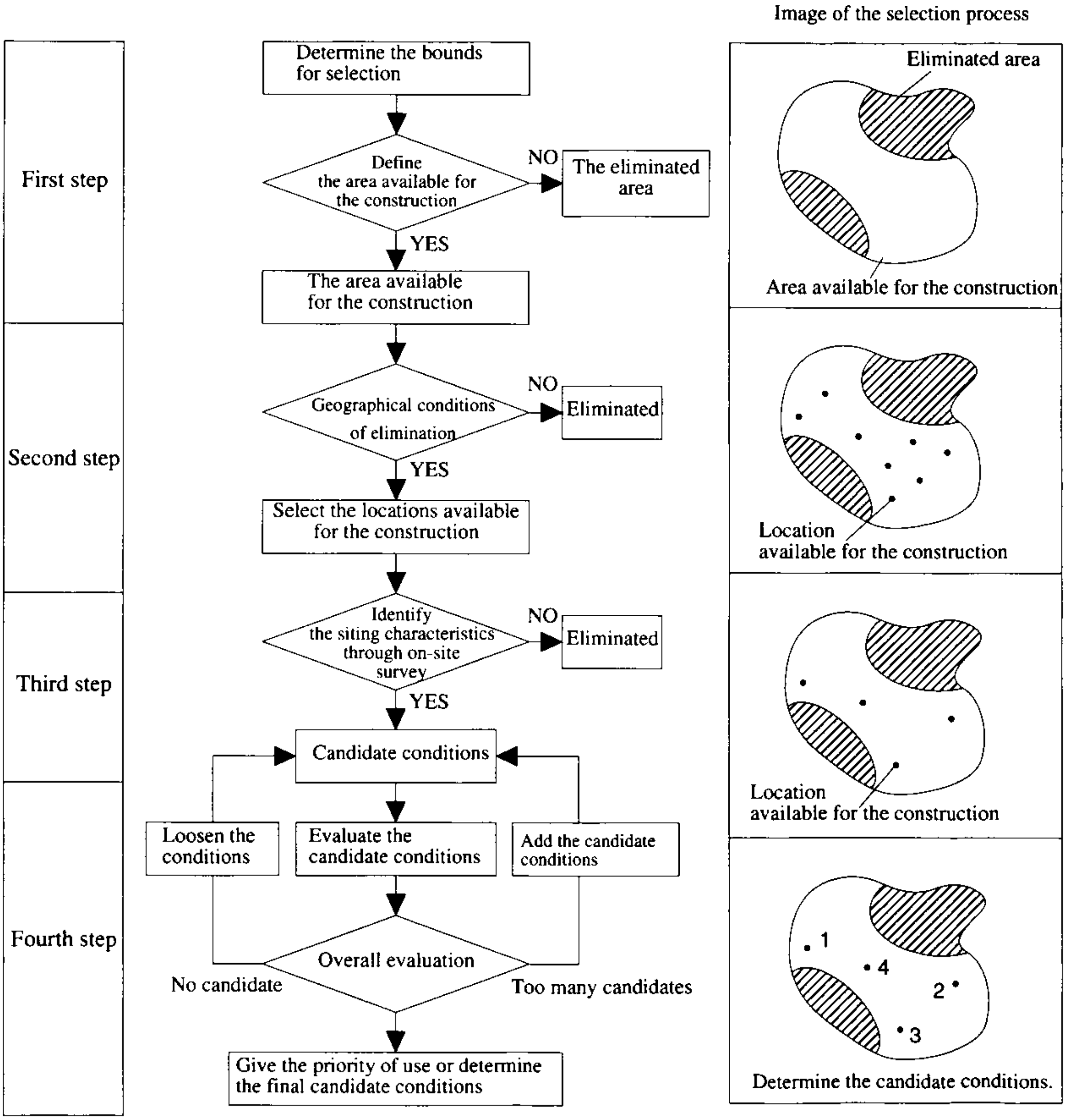


Figure 3-1 Example procedure for selecting a suitable conditions

(2) First step

The first step is to determine the bounds for selecting a location of a landfill site and eliminate the areas that are under legal control by the regulations concerning the land use in terms of locating a landfill site. The area available for the construction of the site are defined through this step.

The areas where the existing regulations cannot be removed easily or approval by the competent authorities of the government are required because of the applicable legal controls concerning the land use are eliminated in advance through this step from the area for selecting a suitable location.

Table 3-1 shows an example classification of areas under legal controls concerning the land use. Which of the listed controls must be considered as the condition of elimination in the first step depends upon each case. In most cases, however, the areas under rank C in Table 3-1 are normally eliminated from the area to be studied.

To define the area, prepare topographical maps of 1/200,000 to 1/50,000 scale depending upon conditions of the area to be selected, and overlay the maps, each representing the area under each legal control that is listed up in the first step as the conditions of elimination. Figure 3-2 illustrates the process.

(3) Second step

In the second step, after the area for selecting the landfill site is defined in the first step, concrete locations available for constructing the site are selected in the area. Defining the geographical conditions for the construction beforehand will allow relatively smooth selection of the candidate locations. The geographical conditions include, for example:

① It must be a mountainous location with a ravine.

② There is no village in the neighborhood.

③ The required landfill capacity can be attained.

④ ....

In selecting the locations, it is recommended to use a topographical map of 1/25,000 to 1/50,000 scale.

Figure 3-3 shows the process image of the second step. Because the area of a land on a map expands by 64 times when the map is scaled up from 1/200,000 to 1/25,000, selection of the locations requires perseverance.

Because the contour lines on a topographical map of 1/25,000 scale are too widely spaced to locate a small size landfill site between them, the above approach is suitable for locating a landfill site of a medium size (more than $100,000m^3$) or larger.

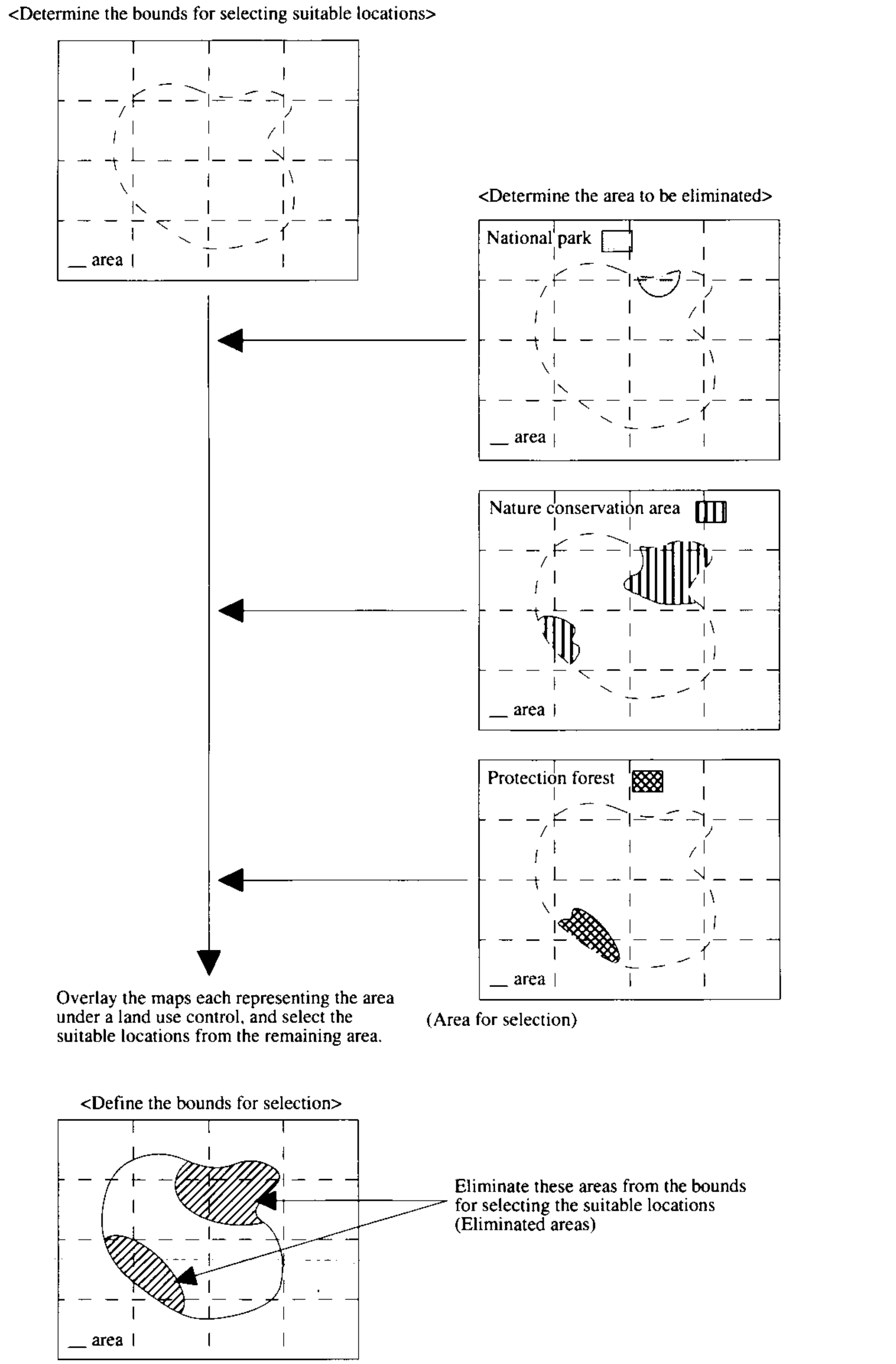
Table 3-1 Classification of Statutory Land Use Restrictions in Japan

Major classification	Area classification	Land use category	Applicable law	Rank
Category of land use plan	Urban area	Urbanization area	City Planning Law	A
		Urbanization control area	City Planning Law	A
		Use district	City Planning Law	A
		Esthetic zone	City Planning Law	A
		Scenic zone	City Planning Law	A
		Green conservation area	City Green Zone Conservation Law	A
		Historic landscape special preservation area	Special Measures Law for the Preservation of the Histtoric spot, bearty spot, natural monument	C
		Production green zone	Production Green Zone Law	A
		Historic spot, beauty spot, natural monument	Law for the Protection of Cultural Properties	C
		Traditional architectures preservation district	Law for the Protection of Cultural Properties	C
	Agricultural area	Farmland	Agricultural Land Law	A
		Agricultural promotion area	Law concerning Development of Agricultural Promotion Area	B
		Production green zone	Production Green Zone Law	A
	Forest	National forest	Forest Law	C
		Private forest	Forest Law	B
		Protection forest	Forest Law	C
Category of natural preservation	Natural park area	National and quasi-national park	Natural Parks Law	C
		Prefectural national park	Natural Parks Law	B
		City park	City Parks Law	B
	Nature conservation area	Green zone conservation area	City Green Zone Conservation Law	A
		Suburban green space conservation area	Suburban Green Space Conservation Law	A
		Wilderness area	Nature Conservation Law	C
		Special wildlife protection area	Wildlife Protection and Hunting Law	C
		Preserved tree	Law concerning Preservation of Trees for Conservation of Scenic Bearty of Cities	C
Category of disaster prevention		River basin	River Law	B
		Landslide prevention area	Landslide Prevention Law	B
		Designated sand control area	Sand Control Law	B
		Sharp slope fall danger area	Law concerning Protection of Disasters due to Fall of Sharp Slope	B
		Housing site preparation construction restricted area	Housing Site Preparation Control Law	B

Rank A
* The control on the development can be removed by the meyor
* The control does not apply to the construction of a landfill site.

Rank B
* The approval of the prefectural governor is required to remove the control on the development.
* The approval of the national government is required, but its procedure is relatively simple.

Rank C
* The approval of the national government is required.
* An important installation that cannot be removed or relocated physically.



* Process base: Topographical map of 1/200,000 to 1/50,000 scale

Figure 3-2 Process in the first step

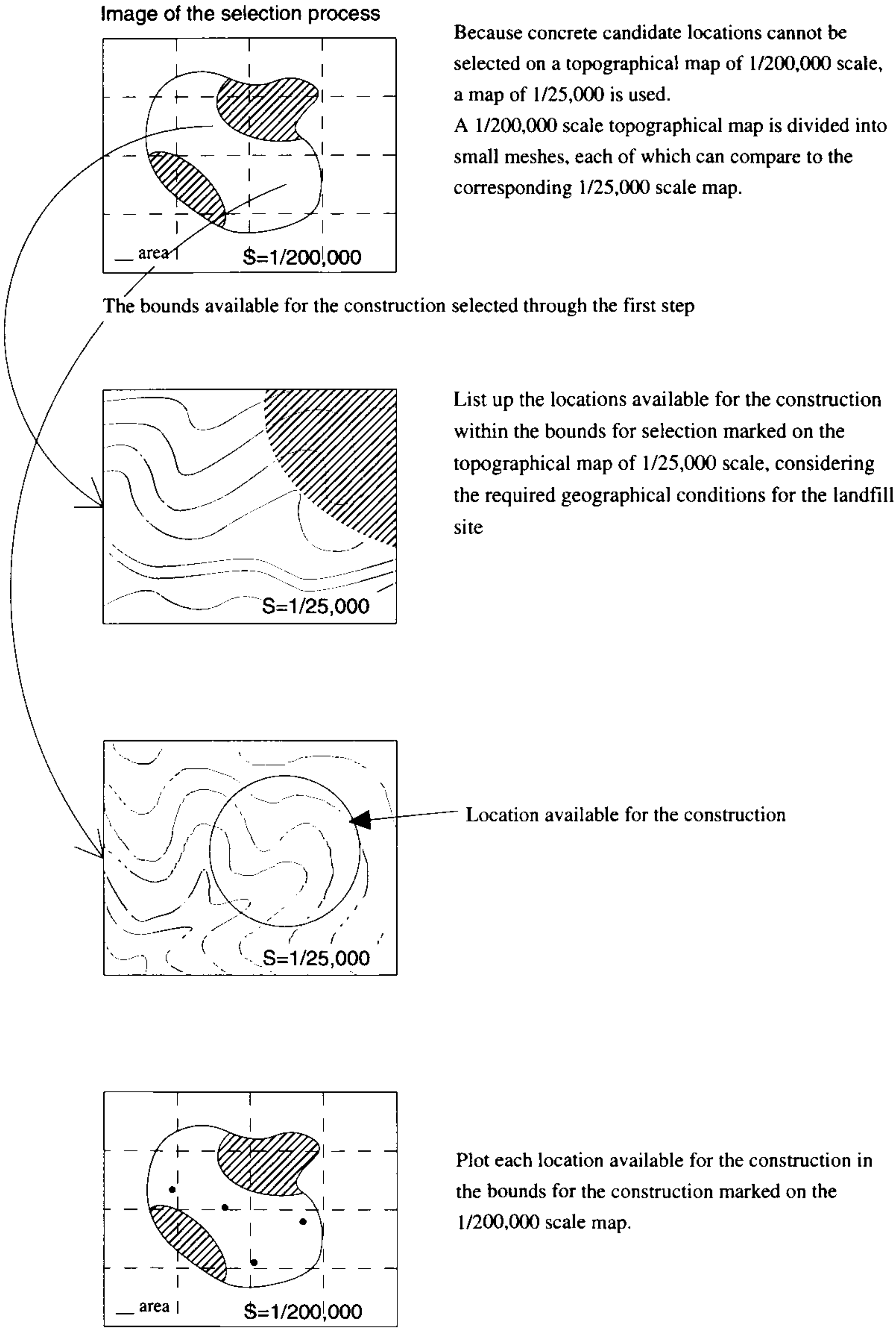


Figure 3-3 Process in the second step

(4) Third step

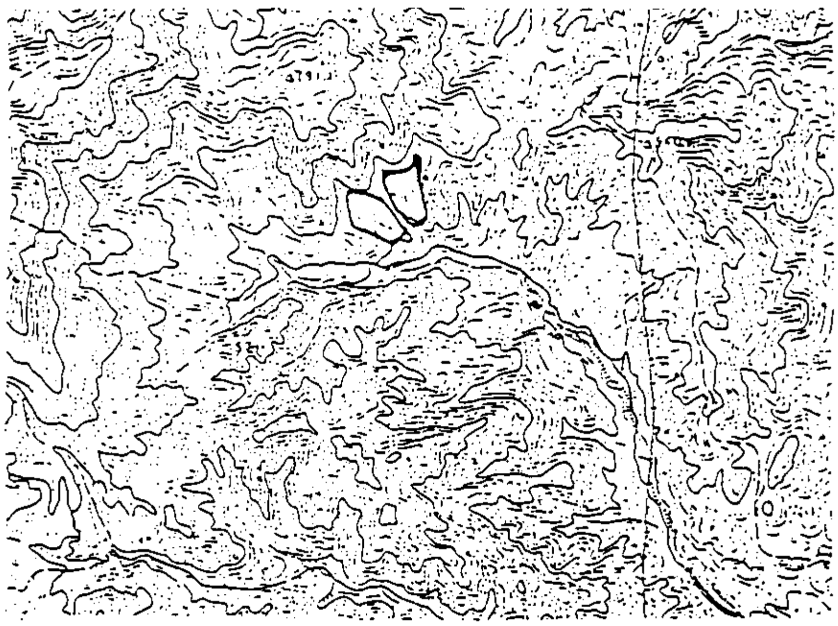
In the third step, an on-site survey is carried out at each candidate location available for the construction selected in the second step. It facilitates the on-site survey to examine the landfill area , landfill capacity, drainage area and other requirements of the location prior to the survey using a more precise topographical map (1/5,000 scale).
The procedure up to the second step is a desk study. Accuracy of the contour lines is rough because topographical maps are based on air photographs.
If any candidate location is close to an area under the land use control, it is necessary to confirm at site that the location is outside the restricted areas are normally indicated on a 1/200,000 scale map. Accordingly, the items to be surveyed and confirmed at site will include the topography, geology, land category, condition of rivers, condition of water utilization, locations of villages, landscape, existence of traffic and urban facilities including transportation access, condition of other legal controls, and overall safety.
If, for any candidate location, an additional legal control or other development program is newly known or if it is found that the city water supply source is located in the downstream area, it must be excluded from the locations available for the construction.
Figure 3-4 is an example on-site survey sheet of a case where the landfill area and capacity are determined according to the basic forest map.

(5) Fourth step

In the fourth step, each of the candidate locations screened through the on-site survey is evaluated and given the priority of use. Thus, the final candidate location is determined.
Items to be evaluated can be grouped into those on the siting characteristics, the environmental characteristics and the economy of the landfill site. The siting characteristic of the landfill site include the landfill efficiency, availability of the cover soil, extension of the access road, and utilization value of the landfill.
The landfill efficiency can be represented by the potential landfill capacity divided by the landfill area. Generally, the size of the landfill site facilities (e.g. leachate treatment facility, leachate collection pipes, and the area of the flexible menblene liner) are apt to be determined by the landfill area, and the construction cost of the facilities depend upon the landfill area. When two landfill sites are compared and if they are of the same landfill area, the one with larger landfill capacity is more economical. It therefore is possible to evaluate the landfill sites according to the mean landfill height which is the potential landfill capacity divided by the landfill area.
Considering the availability of the cover soil, daily cover soil, intermediate cover soil and final cover soil are generally required. Whether the cover soil is available at site or must be purchased from outside is an important factor.
The access road must be as short as possible. However, when the landfill site is located at a mountainous place, the extension of the access road becomes longer due to the higher elevation.
The ultimate land use value of the landfill increases when a flat land acquired as a result of the landfill is wider because the possible application of the land becomes wider. In view of this, it is effective to include in the evaluation items of the siting characteristics the percentage of a flat land out of the complete landfill.
Matters relating to the environmental characteristics can be well managed and the construction can be carried out smoothly by investigating and evaluating details of the natural conditions and social conditions well in advance.
The economy is related particularly closely to the siting characteristics, so the siting characteristics can substitute. The evaluation items are the construction cost and maintenance cost.
The criteria of the evaluation depend upon the conditions of the selected locations. Table 3-2 lists example evaluation items and criteria. The overall evaluation is done on the basis of each evaluation item, and the priority of use for each candidate location is determined. If no location remains any longer as the candidate at this stage of the evaluation, the conditions must be loosened to review the candidate locations. If too many candidate locations still remain at this stage, the conditions must be tightened to reduce the number of the candidates.

When the candidate locations are selected over a wide range of area, expressing each candidate location by means of a radar chart allows to check the local characteristics of the area and the characteristics of each candidate location in a relatively objective view. It is a method to relatively display the mean of the evaluation scores of all candidate locations in the area and the deviation of the score of individual candidate location.

Location available for the construction : No.__



Landfill capacity	m^3	Landfill area	m^2	Drainage area	m^2

Topography	Gentle slope with narrow width. Possible to attain the capacity.
Geology	No active fault in the neighborhood within 1 km. Weathered sand stones.
Land category	Forest, waste land.
Condition of rivers	First Class River ***lines in about 2.0 km to the east. Environmental quality standard model A.
Condition of water utilization	Utilized for agriculutural irrigation.
Locations of villages	Residences in about 500m to the southwest.
Landscape	Cannnot be seen from the public road.
Transportation access	An access road through ***destrict via the prefectural route ***.
Existence of urban facilities	None.
Other legal controls	None.
Overall safety	No private house along the access road. Thus, no traffic interfence.
Others	

Figure 3-4 Process in the third step

Table 3-2 Evaluation Elements and Criteria

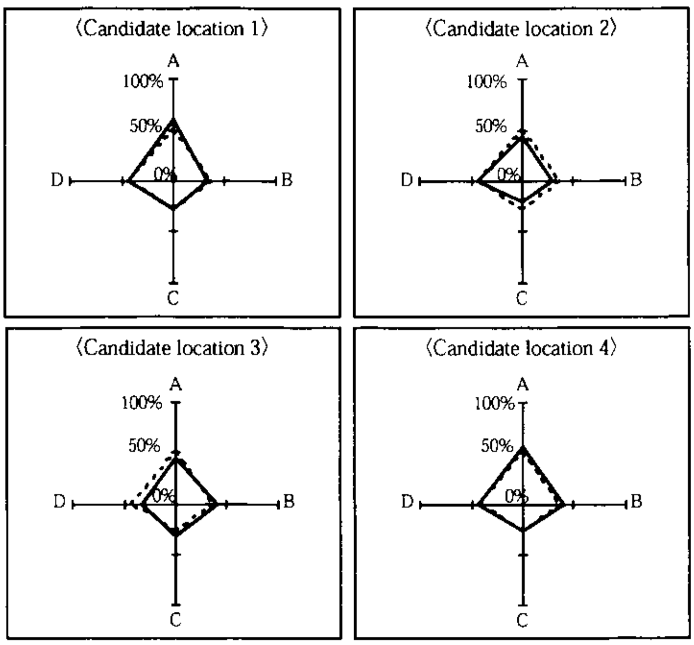
Evaluation items			Criteria		
	Major item	Minor item	Rank 1 (High suitability)	Rank 2 (Ordinary suitability)	Rank 3 (Low suitability)
Siting characteristis	Siting characteristis (A)	Landfill efficiency	The landfill efficiency (landfill capacity m^3/landfill area m^2) is 10 or more.	The landfill efficiency is 5 or more but less than 10.	The landfill efficiency is less than 5.
		Availability of the refill	The entire refill can be obtained at the candidate location.	Part of the refill can be obtained at the candidate location.	No refill is available.
		Extension of the access road	The extension from the public road to the final landfill surface of the landfill site is less than 2,000m.	The extension from the public road to the final landfill surface of the landfill site is 2,000m or more but less than 3,000m.	The extension from the public road to the final landfill surface of the landfill site is more than 3,000m.
		Utilization plan of the landfill (flat land/landfill)	75% or more of the landfill can be made a flat land, which allows smooth utilization of the landfill.	50% or more but less than 75% of the landfill can be made a flat land, which allows normal utilization of the landfill.	Only less than 50% of the landfill can be made a flat land, which does not allow smooth utilization of the landfill.
Environmental characteristics	Natural conditions (B)	Geography	No active fault exists within 1 km around the candidate location, nor any thick colluvium or old colluvial slope is seen.	No active fault exists within 1 km around the candidate location, but thick colluvium or old colluvial slope can be seen in the neighborhood.	No active fault exists within 1 km around the candidate location, but thick colluvium or old colluvial slope can be seen within the candidate location.
		Plant and animal	Inhabitation of special plants or animals has not confirmed within 2 km around the candidate location.	Inhabitation of special plants or animals has been firmed within 2 km around the candidate location.	Inhabitation of special plants or animals has been firmed within the candidate location.
		Vegetation	Degree of natural vegetation is 1 to 3.	Degree of natural vegetation is 4 to 6.	Degree of natural vegetation is 7 to 10.
	Social conditions (C)	Land use	Afforested or cultivated land is less than 1/3.	Afforested or cultivated land is 1/3 or more but less than 2/3.	Afforested or cultivated land is 2/3 or more.
		Cultural properties	Designated cultural properties have not been confirmed within 1 km around the candidate location.	Designated cultural properties have been confirmed 500m or more apart but within 1km around teh candidate location.	Designated cultural properties have been confirmed within 500m around the cadidate location.
		Human residences	There is no human residence within 1 km around the candidate location.	There are human residences 500m or more apart but within 1km arond the candidate location.	There are human residences within 500 m around the candidate location.
	Environmental conditions (D)	Situation of water utilization	The river to which the drain is to be led is not utilized.	The river to which the drain is to be led is utilized for agriculture.	The river to which the drain is to be led is utilized for water industry.
		Smell, noise, vibration	There is no village within 1 km around the candidate location.	There is a village 500 or more apart but within 1km around the candidate location.	There is a village within 500 m around the candidate location.
Economy	Economy conditions (E)	Approximate construction cost (excluding access road)	Less than ¥___/m^3	¥___/m^3 or more but less than ¥___/m^3	¥___/m^3 or more
		Access road constructon cost	Less than ¥___	¥___ or more but less than ¥___	¥___ or more
		Approximate maintenance cost	Less than ¥___/m^3	¥___/m^3 or more but less than ¥___/m^3	¥___/m^3 or more

Even if a suitable location for the landfill site is selected on the scientific basis, it cannot be used as the landfill site unless the consensus of the land owners and neighboring residents cannot be attained. Because the selection process begins with the third step in most cases, argument is focused on the issues relating to an individual location and the question from the residents "Why the landfill site is to be constructed at this location?" cannot be positively answered in most cases. Accordingly, selecting a suitable location on the scientific basis becomes more and more important.

