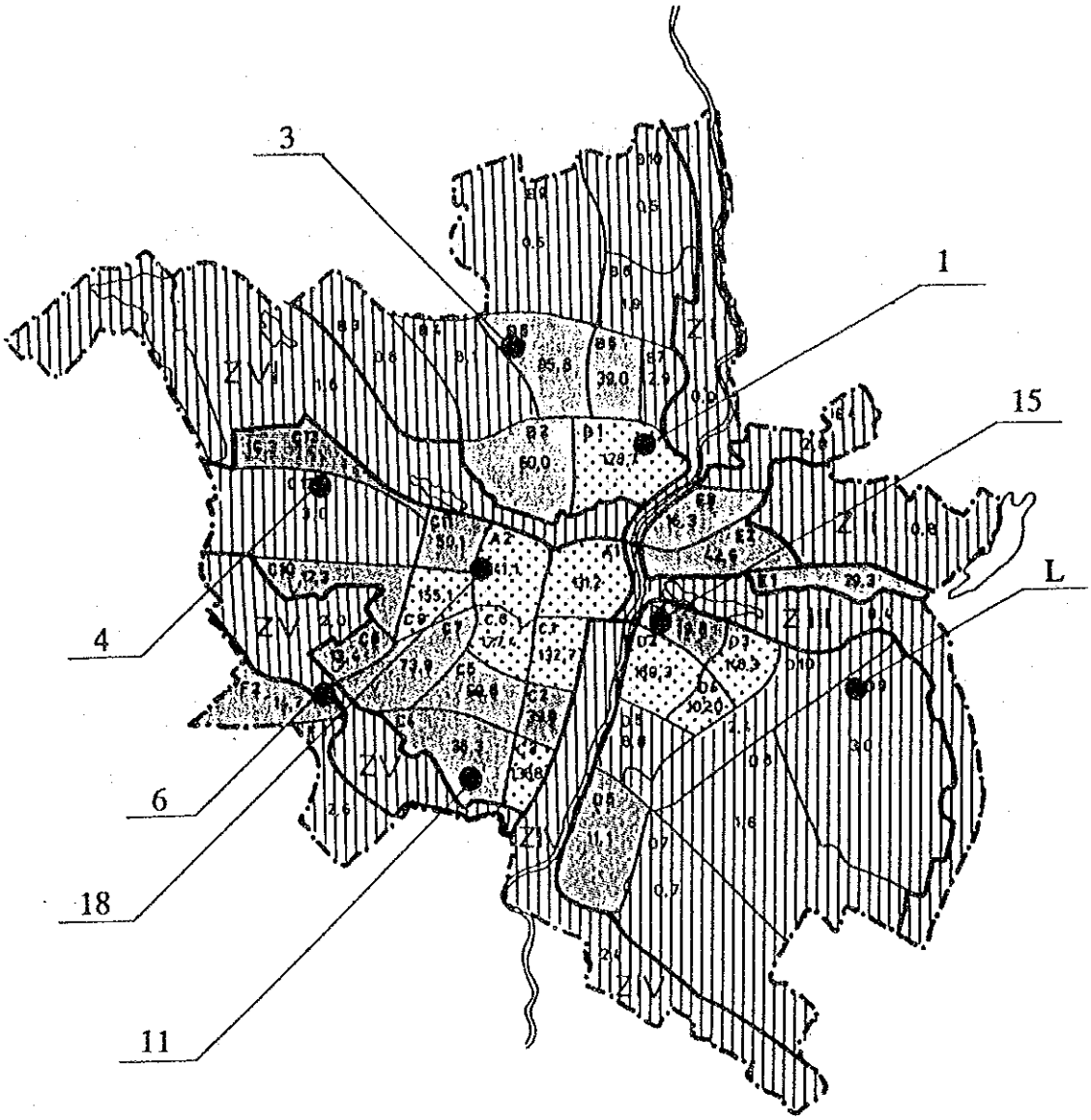


Note; The figures in the map refer to the population density (nos. People/ha) in districts of Poznan.

Symbols:

- Recommended location of recycling centre
- Area with high population density
- Area with medium population density
- Area with low population density

Fig.J.1.3-4 Eight Locations proposed for Recycling Centres in Poznan

The proposed lay-out of the recycling centre at Grunwaldzka St (location no.6, refer Fig.J.1.3-4) is presented in Drawing No.R2.

This location is selected for reasons as follows:

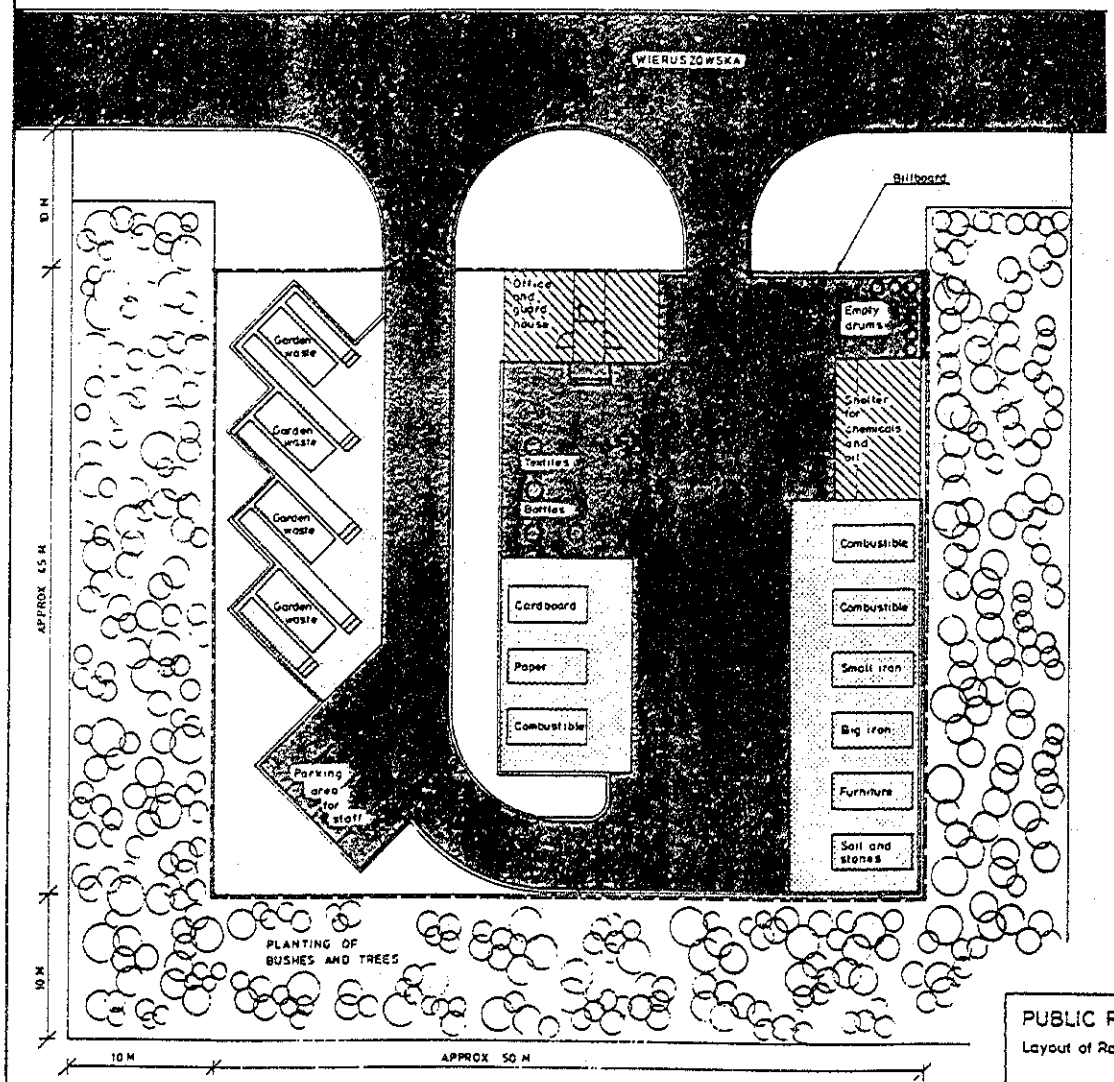
- Provided the recycling centre is furnished with surrounding planting, embankments of soil and fence it is evaluated that a recycling centre in this location will gain public acceptance.

- It is located in an area with many single family houses with gardens. Thus, it is expected that especially garden waste is a problem for the population of the area.

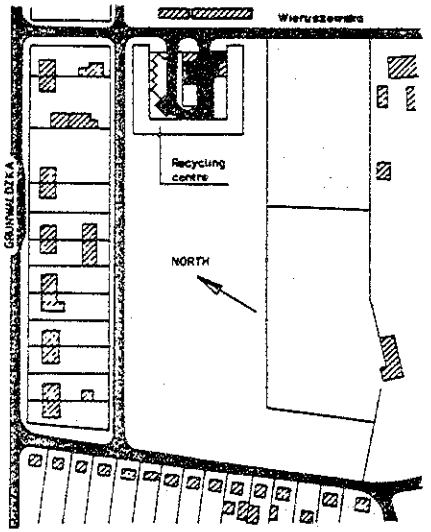
- The population of the area is relatively rich and furnished with own cars. Thus, the population have means of transportation to the recycling centre.

- It is relatively simple to construct an access road from a public main road to the proposed location for the recycling centre.

- The proposed location is appropriate (relatively little earthwork) for the construction of a recycling centre.



LAYOUT OF RECYCLING CENTRE, Scale 1:300



LOCATION OF RECYCLING CENTRE, Scale 1:3000

NOTE:

All containers are designed in accordance with the type of waste to be received.

LEGEND:

- Asphalt pavement
- Pavement of concrete stones

PUBLIC RECYCLING CENTRE

Layout of Recycling Centre at Grunwaldzka

Drawing No.	THE STUDY ON THE SOLID WASTE MANAGEMENT FOR POZNAN CITY IN THE REPUBLIC OF POLAND
R 1	JAPAN INTERNATIONAL COOPERATION AGENCY

J.1.4 Discharge, Storage, Collection and Haulage

Since these activities are closely related to each other, the system constituting various sub-components must be analyzed entirely for the formulation of the optimal system.

1) Introduction

The collection and haulage system in Poznan city has been fully developed in the course of MSWM activities, and is functioning almost satisfactorily. However, to adopt the waste flow proposed in the MEWM Master Plan, some operations should be improved and some new systems have to be introduced.

a. Proposed Modification Measures for the Present System

Discharge, storage, collection and haulage procedures are very difficult to drastically alter in places where they are effectively working because they have become a part of the peoples' way of life. However, because of the introduction of new intermediate treatment facilities to the present collection and haulage system, some modifications will be required. These modifications will lead to changes in the discharge and storage system which have become very much a part of the peoples' way of life.

Since the present system is working well, the modifications will be minimized to help the people cope with the changes smoothly. The modifications will be in conformity with the requirements for the proposed intermediate treatment plants.

b. Proposed New Systems

The introduction of new intermediate treatment facilities requires the enforcement of separate collection which would include the use of a few collection systems.

c. Change in Final Disposal Site

The MSWM Master Plan proposes to change the location of the disposal site from Suchy Las to Franowo-Michalowo. The change in the final disposal site will influence present work efficiency and this should be considered as a precondition for all proposed modifications.

2) Target of Discharge, Storage, Collection and Haulage Plan

- 100 % collection service coverage
  (This target can be attained, provided that a law for compulsory waste collection is introduced.)
- Realization of controlled waste flow
- Highly efficient of collection and haulage works with more cooperation from the citizens

3) Design Conditions

a. Present Design Conditions

Population Structure Serviced by Refuse Truck Category

Referring to the waste amount survey data obtained by the portable truck scale at the Such Las landfill, refuse trucks are providing the population with collection services in the following ratio.

.	Compaction truck	: 67 %
.	Hoist truck	: 23 %
.	No collection	: 10 %

Present Collection Service Area

The present waste collection area serviced by SANITECH, LEWAR AND TECH-KOM in 1992 is shown in Fig.J.1.4-1.

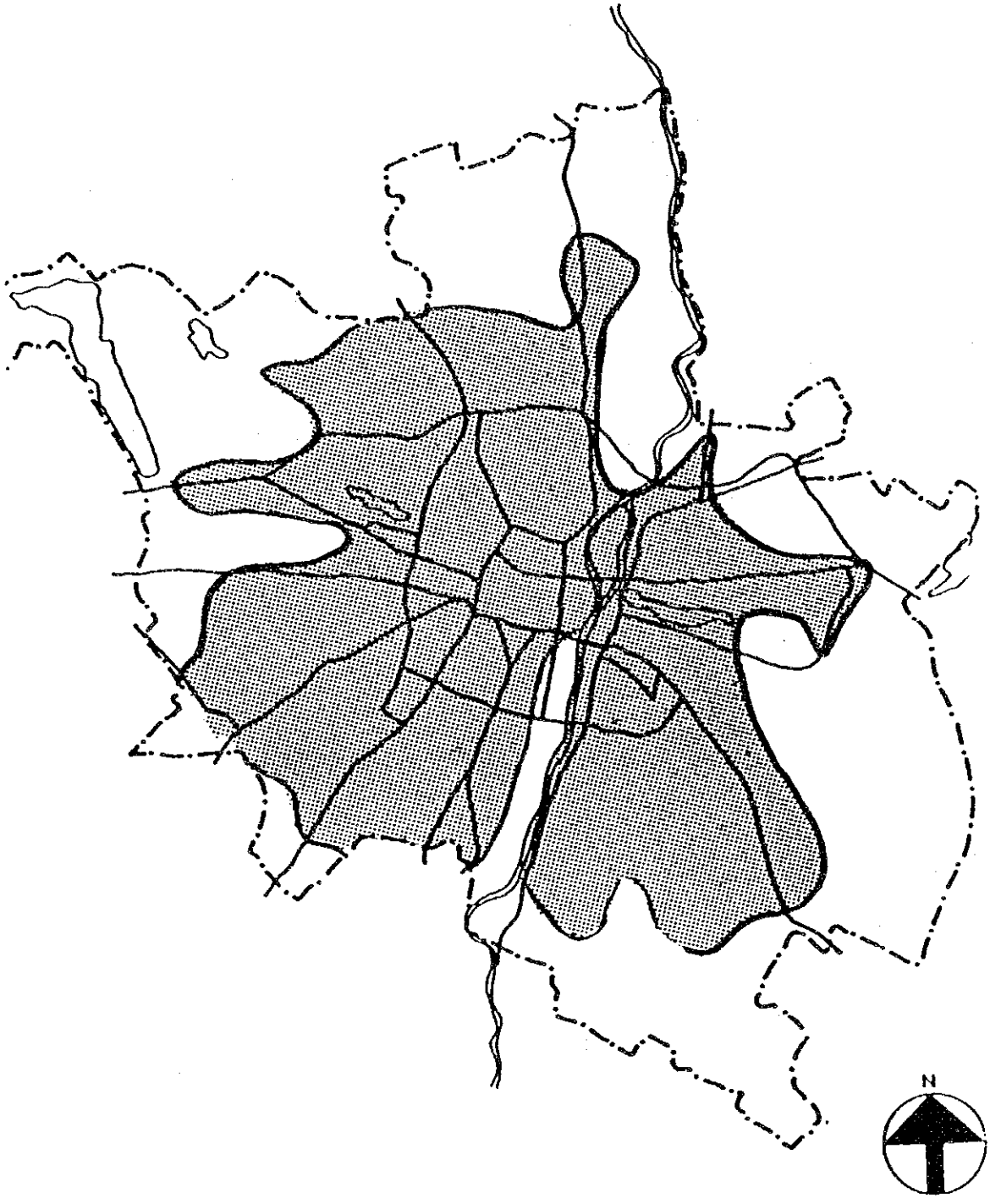


Fig.J.1.4-1 Waste Collection Service Area in 1992

Service Coverage in 1992

The situation of the non-collection service population in 1992 are presented in Table J.1.4-1.

Table J.1.4-1 Service Coverage of Waste Collection in 1992

Category	Estimated Population	Ratio (%)
Non-service population		
Residents outside of service area	9,000	1.5
Squatters	5,000	0.8
Houseowner refusing collection service	47,180	8.0
Total	61,180	10.4
Serviced population	528,920	89.6
Total population in 1991	590,100	100

The service coverage ratio in 1992 is, therefore , concluded as approximately 90 %.

Cycle Time

The average cycle time, including efficiency, of the collection trucks which were estimated with reference to the time and motion survey results and collected data are presented in Table J.1.4-2.

Table J.1.4-2 Cycle Time of Waste Collection Truck

Category of truck	Average distance travelled (km)	Average trip nos. (trip/day)	Cycle time (minutes)			
			Collec-tion	Haulage	Discha-rge	Total
Compaction truck	10.5	2	114	85	17	216
Hoist truck	10.5	4	9	60	12	81

The average direct distance was determined based on Fig.J.2.2-2.

The average number of trips was determined by the performance records.

The cycle time were determined by the time and motion survey results shown in Table J.1.4-3 and -4.

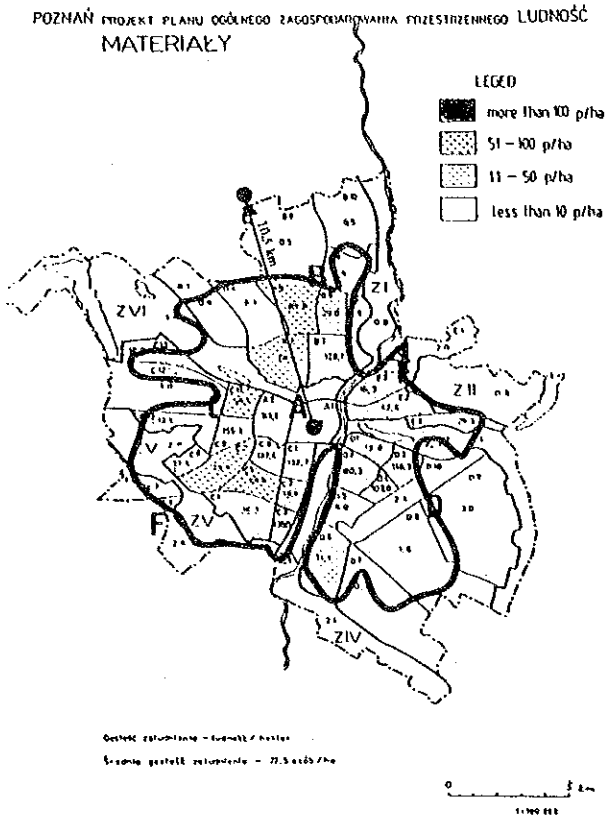


Fig.J.1.4-2 Direct Travel Distance to Suchy Las Landfill

Table J.1.4-3 Cycle Time of Compaction Truck by Time and Motion Survey

Date	Number of Trip	Cycle Time (minutes)		
		Collection	Haulage	Discharge
June 22	2	227	148	47
June 24	2	221	209	25
June 25	2	212	192	33
June 29	3	365	215	50
Total	9	1,025	764	155
Average	1	114	85	17

Table J.1.4-4 Cycle Time of Hoist Truck by Time and Motion Survey

Date	Number of Trip	Cycle Time (minutes)		
		Collection	Haulage	Discharge
June 25	3	35	230	30
June 30	4	30	187	53
Total	7	65	417	83
Average	1	9	60	12

Travel Distance and Population by Block

Poznan city is divided into three blocks for analysis, as shown in Fig.J.1.4-3.

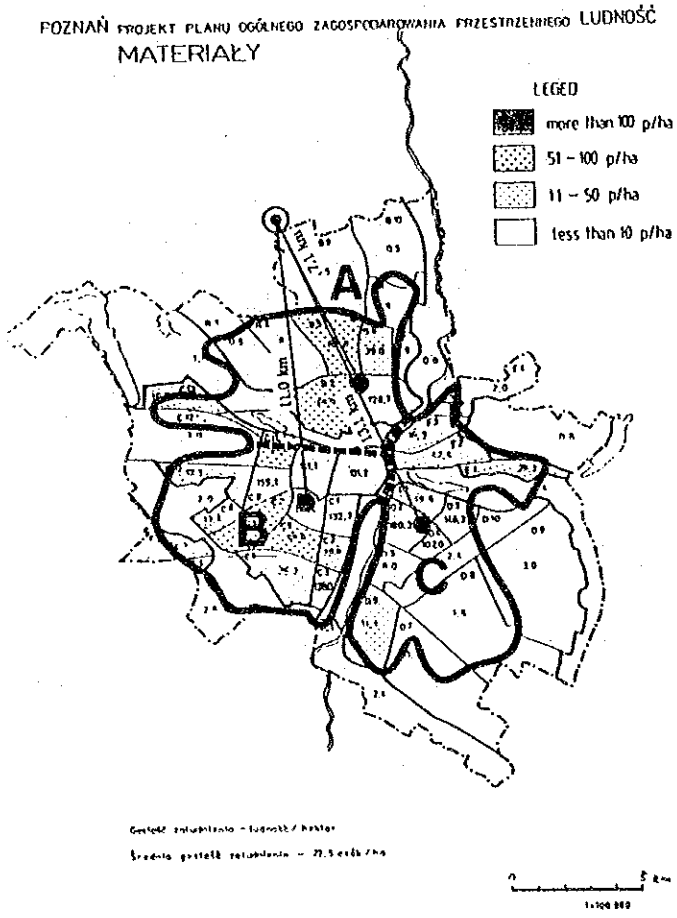


Fig.J.1.4-3 Travel Distance and Cycle Time by Block

The cycle time of compaction trucks and hoist trucks calculated are shown in Table J.1.4-5 and -6.

