2.2 FINAL DISPOSAL

(1) Natural Condition at the object site.

1) Precipitation

The annual average rainfall (1964 – 1998) is approximately 720 mm, the maximum rainfall for past 20 years is approximately 1230 mm in 1984, and minimum one is approximately 380mm in 1992. *Table X.2.7* shows the monthly rainfall in 1984 and in 1993.

Table X.2.7 Monthly rainfall of max and average rainfall for past 20 years unit(mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	319	330	223	44	18	4	4	26	0	158	69	96	1291
1993	176	101	107	53	7	1	0	38	18	69	79	112	761

Station: Puno/co – 708, LAT: 15° 50', LONG: 70° 01', ALT: 3812 m

Over 85% of the rainfall occur from November to March, and over 50% occur from January to March.

2) Pan evaporation

Pan evaporation exceeds the annual rainfall. The maximum rates occur between September and December and average 200.2mm/ month. Over the year as a whole the pan evaporation totals about 2000 mm, about three times the annual rainfall.

3) Topographical and geological condition.

- Topographical condition.

Two candidate sites are prepared for this feasible study. One is the site purchased by the City close to the present site, the other one is the site surveyed by the JST. The Sites are almost flat areas, the gradient of the city owned is about 5% and the site surveyed by the JST is 0.7 % at the plane area and about 5% at hillside area. *Figure X.2.6* shows the two locations of the sites.

- Geological condition.

During the field survey from June, 1999 three pits by manually digging were carried out for geological survey.

The result showed that the underground structure at the site consisted of two layers, the layer by 1 to 2.5 m from the ground level was soft loamy sandy clay or sandy soil and furthermore the deep stratum is windy rock having cracks. Of two layers, upper layer was easily dug, but the rock was impossible to dig by manually. The two layers were considered as permeable or semi-permeable. Of three pits, at the pit dug in most eastern area, ground water were found at the 1.3 m from the ground level.

SITE LOCATION MAP

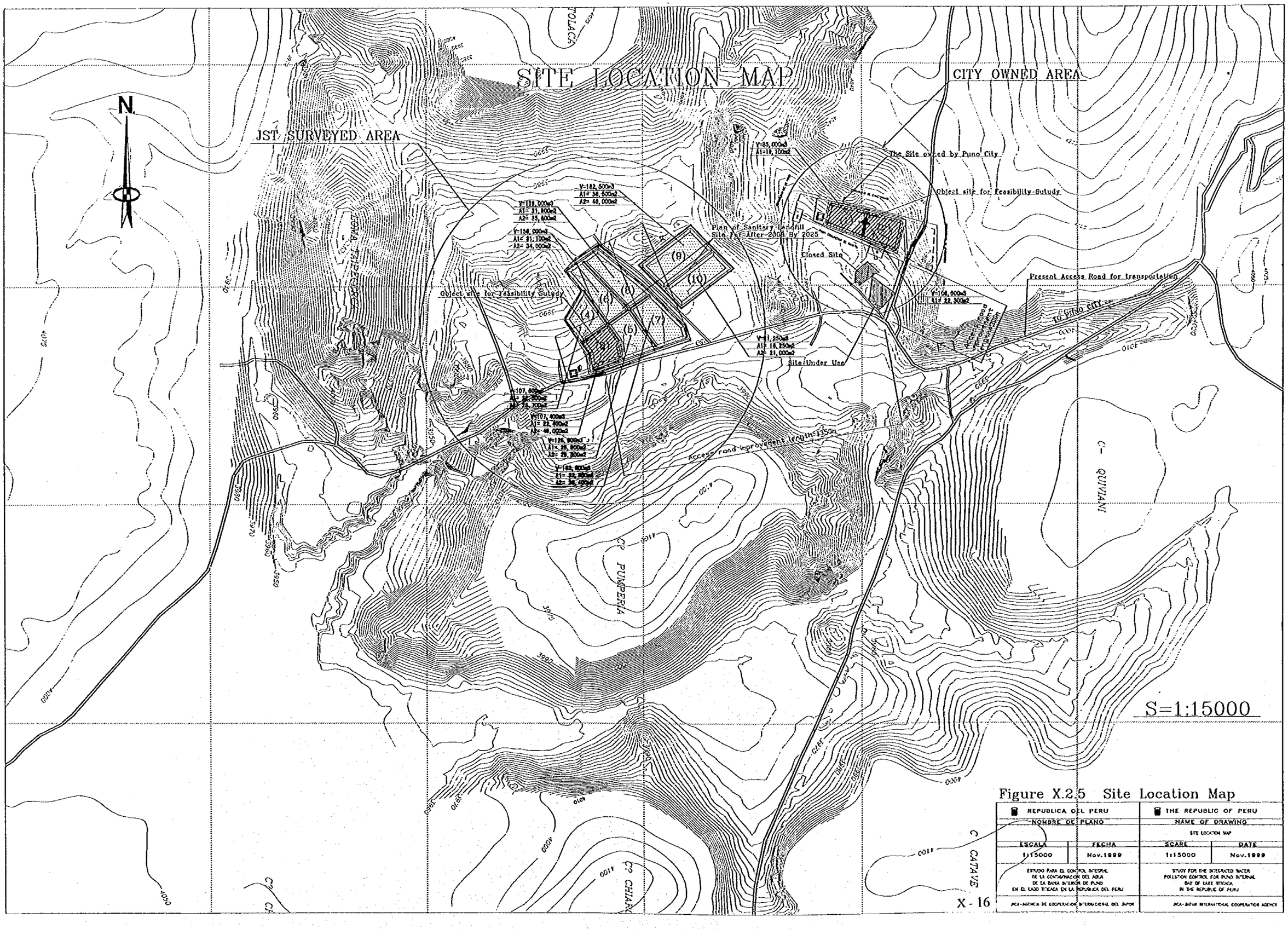


Figure X.2.5 Site Location Map

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
		SITE LOCATION MAP	
ESCALA	FECHA	SCALE	DATE
1:15000	Nov.1999	1:15000	Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA EN LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
JICA-AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON		JICA-JAPAN INTERNATIONAL COOPERATION AGENCY	

(2) Legal regulation for establishment of the Sanitary landfill site.

According to the Technical Standard, legal regulation for establishment of the site is mainly

a) The site establishment is prohibited within 3Km from an airport.

b) Within a natural protection area, the site establishment is prohibited.

c) Within a water resource area, is prohibited.

d) An area where it is difficult to obtain covering soil is prohibited

e) City planning area is prohibited.

The sites in this study do not meet with any above conditions.

(3) Land Use surrounding of the sites locations.

There are few families in the site locations, livestock is grazed and a potato field exists.