Table 3-3 is an example of the evaluation table of candidate locations and Figure 3-5 is an example of the overall evaluation using radar charts.

Table 3-3 Example evaluation of candidate locations

Classification		Item	Candidate locations			
			1	2	3	4
Siting characteristics	Siting characteristics (A)	Landfill efficiency	3	2	1	1
		Availability of the refill	2	2	2	3
		Extension of the access road	3	2	3	3
		Utilization plan of the landfill	3	2	2	3
		Subtotal of evaluation	11	8	8	10
Environmental characteristics	Natural conditions (B)	Geography	3	2	2	2
		Plant and animal	1	1	2	2
		Vegetation	1	1	1	1
		Maximum snowfall in a year	1	1	2	2
		Subtotal of evaluation scores	6	5	7	7
	Social conditions (C)	Land use	2	1	2	1
		Cultural properties	1	1	2	2
		Human residences	1	1	1	1
		Subtotal of evaluation scores	4	3	5	4
	Environmental conditions (D)	Situation of water utilization	2	2	2	2
		Smell, noise, vibration	2	2	1	2
		Subtotal of evaluation scores	4	4	3	4
	Total environmental characteristics scores		14	12	15	15
Approximate project cost	Approximate construction cost		3	2	1	1
	Access road construction cost		3	2	3	3
	Approximate maintenance cost		2	2	1	2
	Subtotal of approximate project cost		8	6	5	6
Total scores			33	26	28	31
Rank			N	1	2	3



A : Siting characteristics
B : Natural conditions
C : Social conditions
D : Environmental conditions

The mean of the evaluation scores of all candidate locations in the area : - - - -
The deviation of the score of individual candidate location : ———

Figure 3-5 Example of overall evaluation using radar charts

3.2 Construction Process

Figure 3-6 is a schematic description of how a landfill site is constructed.

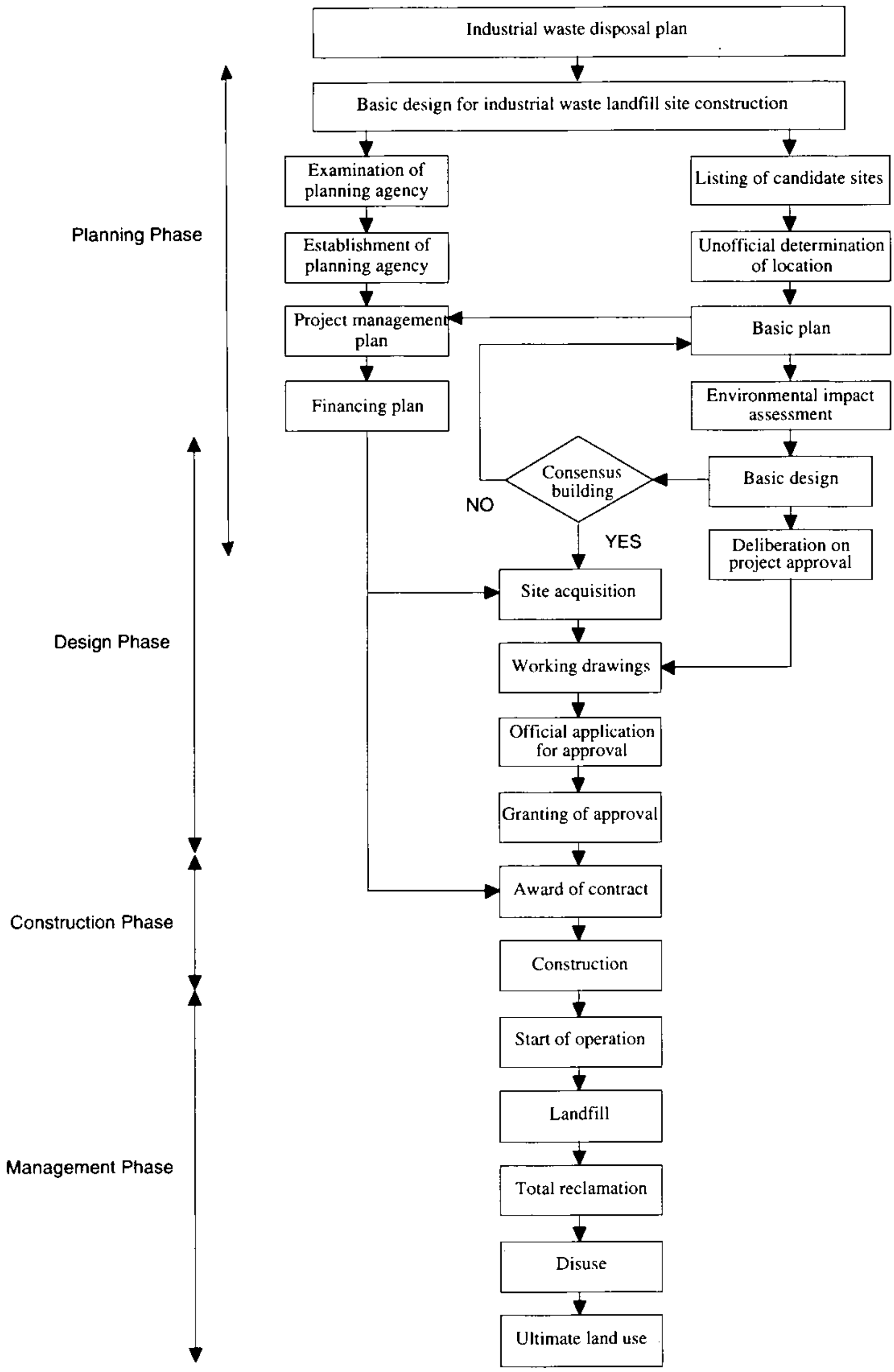


Figure 3-6 Construction Process of Industrial waste landfill site

Phase I begins with the making of a basic design for the construction of a industrial waste landfill site.
Under the provisions of Article 11 of the Waste Disposal Law, the prefectural governor is required to formulate an industrial waste disposal plan. This is a master plan of the prefecture's industrial waste treatment measures, specifying the estimated volume of industrial waste by type, the amount of waste disposal, a volume reduction scheme, and a policy for the establishment of treatment facilities. This prefectural plan, which must be developed once every five years or at equivalent intervals, reflects the prefecture's basic attitude toward the disposal of industrial waste. The drafter of the basic design can know in advance, by grasping this prefectural disposal plan and ensuring the construction of adequate facilities, whether there are competing public or private facilities or what requirements will be imposed on waste collection and delivery. Upon finalization of the basic design, candidate sites will be picked up.
After unofficial determination of the location, the making of a basic plan and a living environment research takes place with respect to the proposed site, with official notice and an opportunity for inspection given to the general public so that interested residents may submit their opinion and experts may be heard on the proposal. Taking all those things into consideration, the prefectural governor approves or disapproves the proposal.
In the second phase, the site is surveyed for acquisition purposes and the boundaries of the area to be purchased or taken on lease are clearly defined. This activity is followed by the making of working drawings to award the contract and obtain necessary approvals. Again in this process, a geological survey and land measurement must be carried out. In the subsequent phase, the construction contract is awarded. The construction of a landfill site is an extremely time-consuming process: at least four years must be allowed for the completion of all steps from site determination to project construction even if consensus is built smoothly. Therefore, a good safety margin should be incorporated into the construction plan. The time needed for construction work itself may range from ten to twenty months depending on the terrain, geological conditions, and size of the site.

3.3 Environmental Impact Assessment

Figure 3-7 shows a typical procedure for an assessment of impact that the landfill site may have upon the living environment. The identification of general local conditions covers the location of the planned area, present environmental conditions both natural and social, and environmental quality. Then the specifics of the construction plan are discussed based on a basic facility construction plan.

All these steps are intended to make clear interrelations between environmental elements and such factors affecting environmental impact as may be presented by the construction of the site and the operation of disposal facilities.

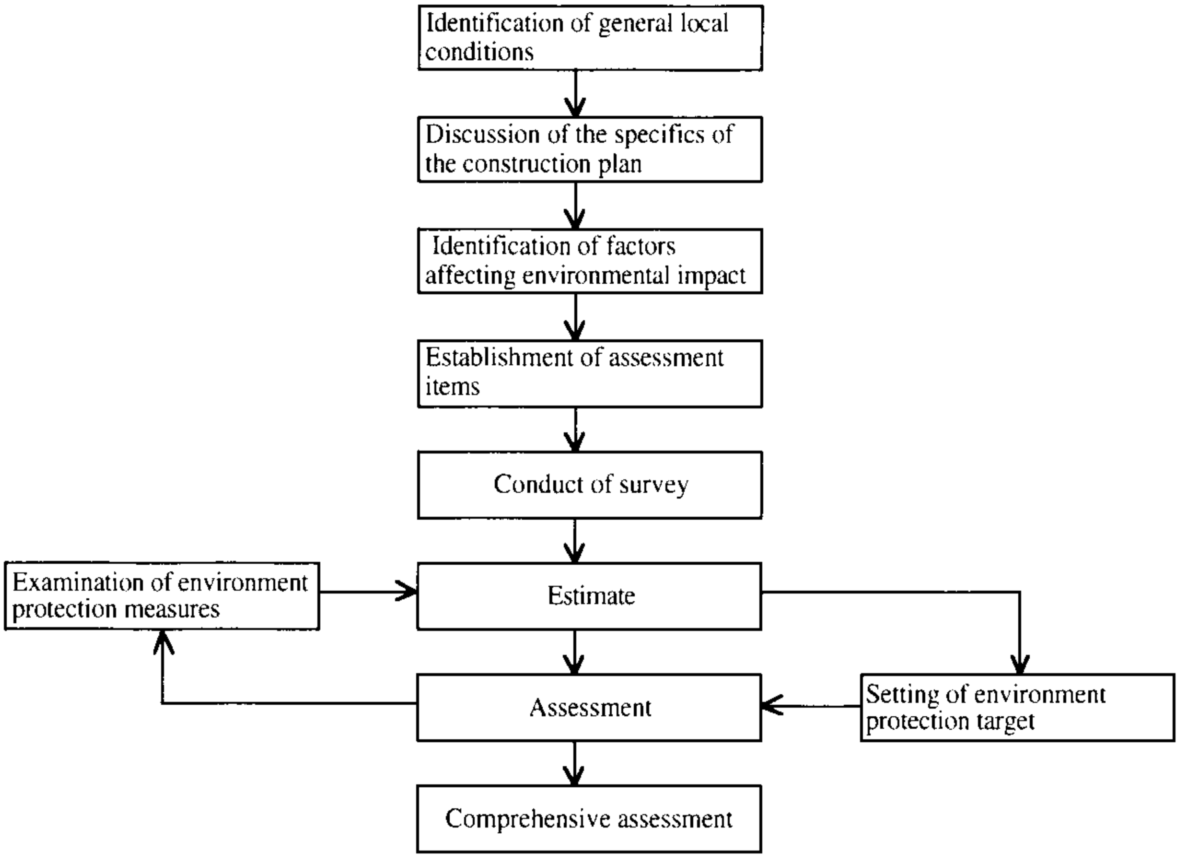


Figure 3-7 Typical Procedure for Environmental Impact Assessment

Figure 3-8 is a schematic description of often observed interrelations between landfill site-originated factors affecting environmental impact and environmental elements, a tabular version of which is provided by Table 3-4. Environmental impact assessment covers those environmental elements which, as a result of analysis of the table, are expected to be (A) very closely or (B) fairly closely linked with the affecting factors.

Besides this assessment, on-the-spot surveys should be conducted, wherever possible, on the quality of the water and riverbed, noises, vibration, offensive odors, flora and fauna, and landscapes. Such surveys should be carried out in every season of the year, but depending on the size of the disposal site and local conditions, any less frequency may be acceptable.

The estimate evaluation process involves the setting of standards related to environmental elements and region-specific environment protection targets, and in the event that the estimates do not reach the targets, environment protection measures are considered and the estimation process is repeated.

Upon completion of the environmental element estimation and assessment, evaluations in all such elements are combined together, the extent of impact that the project may have upon the surrounding environment is ascertained, and the possibility of and measures required for maintaining the present environment at an appropriate level are set forth in the form of comprehensive assessment.

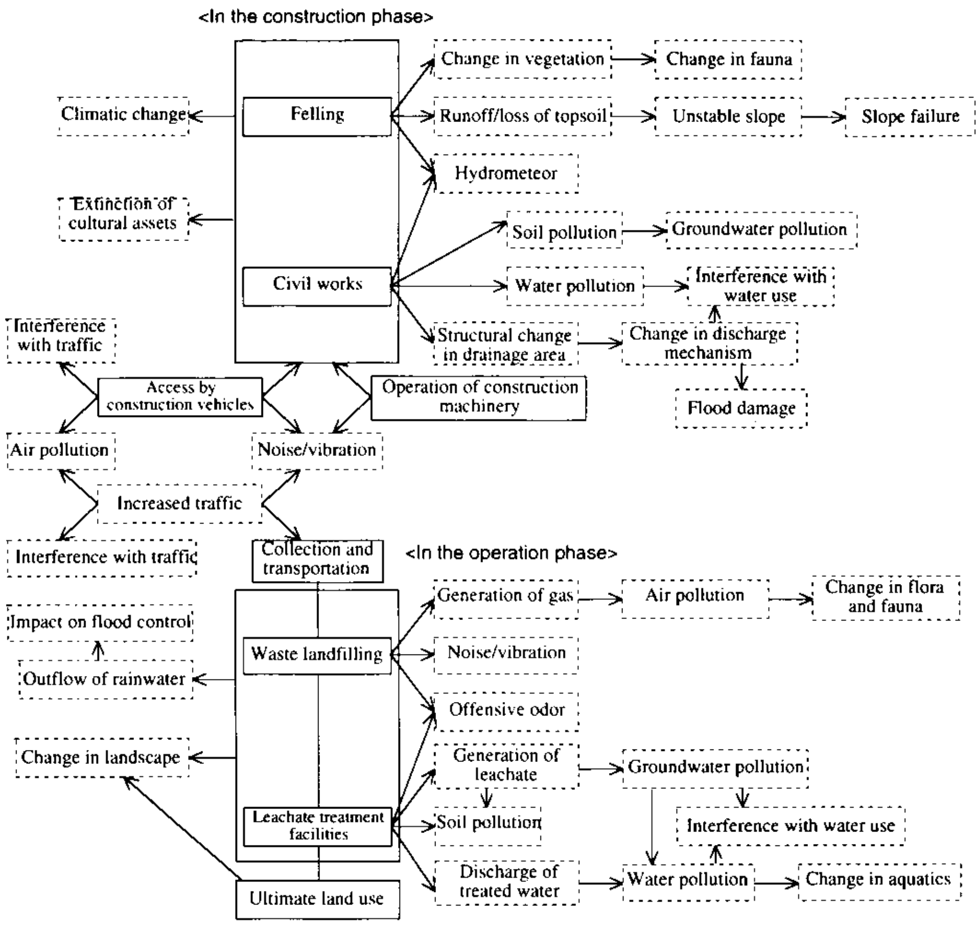


Figure 3-8 Interrelations between Landfill site-Originated Factors Affecting Environmental Impact and Environmental Elements

Table 3-4 Interrelation matorix of Environmental Impact and Environmental Elements

Factors affecting environmental impact / Environmental element		Air quality	Water quality	Soil pollution	Noise	Vibration	Offensive odor	Land subsidence	Flora	Fauna	Landscape	Cultural assets
Construction phase	Felling		C						B	B	A	C
	Civil works		B	B	B	B						C
	Access by construction vehicles	C			B	C						
Operation and post-reclamation phases	Collection and transportation	C			B	C	C					
	Waste landfilling	C			B	C	B	C	B	B	C	
	Leachate treatment facilities				C	C	B					
	Discharge of treated water		A									
	Outflow of rainwater		C									
	Infiltration of leachate		B									
	Ultimate land use										A	

(Note) The extent of interrelation

A : great, B : moderate, C : small, No mark : no interrelation

4. Techniques for Controlled Landfill sites

4-1. Facility Structure

(1) Composition

A landfill site has the facilities shown in Figure 4-1, which altogether form an organic whole. Figure 4-2 is a pictur of these facilities as may be actually laid out on the site.

- Landfill site
  - Major facilities
    - Solid waste retaining structure
    - Liner facility
    - Leachate collection facility
    - Leachate treatment facility
    - Runoff collection facility
    - Gas treatment facility
    - Others
  - Control facilities
    - Transport control facility
    - Monitoring facility
    - Control building
    - Others
  - Incidental facilities
    - Approach road
    - Littering prevention facility
    - Disaster prevention facility

Figure 4-1 Facilities of a Landfill site

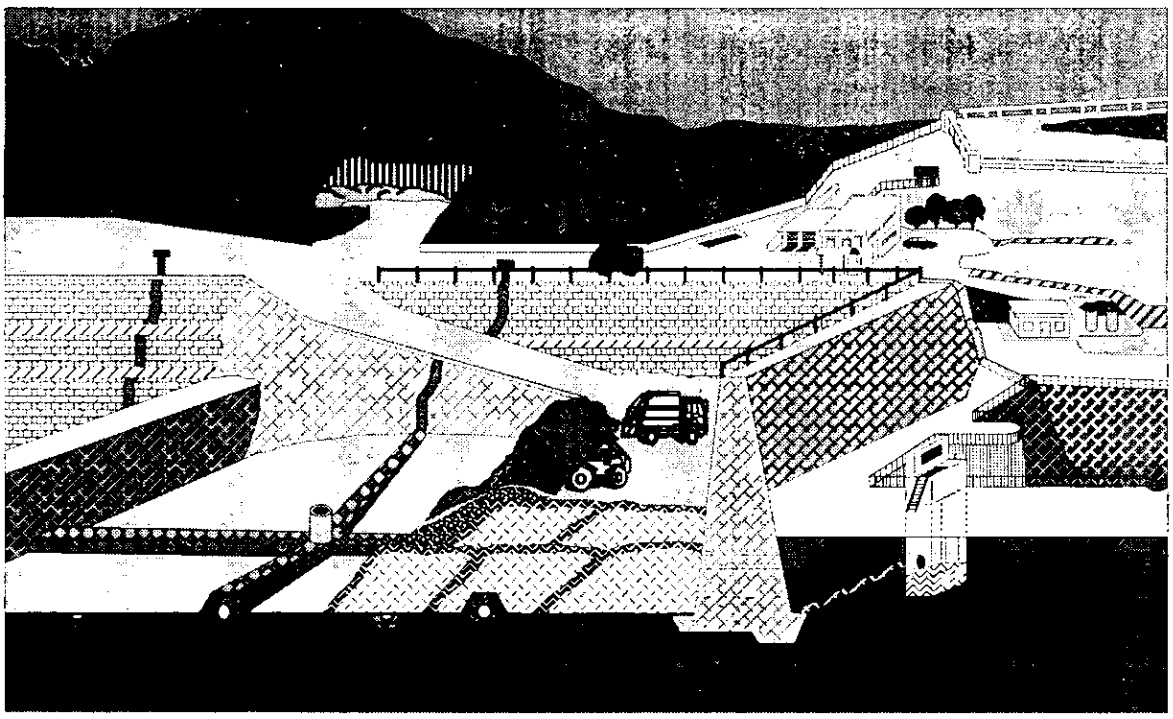


Figure 4-2 Sketch of a Landfill site

(2) Leachate Treatment System [7)]

In many cases, each of these facilities is designed as a separate and independent unit, not so as to function in good coordination with others, a consequence of which is underutilization of its capacity.
In Table 4-1, design factors are listed for each of the facilities.

Table 4-1 Design Factors for a Leachate Treatment System

Facil \ Design factor	Terrain	Geological feature	Rainfall	Ground water	Area of landfill	Volume of landfill	Quality of waste	Note
Land development	○	○	○	○	○	○		
Approach road	○	○						
Transport control facility	○	○				○		
Liner facility		○		○	○		○	Including groundwater drainage pipe.
Collection pipe			○		○		○	Including protective works.
Gas collection facility					○	○	○	
Solid waste retaining structure	○	○	○	○		○		
Leachate treatment facility	○		○	○	○		○	Including leachate regulation facilities.
Runoff collection facility			○		○			
Disaster prevention facility	○	○	○		○			Such as storm-water retention tanks and slope protections.
Littering prevention facility	○						○	
Monitoring facility			○	○	○	○	○	

In addition to pointing out the importance of terrain and geological features as determinants of the size and shape of facilities, this table shows that, in respect of three components closely related with a leachate treatment system, namely the collection pipe, the solid waste retaining structure, and the leachate treatment facility, design factors are rainfall, the area of landfill, and the quality of waste.
This suggests that the quality of leachate and the physicochemical properties of landfilled waste can be computed or estimated from precipitation, the area of landfill, and/or the quality of landfilled waste.
Figure 4-3 is a flow chart of leachate treatment system designing based on the foregoing.
The planning and design of a landfill site begins with a land survey, a geological/groundwater survey, a hydraulic study, and a research on the quality of handled waste.
Next, the findings of the land and geological/groundwater surveys are used to elucidate the water discharge mechanism at the proposed site, a basic policy is set for liner facility, and a land development plan is formulated. This plan is intended to secure a sufficient volume of landfill to accommodate the planned amount of specified waste and ensure the right facility configuration for the effective functioning of a leachate control system. The location and height of the solid waste retaining structure are major considerations in securing adequate landfill space and estimating the water balance at the site.
Land development planning is followed by the planning of the approach road, transport control facility, leachate collection facility, runoff collection facility, gas collection facility, littering prevention facility, and disaster prevention facility. The landfill and facility plans should allow for ultimate land use.
Next, the amount of treated water is set and the amount of leachate is computed from the landfill plan, and the calculated water balance is used to obtain the amount of treated water and determine the capacity of leachate regulation facilities, the solid waste retaining structure, and other facilities.
Fixed as the capacity of leachate treatment facilities is, the amount of leachate varies from day to day according to precipitation. In order to ensure their stable operation, therefore, some leachate amount regulation system must be installed between the landfill and treatment facilities. As the amount of treated water is determined by the capacity of the leachate regulation facility, its optimum amount and the adequate regulation capacity therefor must be figured out from the water balance.