Table J.1.4-5 Cycle Time of Compaction Truck by Block

Category of truck	Average distance travelled (km)	Cycle time (minutes)			
		Collection	Haulage	Discharge	Total
A	7.1	114.0	57.5	17.0	188.5
B	11.0	114.0	89.0	17.0	220.0
C	13.0	114.0	105.2	17.0	236.2

Table J.1.4-6 Cycle Time of Hoist Truck by Block

Category of truck	Average distance travelled (km)	Cycle time (minutes)			
		Collection	Haulage	Discharge	Total
A	7.1	9.0	41.6	12.0	61.4
B	11.0	9.0	62.9	12.0	83.9
C	13.0	9.0	74.3	12.0	95.3

Table J.1.4-7 Population Distribution

Block	Population	in compaction truck area (67%)	in hoist truck area (23%)
A	160,000	107,200	35,800
B	290,100	194,367	66,723
C	140,000	93,800	32,200

b. Designed Conditions for Franowo-Michalowo Landfill Site

The alterations for the final disposal site from Suchy Las to Franowo-Michalowo shortens the travel distance of the waste collection trucks. The change of the final disposal site is favoured by all modifications of collection and haulage work.

Travel Distance

The travel distances from each block to the Franowo-Michalowo site are shown in Fig.J.1.4-4.

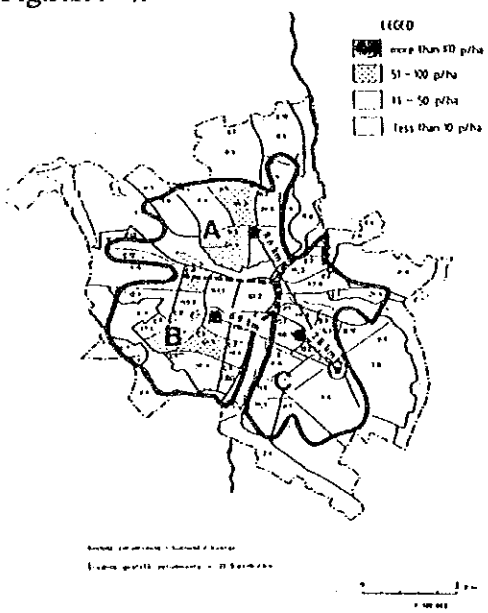


Fig.J.1.4-4 Travel Distance to Franowo-Michalowo Site

The cycle times revised are shown in Table J.1.4-8 and -9.

Table J.1.4-8 Cycle Time of Compaction Truck by Block

Category of truck	Distance (km)			Time reduced (min.)
	to Suchy Las	to Franowo	Difference	
A	7.1	8.6	+1.5	+12.1
B	11.0	6.9	-4.1	-33.2
C	13.0	2.8	+10.2	+82.6

Table J.1.4-9 Cycle Time of Hoist Truck by Block

Category of truck	Distance (km)			Time reduced (min.)
	to Suchy Las	to Franowo	Difference	
A	7.1	8.6	+1.5	+8.6
B	11.0	6.9	-4.1	-23.4
C	13.0	2.8	-10.2	-58.3

4) Proposed Modification Measures on Present System

The proposed modification measures of the present system to realize the targets of the MSWM Master Plan are summarized in Table J.1.4-10

Table J.1.4-10 Modifications to the Present System

Proposed Modification of Present System	Aims		
	100 % Service Coverage	Realization of Waste Flow	Improvement of Efficiency
a. Expansion of service area	x		
b. Regular separate collection		x	
c. Recycling centre collection		x	
d. Bulky waste collection		x	
e. Paper sack and stand		x	x
f. Curb collection			x
g. Prohibition of dust chute		x	

5) Examination of Proposed Modification Measures

a. Expansion of Service Area to attain 100 % Collection Coverage Ratio

i. Introduction

The sanitary condition of Poznan City is almost maintained within a satisfactory level, although the present service coverage level in Poznan is approximately 90 %. On the other hand illegal dumping cases are predominant in many places. Illegal dumping consist of not only industrial waste but also municipal waste. The illegal dumping cases of municipal wastes are deemed to be caused by the remaining non-serviced households. Therefore the collection service coverage should be expanded.

ii. Target

Service coverage is planned to be improved to 100 % by the year 2001 and 100 % collection service shall be maintained after the year 2001.

iii. Analysis

The total number of squatters and house owners refusing waste collection service are approximately 52,180 peoples which is 8.8 % of the total population of Poznan City. Since most of them live within the present waste collection service area, the expansion of waste collection service to these people is estimated not to affect the present work efficiency of waste collection service.

The expansion of the waste collection service to the residents outside of service area is expected to create low work efficiency because they are dispersed from the town centre. Their required haulage distances are much longer than the present average haulage distance. However, this influence is estimated to be very little on the whole, because this involves only 9,000 people which is 1.5 % of the total population. Assuming that the work efficiency for this 1.5 % population is 50 % lower than the standard work efficiency, the cycle time of collection and haulage work are estimated to get longer by 3.0 %.

b. Separate Collection

i. Introduction

A separate collection system must be introduced to maintain a highly efficient incineration plant and also to protect the incinerators from damage caused by unsuitable wastes.

In addition, new collection systems should be provided for wastes unsuitable for incineration, such as bulky wastes, ashes, garden wastes, construction waste, soil and rocks, which might cause problems.

In order to promote recycling and to protect the environment from damages caused by hazardous wastes, such as batteries which are often discharged by households, separate collection is advisable.

The introduction of a separate collection will require the help of the citizens and increase the cost of collection and haulage operations. Although separate collection system consists of four sub-systems, careful review and preparation are required prior to their implementation.

ii. Aims of Sub-systems

Four collection sub-systems shown below were planned:

- Regular separate collection of combustible and non-combustible wastes
- Bulky waste collection
- Public Recycling centre collection
- Private recyclers' collection

The aims of these collection sub-systems are summarized in Table J.1.4-11.

Table J.1.4-11 Aims of Collection Sub-systems

Collection Sub-system	Aims
Regular separate collection of combustible and non-combustible wastes collection	- to supply the higher calorific wastes to an incineration plant. - to protect the incinerators from damage by unsuitable wastes.
Bulky waste collection	- to provide people with a collection service for bulky wastes.
Public Recycling centre collection	- to provide people with a collection system for the wastes which are rejected by the regular collection service. - to promote recycling. - to collect the hazardous waste generated at home.
Private recyclers' collection	- to promote recycling

iii. Method of Collection Sub-systems

The methods of each collection sub-system are presented in Table J.1.4-12.

Table J.1.4-12 Method of Collection Sub-systems

Collection Sub-system	Obligation	Method
Regular separate collection of combustible and non-combustible wastes	Yes	People are request to discharge combustible and non-combustible waste separately. The discharged wastes are regularly collected by the collection agencies.
Bulky waste collection service for bulky waste	No	Bulky wastes, which are not dealt with the regular collection service, are collected by telephone order from the discharger.
Recycling centre collection	Partly	Householders carry their own wastes, which are unsuitable for regular collection, to public recycling centres and sort them into categorized containers.
Private recyclers' collection	No	Recyclable materials, which can be profitable, are collected by private recyclers. This activity is needed to be supported by the administrative and public.

The available collection sub-systems for the waste are presented in Table J.1.4-13.

Table J.1.4-13 Available Collection Systems by Waste Category

Classification	Regular collection		Bulky waste collection	Public Recycling centre collection
	Combustible	Non-combustible		
garbage	x			
paper	x			
textile	x			
plastic	x			
grass and wood	x			
leather and rubber	x			
metal		x		
glass		x		x
ceramic and soil		x		x
ash		x		x
bulky			x	x

vi. Waste Flow by Building Categories

New Apartment Building Areas

Table J.1.4-14 Proposed Waste Flow from New Apartment Buildings Areas to Reception

Collection system		Discharge	Storage	Collection	Haulage	Reception
Regular	Combustibles	Manual delivery	6-10 m^3	Curb	Hoist truck	Incinerator
	Non-combustibles	Manual delivery	6-10 m^3	Curb	Hoist truck	Landfill
Bulky waste		none	in the house	Door to door	Flat-bed truck	Landfill
Recycling centre		none	in the house	none	Personal delivery	P.R.C

Regular collection of combustible waste

- Discharge system : Transported manually
  Dust chute discharge will be prohibited.
- Storage system : 6 to 10 m^3 containers
- Collection system : Container yard collection
  Frequency depends on the covered population.
- Haulage system : Hoist truck

Regular collection of non-combustible waste

- Discharge system : Transported manually
  Dust chute discharge will be prohibited.
- Storage system : 6 to 10 m^3 containers
- Collection system : Container yard collection
  Frequency depends on the covered population.
- Haulage system : Hoist truck

Bulky waste

There are two options available to the people for the discharge of wastes mentioned above.

- Option No.1: Recycling Centres
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : personal delivery
  - . Haulage system : personal delivery

- Option No.2: Bulky waste collection Service
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : Door to door
  - . Haulage system : Flat-bed truck

Recyclable waste

There are two options available to the people for the discharge of recyclable waste.

- Option No.1: Recycling Centres
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : personal delivery
  - . Haulage system : personal delivery

- Option No.2: Private Recycler
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : depends on the recycler
  - . Haulage system : depends on the recycler

Old Building Areas

Table J.1.4-15 Proposed Waste Flow from Old Building Areas to Reception

Collection system		Discharge	Storage	Collection	Haulage	Reception
Regular	Combustibles	Manual delivery	110 l 1.1 m^3	Curb	Compactor truck	Incinerator
	Non-com-bustibles	Manual delivery	110 l 1.1 m^3	Curb	Side loading truck	Landfill
Bulky waste		none	in the house	Door to door	Flat-bed truck	Landfill
Recycling centre		none	in the house	none	Personal delivery	P.R.C

Regular collection of combustible waste

- Discharge system : Transported manually
  Dust chute discharge will be prohibited.
- Storage system : 110 l dustbins and 1.1 m^3 containers, Bobr
- Collection system : Curb collection
  Frequency - approximately once a week.
- Haulage system : Compaction truck

Regular collection of non-combustible waste

- Discharge system : Transported manually
  Dust chute discharge will be prohibited.
- Storage system : 110 l dustbins and 1.1 m^3 containers, Bobr
- Collection system : Curb collection
  Frequency - approximately once a month.
- Haulage system : Compaction truck

Bulky waste

There are two options available to the people for the discharge of bulky waste.

- Option No.1: Recycling Centres
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : personal delivery
  - . Haulage system : personal delivery

- Option No.2: Bulky waste collection Service
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : Door to door
  - . Haulage system : Flat-bed truck

Recyclable waste

There are two options available to the people for the discharge of recyclable waste.

- Option No.1: Recycling Centres
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : personal delivery
  - . Haulage system : personal delivery

- Option No.2: Private Recycler
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : depends on the recycler
  - . Haulage system : depends on the recycler

Detached and Semi-detached Houses

Table J.1.4-16 Proposed Waste Flow from Detached and Semi-detached Houses

Collection system		Discharge	Storage	Collection	Haulage	Reception
Regular	Combustibles	Manual delivery	Paper bag	Curb	Compactor truck	Incinerator
	Non-combustibles	Manual delivery	110 l	Curb	Side loading truck	Landfill
Bulky waste		none	in the house	Door to door	Flat-bed truck	Landfill
Recycling centre		none	in the house	none	Personal delivery	P.R.C

Regular collection of combustible waste

- Discharge system : Transported manually
- Storage system : Paper bags
- Collection system : Curb collection
  Frequency - approximately once a week.
- Haulage system : Compaction truck

Regular collection of non-combustible waste

- Discharge system : transported manually
- Storage system : 110 l dustbins
- Collection system : Curb collection
  Frequency - approximately once a month.
- Haulage system : Side loading truck

Bulky waste

There are two options available to the people for the discharge of bulky waste.

- Option No.1: Recycling Centres
  - Discharge system : Transported manually
  - Storage system : storage in the house
  - Collection system : personal delivery
  - Haulage system : personal delivery

- Option No.2: Bulky waste collection Service
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : Door to door
  - . Haulage system : Flat-bed truck

Recyclable waste

There are two options available to the people for the discharge of recyclable waste.

- Option No.1: Recycling Centres
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : personal delivery
  - . Haulage system : personal delivery

- Option No.2: Private Recycler
  - . Discharge system : Transported manually
  - . Storage system : storage in the house
  - . Collection system : depends on the recycler
  - . Haulage system : depends on the recycler

v. Concept of Each Collection System

Regular Collection of Combustible and Non-combustible Waste

The discharger is required to dispose combustible and non-combustible wastes separately. Combustible wastes included in the regular collection must be suitable for incineration, bulky wastes are, therefore, excluded.

The main waste categories dealt with in the regular collection of combustible waste are:

- kitchen waste
- paper
- textile
- plastics
- grass and wood
- leather and rubber

Other wastes are also included in the regular collection of non-combustible wastes except for bulky wastes, ash, wastes, etc., because they disturb the collection work efficiency.

Bulky waste collection

Bulky waste is received at public recycling centres. However, there are some householders who cannot afford to carry bulky waste to recycling centres due to various reasons such as lack of transportation. Bulky waste collection service is provided for such householders.

Recycling Centres Collection

Recycling centres supervise container sites and admission is free for all householders. The householders carry unsuitable wastes for regular collection to the most convenient recycling centre and sort their waste into appropriate containers. Recyclable wastes are sold to customers and the remainders are carried and disposed of at the landfill.

Private recyclers' collection

Recyclable materials which are profitable for recycling activities are collected by private recyclers by various means.

vi. Estimation of Cycle Time for Regular Collection

Refuse Truck

The cycle time of collection work is estimated to be longer for compaction truck collection because of the expected increase in collection frequency due to the introduction of regular separate collection. Changes, however, are not expected in the cycle time of hoist truck collection.

The cycle time of compaction trucks is estimated to be influenced at a lesser rate: approximately 15 % of the collection time.

114 min. x 15 % = 17.1 min.

Hence, cycle time of collection work of compaction truck is estimated to be longer by 17.1 minutes. However, this 17.1 minutes can be covered by saving time due to alteration of landfill site.

Container

The required number of containers was estimated to increase as shown below, due to the introduction of separate collection:

- 110 litre and 1.1 m^3 : 1.5 times
- 7 to 10 m^3 : 2 times

d. Bulky waste collection

i. Introduction

The introduction of a bulky waste collection service is planned, because bulky waste is refused by regular collection services. There are two collection methods prepared for bulky wastes; one is bulky waste collection and the other is recycling centre collection.

The recycling centre collection will not charge the receipt of bulky waste, but requires that dischargers transport their bulky waste themselves to the recycling centres. The bulky waste collection service on the other hand collects, hauls and disposes these bulky wastes for a certain amount.

The bulky waste collection system is convenient for people who can not carry bulky waste to recycling centres but can afford to pay for its discharge.

Handicapped people, people with low income etc., should be provided with free bulky waste collection services because they are incapable of carrying out both ways.

This service is, therefore, necessary to supplement the regular collection service and recycling centre collection.

ii. Proposed Method

The discharger can always phone a collection agency to request the collection of bulky waste. The collection agency answers the request for a certain fee transports the waste to the final disposal site. The collection fee for bulky wastes should be determined to cover all costs.

iii. Estimation of Cycle Time

The cost are estimated based on the following design data.

–	Type of truck	: Flat-bed with crane truck
–	Payload of truck	: 10 tons
–	Design load	: 3 tons/trip
–	Average number of trips	: 2 trips/day
–	Working days	: 304 days/year
–	Work efficiency	: 0.8

The capacity of the truck was calculated as follows:

3 tons/truck x 2 trips/day x 304 days/year x 0.8 = 1,459 tons/year/truck

Hence, the estimated total amount of bulky waste carried by a truck per year is 1,459 tons.

e. Paper Sack and Stand for Combustible Waste

Paper bags are planned to be introduced for detached and semi-detached houses as equipment for storing combustible waste. The objectives are as follows;

- To minimize the increasing cost of container caused by the introduction of separate collection;
- To restrain the waste generation by delivering paper bags depending on the contract collection frequency;
- To improve the efficiency of waste collection;
- To avoid people discharging garden waste, renovation waste into combustible waste collection; and
- To improve sanitary level of storage equipment.

i. Description of Storage Equipment

This storage equipment is constructed by strong paper sack and a stand, as shown Fig.J.1.4-8. The paper sack is constructed along a galvanized stand and placed inside a galvanized wire mesh cover for protecting the waste from tampering by animals. The durability of the paper bag has been proved to be sufficient even for adverse weather conditions through more than 20 years' experience in Denmark.

Fig.J.1.4–5 Structure of Paper Sack and Stand

ii. Method

The collection company delivers paper bags to each house owner depending on the member number of the family.
The house owner sets a paper sack to the stand and discharge the waste into the paper sack. Once a week, the waste collection worker collect the paper sack containing waste by opening the wire mesh protection.

iii. Advantages

Advantages:

- Sanitation
- Saving time for collection work
- Unsuitable wastes for regular collection such stones and soil are able to be blocked.
- Waste discharge amount is able to be controlled by how many number of paper sacks are delivered.

iv. Analysis of Cost Effect

Two different cost effects are able to be estimated; material cost for paper sacks and sack holder and the change of collection work efficiency.

Material Cost

Sack holder:	300,000 zl	10 years in life year
Paper sack:	1,000 zl	nil

The price of a sack holder is almost same as a 110 litre dustbin. The price of paper sacks are very cheap. The cost effect due to material cost is, therefore, negligible, because the paper sack and holder is a substitute for a 110 litre dustbin.

Estimation of Cycle Time

The collection work efficiency is improved by introduction of this system, because the time to return empty dustbins can be saved.

According to the time and motion survey results summarized in Table J.1.4-14, the distance carried by hand per container is 21.6 meter. It is estimated to be reduced by 50 % with the introduction of paper sack and stand.

Table J.1.4-17 Distance Carried by Hand of Containers

Date	Category	Collection System	Nos. of container collected (nos)	Average distance carried by hand by workers (m)	Total distance carried by hand (m)
June 24	Detached and semi-detached	door to door	30	Retrieve 16.6	498
				Return 23.6	708
			49	Retrieve 10.1	495
				Return 10.1	495
				T-Retrieve	993
				T-Return	1203
				Total	2196
June 25	Detached and semi-detached	door to door	155	Retrieve 10	1550
				Return 10	1550
			158	Retrieve 10	1580
				Return 10	1580
				Total	6260

Population of detached and semi-detached houses which receive collection service was estimated as 20 % of total population. Their wastes are collected with compaction trucks.

The change of collection work of compaction truck is estimated as follows.

114 min. x 0.5 x 0.5 x 20%/67% = 8.5 min.

Hence, 8.5 minutes can be saved on collection time.

It was assumed in the equation above that the actual collection working time was 50 % of collection work cycle time.

f. Curb Collection System

i. Introduction

In this system, the house owner is responsible for placing the containers at the curb on collection day and for returning the empty containers to their storage location after wastes are collected.

In the old building area and the detached and semi-detached housing area, collection workers are at present carrying containers by hands. This work is affects the efficiency of waste collection and many accidents have occurred during this operation. For example, in a detached house, a collection worker was bitten by a dog when entering the premises to carry a container. In an old apartment building, a collection worker broke his leg by falling caused by bad access and inadequate lighting when he carried a container.

The result of the time and motion survey obviously proves that the manual carrying work is creating a load on the waste collection workers and also affecting the work efficiency.

ii. Method

Detached and Semi-detached Houses

Some houses have a container storage place installed within its parameter as shown in Fig.J.1.4-9. This container storage place has two doors inside and outside. Containers can be taken freely from the outside and the inside door can be locked. This system is very safe and very convenient for collection work. The municipality should recommend all householders to adopt this system. House owners who does not have this shall place their container in front of their premises on the waste collection day.

