# CHAPTER – VI SOLID WASTE MANAGEMENT

# CHAPTER - VI

# SOLID WASTE MANAGEMENT

## 1 PRESENT CONDITION

### 1.1 PRESENT SITUATION OF THE SOLID WASTE MANAGEMENT

#### (1) Field Survey

##### 1) Outline of the Field Survey

In order to establish a solid waste management plan, obtaining the information on the collection population, waste quantity and waste characteristics in the area is the most principal as well as important issue.

The following field surveys were conducted to exactly understand the present situation of the solid waste management (SWM) in Puno City.

- Time and Motion Study on the collection work
- Survey on the solid waste quantity transported into the final disposal site
- Survey on the illegal dumping of the waste ( location and the quantity)
- Waste quantity and physical component.
- Measurement of the existing final disposal site

The details of the above surveys are described in the Supporting Report, and considering the importance of the survey results on the waste quantity, waste quality and illegal dumping waste, the results of these surveys are summarized as mentioned in the following paragraphs.

##### 2) Waste quantity and waste component

Dividing the city to the four areas of residential area, commercial area, new developing area and mountain area (A – D), investigation on the waste collection

and waste qualities is made for each location. The Zones are shown in *Figure VI.1.1.*

From the results of the survey, the waste generation per capita and the average specific gravity are 0.33kg/person-day and 0.18kg/l respectively as shown in *Table VI.1.1* and *Table VI.1.2.*

**Table VI.1.1 Generated Waste Per Capita by Zones**

| ZONES | GENERATED WASTE PER CAPITA |
|---|---|
| A-1(commercial) | 1.03 (Kg/stand/day) |
| A-2(markets) | 2.11 (Kg/stand/day) |
| B-1 | 0.30(Kg/person/day) |
| B-2 | 0.39(Kg/person/day) |
| C-1 | 0.22(Kg/person/day) |
| C-2 | 0.25(Kg/person/day) |
| D-1 | 0.41(Kg/person/day) |
| D-2 | 0.41(Kg/person/day) |
| Average | 0.33(Kg/person/day) |

Source : JICA Study Team, 1998

**Table VI.1.2 Specific Gravity of the waste by Zones (kg/l)**

| ZONES | SPECIFIC GRAVITY(kg/l) |
|---|---|
| A-1 | 0.20 |
| A-2 | 0.29 |
| B-1 | 0.17 |
| B-2 | 0.16 |
| C-1 | 0.15 |
| C-2 | 0.21 |
| D-1 | 0.12 |
| D-2 | 0.15 |
| Average | 0.18 |

Source : JICA Study Team, 1998

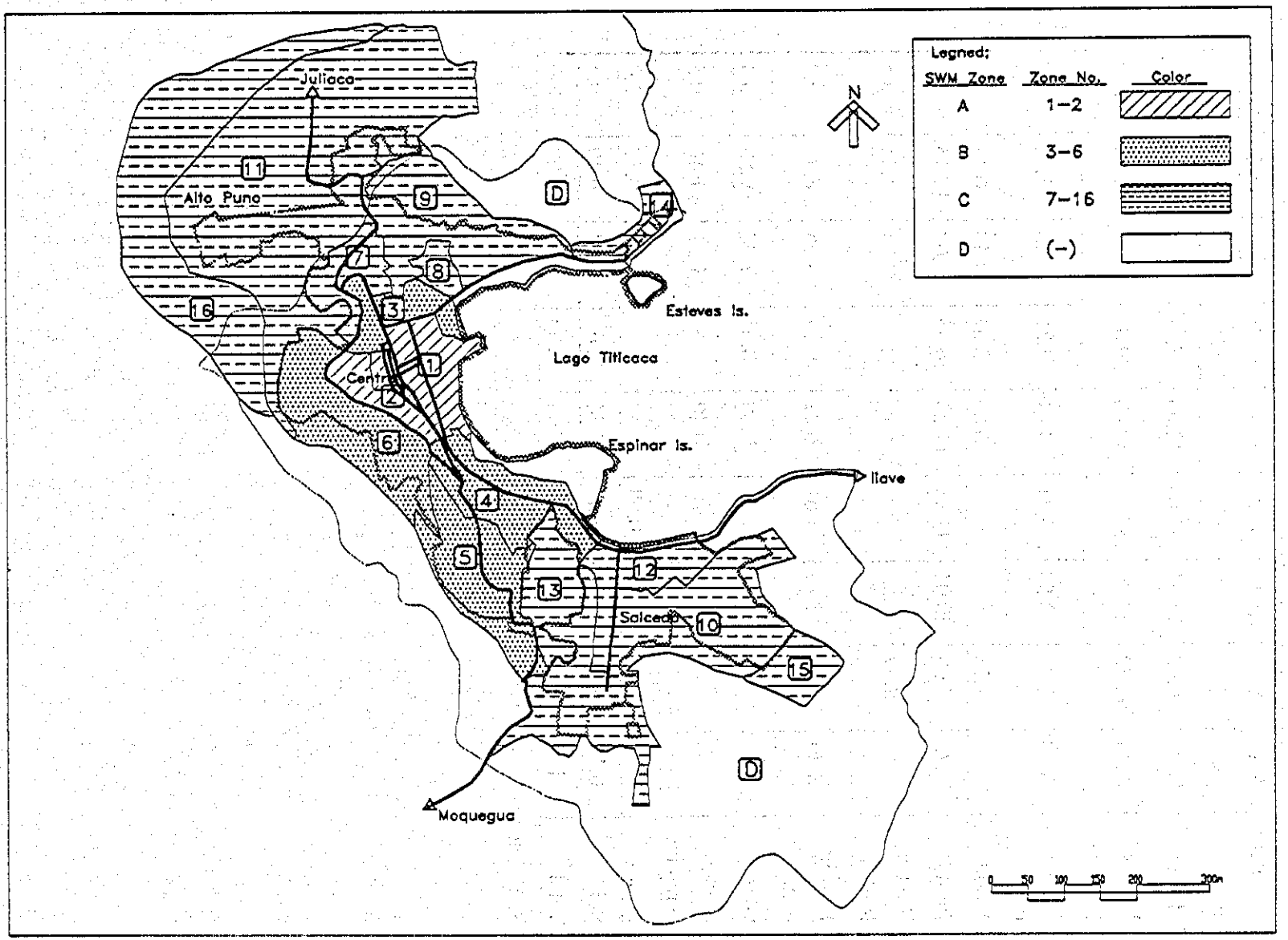



**Figure VI.1.1 Zones for Solid Waste Management**

## Table VI.1.3 Components of Waste by Zone

| ZONES | A-1 | A-2 | B-1 | B-2 | C-1 | C-2 | D-1 | D-2 | Ave. |
|---|---|---|---|---|---|---|---|---|---|
| Items | % | % | % | % | % | % | % | % | |
| Paper | 24.02 | 6.03 | 13.81 | 11.09 | 12.83 | 7.81 | 7.88 | 5.38 | 10.4 |
| Organic Garbage | 38.14 | 62.22 | 47.86 | 59.56 | 39.68 | 29.82 | 38.38 | 47.09 | 43.7 |
| Fiber, cloth | 3.60 | 2.22 | 2.53 | 3.41 | 4.01 | 3.35 | 3.23 | 1.74 | 2.9 |
| Wood | – | 1.11 | – | – | 0.60 | 0.64 | 0.40 | 0.44 | 0.5 |
| Plastic | 20.72 | 5.08 | 20.04 | 11.95 | 17.23 | 16.75 | 22.02 | 17.15 | 16.5 |
| Rubber, leather | – | 8.89 | 2.53 | – | – | – | 3.64 | 1.45 | 2.5 |
| Ferrous metals | 3.30 | 1.11 | 4.28 | 4.61 | 6.21 | 10.37 | 8.08 | 8.72 | 6.2 |
| Glass | 7.52 | 1.11 | 1.95 | 1.87 | 0.60 | 8.61 | 7.08 | 9.59 | 5.4 |
| Stones, ceramics | – | – | – | – | 0.40 | – | 1.21 | 1.46 | 0.5 |
| Bones | – | 8.42 | 3.89 | 0.68 | – | – | 0.40 | 0.58 | 2.0 |
| Soil | 0.15 | 3.81 | 3.11 | 6.83 | 18.44 | 22.65 | 7.68 | 6.40 | 9.4 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Source : JICA Study Team, 1998

**Table VI.1.4 Comparative Table of the Components of Solid Waste in Puno City**

| Components | 1994 1) | 1997 1) | 1998 2) |
|---|---|---|---|
| Paper, Cardboard | 9.5 | 8.2 | 10.4 |
| Kitchen garbage | 49.3 | 39.8 | 43.7 |
| Fiber, cloth | | | 2.9 |
| Wood | | | 0.5 |
| Plastic | 10.3 | 11.4 | 16.5 |
| Rubber, leather | | | 2.5 |
| Ferrous metal | 1.2 | 4.9 | 6.2 |
| Glass | 5.8 | 6.7 | 5.4 |
| Stones, ceramics | | | 0.5 |
| Bones | | | 2.0 |
| Soil | 24.0 | 29.0 | 9.4 |
| Total | 100.0 | 100.0 | 100.0 |

Source: 1) Municipalidad Provincial de Puno; Survey in Nov.1998
2) JICA Study Team, 1998

Components of the waste by zone analyzed in the above survey are shown in *Table VI.1.3.*

Waste characteristics are shown in *Table VI.1.4* including the analyzed results in 1994 and 1997. *Table VI.1.4* shows that the change of the waste characteristics is considered to be small.

### 3) Illegal dumping of the waste

In the city there are some locations where cleansing service is not performed because collection vehicles are unable to access to the locations.

As the result of the survey, 67 locations of illegal dumping were recognized and the total surface area and the quantity of the dumping sites were estimated as 5500$m^2$ and 180$m^3$ respectively.

The areas to where collection vehicles are unable to access were counted as 50 locations and 20 of them are mountain slope areas, 10 are lakeside areas and the remaining 20 are other areas..

### 4) Present Situation of the Solid Waste Management

#### a. Outline of the Solid Waste Management

The resent population of Puno City is 110,013 (in 1998) and the generation of the municipal solid waste is 68.4t/day.

The city owns 7 collection vehicles but only four (4) of them are available for use to collect half of the waste generated in the city. The other three (3) vehicles are out of operation due to poor maintenance.

The household wastes were collected by Bell Collection System in the afternoon but only one third is collected because some locations on the mountain side have difficult access for vehicles. Many of the roads in those areas are narrow and sloping. Some illegal dumping sites also exist in the city.

The wastes collected in the city are transported to the Cancharani final disposal site about 7 km from the center of the city and finally disposed at the site. The site is furnished with some facilities and equipment (such as rain water drainage ditch, gas exhaust pipe, fence, gate, etc.) but the lack of heavy equipment prevents the execution of the sanitary disposal, especially soil covering on the waste.

Therefore the Waste Management System in Puno City is not presently fully functional and improvement of the system is required.

*Figure VI.1.2* shows the flow of solid waste treatment in 1998 and *Table VI.1.5* shows the waste generation and transported quantity of the waste to the final disposal site (FDS). The table shows that the total collection rate of the waste in the city is 52% and rates of the collected waste for household and street cleansing are 35% and 75% respectively.