(4) Projected Quantity of Landfill of Collected Wastes

According to the Technical Standard issued by The DEGESA for Construction of Sanitary landfill Site, each depth of 60cm of landfilled wastes requires 15cm covering by soil and for final covering, 60cm soil covering is compulsory. *Figure X.2.6* shows structure of disposed of waste layer with covering soil layer and seepage control layer in the sanitary landfill site.

Accordingly, the projected necessary volume of the hauled waste at the site is as per *Table X.2.8*

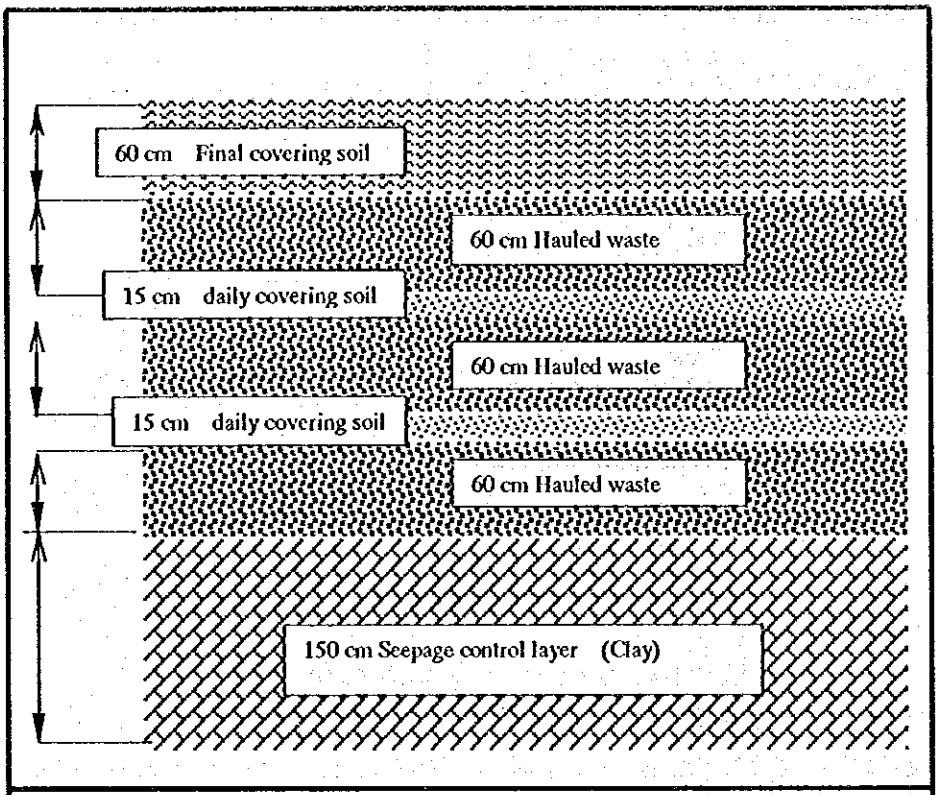


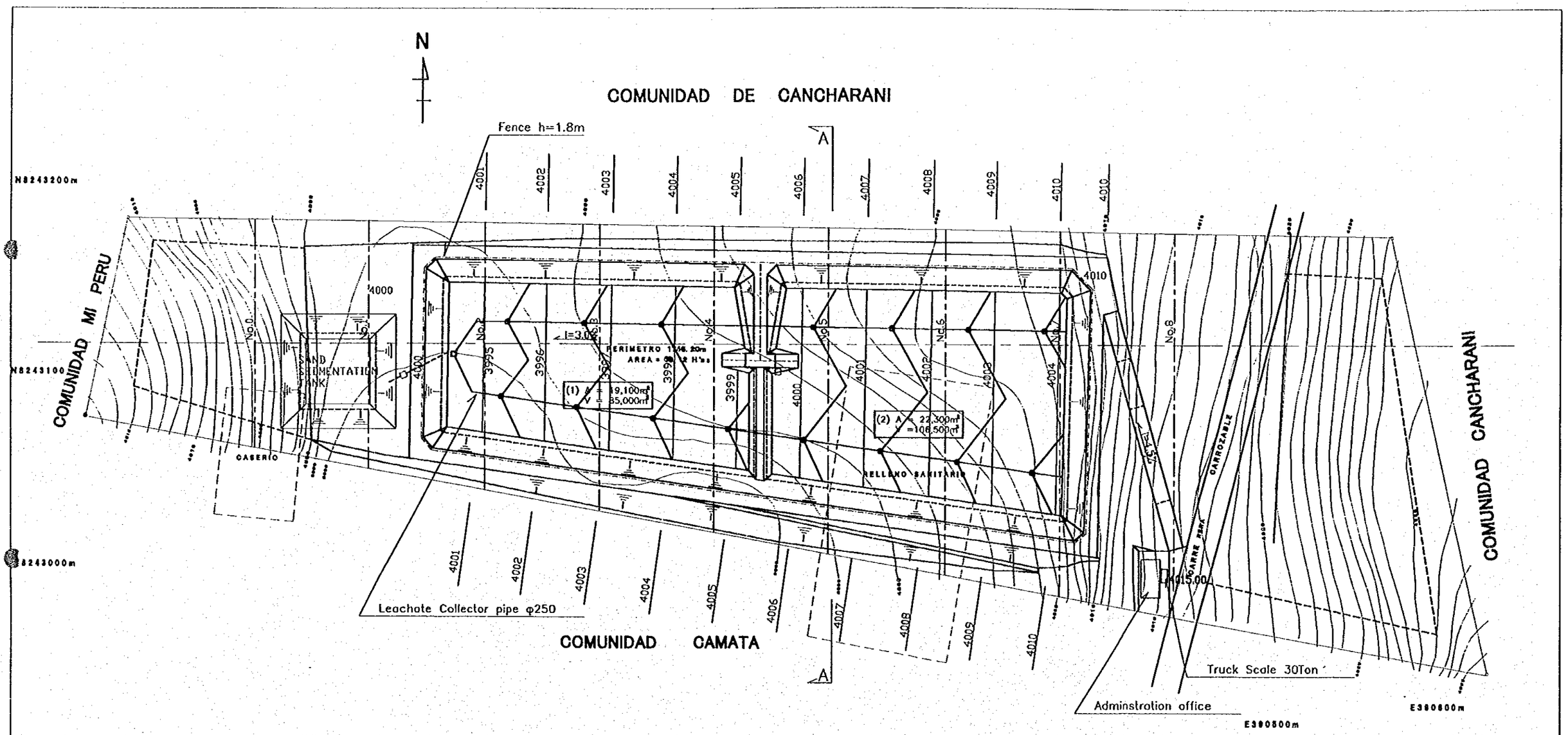
Figure X.2.6 Sectional plan of compacted solid waste layer with covering soil in the sanitary landfill site

Table X.2.8 Necessary Capacity for Sanitary Landfill Site

	Waste Generation (Incl. Direc. carried in)	Wastes Hauled	Wastes Hauled	Volume of Wastes	Covering Soil	Necessary Volume	Volume Accumulated
	T/day	T/day	T/yr	m^3/yr	m^3/yr	m^3/yr	m^3
1998	68.41	35.49	12,954	18,506	4,626	23,131	23,131
2008	87.63	60.07	21,926	31,322	7,829	39,152	236,252
2025	128.39	128.39	46,862	66,946	16,734	83,680	1,269,933

The necessary capacity of Sanitary Landfill Site shall be projected as 236,000m3 by 2008.