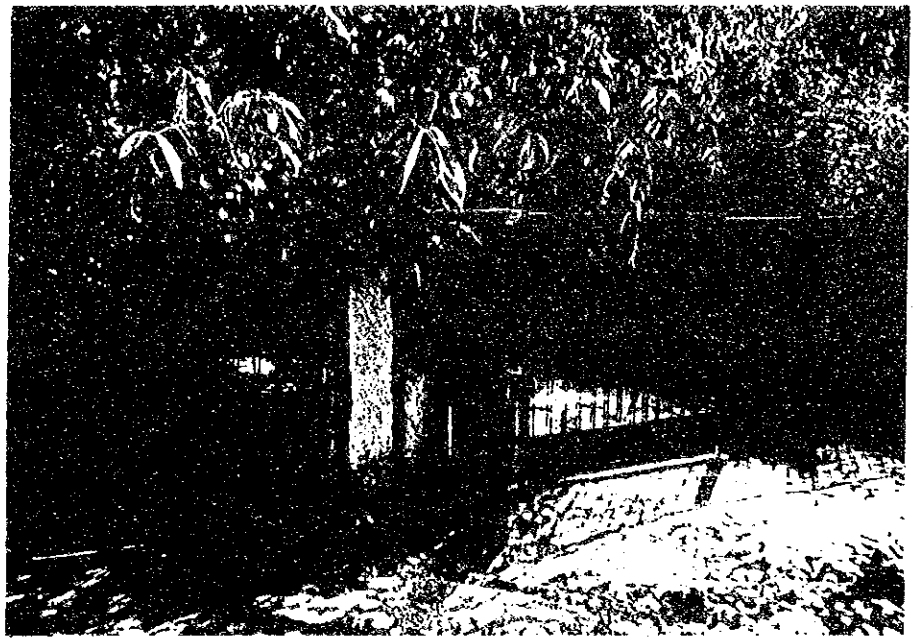


Fig.J.1.4-6 Container Store for Detached House

Old Buildings

A guardian should be responsible for placing the containers at the curb on collection day and for returning empty containers to the back yard after the wastes are collected. Collection gangs are requested to keep the collection schedule to conduct this system successfully.

iii. Estimation of Cycle Time

According to the time and motion survey result shown in Table J.1.4-15, the total distance of container carried per day is usually 5,000 to 6,000 metres. In the case of survey No.1, the guardian of the old buildings cooperate to place containers beside the curb. Therefore the total returning distance of the containers is 4688 meters but the total retrieving distance is only 656 meters, 14 % of the total returning distance.

Table J.1.4-18 Distance of Containers Carried by Hand

Date	Category	Collection System	Nos. of container collected (nos)	Average distance carried by workers (m)	Total hand carry distance (m)
June 23	Old building	curb and door	75	Retrieve 5	375
				Return 31.5	2363
			67	Retrieve 4.2	281
				Return 34.7	2325
				T-Retrieve	656
				T-Return	4688
				Total	5344
June 27	Old building	door to door	59	Retrieve 21	1239
				Return 21	1239
			39	Retrieve 10	390
				Return 10	390
			97	Retrieve 16.4	1591
				Return 16.4	1591
				Total	6440

The following assumptions were made to estimate the change of cycle time.

- Average total distance of containers carried by hand per trip : 3000 m
- After introduction of curb collection : 900 m

The cycle time of collection work is, therefore, calculated as follows;

114 min. x 0.5 x 2100/3000 x 47%/67% = 28 min.

Hence, 28 minutes can be saved by introduction of curb collection.

g. Prohibition of Dust Chute

i. Introduction

The use of chutes are often troublesome; the rough inner surface becomes contaminated with waste and is difficult to clean or disinfect. Chutes are frequently used improperly and become blocked. The use of dust chutes ceased in many apartment buildings due to insanitary and clogging problems.

The use of dust chutes can become an obstacle for introducing the separate collection system. Residents who are still using dust chutes have become accustomed to discharging anything without paying much attention. Although this system might be very convenient for residents using it, the dust chutes should ceased to operate remind the residents the existence of the regulation of separate collection.

ii. Proposed Method

110 litre dustbin and 1.1 m^3 container are being used at places where dust chutes are being used. These containers must be replaced by empty containers by the guardians before overflowing. The container rooms are usually very narrow and it creates difficulty in carrying containers for waste loading. The efficiency of collection work for these containers are much lower than the system of a hoist truck and a large communal container.

The proposed plan is to cease dust chutes, 110 litre dustbin and 1.1 m^3 containers, and to introduce collection by hoist trucks and a large communal container. The introduction of this system has the following effects;

- to improve sanitary condition of apartment buildings;
- to improve efficiency of waste collection and haulage;
- to simplify the discharge and storage system;
- to release the work load on the guardian;

iii. Possibility of Introduction

The population using dust chutes is estimated to be approximately 3 % of the total population of Poznan City according to the public opinion survey. Moreover, 93 % of interviewees express their willingness to cooperate for waste segregation and more than 90 % of interviewees agree to participate in public cooperation.
In view of these survey results, any difficulties resulting from this modification can not be foreseen.

iv. Cost Analysis

Prohibition of dust chute leads to change of collection method from a compaction truck to a hoist truck which means improvement of efficiency. However, the effect of this negligible because the population concerned is few in numbers.

6) Summary of Cycle Time Estimation

Table J.1.4-19 Summary of Cycle Time Change for Compaction Truck by Modification Measures

Block	Item	Cycle Time (min.)			
		Collection	Haulage	Discharge	Total
A	Present (in 1992)	114.0	57.5	17.0	188.5
	Shift landfill to Franowo	0.0	+12.1	0.0	+12.1
	Expansion of service area	+3.4	+1.7	0.0	+5.1
	Separate collection	+17.1	0.0	0.0	+17.1
	Paper sack and stand	-8.5	0.0	0.0	-8.5
	Curb collection	-28.0	0.0	0.0	-28.0
	Sub-total of modifications	-16.0	+13.8	0.0	-2.2
	Total	98.0	71.3	17.0	186.3
B	Present (in 1992)	114.0	89.0	17.0	220.0
	Shift landfill to Franowo	0.0	-33.2	0.0	-33.2
	Expansion of service area	+3.4	+2.7	0.0	+6.1
	Separate collection	+17.1	0.0	0.0	+17.1
	Paper sack and stand	-8.5	0.0	0.0	-8.5
	Curb collection	-28.0	0.0	0.0	-28.0
	Sub-total of modifications	-16.0	-30.5	0.0	-46.5
	Total	98.0	58.5	17.0	173.5
C	Present (in 1992)	114.0	105.2	17.0	236.2
	Shift landfill to Franowo	0.0	-82.6	0.0	-82.6
	Expansion of service area	+3.4	+3.2	0.0	+6.6
	Separate collection	+17.1	0.0	0.0	+17.1
	Paper sack and stand	-8.5	0.0	0.0	-8.5
	Curb collection	-28.0	0.0	0.0	-28.0
	Sub-total of modifications	16.0	-79.4	0.0	-101.1
	Total	98.0	25.8	17.0	140.8

Table J.1.4-20 Summary of Cycle Time Change for Hoist Truck by Modification Measures

Block	Item	Cycle Time (min.)			
		Collection	Haulage	Discharge	Total
A	Present (in 1992)	9.0	40.6	12.0	61.6
	Shift landfill to Franowo	0.0	+8.6	0.0	+8.6
	Expansion of service area	0.0	+1.2	0.0	+1.2
	Separate collection	+1.4	+6.1	0.0	+7.5
	Sub-total of modifications	+1.4	+15.9	0.0	+17.3
	Total	10.4	56.5	12.0	78.9
B	Present (in 1992)	9.0	62.9	12.0	83.9
	Shift landfill to Franowo	0.0	-23.4	0.0	-23.4
	Expansion of service area	0.0	+1.9	0.0	+1.9
	Separate collection	+1.4	+9.4	0.0	+10.8
	Sub-total of modifications	+1.4	-12.1	0.0	-10.7
	Total	10.4	50.8	12.0	73.2
C	Present (in 1992)	9.0	74.3	12.0	95.3
	Shift landfill to Franowo	0.0	-58.3	0.0	-58.3
	Expansion of service area	0.0	+2.2	0.0	+2.2
	Separate collection	+1.4	+11.1	0.0	+12.5
	Sub-total of modifications	+1.4	-45.0	0.0	-43.6
	Total	10.4	29.3	12.0	51.7

The work efficiencies of compaction trucks and hoist trucks were estimated to be improved in correlation with the proposed modification measures. The collection trip number is estimated as follows.

Assuming collection and haulage time is 420 min/day.

Hence, based on the required time of one trip shown in Table J.1.4-19, trip number is estimated as follows;

A block: 420 min./ 186.3 min. = 2.25 trip
B block: 420 min./ 173.5 min. = 2.42 trip
C block: 420 min./ 140.8 min. = 2.98 trip

The average trip number is estimated in **2.55 trips/day** because population of each block are almost same.

7) Cost Estimation

a. Container

The introduction of separate collection will require more containers, as stated in Table J.1.4-21). The required number of containers by the introduction of separate collection, and their prices, are presented below.

Table J.1.4-21 Price List of Containers

Container	Price level in Poland (mill.zl)
- Paper sack holder	0.30
- 110 l dustbin	0.22
- 1.1 m^3 steel container "Bobr"	2.43
- 6 to 10 m^3 communal container	13.92

Table J.1.4-22 Required Number of Containers by the introduction of separate collection

Year	Separate collection ratio	Increased number of container by separate collection		
		110 l dustbin	1.1 m^3	6 - 10 m^3
	100 %	17,340	2,757	651
1998	35 %	6,069	965	298
2002	35 %	6,069	965	298
2007	30 %	5,202	827	255

b. Flat-bed truck for bulky waste collection

Bulky waste collection will use flat-bed trucks for collection and transportation of bulky wastes from users' houses to recycling centres. Costs estimate and the required number are presented below.

Table J.1.4-23 Cost for Bulky Waste Collection

Item	Price level in Poland mill. zl/year
Investment - Flat-bed truck with crane	320
O & M Cost - Labour Cost (Driver and 2 workers) - Diesel and lubricant oil - Maintenance	292 139 32
Annual O & M cost	463

Note: Annual O & M cost excludes tipping fee.

Table J.1.4-24 Required Number of Truck for Bulky Waste Collection

Year	Bulky Waste Discharged		Bulky Waste Collection, 30 % of discharged amount (ton/year)	Required number of Truck (units)
	(ton/day)	(ton/year)		
1995	16.5	6,023	1,807	2
1996	16.8	6,132	1,840	2
1997	17.1	6,242	1,873	2
1998	17.3	6,315	1,895	2
1999	17.6	6,424	1,927	2
2000	17.9	6,534	1,960	2
2001	18.5	6,753	2,026	2
2002	19.1	6,972	2,092	2
2003	19.6	7,154	2,146	2
2004	20.2	7,373	2,212	2
2005	20.8	7,592	2,278	2
2006	21.4	7,811	2,343	2
2007	22.0	8,030	2,409	2
2008	22.7	8,286	2,486	2
2009	23.4	8,541	2,562	2
2010	24.1	8,797	2,639	2

Note: Productivity of a flat-bed truck is 1,459 ton/year/truck.

c. Roll-on Roll-off Truck for Public Recycling Centres

The estimation of the transportation cost from public centres to the final disposal site is presented in Table J.1.4-25 and -26.

Table J.1.4-25 Cost Estimates for Roll-on Roll-off Truck

Item	Price level in Poland mill. zl/year
Investment - Roll-on roll-off truck with crane	470
O & M Cost - Labour Cost (Driver) - Diesel and lubricant oil - Maintenance	139 154 47
Annual O & M cost	340

Note: Annual O & M cost excludes tipping fee.

Table J.1.4-26 Required Number of Roll-on Roll-off Truck

Year	Operated number of R.C.	Amount of residue from Recycling centres		Required number of Roll-on Roll-off (units)
		ton/day	ton/year	
1996	3	20.9	7,629	2
1997	6	42.4	15,476	3
1998	8	57.4	20,951	4
1999	8	58.3	21,280	4
2000	8	59.4	21,681	4
2001	8	61.3	22,375	4
2002	8	63.2	23,068	4
2003	8	64.9	23,689	4
2004	8	67.1	24,492	5
2005	8	69.1	25,222	5
2006	8	71.1	25,952	5
2007	8	73.4	26,791	5
2008	8	75.7	27,631	5
2009	8	78.0	28,470	5
2010	8	80.7	29,456	5

Note: Productivity of a roll-on roll-off truck was estimated at 5,837 ton/year/truck.
20 m^3 x 0.3 ton/m^3 x 0.8 x 4 trip/day = 19.2 ton/day/truck
19.2 ton/day/truck x 304 days/year = 5,837 ton/year/truck

7) Phased Implementation Plan

In the MSWM Master Plan, the incineration plant is to be constructed line by line in 3 stages. The collection system is planned to commence in 3 stages in conformity with the operation schedule of the incineration plant. 3 years training period before operation of the incineration plant was proposed for the purpose of smooth conduct of separate collection.

Separate collection should be commenced from the area where majority of house-holders are cooperative towards source segregation of waste such as new building area. The commercial and office areas are usually difficult for separate collection to be introduced. These areas are recommended to start separate collection in the latter stages.

J.1.5 Final Disposal: Sanitary Landfill

1) Introduction

Sanitary landfill is generally recognized as the basic element in modern solid waste management.

Thus, it is acknowledged that a considerable quantity of waste has to be disposed of even if efforts are provided for their reuse (recycling) or utilization (incineration, composting).

Therefore, as a first step towards modern solid waste management, the landfill activity of Poznan should be strengthened to minimize environmental impacts. Having the requirements for sanitary landfill clarified and the proper design and operation implemented, attention can be focused on other treatment methods.

This Section presents the conceptual lay-out and cost estimates of the new landfill site to be established at Franowo-Michalowo, the site selected by the Municipality of Poznan as the future location of a landfill site and treatment facilities. The site comprises an area of approximately. 180 ha, as shown in Fig.J.1.5-1.

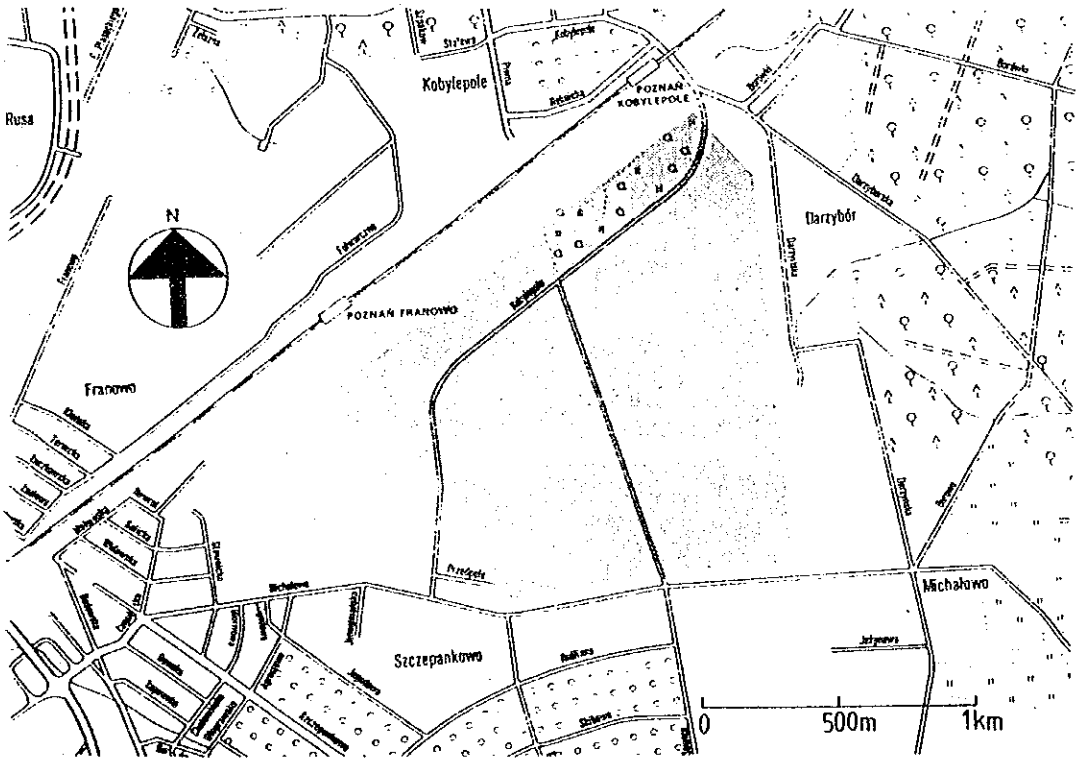


Fig.J.1.5-1 Location of the Selected Area for the New Landfill and Future Treatment Plants.

2) Design Data

a. Waste Quantity for Disposal

Estimates for the quantity of waste generated in Poznan have been elaborated in ANNEX I.1.5. The main figures appear in Table J.1.5-1 as well as the required volume of a new landfill which is assumed to be put into operation in 1995.

The required landfill volume stated in the Table is based on the following precon-ditions:

- An incineration plant, capacity 10.0 tons/hour is put into operation in year 2001.
- The incineration plant is expanded in year 2006 and 2010.
- Eight recycling centres are put into operation during the period 1996 to 1998.

Table J.1.5-1 Estimated Waste Generation in Poznan City and Required Capacity of New Landfill at Franowo-Michalowo

Year	Waste Generation (tons/year)	Incineration plant (nos. of lines)	Recycling centres (nos.)	Required Landfill Volume			
				Annual m^3/year x 1,000		Generated m^3 x 1,000	
				Slag	Other	Slag	Other
1994	191,900	0	0	0	0	0	0
1995	189,900	0	0	0	229	0	229
1996	188,000	0	3	0	227	0	456
1997	186,200	0	6	0	225	0	681
1998	184,300	0	8	0	224	0	905
1999	182,600	0	8	0	223	0	1,129
2000	180,800	0	8	0	223	0	1,351
2001	186,100	1	8	18	157	18	1,508
2002	191,700	1	8	18	164	36	1,672
2003	197,400	1	8	18	171	54	1,842
2004	203,300	1	8	18	178	72	2,020
2005	209,300	1	8	18	185	90	2,223
2006	215,500	2	8	36	120	126	2,326
2007	229,500	2	8	36	128	162	2,454
2008	228,600	2	8	36	136	198	2,590
2009	235,400	2	8	36	145	234	2,635
2010	242,397	3	8	54	81	288	2,815

b. Future Use of the Landfill Area

When the landfilling of the area ends, it will be covered with soil and furnished with planting appropriate for future recreational utilization of the area.

The final cover of the landfill comprises at least 1 m. soil. Uncontrolled release of methane gas released from the waste is avoided by a layer of gravel, one of three recommended precautionary measures against gas.

Most of the soil required for final cover as well as for daily cover of waste may be excavated to the site when preparing areas for later sections of the landfill.

The future landscape plan is presented in Drawing no. L1. No slopes are allowed to be steeper than 1:4 taking into account the varying frictional strength of waste disposed of at the landfill and since no special measures will be taken to ensure the stability of the future hill. This requirement for the slopes of the hill is obtained through the experiences from landfills in Western Europe.

The general slope of the hill is proposed to be 1:8 to accommodate the surrounding landscape. The final design of the hill is recommended to be designed by a professional architect.

Assuming a future landscape as presented in Drawing no. L1, approximately. 7.0 mill. m^3 of compacted waste may be disposed of on the site. This is more than twice as much as the required volume for the planning period (up to year 2010).

The proposed future landscape does not include any filling in the north eastern part of the selected area. This area is reserved for future treatment plants, incineration etc..

c. Capacity of Landfill Sections

The area for waste disposal is proposed to be divided into sections as shown in Drawing No. L4. Each section of the sanitary landfill is to be filled up corresponding to the planned final terrain before a new section is opened. This way, the total area open for infiltration of rain water is kept at a minimum, as well as the generation of leachate.

From year 2001 the landfill is supposed to receive slag and ash from waste incineration. In order to avoid a substantial washing out of metals and other pollutants from wastes, separate landfill sections are constructed for slag and ash.

This washing out of slag and ash will occur in case acid leachate from other waste infiltrate the slag.

It is appropriate to design and construct landfill sections with a capacity complying with the volume required for 2 to 3 years use.

In compliance with the estimated waste generation and the required landfill capacity presented in Table J.1.5-1, the recommended capacity of the landfill sections as well as the construction year appear in Table J.1.5-2 and J.1.5-3.