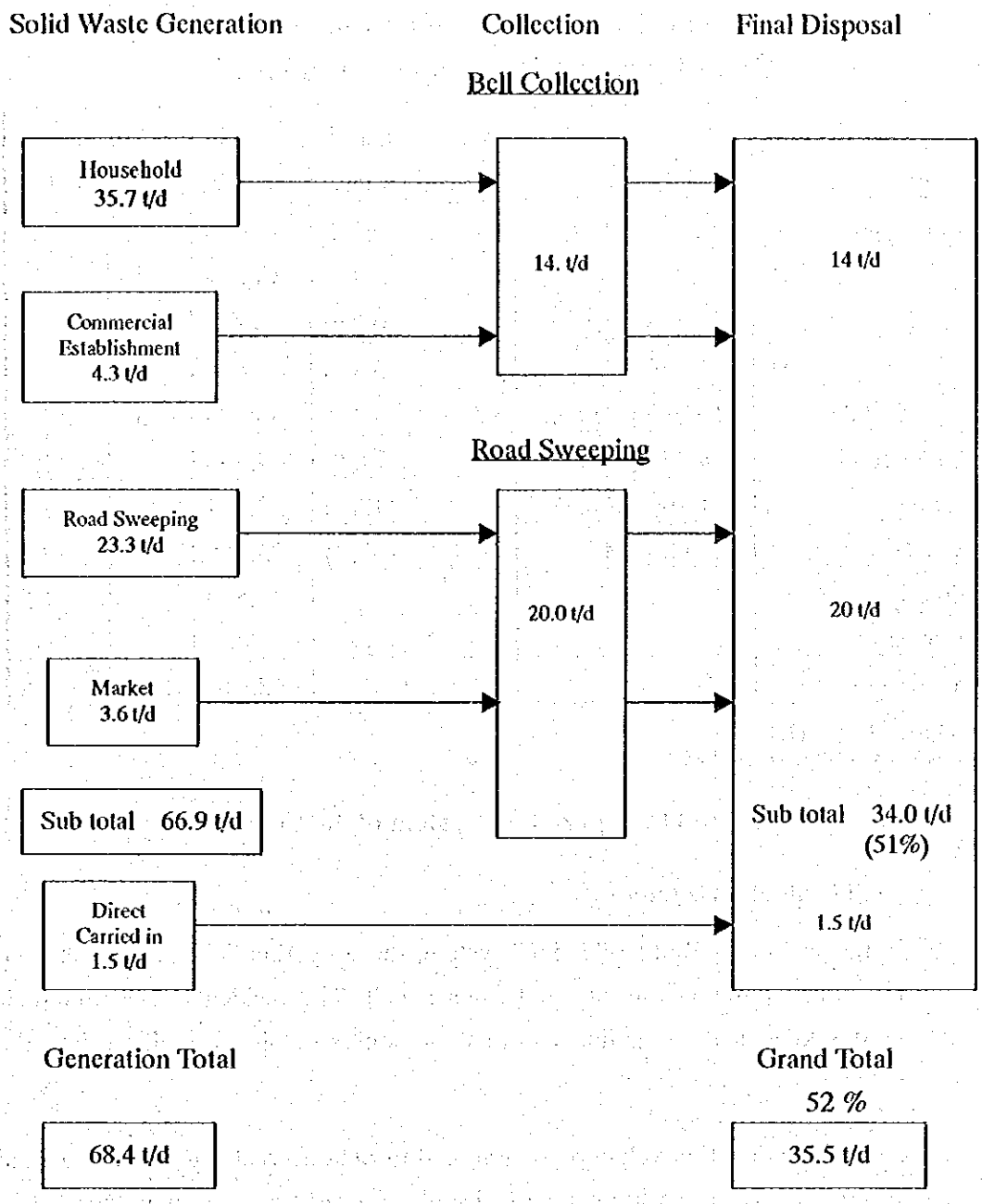



**Figure VI.1.2 Flow of Solid Wastes in Puno City (1998)**

## Table VI.1.5 Quantity of Waste Generation in Puno City And Quantity of Waste transported to F.D.S

| Origin | | Quantity of Waste Generation | | | | Collection | |
|---|---|---|---|---|---|---|---|
| | | Population | | Per capita/ day | kg/day | % | T/day |
| Household | A | 28,615 | Person | 0.350 | 10,015 | | |
| | B | 53,369 | Person | 0.350 | 18,679 | | |
| | C | 26,473 | Person | 0.240 | 6,354 | | |
| | D | 1,556 | Person | 0.416 | 647 | | |
| Total | | 110,013 | Person | 0.324 | 35,695 | 35 | 12.5 |
| Commercial | | 4,236 | Est. | 1.030 | 4,363 | | 1.5 |
| Market | | 1,700 | Stand | 2.110(1) | 3,587 | | 2.6 |
| Road Sweeping | | 82.5 | Ha | 282(2) | 23,265 | 75 | 17.4 |
| Directly Transported | | | | | 1,500 | | 1.5 |
| Grand Total | | | | | 68,410 | 52.0 | 35.5 |

(1) kg/Stand (2) kg/ha
Source :JICA Study Team, 1998

### b. Collection and transportation System of the Solid Waste

#### -Bell Collection System

In the so-called "Bell Collection" system, the collection vehicle stops at each prescribed point in the city and rings a bell. The residents bring out their wastes kept in the containers from their houses or shops to throw into the vehicle.

Available collection vehicles are assigned to run different routes. The average speed of the car is 5.5 km/h and the distance for one trip is 20 to 36 km.

#### -Road Sweeping System

Sixty six (66) crew are assigned to sweep the designated areas manually and the swept wastes are gathered to 22 accumulation points in the city by tricycle to transport by 4 collection vehicles.

The speed of the collection vehicle is 6.2 km/h on average and it runs 25km in the city for one trip to carry the waste to the final disposal site.

**-Collection Vehicles**

Seven (7 ) vehicles are owned by Puno Provincial Municipality but most of them are old and even the newest vehicle is ten years old. Presently only four vehicles, two compactors ($12m^3$ and $6m^3$ ) and two open dump trucks (each 5 ton), are available because of the lack of maintenance. These four vehicles run in the city two times a day, early in the morning and in the afternoon , for five days a week.

Each vehicle collects wastes from roads and markets in the morning and collects waste from households, shops, schools and hospitals in the afternoon for transport to the Cancharani final disposal site.

*Table VI.1.6* shows the present data on the vehicles owned by Puno Provincial Municipality.

**Table VI.1.6 Vehicles owned by Puno Provincial Municipality**

| | | Unit | $M^3$ | Year of Manufacture | Present Situation |
|---|---|---|---|---|---|
| 1 | Compactor D500 | 1 | 6 | 1976 | In Use |
| 2 | Open Dump D500 | 1 | 5 | 1981 | In Use |
| 3 | Open Dump 3041 | 1 | 7 | 1983 | Not Used |
| 4 | Open Dump | 1 | 5 | 1988 | In Use |
| 5 | Compactor D500 | 1 | 12 | 1981 | In Use |
| 6 | Compactor | 1 | 12 | 1981 | Not Used |
| 7 | Utility Car | 1 | - | 1983 | Not Used |

Source: PUNO Provincial Municipality

**c. Re-use of the wastes**

At each waste accumulation point in the city, re-usable waste materials are salvaged but this collection is not so useful for reduction of waste because it is not organized.

So-called scavengers were not recognized in Puno City as well as at the final disposal site.

### d. Cancharani Final Disposal Site

#### -Geographic Characteristics

At the foot of the Mt Cancharani, about 7km from the center of the city, Puno Provincial Municipality has a final disposal site (the site is 4000m above sea level and about 200m higher than the surface of Lake Titicaca)

The leachate, if any, from the final disposal site does not flow into the Puno basin, because the site is located behind the watershed of Puno Interior Bay. However the leachate may go into Lake Titicaca by a different route from Puno City via the Illabe river. The whole surrounding area of the final disposal site is in the catchment area of Lake Titicaca. Treatment of the leachate from the final disposal site should be considered.

#### - The Capacity of the Final Disposal Site

The Cancharani final disposal site is about 10ha and the half of the area has been already buried. In *Table VI.1.7*, the capacity is shown.

## Table VI.1.7 Estimation of the Expected Capacity of Cancharani Site

| EXPECTED CAPACITY OF CANCHARANI SITE PREPARED BY THE CITY | | | | | |
|---|---|---|---|---|---|
| Site No. | Area m2 | Average depth of the sites | Capacity (m3) | Life Expectation Years | Remarks |
| Site 1 | 5030 | 6 | 0 | | Closed |
| Site 2 | 12640 | 6 | 75,840 | 0.7 | Half used |
| Site 3 | 8130 | 6 | 48,780 | 1.0 | |
| Site 4 | 11730 | 6 | 70,380 | 1.4 | |
| Site 5 | 11390 | 6 | 68,340 | 1.3 | |
| Total | | | 263,340 | 4.4 | |
| In this calculation, the transported waste is assumed as 70 t/d, total 25,550 t/y or 51,110 m3/y (specific weight : 0.5 t/m$^3$) | | | | | |
| According to the World Bank Report, the depth of the site is 9m; however, the survey shows 6m at max. | | | | | |

Source : JICA Study Team

According to the above table, the remaining life of the final disposal site is about four years in total and an early expansion of the final disposal site is required.

**- Covering Soil**

In order to make sanitary landfill, covering the waste with soil is the principal issue. Presently this is not well performed in the final disposal site because the Puno Provincial Municipality does not own such necessary equipment as bulldozer, excavator and dump truck to transport the soil and these are rented by contract. The spreading, compacting and daily soil covering are not performed.

**- Facilities and equipment supplied in the site.**

Present facilities and equipment furnished at the site are not enough to perform a sanitary landfill although the site is furnished by border fence, rainwater drainage, open channel, gas ventilation pipe stock yard and coves soil.

New construction technical standards for sanitary landfill will be shortly put into effect by DIGESA. These will include:

- Seepage Control Layer
- Installation Leachate Collection Pipes
- Gas ventilation facility
- Installation of a fence
- Access road to the landfill site
- Leachate treatment facility
- Facility for generation of electricity

Furthermore, other than the above mentioned facilities and equipment, the Cancharani site has no truck scale to weigh the waste quantity carried to the site and no vehicle repair facility vehicle.

### e. Organization for the Solid Waste Management, Repair and Maintenance in Puno City.

The solid waste management in Puno City is directly executed by the Department of Public Cleansing which belongs to the Health and Environmental Sanitation Division under the Municipal Service Directorate.

This department directly carries out the city cleansing activities. However due to a small budget, it is difficult to employ qualified staff in the planning section to make plans. There is no solid waste management plan for the future. Consequently, the solid waste management carried out at present does not have appropriate policies to improve the administrative management.

In the city there is station to keep the vehicles and warehouse to keep the equipment for collection and transportation. However there is no specific repair shop for vehicles and equipment. They are repaired and maintained at privately owned workshops in Puno City. Therefore, this situation causes lack of maintenance of the vehicles as well as insufficient management of the spare parts. Consequently, the system for maintaining and renewing the equipment cannot work well, and the low efficiency of waste collection and transportation makes the hillside area and the lakeside area unclean.

## 1.2 EVALUATION OF PRESENT CONDITION

### (1) Situation of the Scattered Solid Waste in the City

Puno City has developed on the mountain slope facing to Lake Titicaca. On the hillside many roads were poorly constructed because of steep slopes. Because of this some parts of the city are not included in the waste collection service and in those areas wastes are illegally dumped into the streams or drainage in the city, which eventually bring the wastes into the lake.

In the city, some wastes are scattered at many places, resulting in the low collection rate of 52 %.

### (2) Solid Waste Management System

Puno Provincial Municipality is in charge of collection, transport and disposal of solid wastes; however the collection system and the shortage of equipment such as collection vehicles are problems to be urgently solved.

### (3) Final Disposal Site

At the final disposal site, daily soil covering is not performed due to the lack of heavy equipment and so the site is in an unsanitary condition which makes it a breeding place of harmful insects.

The present final disposal site will only last about four years and therefore preparation of a new landfill site is urgent subject for consideration.

Enactment of the new technical standard on sanitary landfill construction will become effective in the near future and the provincial municipality has to have a design of the new land fill site that complies with the standard, in parallel with the acquisition of the new site.

## 1.3 IDENTIFICATION OF PROBLEM

### (1) Short term problem

#### 1) Illegally dumped wastes

- Areas of uncollected wastes
- Shortage of collection time
- Insufficient collection frequency for existing containers

#### 2) Collection vehicles

- Lack of collection vehicles
- Very old type vehicles
- Poor maintenance

#### 3) Unsatisfactory situation of the final disposal site

- Lack of soil covering
- Lack of heavy equipment

#### 4) Administration and organization

- Lack of systems for maintaining and renewing the equipment required for waste collection & transportation
- Lack of campaign for promoting citizen's participation
- Inefficient charging system for the cost for the solid waste management

### (2) Intermediate term problems

- Uncertainty of the land acquisition for future final disposal site
- Lack of knowledge to establish a long term solid waste management plan
- Lack of staff members in the Department of Public Cleaning

# 2. MASTER PLAN

## 2.1 TARGET AND STRATEGY

The target of the present project is to achieve 100% collection rate of the municipal solid waste generated in Puno City. It will realize the reduction of the pollution loads generated from solid wastes, which can be one of the countermeasures to prevent the water pollution in Puno Interior Bay.