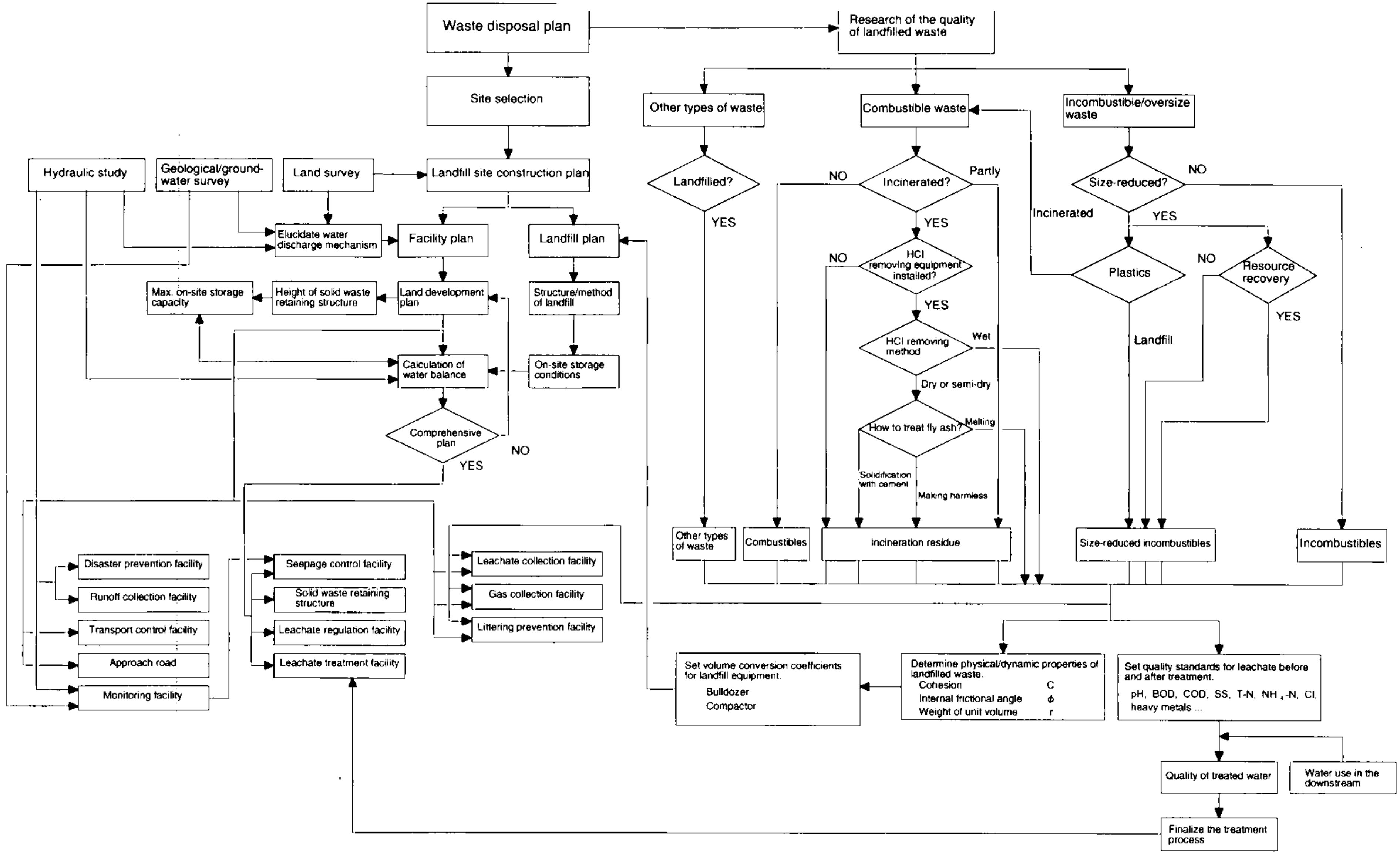
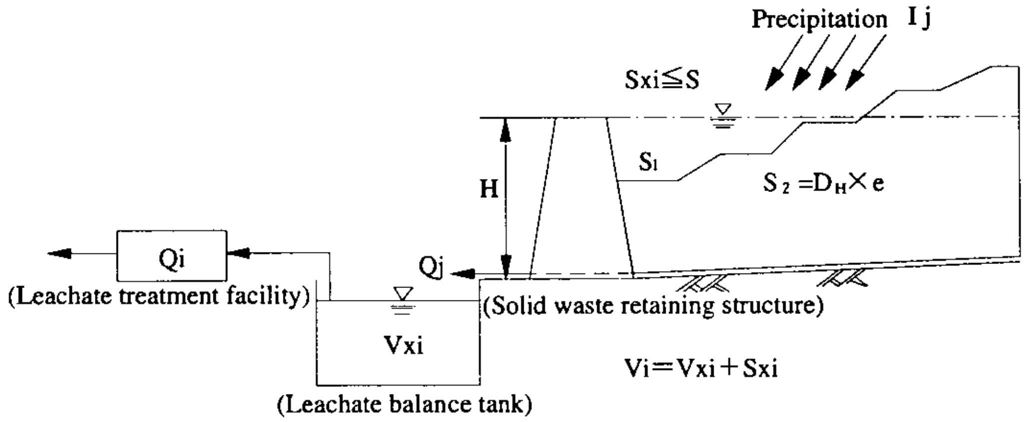


Figure 4-3 Leachate Control System Designing Process

However, in winter or in the year of less leachate, it would be necessary to reduce the amount of treated water according to the remaining capacity of the leachate regulation facility so as to protect the bioremediation process. The number of rainy days used in the calculation of the water balance should be determined on the basis of the year with the record high annual or monthly precipitation or the average rainfall over the past twenty years, which can be identified by reference to precipitation records, with necessary adjustments for hydrologic probabilities.

A leachate regulation facility is generally backed up with internal storage, though this depends on the definition of hydrologic probability. Internal storage will, however, result in water sealing of the landfill layer, which in turn will give rise to anaerobic conditions and cause water quality to deteriorate. It is thus necessary to limit the length of continuous internal storage in light of the landfill structure.

Where the required capacity of a leachate regulation facility (Vxi) is a sufficient amount to meet both the requirement that the semi-aerobic landfill be maintained for a specified number of days per year and a limitation on the number of days of continuous internal storage and the required internal storage amount (Sxi) is any amount beyond that capacity, Sxi is obtained by deducting Vxi from Vi (where Vi is the leachate regulation capacity computed from the water balance) (see Figure 4-4).



$Qj=1/1.000 \cdot Ij \cdot (C_1 \cdot A_1+C_2 \cdot A_2)$

Where Ij is precipitation on Day J (mm/day); A_1 is the area of the section currently under waste landfill (m^2); A_2 is the area of the landfill section after completion of landfill (m^2); C_1 is the leachate coefficient before landfill is completed (0.5); C_2 is the leachate coefficient after landfill is completed (0.3); Qi is the amount of treated water (m^3/day); Vxi is a regulation capacity based on the average annual rainfall (required regulation capacity; m^3); Vi is a regulation capacity based on the record high annual precipitation (maximum leachate regulation capacity; m^3); Sxi is the required internal storage amount (Sxi=Vxi-Vi; m^3); H is the height of the solid waste retaining structure (m); S is the maximum internal storage capacity ($S=S_1+S_2$; m^3); D_H is the landfill capacity when the depth of the landfill section is equal to the height of the solid waste retaining structure H (m^3); and e is the porosity of the landfill layer available for leachate storage (5% - 10%).

Figure 4-4 Interrelations of Facilities

As shown in Figure 4-4, the internal storage capacity (S) is limited by the height of the solid waste retaining structure (H). Where D_H is the landfill capacity when the depth of the landfill section is equal to that height (H) and e is the porosity of the landfill layer, the internal storage capacity (S) can be calculated by the following expression.

$S = S_1 + S_2 = S_1 + (D_H \times e)$

Where

S is the internal storage capacity;

S_1 is the empty capacity below the height of the solid waste retaining structure (H); and

S_2 is the amount of leachate stored in the landfill layer below the height of the solid waste retaining structure (H).

The amount of treated water (Qi), the required capacity of a leachate regulation facility (Vxi), and the height of the solid waste retaining structure (H) must meet the requirement that the required internal storage amount (Sx) be equal to or less than the internal storage capacity (S) and must be optimum in light of the site's overall evaluation, including economy and maintenance/management policy.

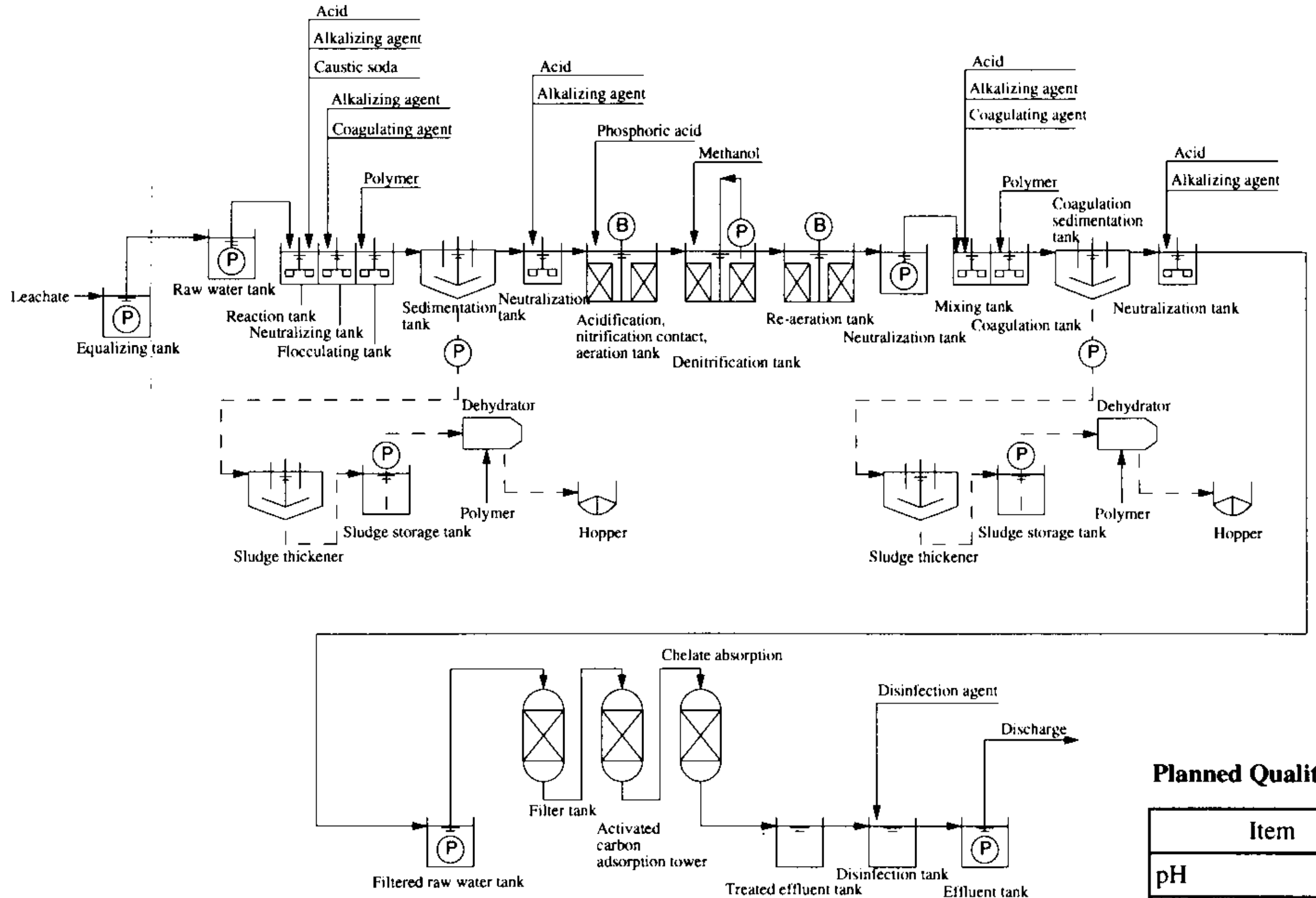
In the meantime, the physical/dynamic and chemical properties of landfilled waste should be determined for incorporation into the landfill plan and the leachate treatment/gas collection facility plan, respectively.

With the advance of intermediate treatment facilities and advanced separation of recyclable waste, it carried into landfill sites has become diverse in property. Consistent with Figure 4-3, landfilled waste is generally classified as shown in Figure 4-5.

- Landfilled waste
  - Combustible waste
  - Incineration residue
    - Where there are no facilities for removing hazardous gas
    - Where there are wet-type facilities for removing hazardous gas
    - Where there are dry- or semi-dry-type facilities for removing hazardous gas
      - Where fly ash has been treated
      - Where fly ash has not bee treated
    - Where there is a dust collector but it can not sort out fly ash
  - Incombustible/oversize waste
  - Pulverized incombustible waste
    - Those containing plastics
    - Those not containing plastics
    - Those containing recyclable waste (iron, bottles, etc.)
    - Those not containing recyclable waste (iron, bottles, etc.)
  - Other types of waste

Figure 4-5 Classification of Waste

Which types of waste will be disposed of in a landfill is determined by a basic waste disposal plan specifying the fundamental collection and disposal policy. This makes it possible to determine the physical and dynamic properties (especially c, ϕ , and r) of landfilled waste beforehand and incorporate them into a landfill plan and design requirements (such as the volumetric conversion coefficient, the internal storage capacity, and slope protection).
The facilities comprising a landfill site are thus organically linked with other facilities and plans, and it is extremely important to consider them in facility construction and management.
The leachate treatment process, although dependent on the type of landfilled waste and uses for the river into which treated water is discharged, consists generally of biological treatment using a rotating contactor or biological contact aeration equipment, coagulating sedimentation, and physicochemical treatment using filters or activated charcoal.
Figure 4-6 shows a typical leachate treatment process.
The quality of leachate varies according to the types of waste accepted for landfill.
Any treated water may not be discharged before its quality satisfies the effluent standards set forth in Table 4-2; in many cases, however, lower thresholds are applied in practice (see Figure 4-6).



Area:Leachate treatment facilities 3,300 sq. m.

Leachate regulation reservoir 5,200 sq. m.

Capacity: 280 cub. m. per day (two biological treatment systems 140 cub. m. per day per system)

Treatment methods: Pre-treatment (coagulating sedimentation) + contact aeration (including biological denitrification) + coagulating sedimentation + tertiary treatment

Figure 4-6 Leachate Treatment Process

Planned Quality of Leachate and Discharged Water

Item		Leachate	Treated water
pH		5~9	5.8~8.6
BOD	(mg/L)	470	20
COD_{Mn}	(mg/L)	410	30
SS	(mg/L)	300	10
T−N	(mg/L)	200	10
T−P	(mg/L)	10	10
Ca Ion	(mg/L)	600	100

Table 4-2 Effluent Standards by Ordinance of Prime Minister's Office

【Health-related items】

Types of hazardous matter	Effluent standard
	Max. permissible amount
Cadmium and compound there of	0.1mg/L (as cadmium)
Cyanide compound	1mg/L (as cyanide)
Organic phosphorous compound (only parathion, methyl parathion, methyl dimedone, and EPN)	1mg/L
Lead or compound thereof	0.1mg/L (as lead)
Hexavalent chromium compound	0.5mg/L (as hexavalent chromium)
Arsenic or compound thereof	0.1mg/L (as arsenic)
Mercury and alkyl mercury and other mercury compound	0.005mg/L (as mercury)
Alkyl mercury compound	Not detectable
PCB	0.003mg/L
Trichloroethylene	0.3mg/L
Tetrachloroethylene	0.1mg/L
Dichloromethane	0.2mg/L
Carbon tetrachloride	0.02mg/L
1.2-dichloroethane	0.04mg/L
1.1-dichloroethane	0.2mg/L
Cis 1.2-dichloroethylene	0.4mg/L
1.1.1-trichloroethane	3mg/L
1.1.2-trichloroethane	0.06mg/L
1.3-dichrolopropane (D-D)	0.02mg/L
Thiuram	0.06mg/L
Simazine (CAT)	0.03mg/L
Benthiocarb	0.2mg/L
Benzene	0.1mg/L
Selenium and its compounds	0.1mg/L (as selenium)

【General items】

Item	Effluent standard
	Max. permissible amount
pH	5.8 - 8.6 (effluent into public waters other than sea areas)
	5.0 - 9.9 (effluent into sea areas)
BOD	60mg/L
COD_{Mn}	90mg/L
SS	60mg/L
n-Hexane extracts content (mineral oil content)	5mg/L
n-Hexane extracts content (animal/vegetable oil content)	30mg/L
Phenols content	5mg/L
Copper content	3mg/L
Zinc content	5mg/L
Soluble iron content	10mg/L
Soluble manganese content	10mg/L
Chromium content	2mg/L
Fluorine content	15mg/L
Number of coliform groups	3,000 groups/cm^3 (daily average)
Nitrogen content	120mg/L (daily average)
Phosphorus content	16mg/L (daily average)

(3) Seepage Control System [9) 10)]

Seepage control is fully carried out not by a liner alone, but through the operation of a system comprised of the material and supplementary facilities such as those for leachate and groundwater collection.

A seepage control system is a group of facilities designed to separate water in the landfill layer from the surrounding environment for its protection, that is, liner facility, collection facilities, and monitoring facilities (see Figure 4-7). Liner facility means a facility or equipment installed at the interface between the landfill layer and the surrounding environment to enhance seepage prevention capability primarily by reducing the permeability coefficient.

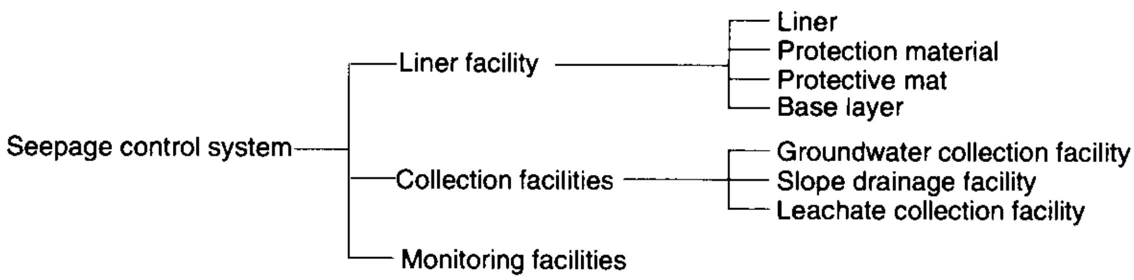


Figure 4-7 Components of a Seepage Control System

1) Liner facility

All landfill sites must have a liner facility except where there is a stratum with a permeability coefficient of not more than 1×10^{-5} cm/sec or five-meter or thicker bedrock of 1 Rudion or less. The facility work must satisfy the following requirements.

(i) No water must leak from any joint in the facility.

(ii) The facility must allow for a certain amount of ground subsidence.

(iii) The facility must be chemical-resistant.

(iv) The facility must be weathering-resistant.

(v) No deleterious matter must elute from the material itself.

(vi) The facility must have required dynamic properties (strength, extendibility, and thickness).

It is also important to ensure proper construction of the facility.

There are two types of liner facility, surface and vertical, according to material and structure.

2) Vertical Liner facility

Where the surface layer is permeable but supported by a sufficiently wide impermeable stratum running horizontally not so deep in the ground, cut-off walls are built in the upper layer for seepage prevention. This vertical liner facility may be a cut-off core, a pile of steel sheets, grout, or underground serial walls. (See Figure 4-8.)

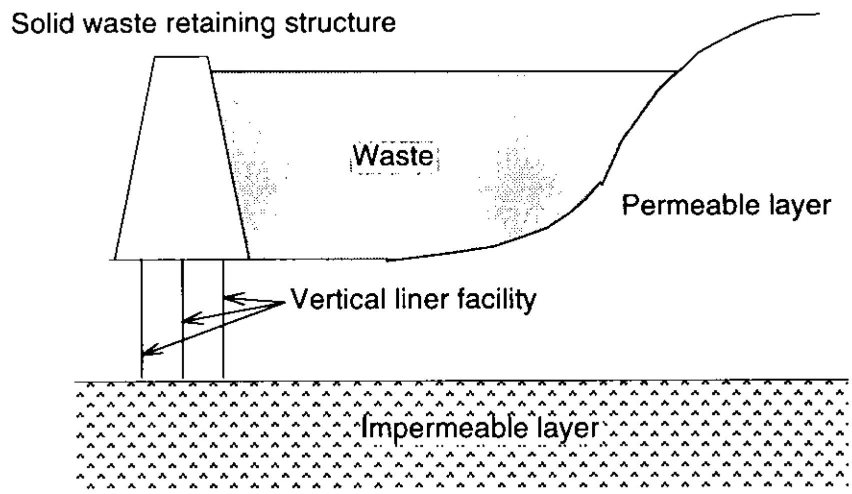


Figure 4-8 Vertical Seepage Control Work

Vertical liner facility is most suitable for the site that meets all of the following requirements.
(i) There must be a sufficiently long impermeable layer.
(ii) The layer must run in such a way as to stop groundwater flowing across the channel (see Figure 4-9).

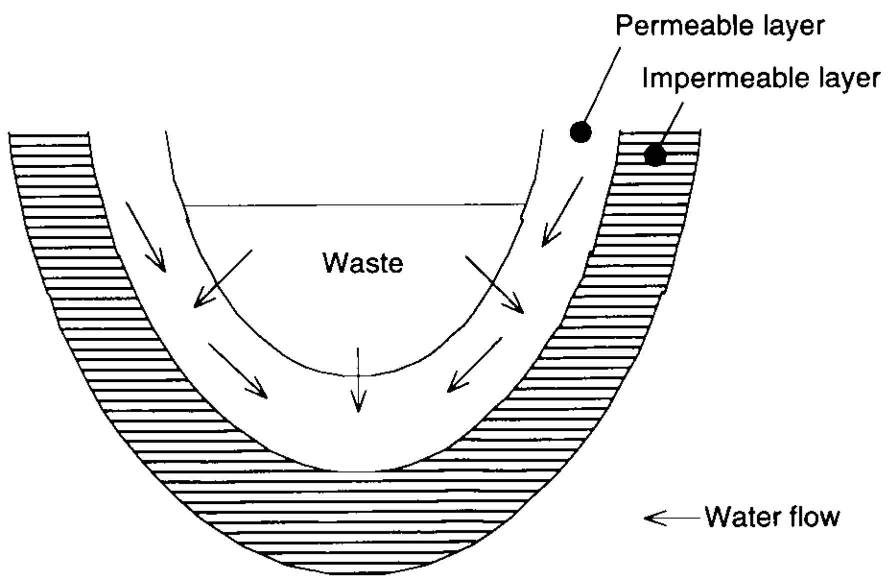


Figure 4-9 Requisites for Vertical Seepage Control Work

In addition, there are specific requirements for each particular type of vertical liner facility: grouting must not be chosen unless the layer on the impermeable stratum has a Rudion of not more than 1; and serial walls must each be at least 50 centimeters thick and have a permeability coefficient of not more than 1×10^{-6} cm/sec.

3) Surface Liner facility

The covering of the surface of the base layer with a seepage control facility. This is the most popular seepage control technique. Lining materials in wide use are shown in Figure 4-10. In order to increase seepage prevention capability, this facility is made up of several liners, which must be carefully selected in light of the geographical/ geological features, groundwater conditions, etc., of the landfill site.