Table J.1.5-2 Required Capacity and Year for construction of Landfill: Sections for Other Waste but Slag and Ash

Landfill Section for Other Waste No.	Year for Construction	Required Capacity of Landfill Section (m^3)	Disposal Period (year)
W 1	1994	681,000	1995 - 1997
W 2	1997	670,000	1998 - 2000
W 3	2000	491,000	2001 - 2003
W 4	2003	484,000	2004 - 2006
W 5	2006	489,000	2007 - 2010
Total	-	2,815,000	1995 - 2010

Table J.1.5-3 Required Capacity and Year for Construction of Landfill Sections for Slag and Ash.

Landfill section for slag and ash No.	Year for Construction	Required Capacity of Landfill Section (m^3)	Disposal Period (year)
S 1	2000	90,000	2001 - 2005
S 2	2005	108,000	2006 - 2008
S 3	2008	90,000	2009 - 2010
Total	-	288,000	2001 - 2010

d. Forecasts for Leachate

Composition of Leachate from Organic Waste

The composition of leachate from the landfill sections for organic waste depends on the actual character of the waste, quantity of percolating water, climatic conditions, the operation, and age of the landfill. The composition of leachate varies considerably with time and from landfill to landfill.

Based on investigations of Danish and German landfills Table J.1.5-4 presents concentrations of various substances in leachate from landfills for organic waste.

The variations between various landfills have been taken into consideration by giving values for "weak" and "strong" leachate. Furthermore, a distinction is made between young and old leachate, young leachate deriving from new landfill sections (½ to 3 years of age) and old leachate from older landfill sections.

Table J.1.5-4 Leachate from Landfills for Organic Waste. (Values before and after the oblique refer to young and old leachate respectively)

Parameter	Unit	Weak*	Strong*
Dry matter	mg/l	5,000	25,000
COD	mg/l	5,000/1,000	30,000/5,000
BOD	mg/l	4,000/200	20,000/1,000
Ignition loss	mg/l	3,000/1,000	8,000/2,000
Cl	mg/l	1,000	3,000
SO_4	mg S/l	10/10	400/30
NH_4	mg N/l	200	1,200
Kj.-N	mg N/l	500	1,500
Fe	mg/l	200/20	1,000/100
Mn	mg/l	10	400
K	mg/l	100	1,500
Na	mg/l	500	2,000
Ca	mg/l	500/80	1,500/200
Mg	mg/l	100	1,000
Phenol	mg/l	0.5	5
Min.oil-fat	mg/l	2	20
Cd	µg/l	10	100
Ni	µg/l	50	2,000
Cu	µg/l	10	1,000
Cr	µg/l	20	1,000
Pb	µg/l	20	1,000
Conduct.	milli S/m	500/250	3,000/1,500
Co	µg/l	10	800
Bor.B	mg/l	0.5	5
As	µg/l	20	300
Zn	mg/l	0.1	10

For a landfill in operation a thin aerobic zone will be found in the upper part of the landfill, while lower layers are anaerobic. The anaerobic processes can be described in a very schematic way by the so-called acetogenic stage and methanogenic stage. In the first years anaerobic processes will take place under transformation of the organic content in the waste into short acids with a low pH. After this, the methanogenic phase follows where relatively sensitive groups of micro organisms transform the organic acids into methane and carbon dioxide in neutral to weak, alkaline environments.

From Table J.1.5-4 it can be seen that the COD and BOD concentrations are relative high in young leachate. In old leachate where the produced acids are transformed into methane and carbon dioxide, the COD and BOD concentrations are relative low.

When a landfill section has reached the stage with an effective formation of methane the landfill section might be utilized for purification of young leachate which is recirculated in the old landfill section. This will lead to a reduced capacity for treatment of leachate.

Composition of Leachate from Slag and Ash from Waste Incineration Plants

In Table J.1.5-5 "low" and "high" parameter values are shown. Also here the parameters should be used isolated, since they are not as a whole representative of a realistic leachate composition.

The leachate reflects the composition of slag/fly ash and thereby also the composition of incinerated waste. It is generally characterized by a relative high pH (9 to 10.5, decreasing with time), high concentrations inorganic salts (Cl^{--}, SO_4^{--}, Na^{+}, K^{+}), and moderate values of BOD and COD.

Table J.1.5-5 Leachate from slag/fly ash deriving from waste incineration plants

Parameter	Unit	Low Conc.	High Conc.
Conduct.	mS/m	1,500	4,000
COD	mg O_2/l	100	600
BOD	mg O_2/l	5	200
Alkalinity	meqv/l	1.5	6
SO_4^{--}	mg/l	1,000	4,500
S^{--}	mg/l	-	100
Cl^-	mg/l	3,000	20,000
Total-P	mg/l	0.1	0.8
PO_4^3-P	mg/l	0.02	0.5
Total-N	mg/l	8	50
NO_2+NO_3-N	mg/l	0.01	0.5
NH_3-N	mg/l	6	50
Na	mg/l	3,000	7,000
K	mg/l	1,300	6,000
Ca	mg/l	250	1,000
Mg	mg/l	0.05	40
Fe	mg/l	0.02	0.3
Mn	mg/l	-	0.05
As	mg/l	0.008	0.02
Cd	mg/l	0.00002	0.0002
Co	mg/l	-	-
Cr (total)	mg/l	-	0.08
Cu	mg/l	-	0.005
Hg	mg/l	-	0.0004
Ni	mg/l	-	0.005
Pb	mg/l	0.0005	0.01
Zn	mg/l	0.01	0.2
H	-	7 - 10.8	0.2

Quantity of Leachate

The quantity of leachate which is generated from the landfill depends primarily on the following :

- The precipitation and evaporation at the site of the landfill
- The size of the area which has been occupied by landfill sections with disposed waste
- The capability of the waste for absorbance of water

According to information from the Statistical Year Book of Poland (1991) the average annual precipitation in Poznan during the last decade is calculated at 480 m. The average evaporation is estimated at 350 mm/year.

Based on experience from landfills in Western Europe the generation of leachate from a landfill with bottom liner at Poznan is assessed as follows:

- Approx. 300 mm/year for landfill sections under filling with waste

- Approx. 150 mm/year for landfill sections which have been utilised for waste disposal and are furnished with final soil coverage

Assuming the landfill sections are filled up corresponding to the planned final terrain and furnished with final coverage before a new section is commenced the generation of leachate is kept at a minimum. The generation of leachate is estimated as presented in Table 3.4.2.

Table 3.4.7.-2 Estimated Generation of Leachate from the Landfill.

	Landfill Section Operated	Estimated Leachate Generation (cu.m./year)
1994	-	0
1995	W1	0.3 x 40,000 = 12,000
1996	W1	12,000
1997	W1	12,000
1998	W2	(0.3+0.15) 40,000 = 18,000
1999	W2	18,000
2000	W2	18,000
2001	W3+S1	0.3 (30,000+10,000) + 0.15 x 80,000 = 24,000
2002	W3+S1	24,000
2003	W3+S1	24,000
2004	W4+S1	0.3 (30,000+10,000) + 0.15 x 110,000 = 33,000
2005	W4+S2	0.3 (30,000+10,000) + 0.15 x 120,000 = 28,500
2006	W4+S2	28,500
2007	W5+S2	0.3 (30,000+10,000) + 0.15 x 150,000 = 34,500
2008	W5+S3	0.3 (30,000+10,000) + 0.15 x 160,000 = 36,000
2009	W5+S3	36,000
2010	W5+S3	36,000

e. Landfill Gas

The production of gas is depending on the quantity of organic material, the degree of compaction and the water content of the landfill. The production of gas in ordinary sanitary landfills passes four phases during the lifetime of a landfill.

The first phase is aerobic and of very short duration (days). The gas principally consists of nitrogen (N_2). The second phase is also aerobic and here the dominant gas component is carbon dioxide (CO_2). The last tow phases are anaerobic where the dominant methane (CH) production increases to a stable level after a short period of hydrogen production.

Landfill gas is 3 to 35 l/kg moist household waste per year and approximately 160 l/kg of organic matter is totally produced.

Landfill gas has a calorific value of 15 to 21 MJ/cu.m. The calorific value does not remain constant in the lifetime of a landfill and decreases is time.

A number of problems has been experienced:

- dying of vegetation
- fires
- explosions

To avoid the recurrence of these problems, many countries are now requiring monitoring and control of landfill gas. The British authorities, for one, have produced a second edition of a guideline for the control of landfill gas.

It is important to ensure that landfill gas is not spread to neighbouring buildings and areas. Suitable measures should be taken to deal with landfill gas on completed landfills.

The migration of landfill gas depends on local ground conditions. The problems with migration of gas have particularly been noticed when former quarries were used for landfilling. Problems with migration of gas are seldom observed near landfills on flat areas of land.

A number of methods can be applied to deal with landfill gas:

- Collection of landfill gas by suction pumps and gas drain pipes. The gas can be utilized for heating or production of electricity, ventilated or burned.

- Dispersion of landfill gas through a porous final capping.

- Collection of landfill gas in drain pipes and ventilating the gas through shafts.

- Collection of landfill gas in porous layers of sand and gravel. The gas is ventilated through compost filters where it is being bio-degraded by micro organisms.

f. Hydrogeological Investigations

As part of a Landfill project for the City of Poznan financed by the Danish Ministry of Environment and carried out by the Danish company, RH&H Consult, a hydrogeological investigation was carried out in 1992. A report on existing information (Plan of geological investigation of the site in the region Michalowo Franowo, October 1992) was carried out by the Polish company: Geokom.

As a result of the above mentioned investigations, two reports were elaborated: "Hydrogeological investigations of Site at Michalowo Franowo, January 1993" by Geokom, and "Hydrogeological investigations at Michalowo Franowo, February 1993", by RH&H Consult.

Summary of reports is presented below.

Geological conditions

Within 15 m from the upper surface are glacial deposits, primarily of sandy boulder clay layers, interbedded with sandlenses/-layers.

In some parts of the area, primarily in the northern and eastern part, two sandy layers have been found:
- one unsaturated layer around 1-3 m below the ground
- one saturated layer within 6-12 m below the ground

Only boulder clay was found about 60-70 m below these layers, where the tertiary deposits are distributed. The upper 30-50 m of tertiary deposits comprise primarily of silt subsequently followed by sand interbedded with organic deposits like charcoal.

Hydrogeological conditions

The regional primary groundwater reservoir, a confined sand reservoir with a groundwater table of about 20 m below the ground, is located in the tertiary deposits at, approx. 100–120 m below the ground.
Furthermore there are local secondary partly confined, partly unconfined reservoirs in the sand layers within the upper 15 m of glacial deposits. The water tables are situated at 3 m below the ground.

Locally, the secondary reservoirs are used as drinking water sources. Some of the houses located east of the site have private wells with a depth of about 5–10 m below the ground.

Water in the primary reservoir is expected to flow eastward while those in the secondary sand reservoirs flow northward then eastward. In the northern part of the Site, the flow direction is north – north–west due to a local drainage system.

Assessment on vulnerability of the ground water reservoirs:

The upper secondary reservoirs in the sandy glacial deposits are very vulnerable to surface pollution as there is no or only little delay in the infiltration due to a low content of clay in the upper near surface layers.

The primary reservoir is locally well protected because of the thick layer of boulder clay and tertiary silt above the formation.

However, regionally there may be a risk, that a heavy surface pollution would reach the upper sand reservoirs and flow to the east against the Michalowka river, where (within 500–1000 m from the site) the protection of the primary reservoir is much less effective.

3) Technical Description

a. Main Principles for Design and Operation of the Sanitary Landfill

The main task involved in sanitary landfill is to have waste disposal under full control, to avoid environmental pollution. The main hazards caused by a landfill are:

- Ground water pollution

- Surface water pollution
- Air pollution
- Diseases spread by insects, rodents, birds, etc.
- Noise

Fig.J.1.5-2 Illustrates the above mentioned hazards.

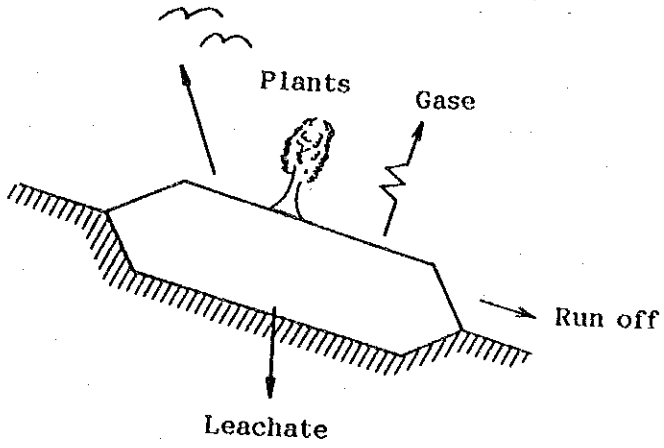


Fig.J.1.5-2 Hazards at a Landfill.

Preliminary lay-out and principles for the sanitary landfill located at Franowo-Michalowo is shown in the Drawings No. L1 to L6.

The above-mentioned hazards are overcome by the following measures:

- Bottom liner made of clay is constructed to prevent leachate from percolating into the ground. It is assumed that an appropriate formation of clay is available on or near the site. Otherwise, an artificial bottom liner (eg. polyethylene) might be used.

- Above the bottom liner a gravel layer comprising a system of stone drains is constructed for collection of leachate. The leachate is assumed to be pumped to a future municipal sewage treatment plant (refer to Drawings L3 and 4).

- Compaction of waste by heavy equipment to reduce the required volume of landfill and diseases being spread by rodents.

- Daily cover of waste with soil to prevent air pollution and spreading of diseases by insects, etc.

- Avoiding fires at the site to prevent air pollution.

- Planting of trees and construction of embankments around the landfill area to prevent visual nuisance.

- Boundary fencing to prevent scavenging.

- Control of incoming waste including construction of a weigh bridge.

- Construction of a leachate control and monitoring system based on a set of boreholes at the landfill area.

- Phased restoration of landfill areas including approximately 1 m soil cover, measures against gas and planting.

The quantity of leachate and contaminated run-off water produced is limited by the following precautions:

- Construction of landfill sections with a capacity corresponding to the required volume for about 2 to 3 years' disposal.

- Construction of ditches around the landfill area to prevent run-off water from the surrounding areas from infiltrating the waste.

- The daily covering of waste with soil will also reduce the quantity of rain water that infiltrates the waste.

The sanitary landfill will be operated by the following permanent staff:

- A foreman, to supervise the operation at the landfill.

- Inspectors, to undertake the registration at the weigh bridge and guide the trucks to the correct site for unloading of waste.

- Operators of heavy equipment, to be responsible for compacting and covering the waste with soil.

- Labourers, to maintain tidiness of the surroundings.

Working hours will be 6.00 to 15.00 hours.

b. Arrangements for the Sanitary Landfill

The proposed arrangements for the sanitary landfill (Phase 1) are shown in Drawing No. L3, and include the following main items:

- Access road to the sanitary landfill.
- Fencing and planting.
- Entrance area with weigh bridge and guard house.
- Administration building and workers' canteen and staff rooms.
- Garage with workshop.
- Heavy equipment for compaction of waste.
- Construction of bottom liner and drainage system for the disposal area, Section W 1.
- Construction of system for leachate including reservoir and pump station.
- Ditches and embankments around the landfill (Phase 1).
- System of boreholes for control of leaking leachate.

The Sanitary landfill (Phase 1) is proposed to be constructed in year 1994.

The disposal areas W 2 to W 5 will be constructed during the period 1997 to 2006 (refer to Drawing L4).

The disposal areas S 1 to S 3 for slags and ashes from the incineration of waste will be constructed during the period 2000 to 2007.

Leachate from the sanitary landfill is assumed to be pumped for treatment at the nearest municipal sewage treatment plant. During operation of the landfill section W1, leachate will be transported by truck.

As the generated quantity of leachate increases as more landfill sections are constructed, a pipe line for pumping of leachate to the nearest municipal sewage system should be built when the landfill area is expanded with the construction of the disposal area Section W2.

The nearest existing pipe line for sewage is located at Darzyborska St. This pipe line is 100 mm in diameter and connected to a bigger system at Piwna St. (refer to Drawing No. L4).

Alternative methods for treatment and removal of some of the leachate are as follows:

- Pumping and recirculation of leachate into old waste. This method is based on the idea that old wastes work as a biological filter. Thus, it is possible to transform "young" leachate into "old" leachate (refer to Table 8.1.5-7).

- Pumping and sprinkling of leachate on top of landfill areas to utilize the evaporation during the summer months.

- Pumping of excess leachate to the municipal system for rain water should be avoided, unless the landfill is equipped with its own sewerage treatment plant.

c. Bottom Liner and Drainage System

The bottom of the sanitary landfill is furnished with a liner appropriate for the prevention of leachate from infiltrating the ground. On top of the bottom liner is a system constructed for collection and drainage of leachate to a storage tank (see drawings No. L3 and L4). From the storage tank the leachate is pumped or transported by truck to a facility for treatment before discharge to the surrounding body of water.

The liner must be designed taking into account the physical, chemical, and biological effects which will or may take place during the construction phase as well as in the entire lifetime of the landfill. Materials to be used for the bottom liner, through experience or ageing tests, be proven that they are resistant to both young and old leachate.

In Western Europe, most bottom liners are constructed either with clay of low permeability or with a polymeric membrane.

The geotechnical investigations which have been carried out for the site, Franowo-Michalowo, indicate that appropriate clay might be found on the site. However, it is not possible to estimate the actual quantity of clay available on the site. Therefore, both liner constructions are described in the following. Reference is made to Drawing no. L5.

Clay liner

A distinction is made between in-situ and installed clay liners. In-situ clay liners are made by the adjustment and homogenization of the surface of native clay deposits. Installed clay liners are built from two or more layers of homogeneous clay that is transported to the site from a clay pit.

The clay material must be selected and installed in order that the liner has the required degree of tightness. It is recommended that the clay liner should have a thickness of at least 0.5 m and a coefficient of permeability (k) not exceeding 10^{-10} m/sec.

Thus, materials for clay liners must contain more than 14 % clay and a plasticity index (I_p) larger than 5%. The material must be homogenous without layers and lenses of sand and silt. The water content of the clay should, at the time of application, be superior to the optimum water content, determined by Standard Proctor tests. However, it must be possible to build the materials to at least 95% of the maximum dry density of this test.

The installation method and season for construction of a clay liner shall be planned and selected in order that the works will take place in a geotechnical appropriate way. Immediately after installation clay liners shall be protected against damage in form of drying out, erosion and freezing.

The collection and drainage system comprise a 0.3 m thick drainage layer with drains. The drainage layer must consist of a granular material appropriate for drainage ($k > 10^{-3}$ m/sec) and be free from clay and silt. The drains may be pebble drains which have proved appropriate for resisting the load from heigh fillings of the landfill. The distance between the drains should not exceed 20 m.

Polymeric Membrane Liner

The construction of the bottom liner may be as follows:

- 0.1 m fine sand to protect the polymeric membrane against perforation and tearing caused by stones in the subgrade.

- 1.0 mm thick membrane from polyethylene. The elongation at break must be at least 50%. The membrane should be delivered to the site in sections of up to 800 m^2. The sections should be constructed from at least 4 m wide membrane rolls that are welded together in the workshop.

- 0.3 m drainage layer with drains. The requirements to this layer and the draines are as for the clay liner. However, the drainage layer must not comprise stones and the pebble drains must be designed in a way that the membrane is protected against perforation.

4) Cost Estimates

Based on the described preliminary design of the sanitary landfill, this section presents cost estimates for the construction, operation and re-establishment of the sanitary landfill.

All estimates are elaborated assuming:

- Price level as described in ANNEX I.1.5.

- Leachate can be treated in a future municipal sewerage plant located near the sanitary landfill.

- Bottom liners can be constructed from a clay formation located on or near the site.

- Investments for pre-investigation (location, hydrogeological investigations, etc.) are not included.

a. Initial Investments

The following initial investments for facilities have to be performed when constructing the sanitary landfill, Phase 1. These facilities will be utilized throughout the life span of the sanitary landfill:

Table J.1.5-6 Initial Investments for Sanitary Landfill

Item	Price level in	
	Western Europe USD x 1000	Poland mill. ZL
– Access road and entrance area including 2,000 m^2 asphalt pavement		1,390
– Weigh bridge, computerized	100	120
– Guard house and weigh room (50 m^2)		290
– Administration building and staff rooms (200 m^2)		990
– Garage (250 m^2)		930
– Water, electricity and sewerage		520
– Installation for leachate . Storage tank . Pump installation . Conduct for leachate (1,000 m.) . Electrical installation		1,740
– Boreholes (50 m.) for control of ground water		580
– Fencing		810
– Planting		580
– Connection fee (electricity, water, sewerage)		580
– Training of employees	20	
– Design and supervision	100	1,510
– Miscellaneous (20 %)	30	2,060
TOTAL initial investments	250	12,100

b. Equipment

In compliance with the composition and quantity of waste (approximately 200,000 tons/year up to year 2000), the landfill is proposed to be equipped as stated below:

Table J.1.5-7 Proposed Equipment up to year 2000

Sanitary landfill, capacity 200,000 tons/year Equipment	Price level in Poland mill. ZL
- 2 compactors	3,480
- 1 traxcavator	1,390
- 1 dump truck	470
- 1 tractor with brush and watering equipment	230
- Others, tools and spare parts	230
TOTAL, equipment	5,800

c. Landfill Sections

The following cost estimate meets the costs for construction of a landfill section with a capacity of 700,000 m^3 corresponding to the required capacity for each of the landfill sections W 1 and W 2.