The final target year is set in 2025, the same as that of the water supply and sewerage project.

**Short term target**

the year 2008 : Implementation of sanitary landfill and increase of waste collection rate

**Long term target**

the year 2025: Achievement of waste collection rate = 100 %

**Strategic target**

The following three items shall be implemented to achieve the target strategically.

- Removal of the illegally dumped wastes( continuous removal of the illegally dumped wastes and elimination of illegal dumping)
- Improvement of the collection rate of the solid wastes (improvement of the collection system, purchase of additional collection vehicles, enhancement of the citizen's consciousness
- Improvement of the final disposal site (thoroughness of sanitary landfill method, acquisition of necessary space for final disposition)

The Master Plan is formulated considering the achievement of the above targets.

## 2.2 PLANNING CONDITION

### (1) Population and Land use

#### a. Population

As described in Section 1 (Present Condition), of this chapter, the population of Puno City is increasing every year and the population in 2025 is forecasted as 186,560 which corresponds to about 1.7 times as many as the present population in 1998.

Forecast of the future population is shown in *Table VI.2.1*.

**Table VI.2.1 Estimation of Population Growth in Puno City**

| Zone | A | B | C | D | TOTAL |
|---|---|---|---|---|---|
| 1998 | 28,615 | 53,369 | 26,473 | 1,556 | 110,013 |
| 2008 | 27,453 | 61,434 | 50,188 | 1,556 | 140,631 |
| 2025 | 25,710 | 73,533 | 85,761 | 1,556 | 186,560 |
| GROWTH RATE | 90% | 138% | 324% | 100% | 170% |

*Table VI.2.1* shows that the future distribution of the population is different by zone in the city. Population will decrease 10% in Zone A and that of Zone C will increase three times as many as the present population.

#### b. Land utilization

Among the four zones of Puno City, noted as Zone A, Zone B, Zone C and Zone D, Zone A and Zone B are located in the center of the city which includes some residential quarters and Zone C is a newly developed area and Zone D is not suitable for residents. In the future, a tourist resort zone will be constructed along the shoreline of the lake, and main trunk roads will be constructed as well with the progress of the development plan. The realization of the new road construction will make the collection and transportation of solid wastes easier as well as giving the benefit for general transportation.

## (2) Planning Criteria

### 1) Solid Waste Quantity and Characteristics

*Table VI.2.2* shows a future prediction of waste generation in Puno City. In this the figures of the waste generation per capita is calculated based on the assumption that the annual economic growth ratio of the City is 1.5%.

The generated waste will be 86 t/day in 2008 compared with the amount of 67 t/day in 1998.

No yearly change of the waste characteristics as shown in *Table VI.1.4* is assumed, although the precise situation is not easy to predict.

*Table VI.2.2* and *Figure VI.2.1* predict the waste generation in Puno City.

**Table VI.2.2 Estimation of Waste Generation in Puno City**

| | POPULATION | | | GENERATION PER CAPITA (kg/d/capita) | | | GENERATION(kg/d) | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | 1998 | 2008 | 2025 | 1998 | 2008 | 2025 | 1998 | 2008 | 2025 |
| Zone A | 28,615 | 27,453 | 25,710 | 0.350 | 0.406 | 0.523 | 10,015 | 11,151 | 13,451 |
| Zone B | 53,369 | 61,434 | 73,533 | 0.350 | 0.406 | 0.523 | 18,679 | 24,954 | 38,471 |
| Zone C | 26,473 | 50,188 | 85,761 | 0.240 | 0.278 | 0.359 | 6,354 | 13,979 | 30,767 |
| Zone D | 1,556 | 1,556 | 1,556 | 0.410 | 0.476 | 0.613 | 638 | 740 | 954 |
| Total (Average) | 110,013 | 140,631 | 186,560 | (0.330) | (0.392) | (0.505) | 35,686 | 50,825 | 83,643 |
| A-1 Commercial No. of Est. | 4,236 | 4,155 | 4,011 | 1.03 | 1.03 | 1.03 | 4,363 | 4,279 | 4,131 |
| Commercial Waste No. of Stand | 1,700 | 1,700 | 1,700 | 2.11 | 2.11 | 2.11 | 3,587 | 3,587 | 3,587 |
| Road Sweeping Kg/ha-road | 825 | 95.3 | 123.3 | 2.82 | 2.82 | 2.82 | 23,265 | 27,006 | 34,777 |
| Total Generation Waste | | | | | | | 66,901 | 85,697 | 126,137 |
| Directly Transported to site | | | | | | | 1,500 | 1,741 | 2,242 |
| GRAND Total | | | | | | | 68,401 | 87,439 | 128,380 |

*Figure VI.2.1* shows the predicted flow of solid waste treatment in 2025 in Puno City.

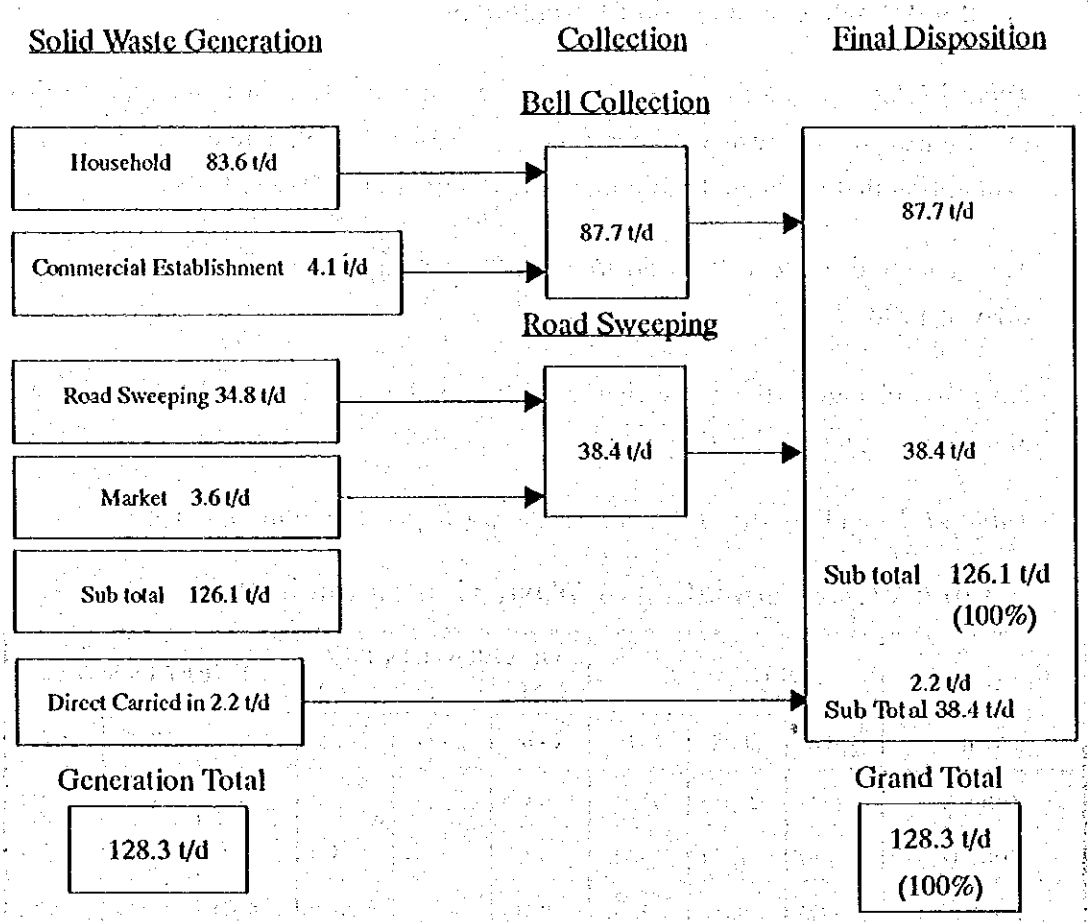



**Figure VI.2.1 Flow of Solid Waste in Puno City (2025)**

### 2) System Consideration

Solid waste management in Puno City is executed by the Cleansing Department. The wastes come not only from general households but also from commercial establishments, business areas, road sweeping, public cleansing, parks, factories and from hospitals and are collected and carried to the final disposal site.

Frequency of the collection for the household waste by the Bell Collection System is two to three times a week for Zone A and Zone B, once a week for Zone C and for Zone D no regular collection is performed.

The wastes from street sweeping and from the market are collected by the Street Collection System.

## 2.3 ALTERNATIVE PLANS FOR STRUCTURAL MEASURES

### (1) Possible Measures

#### 1) Improvement for Collection and Transportation

- Additional purchase of collection vehicles

  Seven collection vehicles are owned by Puno City, but among them only four vehicles are available to work because of the deterioration of other vehicles. In order to improve the waste collection rate, more vehicles are required.

  *Table VI.2.3* shows the present and the required numbers of the vehicles.

**Table VI.2.3 Required number of Vehicles for Collection**

| Kind of Vehicle | At present | Future Numbers required |
|---|---|---|
| | 1999 | Refer to Table VI.2.5 |
| 12m3 Compactor | 1 | |
| 6m3 Compactor | 1 | |
| 5ton Dump Truck | 2 | |
| 4.0m$^3$ Compactor | 2 | |
| Total | 6 | |

Therefore preparation of the budget to purchase the new vehicles should be done as soon as possible.

- Improvement of the collection system

  In order to improve the present low collection rate of 35% for household waste, in addition to the supplement of the new vehicles an increase of the collection frequency and a study to set up the new carrying routes which is effective to the collection are required.

- Improvement of the performance level for road sweeping

  In addition to the present manual sweeping method it is recommended to have the arrangement of the containers and of the collection vehicles (Roll-on-off vehicle etc.)

- Study on the collection system

There are many slopes in Puno City and poor construction of the road in the steep slope area makes it difficult for specific container hauling vehicles to access.

It is required to make a study to introduce an appropriate collection system for such site conditions, for example arrangement of the containers and small compactor cars.

### 2) Improvement of the final disposal site

- Additions to the heavy equipment owned by the provincial municipality

  Daily covering by soil is not performed for the landfill due to the lack of heavy equipment. Additional equipment such as bulldozer, excavator and dump truck owned by the provincial municipality is required.

- Acquisition of the new land for the expansion of the landfill

  Present landfill site will be filled after several years and the new landfill site should be bought or leased.

- Leachate treatment system

  Leachate treatment system should be newly installed, because new regulations to stipulate this for the construction of the landfill will be enacted in near future.

### 3) Removal of the illegally dumped wastes

Illegally dumped wastes in the various places in the city contaminate the lake water, especially when they are flushed out by rain, therefore removal of the waste is required as soon as possible.

The removal work should be done in cooperation with PRONAA. Organization of a monitoring system to detect illegal dumping as well as the implementation of education on public sanitation is necessary.

#### 4) Management

- Strengthening of the organization and institution

  It is desirable to unite the many organizations which are involved in the solid waste management. Presently collection and transportation are done by the Cleansing Department, maintenance of the vehicles by Maintenance Department, collection of the tipping fee and public education are done by two different organizations.

- Strengthening of the financial foundation

  Financial analysis of the solid waste management is difficult because of insufficient records of the financial/accounting issues up to now. The improvement of this situation is required.

- Public education and the enhancement of the resident's motivation to participate

  Implementation of the public's sanitary education and the enhancement of resident's motivation to participate in that are necessary because their knowledge on the municipal waste handling is very small.

### (2) Alternative Plans

#### 1) Collection and Transport

A study to prepare an improvement plan based on the present collection systems was made.