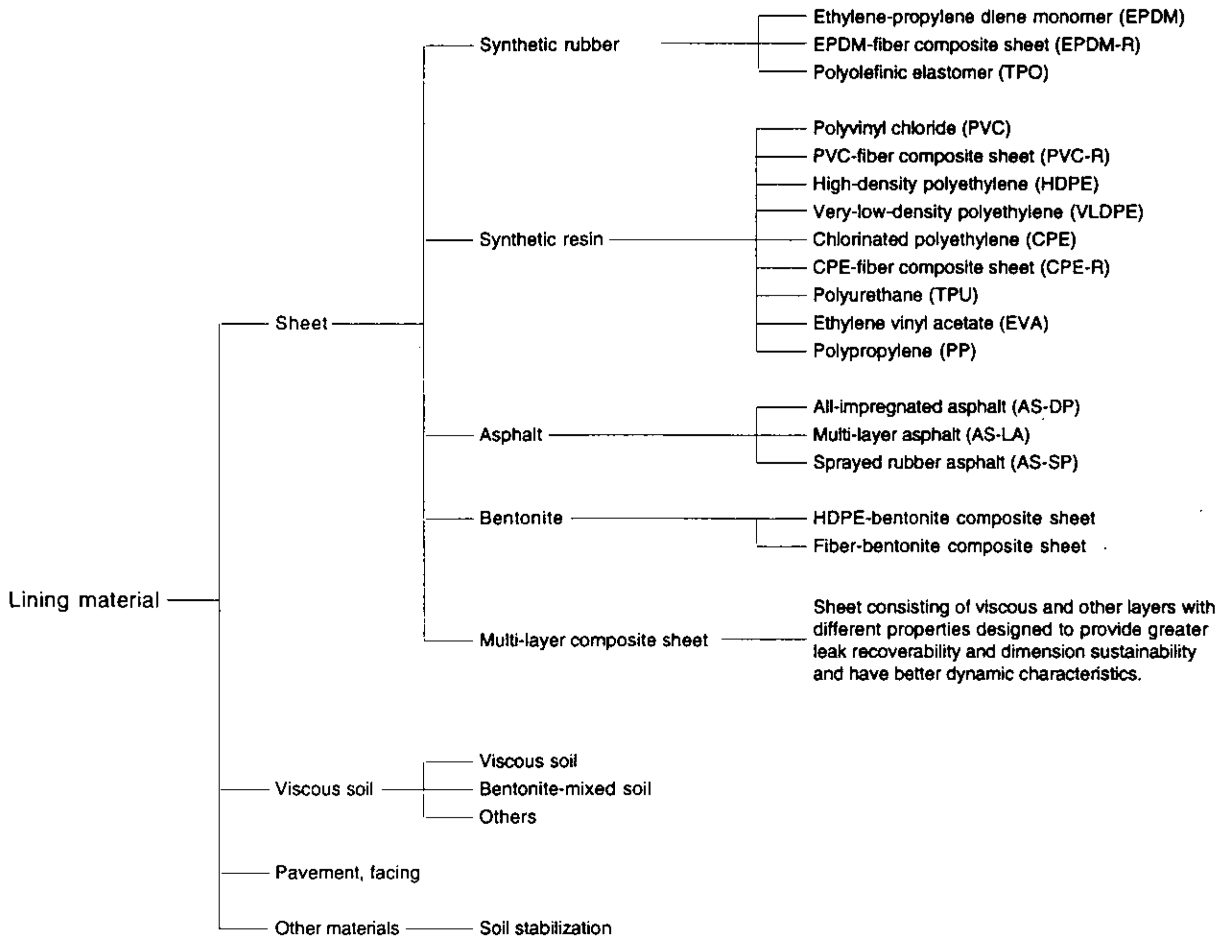


Figure 4-10 Popular Liners

·In general, there are three ways to build a surface seepage control facility.

① Laying a seepage control sheet on the surface of a clay or other layer having a thickness of 50 centimeters or more and a permeability coefficient of not more than 1 × 10^{-6} cm/sec.

Where it is difficult to obtain viscous soil, soil at the landfill site or bought in from somewhere else is improved with bentonite to use as an impermeable layer. There must be no space between the clay layer and the sheet. The gradient of the slope must be 1:2 or greater, in principle. Any part of the sheet's surface that is directly exposed to the sunlight must be covered with lighttight, durable nonwoven, etc. The bottom part of the seepage control facility must also be covered with nonwoven cloth and a layer of sand or other covering material at least 50 centimeters thick for protection against damage by heavy machinery.

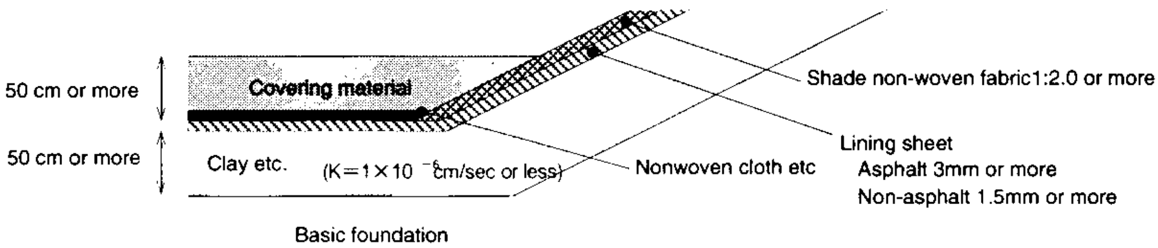


Figure 4-11 Clay + Sheet

② Laying a seepage control sheet on the surface of an asphalt concrete layer having a thickness of five centimeters or more and a permeability coefficient of not more than 1 × 10^{-7} cm/sec.

The same requirements - no space, 1:2 gradient, and lighttight covering - apply to this structure. The base layer must have enough strength for application of this method.

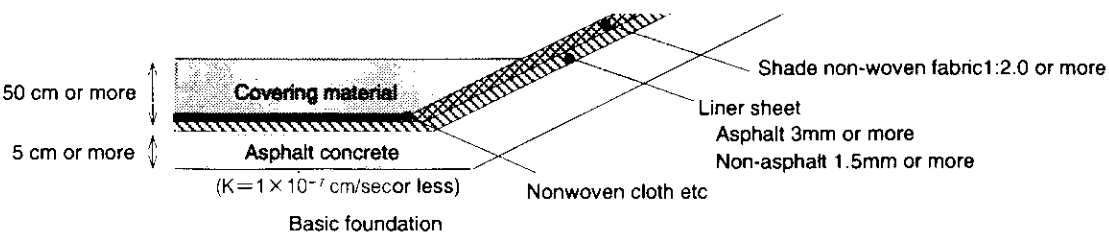


Figure 4-12 Asphalt Concrete + Sheet

③ Laying on the surface of the layer of nonwoven or other material two seepage control sheets between which there must a layer of nonwoven or other material.

This "double-liner" structure consists of five layers: two seepage control sheets and three layers of nonwoven (bottom, in-between, and top). This facility should have any projections removed from its bottom surface and should have sufficient strength to resist against subsidence, and the surface of the uppermost layer should be made flat.

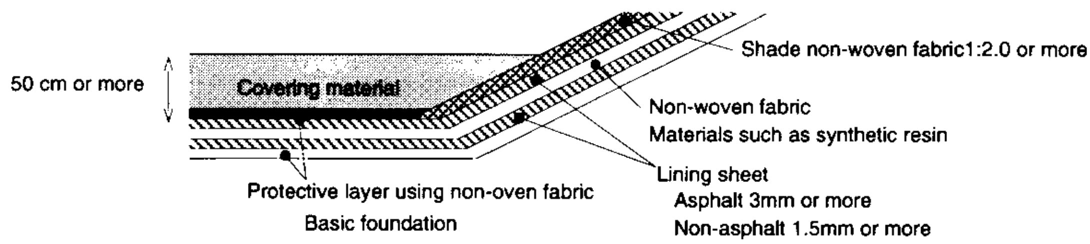


Figure 4-13 Double-Liner Structure

It is provided that the seepage control sheet be at least 1.5 mm thick, or if of asphalt, at least 3 mm thick. While geographical and geological features are a major consideration in its selection, it must have sufficient strength and resistivity against weathering and chemicals.
The gradient of the slope must be 1:2.0 or more gentle. However, some geographical or geological need for large-scale cutting-filling work may make it impossible to secure a desired landfill capacity.
In this case, the slope can be made more steep than 1:2.0 by applying mortar on the base layer and covering it with a seepage control sheet or rubber asphalt. However, this work must be in such a place as may not be reached by internally stored leachate.

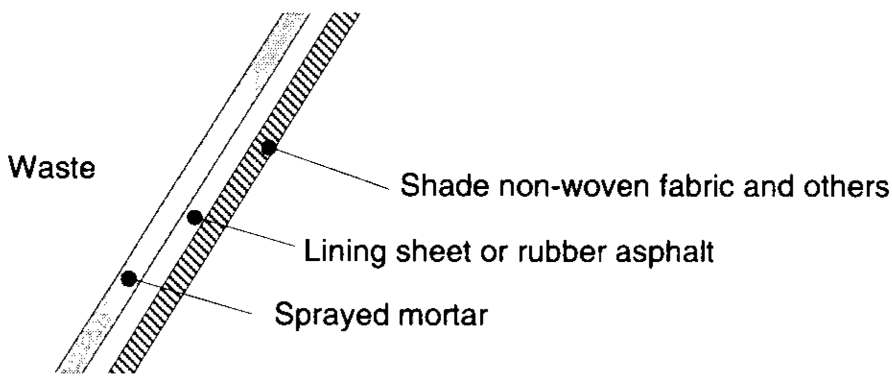


Figure 4-14 Seepage Control Work Where Gradient is 1:2 or Lower

4) Covering

Covering is not only a protection for the seepage control sheet against damage by landfilled waste and heavy machinery, but it also guides leachate into the leachate collection line. Any operation of heavy machinery on the spot where part of covering has been washed away by rain and the covering layer has become thinner may result in a rupture in the seepage control sheet; it must be ensured that the covering layer is at least 50 cm thick at any time. In the event that the covering material causes protective crushed stones to stop up a collection line, collection capability will be considerably damaged. Therefore, in early years of landfilling, it must be ensured that there is a clearance between the top of the crushed stone protection and the covering layer of at least 50 cm if the protection is for a main line, or of at least 30 cm if for a branch line.

5) Nonwoven Cloth

Nonwoven cloth is used to keep the seepage control sheet from touching, or being damaged by touching, any structure within the landfill site (e.g., the leachate or groundwater collection line) or landfilled waste.
In principle, inside and outside of the sheet must be covered with nonwoven cloth.
Nothing hazardous must seep from nonwoven cloth.

6) Base Layer

As the base layer and accordingly the seepage control sheet covering it subside under the weight of landfilled waste, the amount of subsidence should be estimated beforehand and land improvement be made wherever necessary. The surface of the base layer to be covered with the seepage control sheet must be so even as to ensure total contact with the sheet.

7) Groundwater Collection Line

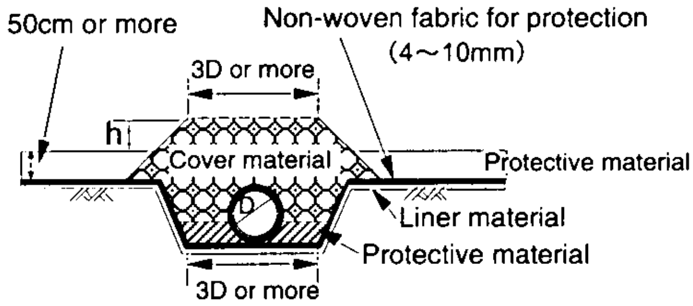
A groundwater collection line prevents a rise in the groundwater level potentially resulting in the generation of uplift pressure. It may also be designed to monitor and collect any leachate from any rupture or opening in the seepage control sheet.

8) Slope Drainage Facility

Any water flowing out from the slope must be immediately drained so as to prevent a rupture in the slope. In case the slope should collapse, the landslide may cause damage to the seepage control sheet or the rupture in the slope may result in further collapse due to pressure from landfilled waste.
The seepage control sheet is kept safe from damage due to water pressure as long as the water level on the back side of it is kept sufficiently low. Slope drainage facilities must thus be so structured and concentrated as to offer sufficient drainage capability.

9) Leachate Collection Line

A leachate collection line is installed for the purpose of prompt collection and feeding of leachate to a leachate treatment facility off the landfill site. Any stoppage in the line will result in stagnant leachate within the site, which in turn will, by its pressure, promote seepage from any rupture in the seepage control sheet. Therefore, the line must be protected with covering material so that it can perform its intended function without stoppage.
This collection facility must be sufficiently wide as shown in Figure 4-15.
The collection pipe may be of a perforated hume or perforated polyethylene type.



	D	h
Main line	Min. 600 mm	Min. 50 cm
Branch line	Min. 200 mm	Min. 30 cm

Figure 4-15 Cross Section of a Leachate Collection Facility

10) Monitoring Facilities

The performance of the seepage control work's function, that is, the prevention of any adverse effect on the surrounding environment, must be monitored by certain facilities.

In determining the items, frequency, method, and location for monitoring, the finding of prior surveys of the types of waste handled and the geological, soil, and groundwater conditions and the use of groundwater in the downstream area must be taken into consideration.

The quality monitoring of water taken from an observation well or a groundwater collection line may cover two groups of items: those which can be continuously measured with certain instruments and those which can be measured by sampling. Those requiring constant monitoring, such as pH and conductivity, must be continuously monitored by the use of electric signals, etc., and must be subject to appropriate direction and documentation.

The observation of any abnormality by monitoring must be immediately followed by the investigation of the cause, the assessment of any effect on the surrounding environment, and the formulation of appropriate countermeasures.

11) Protection of the Seepage Control System

There will be no effective seepage control unless all of these facilities perform their intended functions in a satisfactory manner.

These facilities must, therefore, be so designed and constructed as to perform their intended functions to the full and must be subject to regular maintenance.

Regular maintenance activities to keep the seepage control system in effective operation should

(i) make sure that there is no rupture in the seepage control sheet about to be covered with covering material;

(ii) make sure that protective material has not been washed away by rain, etc., and has not been clogged;

(iii) make sure that appropriate measures have been taken to prevent the seepage control sheet being broken by heavy machinery or during the course of landfilling;

(iv) make sure that there is no rupture in the slope;

(v) identify the condition of leachate retained within the landfill site;

(vi) make sure that the leachate collection line functions normally;

(vii) make sure that the groundwater collection line functions normally;

(viii) identify any subsidence of the base layer; and

(ix) monitor the seepage control function.

Table 4-3 provides a list of leachate detection system techniques.

Table 4-3 Types of Leachate Control Function Monitoring Systems

Item	Water quality analysis methods			Electric seepage detection methods			Vacuum suction
	Groundwater quality analysis	Double-liner	Double-liner + sectional drainage	Potential	Electric current	Potential-specific resistance	
1. Principle	Analyze the quality of water flowing through the groundwater collection line beneath the seepage control work to detect any seepage.	Analyze the quality of water in the drainage layer between the liners to detect any seepage.	Analyze the quality of water flowing through drainage pipes linked to each section of the drain-age layer between the liners to detect and locate any seepage.	Identify any variation in potential of the seepage control sheet to detect and locate any rupture therein.	Identify any change in electric conductivity of the seep-age control sheet to detect and locate any rupture therein. This method is based on electric current measurement, phase detection, and aeolotropic conductivity detection.	Measure the distribution of potential and specific resistance and compute the amount of vertical electric current to detect and locate any rupture in the seepage control sheet.	Divide the layer between the liners into several bag-like blocks and apply vacuum suction to each block to measure any change in vacuum pressure and detect any rupture in the seepage control sheet.
2. Suitability	Not suitable for a landfill site where the groundwater level is high or the base layer is sandy.	A drainage pipe must be installed.	Drainage pipes must be installed for each section.	May not be able to locate more than one rupture.	Affected by a pavement and a concrete structure.	Affected by a pavement and a concrete structure.	A backup vacuum pump or compressor must be provided for rupture repair work.
3. Ability to locate seepage	Able to locate any seepage within a certain area if groundwater collection lines are independent of one another.	Able to locate any seepage within a certain area if groundwater collection lines are independent of one another.	Able to locate the section of seepage.	Able to locate the spot of seepage.	Able to locate the spot of seepage.	Able to locate the spot of seepage.	Able to locate the block of seepage.
4. Ability to measure the amount of seepage	Unable	Able if there is no rupture in the lower sheet.	Able if there is no rupture in the lower sheet.	Able to estimate the size of the rupture. Able to measure the amount of seepage if the permeability coefficient of the soil both above and beneath the seepage control sheet and the level of internally stored leachate are available.	Unable to estimate the amount of seepage because the size of the rupture can not be measured.	Able to estimate the size of the rupture. Able to measure the amount of seepage if the permeability coefficient of the soil both above and beneath the seepage control sheet and the level of internally stored leachate are available.	Able if there is no rupture in the lower sheet.

(4) Landfill site Construction Cost

How much money will be needed to construct a landfill site varies according to the size, specifications (the structure of seepage control work and the level of leachate treatment), etc.
By way of example, a functional expression is given below to obtain the construction cost for a general waste landfill site.

$$Y = 0.3986X + 13{,}800$$

Where Y stands for the cost of construction (10^4 yen) and X represents the landfill capacity (m^3).

Note that this expression is derived from the actual construction costs of landfill sites built during the 1990-1992 period and does not include the cost of the site and the approach road. It also assumes that the leachate treatment facility performs the functions of BOD/nitrogen removal by biological treatment and COD/SS removal by the use of coagulating sedimentation, sand filtering and activated charcoal.
As a controlled landfill site for industrial waste is identical in basic structure with a general waste landfill site, the above expression will serve as a guide. However, price fluctuations and other variable factors should be taken into consideration.

4.2 Maintenance and Management

(1) Transport Control

In order to protect the security of landfill site related facilities and ensure smooth operation of landfill work, the types, amounts, etc. of waste brought into the site must be placed under appropriate control.

Control schemes should cover, for example,

(i) the types of waste;

(ii) the amount of waste;

(iii) the amount and material of cover soil; and

(iv) the mode of delivery.

Figure 4-16 shows a sample of a transport control facility.

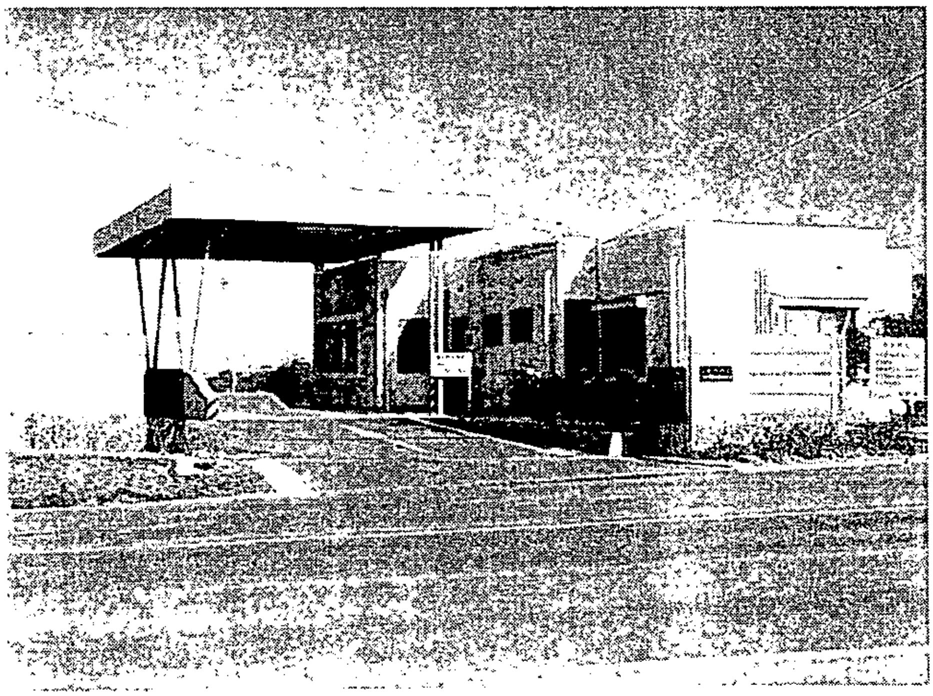


Figure 4-16 Transport Control Facility

(2) Control of Landfill Work

In order to keep the base layer stable, prevent damage to the liner facility, and control the quality of leachate and the generation of gases, landfill work must be so directed as to ensure appropriate landfill of waste.
A landfill work control system is shown in Figure 4-17.

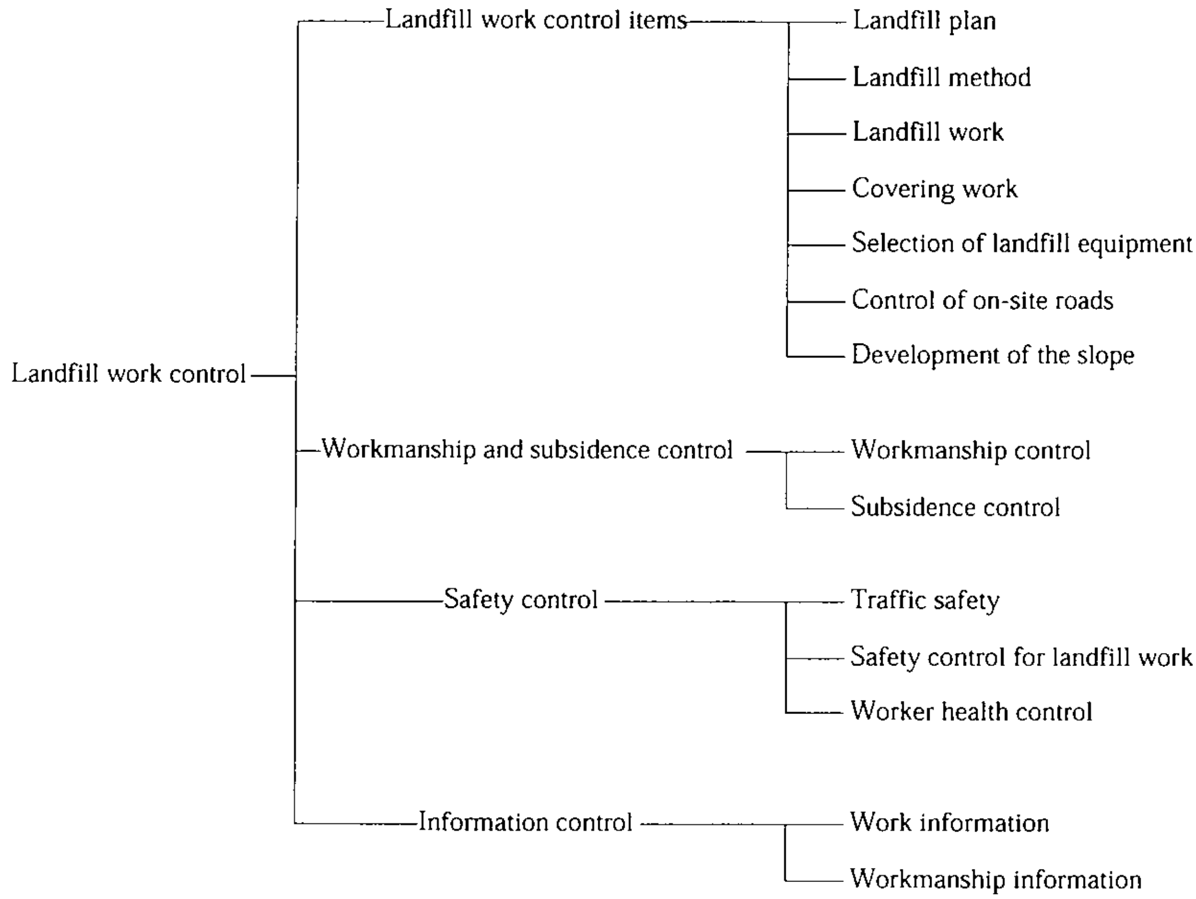


Figure 4-17 Landfill Work Controls

(i) Landfill Plan

A landfill plan should be developed that specifies the sequence of landfill steps, the depth of the landfill site, etc., taking geographical, climatic, and other natural conditions into consideration. Figure 4-18 shows an example of a landfill plan.