Table J.1.5-8 Cost Estimate for Landfill Section, capacity 700,000 m^3

Capacity:		Price level in	
- Volume:	700,000 m^3		
- Area:	40,000 m^2	Western Europe USD x 1,000	Poland mill. Zl
- Waste quantity:	approx 200,000 t/year		
- Clearing and earthworks for bottom and embankment			2,670
- Bottom liner (0.5 m clay 40,000 m^2)			8,930
- Drainage layer (0.3 m gravel, 40,000 m^2)			3,480
- Leachate drains			1,740
- Temporary roads			230
- Design and supervision,		50	2,320
- Miscellaneous, 20 %			3,830
TOTAL, landfill section 700,000 m^3		50	23,200

Cost estimates for landfill sections with capacity of 500,000 m^3 (W3, W4 and W5) and 100,000 m^3 (S1, S2 and S3) are elaborated as follows:

Table J.1.5-9 Cost Estimates for Landfill Sections: Capacity 500,000 m^3 and 100,000 m^3

Capacity: Volume: / Area:	500,000 m^3 / 30,000 m^2		100,000 m^3 / 10,000 m^2	
	Price level in			
	Western Europe USD x 1,000	Poland mill. Zl	Western Europe USD x 1,000	Poland mill. Zl
TOTAL landfill section	50	21,000	50	5,800

d. Operation Costs

The following cost estimates meet the average annual costs for operation and maintenance of the landfill during the period 1995 to 2010 (approximately 200,000 tons/year). These costs, especially the costs for maintenance of equipment, may considerably vary annually.

Table J.1.5-10 Operation Costs for Landfill, Capacity 200,000 tons/year.

Operation Costs	Mill. Zl/year
- Salaries . 5 operators of equipment . 1 mechanician . 1 operator of weighbridge . 1 foreman . 10 workers	1,740
- Administration	120
- Diesel and lubricants	810
- Maintenance of equipment	700
- Maintenance of buildings	120
- Current earth works: . Excavation of soil for daily coverage . Measures against bio gas . Internal roads	1,160
- Operation and maintenance of system for leachate	230
- Insurance, electricity and water	60
- Control and monitoring	60
- Miscellaneous (20%)	1,000
TOTAL, operation costs	6,000

Note: Fees for treatment of leachate at the future municipal sewerage treatment plant is not included.

Based on the annual waste quantity disposed of at the landfill, the operation costs during the planning period are estimated as follows:

Table J.1.5-11 Operation Costs for Sanitary Landfill at Franowo-Michalowo.

Year	Waste Generation (tons/year)	Annual m^3/year x 1000 in Section		Operation Costs mill Zl/year
		Slag and ash	Other waste	
1994	191,900	0	0	0
1995	189,900	0	229 - W1	5,706 *1
1996	188,000	0	227 - W1	
1997	186,200	0	225 - W1	5,600
1998	184,000	0	224 - W2	5,570
1999	182,600	0	223 - W2	5,550
2000	180,800	0	223 - W2	5,550
2001	186,100	18 - S1	157 - W3	4,350 *3
2002	191,700	18 - S1	164 - W3	4,530
2003	197,400	18 - S1	171 - W3	4,700
2004	203,300	18 - S1	178 - W4	4,880
2005	209,300	18 - S1	185 - W4	5,050
2006	215,500	36 - S2	120 - W4	3,880
2007	221,900	36 - S2	128 - W5	4,080
2008	228,600	36 - S2	136 - W5	4,280
2009	235,400	36 - S3	145 - W5	4,500
2010	242,400	54 - S3	81 - W5	3,360

Operation cost were estimated in proportion to waste amount based on the standard operation cost given by Table J.1.5-10, for example;

*1 6,000 x (189,900/200,000) = 5,697 → 5,700 mill. Zl
*2 5,697 x (227/229) = 5,647 → 5,650 mill. Zl
*3 5,697 x ((18 + 157)/229) = 4,354 → 4,350 mill. Zl

e. Re-establishment of the Site

When the capacity of a landfill section is utilized the landfill section must be covered with soil and the final measures against bio gas must be established.

The cost estimate for re-establishment of landfill section (each 4 ha) is as follows:

Table J.1.5-12 Cost Estimate for re-establishment of Landfill Section, 4 ha.

Re-establishment, landfill section 4 ha (volume 700,000 m3)	Mill. ZL
- Final coverage (0.2 m gravel and 1.0 m soil) including measures against gas	3,500
- Planting of grass and bushes	600
- Miscellaneous	600
TOTAL	4,700

Estimates for re-establishment of other landfill sections are elaborated as follows:

Table J.1.5-13 Cost Estimate for re-establishment of Landfill Sections, 3 ha and 1 ha

Landfill section Volume: / Area:	500,000 m^3 / 30,000 m^2	100,000 m^3 / 10,000 m^2
	Mill. Zl	Mill. Zl
TOTAL, re-establishment	3,500	1,200

f. Operation After Completion

Operation costs for the following items will continue after completion of the landfill. The cost estimate is as follows:

Table J.1.5-14 Operation Costs after completion of the Landfill.

Operation after completion	Mill. Zl
- Operation and maintenance of system for leachate	230
- Control and monitoring	60
- Miscellaneous	60
TOTAL, operation after completion	350

5) Payment Schedule

Based on the cost estimates for the described sanitary landfill, the following Table presents payment schedule for construction costs, operation costs and costs for re-establishment of the sanitary landfill.

The payment schedule is based on the following preconditions:

- An incineration plant with a capacity of 10 tons/hour will operate in the year 2001.

- The capacity of the incineration plant will be doubled in the year 2006 and tripled in the year 2010.

- Eight recycling centres will operate in Poznan during the period 1996 to 1998.

Table J.1.5-15 Investments for Sanitary Landfill at Franowo-Michalowo

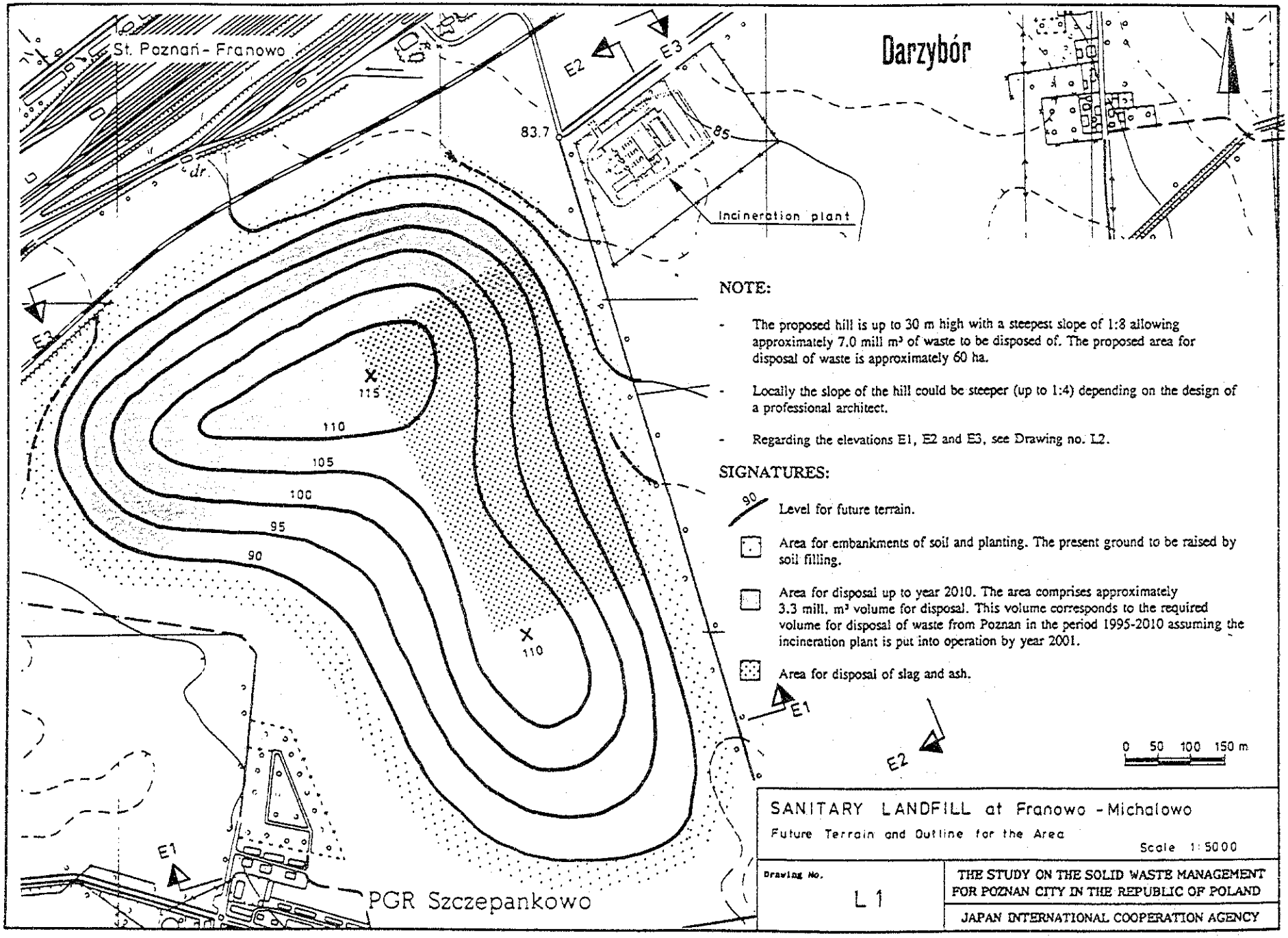
Year	Initial invest-ment	Equip-ment (mill. Zl)	Landfill	Operation costs (mill. Zl)	Re-estab-lishment (mill. Zl)	Costs after comple-tion	Utilized capacity (mill. m³)
1994	S	5,000	W1				
1995				5,700			0.2
1996				5,650			0.5
1997			W2	5,600			0.7
1998				5,570	4,700		0.9
1999				5,550			1.1
2000			W3 + S1	5,550			1.4
2001		3,130 *1		4,350	4,700		1.5
2002				4,530			1.7
2003			W4	4,700			1.9
2004				4,880	3,500		2.1
2005			S2	5,050			2.3
2006			W5	3,880	1,200		2.5
2007				4,080	3,500		2.6
2008		3,130 *2	S3	4,280			2.8
2009				4,500	1,200		2.9
2010				3,360			3.1
2011					4,700	C	
2012						C	
2013						C	
2014						C	
2015						C	
2016						C	
2017						C	
2018						C	
2019						C	
2020						C	

S = 250,000 USD + 12,100 mill. Zl.
W1 = W2 = 50,000 USD + 23,200 mill. Zl (capacity: 700,000 m³)
W3 = W4 = W5 = 50,000 USD + 21,000 mill. Zl (capacity: 500,000 m³)
S1 = S2 = S3 = 50,000 USD + 5,800 mill. Zl (capacity: 100,000 m³)
C = 350 mill. Zl. These annual costs will proceed beyond year 2020.

*1

- 1 compactors - 1,740 Mill Zl
- 1 excavator - 1,390 Mill Zl

3.130 Mill Zl



NOTE:

- The proposed hill is up to 30 m high with a steepest slope of 1:8 allowing approximately 7.0 mill m³ of waste to be disposed of. The proposed area for disposal of waste is approximately 60 ha.
- Locally the slope of the hill could be steeper (up to 1:4) depending on the design of a professional architect.
- Regarding the elevations E1, E2 and E3, see Drawing no. L2.

SIGNATURES:

90 Level for future terrain.

Area for embankments of soil and planting. The present ground to be raised by soil filling.

Area for disposal up to year 2010. The area comprises approximately 3.3 mill. m³ volume for disposal. This volume corresponds to the required volume for disposal of waste from Poznan in the period 1995-2010 assuming the incineration plant is put into operation by year 2001.

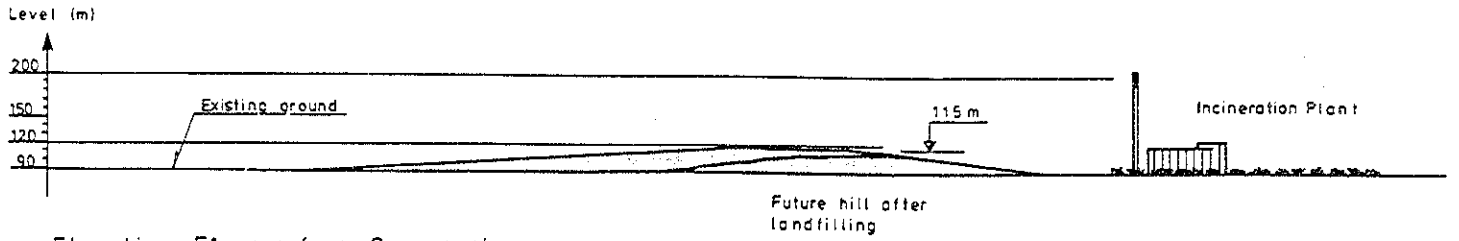
Area for disposal of slag and ash.

SANITARY LANDFILL at Franowo - Michalowo

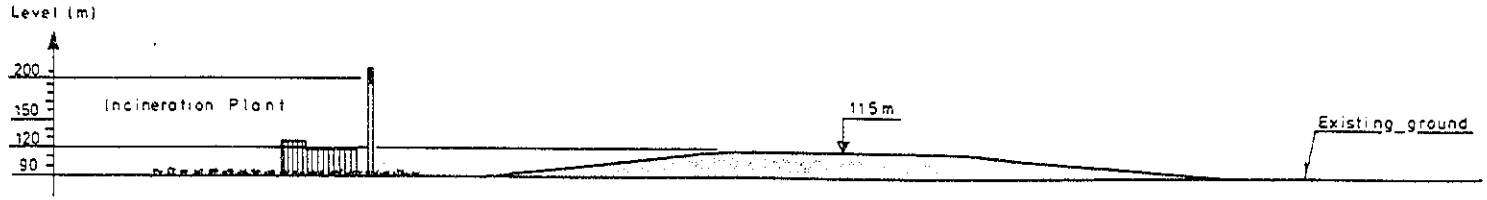
Future Terrain and Outline for the Area

Scale 1:5000

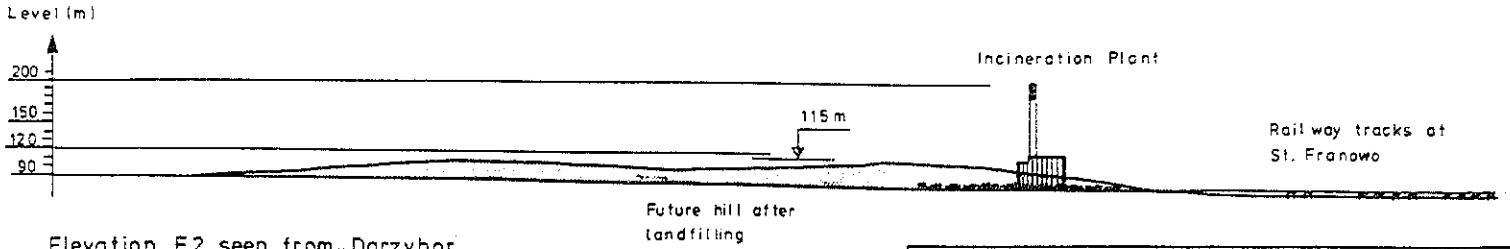
Drawing No.	THE STUDY ON THE SOLID WASTE MANAGEMENT FOR POZNAN CITY IN THE REPUBLIC OF POLAND
L 1	JAPAN INTERNATIONAL COOPERATION AGENCY



Elevation E1, seen from Szczepankowo



Elevation E3, seen from St.Franowo



Elevation E2 seen from Darzybor

NOTE:

Regarding direction for elevation, see Drawing no. L1

0 50 100 150 m

SANITARY LANDFILL at Franowo - Michalowo

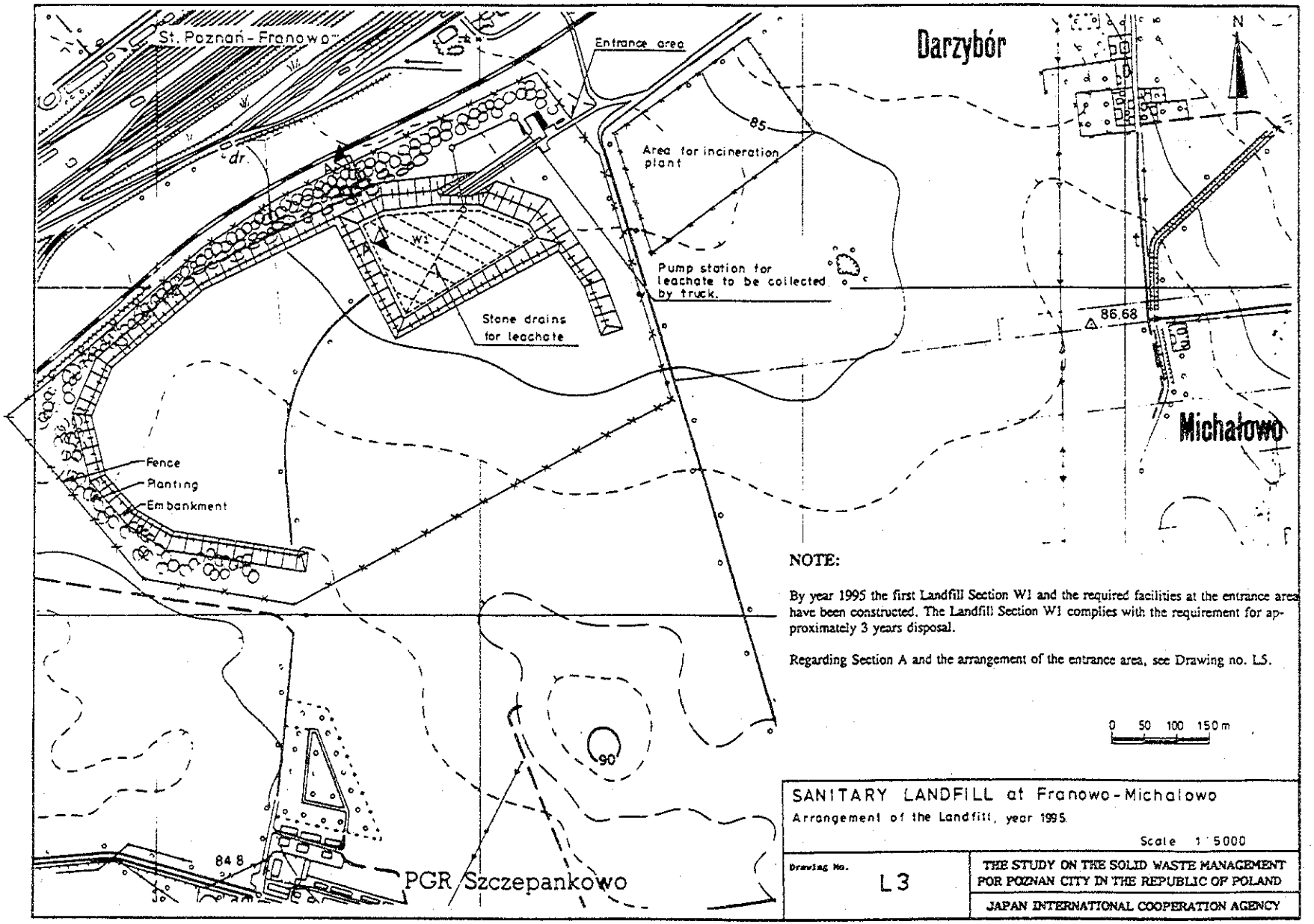
Elevations

scale 1:5000

Drawing No. L2

THE STUDY ON THE SOLID WASTE MANAGEMENT FOR POZNAN CITY IN THE REPUBLIC OF POLAND

JAPAN INTERNATIONAL COOPERATION AGENCY



NOTE:

By year 1995 the first Landfill Section W1 and the required facilities at the entrance area have been constructed. The Landfill Section W1 complies with the requirement for approximately 3 years disposal.