As the general condition,

- The project will start from 2002
- Comparison of the required equipment and size of the work force
- Adoption of the collection system fit for individual collection area

Alternative 1 (A-1) : Adoption of the present Bell Collection System for the whole area of Zone A, B, C and D with collection frequency of twice a week

Alternative 2 (A-2) : For Zone A and Zone B the collection system which is used for A-1 is adopted and for Zone C and Zone D a new system based on the combination of container setting and introduction of special vehicles is adopted.

Alternative 3 (A-3) : Container is arranged for Zone C in the above A-2.

The evaluation of these three alternatives and the results are shown in *Table VI.2.4*. These results include weight of population and weight of cost of each alternative.

As shown in *Table VI.2.4*, the totally evaluated marks are [A-1]=17.1, [A-2]=16.05, [A-3]=15.99. The best alternative is A-1.

*Table VI.2.5* shows the required vehicles and machines to achieve 100% waste collection rate in 2008, and since then, the rate will be kept up to 2025. If the rate of 100 % will be achieved in 2008, necessary costs based upon *Table VI.2.5* are shown in *Table VI.2.6*.

## Table VI.2.4 Evaluation for Alternatives

### EVALUATION CRITERIA

| | Evaluation Point | |
|---|---|---|
| 1) Topographical shape | Flat Area | Hill Side |
| | 2 | 1 |
| 2) Distance to points of discharge | Longer | Shorter |
| | 1 | 2 |
| 3)Restriction of timing for discharge | Weak | Strong |
| | 2 | 1 |
| 4)Road Conditions | Wider | Narrow |
| | 2 | 1 |
| 5)Possibility of illegal dumping | Higher | Lower |
| | 1 | 2 |
| 6) Possibility of repetition of illegal dumping | Higher | Lower |
| | 1 | 2 |

## RESULTS OF EVALUATION;

### Alternative 1

| No. | Items of Evaluation | Classification of Zone | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | TOTAL |
| 1 | Topographical shape | 2.0 | 2.0 | 1.0 | 1.0 | 6.0 |
| 2 | Difficulty of discharge | 3.0 | 3.0 | 2.5 | 2.0 | 10.5 |
| 2-1 | Distance to points of discharge | 2.0 | 2.0 | 1.5 | 1.0 | 6.5 |
| 2-2 | Restriction of timing for discharge | 1.0 | 1.0 | 1.0 | 1.0 | 4.0 |
| 3 | Road Conditions | 1.0 | 1.0 | 1.5 | 1.0 | 4.5 |
| 4 | Possibility of illegal dumping | 1.0 | 1.0 | 1.0 | 1.0 | 4.0 |
| 5 | Possibility of repetition of illegal dumping | 1.0 | 1.0 | 1.0 | 1.0 | 4.0 |
| | Total | 8.0 | 8.0 | 7.0 | 6.0 | 29.0 |
| | Consideration of Population Weight | 4.0 | 8.0 | 4.9 | 0.2 | 17.1 |
| | Consideration of Cost Weight | 4.00 | 8.00 | 4.90 | 0.2 | 17.1 |

### Alternative 2

| No. | Items of Evaluation | Classification of Zone | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | TOTAL |
| 1 | Topographical shape | 2.0 | 2.0 | 1.5 | 2.0 | 7.5 |
| 2 | Difficulty of discharge | 3.0 | 3.0 | 3.3 | 4.0 | 13.3 |
| 2-1 | Distance to points of discharge | 2.0 | 2.0 | 1.8 | 2.0 | 7.8 |
| 2-2 | Restriction of timing for discharge | 1.0 | 1.0 | 1.5 | 2.0 | 5.5 |
| 3 | Road Conditions | 1.0 | 1.0 | 1.5 | 2.0 | 5.5 |
| 4 | Possibility of illegal dumping | 1.0 | 1.0 | 1.8 | 2.0 | 5.8 |
| 5 | Possibility of repetition of illegal dumping | 1.0 | 1.0 | 1.5 | 2.0 | 5.5 |
| | Total | 8.0 | 8.0 | 9.5 | 12.0 | 37.5 |
| | Consideration of Population Weight | 4.0 | 8.0 | 6.7 | 0.4 | 19.0 |
| | Consideration of Cost Weight | 3.32 | 6.64 | 5.56 | 0.33 | 15.85 |

## Alternative 3

| No. | Items of Evaluation | Classification of Zone | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | TOTAL |
| 1 | Topographical shape | 2.0 | 2.0 | 2.0 | 2.0 | 8.0 |
| 2 | Difficulty of discharge | 3.0 | 3.0 | 4.0 | 4.0 | 14.0 |
| 2-1 | Distance to points of discharge | 2.0 | 2.0 | 2.0 | 2.0 | 8.0 |
| 2-2 | Restriction of timing for discharge | 1.0 | 1.0 | 2.0 | 2.0 | 6.0 |
| 3 | Road Conditions | 1.0 | 1.0 | 1.5 | 2.0 | 5.5 |
| 4 | Possibility of illegal dumping | 1.0 | 1.0 | 2.0 | 2.0 | 6.0 |
| 5 | Possibility of repetition of illegal dumping | 1.0 | 1.0 | 2.0 | 2.0 | 6.0 |
| | Total | 8.0 | 8.0 | 11.5 | 12.0 | 39.5 |
| | Consideration of Population Weight (A) | 4.0 | 8.0 | 8.1 | 0.4 | 20.4 |
| | Consideration of Cost Weight (B) | 3.08 | 6.16 | 6.24 | 0.31 | 15.79 |

## *Condition of Population Weight

| | Zone | A | B | C | D |
|---|---|---|---|---|---|
| A | Weight of Population(2008) | 21% | 45% | 33% | 1.3% |
| | Ratio | 0.5 | 1.0 | 0.7 | 0.03 |

## *Condition of Cost Weight

| | Classification of Alternative | A-1 | A-2 | A-3 |
|---|---|---|---|---|
| B | Cost (Unit:Soles/year) | 4,401,400 | 5,290,113 | 5,709,862 |
| | Weight of Cost A2=A-1/A-2, A3=A-1/A-3 | 1.00 | 0.83 | 0.77 |

## Table VI.2.5 Comparison of Required Number of Equipment

| | | A-1 | | A-2 | | A-3 | |
|---|---|---|---|---|---|---|---|
| | | 2008 | 2025 | 2008 | 2025 | 2008 | 2025 |
| (A) Equipment for collection/Transportation | | | | | | | |
| 1) | 12 m3 compactor | 2 | 2 | 1 | 2 | 1 | 2 |
| 2) | 4 m3 compactor | 11 | 15 | 7 | 12 | 4 | 7 |
| 3) | 6.8 m3 dump truck | 3 | 5 | 2 | 5 | 2 | 3 |
| 4) | Tricycle | 5 | 5 | 5 | 5 | 5 | 5 |
| 5) | 3 ton lift roll on/off | - | - | 2 | 5 | 5 | 14 |
| 6) | 4 m3 containers | - | - | 8 | 17 | 22 | 57 |
| 7) | Maintenance Equipment & Tool | 1 | 1 | 1 | 1 | 1 | 1 |
| (B) Equipment for final disposal site | | | | | | | |
| 1) | Bulldozer | 1 | 1 | 1 | 1 | 1 | 1 |
| 2) | Excavator | 1 | 1 | 1 | 1 | 1 | 1 |
| 3) | Dump truck | 1 | 1 | 1 | 1 | 1 | 1 |
| 4) | Generator | 1 | 1 | 1 | 1 | 1 | 1 |
| 5) | Truck Scale | 1 | 1 | 1 | 1 | 1 | 1 |

## MAN POWER

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | For collection & Transportation | 176 | 204 | 228 | 249 | 227 | 248 |
| | For F.D.S | 6 | 6 | 6 | 6 | 6 | 6 |
| TOTAL | | 182 | 210 | 234 | 255 | 233 | 254 |

Source: JICA Study Team, 1999

## Table VI.2.6 Necessary Costs for Alternatives. (Soles / year)

| Alternative | A - 1 | A - 2 | A – 3 |
|---|---|---|---|
| Cost | 4,401,400 | 5,290,131 | 5,709,862 |

Note: IGV (general sales tax) is excluded.

Among the above three alternatives, the most effective technical advantage is Alternative-3 superior to Alternative–2 and Alternative–1 (hereinafter referred to as A–3, A–2, and A-1 respectively) in the criteria of topographical shape, difficulty of discharge, road conditions, possibility of illegal dumping, and possibility of repetition of illegal dumping. Considering the proportion of zone population, this result is unchanged. However, in case of the overall cost consideration, the result is A-1 followed by A-2 and then A-3.

Earliest achievement of the collection rate of 100% is the best from the fundamental consideration of solid waste management. However, urgent achievement of the complete collection rate will be difficult because of the financial condition of Puno Provincial Municipality.

Costs to achieve the waste collection rate of 100% were studied and compared under the following condition.

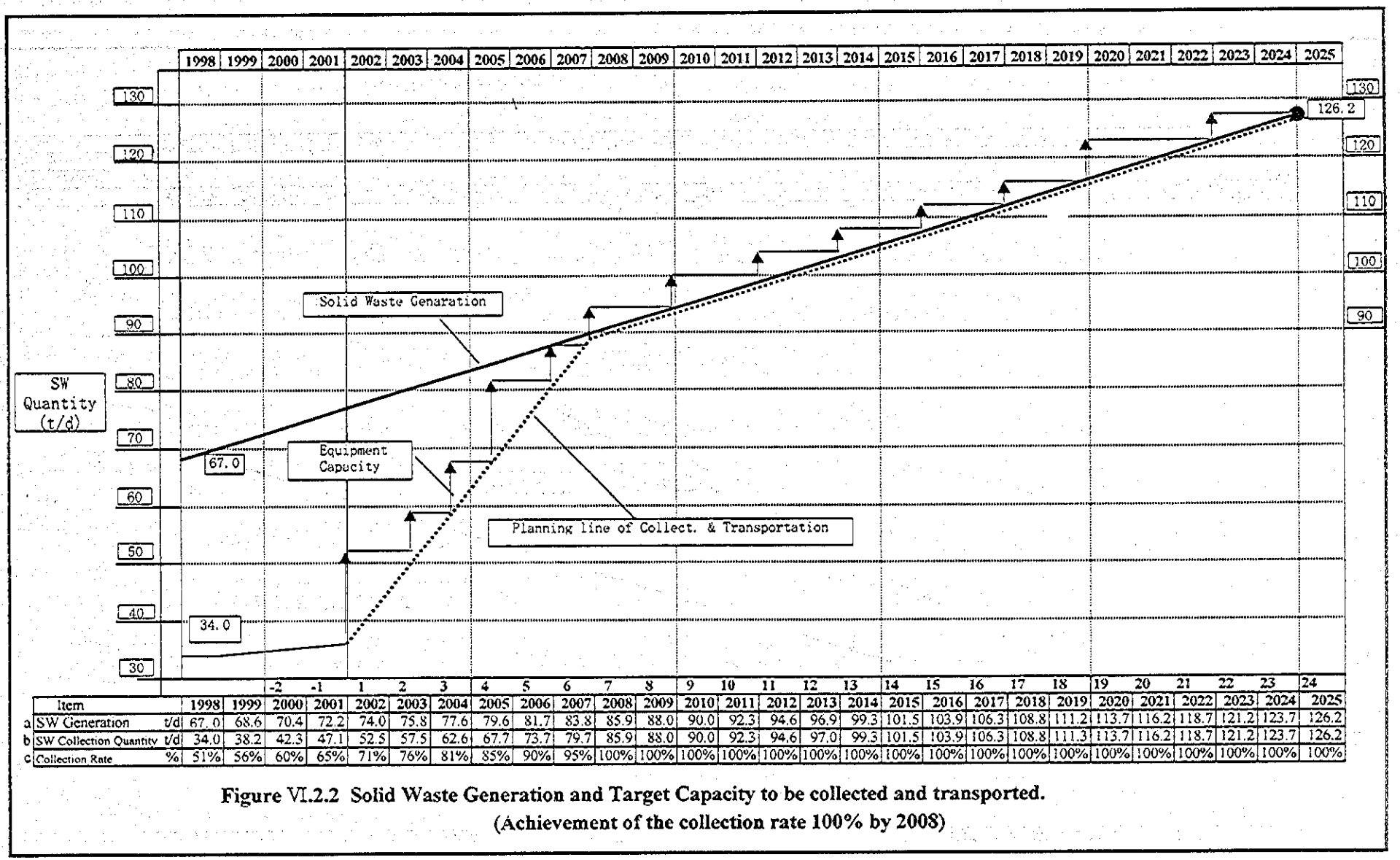
- Urgent achievement of the collection rate of 100% by the year 2008.
  (defined as Alternative F-1)

- Moderate achievement of the collection rate of 100% by 2025.
  (defined as Alternative F-2)

Planning conditions of the above two alternatives are shown in *Figure VI.2.2* and *Figure VI.2.3*.