As the present Cancharani Final Disposal Site has 10Ha of which in 5Ha, the quantity of 191,000 m^3 wastes to be disposed of is projected. And the remaining quantity of Wastes for 45,000 m3 shall be disposed of in the new Site of 25 ha which is the area under the last JST Survey. *Figure X.2.7* and *X.2.9* shows the



(1) Area of Landfilling = 19,100m²
Vlume of Landfilling = 85,000m³

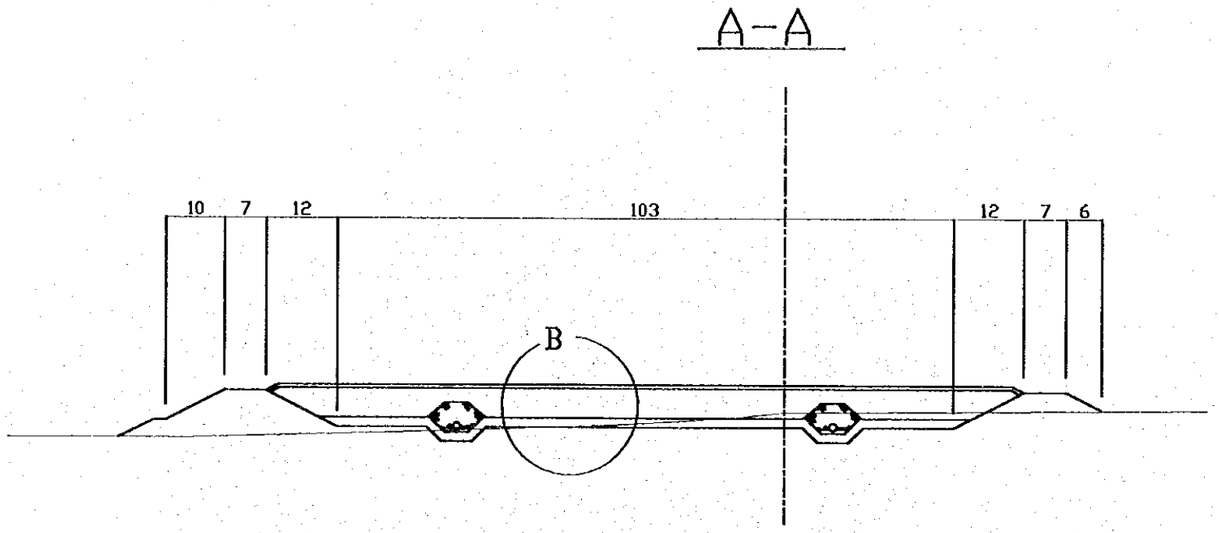
(2) Area of Landfilling = 22,300m²
Vlume of Landfilling = 106,500m³

AREA DE RELLENO SANITARIO = 41,400m²
VOLUMEN DE RELLENO SANITARIO = 191,500m³

Figure X.2.7 PLAN OF SANITARY LANDFILL SITE AT MUNICIPAL OWNED AREA

MUNICIPALIDAD PROVINCIA DE PUNO			
DIVISION DE ESTUDIOS Y PROYECTOS			
PROYECTO: RELLENO SANITARIO			
PLANO: TOPOGRAFICO PERIMETRAL			
ESCALA: 1 / 1000	FECHA: JULIO 1999	APROB.	DIB. GERMAN C.O. / UNV. BARRIO CH.

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
EL PLANDE SITIO DEL RELLENO SANITARIO A LA TIERRA POSESA MUNICIPAL		PLAN OF SANITARY LANDFILL SITE AT MUNICIPAL OWNED AREA	
ESCALA	FECHA	SCARE	DATE
1:2000	Nov.1999	1:2000	Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA EN LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
JICA-AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON		JICA-JAPAN INTERNATIONAL COOPERATION AGENCY	