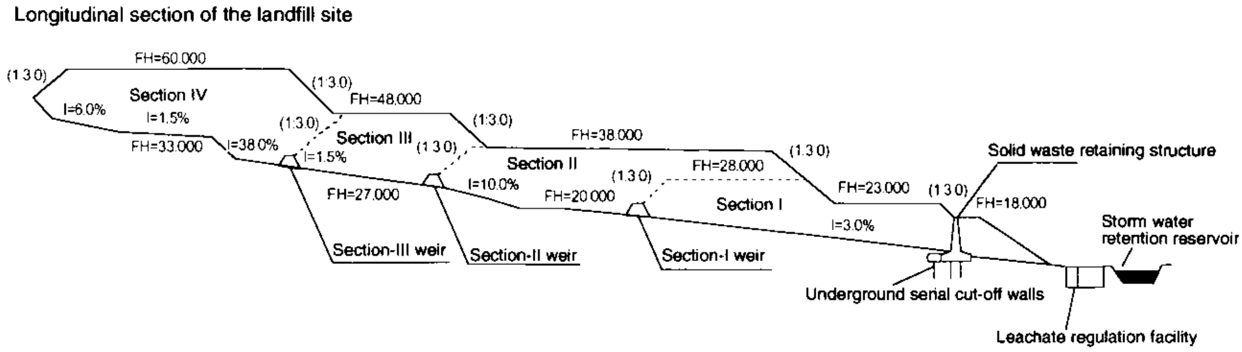


Figure 4-18 Landfill Plan

(ii) Landfill Method

Landfilling is performed by the sandwich, cell, or other method. The former is intended to prevent littering of waste, offensive odors, and fire by piling up waste and cover soil by turns (see Figure 4-19).

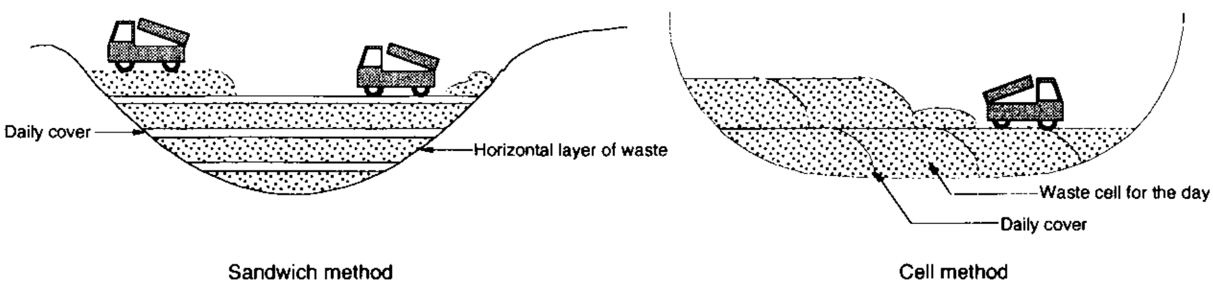


Figure 4-19 Landfill Methods

(iii) Landfill Work

Landfill work must be carried out in accordance with the landfill method, the sequence of landfill steps, etc. Figure 4-20 shows an example of the landfill process.

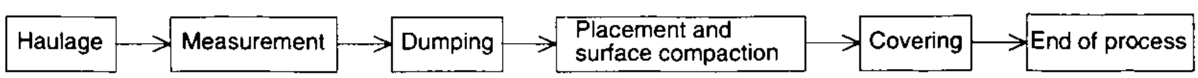


Figure 4-20 Landfill Process

Carried-in waste is compacted during the landfill process down to 0.7 - 1.5 cubic meters per ton, depending on the type of compacting machinery and waste.

(iv) Covering

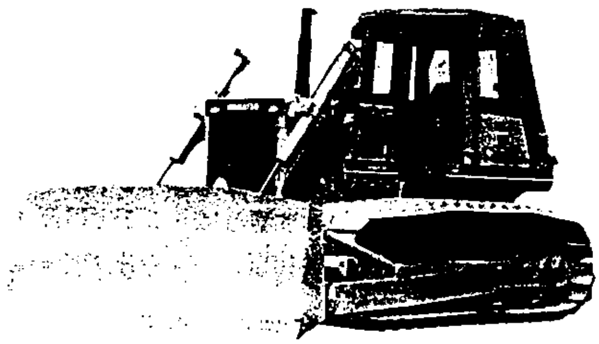
The purpose of covering is to prevent offensive odors or make the reclaimed land usable. Covering material should be the one that best fits the landfill structure and plan; for a semi-aerobic landfill site, the most desirable material is sandy soil with a high water and gas permeability. The purpose of leachate reduction may be best served by viscous soil with a low gas permeability.

The thickness of covering should be between 30 cm and 50 cm for daily cover, around 50 cm for intermediate cover, and at least 1.0 m for final cover.

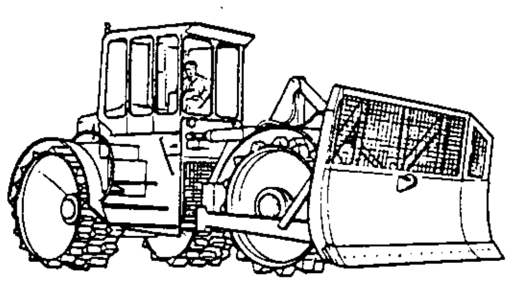
(v) Landfill Equipment

Among landfill equipment are bulldozers, compactors, and tractor-shovels.

Some of them are illustrated in Figure 4-21.



bulldozer



compactor

Figure 4-21 Landfill Equipment

(3) Facility Management

A landfill site consists of various facilities forming an organic whole.

To ensure their proper functioning, there must be appropriate management in place.

Such management may include daily inspection, in-depth examination, and the implementation of measures to eliminate any observed abnormalities.

Figures 4-22 through 4-24 show a liner facility management procedure and repair methods.

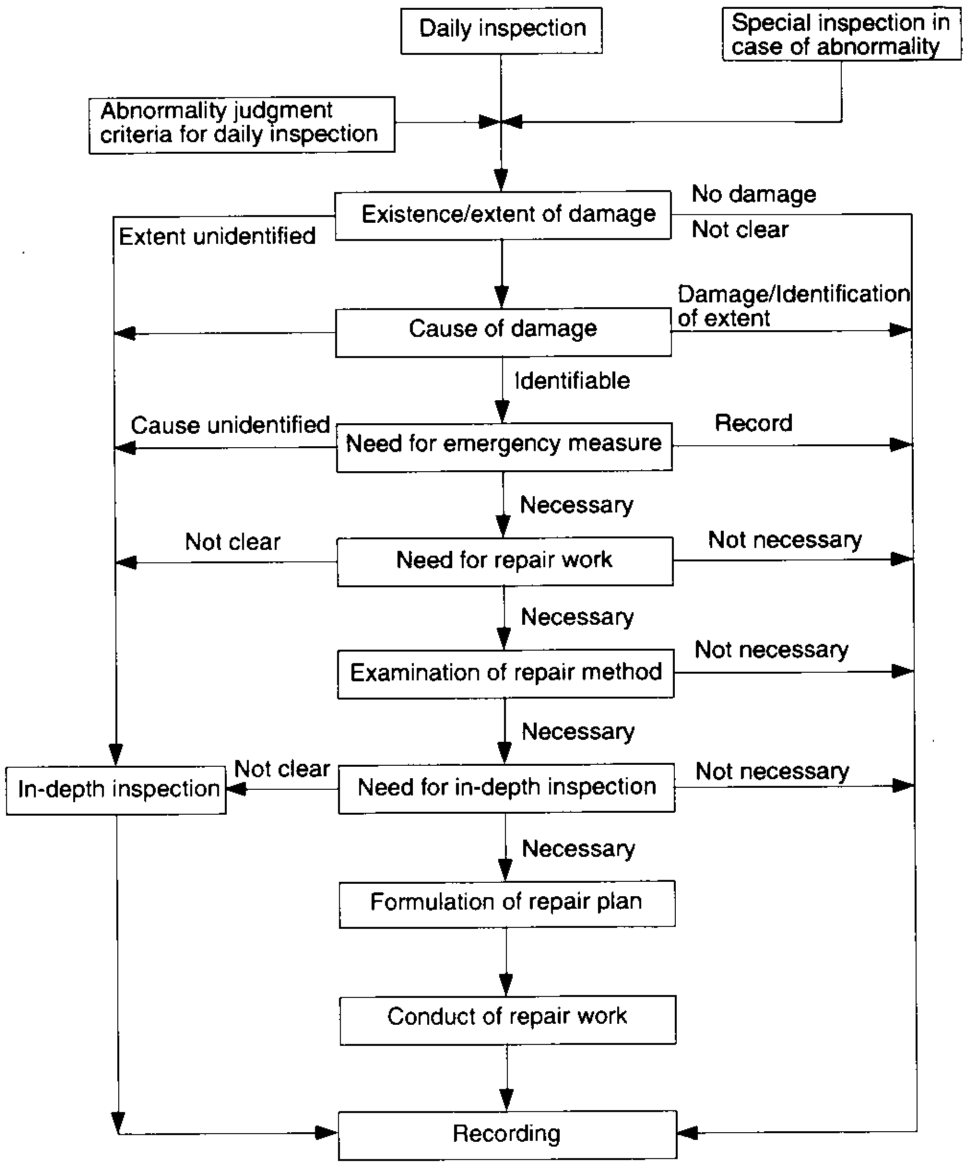


Figure 4-22 Liner Facility Management Procedure

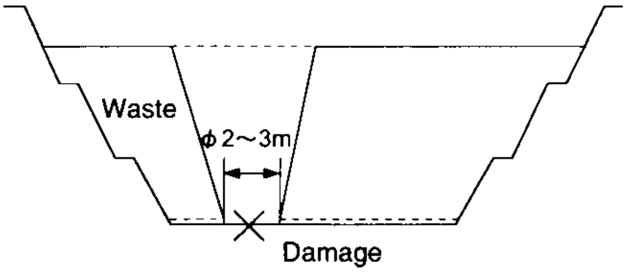


Figure 4-23 Repairing by Open Excavation

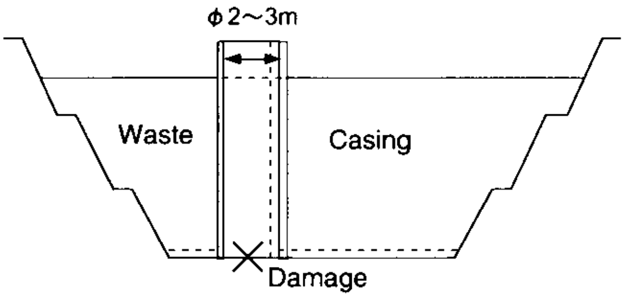


Figure 4-24 Repairing by Casing

(4) Leachate Management

As rainfall generates leachate, it is necessary to place the amount, quality, etc., of leachate under appropriate management. Management may include the following.

(i) Compilation and analysis of data on precipitation and the volume and quality of water.

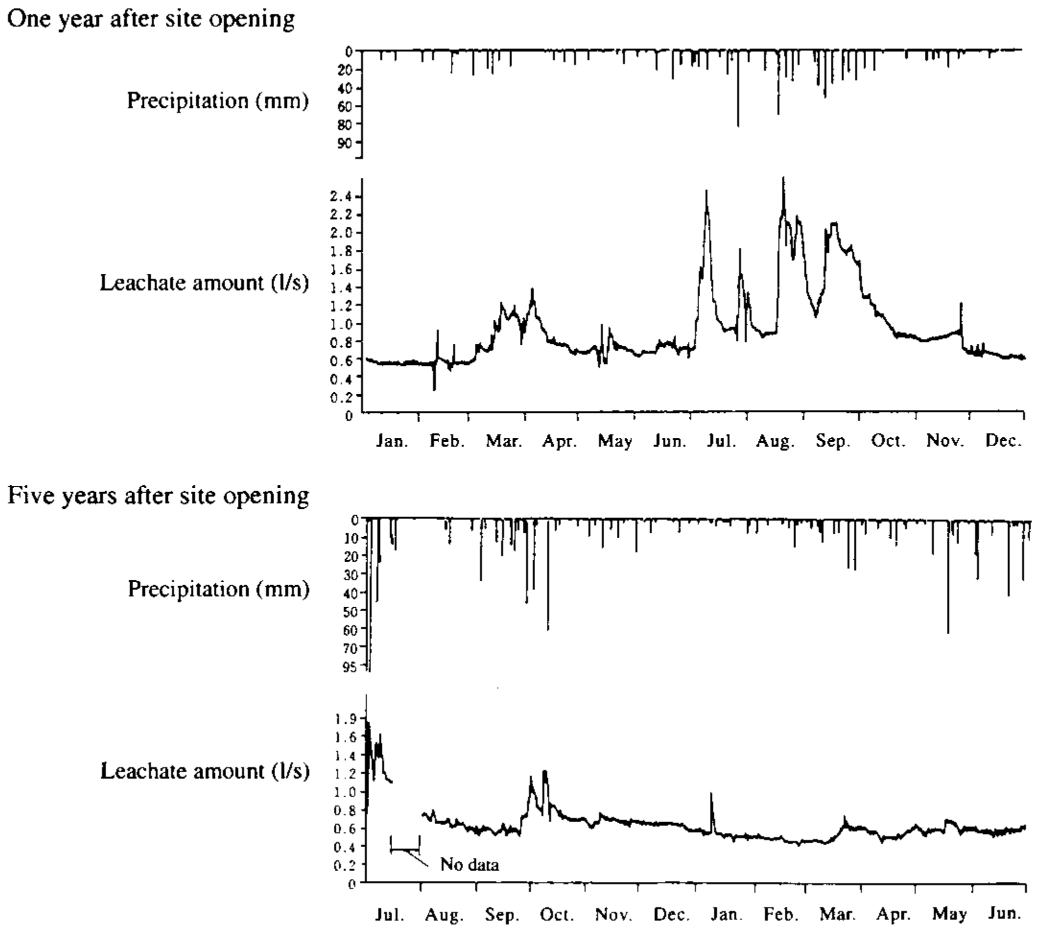
(ii) Response to any change in water volume.

(iii) Response to any change in water quality.

(iv) Response to any climatic change.

(v) Inspection of the leachate treatment facility.

Figure 4-25 gives a graphic presentation of fluctuations in the amount of leachate and rainfall, but it is not all-inclusive; water quality may change according to the time of landfill. Stable leachate treatment thus requires proper leachate regulation facility (see Figure 4-26).



1-ha landfill site in the mountains
59,000-cub.-m. landfill capacity
No surface liner facility work

Figure 4-25 Fluctuations in Leachate Amount

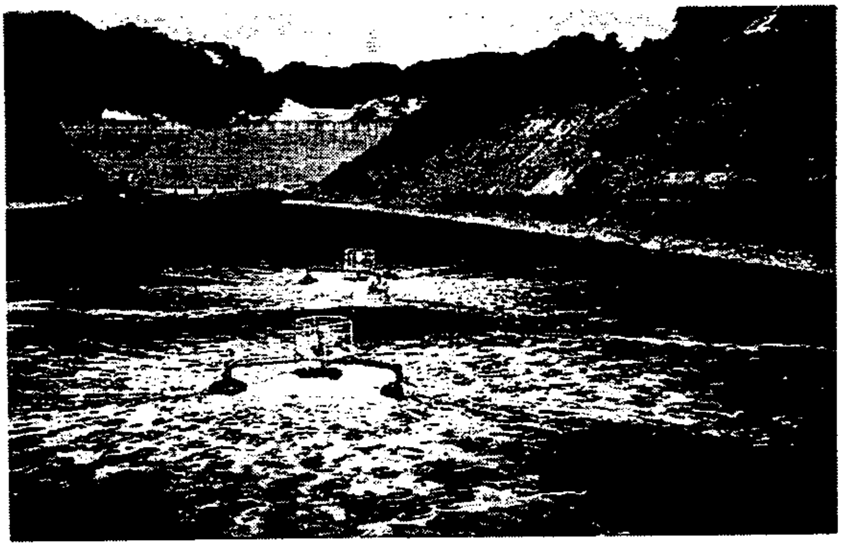


Figure 4-26 Leachate Regulation Facility (Aeration)

(5) Environmental Management

Environment management must be carried out periodically so that landfilled waste, leachate, or gasses will not harm the surrounding environment. Management items may include the following.

(i) Groundwater monitoring.
(ii) Quality of water (of the river into which treated water is discharged).
(iii) Soil (on the river into which treated water is discharged and around the disposal site).
(iv) Offensive odor (on the site's border)
(v) Noise and vibration (on the site's border)
(vi) Ecological toxicity assessment (plants, aquatics, etc.)

Figure 4-27 shows the monitoring of groundwater and the ecological toxicity assessment of treated water carried out in a certain biotope.

Figure 4-27 Monitoring

5. Examples of Facilities Construction

(Financed by Japan Environment Corp.)

5.1 Coastal Reclamation

(an Osaka Bay Wide-Area Coastal Environment Improvement Center project)

The Osaka Bay Wide-Area Coastal Environment Improvement Center began to offer wide-area disposal site construction services upon authorization of the Basic Plan for Constructing Wide-Area Waste Disposal Facilities in the Osaka Bay Area by the Health and Welfare Minister and Transport Ministers in 1984 and began to reclaim land from the sea off Amagasaki in 1988 and off Izumiotsu in 1991 using waste generated in the service area (covering 171 municipalities, i.e., 79 cities, 89 towns, and three villages, within six prefectures in the Kinki Region).

The amount of waste accepted by the Amagasaki offshore disposal site by 1997 is equivalent to about 77.4% of the total landfill capacity of all least controlled landfill sites and about 88.5% of that of all controlled landfill sites. The figures stand at about 48.9% and 64.8%, respectively, for the Izumiotsu offshore disposal site. It is evident from this that these two sites play an important role in waste disposal in the Kinki Region. Japan Environment Corp. has loaned out a total of about 47 billion yen to fund facility construction/improvement in each site.

(1) Outline of the Facilities

1) Landfill Sites (see Figure 5-1)

Landfill sites	Area (ha)	Landfill capacity (m^3)	Types of waste			
			General waste	Industrial/disaster-related	Surplus soil	Dredge soil
Off Izumiotsu	203	3,000	400	860	1,270	470
Off Amagasaki	113	1,500	200	280	690	330
Off Kobe	88	1,500	460	740	300	0
Off Osaka	95	1,400	490	630	280	0
Total	499	7,400	1,550	2,510	2,540	800

(Unit: million cubic meters)

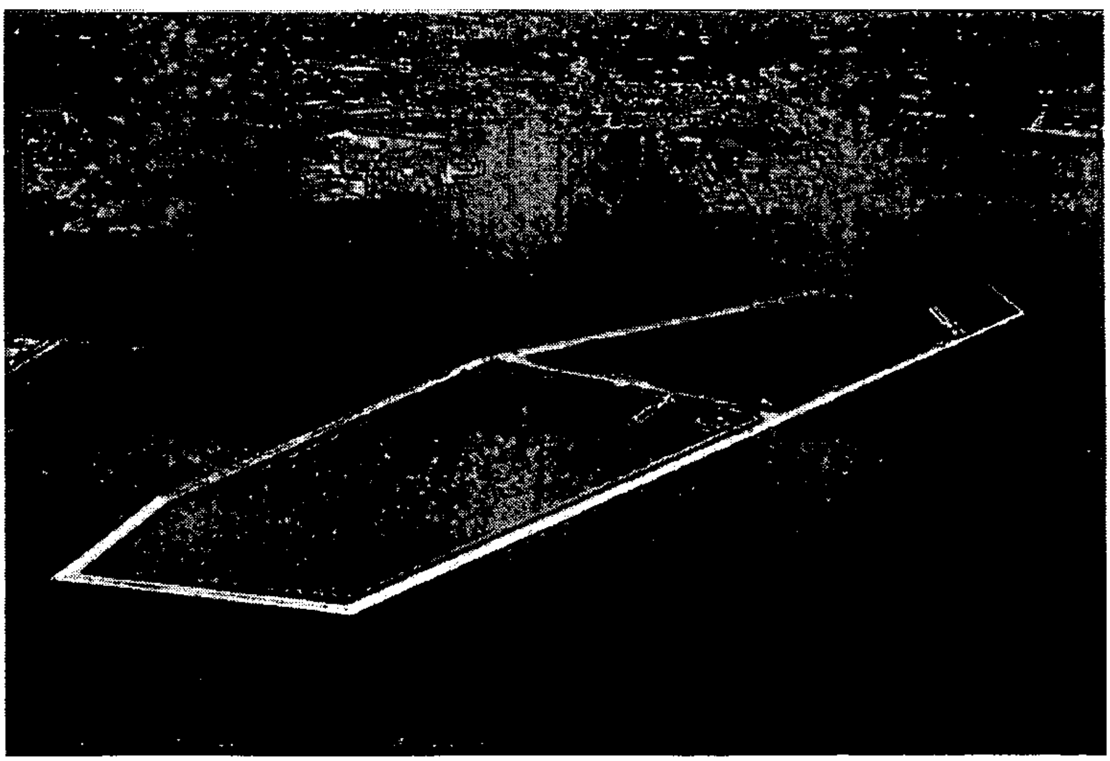


Figure 5-1 Whole View of a Landfill Site

2) Location and Size of Nine Stations (Waste Reception Facilities)

Item \ Station		Himeji	Harima	Kobe		Amagasaki	Osaka	Sakai	Izumiotsu	Wakayama	Tsuna
Handling capacity (tons/day)		600	1,700	6,700		12,000	12,000	9,900	5,000	2,100	110
Area of the site (m²)		14,000	3,000	4,000	15,000	25,000	30,000	30,000	10,000	13,000	5,000
Loading method		Direct from dump truck.	Direct from dump truck.	Direct from dump truck.	Direct from dump truck.	Direct from dump truck.	Direct from dump truck.	Direct from dump truck.	Direct from dump truck.	Direct from dump truck.	Direct from dump truck.
Number of reception gates		1	1	2	2	3	4	4	3	2	1
Storage facilities	Storage method	Lay flat	Lay flat	Lay flat	Lay flat	Lay flat	Lay flat	Lay flat	Lay flat	Lay flat	Lay flat
	Storage area (m²)	700	800	700	3,000	6,000	8,000	4,000	1,000	2,000	300
Control building (floorage: m²)		200	100	100	200	300	600	400	200	200	100
Environment control facility		Dust collector	Dust collector	Dust collector	Dust collector	Dust collector	Dust collector	Dust collector	Dust collector	Dust collector	Dust collector
Site owner		Hyogo Pref.	Hyogo Pref.	Kobe city	Center	Hyogo Pref.	Center	Osaka Pref.	Osaka Pref.	Sumitomo	Hyogo Pref.

Note: With respect to the Kobe Station, the left column shows data on the existing facilities, while the right one gives data on the facilities planned for alteration.