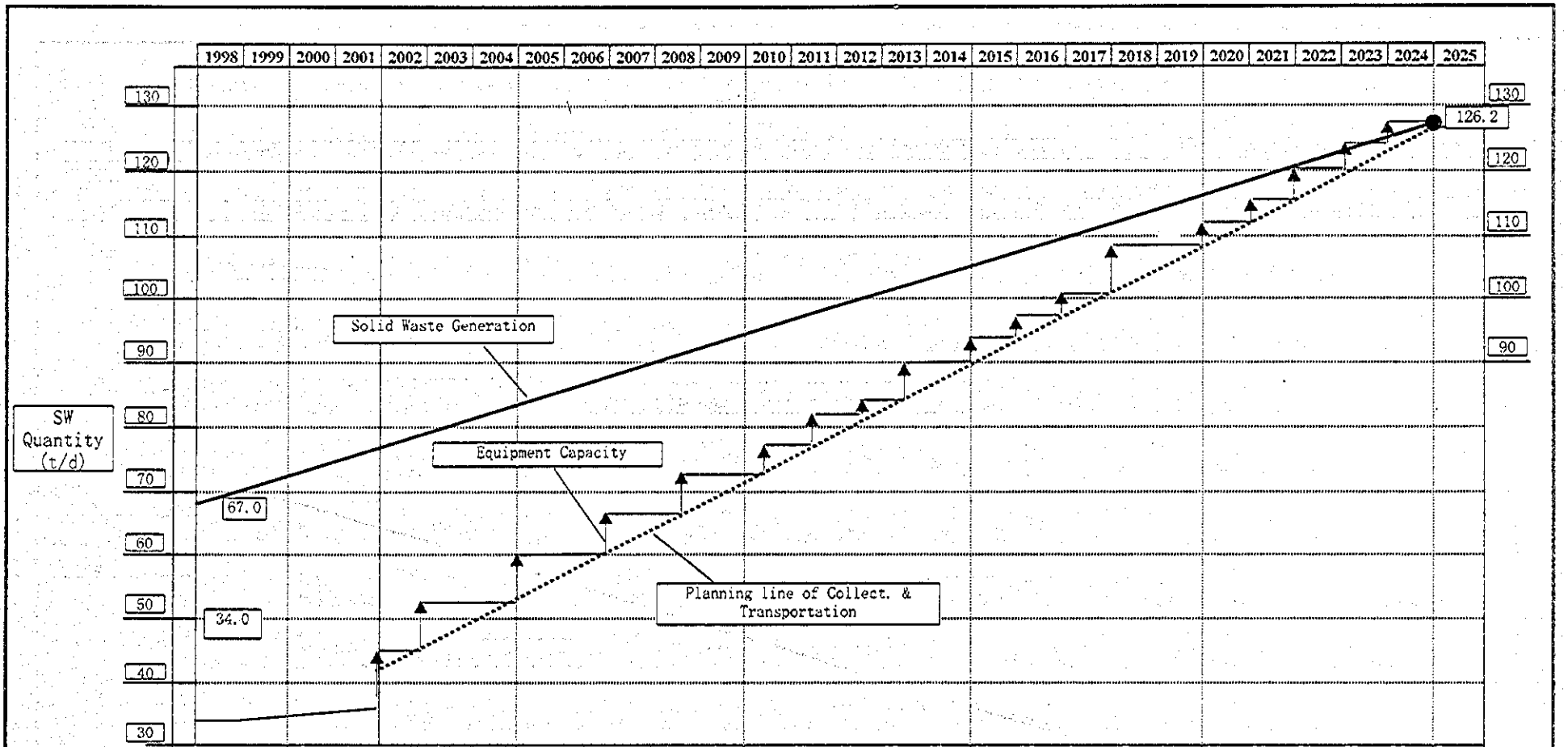
The comparative table for F-1 and F-2 suggests necessary numbers of collection vehicles and manpower as shown in *Table VI.2.7*.

According to the *Table VI.2.7*, comparison of necessary costs for F-1 and F-2 are shown in *Table VI.2.8*.




| Item | | 1998 | 1999 | -2 2000 | -1 2001 | 1 2002 | 2 2003 | 3 2004 | 4 2005 | 5 2006 | 6 2007 | 7 2008 | 8 2009 | 9 2010 | 10 2011 | 11 2012 | 12 2013 | 13 2014 | 14 2015 | 15 2016 | 16 2017 | 17 2018 | 18 2019 | 19 2020 | 20 2021 | 21 2022 | 22 2023 | 23 2024 | 24 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | SW Generation | t/d | 67.0 | 68.6 | 70.4 | 72.2 | 74.0 | 75.8 | 77.6 | 79.6 | 81.7 | 83.8 | 85.9 | 88.0 | 90.0 | 92.3 | 94.6 | 96.9 | 99.3 | 101.5 | 103.9 | 106.3 | 108.8 | 111.2 | 113.7 | 116.2 | 118.7 | 121.2 | 123.7 | 126.2 |
| b | SW Collection Quantity | t/d | 34.0 | 38.2 | 42.3 | 47.1 | 52.5 | 57.5 | 62.6 | 67.7 | 73.7 | 79.7 | 85.9 | 88.0 | 90.0 | 92.3 | 94.6 | 97.0 | 99.3 | 101.5 | 103.9 | 106.3 | 108.8 | 111.3 | 113.7 | 116.2 | 118.7 | 121.2 | 123.7 | 126.2 |
| c | Collection Rate | % | 51% | 56% | 60% | 65% | 71% | 76% | 81% | 85% | 90% | 95% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Figure VI.2.2 Solid Waste Generation and Target Capacity to be collected and transported.**
**(Achievement of the collection rate 100% by 2008)**




| | Item | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | -2 | -1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | | |
| a | SW Generation | t/d | 67.0 | 68.6 | 70.4 | 72.2 | 74.0 | 75.8 | 77.6 | 79.6 | 81.7 | 83.8 | 85.9 | 88.0 | 90.0 | 92.3 | 94.6 | 96.9 | 99.3 | 101.5 | 103.9 | 106.3 | 108.8 | 111.2 | 113.7 | 116.2 | 118.7 | 121.2 | 123.7 | 126.2 |
| b | SW Collection Quantity | t/d | 34.0 | 36.0 | 38.1 | 40.3 | 42.5 | 44.8 | 47.2 | 49.9 | 52.6 | 55.4 | 58.3 | 61.3 | 63.2 | 66.9 | 70.7 | 74.4 | 78.2 | 81.9 | 86.1 | 90.2 | 94.3 | 98.5 | 102.7 | 107.3 | 112.0 | 116.7 | 121.4 | 126.2 |
| c | Collection Rate | % | 51% | 52% | 54% | 56% | 57% | 59% | 61% | 63% | 64% | 66% | 68% | 70% | 70% | 73% | 75% | 77% | 79% | 81% | 83% | 85% | 87% | 89% | 90% | 92% | 94% | 96% | 98% | 100% |

**Figure VI.2.3 Solid Waste Generation and Target Capacity to be Collected and Transported.**
**(Achievement of the collection rate 100% by 2025)**

## Table VI.2.7 Required Waste Collection Vehicles for Alternative –1

| Case | Year | 12m³ compactor | 4m³ compactor | 6.8m³ Dump | Tricycle | Bulldozer | Excavator | Dump | Generator | Truck scale |
|---|---|---|---|---|---|---|---|---|---|---|
| F-1 | 2002 | 1 | 4 | 2 | 5 | 1 | 1 | 1 | 1 | 1 |
| | 2008 | 2 | 11 | 3 | 5 | 1 | 1 | 1 | 1 | 1 |
| | 2025 | 2 | 15 | 5 | 5 | 1 | 1 | 1 | 1 | 1 |
| | | Manpower | | | | | | | | |
| | | For collection & Transportation | | | | For sanitary landfill site | | | | |
| | 2002 | 142 | | | | 6 | | | | |
| | 2008 | 176 | | | | 6 | | | | |
| | 2025 | 204 | | | | 6 | | | | |
| F-2 | 2002 | 1 | 3 | 1 | 5 | 1 | 1 | 1 | 1 | 1 |
| | 2008 | 1 | 7 | 1 | 5 | 1 | 1 | 1 | 1 | 1 |
| | 2025 | 2 | 15 | 5 | 5 | 1 | 1 | 1 | 1 | 1 |
| | | Manpower | | | | | | | | |
| | | For collection & Transportation | | | | For sanitary landfill site | | | | |
| | 2002 | 137 | | | | 6 | | | | |
| | 2008 | 153 | | | | 6 | | | | |
| | 2025 | 204 | | | | 6 | | | | |

## Table VI.2.8 Comparison of Costs for two collection rate alternatives

| | |
|---|---|
| F-1 | 4,401,400 Soles/year |
| F-2 | 3,432,025 Soles/year |

Note: IGV (general sales tax) is excluded.

As the result of the case study for above two alternatives, both will cost a large amount. Considering the financial difficulties of Puno Provincial Municipality, there is no way except selecting Alternative F-2. Therefore, the plan based on the alternatives A-1 and F-2 has been proposed.

#### 2) Final Disposal Site

Landfill site shall be designed in accordance with the technical guidelines of DIGESA ( shortly to be enacted upon the approval of the National Congress)

Specifically, the following facilities should be considered for the sanitary landfill site in accordance with the technical guidelines:

- Retaining wall to prevent waste out flows.
- Drainage for superficial water due to rain.
- Leachate collector facility.
- Seepage control layer for leachate.
- Fence for preventing scattered waste due to wind blow.
- Access road.
- Leachate treatment facility.
- Site administration facility including weigh bridge.

## 2.4 PROPOSED PLAN

### (1) Structural Measure

#### 1) Collection and Transport

The alternative plans for the waste collection system were evaluated considering the geographical condition, distance to the generation point of the waste, road condition, and possibility of illegal dumping and cost estimation. Alternative 1 was selected as the proposed plan. As for the target of waste collection rate, 100 % should be achieved as early as possible. However, it will be hard to realize it by the year 2008 considering the financial difficulties of Puno Provincial Municipality. Therefore the waste collection rate should be increased stepwise with the aim of achieving 100 % by the year 2025.

#### 2) Final Disposal Site

Sanitary landfill has been proposed for the final disposal site according to the technical guideline issued by DIGESA.

### (2) Non-Structural Measures

The most important non-structural measure is the complete removal of the wastes scattered in the city by using citizen's participation.

Basically the removal shall be done using equipment owned by the provincial municipality, but other than ordinary service by the municipality voluntary involvement of citizens in this work is desirable.

Effective systems or organizations which encourage citizen's participation should be established to prevent the repetition of illegal dumping.

## 2.5 IMPLEMENTATION PLAN

### (1) Construction Plan for Structural Measures

#### 1) Removal of Illegally dumped waste

The work shall be done by the Cleansing Department of Puno Provincial Municipality based on the collection plan made by them in cooperation with PRONAA.

10 to 20 working crew shall gather the scattered wastes to transport the materials to the final disposal site by collection vehicles owned by the provincial municipality on every weekend . It will take 6 months for the work to be completed.

Present collection system should be improved to prevent repetition of illegal dumping at the places where this traditionally occurs.