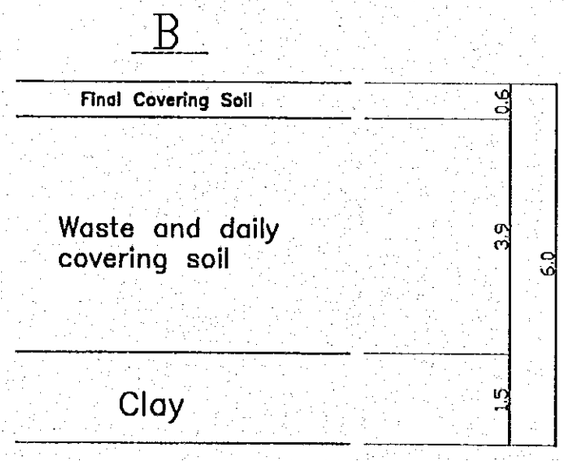
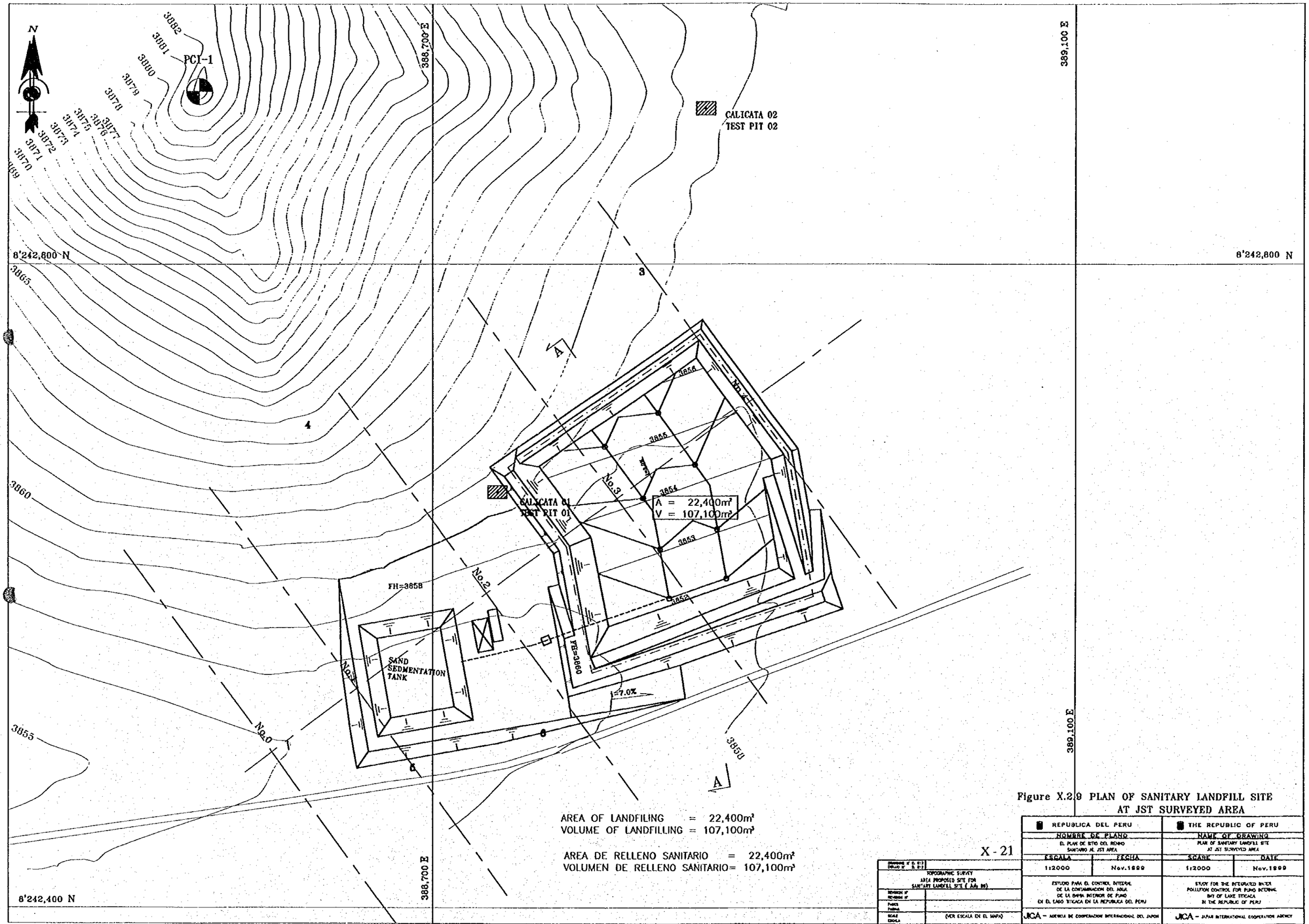


Figure X.2.8 STANDARD SECTION AT SANITARY LANDFILL SITE OF CITY OWNED SITE

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
SECCION NORMAL DE SITIO DEL RELLENO SANITARIO		STANDARD SECTION AT SANITARY LANDFILL SITE	
ESCALA	FECHA	SCALE	DATE
1:100	Nov.1999	1:100	Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA EN LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
JICA-AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON		JICA-JAPAN INTERNATIONAL COOPERATION AGENCY	



AREA OF LANDFILING = 22,400m²
VOLUME OF LANDFILLING = 107,100m³

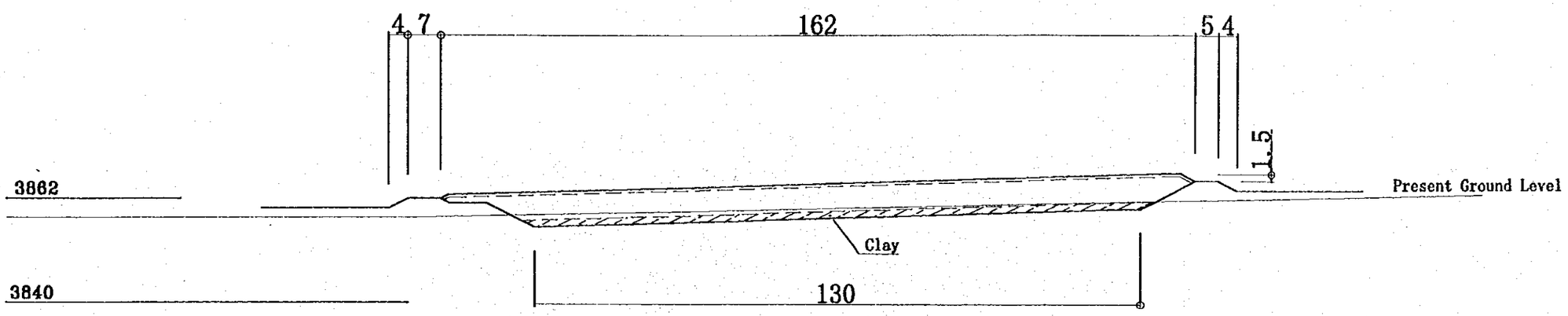
AREA DE RELLENO SANITARIO = 22,400m²
VOLUMEN DE RELLENO SANITARIO= 107,100m³

Figure X.2.9 PLAN OF SANITARY LANDFILL SITE AT JST SURVEYED AREA

TOPOGRAPHIC SURVEY	
AREA PROPOSED SITE FOR SANITARY LANDFILL SITE (Adq 98)	
REVISION Nº / REVISION Nº	
FECHA / Fecha	
ESCALA / Escala	(VER ESCALA EN EL MAPA)

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
EL PLAN DE SITIO DEL RELLENO SANITARIO AL JST AREA		PLAN OF SANITARY LANDFILL SITE AT JST SURVEYED AREA	
ESCALA	FECHA	SCARE	DATE
1:2000	Nov.1999	1:2000	Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA EN LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
JICA – AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON		JICA – JAPAN INTERNATIONAL COOPERATION AGENCY	