Regarding Section A and the arrangement of the entrance area, see Drawing no. L5.

SANITARY LANDFILL at Franowo - Michałowo

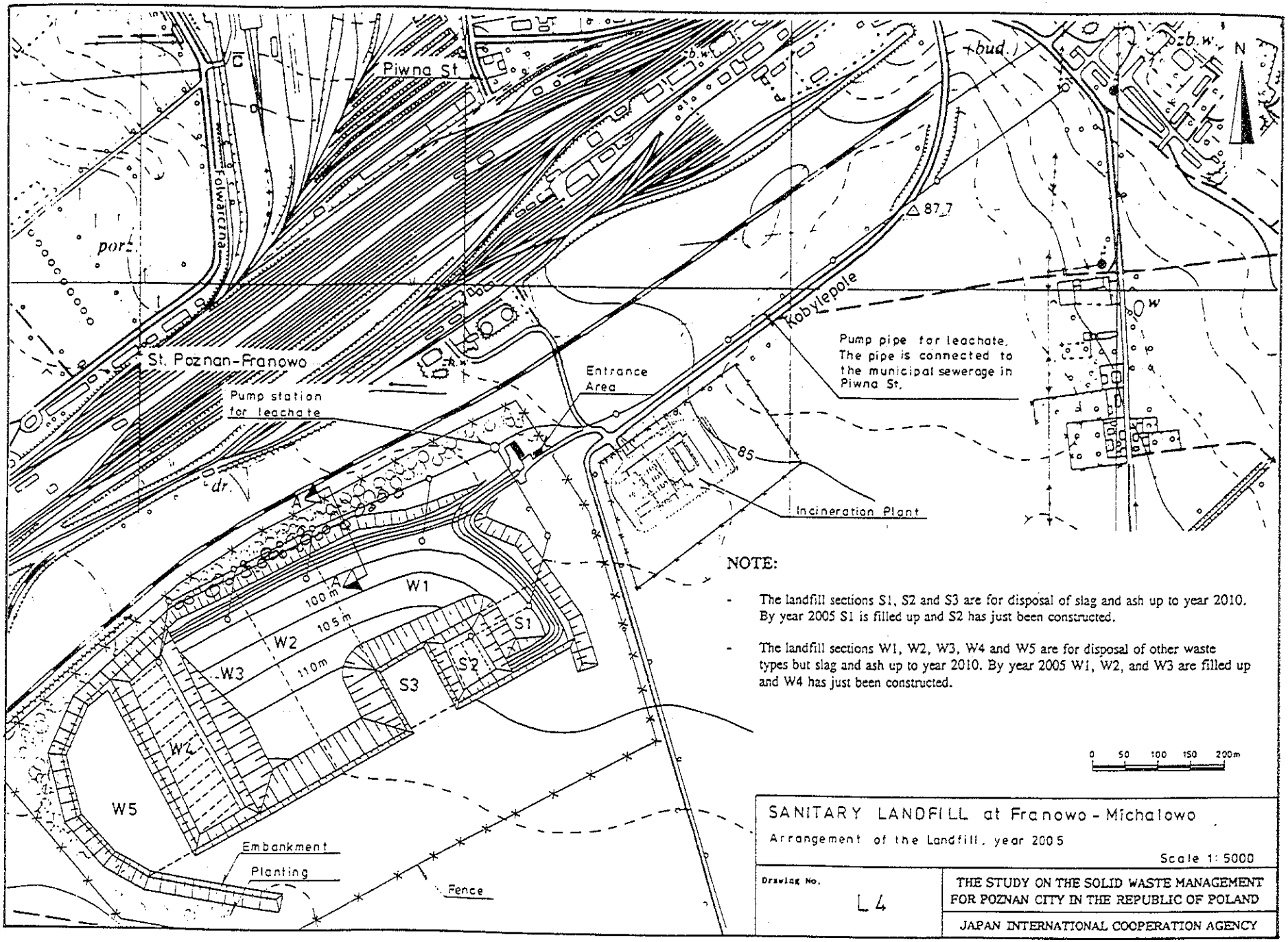
Arrangement of the Landfill, year 1995

Scale 1 : 5000

Drawing No. L3

THE STUDY ON THE SOLID WASTE MANAGEMENT FOR POZNAN CITY IN THE REPUBLIC OF POLAND

JAPAN INTERNATIONAL COOPERATION AGENCY



NOTE:

- The landfill sections S1, S2 and S3 are for disposal of slag and ash up to year 2010. By year 2005 S1 is filled up and S2 has just been constructed.
- The landfill sections W1, W2, W3, W4 and W5 are for disposal of other waste types but slag and ash up to year 2010. By year 2005 W1, W2, and W3 are filled up and W4 has just been constructed.

SANITARY LANDFILL at Franowo - Michalowo

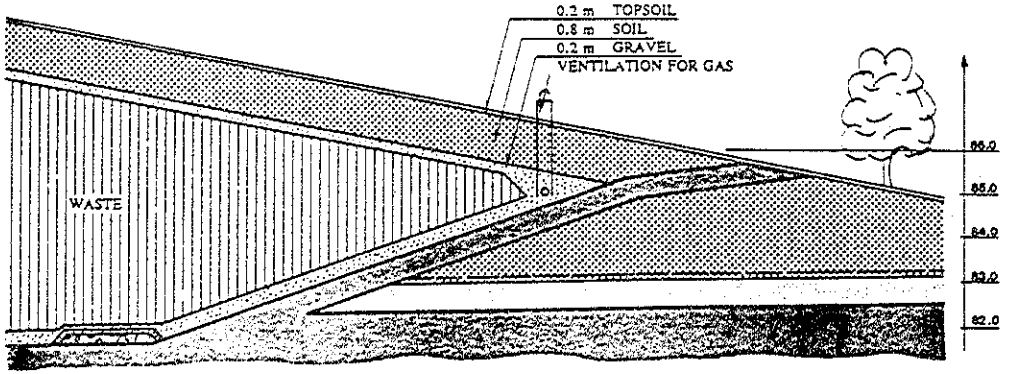
Arrangement of the Landfill, year 2005

Scale 1: 5000

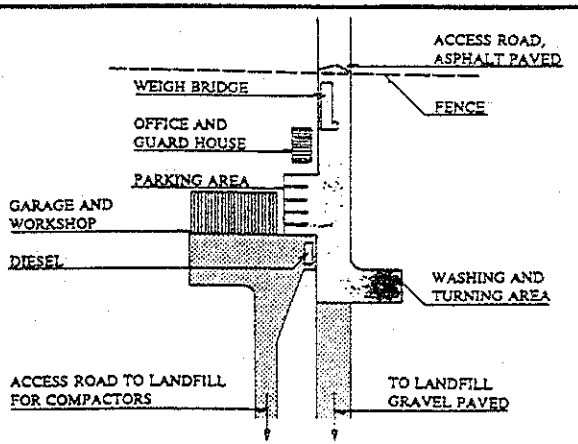
Drawing No. L4

THE STUDY ON THE SOLID WASTE MANAGEMENT FOR POZNAN CITY IN THE REPUBLIC OF POLAND

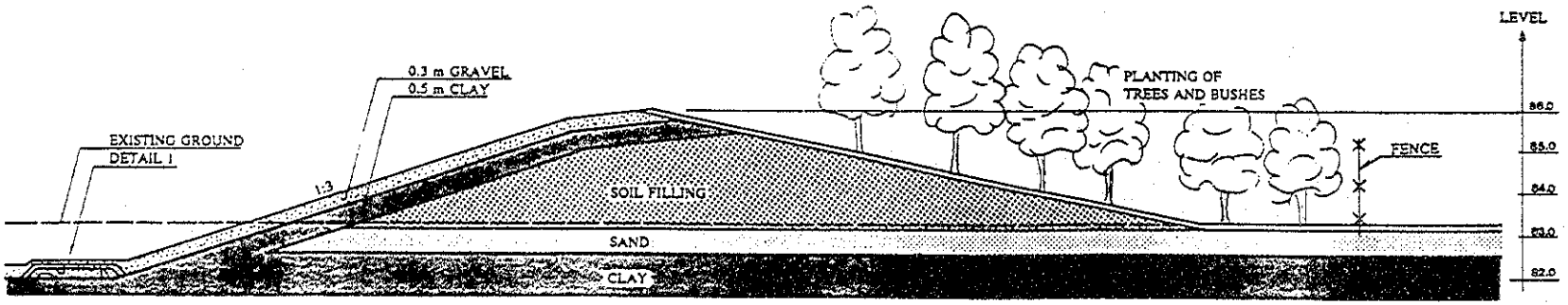
JAPAN INTERNATIONAL COOPERATION AGENCY



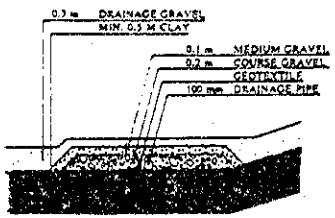
SECTION A, Scale 1:100
(after waste filling and final soil coverage)



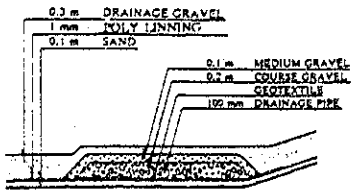
ENTRANCE AREA, Scale 1:100



SECTION A, Scale 1:100
(before waste filling)



DETAIL 1, Scale 1:50
(in case of clay liner)



DETAIL 1, Scale 1:50
(in case of polymermembran)

SANITARY LANDFILL

Sections and Details of Principle

Drawing No. L 5

THE STUDY ON THE SOLID WASTE MANAGEMENT FOR POZNAN CITY IN THE REPUBLIC OF POLAND

JAPAN INTERNATIONAL COOPERATION AGENCY

J.1.6 Recycling

1) Introduction

"Recycling" is the reutilization of non-valuable materials as resources or refers to the collection and reproduction of these for effective reuse. Recycling reduces the waste generation amount and decreases consumption of natural resources. Therefore, with increase in waste generation, recycling is expected to play a very important role in municipal solid waste management in the future.

At present there are some recycling systems in Poznan. Most recycling activities are being carried out by SURMET, a private recycling company that collects reusable materials and sells them to producer for reproduction. This recycling business is observed to be stagnant and is not supported by the people. The recycling business is not stable, as it is easily influenced by the fluctuating market prices of salvaged recyclable materials. One of the unfortunate results was the liquidation of the other recycling company S & W in 1991.

Conclusively, proper strategies must be formulated and implemented to stabilize and develop the recycling business.

2) Strategy

There are many sorts of recycling activities. There are profitable recycling activities and non-profitable activities, but the most activities are categorized as non-profitable.

Profitable recycling activities should be executed by private companies with support from the local administration and the public for stability.

Non-profitable recycling activities should be initiated by the administration, and public cooperation must be utilized as much as possible.

3) Planned Recycling Activities

a. Heat recovery by incinerating wastes

i. Introduction

The calorific value of municipal waste in Poznan has been confirmed to be sufficiently high for incineration after separate collection process by the field survey. In 2010, combustible wastes will occupy 71 % of the total municipal wastes and are planned to be incinerated for heat recovery. This method will help realize a large scale recycling activity.

ii. Method

The method for heat recovery is described in the section of incineration plant.

b. Administrative support in private recycling business

i. Introduction

Private recycling business highly depends on the market price of a reusable material. Market prices usually fluctuate in very wide ranges, making the recycling business unstable.

Private recycling business activities are very important because they contribute to the reduction of the generated amount of waste and consumption of raw material. Therefore, the expansion of the private recycling business should be promoted.

Since fluctuating demands for and selling prices of reusable materials greatly obstruct the development of private recycling businesses, the municipality should control and stabilize market conditions.

ii. Method

- The municipality will bring about a demand for recycled paper by imposing the use of recycled paper in all government institutions.

- The municipality provides private recycling companies with public spaces for installation of containers, collection stations for reusable materials, etc., free of charge.

- The municipality provides them with opportunities to advertise free of charge.

c. Promotion of public cooperation initiated by the administration

i. Introduction

Most recycling activities are unprofitable mainly due to high cost of collection work. Public cooperation is, therefore, most effective to minimize collection cost.

According to the public opinion survey result, more than 90 % of the interviewees indicated willingness to cooperate in recycling activities. Their willingness to cooperate should be utilized for the collection of recyclable materials. Although this is not organized in Poznan, this is widely practised in many developed countries at present.

In order to promote public cooperation in the collection of recyclable materials, the municipality should establish incentives to stimulate and motivate the public. The cost for such activities might be cheaper than the treatment cost of wastes.

ii. Method

- To organize events for SWM promotion and education.
- To invite citizens and students to SWM facilities.

d. Introduction of on-site composting of household waste

i. Introduction

Composting is technically the simplest method for utilization of waste. In order to maintain the acceptable quality of compost, it is essential to supply only qualified organic wastes after segregation. Segregation is too difficult to be satisfactorily executed in a largely populated town. However the on-site composting method is easy to apply for wastes of detached and semi-detached houses. The initial investment is little. A good compost quality can be produced depending on the householders' efforts, because the producer of waste will be the compost user at the same time. The introduction of on-site composting method to the detached and semi-detached houses is also effective for the reduction of waste generation amount.

ii. Method

An on-site composting container will be installed in the yard. The householder discharges kitchen wastes into the on-site composting container and leaves it until it decomposes. Composts are utilized as soil conditioners in the householder's yard.

On-site composting requires:

- the sorting of organic wastes in the kitchen
- the provision of a standard model closed compost container for each household, or several for each block of flats.

For use in Poland where the climate in winter is very cold, the container should be simply insulated or placed in a shed or shelter so as to avoid freezing.

The microbiological process is accelerated by adding water to the container so as to keep a dry matter content in the range of 300 to 500 kg per ton of waste.

The contents have to be aerated by mixing them occasionally, a handling technique that also accelerates composting with substantial microbial heat production.

The generation of offensive odour is also avoided by mixing the contents.

iii. Suggestions

For on-site composting, it is recommended that only vegetable wastes should be used.

The following materials are normally acceptable:

- vegetable wastes from the kitchen
- flowers, including roots and soil
- coffee grounds and tea leaves including possible paper filters
- fruit waste
- bread waste
- egg shells
- paper used for drying etc. in kitchen
- wastes from small domestic animals

The microbial process is accelerated by adding small amount of wooden chips, small branches from hedge trimming etc.

Other similar materials may be used, but meat wastes as well as fish wastes, sauces and similar wastes should be avoided.

Adding meat wastes enhances the possibility of odour production, and attracts rats.

If meat wastes are to be added, compost containers should be placed in a steel net as to keep out rats, and the composting matter has to be mixed more frequently.

J.1.7 Road Sweeping and Public Area Cleansing

The present road sweeping and the public area cleansing services performed in Poznan City are sufficiently functioning, from the satisfactory results observed. Therefore, special improvements are not required immediately, although the following suggestions were made:

1) Road Sweeping

A road sweeping system in Poznan City has been established and a sufficient number of equipment have been ready for the works. There are twelve units of road sweeping equipment in Poznan City, however, only four are being employed in 1992 due to financial difficulties.

Consequently, the existing problems concerning the road sweeping work in Poznan City are not technological in nature but mainly financial.

Most of the work is executed by the authority for provincial roads. In order to cope with the financial problem this authority introduced tendering to select a contractor in 1992, which resulted in the consignment of the works to four contractors. Prior to the tendering, SANITECH monopolized the works. The tender system should be continued to curtail cost, although it might deteriorate work quality. The authority for roads should be completely capable of supervising the works to motivate the contractor to fulfil the specified work quality and to avoid corruption.

The targets of road sweeping work are, thereby, set as follows:

- The performance level of the year 1991 should be maintained until the year 2010, as the 1992 level is proven to be insufficient.

- Introduction of more tendering cases.

- Improvement of supervision capability.

2) Public Area Cleansing

A public area cleansing system has been also established and functioning nicely in Poznan City as evidenced from the well kept public spaces.

The authority on green areas is in charge of this work in Poznan. Most works are directly carried out by this authority although it is expected to introduce more tendering in future. The introduction of tendering is unavoidable and desirable to minimize cost, although it might deteriorate work quality. The authority on green areas should be completely capable of supervising the works to motivate the contractor to fulfil the specified work quality and to avoid corruption.

The targets of public area cleansing are, thereby, set as follows:

- The performance level of the year 1991 is maintained until the year 2010.

- gauged tendering.

- gauged supervision capability.

J.1.8 Environmental Examination

1) Objective of the Environmental Survey (Phase II)

The objective of the environmental survey is to forecast and evaluate the environmental impacts caused by the construction and operation of the proposed incineration plant and sanitary landfill on the area adjacent to the proposed site.

2) Method of the Environmental Survey

Preparatory work

At first, in order to identify the significant environmental impacts caused by the construction and operation of the proposed incineration plant and sanitary landfill, the environmental factor-impact element matrix was prepared taking into consideration the existing EC (European Communities) environmental guidelines.

After that, the environmental factors, which may have a significant impact on the environment and need to be forecasted, were screened with the environmental survey results of this project and the information available. (refer to Table J.1.8-1)

Field survey

The field survey includes the following items;

Field survey by the compilation of existing data

The counterparts of the JICA Study Team, Institute of Meteorological and Water Management Branch in Poznan and Provincial Sanitary - Epidemical Office in Poznan City have collected the following data and information adjacent to the proposed site;

- Meteorological conditions
- Background pollution concentration level

The above information was complied by the study team.

Table J.1.8-1 Possible Pollution Factors related to the proposed site

Environmental factors / Environmental impact element		Living Environment							Natural environmet			Socio-economic environment		
		Air pollution	Offensive odour	Water pollution: Surface	Water pollution: Ground	Soil pollution	Noise pollution	Vibration	Climatic factors	Fauna	Flora	Population	Landscape	Materia assets
Incineration Plant	Stack	●												
	Plant		●	●	○		●							
Landfill	Operation		●	●	●	○							○	
Collection vehicle	Operation	○					●							
Recycling centre	Operation		○				○						○	

Legend

● : Possibility of significant impact on environment, detailed forcast needed

○ : Minor impact on environment

Field Survey by taking samples and analyzing the data

The Inspectorate of Environmental Protection in Poznan Provincial Government (voivodeship), Adam Mickiewicz University in Poznan city and the National Institute of Hygiene in Warsaw took each sample and analyzed the data relating to the following environmental factors under the supervision of the Study Team;

- Water quality (including the ground water)
- Noise nuisance
- Traffic volume
- Land use

3) Results of the Field Survey

Air pollution

Meteorological conditions

Characteristics of the meteorological conditions (wind and stability of atmosphere) adjacent to the proposed site in 1990 are shown in Table J.1.8-2.

Table J.1.8-2 Meteorological conditions adjacent to the proposed site

unit : %

YEAR 1990 Wind speed (m/s)	Stability of atmosphere						
	A	B	C	D	E	F	Total
< 1.0	-	-	-	-	-	-	-
1.0 - 2.9	19.08	3.70	10.04	4.59	4.28	1.78	43.47
3.0 - 4.9	3.94	6.27	8.94	5.89	3.97	0.07	29.09
5.0 - 6.9	0.00	1.37	10.72	4.66	0.65	0.00	17.40
7.0 <=	0.00	0.00	9.15	0.89	0.00	0.00	10.04
Total	23.02	11.34	38.85	16.03	8.91	1.85	100.00

Note: The grade of stability of atmosphere is as below;

A B C D E F

unstable ← → stable

(source: Data of Institute of Meteorological and Water Management Branch in Poznan)

Background on air pollution concentration level

According to the data from the Provincial Sanitary - Epidemical Office in Poznan City, in 1991 the concentrations near the proposed site was recorded high, almost reaching the maximum permitted value of the environmental standards.

The data is shown below;

- SO_2 0.041 mg/m^3
- NO_x 0.053 mg/m^3
- Dust 0.038 mg/m^3

note: the values indicate annual average level.

(source: Data of Provincial Sanitary - Epidemical Office in Poznan City)

Water Quality

The water quality survey on the area surrounding the proposed site was conducted as follows ;

Sampling

Water sampling was carried out at the following points (refer to Fig. J.1.8-1);

- W1 (east of the proposed site).
- W2 (along the existing centre road)
  Water-level at 4.4 m below the ground surface
- W3 (west of the proposed site)
  Water-level at 4.0 m below the ground surface

Test items

12 items listed below were tested at the laboratory;

pH, COD, BOD, Total nitrogen (T-N), sulphates (SO_4^{2-}), chloride Ion (Cl^-), lead (Pb), arsenic (As), cadmium (Cd), hexavalent chromium (Cr^{6+}), mercury (Hg), PCB.

Analytical methods

All determinations were made in accordance with standards obligatory in Poland or with methods allowed by the Ministry of Environmental Protection, Nature Resources and Forestry.