### 2) Expansion of the final disposal site

Until the target year 2025, approximately 1,270,000m$^3$ of wastes including 254,000m$^3$ of covering soil is projected to be disposed of at the final disposal site. It is required to construct the final disposal site with the mentioned capacity.

The construction of the new final disposal site shall comply with the new technical standard regulated by the Ministry of Health, with the leachate collection equipment, leachate treatment facility, gas ventilation, fence etc. as required.

Together with the construction, an access road, a truck scale, heavy machines, an electric generator and an administrative house shall be furnished for the site.

### 3) Supplement of the collection vehicles

The most important issue in this project is to increase of the collection vehicles. Equipment shall be procured stepwise as shown in *Table VI.2.9*. One large compactor, one small compactors, five medium size dump tracks and a complete set of maintenance tools shall be procured by the year 2002 at latest.

**Table VI.2.9 Supplement plan of the equipment**

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 m$^3$ Compactor | 1 | | | | | 1 | | | | | | |
| 4 m$^3$ Compactor | 1 | 1 | | 1 | 1 | | 1 | | | 1 | | 1 |
| 6.8 m$^3$ Garbage Dump | 1 | | | | | | | 1 | | | 1 | |
| Maintenance Tools | 1 | | | | | | | | | | | |

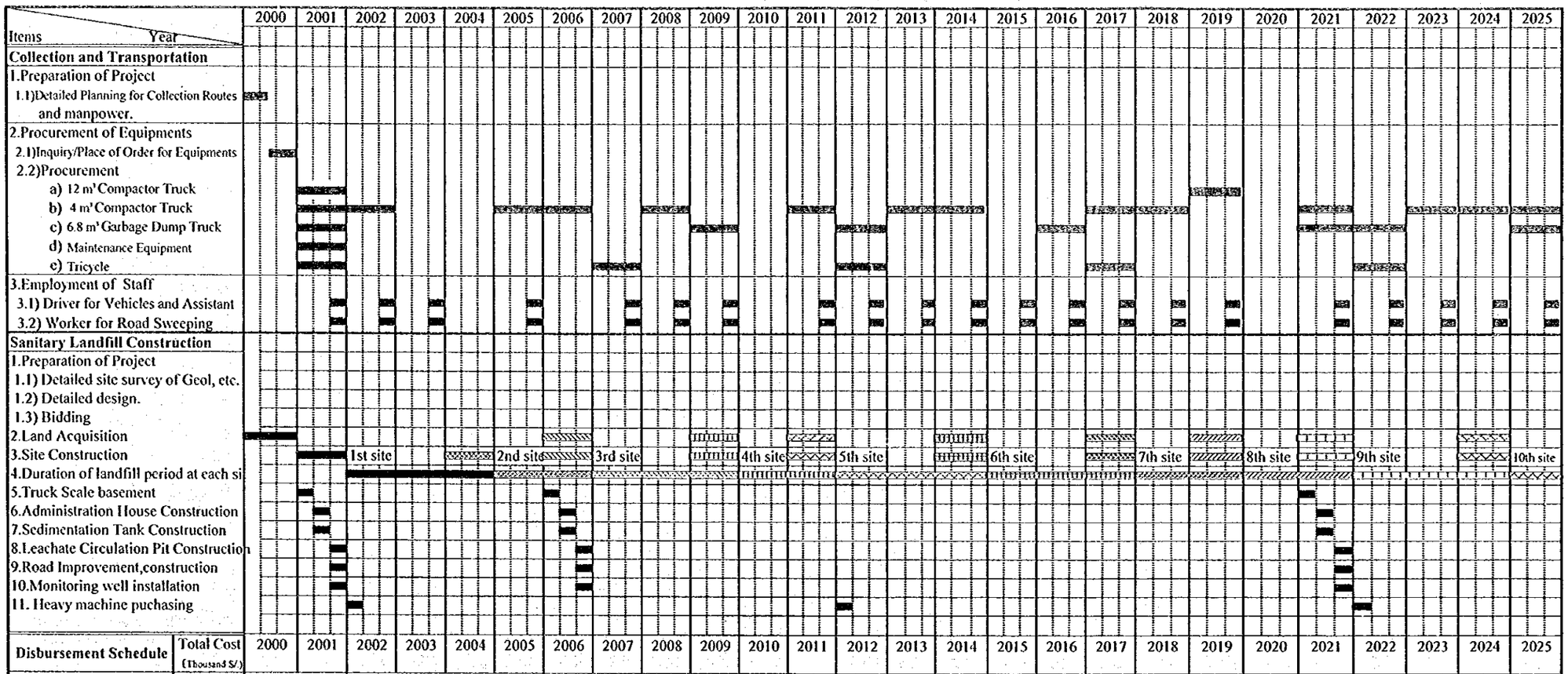
| Year | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 m$^3$ Compactor | | | | | | | | | | | | |
| 4 m$^3$ Compactor | 1 | | | 1 | 1 | | | | | 1 | 1 | 1 |
| 6.8 m$^3$ Garbage Dump | | | 1 | | | | | | 1 | | | |
| Maintenance Tools | | | | | | | | | | | | |

Source: JICA Study Team

### (2) Implementation Schedule

- Commence the removal of the existing illegally dumped wastes from the year 2000 and complete the work within one year.
- Commence the construction of the final disposal site from the year 2001, and construct the 10 sites having 20,000m$^2$ – 37,000m$^2$ until the year 2025.
- Procurement of the collection vehicles shall be performed in the years 2003, 2006, 2007, 2013 and 2018.

Implementation schedule is shown in *Figure VI.2.4.*




| Disbursement Schedule | Total Cost (Thousand $) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collection and Maintenance | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 Procurement | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1)Vehicles | 8,781 | | | 1,117 | 216 | 0 | 216 | 216 | 2 | 216 | 251 | 0 | 216 | 1,450 | 432 | 216 | 216 | 467 | 218 | 684 | 297 | 0 | 467 | 550.0 | 432 | 432 | 467 |
| | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.IGV(18%) | 1,581 | | | 201 | 39 | 0 | 39 | 39 | 0 | 39 | 45 | 0 | 39 | 261 | 78 | 39 | 39 | 84 | 39 | 123 | 54 | 0 | 84 | 99.0 | 78 | 78 | 84 |
| 3.Manpower | 23,453 | | | 788 | 804 | 804 | 819 | 834 | 835 | 850 | 873 | 911 | 926 | 949 | 965 | 980 | 980 | 1,003 | 1,018 | 1,072 | 1,125 | 1,125 | 1,125 | 1,148.0 | 1,164 | 1,179 | 1,175 |
| 4.Operation and Maintenance | 8,361 | | | 156 | 139 | 128 | 167 | 196 | 185 | 196 | 226 | 214 | 253 | 443 | 378 | 396 | 367 | 408 | 424 | 533 | 528 | 513 | 565 | 455.0 | 449 | 506 | 536 |
| Total for collection & trans. | 42,174 | | | 2,262 | 1,198 | 932 | 1,241 | 1,286 | 1,022 | 1,301 | 1,395 | 1,125 | 1,435 | 3,103 | 1,853 | 1,631 | 1,602 | 1,962 | 1,700 | 2,412 | 2,004 | 1,638 | 2,241 | 2,252 | 2,123 | 2,195 | 2,262 |
| Sanitary Landfill Construction | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.Land Acquisition | 53 | 14 | | | | | | 8 | | | 3 | | 4 | | | 4 | | | 5 | | 5 | | 7 | | | 3 | |
| 2.Site Construction | 25, 752 | | 1,944 | | | 1,944 | | 2,233 | | | 2243 | | 2581 | | | 3100 | | | 3270 | | 3179 | | 3638 | | | 1620 | |
| 3. Facilities construction | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1, 516 | | 368 | | | | | 574 | | | | | | | | | | | | | | | 574 | | | | |
| 4.Road Improvement | 378 | | 53 | | | | | 236 | | | | | | | | | | | | | | | 89 | | | | |
| 5.Monitoring well installation | 175 | | 87 | | | | | 88 | | | | | | | | | | | | | | | | | | | |
| 6 Procurement of Heavy Machine | 4, 133 | | | 1,753 | | | | | | | | | | 1190 | | | | | | | | | | 1190 | | | |
| 7. Engineering Service | 1, 391 | | 123 | 0 | | 97 | | 157 | | | 112 | | 129 | 0 | | 155 | | | 163 | | 159 | | 215 | 0 | | 81 | |
| 8. Operation cost | 8, 753 | | | 258 | 260 | 414 | 264 | 441 | 265 | 268 | 451 | 274 | 451 | 274 | 277 | 485 | 282 | 285 | 542 | 298 | 561 | 303 | 560 | 309 | 313 | 602 | 316 |
| 9. Maintenance cost | 2, 104 | | | 87 | 88 | 87 | 88 | 87 | 88 | 87 | 88 | 87 | 88 | 87 | 88 | 87 | 88 | 87 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 |
| 10. Contingency | 4, 382 | | 386 | 0 | | 307 | | 494 | | | 353 | | 406 | 0 | | 488 | | | 515 | | 501 | | 677 | 0 | | 255 | |
| 11. IGV | 6, 791 | | 533 | 316 | | 422 | | 681 | | | 487 | | 561 | 214 | | 674 | | | 711 | | 691 | | 935 | 214 | | 352 | |
| Total for Landfill const. | 55, 428 | 14 | 3,494 | 2,414 | 348 | 3,271 | 352 | 4,999 | 353 | 355 | 3,737 | 361 | 4,220 | 1,765 | 365 | 4,993 | 370 | 372 | 5,294 | 386 | 5,184 | 391 | 6,783 | 1,801 | 401 | 3,001 | 404 |
| Grand Total | 97,602 | 14 | 3,494 | 4,676 | 1,546 | 4,203 | 1,593 | 6,285 | 1,375 | 1,656 | 5,132 | 1,486 | 5,655 | 4,868 | 2,218 | 6,624 | 1,972 | 2,334 | 6,994 | 2,798 | 7,188 | 2,029 | 9,024 | 4,053 | 2,524 | 5,196 | 2,666 |

**FigureVI.2.4 Project Implementation and Disbursement Schedule**

## 2.6 COST ESTIMATION

### (1) Condition

Conditions for cost calculations are summarized as follows,

1) Most costs are expressed under the economic conditions that prevailed in 1998, and price escalation is not considered.

2) The construction work is assumed to be contracted to Peruvian general contractors, and the operation and maintenance work is conducted by the staff of the municipality.

3) For the estimation, the costs in Peru are used except that in Japan which is used for leachate collection pipe.

4) The engineering service cost is assumed to be 5 % of the total of direct construction costs

5) The physical contingency is assumed to be 15 % of the total of the direct construction costs and the engineering service costs.

**(2) Construction cost** **total : 33,649,000 Soles**

Breakdown;

| | |
|---|---|
| 1) Direct Construction Cost | 27,823,000 |
| 2) Land Acquisition Cost | 53,000 |
| 3) Engineering Service Cost [=1) x 5%] | 1,391,000 |
| 4) Contingency [={ 1) + 3) } x 15%] | 4,382,000 |

**(3) Equipment** **12,913,000 Soles**

| | |
|---|---|
| 1) Vehicles for collection & transportation | 8,780,000 |
| 2) Heavy machines & dump truck | 4,133,000 |

**(4) Operation and Maintenance Cost** **42,671,000 Soles**

| | |
|---|---|
| 1) For collection & transportation | 31,814,000 |
| 2) For final disposition | 10,857,000 |

**(5) Grand Total** **89,233,000 Soles (not including IGV)**

## 2.7 ORGANIZATION FOR OPERATION AND MAINTENANCE

### (1) Management of the Project

Presently the solid waste management of Puno City is executed by Puno Provincial Municipality. However future plan for the solid waste management is not clear and new action against the lack of the technical standard as well as against the financial problems shall be taken.

The Cleansing Department is in charge of operations for waste collection and disposal. However the maintenance of equipment or the task of charging are done by different regional departments of the maintenance of the equipment and the Department which in charge of the Tipping Fee Collection is required. Unification of these departments is required for efficient management.