A--A



B

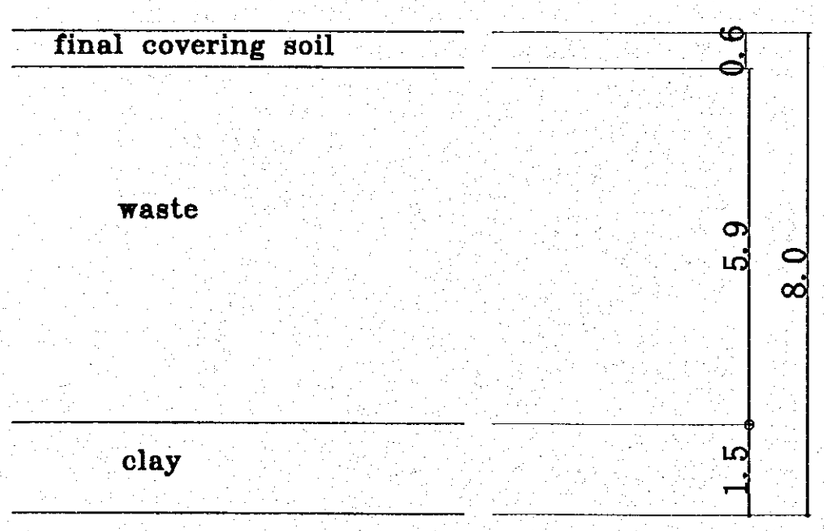


Figure X.2.10 STSNDARD SECTION OF SANITARY LANDFILL SITE AT JST SURVEYED AREA

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
SECCION NORMAL DE SITIO DEL RELLENO SANITARIO		STANDARD SECTION OF SANITARY LANDFILL SITE	
ESCALA	FECHA	SCALE	DATE
1:1000	Nov.1999	1:1000	Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA EN LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
JICA-AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON		JICA-JAPAN INTERNATIONAL COOPERATION AGENCY	

plan of plane view of the sanitary landfill site in each area. And *Figure X.2.5* shows the location of the two sites, which are necessary by 2025. *Table X.2.9* shows site construction plan schedule.

Table X.2.9 Site Construction Planned Schedule.

Number of site.	Location of the site.	Site Volume (1000 m^3)	Site Area (ha)	Life Span (year)	Duration. y - y
[1]	City, owned	85.0	1.91	3	'02-'04
[2]	City, owned	106.5	2.23	2	'05-'06
[3]	JST surveyed	125.9	2.24	3	'07-'09
[4]	JST surveyed	107.4	2.25	2	'10-'11
[5]	JST surveyed	125.9	2.59	3	'12-'14
[6]	JST surveyed	156.0	3.11	3	'15-'17
[7]	JST surveyed	162.8	3.28	2	'18-'19
[8]	JST surveyed	156.0	3.19	2	'20-'21
[9]	JST surveyed	182.5	3.65	3	'22-'24
[10]	JST surveyed	81.3	1.63	1+ α	'25-'25+ α
Total		1,289.3	26.08	24+ α	

Hatching means the duration of Feasibility Study.

The relevant Site is observed as flat and the Site is constructed after necessary construction by dig-down for several meters and then is covered the bottom with seepage control layer made with clay.

(5) Plan for Construction of Facilities

The following Facilities shall be established in compliance with the Technical Standard of the DIGESA. Mainly, the items are as followings.

1) Access road

Technical Standard:

The access road to the sanitary landfill site shall be projected according to the technical standard for "the Designs of Highways of the Ministry of Transports, Communications, Housing and Construction. The road will be built for any climatic condition.

Plan in this project:

Road bed with compacted soil, and crushed stone pavement is planned. *Figure X.2.11* shows the standard section of the access road.

2) Peripheral Fence

Technical Standard

The peripheral Fence should be planned for the main objective of impeding the access of strange people and of animals. The construction is made using of most preferable and available materials in the site, with a height, minimum of 1.5 m.

Plan in this project

It is planned that Height of fence is 1.8 m. *Figure X.2.11* shows the Fence.

3) Embankment to prevent flowing the waste.

Technical Standard

The Embankment of section should be planned in such way that makes sure their stability, taking into account the heights, the floor types and any other factor that affects them. The advisable banks is pointed out as followings.

Type of Material	Embankment		
	Vertical	vs.	Horizontal
Loose rock	4.0		1.0
Conglomerate	3.0		1.0
Compact earth (several lands)	2.0		1.0
Sand	0.5		1.0
Plan in this project	0.5		1.0

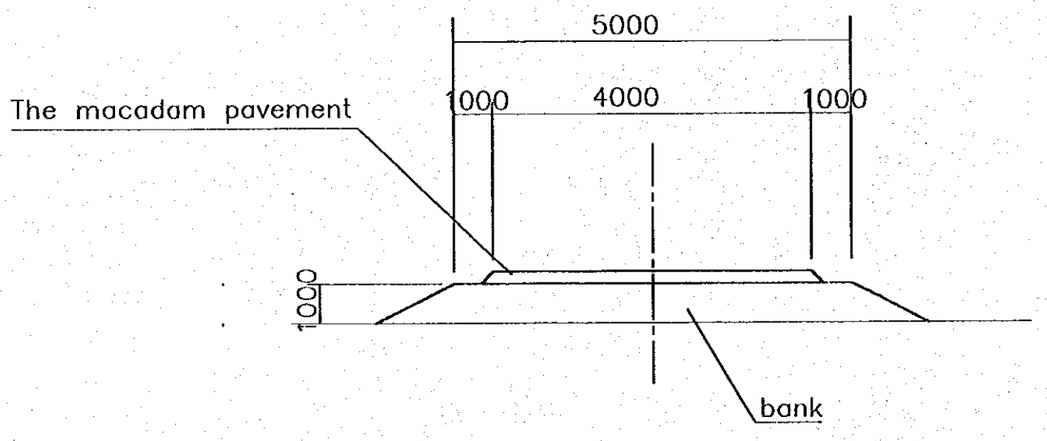
4) Seepage control layer for leachate (Impermeable layer at the bottom of the site)

Technical Standard

If natural geologic barrier that impedes the contamination of the underground waters for effect of those leachate, doesn't exist, it should be planned an impermeabilization system with clay layers or other material (geo-membrane and geo-textiles) of appropriate characteristic for this, taking into account the natural conditions of the place at the location of the sanitary landfill site (ground water level, climate, etc).