The result of the analysis

The result of the analysis is tabulated in Table J.1.8-3.

The result of analysis presents that BOD, SO_4^{2-} and Cd at W3 and Pb at W2 exceed the Polish Standard.

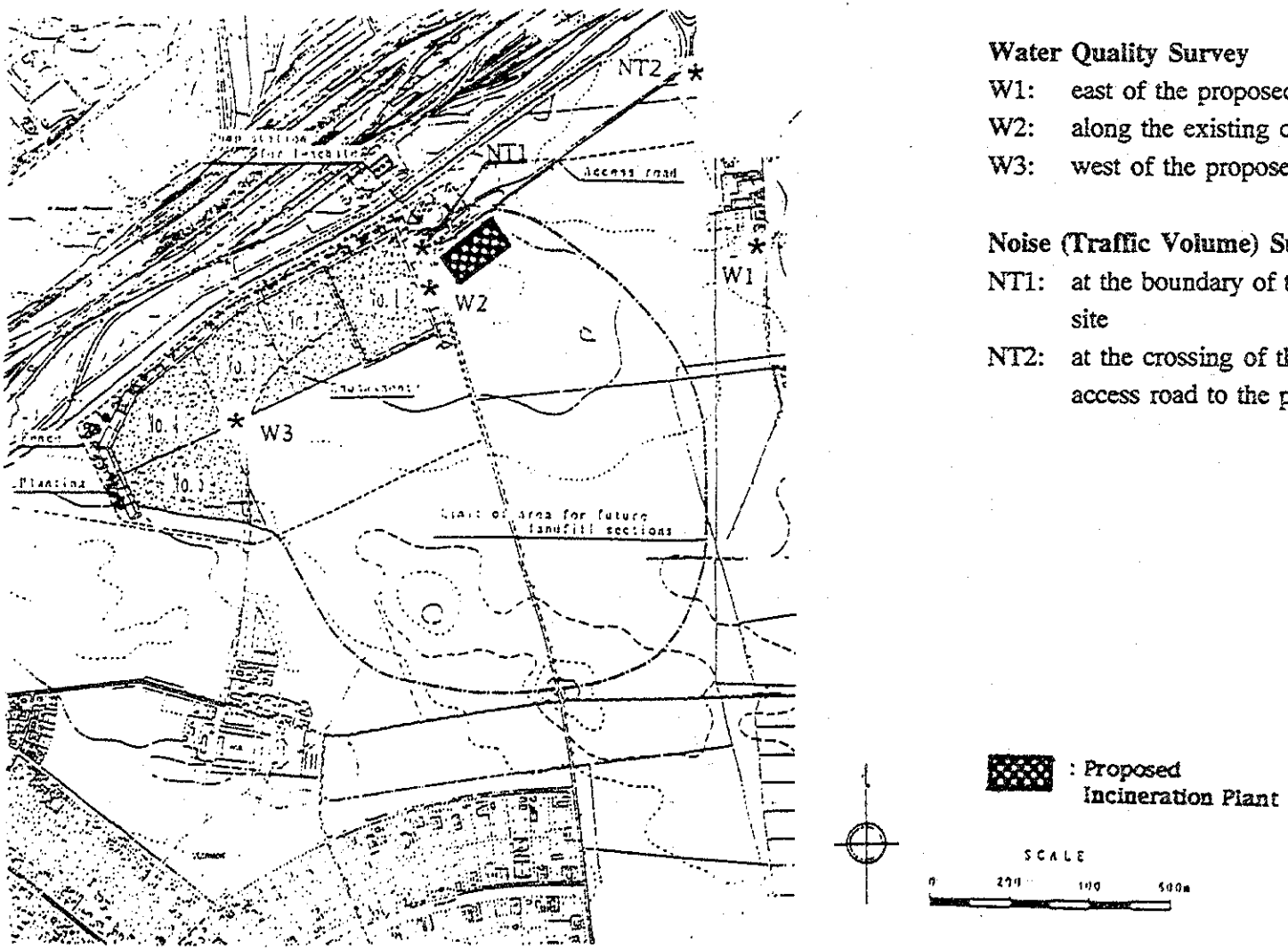
Table J.1.8-3 Water Quality Survey Results

Date: 7th Dec., 1992

General Conditions: Weather – Cloudy Temparature –5°C		Result of each sampling point		
Item	Unit	W1	W2	W3
pH		6.8	6.8	6.9
COD (by dichromate method)	mg O_2/l	11.0	35.0	20.0
BOD_5	mg O_2/l	0.8	2.6	6.0
Total Nitrogen (T–N)	mg N/l	1.35	1.55	8.60
SO_4^{2-}	mg SO_4/l	250.0	278.0	427.0
Chloride Ion (Cl^-)	mg Cl/l	96.5	93.5	145.5
Lead (Pb)	mg Pb/l	0.0340	0.1366	0.0550
Arsenic (As)	mg As/l	0.0000	0.0000	0.0000
Cadmium (Cd)	mg Cd/l	0.0006	0.0026	0.0050
Hexavalent Chromium (Cr^{6+})	mg Cr/l	0.0000	0.0000	0.0000
Mercury (Hg)	mg Hg/l	0.0000	0.0000	0.0000
PCB	mg/l	0.0003	0.0004	0.0003
Water Temparature	°C	4.0	10.0	10.0

Date: 8th Dec., 1992

General Condition : Weather – Cloudy Temparature 4°C		Result of each sampling point		
Item	Unit	W1	W2	W3
pH		7.1	6.9	6.7
COD (by dichromate method)	mg O_2/l	9.0	29.0	23.0
BOD_5	mg O_2/l	1.0	3.6	2.4
Total Nitrogen (T–N)	mg N/l	1.40	1.60	2.35
SO_4^{2-}	mg SO_4/l	245.0	262.0	423.0
Chloride Ion (Cl^-)	mg Cl/l	89.5	101.5	124.5
Lead (Pb)	mg Pb/l	0.0234	0.1209	0.0410
Arsenic (As)	mg As/l	0.0000	0.0000	0.0000
Cadmium (Cd)	mg Cd/l	0.0003	0.0041	0.0061
Hexavalent Chromium (Cr^{6+})	mg Cr/l	0.0000	0.0000	0.0000
Mercury (Hg)	mg Hg/l	0.0007	0.0003	0.0007
PCB	mg/l	0.0003	0.0005	0.0003
Water Temparature	°C	7.0	10.0	10.0



Water Quality Survey

W1: east of the proposed site

W2: along the existing centre road

W3: west of the proposed site

Noise (Traffic Volume) Survey

NT1: at the boundary of the proposed site

NT2: at the crossing of the street and access road to the proposed site

Fig.J.1.8–1 Sampling Points for Water Quality and Noise (including Traffic Volume) Survey

Noise and Traffic Volume

In order to have an insight on the noise nuisance in the surrounding areas of the proposed site, noise and traffic volume surveys were carried out as follows.

Survey points

The survey of noise and traffic volume was conducted at the same survey points. The points are shown in Fig. J.1.8-1.

- NT1 (located at the northern boundary of the proposed site)
- NT2 (located at the crossing of Kobylepole street, Darzybor street and access road to the proposed site)

Survey items

- Traffic noise (Survey points - NT1,NT2)
- The number and direction of vehicles categorized is;
  - i) large vehicle
  - ii) small vehicle

Survey time

12 hours from 7:00 to 19:00 on a weekday (10 th of December 1992).

Noise level measurement method

Noise level measurement methods are based on the following standards and regulations

- Noise Measurement methods (PN - 81/N - 01306)
- Sound level meters. General requirements and tests (PN - 79/T - 06460)
- The Cabinet Decree of 30 th September, 1980 on environmental protection from noise and vibrations.

The results of the noise and traffic volume survey

The results of the noise and traffic volume are tabulated in Table J.1.8-4 and J.1.8-5.

Table J.1.8-4 Noise Survey Result unit: dB(A)

Survey point	NT1		NT2	
Measurement Hour	Traffic Volume		Traffic Volume	
	Leq	L_{50}	Leq	L_{50}
7:00 - 8:00	59.6	50.6	67.4	59.5
8:00 - 9:00	55.8	46.8	67.8	58.8
9:00 - 10:00	58.9	49.9	68.0	59.0
10:00 - 11:00	57.1	48.1	68.4	59.4
11:00 - 12:00	56.8	47.8	67.8	59.5
12:00 - 13:00	54.7	45.7	67.3	58.0
13:00 - 14:00	55.5	46.5	65.3	57.5
14:00 - 15:00	60.8	51.8	65.5	56.5
15:00 - 16:00	51.1	42.1	62.6	56.0
16:00 - 17:00	51.2	42.2	63.4	53.3
17:00 - 18:00	54.7	45.7	65.0	53.0
18:00 - 19:00	54.1	45.1	64.4	51.6

Interpretation:
Leq: - equivalent sound level
L50: - mean sound level

Table J.1.8-5 Traffic Volume Survey Result unit: vehicle

Survey point	NT1			NT2		
Measurement Hour	Traffic Volume			Traffic Volume		
	Large	Small	Total	Large	Small	Total
7:00 - 8:00	4	9	13	43	109	152
8:00 - 9:00	4	12	16	57	119	176
9:00 - 10:00	6	12	18	48	103	151
10:00 - 11:00	5	14	19	28	108	136
11:00 - 12:00	4	12	16	34	79	113
12:00 - 13:00	2	9	11	41	125	166
13:00 - 14:00	1	11	12	41	124	165
14:00 - 15:00	3	10	13	17	137	154
15:00 - 16:00	0	5	5	30	119	149
16:00 - 17:00	0	7	7	7	130	137
17:00 - 18:00	1	14	15	18	118	136
18:00 - 19:00	1	8	9	13	95	108
TOTAL	31	123	154	377	1,366	1,743

The daily traffic volume is very small at survey point NT1, because it is located along a rural road. As the survey point NT2 is located at the crossing of Kobyle-pole street and Darzybor street, some large vehicles like buses and large trucks occasionally pass along the streets. Therefore, the noise level of point NT2 is occasionally recorded high.

Land use of the areas surrounding the proposed site

The land use of the areas surroundings (4 km^2) the proposed site is shown in Table J.1.8-6.

Table J.1.8-6 Land use of the areas surroundings the proposed site

Land use	Area (unit: $x10^3$ m^2)	Percentage
Cultivated area	2.490	62.25%
Forest	0.265	6.63%
Waste dumps	0.148	3.70%
Garden plots	0.152	3.81%
Residential	0.016	0.41%
Public facility	0.920	22.99%
Others	0.009	0.21%
Total	4.000	100.0%

The above result shows that more than 60% of the land in the surroundings of the site is cultivated. Residential area amounts to less than 1 %.

4) Forecast of the environmental impacts

Target year of Forecast

The facilities are targeted to be in full operation in the year 2010.

a. Air pollution

i. Forecast model

Diffusion of emission gas from stacks of the incineration plant is forecast applying the following equations.

$$C(x, y, z) = Q / 2 * \pi * \delta_y * \delta_z * U \cdot \exp(-y^2 / 2\delta_y^2) * [\exp\{-(z - H_e)^2 / 2 * \delta_z^2\} + \exp\{-(z + H_e)^2 / 2 * \delta_z^2\}]$$

where,	C(x, y ,z)	: Concentration at point (x, y, z)	[ppm]
	x	: Leeward distance from the emission source	[m]
	y	: Horizontal distance from x line	[m]
	z	: Vertical distance from x line	[m]
	Q	: Intensity of emission gas	[g/s]
	U	: Wind velocity	[m/s]
	H_e	: Height of the emission source	[m]
	δ_y	: Horizontal diffusion width	[m]
	δ_z	: Vertical diffusion width	[m]

Technical Note

H_e is calculated using the following formula:

$H_e = H_o + h$

H_o : Height of stack

h : Height of gas ascent

h is calculated using the following condition:

In windy conditions, h is applied with the CONCAW Model. The CONCAW Model is as follows:

$h = 0.175 \cdot Q_h^{1/2} \cdot U^{-3/4}$

Q_h : Calory of emission gas

U : Wind speed at height of Stack [m/s]

Q_h is calculated using the following formula:

$Q_h = p \cdot Q \cdot C^p \cdot t$

p : Density of emission gas at 15°C,
1.225×10^3 [g/m^3]

Q : Emission gas volume [Nm^3/s]

C^p : Specific heat at constant pressure
0.24 [Cal/kg]

t Temperature of gas at the outlet of stack
- temperature of Atmosphere 135°C

U is calculated using the following formula:

$U = U_S (Z/Z_S)^p$

U_S : Ground wind speed [m/s]

Z : Height of stack [m]

Z_S: : Height of ground wind [m]

p : Number of Pasquill

ii. Conditions for forecast

Conditions for calculation of the following representative cases under the following assumptions ;

a. Assumptions

- Emission gas volume : 73,000 $Nm^3/hr \times 3$
- Concentration of gas at stack outlet :
  - SO_2 = 0.30 g/Nm^3
  - NO_X = 0.25 g/Nm^3
  - Dust = 0.03 g/Nm^3
  - HCL = 0.05 g/Nm^3

note: These values are EC Emission limit values as a function of the norminal capacity of the incineration plant.

(*source: "Council Directive of 8 June 1989 on the prevention of air pollution from new municipal waste incineration plants* ")

- Stack and characteristics of gas
  - Number of stack : 3
  - Gas temperature : 150°C
- Climate
  - Atmospheric temperature : 15°C

b. Calculation case

The following calculation cases are selected by the representative climate conditions in the surroundings of the proposed site and proposed stack height. (refer to Table J.1.8-2). The combinations of Wind speed and stability of atmosphere are selected according to the frequency of appearance of climate condition.

Case:	Wind speed	Stack height	Stability of atmosphere
case 1):	2.0 m	75 m	6 (Pasquill)
case 2):	2.0 m	100 m	6 (Pasquill)
case 3):	2.0 m	125 m	6 (Pasquill)
case 4):	2.0 m	75 m	4 (Pasquill)
case 5):	2.0 m	100 m	4 (Pasquill)
case 6):	2.0 m	125 m	4 (Pasquill)
case 7):	6.0 m	75 m	4 (Pasquill)
case 8):	6.0 m	100 m	4 (Pasquill)
case 9):	6.0 m	125 m	4 (Pasquill)

iii. Result of Forecast

As the result of the above calculation, both the maximum pollutants concentration values and the values at the boundary of the proposed site (annual average level) by the emission gas from the incineration plant will be estimated as shown in Table J.1.8-7.

Table J.1.8-7 Results of Air Pollution Forecast

Pollutant	Stack Height	Maximum	Boundary $x10^{-5}$
SO_2	75 m	0.006 ppm	28.128 ppb
	100 m	0.005 ppm	1.002 ppb
	125 m	0.004 ppm	0.022 ppb
NO_x	75 m	0.005 ppm	23.440 ppb
	100 m	0.004 ppm	0.835 ppb
	125 m	0.003 ppm	0.018 ppb
Dust	75 m	0.001 mg/Nm^3	2.812 mg/Nm^3
	100 m	0.001 mg/Nm^3	0.100 mg/Nm^3
	125 m	0.001 mg/Nm^3	0.002 mg/Nm^3
HCL	75 m	0.001 ppm	4.688 ppb
	100 m	0.001 ppm	0.167 ppb
	125 m	0.001 ppm	0.003 ppb

b. Offensive odour (Landfill site and Incineration plant)

It is difficult to apply the forecasting method of the odour diffusion by a calculation model because uncertain factors still remain. Furthermore, this offensive odour concentration can be very small by soil coverage.

According to the environmental survey of this project, offensive odours (CH_4, NH_3, H_2S) at the boundary of the existing landfill site (Suchy Las landfill site) in Poznan city does not exceed Polish air quality standard in spite of lacks of the daily coverage of waste with soil and other countermeasures against offensive odour. (refer to Table J.1.8-8)

Table J.1.8-8 Offensive odour caused by the existing landfill site

Item	Unit	30-minute concentration value		
		NH_3	CH_4	H_2S
at the boundary of site (A)	mg/m^3	0.04221	0.0333	0.02195
Polish standard values (B)	mg/m^3	0.40000	-	0.03000
(A)/(B)		1/9.5	-	1/1.4

note: NH_3, H_2S were measured on 15th of June
CH_4 was measured on 30th of June
Polish standard of CH_4 is not set up

The proposed sanitary landfill is superior to the existing landfill in reducing the diffusion of offensive odour with the proposed environmental counter measures, especially, by the daily coverage of waste with soil. Offensive odours generated in the proposed sanitary landfill site will be very much weakened before reaching the boundary.

Also, the proposed incineration plant includes a modernized wastes reception section. The inlet of combustion air fan will be placed in the waste pit hall, which ensures that odours from the waste is burned as a part of the combustion process.

Offensive odours from the incineration plant is thereby reduced to an absolute minimum.

c. Water pollution

The anticipated impact on the water quality (including the ground water) caused by the operation of the proposed facilities (the sanitary landfill and the incineration plant) would have very little effect on the water in the surroundings for the following reasons.

The proposed sanitary landfill

- The landfill is equipped with an artificial liner at the bottom. It is prepared to prevent leachate from percolating into the ground the bottom liner under a gravel layer comprising a system of stone drains is constructed for collection of leachate. The leachate is assumed to be pumped to the municipal sewage treatment.

- According to the preliminary plan, leachate control and monitoring systems based on a set of boreholes at the proposed sanitary landfill area are prepared.

The proposed Incineration plant

- The plant is equipped with facilities for internal treatment of the waste water.

- In the plant, solid waste is stored in the pit area. The amount of leachate is small due to the short period of storage as it is collected and diverted to the sewerage system.

d. Noise (Incineration plant)

According to the preliminary design of the proposed incineration plant, most of the anticipated noise sources are placed inside the building with noise countermeasure equipment. However, fans for air-conditioning are installed outside the building and noise may disperse. Therefore, the noise from the ventilation fans was forecast concerning the operation of the incineration plant.

i. Forecast model

The noise level is calculated by the following formula ;

$$L_f = L_w - 20 \log r - 8$$

where,	L_f :	Noise level at the receiving point	[dB(A)]
	L_w :	Power level of the noise source,	[dB(A)]
	r:	Distance from the noise source to the receiving point	[m]

ii. Conditions for the forecast

- Noise level from each ventilation fan	90 dB(A)
- Distance from the noise source to the receiving point	45 m
- Background noise level at the receiving point	47.8 dB(A)

The noise level from the ventilation fan is adopted from actual values measured in Japan.

The background noise level is decided based on the noise survey results of this study.

The transmission loss due to the safety cover of the fans is not taken into account.

iii. Result of Forecast

The noise level caused by operation of the fans is forecasted at the boundary of the incineration plant site as follows.
The noise level from three ventilation fans accumulates.

$$L_p = 10 \log (10^{L_{A10}} + 10^{L_{A10}} + 10^{L_{A10}})$$

L_1, L_2, L_3 :
Noise level from each ventilation fan 48.9 [dB(A)]

Lp: Noise level from the three ventilation fans
L_P = 53.7 [dB(A)]

Furthermore, the noise level at the boundary of the proposed incineration facility is added to background noise level.

$L = 10 \log (10^{L_P/10} + 10^{L_B/10})$

L_P: Noise level from the three ventilation fans 53.7 [dB(A)]
L_B : Average background noise level 47.8 [dB(A)]
L = 54.7 [dB(A)]

The above results indicate that the main noise sources of the proposed incineration plant will increase the noise level by 6.9 dB(A), from 47.8 dB(A) to 54.7 dB(A), at the boundary of the site.

e. Noise (collection vehicles)

Vehicles which transport solid waste to the landfill site causes nuisance noise.
According to the traffic volume survey, total traffic volume is only 154 per day on the access road.

By taking the number of large collection vehicles as a/hour and smaller collection vehicles as b/hour, traffic noise emission is calculated using the formula 10log(10a+b). The number of large collection vehicles will be the highest between 9:00 and 10:00.

Number of large collection vehicles: 6+25=31
Number of small collection vehicles: 12

Therefore, the noise level produced by the collection vehicles is:

= 10log(31 x 10 + 12)-10log(b x 10 + 12)
= 6.5 dB(A)

The present noise emission level is Leq = 58.9 dB(A), therefore, the future noise emission level is as follows:

58.9 + 6.5 = 65.4 dB(A)

J.2 Institutional Plan

This section will provide recommendations for the institutional development for the implementation of the First Priority Project addressed to Poznan Municipality.

The overall institutional system for Poznan Municipality included a combination of direct tendering and introduction of a municipal company for execution of waste services.