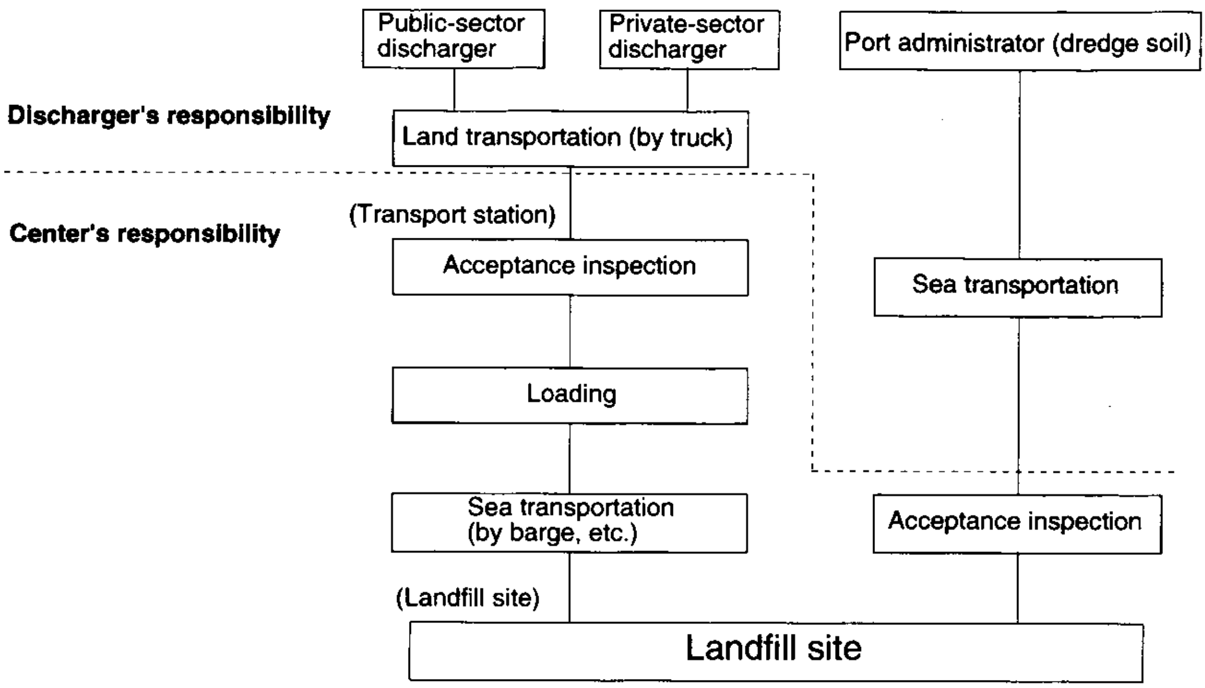
3) Land Use and Size

Amagasaki Offshore	
Use	Area
Wharf	12 ha
Port related facilities	28 ha
Urban redevelopment	47 ha
Urban facilities	2 ha
Sewage treatment plant	2 ha
Green space	16 ha
Road	6 ha
Total	113 ha

Izumiotsu Offshore	
Use	Area
Port related facilities	45 ha
Urban redevelopment	74 ha
Urban facilities	2 ha
Green space	63 ha
Marina	8 ha
Road	11 ha
Total	203 ha

Kobe Offshore	
Use	Area
Port related facilities	66 ha
Distribution base	3 ha
Green space	19 ha
Total	88 ha

(2) Flow of Waste and Responsibility for Disposal



(3) Disposal Fees (as of April 1, 1998)

(Unit: Yen per ton)

Item		Disposal fee
General waste		4,200
Industrial waste	City water sludge (public sector)	3,885
	Sewage sludge (public sector)	3,885
	Ash	8,400
	Sludge	7,035
	Slag	4,200
	Dust	8,400
	Waste plastics	7,035
	Waste rubber	3,360
	Debris	5,460
	Waste metal	5,460
	Waste glass and chinaware	5,460
	Other controlled industrial waste	8,400
Surplus soil		2,625

(taxed)

(4) Effluent Treatment

(see Figures 5-2 and 5-3)

Type of facility	Floating boat type
Handled waste water	landfill spill from controlled landfill sites
Capacity	1,600 m^3/day
Treatment process	Pretreatment + biological treatment + coagulation sedimentation + sterilization

Water quality

Item	Unit	Quality of waste water	Quality of treated water
pH	—	7~10	5~9
BOD	mg/L	200	Max. 40
COD_{Mn}	mg/L	170	Max. 60
SS	mg/L	200	Max. 50

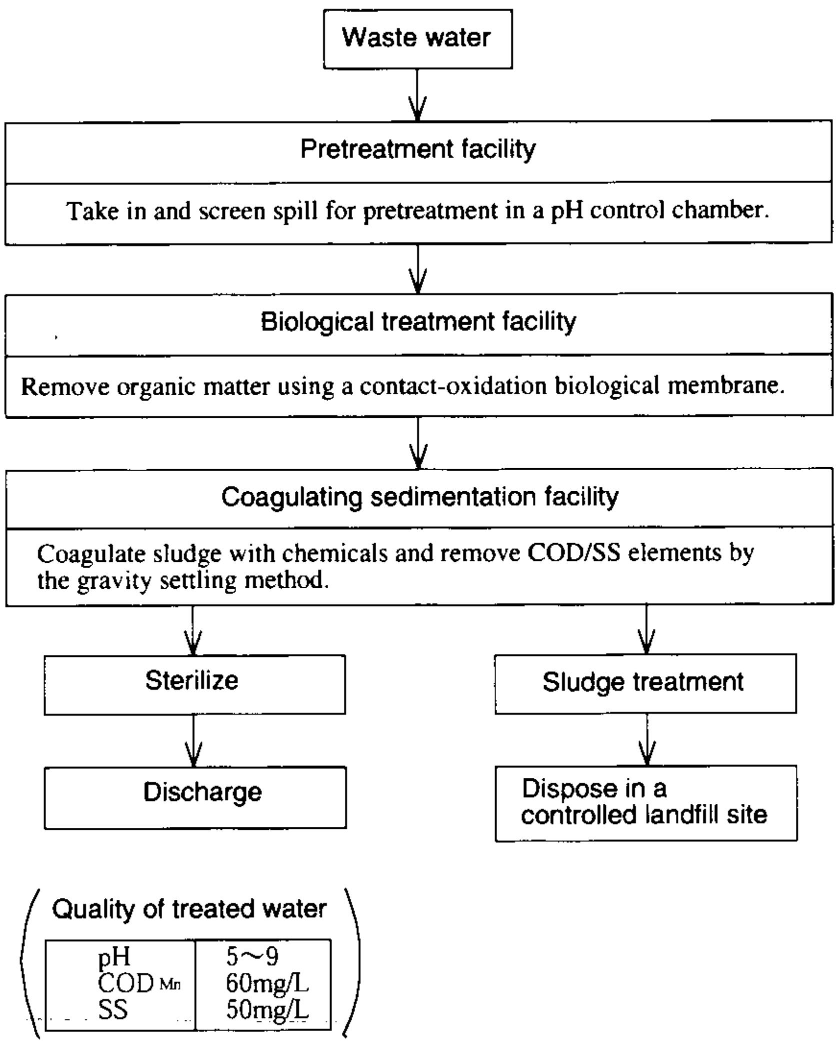


Figure 5-2 Treatment Process

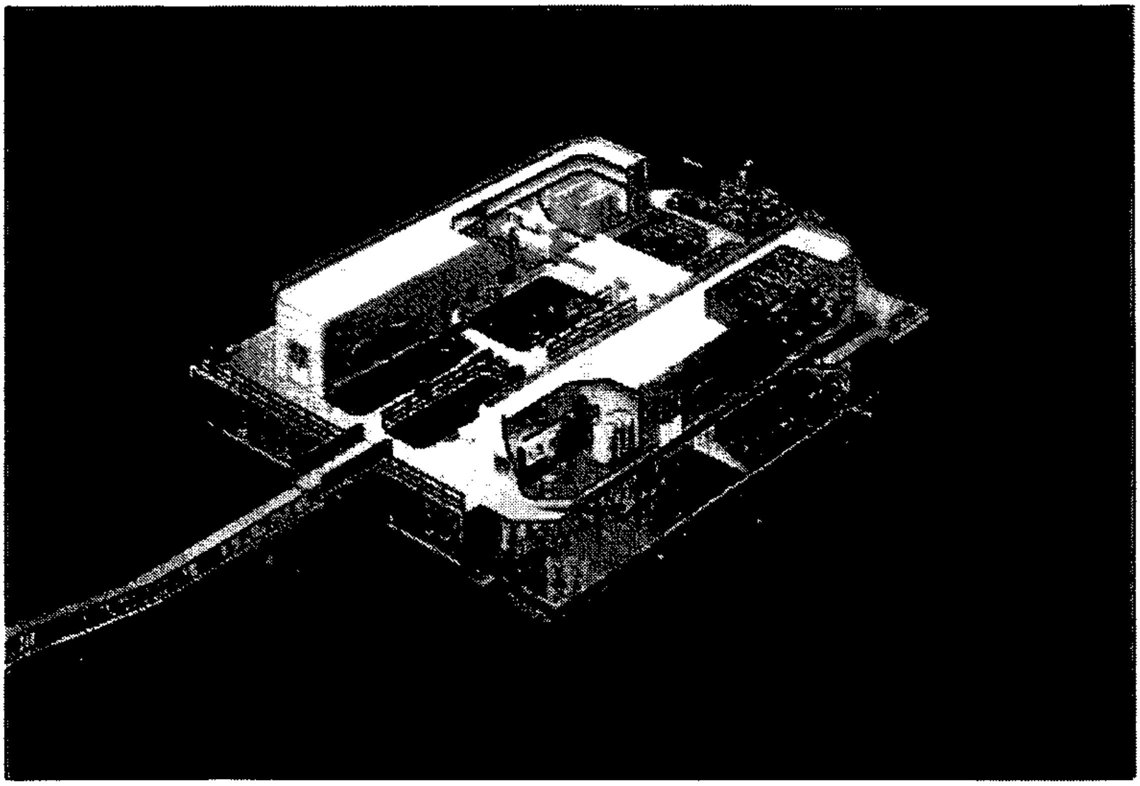


Figure 5-3 Waste water Treatment Facility

5.2 Inland Reclamation

("EcoPark Izumozaki", a Niigata Environment Protection Foundation project)

In October 1992, Niigata Prefecture established Niigata Environment Protection Foundation ("Foundation"), a prefectural agency providing industrial waste disposal services, with a view to protecting the environment against various types of industrial waste generated in the course of industrial activities and promoting industrial activities within the prefecture. The Foundation, while recognizing the principle of "responsibility on the discharger", intends to construct facilities that serve as both a supplement and model to private businesses and offer services associated with proper disposal of industrial waste. The purpose of the Foundation also includes raising environmental awareness, helping the citizens to make their living environment more comfortable, and contributing to the sound growth of the prefectural economy.

EcoPark Izumozaki is composed of incineration and pulverization facilities, a controlled landfill site, a control office, etc.

(1) Outline of the Facilities

EcoPark Izumozaki is located at Inagawa 884, Izumozaki, Santo County, Niigata Prefecture, with the facilities listed in Table 5-3 laid out as shown in Figure 5-4. This US$151.7million waste disposal complex covers an area of 586,000 square meters. Its controlled landfill site and leachate treatment facility are outlined below.

Table 5-3 General Data on the Facilities

Type of facility	General description	Capacity	Floorage (m^2)	% to total area (%)
Incineration facility	Rotary kiln + stoker furnace	50 t / d	14,400	2.5
Pulverization facility	Low-speed rotation type Reciprocating shear type	28 t / d		
Landfill site	Controlled	1,484,000m^3	98,000	16.7
	Leachate treatment facility	280m^3/d	3,300	0.6
	Leachate regulation reservoir	14,000m^3	5,200	0.9
Control building	R&D and awareness raising facilities	1,130m^3	8,800	1.5
Incidental facilities	Disaster prevention pond	16,720m^3	11,200	1.9
	Agricultural pond	1,400m^3	3,400	0.6
	Road, cover soil storage, green space on the slope, etc.	———	131,035	22.3
Green space, etc.	———	———	311,000	53
Total	———	———	586,335	100

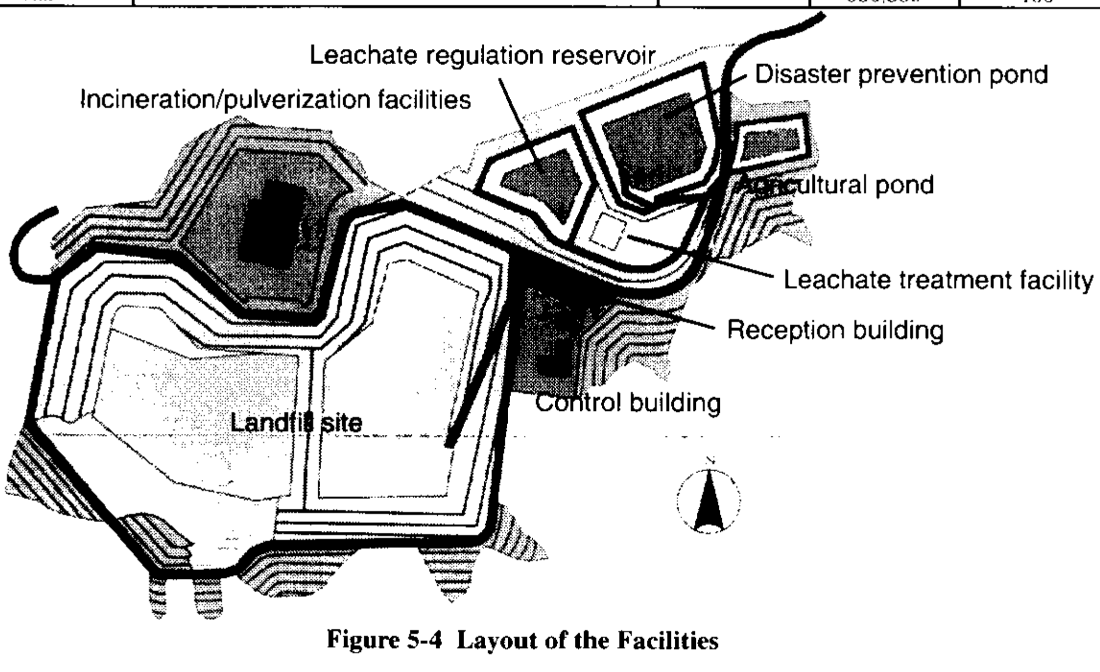


Figure 5-4 Layout of the Facilities

1) Landfill site

According to the construction plan, the landfill site will ultimately have a landfill area of 9.8 hectares and a landfill capacity of 1,484,000 cubic meters, but so far, only an 800,000-cub.-m. Phase-I landfill section has been completed and offered for use. Figures 5-5 and 5-6 provide the standard longitudinal and cross sections of the site, respectively.

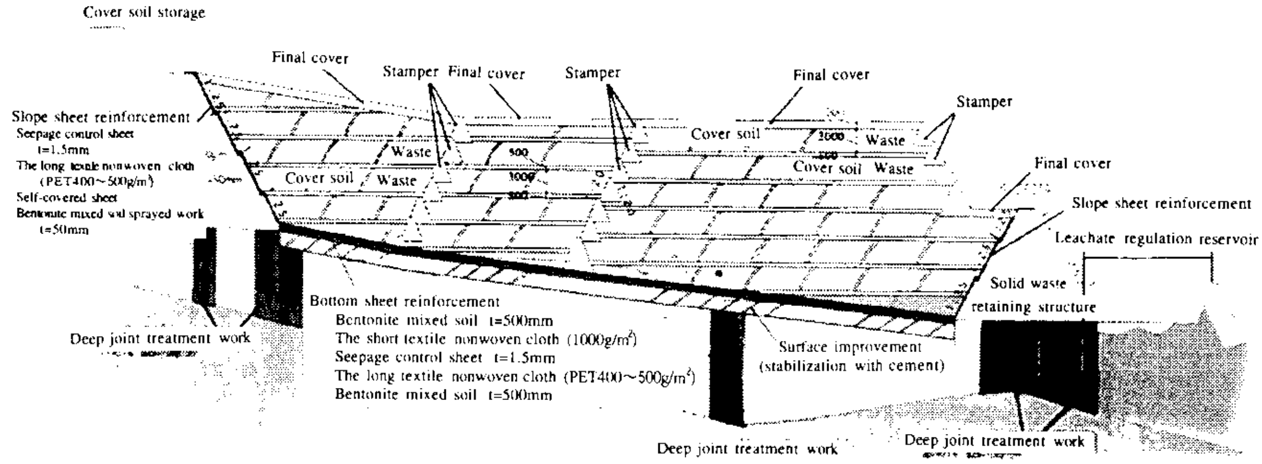


Figure 5-5 Standard Longitudinal Section

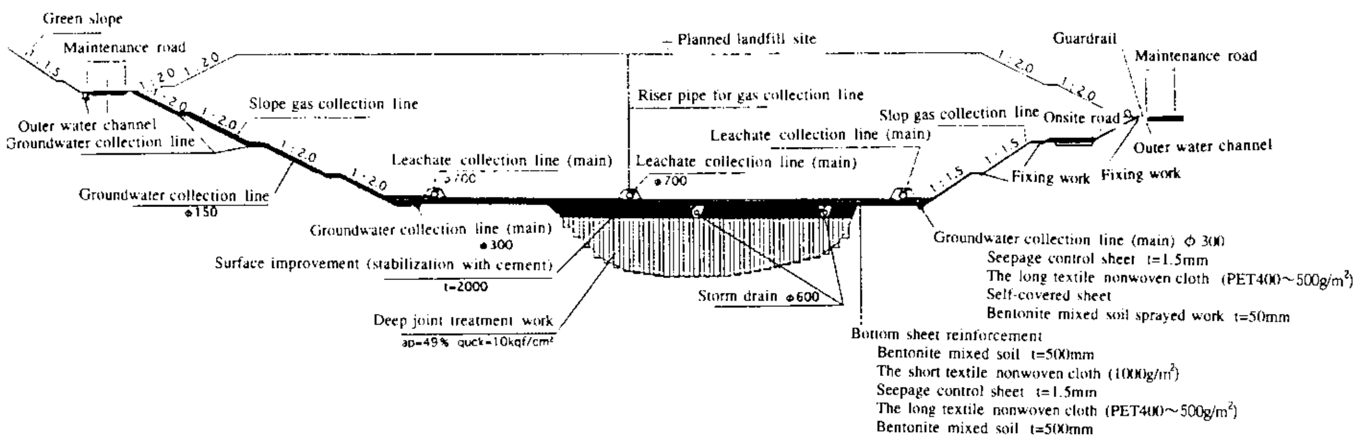


Figure 5-6 Standard Cross Section

2) Leachate Treatment Facility

This landfill site has two 7,000-cub.-m. reservoirs for leachate regulation (a total capacity of 14,000 cubic meters) in order to keep the leachate treatment process from being affected by any fluctuation in the volume and quality of influent. The leachate treatment facility is capable of 280 cubic meters a day (i.e., the total capacity of two sets of biological treatment equipment each with a daily capacity of 140 cubic meters) and handles an advanced process comprised of pretreatment (coagulating sedimentation), contact aeration (including biological denitrification), co-agulating sedimentation, sand filtering, activated charcoal absorption, etc. Treated water is partly used to cool the incineration facility, with the remainder discharged to the Ina River. Table 5-4 is a list of standards for the quality of leachate and treated water, and Figure 5-7 gives a flow of treatment steps.

Table 5-4 Quality of Leachate and Treated Water

Item		Leachate	Treated water
pH		5～9	5.8～8.6
BOD	(mg/L)	470	20
COD_{Mn}	(mg/L)	410	30
SS	(mg/L)	300	10
T−N	(mg/L)	200	10
T−P	(mg/L)	10	10
Ca	(mg/L)	600	100

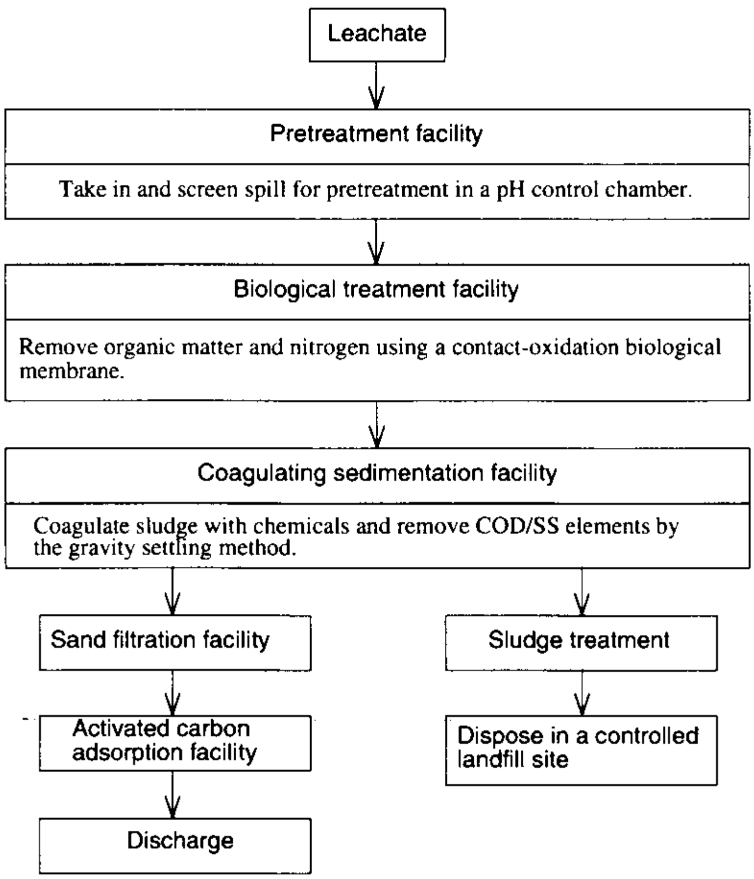


Figure 5-7 Flow of Treatment Steps

5.3 Inland Reclamation (Industrial Waste Landfill Site in Futaba, Fukushima Pref.)

Total area: Approx. 15 ha

Location: On a hill remote from the city center; there are several houses around the site.

Total project cost: Approx. 3.9 billion yen (0.6 billion yen for site acquisition and 3.3 billion yen for construction).

Construction period: Five years (three for study and design, two for construction).

Duration of reclamation (time needed for investment recovery): 20 years.

Accepted waste: Ash, sludge, slag, waste textile, waste plastics, waste wood, dust, waste paper, waste metal, waste chinaware.

Disposal fee: 21,000 yen per each cubic meter of controlled waste (average fee over twenty years).

Facility outline

(i) Controlled landfill site

Area for landfill: 4.3 ha

Landfill capacity: 500,000 cubic meters

(ii) Main facilities

Storage facility: one soil dike.

Seepage control facilities: 10-mm-thick nonwoven cloth (green for the slope).
1.5-mm-thick high-density polyethylene sheet.
10-mm-thick nonwoven cloth.
1.5-mm-thick rubber sheet.
10-mm-thick nonwoven cloth.
Seepage detection

Runoff collection facility: side ditches
600- to 1,500-mm-dia. drain pipes

Groundwater collection facility: 150 mm to 300 mm in diameter.

Leachate collection facility: 200 mm to 900 mm in diameter.

Leachate regulation reservoir: reinforced concrete.

Leachate treatment facility: 60 cubic meters a day
(contact aeration + coagulating sedimentation + filtering + activated charcoal + chelate absorption)

Discharge facility: 100-mm-dia. HVP

Landfill gas treatment facility: 200-mm-dia. perforated polyethylene pipe
200-mm-dia. riser pipe

(iii) Control facilities

Control building: reinforced concrete; 150 square meters in floorage.
Surveillance monitor
Car washing facility
Truck scale: up to 25 tons
Observation well
Groundwater monitoring: manhole

(iv) Incidental facilities

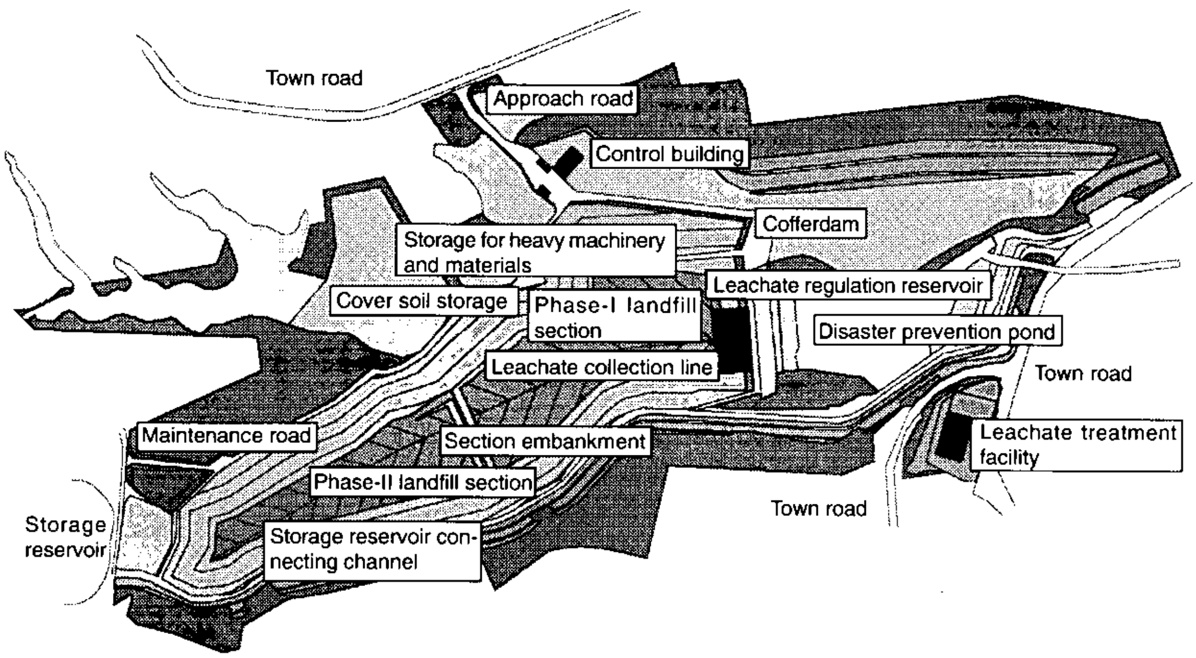
Roads: 6.0-m-wide approach road
4.0-m-wide onsite road
3.0- to 3.5-m-wide maintenance road

Littering prevention facility: 1.8-m-high net fence

Disaster prevention pond: probability of one event in every fifty years.