STANDARD SECTION OF THE APPROACH ROAD

S=1:300



FENCE

S=1:30

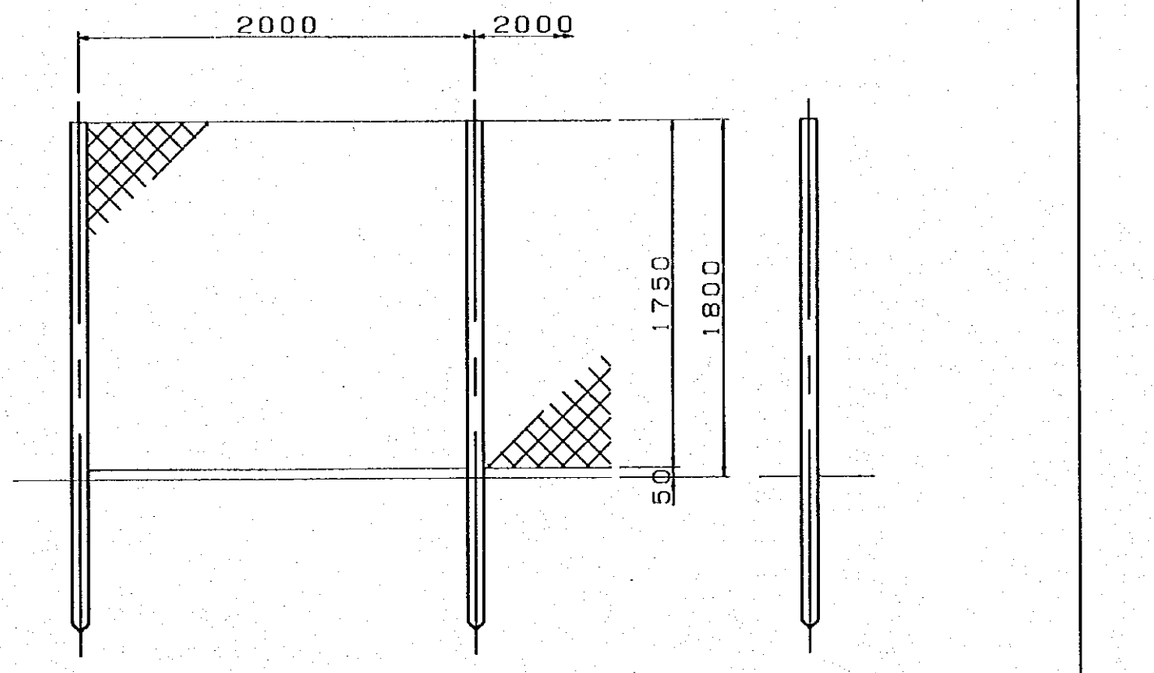


Figure X.2.11 STANDARD SECTION OF THE ACCESS ROAD

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
		STANDARD SECTION OF THE ACCESS ROAD	
ESCALA	FECHA	SCALE	DATE
	Nov.1999		Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA EN LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
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The permeability of the material to use won't be larger than k = 10^{-5} cm/s. And the minimum total thickness of the clay layers will be in function of the depth of the ground water level from the surface of the site and of the pluvial precipitation of the site.

RECOMENDABLE MINIMUM THICKNESS OF THE CLAY LAYER.

Precipitation/ year	Level of ground water.		
	More than 100m	30-100m	up to 30m
Up to 50mm	0.30 m	0.60m	0.90m
50-300mm	0.60	0.90	1.20
Over 300mm	0.90	1.20	1.50

Plan in this project The thickness of the layer takes 1.5m. *Figure X.2.8* shows the situation of installation of clay layer.

5) Drainage of Leachate

Technical Standard.

For the reception and evacuation of leachate, drainage is planned so much installed in the bases of the site (in form of fish thorn, taking advantage of the system of natural drainage or other forms) to the foot of the banks of each platform. The drainage made by gutters of stones, perforated pipes or of another type, with a minimum longitudinal slope of 2 % and compatible dimensions with the prospective flows of leachate.

Plan in this project

Main pipe of HDP pipe wrapped with cobblestone is planned and branches made by gutters of stones are planned. *Figure X.2.12* shows the section of them

6) Treatment of leachate

Technical Standard.

According to the characteristics of leachate generated in the sanitary landfill site, treatment system is planned to reduce to permissible limit of contaminants, such as re-circulation, percolated filters, stabilization lagoons anaerobic reactors of upward flow, or others.

Plan in this project.

Circulation system is adopted.