### (2) Strengthening of the organization

**Training of personnel.**

For the fields of collection, transportation and final disposition an appropriate program for staff training is important.

The training program shall be prepared for all levels of management in the DPC which can be named " the Research and Development Unit". This unit should study the issues on the effective management of solid waste required for the Puno City in the coming years.

The number of personnel to be trained and the type of course to be offered will be determined before commencing the training program, as well as the people to supervise the program and the courses. It is desirable to educate of the staff to enhance their technical levels as well as to dispatch them to the technical training which is held by the state government or international organizations such as DIGESA or CEPIS.

### (3) Promotion of the Non-Structural Measure

In the project the provincial municipality will remove the existing illegally dumped wastes in cooperation with PRONAA involving the resident's voluntary participation. In order to gain the resident's voluntary participation, the need for a

sanitary and efficient system should be made clear to the public. The most effective public cooperation is attained voluntarily through informative, educational, and persuasive measures. Four items are indispensable to attain the public cooperation as follows.

1) **Public relations and communications.**
2) **Good relations through effective Solid Waste Manager.**
3) **Public education.**
4) **Handling complaints.**

As for "public relations and communications", these are methods and activities that should be employed by the Puno Provincial Municipality to promote a favorable relationship with the public. Residents are to be informed about SWM i.e. magnitude of the problem, costs, organization of the system, collection schedules and their deviations, rules for collection and penalties, new methods of waste disposal, etc.

As for "good relations through effective SWM", all municipal employees are obliged to be courteous and polite to the public who are in effect customers. Solid waste collectors in particular should be more polite as they have more direct contact with residents than those working in other sections. This calls for proper training of the employees to conduct waste collection and thus eliminating complaints and promoting better public relations. The employees should look presentable, be courteous and answer in clear and definite terms whatever queries are put to them. The language and the tone of voice used by the workers should be considerate.

As for "public education", the carelessness and thoughtlessness of citizens and their disregard for even the simplest rules of cleanliness and sanitation, is reflected in littered streets, alleys, parks, vacant lots, and even private premises. This tends to produce an untidy appearance throughout the community and a general lowering of public morale. While ordinances, rules, regulations and penalties have their rightful place in a solid waste management plan, their enforcement leaves much to be desired. It has been found that as a part of the public communication program, a much easier and more sensible solution is to secure public cooperation through public education.

The following public education programs will be considered:

- Citizen groups, such as the church, chamber of commerce, or women's groups,
- Public education through the media, such as newspapers, television, etc.,
- Seasonal clean-up campaigns,
- Education programs for school children, and
- Clean-up campaigns include sanitation parades, and trash baskets, reminders for the public to keep their city clean

Public education should be related to enforcement.

As for " Handling Complaints", the number of complaints is a good indicator of how successful a city's cleansing services are conducted: positive criticisms often pave the way towards an improved implementation of these services.

## 2.8 PROJECT EVALUATION

### (1) Technical Evaluation

The collection system adopted in this project is the most universal one and special training is not required for the crew. Elimination of illegally dumped wastes needs a new citizen's voluntary cooperation for collection and transportation of them. But it is not difficult to carry out because this system is experienced through lake water cleaning campaign.

The construction of the final disposal site will comply with the latest standard of Peru, which will contribute to the improvement of the public health conditions in Puno City.

### (2) Environmental Aspect

The final target of the present project is " Zero Uncollected Municipal Waste" as the result of the improvement of the waste collection rate. Achievement of the target will contribute to the purification of the water quality of Lake Titicaca as well as the environmental improvement.

The Initial Environmental Evaluation(IEE) was made, and 23 items were evaluated for the degree of the impact and the result is as follows;

## Table VI.2.10 Result of Initial Environmental Evaluation (IEE)

| Items | | | Point | Reason |
|---|---|---|---|---|
| Social Aspect | 1. | Removal of the people | D | No resident in the present landfill site and the projected site |
| | 2. | Economic Activity | D | Recycling of wastes not popular |
| | 3. | Transport / Life facility | C | Remarks on the case of traffic jam. |
| | 4. | Separation of Districts | D | No facilities to divide. |
| | 5. | Historical Remains & Cultural Assets | C | The way to the Remain of Old PUNO is located in the future site. |
| | 6. | Fishery Right | D | No plan to landfill in fishery areas |
| | 7. | People's Health | C | Few people live in the landfill site area. |
| | 8. | Waste Treatment | D | No intermediate treatment of waste |
| | 9. | Risk of Natural Disaster | D | Less risk in the area. |
| Natural Environment | 10 | Topographical & geographical aspect | D | Embanking of 5 or 6 m is carried out, but the watershed is not changed. |
| | 11 | Erosion of Soil | C | Inclination of the landfill site is small, and annual rainfall is not big. Open channel is installed in order to prevent erosion. |
| | 12 | Underground Water | C | Possibility of water contamination depends on the performance of clay layer. |
| | 13 | Conditions of Lake and River | D | No change by landfill |
| | 14 | Lake and lakeside | D | No change by landfill |
| | 15 | Animal and Plants | D | Possible presence of vermin |
| | 16 | Meteorology | D | No change by set up the sites. |
| | 17 | Natural Scene | C | Appearance of FDS |
| Pollution | 18 | Air Pollution | D | No influence from exhaust fume due to mountainous feature |
| | 19 | Water Pollution | C | Possible: leachate from landfill site in the same reason mentioned Item 12 in the above. |
| | 20 | Soil Contamination | C | From leachate as same as Item 12. |
| | 21 | Noise and Vibration | D | Less influence from construction equipment, heavy machines and vehicles because no residents close to the site. |
| | 22 | Land Subsidence | D | No pumping up of underground water |
| | 23 | Offensive Odor | C | Generation of Odor from Wastes is low for covering the wastes with soil over. |

A - Considerable Impact predicted

B - Small Impact predicted

C - Not clear (Necessary to be studied. Considered becoming clear along with the process of study)

D - Less Impact prospected and accordingly applicable Item not included in IEE and EIA.

As the result of IEE, A - level is 0, B - level is 0, C - level is 9, D - level is 14. This means that there would be little environmental influence from the construction of the sanitary landfill site. However, there would be the possibility of ground water pollution at the periphery of the sites depending on the performance of the clay seepage control layer.

## (3) Financial Aspect

### 1) Conditions for Finance Analysis

In order to analyze the financial aspect of the proposed plan, there are some conditions as follows,

(a) Inflation estimation is omitted

(b) Profit tax of solid waste project is not counted

(c) Revenue of solid waste project will grow with

i) the increase of Puno household

ii) the increase of solid waste charge with economic growth

(=1.5%/yr. This figure reflects the economic growth rate in Puno department)

iii) the increase of collection rate of waste handling charge

(=1.46%/yr. The goal of the collection rate in 2025 is set as 70%. The present rate is 48%)

iv) the implementation of environment fee to save Lake Titicaca for tourists

(When solid waste management in Puno is neatly organized, tourists are able to enjoy esthetic enjoyment of environment as benefit, therefore tourists should share the cost of this project by paying environment fee. The suitable price of environment fee is analyzed in the *Table XI.2.12*)

v) the contribution by PRONAA

vi) the contribution of S/. 550,000 every year by Puno municipality

vii) the contribution by the state government

(d) The part of construction cost will be financed by local loan with 7% interest rate. Repayment period of the loan is 20 years and grace period is 5 years. The loan will cover the contingency of construction work, but not IGV of construction work.

(e) Equipment cost, engineering service, vehicles, and manpower will be financed by local fund without interest.

(f) Vehicles are depreciated with 10 years. After 10 years, the vehicles will be purchased again at same price.

(g) Contingency (15%) is considered on the cost of construction work and engineering service.

(h) IGV (18%) is considered on the cost of construction work, equipment cost, engineering service, contingency and vehicles.

(i) Civil work and equipment will be sold out at the remaining value in 2025F/Y

### 2) Financial Viability of Proposed Project

In order to estimate the most suitable measure to make the proposed plan feasible, FIRRs of following 5 cases are calculated.

**(i) Purpose of Each Case**

- Case1: The present waste handling charge in average(32 soles/household/yr) is applied to see the viability of present charge system against the proposed plan.
- Case2: The present waste handling charge in average(32 soles/household/yr) and an environment fee are applied to see the influence of introducing an environment fee against the proposed plan.
- Case3: A more expensive waste handling charge is applied to see the influence of increasing handling charge against the proposed plan.
- Case4: An assumption that the labor cost for waste handling staff is decreased by 30% is applied to see the influence of cutting the O/M expenditure.

- Case5: An assumption that the expenditure for heavy machines, and vehicles is covered by a contribution of Peru government is applied to see the influence of the contribution.(Engineering service is supposed to be covered by the state government in case1,2,3,4,5)

**(ii) Results of Financial Viability**

In the *Table VI.2.11*, combinations of a waste handling charge and an environment fee, and FIRRs (Financial Internal Rate of Return) of each case are shown.

**Table VI.2.11 Results of Financial Viability**

| | Waste Handling Charge | Environment Fee | O/M expenditure cut | Subsidy by the state government | FIRR |
|---|---|---|---|---|---|
| | soles/household/yr | $/day/person | % | | % |
| Case 1 | 32 | 0 | 0 | Eng. service | -38.8 |
| Case 2 | 32 | 1.7 | 0 | Eng. service | 7.5 |
| Case 3 | 115 | 0 | 0 | Eng. service | 8.3 |
| Case 4 | 32 | 0 | 30 | Eng. service | -32.6 |
| Case 5 | 32 | 0 | 0 | Eng. service + heavy machine + vehicle | -27.1 |

*1)Eng. is engineering.

From the results of financial viability, next things can be said.

- Result of analysis on Case1:

The proposed plan is not feasible under the present system of a waste handling charge (32 soles/household/yr as a handling charge and no environment fee), because FIRR of Case 1 is negative.

- Result of analysis on Case2:

Implementation of an environment fee has an influence to make the proposed plan viable, because FIRR of Case 2 exceeds 7% assumed as an interest rate of soft loan.

- Result of analysis on Case3:

An increase of a waste handling charge has an influence to make the proposed plan viable, because FIRR of Case 3 exceeds 7% assumed as an interest rate of soft loan.

- Result of analysis on Case4:

A decrease of the labor cost for waste handling is not effective to make the proposed plan viable, because FIRR of Case 4 is still negative.

- Result of analysis on Case5:

Given the results of FIRR, the contribution for engineering service, heavy machines, and vehicles is considered to be more effective than the decrease of labor cost, but FIRR of Case 5 is still negative under the present system of the waste handling charge (32 soles/household/yr as handling charge and no environment fee).

### 3) Financial Plan

(i) Calculation for Acceptable Financial Plan

As analyzed in the previous section, it is estimated that increasing the present waste handling charge and introducing an environment fee are effective to enlarge the amount of revenue of solid waste management in Puno. In this section, an acceptable waste handling charge, environment fee, and the state government's subsidy are analyzed in consideration of a burden for Puno citizens and for tourists.

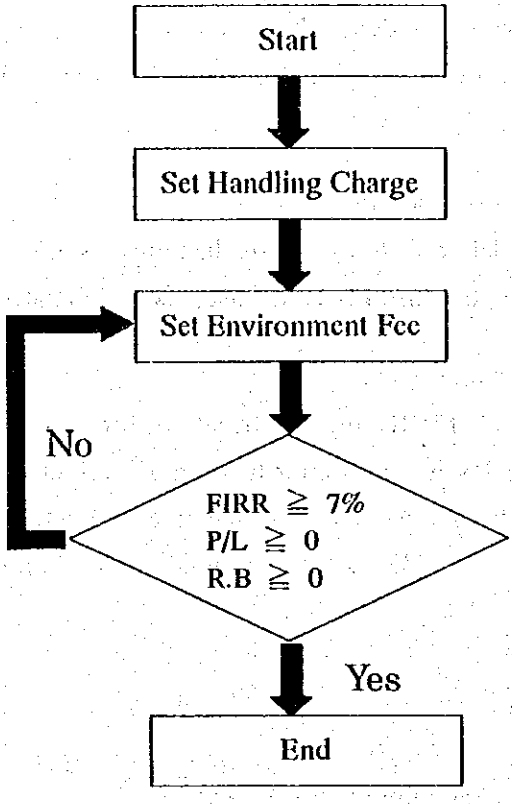



**Figure VI.2.5 Procedures of Financial Plan**

*1: P/L stands for profit and loss estimation.