Storage reservoir connecting channel: 3.0 m x 2.5 m

Planted trees: cherry trees, zelkova, iris, etc.
Small arbor, benches, guideposts, bridge.



6. Ultimate Land Use

6.1 Ultimate Land Use: Modes

The following is a summary of the findings of a survey conducted in 1985 by the Ministry of Health and Welfare.

(1) General Waste Landfill Sites

- The survey covered 657 disposal sites which were completely reclaimed within about ten years before 1983.
- 67% of all surveyed sites are offered for some use.
- Major uses are farmland (44% of all surveyed sites), parks (15%), forests (8%), and residential sites (5%).
- The utilization rate is high with flat reclaimed land and low with completed landfills in the mountains.
- Location-wise, completed landfills in the mountains, in flat areas, and on the waters are mostly converted into forests, farmland or residential sites, and parks or industrial sites, respectively.

(2) Industrial Waste Landfill Sites

- The survey covered 558 sites (327 controlled, 203 least controlled, and 28 strictly controlled).
- 70% of all surveyed sites are offered for some use.
- Major uses are farmland (57% of all surveyed sites), industrial sites (15%), parks (8%), and residential sites (6%).
- The utilization rate is high with flat reclaimed land and low with completed landfills in the mountains.
- Location-wise, completed landfills in the mountains, in flat areas, and on the waters are mostly converted into forests, farmland or residential sites, and parks or industrial sites, respectively.

Table 6-1 Location and Use after Reclamation

●Completed landfill sites for general waste

(Unit: upper: number of sites: lower: % to total)

Location	Surveyed sites	Sites in use	Land use						
			Residential site	Industrial site	Farmland	Park	Road	Forest	Others
In the mountains	222	133	6	2	57	16	3	24	25
		59.9%	4.5%	1.5%	42.9%	12.0%	2.3%	18.0%	18.8%
In flat areas	378	265	14	15	124	42	8	10	52
		70.1%	5.3%	5.7%	46.8%	15.8%	3.0%	3.8%	19.6%
On the waters	38	25	1	3	6	7	2	0	6
		65.8%	4.0%	12.0%	24.0%	28.0%	8.0%	0.0%	24.0%
Others	19	12	2	–	6	–	2	–	2
		63.2%	16.7%	–	50.0%	–	16.7%	–	16.7%
Total	657	435	23	20	193	65	15	34	85
		66.2%	5.3%	4.6%	44.4%	14.9%	3.4%	7.8%	19.5%

●Completed landfill sites for industrial waste

(Unit: upper: number of sites: lower: % to total)

Location	Surveyed sites	Sites in use	Land use						
			Residential site	Industrial site	Farmland	Park	Road	Forest	Others
In the mountains	112	67	2	2	41	3	2	16	1
		59.8%	3.0%	3.0%	61.2%	4.5%	3.0%	23.9%	1.5%
In flat areas	379	277	19	30	178	23	7	2	18
		73.1%	6.9%	10.8%	64.3%	8.3%	2.5%	0.7%	6.5%
On the waters	9	6	1	2	–	1	–	–	2
		66.7%	16.7%	33.3%	–	16.7%	–	–	33.3%
Others	58	39	2	26	2	6	0	0	3
		67.2%	5.1%	66.7%	5.1%	15.4%	0.0%	0.0%	7.7%
Total	558	389	24	60	221	33	9	18	24
		69.7%	6.2%	15.4%	56.8%	8.5%	2.3%	4.6%	6.2%

* The percentage of "sites in use" is to the number of "surveyed sites", while the percentage figures shown in the Land Use block are to the number of "sites in use".

6.2 Ultimate Land Use: Some Cases and Problems

(1) Illustrative Cases

Some cases of ultimate land use are listed in Table 6-2. The table shows that on those sites offered for residential use are built houses (by the Housing Corporation, etc.), schools, offices, warehouses. Sites offered for industrial use are mostly used for waste treatment. Parks range from city parks, large and small, to sports facilities such as tennis courts and recreational facilities such as golf courses.

Analysis by location reveals that the utilization rate is high with flat reclaimed land, while it is rather low with completed landfills in the mountains. This indicates greater demand and more uses for completed landfills in flat areas. Reclaimed land in the mountains, on the other hand, has only a limited range of uses due to its closeness to residential areas, etc., and is mostly converted "back" into farmland or forests as there is no other choice.

By size, small disposal sites are used variously, after completion, as farmland, forests, residential areas, plant sites, or parks. By contrast, larger reclaimed land was mostly used as parks, public sites, or industrial sites (mostly for waste disposal purposes); however, recent years have seen the advent of new uses for these sites, such as offices and gymnasiums.

Table 6-2 Some Cases of Ultimate Land Use

No	Category of land use	Specific use	Site name	Location	Size (ha)	Type of landfill	Landfilled waste	Note	Source
1	Residential site	Housing, park	Nambu Incombustibles Disposal Site	Otsu City, Shiga Pref.	3.2		Incombustible waste		(1)
2		Junior high school, gymnasium	Hatta Disposal Site	Fukuoka City	7.04	Wet	General waste (garbage), incombustible waste	Top priority is given to gas collection measures in preparation for ultimate land use.	(3)
3		Employment promotion housing, high school	Enokizu Disposal Site	Nagoya City, Aichi	3.1		General waste		(1)
4		Office center	Honmoku Wharf	Yokohama City,	64		Dredge soil, residue		(1)
5		Gymnasium	Kawagoe Landfill site	Mie County,	22.5		Industrial waste, surplus soil		(1)
6		Office, warehouse	Nagata Landfill Site	Niigata City	Floorage 50 (m^2)				(2)
7		Gymnasium	Tsushimaya Landfill Site	Niigata City	Floorage 868 (m^2)				(2)
8		Elementary and junior high schools	Hatta Landfill Site	Fukuoka City	Floorage 3700 (m^2)				(2)
9		School for handicapped children	Imazu Landfill Site	Fukuoka City	Floorage 50 (m^2)				(2)
10		Gymnasium, athletic field	Higashi-Nagasaki Landfill Site	Nagasaki City					(2)
11		Apartment buildings by Housing Corporation	Himehama Landfill Site	Fukuoka City	Floorage 50 (m^2)				(2)
12	Industrial site	Disposal facilities	Tatsuno General Waste Disposal Site	Tatsuno City			Oversize waste		(2)
13		Compost plant	Tokyo Bay Site No. 8	Shiomi, Tokyo	36		General waste (garbage)		(1)
14		Waste incineration plant	Tokyo Bay Site No. 14	Yumenoshima, Tokyo	45		General waste (garbage)		(1)
15		Pump site	Oi Wharf No. 2	Jonan Isl., Tokyo	113		Dredge soil, residue		(1)
16		Clean center	Handa General Waste Disposal Site	Handa City	Floorage 6240 (m^2)		General waste		(2)
17		Waste incineration plant, etc.	Yokooji Landfill Site		Floorage 9361 (m^2)				(2)
18		Industrial park	Shimookubo, Urawa City	Urawa City	Floorage 50 (m^2)		General waste	Replacement process, cement improvement	(2)
19	Farmland	Upland field	Wako Disposal Site	Hamamatsu City,	1.2		General waste		(1)
20		Agricultural facilities	Ojin-cho Nishisadakata Landfill Site	Tokushima City					(2)
21	Park	General park	Moere Disposal Site	Sapporo City, Hokkaido	105	Controlled	Incombustible and combustible waste, incineration ash, cover soil	A landfill site and a park were developed simultaneously under the Green Loop Belt Scheme and the Sapporo Basic Green Plan.	(1)
22		General green park	Yamamoto Landfill Site	Sapporo City,	194		Incombustible waste, incineration ash, cover soil		(1)
23		Green buffer, etc.	Aiki Landfill Site	Tajimi City, Gifu	109		Incineration ash, incombustible waste,		(1)

(2) Problems

Ultimate land use may be restricted by two categories of negative factors, technical or relating to the properties of the landfill site, and locational.

1) Technical Problems

- Table 6-3 shows land improvement works necessary for the landfill site to be used for specific purposes. There are many requirements that it must meet to be offered for advanced purposes such as construction of structures.
- However, the technical problems listed in the table are not something that can not be overcome today.

Table 6-3 Land Improvement Works for Ultimate Land Use

Ultimate land use / Problem with land	(a) Park/green space	(b) Golf course	(c) Road/channel	(d) Parking space/athletic field	(e) Low-rise wooden house	(f) Official truck	(g) Small-scale plumbing	(h) High-rise wooden house	(i) Commercial site/industrial park	(j) Tank/silo station	(k) Plumbing for large plant
① Subsidence	○	○	△	△	Tamping needed	Tamping needed	△	Piling needed	Piling needed	Piling needed	Piling needed
② Land's bearing power	○	○	△	△	Tamping needed	Tamping needed	△	△	Piling needed	Piling needed	△
③ Generation of gas	△	△	△	△	Gas discharge equipment needed	Gas discharge equipment needed	△	Gas discharge equipment needed	Gas discharge equipment needed	Gas discharge equipment needed	△
④ Generation of leachate (groundwater level)	Leachate prevention needed	Leachate collection/treatment facilities needed	Pavement needed; drainage work not needed	Anti-permeation measures such as pavement needed	Anti-permeation measures such as pavement needed	Anti-permeation measures such as pavement needed	△	Anti-permeation measures such as pavement needed	Anti-permeation measures such as pavement needed	Anti-permeation measures such as pavement needed	△
⑤ Corrosion of metal/concrete	○	○	○	○	○	○	△	Special piling, coating, etc., needed	Special piling, coating, etc., needed	Special piling, coating, etc., needed	Special piling, coating, etc., needed
⑥ Flora undergrowth	Quality cover soil needed	Quality cover soil needed	○	△	Quality cover soil needed	△	○	Quality cover soil needed	△	○	○
⑦ Physical properties of landfill waste(Size of waste)	○	○	○	○	○	○	○	Special piling needed	Special piling needed	Special piling needed	Special piling needed
⑧ Physical properties of landfill waste(Water permeability of waste)	△	△	△	△	Surface seepage control work needed	Surface seepage control work needed	△	△	△	△	△
⑨ Disposal of waste from excavation	△	△	Disposal in controlled landfill site needed	Disposal in controlled landfill site needed	Disposal in controlled landfill site needed	Disposal in controlled landfill site needed	Disposal in controlled landfill site needed	Disposal in controlled landfill site needed	Disposal in controlled landfill site needed	Disposal in controlled landfill site needed	Disposal in controlled landfill site needed
Typical requirements	Tree growing capability; easy drainage; no offensive odor.	Tree growing capability; easy drainage; no offensive odor.	No differential settlement; adequate bearing power.	No differential settlement; no gas.	No differential settlement; no gas; tree growing capability.	No differential settlement; no gas; tree growing capability.	No differential settlement.	No differential settlement; no gas; piling possible.	No differential settlement; no gas; piling possible.	No differential settlement; no gas; piling possible.	Little differential settlement; piling possible.

Legends: △ Not an important consideration ○ Not a consideration

Source: "Research on the Development of Technology for Global-Warming-Causative Gas Treatment and Land Stabilization at Final Waste Disposal Sites" Ministry of Health and Welfare (March 1994).

2) Locational Problems

- Ultimate land use is determined by local demand as well as geographical, geological, size, and environmental restrictions that the site may have. With advances in technology for solving engineering and technical problems, geographical restrictions are becoming the most important determinant of ultimate land use.
- Completed landfills located in flat areas near city centers, or spots easy to access, may be used for various purposes, including high-level uses as schools and gymnasiums.
- On the other hand, any project for building daily facilities (schools, urban parks, industrial parks, etc.) on reclaimed land in the mountains remote from any human dwelling, as is often the case with Japan, must be underpinned by a plan for easy accessibility. In the interest of effective land use, however, a preferable option may be a site for facilities that are not used regularly and therefore may be remote from the city center (such as shelters, temporary housing, and event facilities), storage facilities (such as waste storage facilities and warehouses), or transportation facilities (such interchanges and heliports).
- Recent years have seen a new type of landfill site construction plans, which address ultimate land use in advance. In light of the fact that the duration of reclamation is twenty years at the longest and Japan is a country where land use is seriously restricted, it is of extreme importance to consider effective use of the land after completion of landfilling. It is thus necessary to choose the ultimate land use that best meets the demand of the community to ensure long-term utilization or to consider ultimate land use in the selection of candidate waste disposal sites.

3) Structural Problems for Closure of a Landfill site

A seepage control sheet may be broken in the course of improvement works for ultimate land use. Therefore, any structure that requires pile foundation must be avoided. Any other types of structures should be built on a cut foundation as the landfill layer itself may subside.

It must also be noted that any excavation of the landfill layer during improvement works for ultimate land use may result in a rise in the concentration of leachate and a delayed closure of the landfill site.

Table 6-4 Problems and Countermeasures

Technical problems	Possible signs	Countermeasures
① Subsidence	Differential settlement of a structure Damage to a structure facility Damage to plumbing Cave-in in a road Protection against long-term subsidence Banking not available according to plan Negative-friction damage to a bearing pile *	· Soil stabilization Wheel-load banking Dynamic compaction engineering method Sand compaction Deep joint treatment Grouting Replacement with quality soil Removal of waste layer · Pile foundation* Bearing pile Friction pile Ladder base Replacement of foundation materials Friction cut · Artificial flooring, public utility conduit · Use of expansion pipes, selection of joints · Selection of pluming route (avoid banking) · Banking thickness control
②Land's bearing power	Collapse of banking Subsidence of a structure	· Soil stabilization (see above) · Pile foundation* (see above)
③Generation of gas	Gas poisoning Oxygen shortage Fire, explosion Offensive odor ⑤Corrosion of metal, concrete ⑥Slower growth of plants	· Construction of an additional gas collection well · Construction of a network of gas collection lines · Establishment of a gas discharge building, etc. · Measures to ensure that no space under the floor, etc., is filled with gas (high floor, forced ventilation) · Avoidance of such covers as may cause gas stagnation. · Measures to make sure that any cave-in is ventilated during work (to prevent gas poisoning and oxygen shortage). · Measures to ensure that fire is handled with greatest care. · Use of an odor neutralizing agent, etc. · Addition of fertile soil. · Coating with acid-resistant material, etc. · Soil stabilization (Dynamic compaction engineering method, etc.)
④Generation of leachate	Generation of leachate/effluent during work (Water change during excavation, falling of open waste surface) Increase of leachate as a result of work Seepage from the slope of the landfill site (odor, color) Offensive odor ⑤Corrosion of metal, concrete ⑥Slower growth of plants	· Temporary construction of a regulation reservoir. · Formulation of a leachate treatment plan. · Implementation of Measures to reduce leachate. Seepage prevention works. (sheet, cover soil, runoff collection network) · Establishment of a network of leachate collection lines. Works to lower the groundwater level. (Underdrainage, forced drainage) · Coating with acid-resistant material.
⑦Physical properties of waste (size)	Inability to set foundation pilings.	· Adoption of mat foundation with increased rigidity.
⑧Physical properties of waste (pH, grain size, etc.)	⑥Slower growth of plants. Difficulty in setting pilings. Ground subsidence due to improper landfill of waste diverted for excavation.	· Addition of fertile soil. · Control of gas generation. · Prior research. · Leading excavation. · Site selection. · Avoidance of high banking. · Selection of diverted waste.
⑨Disposal of excavated waste	Treatment and disposal of waste excavated during the course of work.	· Treat or dispose of as work-generated waste if it is general waste.

* Work must be so carried out not to break any seepage control sheet.

Source: "Research on the Development of Technology for Global-Warming-Causative Gas Treatment and Land Stabilization at Landfill Sites" Ministry of Health and Welfare (March 1994).

7. Japan Environment Corporation's Roles in Industrial Waste Disposal

7.1 The Corporation's Functions and Roles

- Establishment

Japan attained a rapid economic growth from the late fifties to the sixties. But, at the same time, a rapid expansion of industrial production brought with it industrial pollution that seriously damaged the health of citizens, and a concentration of population in urban areas led to deteriorations in the living environment.
In this context, the central government established Pollution Prevention Corporation (which later developed into Japan Environment Corporation) in 1960 to encourage and assist private enterprises and local governments to implement antipollution measures.

- Scope of Activity

Japan Environment Corporation has provided three categories of services. Funds necessary for its projects may be borrowed from the national government on a long-term, low-rate basis. Private companies and other entities which carry out antipollution or environmental protection measures on JEC projects can thus enjoy the benefit of this favorable loan arrangement.

(1) Build-Transfer Service

This is the type of service that involves Japan Environment Corporation's construction and transfer of antipollution or environmentally friendly facilities on application from and on behalf of those companies or public entities having plans for implementing pollution control or environment protection schemes. The applicant must make a down payment of 5% to 10% of the total project cost and pay the rest in fifteen to twenty years.
A. Construction of common antipollution facilities:
Construction of drainage and other facilities that two or more companies will share.
B: Construction of industrial park facilities (common plants and sites for plants):
Development of building lots and construction of plant facilities in a safe area to which pollution-causing factories located in a city area will be relocated.
C: Construction of a buffer green zone:
Construction of a green belt to between industrial and city areas.
D: Construction of a green area for air pollution control:
Construction of a green area to reduce air pollution.
E. Simultaneous construction of an industrial waste landfill site and a green area:
Construction of an industrial waste landfill site surrounded by a green area or of green space on the completed landfill.
F. Construction of natural park facilities:
Construction of facilities both friendly to the environment and beneficial to users in national or quasi-national parks.

(2) Financing

Japan Environment Corporation finances a private enterprise or local public entity's plan to build pollution control or waste disposal facilities.

A. Financing of construction of industrial pollution control facilities:

Facilities designed to control air or water pollution, noise, offensive odor, CFC, etc.

B. Financing of construction of industrial waste disposal facilities:

Facilities for waste collection/transport/storage, intermediate treatment, reutilization/recycling, final disposal, dioxin control, etc.

C. Financing of soil pollution prevention projects:

Measures to make harmless, stabilize, enclose pollutants.

D. Financing of installation of combined-treatment septic tanks:

Home-use sewage disposal equipment.

(3) Protection of the Global Environment

In the interest of the global environment, the Corporation assists entities mainly in developing areas to implement environment protection measures.

A. Global Environment Fund:

A pool of contributions from the national government and individual persons/companies to fund the activities of nongovernmental green organizations around the world.

B. Provision of Environmental Information:

The service of providing developing countries, etc., with information on the Corporation's environment protection technology.

- Roles

Japan Environment Corporation, as a special antipollution agency, has played the following role in the implementation of national measures to address serious pollution issues.

1. It played an important role in eliminating improper land use and improving citizens' living environment by building and transferring facilities to the applicant.

With a view to improving the urban environment, it encouraged factories and business establishments in urban areas to move collectively to suitable locations or constructed buffer green zones or park facilities between residential areas and industrial areas where heavy chemical industry plants are located.

It also carried out those pollution control projects which were ahead of the times in term of both technology and technique and led private enterprises in the area of pollution prevention.

2. It functioned as one of the leading institutions to finance the environment protection activities of private companies.

For some fifteen years after its foundation (or until around 1980), heavy investments were made in pollution control facilities so as to comply with increasingly tough antipollution regulations. However, as it was also a period of financial shortage, private financial institutions were not willing to finance the introduction of pollution control facilities that were neither a direct propellant of productivity nor reached technological perfection. In this context, Japan Environment Corporation's financing facility was one of the driving forces behind the country's antipollution policy.

With greater public awareness of the importance of pollution control in later years, private bankers began to furnish more money in this area, but the total amount of the Corporation's lending still accounted for about ten percent of all required private-sector investments in industrial pollution control facilities.

The same was true with the financing of industrial waste measures; the Corporation has been also willing to fund industrial waste disposal schemes, which private financial institutions were reluctant to do, as they would, in its opinion, meet the needs of the society. Thus, it played an important role in waste treatment and disposal as well.

7.2 Financing of Industrial Waste Disposal Facilities

Japan Environment Corporation launched the service of financing industrial waste disposal facilities in 1972, two years after new legislation was enacted for the disposal of industrial waste in 1970.

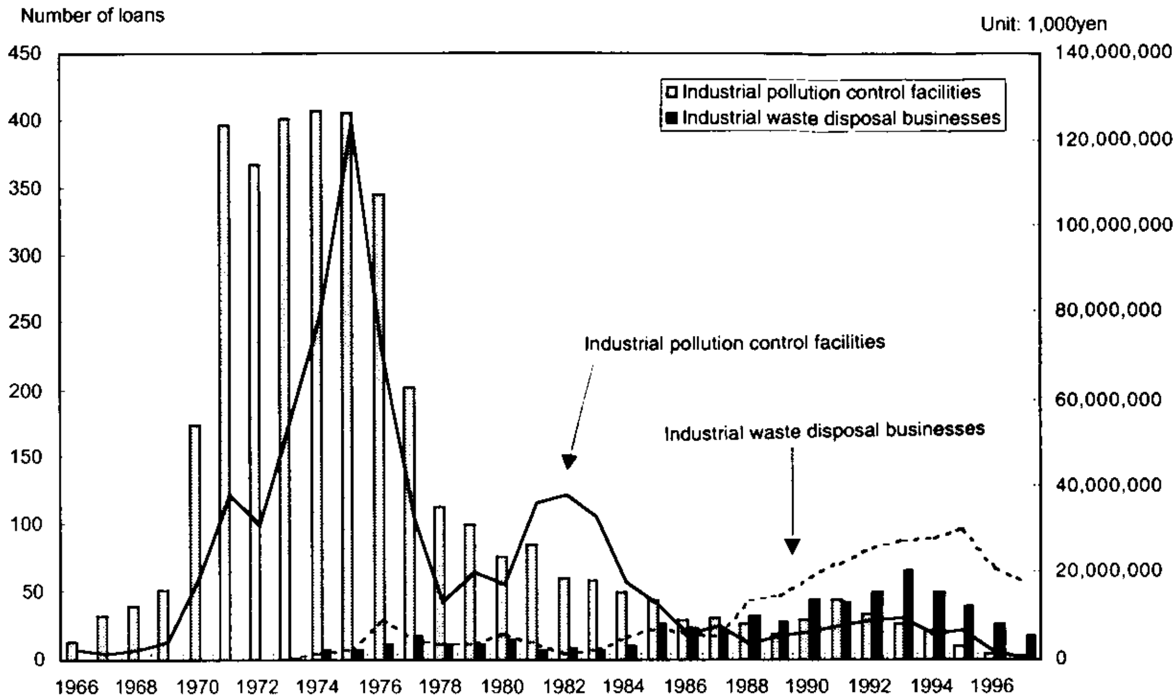
Just when efforts to tackle serious industrial pollution were put on track and began to produce some good results, proper disposal of industrial waste emerged as a new big problem. The system of mass production, mass consumption, and mass disposal that was built up during the high economic growth period now gave birth to a headache of improper waste disposal.

Until that time, public awareness of industrial waste, which discharging businesses were liable to dispose of, was not as great as that of general waste, which must be disposed of by municipal governments. Accordingly, no public loan was available for industrial waste disposal except from Japan Environment Corporation, and private financial institutions were unwilling to finance these high-risk companies. The Corporation was thus the first to offer a waste disposal financing facility.

The Corporation has extended this program, originally designed to cover waste disposal facilities owned and operated by the discharging company itself, to include outside disposal businesses as most industrial waste is transferred to them for treatment and disposal.