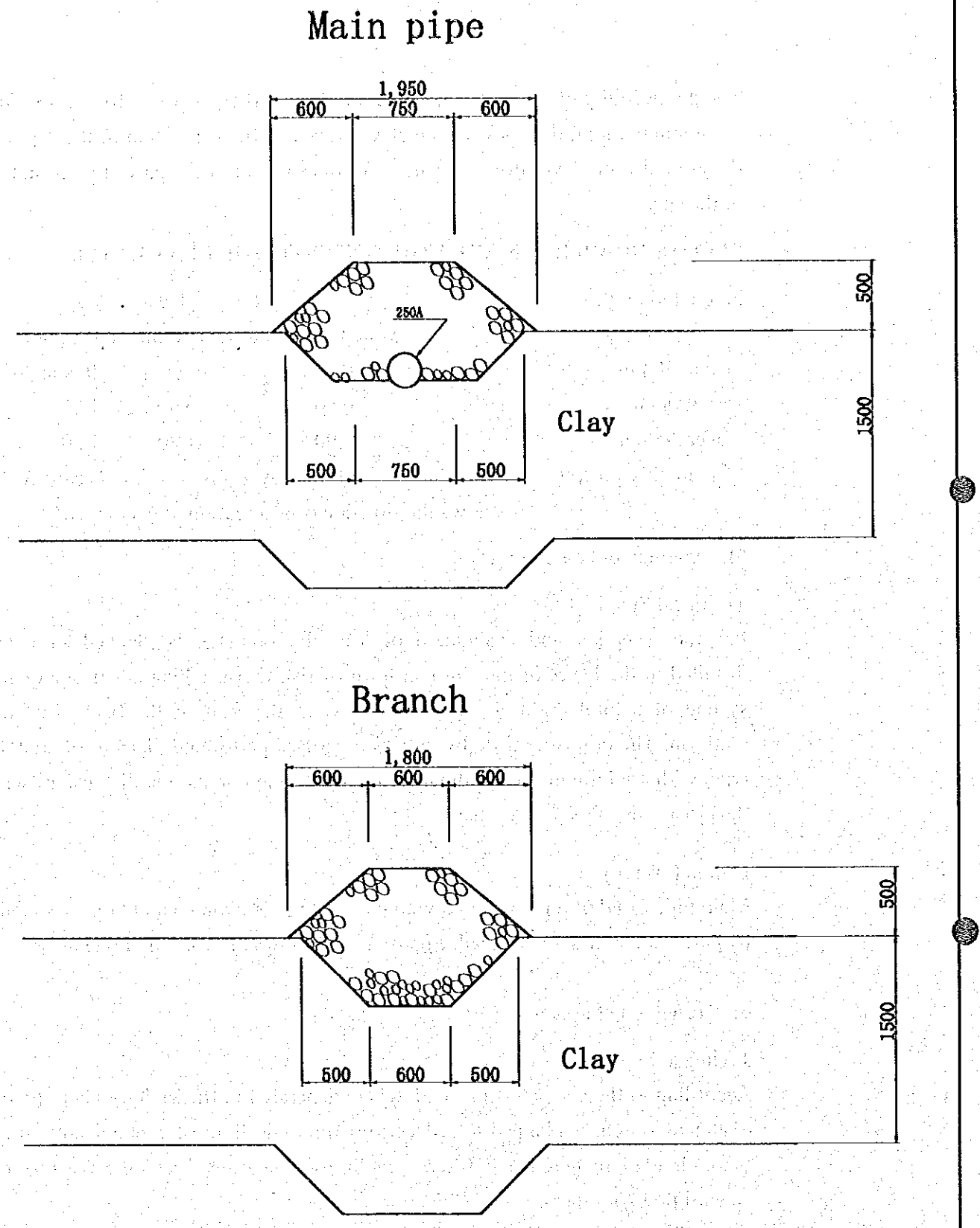

Figure X.2.12 Section of Leachate Collection Pipe

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
		Section of Leachate Collection Pipe	
ESCALA	FECHA	SCARE	DATE
1:200	Nov.1999	1:200	Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA DE LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
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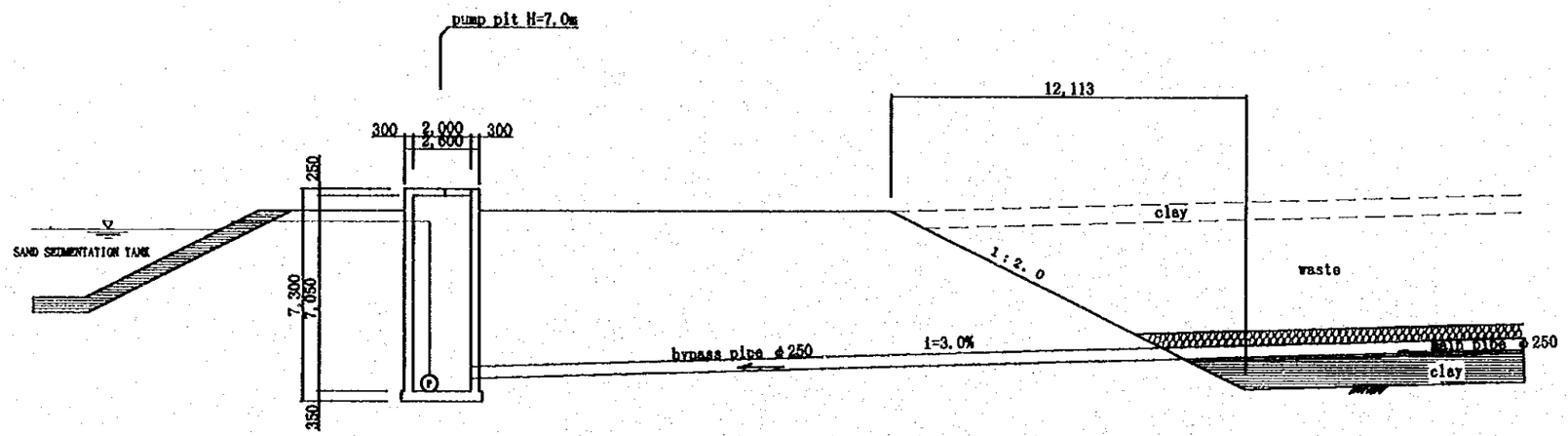
As previously mentioned, annual average rainfall approx.720 mm/year is lower than average pan evaporation approx.2000 mm/year. For this reason, as the leachate treatment facility, circulation system is adopted. But, during the rainy season, as evaporation is lower than daily rainfall, leachate is generated. Then, leachate should be stored in the site, and through a year, it can be treated from the water income and outgo balance if the leachate is kept circulating. Leachate treatment facilities are consisted of sand sedimentation tank, circulation pit and circulation pump. Figure X.2.13. shows those these facilities.

As an example, calculation of leachate generation is shown, in case of the rainfall pattern is maximum rainfall for past 20years and average rainfall pattern as well. The result is shown in *Table X.2.10* and *Table X.2.11* respectively.

As for environmental facility, the monitoring well is planed. Four monitoring wells have to be installed per sites. Figure *X.2.14.* shows the monitoring well.



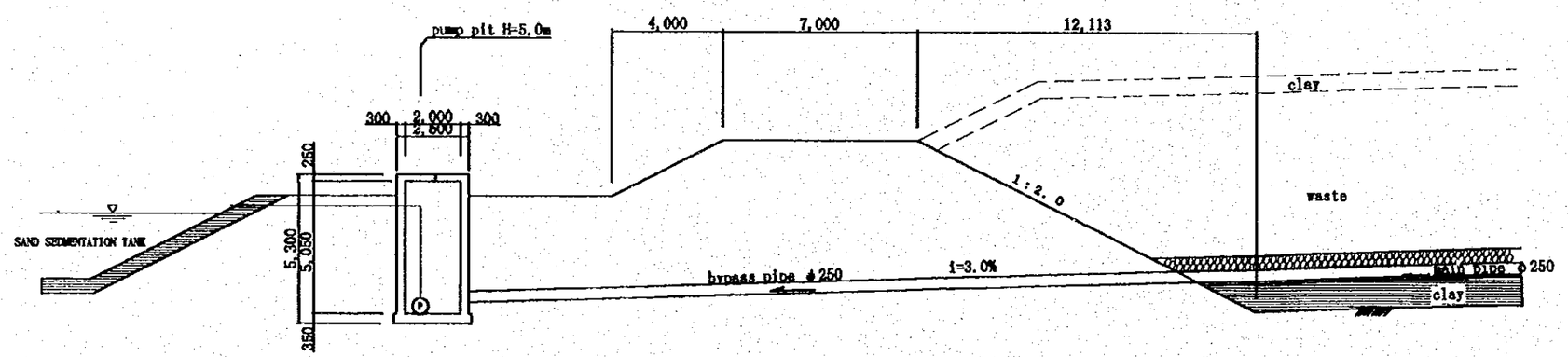


Figure X.2.13 STANDARD SECTION OF PUMP IT LOCATION

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
SECCION NORMAL DE BOMBA MODIFICACION HOYO SITUACION		STANDARD SECTION OF PUMPPIT LOCATION	
ESCALA	FECHA	SCALE	DATE
1:200	Nov.1999	1:200	Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA EN LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
JICA-AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON		JICA-JAPAN INTERNATIONAL COOPERATION AGENCY	

Table X.2.10(1) Leachate Generation Quantity due to Maximum Daily Precipitation for Past 20 Years at the City Owned Site.