*2: R.B stands for revenue balance.

In the Case6 and 7, the expenditure for engineering service is assumed to be covered by a contribution of Peru government. While, in the Case8, the expenditure for engineering service, heavy machines, and vehicles is assumed to be covered by a contribution of Peru government.

**Table VI.2.12 Recommendable Combinations**

| | Waste Handling Charge | Environment Fee | FIRR | P/L | Revenue Balance |
|---|---|---|---|---|---|
| | Soles/household/yr | $/day/person | % | 1,000 soles | 1,000 soles |
| Case 6 | 48 | 1.4 | 8.1 | 273 | 303 |
| Case 7 | 64 | 1.1 | 8.7 | 1,553 | 1,583 |
| Case 8 | 48 | 1.2 | 17.3 | 2,143 | 2,173 |

*1:P/L stands for Profit – Loss.

Based on the results of analyses shown in the *Table VI.2.12*, Case 6, 7 and 8 are recommendable to expand the revenue of solid waste management in Puno municipality. Reasons in detail to choose Case 6, 7 and 8 are descried as follows:

Reason1: FIRRs are over 7% of interest rate of soft loan.

Reason2: P/Ls are positive.

Reason3: 48 and 64 soles/household/yr are considered as payable for Puno citizens.

Assuming that the average monthly income in Puno is 700 soles/month /household, one family is able to pay approximately 300 soles/year /household for a bay cleaning project. Thus, one family can afford to pay at least 64 soles/household/yr for solid waste management.

*Quotation: Considering the monthly average income estimated by the INEI-ENSECO for 1991, the 46.52% of the families are willing to pay 3.63% of their monthly income for a bay cleaning project. (Estudio de Facilibilidad Descontaminacion y Desarrollo de la Bahia Interior de Puno, ATA Octubure de 1997 Tomo 1 Informe Principal page19)*

Reason4: Compared with accommodation charge (about 20$/day/person) in Puno, 1.1-1.4 $/day/person for an environment fee seems acceptable.

(ii) Implementation of Financial Plan

In the *Table VI.2.13*, advantages of each case are described.

## TableVI.2.13 Advantage of Each Case

| | Waste Handling Charge | Environment. Fee | Advantage |
|---|---|---|---|
| | soles/household/yr | $/day/person | |
| Case 6 | 48 | 1.4 | If the priority of citizens is higher than the one of tourist, and if heavy machines and vehicles are not covered by a contribution, Case6 is most suitable. |
| Case 7 | 64 | 1.1 | If the priority of tourist is higher than the one of citizens, and if heavy machines and vehicles are not covered by a contribution, Case7 is most suitable. |
| Case 8 | 48 | 1.2 | If the expenditure of engineering service, heavy machines and vehicle is covered by a contribution of Peru government, Case8 is most suitable. |

There are some crucial points to execute Case6,7,8 as follows:

Point1:The present collection rate of the waste handling charge must be increased from 48% to 70%. This method can be executed without a fundamental change of solid waste management in Puno.

Point2: The raise of the present waste handling charge must be regulated.

Point3: The raise of the present waste handling charge must be informed well to Puno citizens from the preparation stage of the project.

Point4: In order to mitigate the impact of the raise on the lower-income households, a certain type of mean could be considered. For example, Puno should be divided into higher income areas and lower income areas. Then, a higher increasing rate of waste handling charge should be applied at higher income areas.

Point5: Introduction of environment fee must be regulated and informed well to the hotels in Puno.

Point6: The state government should recognize that the value and benefit generated by the tourism at Lake Titicaca are worthy to provide a subsidy for an environmental improvement.

### (4) General Evaluation

Result of the general evaluation is shown in *Table VI.2.14*.

**Table VI.2.14 Project Evaluation on Solid Waste Management**

| ITEM | REMOVAL OF ILLEGAL DUMPED WASTES | IMPROVEMENT OF WASTE COLLECTION RATE | CONSTRUCTION OF FINAL DISPOSAL SITE |
|---|---|---|---|
| Technical Aspect | No required special skill to execute | As for the collection system of the proposed plan, Municipality of Puno has to comply with the proposed system | It is indispensable the technical training for sanitary landfill. |
| Environ-mental Aspect | Effective from view point of Sanitation | By reduction of the quantity of uncollected wastes, it is anticipated that the environment of the lake water will be improved. | To prevent dispersion of the illegal dumped wastes is indispensable for environmental improvement and public health conditions. |
| Financial Aspect | Subsidy from PRONAA and the campaign of PRONAA can be available. | At the present prospect, it is necessary to increase the revenue and to gain financial support by the state government.. | Same as the reason of left column. |

## 2.9 RECOMMENDATION

In order to improve the present situation of solid waste management in Puno, JICA Study Team divides the waste management into 6 categories such as (1) Collection and Transfer, (2) Final Disposal Site, (3) Education, (4) Administration, (5) Finance, (6) Illegally dumped waste, and recommends some tactics for each category as follows:

### (1) Collection and Transfer

- Achievement of 100% collection rate by 2025
- Adoption of the present Bell Collection System for the whole area with collection frequency of twice a week.

- Improvement of the performance level of road sweeping by introducing new types of containers and collection carts

- Purchase of collection trucks to raise waste collection rate

*Table VI.2.3* shows the required numbers of the trucks to meet the goal of 100 % collection rate in 2025

**(2) Final Disposal Site**

- Construction of a new disposal site with the consideration of environment

- Purchase of heavy equipment such as bulldozer and excavator to execute sanitary landfill

- Introduction of leachate treatment system for a new disposal site

**(3) Education**

- Education on public health for citizens at church, chamber of commerce, and school to prevent illegal dumping of waste

- Use of media such as newspapers, television, and radio to educate citizens

- Execution of Seasonal clean-up campaigns

- Implementation of Clean-up campaigns include sanitation parades to enhance citizen's awareness

**(4) Administration**

- Strengthen of the relationship among organizations and institutions in order to execute solid waste management comprehensively.

**(5) Finance**

- Finding of a finance source of lower interest than 7 % and contribution as well.

- Increase of a collection rate of waste handling charge, the present collection rate is approximately 48%.

- Raise of a solid waste handling charge ( 1.5% up per every year). The present charge in Puno is approximately 32 soles/household/year.

- Implementation of environment fee for tourist.

### (6) Illegally Dumped Waste

- Prompt removal of illegally dumped waste with the help of monitoring system to find illegal dumping.

- Use of subsidy such as PRONAA for citizens who attend the campaign of illegally dumped waste collection

# CHAPTER – VII OTHER MEASURES

# CHAPTER – VII

# OTHER MEASURES

Expansion and improvement of sewerage systems and solid waste management have been discussed as major measures to be taken with highest priority in the previous chapters. In this chapter, remaining possible structural measures are discussed in order to reinforce the integrated water pollution control plan for Puno Interior Bay.

Urban drainage system should be improved to effectively operate the sanitary sewer system rather than to directly reduce non-point pollution loads. Especially it is expected that a proper urban drainage system will prevent the rainwater from flowing into the sewer which lessens the effect of the sewage treatment facility. Mainly from this point of view, the improvement of urban drainage system is discussed.

In general, the in-lake structural measures are applied to lake environmental management expecting direct effects. Several methods have been developed and available. However most methods are experimental and their effects are uncertain to apply to a full-scale water body. Some possible measures are discussed taking the applicability to Puno Interior Bay.

## 1. URBAN DRAINAGE SYSTEM

### 1.1 PRESENT CONDITIONS

#### (1) Outline of the system

##### 1) Drainage system

###### a. Drainage channels

- Concrete open channel
- Concrete box culvert
- Earth channel

b. Natural drainage ways (microcuencas)

2) Erosion and sediment control measures

- Infiltration ditches
- Masonry walls to hold soil

3) Operation and maintenance

- Maintenance of channel structures
- Silt and debris removal
- Repair of erosion control facilities

(2) Evaluation of present conditions

- No serious flooding in residential area (only street flooding)
- Past flooding caused by rise in the water level of Titicaca lake
- Disposal of solid wastes, human excreta and used construction materials to the drainage ways
- Hillside erosion controlled by measures initiated by PELT

(3) Identification of Problems

- Street flooding
- Sediment in the drainage ways
- Rainwater inflow to the sanitary sewer system
- Sediment and contaminant discharge to the interior bay of Puno

## 1.2 HYDROLOGICAL ANALYSIS

### (1) Rainfall analysis

#### 1) Annual maximum rainfalls

- Data: Pluviographic charts from year 1965 to year 1989 (SENAMHI)
- Probability analysis: Gumbel's distribution method
- Annual maximum rainfall intensity (60 minutes)

| Return period (years) | 2 | 3 | 5 | 10 |
|---|---|---|---|---|
| Maximum rainfall (mm/hr) | 15 | 18 | 21 | 24 |

#### 2) Intensity – Duration – Frequency (IDF) Curve

- Equation : Kimijima (Wenzel)

$$i = \frac{a}{t_d{}^b + c}$$

where i: rainfall intensity (mm/hr)

$t_d$: duration (minutes)

- Constants for rainfall equation for 5, 10-year return period

| Duration (min) | Return period (year) | a | b | c |
|---|---|---|---|---|
| 0 – 180 | 5 | 3240 | 1.07 | 81.4 |
| | 10 | 3010 | 1.04 | 56.7 |
| 180-1440 | 5 | 1190 | 0.88 | 26.2 |
| | 10 | 1070 | 0.85 | 14.0 |

#### 3) Arial reduction factor (proposed Peru standard (S. 124.5))

| Area | Reduction factor |
|---|---|
| ≧ 200 ha | 1.0 |
| 200 – 500 ha | 0.9 |
| 500 ha – 1,000 ha | 0.83 |

## (2) Discharge analysis

### 1) Analytical method

- Peak discharge analysis: Rational method
- Division of urban drainage area: 16 catchments
  (*Figure VII.1.1*) 84 sub-catchments
- Rational formula

$$Q_p = 1/3.6 \times C \times I \times A \times f$$

where $Q_p$: peak runoff ($m^3/s$)
C: runoff coefficient
f: areal reduction factor
A: catchment area ($km^2$)

- Time of inlet ($T_i$) : Kirpich formula

$$Ti = 0.0078\ L^{0.77} \times S^{0.385}$$

where L: length of natural channel / catchment (ft)
S: average watershed slope

- Channel flow velocity ($T_f$)calculation: Manning formula
- Time of concentration ($T_c$): $T_c = T_i + T_f$
- Runoff coefficient

| Year | Urban area | Hill |
|---|---|---|
| 1998 | 0.8 | 0.6 |
| 2025 | 0.9 | 0.8 |

- Return period (Peru standard (S.124.5))

Residential 1 – 5 years
Commercial 5 – 10 years

2) **Result of discharge analysis (*Table VII.1.1*)**

Return period: 5 years and 10 years

3) **Evaluation of existing channel capacity (*Table VII.1.2*)**

Locations where discharge exceeds channel capacity (*Figure VII.1.1*)

## 1.3 MEASURES FOR DRAINAGE IMPROVEMENT

### (1) Target

- control street flooding
- reduce sediment and contaminant inflow to the interior bay of Puno
- prevent rainwater inflow to sanitary sewer system

### (2) Strategy

- maximum use of natural drainage ways and existing channels to minimize cost
- detention basin to improve water quality and sediment trapping

### (3) Proposed measures

**(Structural measures)**

- enlargement and lining of existing channels
- construction of additional drainage ways
- construction of check dams and drop structures to control flow velocity and sediment
- construction of wet detention basins in the flood area (basins will be abandoned after 5-10 years in use to accommodate tourism and commercial development in the area)
- installation of proper street drainage
- separation of drainage ways and sanitary sewer system