J.2.1 Overall Institutional System for Poznan Municipality

For implementation of the Master Plan, the following overall institutional system was proposed:

BODY	TASKS
Department for Municipal Solid Waste Management in Poznan Municipality as overall responsible body for MSWM	* Planning * Administration * Collection of fees * Control and supervision
Subordinated municipal companies under municipal control as executive bodies (or through direct tendering from responsible body)	* Operation of collection services * Operation of recycling centres * Operation of incineration plant * Operation of sanitary landfill * Execution of road sweeping * Execution of public area cleansing

Fig.J.2.1-1 Proposed overall Institutional System for Poznan Municipality

J.2.2 Executive Bodies

Generally, establishment of a municipal company is the recommendable way of organizing execution of MSWM where complex technology or high level of activity are involved, while direct tendering can be applied for well defined services as eg. road sweeping and public area cleansing.

The ideal institutional plan includes 2 municipal companies under municipal control for execution of services related to collection of waste and treatment/disposal of waste respectively.

The limited liability company formed of Poznan Municipality and the private investor Rethman Recycling GmbH could be appointed as the municipal company responsible for all collection services, however, due to the majority in shareholding to the private investor, we recommend that the company will have status as private contractor. It means, that the company's execution of compulsory municipal service will take place under strengthened supervision and control by the municipality.

Basically, municipal waste management is a public duty and a non-profit business. Thus, a municipal company should be based on non-profit basis. For Rethman-Poznan Waste Management Co. Ltd. the division in shareholding cannot secure municipal control with activities related to compulsory waste services without special arrangements.

We recommend that the responsibility for execution of compulsory municipal waste collection services are maintained in the Department for Municipal Solid Waste Management and the execution is carried out as follows:

- Through a tender of districts (at least 25% of the volume, but it may be more as Rethman-Poznan Waste Management Co. Ltd. can participate in the tender). The tender must be made in appropriate districts, so also smaller companies may take part in the tender.

- Through direct contract with Rethman-Poznan Waste Management Co. Ltd. with determination of fees based on the tender result from the tendered districts.

For execution of duties related to Recycling Centres, Incineration Plant and Sanitary Landfill, we propose formation of a municipal company with municipal majority in shareholding.

For road sweeping and public area cleansing we propose to maintain the present system with direct tender of the activities.

These considerations lead to the following institutional plan.

RESPONSIBLE BODY	Department for Municipal Solid Waste Management in Poznan Municipality	- Planning - Administration - Collection of fees - Control and supervision

EXECUTIVE BODIES	Department for Municipal Solid Waste Management in Poznan Municipality through direct tender	Operation of collection systems
	Poznan Waste Treatment and Disposal Company	Operation of: - Incineration plant - Sanitary landfill - Recycling centres
	Provincial Road Authority and Department for Municipal Solid Waste Management through direct tender	Execution of road sweeping
	Forest Authority and Green Area Authority through direct tender	Execution of public area cleansing

Fig.J.2.2-1 Institutional Plan

Below Poznan Waste Treatment and Disposal Company is presented.

J.2.3 Poznan Waste Treatment and Disposal Company

The formation of a municipally controlled company responsible for waste treatment and disposal is recommended. It is essential that Poznan Municipality has full ownership and responsibility for the company as it will include disposal activity.

The company should have a director to take charge of investigations required for the construction of treatment and disposal facilities. A director is especially necessary to supervise the design and tender aspect of the construction of the incineration plant, as well as the managing of the contract for the sale of heat and other works required prior to the start of operation.

Of the new facilities, the recycling centres may be operated by Rethman–Poznan Waste Management Co., Ltd. through a tender, however, we recommended it to be part of the new company for Incineration Plant and Sanitary Landfill.

Thus, the following organization of the Poznan Waste Treatment and Disposal Company is recommended:

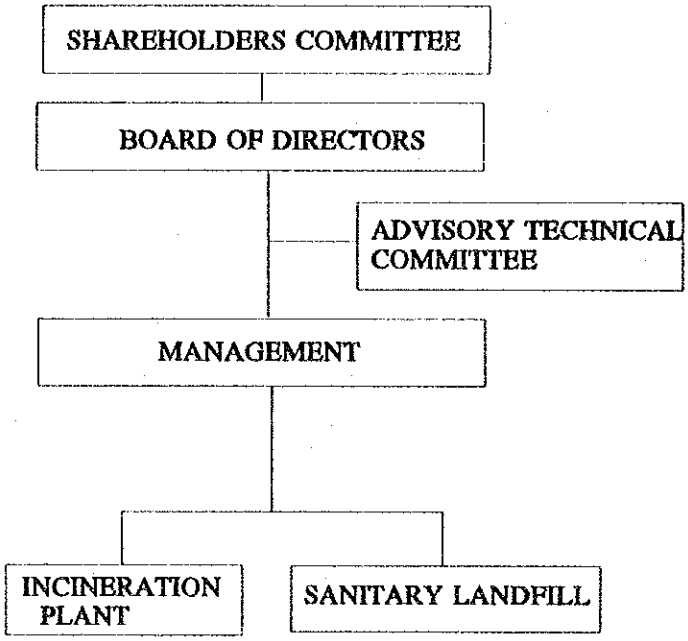


Fig.J.2.3–1 Recommended Organization of the Poznan Waste Treatment and Disposal Company.

We recommend a company structure similar to the Rethman–Poznan Waste Management Co. Ltd., however, with increased governmental influence and a decision–making body unanimous in their decisions. Although increased governmental influence would mean vesting less authority on the Management level, as compared with the collection company, (see presentation in section 4.8.3), past experiences show that careful preparation of the projects can secure a continuity in the operation of the company despite political changes.

Political or governmental influence is necessary due to the public responsibility of the company regarding waste management. The companies cannot only be regarded as profitable short–term business ventures, but should be viewed in terms of their responsibilities to the public.

The proposed organs in the company are:

1) Shareholders Committee

The Shareholders Committee will be composed of politicians and the committee will meet once or twice a year.

Duties:

Approves the report from the Board of Directors and Management and approves the budget for next year.

Representatives:

8 persons appointed by the City Council. The representatives will be remunerated with allowances for the meetings.

Decision-making:

Unanimously.

2) Board of Directors

The Board of Directors, also composed by politicians, will be the legally responsible organ for the company. The Board will meet once a month and the Chairman of the Board will have a close cooperation with the Management.

The Chairman of the Board and the Management will prepare projects for decisions in the Board of Directors.

Duties:

The Board of Directors carry out the following duties:

- Approves all projects within the approved budget.
- Prepares budgets and operation plans.
- Supervision of the Management.
- Counsellor for the Management.

Representatives:

6 members consisting of the Vice-Mayor for Technical Affairs and 5 members appointed by the City Council.

The representatives will be remunerated with allowances for the meetings. The Chairman of the Board will have a salary corresponding to approx. 2 months salary of the Director as he will spend time preparing projects for decision in the Board of Directors and planning of the operation with the Management.

Decision-making:

Unanimously.

3) Advisory Technical Committee

The Advisory Technical Committee is optional as it has a counsellor function. It is, however, deemed appropriate as a support to the technical development of the company.

The Committee shall be composed of technical experts from the municipal organization or other technicians. The Committee will convene once a month with the Chairman of the Board and the Management.

Duties:

To act as counsellor for the Board of Directors and the Management by generating ideas and participate in the evaluation of technical proposals.

In case construction works are prepared or ongoing (especially for the incineration plant), the Committee can participate in the planning and supervision.

Representatives:

2-3 persons appointed by the Board of Directors.

Decision-making:

Has a counsellor role.

4) Management

The Board of Directors will employ a Director as head for the Management. The Director will be responsible for further employment of staff after agreement with the Board of Directors.

The Director will participate in meetings of Shareholders Committee and Board of Directors nonvoting.

Duties:

The Management has the following duties:

- Daily administration and operation of the company.
- Preparation of projects, reports, accounts, budgets etc. for approval by the Board of Directors and the Shareholders Committee.

Representatives:

The Director is assigned by the Board of Directors for an unlimited period of time as head of Management. The Director will be responsible for employment of necessary staff to the company for administrative tasks and operation.

Decision-making:

Can take decisions related to the daily operation based on the power of attorney from the Board of Directors. Decisions must conform with the decisions taken by the Board of Directors.

5) Organization of the Management in Poznan Waste Treatment and Disposal Company

In this sub-section an organization chart for the Management of the Poznan Waste Treatment and Disposal Company is proposed. The proposal is based on the prerequisite that the company will operate Incineration Plant and Sanitary Landfill.

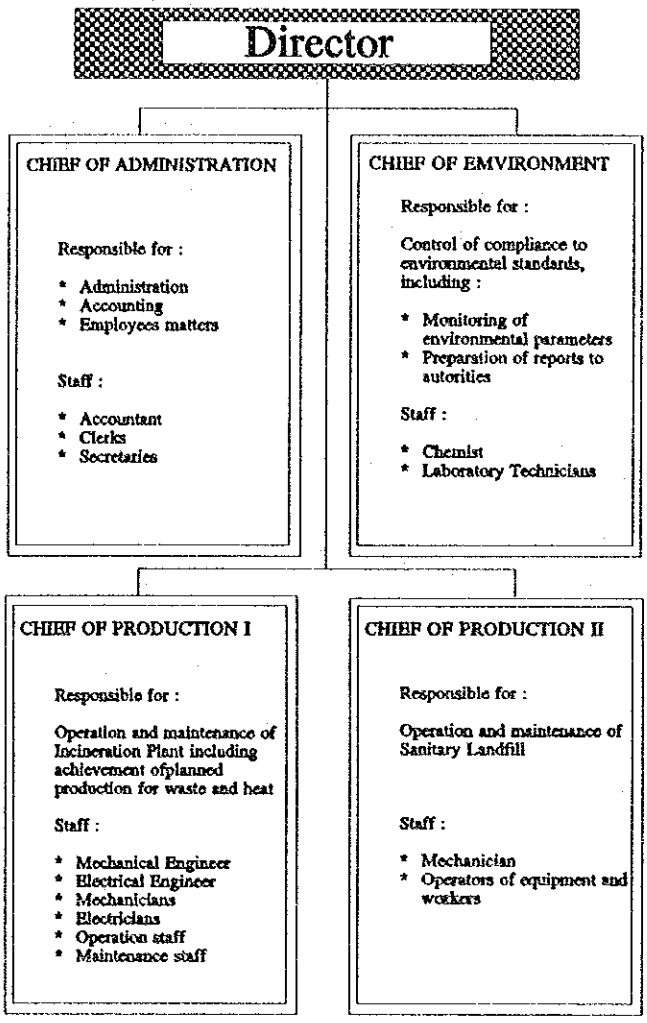


Fig.J.2.3–2 Organization of the Management in Poznan Waste Treatment and Disposal Company

The proposed organization includes two Production Chiefs:

- Production Chief I is responsible for the Incineration Plant.
- Production Chief II is responsible for the Sanitary Landfill and Recycling Centres.

We propose a Chief of Environment to be responsible for monitoring and reporting to authorities. The separation of the production units from the monitoring unit will enable independent control over delegated responsibilities.

Each production unit will be organized under the responsibility of the Production Chiefs.

J.2.4 Laws and Regulations

See Annex I, the Master Plan, section I.3.4.

J.2.5 Tendering

Hard competition is inherent in a free market economy, therefore, it is profitable to carefully examine the market prior to purchase or construction.

In case of a major purchase or construction, tendering (competitive bidding) should carried out. Along with the definition of the conditions of the contract, the tender documents will contain the demands and requirements of the investor regarding the purchase or construction. These documents will be made available to possible candidates for competitive bidding.

The advantages gained from tendering are:

- The investor can define his demands.
- The equal basis for provision of tender allows for full competition and, thus, the cheapest price.
- The equal basis for provision of tender allows for an easier comparison and evaluation of the tenders.

The First Priority Project should be subject for tendering to secure that the Incineration Plant will meet the requirements and that performance guarantees etc., are issued to protect the investor from a failed investment due to purchasing materials of poor quality.

There are several ways of tendering, but the following two are mainly used:

- Open tender based on an announcement in magazines and newspapers.

In this tender all interested companies can participate and tender.

- selective tender. Only selected suppliers, those prequalified can participate after a pre-qualification.

The World Bank has specified demands for the tendering of their own projects and these demands may be applied to the facilities involved. A World Bank tender includes the following documents prepared by the purchaser and submitted to the tenderers:

- Volume 1, General Conditions

  . Invitation to Bid
  . Instruction to Bidders
  . Conditions of Contract
    - Part I, General Conditions
    - Part II, Conditions of Particular Application
  . Contract Forms
    - Form of Tender
    - Bid Security Form
    - Form of Agreement
    - Form of Performance Security
    - Letter of Credit
    - Certificate of Insurance
    - Schedules

- Volume 2, Technical Specifications

  Technical requirements for the purchase including standard for the works, demands on performance, etc.

- Volume 3, Bills of Quantities

  Quantities of works, materials and equipment in the Contract (eg. amount of earthworks, concrete, reinforcement, etc.).

- Volume 4, Drawings

  Necessary drawings or illustrations

There exists international "Conditions of Contract" prepared by FIDIC for civil works and machinery and electrical works respectively. These conditions are well implemented by investors, donators like the World Bank, consultants, and suppliers and, thus, they are often used.

For tender of the incineration plant in Poznan Municipality, the FIDIC conditions are applicable.

For tender method adopted for the Incineration Plant is assumed to affect the total price of the plant.

The machinery may be tendered internationally, while the civil works may be tendered in Poland. Thus, there are several models for the tender:

A: One Contract with the supplier of machinery as holder of Contract for machinery and civil works.

B: One Contract with the civil works contractor as holder of Contract for machinery and civil works.

C: Two Contracts; one with the supplier of the machinery and one with the contractor for civil works.

For A and B, the holder of the Contract must guarantee the safe administration of the whole contract (the holder must be fully responsible, for the safety of another contractor consigned to do work on an area where he is not very familiar of).

Thus, we recommend the implementation of model C with an international tender of the machinery and subsequent detailed design of civil works, followed by a tender in Poland. Thus, the purchaser (herein refers to Poznan Municipality) will make the necessary arrangements for the two Contracts through his consultant engineer. This model will require, all Contract holders to be familiar with their area of responsibility and the Contract prices are assumed to be the cheapest. Furthermore, through the detailed design, Poznan Municipality will be given the opportunity to include its own architectural design and demand in the lay-out.

Model C necessitates a competent consultant engineer for the detailed design, tendering, administration and coordination of Contracts and the supervision of the works.

Fig.J.2.5-1 illustrates the recommended structure of the tender.

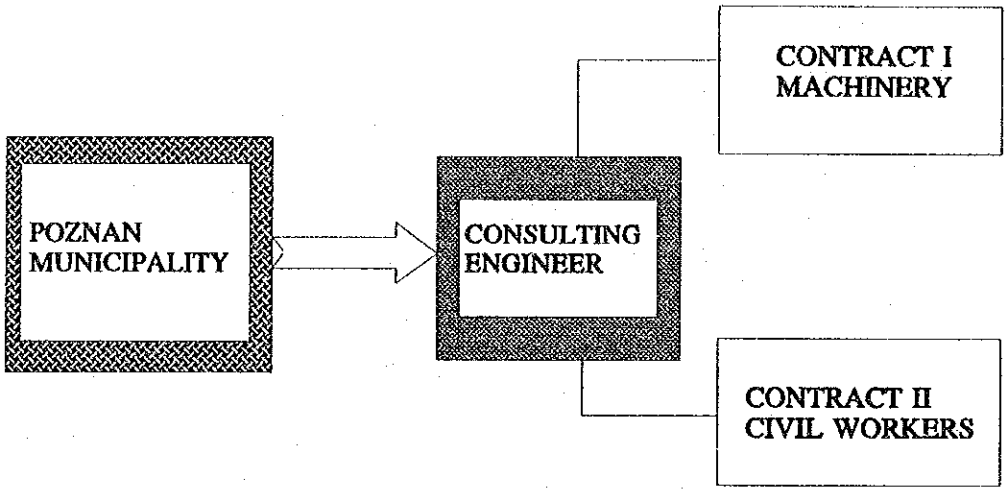


Fig.J.2.5-1 Proposed structure for the tender of Incineration Plant

Tender of Collection Services

Tender of collection services can be carried out based on similar principles as the above described, however, compared with tender of an incineration plant, the tender documents are less comprehensive.

The tender of collection services must be planned and carried out in appropriate districts allowing for participation of smaller contractors. On the other hand, the district must have enough waste volume, so truck capacities, staff, etc., can be utilized to the fullest.

J.2.6 Public Education

Localization of the Incineration Plant will meet opponents in the public. Information will be the key to gain acceptance, however, it is unrealistic to expect elimination of all protesting. By forming the organization responsible for the Incineration Plant at an early stage, the information campaign can be planned and executed timely with the maximum effect.

J.2.7 Training of MSWM Personnel

Training of staff for operation of the Incineration Plant must be included in the contract for machinery. The training (and education) may be divided into the following main categories:

- General and not very detailed courses on the entire operation process and operation of all equipment. Target group is the whole staff.

  The general courses shall be held in advance prior to the start of operation.

- Specific courses for:

  . Machinery operation.

  . Monitoring and control system.

  Target group is the personnel assigned for daily operation and maintenance.

  The specific courses shall be held in the early operation (in the test period where the contractor's staff is responsible for the operation and will be present at the plant).

- Trouble shooting courses to be held at the end of the test period before the take over. At this time the staff will be familiar with the plant and, thus, have gained full benefit of very detailed courses.

It has been observed from past experiences that introductory detailed courses are not very beneficial, while some months of on the job training provides the best foundation for detailed courses.

For a selected group of leading operational staff, on the job training at an incineration plant is recommended.

J.3 Estimation of Project Cost

J.3.1 Contents of the Feasibility Study Projects

The projects for the feasibility study are as follows.

i. Technical aspect

- Incineration plant project 1st phase
- Sanitary landfill site of 1st section
- 8 number of public recycling centres

ii. Financial aspect

- Incineration plant project 1st phase

Therefore, among the technical systems which were examined in section J.1, the contents of only incineration plant 1st phase, sanitary landfill site of 1st section and 8 number of public recycling centres are summarized in this section.

1) Public Recycling Centres

Table J.3.1-1 outlines the contents of 8 number of the recycling centres to be constructed during Stage 1 of the Master Plan which will be studied for its feasibility.

Table J.3.1-1 Public Recycling Centres

Item	Plan
a. Number of Centres	8 places in total, 2 large and 6 small centres
b. Location	1. between Naramowicka St. and Lechicka St. 2. in Marysienki Residential Area 3. in Sytkowo near Dabrowskiego St. 4. at the crossing of Grunwaldzka St. and Malwowa St. 5. in Swierczewo near Opolska St. 6. at the river Cybina near Zamenhofa St. 7. in Polna st. near Dabrowskiego St. 8. beside the incineration plant in Franowo
c. Waste amount through recycling centres (304 days/year)	Input: from Bulky waste collection : 29.0 tons/day from Recycling centre collection : 67.8 tons/day Output: to Incineration plant : 57.8 tons/day to recycling : 9.7 tons/day to final disposal : 29.3 tons/day
d. Proposed Area	Large centres : 3,000 m^2 x 2 sites = 6,000 m^2 Small centres : 2,000 m^2 x 6 sites = 12,000 m^2
e. Equipment	Large centres : 5 small and 16 large containers Small centres : 3 small and 10 large containers
f. Personnel	Large centres : 3 workers Small centres : 2 workers

2) Incineration Plant

Table J.3.1-2 outlines the contents of the incineration plant Phase 1 to be constructed during the stage 1 of the Master Plan.

Table J.3.1-2 Outline of Incineration Plant

Items	Contents	Remarks
a. Target Year	2001	
b. Service Population	206,000	
c. Proposed Site	Franowo-Michalowo	Site area 5.0 ha
d. Received Waste	Combustible Waste - Household Waste - Commercial Waste - Market Waste - Institutional Waste - Bulky Waste - Sewage Sludge - Hospital Waste	Calorific value Low 1,400 kcal/kg STD 2,100 kcal/kg High 2,500 kcal/kg
e. Capacity	10 ton/hour/line x 1 line	240 tons/day
f. Working Hours	24 hour/day	7,000 hours/year
g. Facilities Outline	Reception Facilities - Access road - Weigh bridge - Building for waste reception Waste pit Waste cranes Incineration Lines Boiler Bottom and Fly Ash Handling System Flue Gas Cleaning System Auxiliary Equipment	 Movable grate system Water tube boiler (Natural water circulation) Semi-dry system Emission Gas Quality Dust: 30 mg/Nm^3 HCl: 50 mg/Nm^3 SO2: 300 mg/Nm^3
h. Heat Recovery	Hot water supply	332 TJ/year
i. Personnel	80 persons	
j. Construction Period	4 Years	1997 Planing and Basic Design 1998 Tender and Construction 1999 Construction 2000 Construction and Test Run 2001 Take over