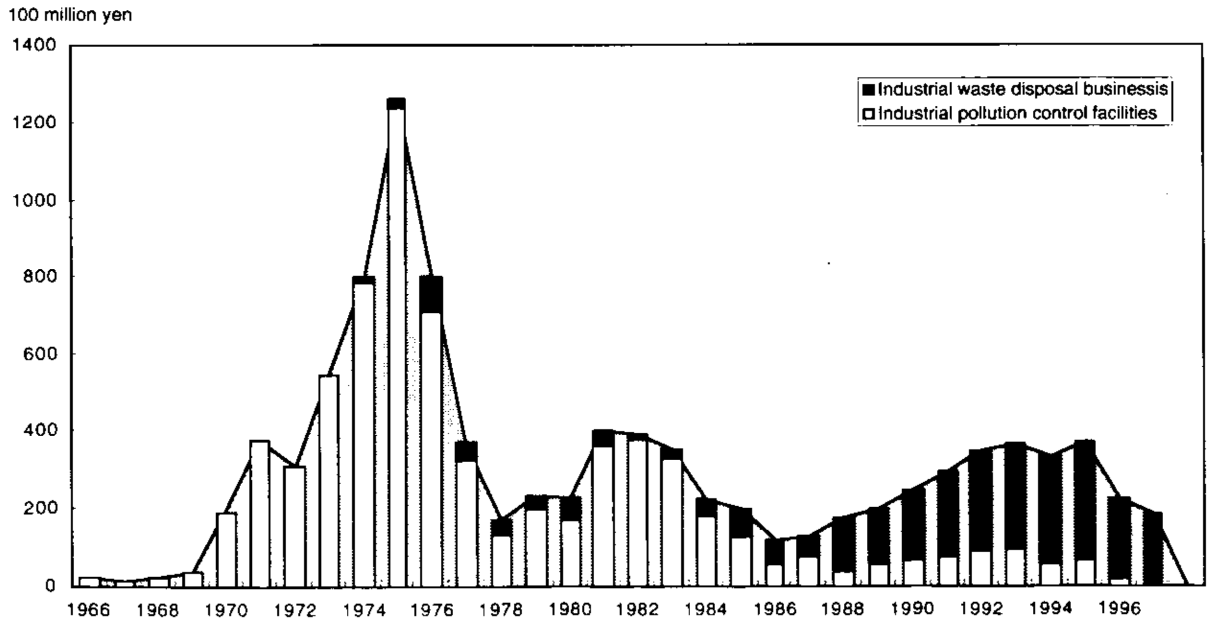
While the review of the financial status and payment ability of players in this newborn market involves many uncertainties, the Corporation emphasizes the fact that, unlike waste disposal facilities owned by discharging companies, those held by waste disposal businesses are both an essential business infrastructure and source of profit.

When industrial pollution prevention measures began to produce some good results and a wave of antipollution investments in existing production equipment was over, more loans began to go to industrial waste disposal facilities. As a result, in 1986, total lending on antipollution equipment was outstripped by that on industrial waste disposal facilities.



Note: JEC loans are available for 50% in value of the covered equipment in the case of large companies and 80% in the case of smaller businesses.

Figure 7-1 Results of JEC's Financing Service



Note: JEC loans are available for 50% in value of the covered equipment in the case of large companies and 80% in the case of smaller businesses.

Figure 7-2 JEC's Financing Service for Indusrial waste disposal businessis and Industrial pollution control facilities (amount per loan)

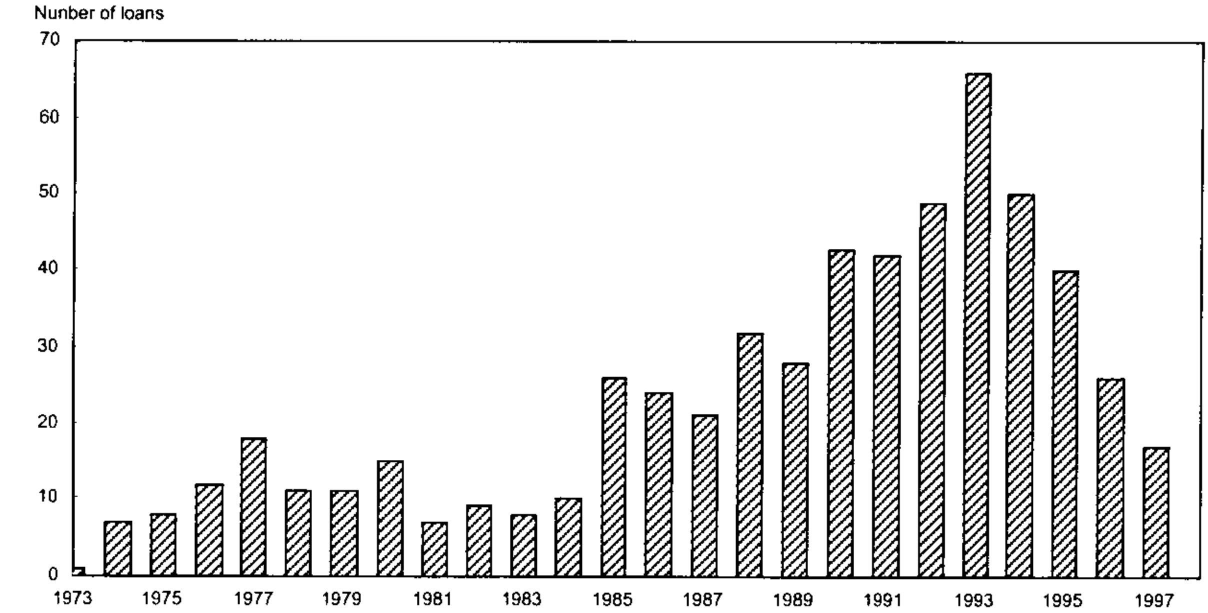


Figure 7-3 Financing by JEC (on an amount basis)

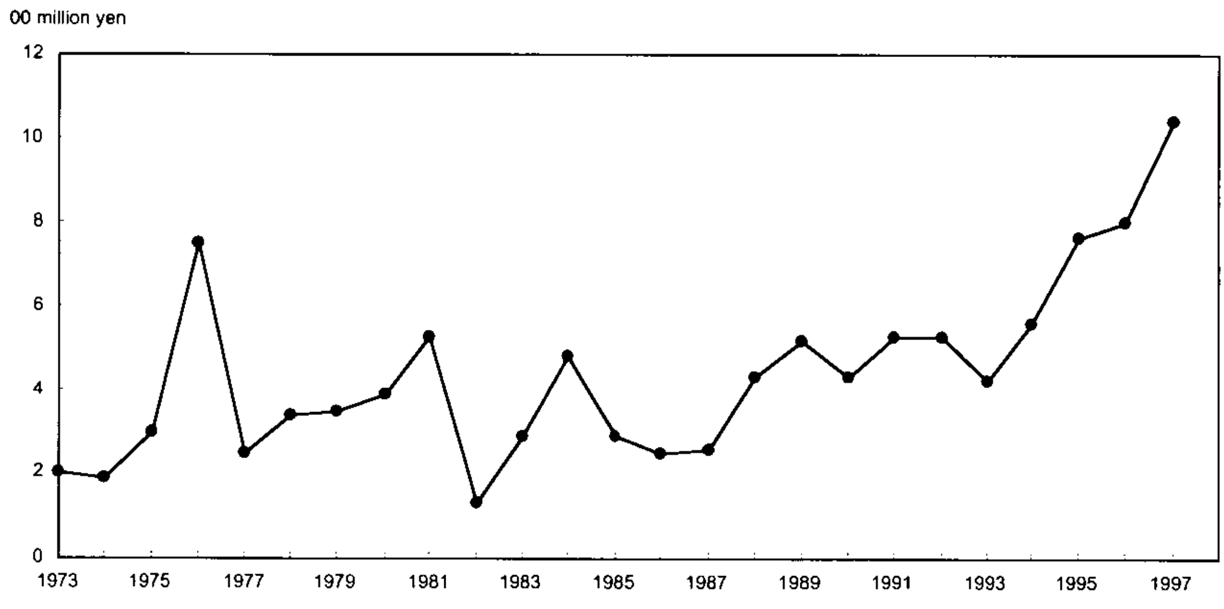


Figure 7-4 Financing by JEC (on a number-of-loan basis)

7.3 Construction and Transfer of Industrial Waste Disposal Facilities

Industrial Waste Landfill Site Combined with Green Space

The construction of waste disposal facilities now is a difficult task because the site is often difficult to find and residents stand against it asserting they are no more than a nuisance. In particular, a new private-sector landfill site for industrial waste, which discharging businesses must dispose of responsibly, has become an extreme difficulty as increased wide-area waste traffic, improper disposal, and illegal dumping have stirred up civil unrest and residents are mostly reluctant to give their consent. Public-sector involvement in the construction of industrial waste landfill sites is thus called for in order to ensure their safety, reliability, and friendliness to the surrounding environment.

The disposal site plus green space construction service, introduced to meet this demand, consists of the construction and transfer to local public entities of the following. The project cost must be paid up in twenty years.

(i) A sizable industrial waste landfill site and intermediate treatment facilities therefor that serve a wide area; and

(ii) A city park near the site or on the reclaimed land designed to protect the living environment for residents around the site.

Japan Environment Corporation plans to extend this service to include those landfill sites which handle both industrial and general waste.

It is also committed to the construction of zero-emission industrial parks where ultimate waste discharge is minimized by a recycling process.

Examples

1. Shimane industrial waste landfill site (for controlled and least controlled waste)

Area: Approx. 25 ha

Location: In the mountains in the reaches of a branch of a small river flowing into the Sea of Japan; about six kilometers from a city area.

Total project cost: Approx. 5.2 billion yen (600 million yen for site acquisition and 4.6 billion yen for construction).

Project period: Nine years (six for research and design and three for construction).

Environmental impact assessment: The assessment was carried out and local residents' consent was obtained before the construction was commenced.

Duration of reclamation (time needed to recover investment): 15 years.

Landfilled waste

Controlled: Ash, sludge, slag, paper, textile, wood, dust.

Least controlled: Construction waste, plastics, metal, glass, chinaware, rubber.

Disposal fee

Controlled waste: 11,500 yen per cubic meter (average over 15 years)

Least controlled waste: 6,500 yen per cubic meter (average over 15 years)

Outline of the facilities

(i) Controlled final landfill site

Area for landfill: 4.5 ha

Landfill capacity: 720,000 cubic meters

(ii) Least controlled landfill site

Area for landfill: Approx. 7.0 ha

Landfill capacity: Approx. 120,000,000 cubic meters

(iii) Major facilities

Common: Solid waste retaining structure (soil banking), transport control facilities (a control building and a truck scale), approach and maintenance roads, a disaster prevention pond (11,000 cubic meters), runoff collection facilities.

For controlled landfill: Seepage control sheets (double-liner, with electricity leak detection capability), leachate treatment facilities (55 cubic meters a day; biological treatment + coagulating sedimentation + secondary treatment), groundwater collection facilities.

(iv) Landfill method

Cell method (i.e., crushing and spreading waste with bulldozers and putting cover soil over it).

2. Yamaguchi industrial waste final disposal facilities combined with green space

Area: Approx. 10.5 ha

Location: A green area close to the city center where there once was a coal mine.

Total project cost: 3.5 billion yen (2.2 billion yen for site acquisition and 1.3 billion yen for construction).

Construction period: Five years (two for research and design and three for construction).

Duration of reclamation (time needed to recover investment): 20 years.

Landfilled waste: Construction waste, glass, chinaware.

Disposal fee: 7,250 yen for each cubic meter of least controlled waste (average over 20 years).

Outline of the facilities

(i) Least controlled final landfill site

Area for landfill: 3.4 ha.

Landfill capacity: 300,000 cubic meters.

Structure: Soil taken off from the landfill site (commensurate with the landfill capacity) is used for banking in the surrounding green space.

Project cost: 930 million yen (750 million yen for site acquisition and 180 million yen for construction).

(ii) Green space

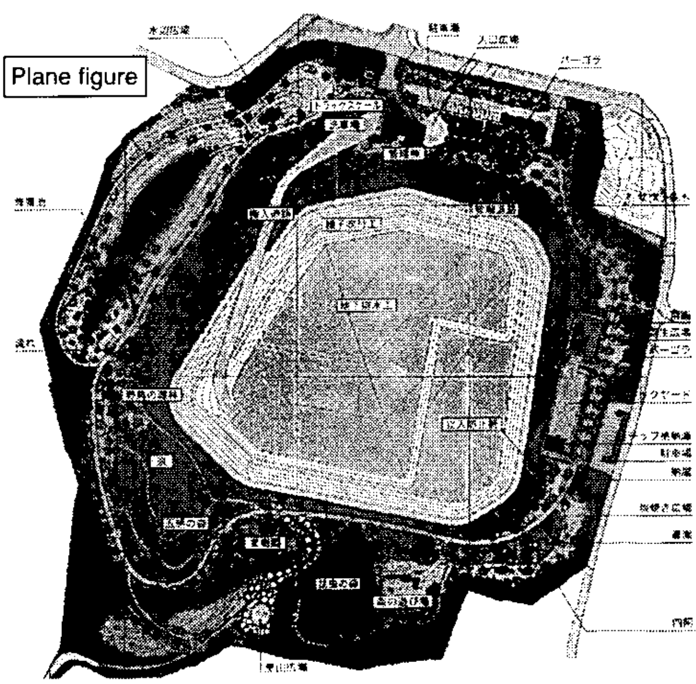
Area: 7.1 ha.

Facilities: A green park, natural environment restoration facilities, environmental learning facilities, a citizens' farm, etc.

Project cost: 2.57 billion yen (1.45 billion yen for site acquisition and 1.12 billion yen for construction).

(iii) Note

The landfill site will be converted in a green space after completion (at additional charges).



7.4 Research on the Disposal of Industrial Waste

As the proper disposal of industrial waste became a social problem and the development of technology therefor became an imperative, Japan Environment Corporation initiated research on technology for industrial waste disposal in addition to that for industrial pollution control (effluent control in particular). It is now studying ways from various angles to treat and dispose of industrial waste with maximum efficiency and minimum pressure on the environment. The findings have been provided to various public organizations and private entities in related industries and have received high appraisals.

The Corporation will use private enterprises' R&D capabilities to accelerate the development of waste disposal technology and will make any developments widely available.

1977 Technology for developing an industrial waste landfill site.

1978 Methods of treating waste plastics.

1979 Proper disposal of industrial waste (sludge).

1980 Proper disposal of industrial waste (waste oil).

1981 Proper disposal of industrial waste (mixed waste).

1982 Proper disposal of industrial waste (hazardous waste).

1983 Industrial waste landfill site (with controlled landfill).

1984 Seepage control work for a controlled final disposed site.

1985 Reutilization and recycling of industrial waste.

1986 - 1989 Ultimate land use for industrial waste landfill sites.

1990 Techniques for recycling and reutilizing construction waste, etc.

1991 - 1992 Utilization of organic waste (sludge, animal/vegetable residue, etc.).

1993 Technology for utilization of waste plastics.

1994 - 1996 Efficient promotion of the industrial waste disposal facility construction service (projects with public-sector involvement and private projects).

1994 Technological development for improvement of industrial waste disposal facilities (surface seepage control work for a controlled landfill site).

1995 Technological development for improvement of industrial waste disposal facilities (water treatment facilities for a controlled landfill site).

1996 Technological development for improvement of industrial waste disposal facilities (development of areas around the site and of the reclaimed land, and least controlled landfill sites).

1997 Technological development for improvement of industrial waste disposal facilities (risk management systems for landfill sites).

1997 Recommended consensus building process for industrial waste disposal facility construction projects.

1998 Recommended consensus building process for industrial waste disposal facility construction projects (disposal of waste discharged from intermediate treatment facilities).

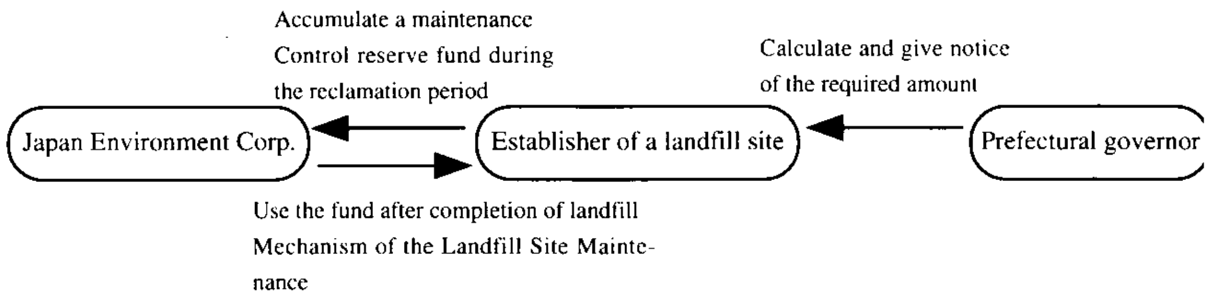
1998 Impact of industrial waste disposal facilities upon the living environment and consideration of environmental protection measures.

7.5 Management of a Reserve Fund

Any landfill site, even after its completion and despite its inability to bring profits, still requires long-term maintenance and control, including leachate treatment measures, until the risk of landfilled waste polluting the environment is reduced to an acceptable level.

To ensure proper maintenance and control of completed landfills, the Waste Disposal Law as amended in 199 stipulates that whoever established a landfill site requiring post-completion maintenance and control except fo public organizations shall accumulate a reserve fund therefor during the reclamation period.

Japan Environment Corporation takes custody of and manages such fund.



Control Reserve Fund Building System

Reference

1. Major Related Organizations to Contact for Guidance

(1) National City Cleansing Conference

IPB Ochanomizu 7th floor, Hongo 3-3-11, Bunkyo-ku, Tokyo, 113-0033

Tel: +81-3-5804-6281

(2) Waste Research Foundation

Kagurazaka 1-chome Bldg., Kagurazaka 1-15, Shinjuku-ku, Tokyo, 162-0825

Tel: +81-3-5261-9391

(3) Japan Environmental Sanitation Industry Association

Nihonbashi Core Bldg., Horidome-cho 2-8-4, Nihonbashi, Chuo-ku, Tokyo, 103-0012

Tel: +81-3-3558-1881

(4) National Federation of Industrial Waste Disposal Businesses

Daini AB Bldg. 4th floor, Roppongi 3-1-17, Minato-ku, Tokyo, 106-0032

Tel: +81-3-3224-0811

(5) Japan Environmental Sanitation Center

Yotsuyakami-cho 10-6, Kawasaki-ku, Kawasaki, Kanagawa, 210-0828

Tel: +81-44-288-4896

(6) Clean Japan Center

Daini Akiyama Bldg., Toranomon 3-6-2, Minato-ku, Tokyo, 105-0001

Tel: +81-3-3432-6301

(7) The Japan Society of Waste Management Experts

Buzenya Bldg. 5th floor, Shiba 5-1-9, Minato-ku, Tokyo, 108-0014

Tel: +81-3-3769-5099

(8) Japan Industrial Waste Technology Center

Nihonbashi Core Bldg., Horidome-cho 2-8-4, Nihonbashi, Chuo-ku, Tokyo, 103-0012

(9) Japan Ocean Disposal Businesses' Cooperative Association

Lion's Mansion #606, Shinjuku 2-3-16, Shinjuku-ku, Tokyo, 160-0022

Tel: +81-3-3356-0587

(10) Japan Waste Consultants' Association

Tokyo Sakurada Bldg. #506, Nishishinbashi 1-1-3, Minato-ku, Tokyo, 103-0003

Tel: +81-3-3593-6736

(11) Osaka Bay Wide-Area Coastal Environment Improvement Center

Midosuji Mitsui Bldg., Bingo-machi 4-1-3, Chuo-ku, Osaka, Osaka 541-0051

Tel: +81-6-6204-1721

(12) Japan Industrial Waste Management Foundation

Taiyo Horidome Bldg., Horidome-cho 1-8-13, Nihonbashi, Chuo-ku, Tokyo, 103-0012

Tel: +81-3-3639-9040

(13) The Landfill System Technologies Research Association

Within Environmental Facility Division, Japan Engineering Consultants Co.,Ltd

Honcho 5-33-11, Nakano-ku, Tokyo, 164-8601

Tel: +81-3-5385-5111 (ext. 2407)

(14) Overseas Environmental Cooperation Center

Shiba Koen Annex Bldg. 7th floor, Shiba-koen 3-1-8, Minato-ku, Tokyo, 105-0011

Tel: +81-3-5472-0144

(15) Japan Liner Association

Within Civil Engineering Division, Taiyo Kogyo

Higashiyama 3-22-1, Meguro-ku, Tokyo, 153-0043

Tel: +81-3-3714-3362

2. Cost-of-Construction Index

Year	Total average	Construction material	Durable consumer goods	Exchange rate (yen to US dollar)
1965	43.7	40.4	81.6	360.00
1966	44.7	43.3	81.4	360.00
1967	45.6	45.6	81.3	360.00
1968	45.9	45.6	81.0	360.00
1969	46.9	46.7	81.1	360.00
1970	48.6	49.0	82.6	360.00
1971	48.2	47.0	81.2	308.00
1972	48.6	49.7	81.3	308.00
1973	56.3	64.1	84.9	308.00
1974	74.0	79.6	102.9	308.00
1975	76.2	73.9	103.7	308.00
1976	80.0	78.3	102.6	308.00
1977	81.5	82.5	102.5	308.00
1978	79.5	84.0	101.5	234.00
1979	85.3	94.0	101.2	206.00
1980	100.5	105.0	102.9	242.00
1981	101.9	101.3	102.6	210.00
1982	103.7	100.9	102.1	233.00
1983	101.4	100.2	100.6	237.00
1984	101.1	101.3	100.3	231.00
1985	100.0	100.0	100.0	254.00
1986	90.9	97.5	97.4	185.00
1987	87.5	98.7	94.5	151.00
1988	86.6	100.4	90.9	127.00
1989	88.8	104.9	86.2	130.00
1990	90.6	108.6	84.6	150.00
1991	90.0	110.9	83.2	135.00
1992	88.6	110.2	82.9	130.00
1993	86.1	109.3	81.3	118.00
1994	84.3	106.5	79.4	107.00
1995	83.5	105.9	77.6	93.00

Source: Japan Statistical Yearbook (The table is based on data listed in 1997, 1990, 1984, 1979, 1974, and 1969 editions with the 1985 level at 100.)

Guidance on Use

(1) The general average is based on the basic category index under the general wholesale price index, and the price indexes for construction material and durable consumer goods are based on the special-demand-level specific and use specific price indexes.

(2) a. For a collective price conversion of several items, use the general average.

b. For semi-finished construction material, use the construction material price index.

c. For finished products such as equipment, use the price index for durable consumer goods.

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Afterword

This Project was carried out in 1998 by Overseas Environmental Cooperation Center on behalf of Japan Environment Corporation.

Since its foundation in 1965, Japan Environment Corporation has been engaged primarily in the financing of pollution prevention measures by private enterprises, granting more than 5,000 loans up to date. Its financing files contain such valuable information as the background, contents, effectiveness, and cost of improvements for pollution control.

Written as part of the industry-specific technical manual preparation project that was launched in 1995 and as a source of information for developing countries on antipollution techniques and some of Japan Environment Corporation's projects, this Manual Vol. 4 deals with landfill sites for industrial waste. For your reference, Vol. 1 (1995) covers the metal plating and marine products processing industries, Vol. 2 (1996) deals with the textile dyeing/finishing industry and meat processing industries, and Vol. 3 (1997) is intended for Pulp and Paper Industry.

This book was written by Yamamoto Mitsuhiro, Overseas Environmental Cooperation Center and Higuchi Sotaro, Japan Engineering Consultants Co., Ltd.

Japan was faced with serious waste problems in the wake of the high economic growth in the sixties. In light of enormous difficulty in finding sites for final disposal facilities in this small country, the national government adopted a basic strategy of putting all waste through intermediate treatment and disposing of any residue in landfills, a consequence of which is an increase of inorganic waste. Another feature of Japan, that is, its location in the Temperate Monsoon Zone, has promoted the development of a quasi-aerobic landfill, which uses aerobic microorganisms to decompose organic matter, and the landfill stabilization process of washing away pollutants from the landfill layer in rainwater and putting the leachate through appropriate treatment before release into the environment.

These techniques are original to Japan and totally different from the Western way, that is, keeping the landfill site in an anaerobic condition and collecting methane gas. As the need for global environmental protection has increased, Japan's final disposal technology will, though not applicable anywhere in the world, provide good guidance to those countries which have similar climatic conditions; it enables the reduction of a greenhouse-effect gas, methane, the avoidance of negative carryover, and economical landfilling.

We hope that this book will be a source of useful information to those countries which are implementing antipollution measures and thereby make some contribution to the protection of the global environment.