Area operating A1 = 22,400 m²
Area operated . A2 = 0 m²

Eva quant E= 105 m³/d
Max leachate generation 1,219 m³/d
Necess adjust Pond Vlm 7,880 m³/d
Site inside storage vl 115 d/y
I 4.7 mm/d

The Year is 1984
Observation Station
PUNO / CO-708
L.C quant 21,659

LAT. : 15° 50' "S"
LONG : 70° 01' "W"
ALT : 3812 m

DPTO. PUNO
PROV. PUNO
DIST. PUNO

Sinking coefficient

C1 =	0.89		0.91		0.83		0.21		0		0		0		0		0		0.76		0.48		0.61	
C2 =	0.89		0.91		0.83		0.21		0		0		0		0		0		0.76		0.48		0.61	

	January		February		March		April		May		June		July		August		September		October		November		December	
	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm
1	12	12	267	3,454	37	6,769	39	7,653	0	4,664	0	1,401	0	0	0	0	0	0	0	0	0	295	3	3
2	439	439	102	3,451	296	6,959	8	7,556	0	4,559	0	1,296	0	0	0	0	0	0	0	0	0	190	60	60
3	397	730	106	3,452	389	7,243	0	7,451	0	4,454	0	1,190	0	0	0	0	0	0	150	150	0	84	56	56
4	179	804	532	3,878	67	7,204	0	7,346	0	4,349	0	1,085	0	0	0	0	0	0	128	172	66	66	4	4
5	387	1,086	143	3,916	6	7,104	0	7,240	0	4,243	0	980	0	0	0	0	0	0	5	72	0	0	0	0
6	98	1,078	275	4,086	37	7,036	0	7,135	0	4,138	0	874	0	0	0	0	0	0	65	65	0	0	68	68
7	10	983	526	4,506	0	6,931	0	7,030	0	4,033	0	759	0	0	0	0	0	0	0	0	0	0	156	156
8	116	993	236	4,637	30	6,856	0	6,925	0	3,928	0	664	0	0	0	0	0	0	14	14	0	0	78	128
9	596	1,484	100	4,632	171	6,921	0	6,819	0	3,822	0	559	0	0	0	0	0	0	0	0	0	0	104	127
10	159	1,538	24	4,551	0	6,816	0	6,714	0	3,717	0	453	0	0	0	0	0	0	0	0	0	0	150	172
11	221	1,654	57	4,503	363	7,073	0	6,609	0	3,612	0	348	0	0	0	0	0	0	1,219	1,219	0	0	4	71
12	50	1,599	304	4,701	180	7,148	0	6,503	0	3,506	0	243	0	0	0	0	0	0	148	1,262	32	32	0	0
13	22	1,515	797	5,393	130	7,173	0	6,398	0	3,401	0	137	0	0	0	0	0	0	0	1,156	24	24	15	15
14	20	1,430	271	5,559	37	7,105	0	6,293	0	3,296	0	32	0	0	0	0	0	0	3	1,055	1	1	0	0
15	36	1,361	359	5,813	0	7,000	0	6,188	0	3,191	0	0	0	0	0	0	0	0	184	1,133	19	19	0	0
16	419	1,674	591	6,298	0	6,895	0	6,082	0	3,085	0	0	0	0	0	0	0	0	7	1,035	46	46	0	0
17	52	1,621	183	6,377	236	7,025	0	5,977	0	2,980	0	0	0	0	0	0	0	0	0	929	180	180	0	0
18	265	1,780	304	6,575	110	7,030	0	5,872	0	2,875	0	0	0	0	0	0	0	0	117	942	6	81	0	0
19	64	1,739	334	6,804	266	7,190	0	5,766	0	2,769	0	0	0	0	0	0	0	0	0	836	2	2	0	0
20	50	1,683	175	6,874	463	7,548	37	5,698	0	2,664	0	0	0	0	0	0	0	0	37	768	30	30	0	0
21	175	1,754	12	6,781	151	7,593	14	5,606	0	2,559	0	0	0	0	0	0	0	0	17	680	10	10	60	60
22	173	1,822	308	6,984	0	7,488	40	5,541	0	2,454	0	0	0	0	0	0	0	0	3	578	92	92	5	5
23	341	2,057	94	6,972	310	7,693	8	5,443	0	2,348	0	0	0	0	0	0	0	0	0	473	28	28	7	7
24	337	2,289	359	7,225	104	7,692	54	5,392	0	2,243	0	0	0	0	0	0	0	0	0	368	105	105	78	78
25	108	2,291	33	7,153	136	7,724	0	5,287	0	2,138	0	0	0	0	0	0	0	0	5	268	6	7	12	12
26	4	2,190	0	7,048	58	7,677	9	5,191	0	2,032	0	0	0	0	0	0	0	0	167	329	30	30	0	0
27	80	2,165	0	6,942	121	7,692	0	5,086	0	1,927	0	0	0	0	0	0	0	0	2	226	31	31	0	0
28	514	2,574	0	6,837	171	7,758	0	4,980	0	1,822	0	0	0	0	0	0	0	0	10	131	30	30	0	0
29	626	3,094			227	7,880	0	4,875	0	1,717	0	0	0	0	0	0	0	0	0	25	0	0	0	0
30	307	3,296			37	7,812	0	4,770	0	1,611	0	0	0	0	0	0	0	0	0	0	0	0	86	86
31	102	3,293			13	7,719			0	1,506			0	0	0	0			400	400			86	86

As the calculation result, necessary leachate adjustment pond (or sand sedimentation tank) is approximately 15,000 m³.
However, leachate can be storaged inside the sanitary landfill site of which capacity is 4600m³.
Therefore, actually necessary capacity of the pond is approximately, 10,000 m³.

Table X.2.10(2) Leachate Generation Quantity due to Maximum Daily Precipitation for Past 20 Years at the JST Surveyed Site.

Area operating A1 = 44,900 m²
Area operated A2 = 0 m²

Eva quant E= 211 m³/d
Max leachate generation 2,443 m³/d
Necess adjust Pond Vlm 15,795 m³/d
Site inside storage vl 148 d/y
I 4.7 mm/d

The Year is 1984
Observation Station
PUNO / CO-708
L G quant 43,414

LAT. : 15° 50' "S"
LONG : 70° 01' "W"
ALT : 3812 m

DPTO. PUNO
PROV. PUNO
DIST. PUNO

Sinking coefficient

C1 =	0.89		0.91		0.83		0.21		0		0		0		0		0		0.76		0.48		0.61	
C2 =	0.89		0.91		0.83		0.21		0		0		0		0		0		0.76		0.48		0.61	

	January		Febrary		March		April		May		June		July		August		September		Qctorber		November		December	
	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm	Leacht. qunt	Pond vlm
1	24	24	535	6,924	75	13,568	78	15,340	0	9,350	0	2,808	0	0	0	0	0	0	0	0	0	591	5	5
2	879	879	204	6,917	593	13,949	17	15,146	0	9,139	0	2,597	0	0	0	0	0	0	0	0	0	380	121	121
3	795	1,463	212	6,919	779	14,517	0	14,935	0	8,928	0	2,386	0	0	0	0	0	0	300	300	0	169	112	112
4	360	1,612	1,066	7,774	134	14,440	0	14,724	0	8,717	0	2,175	0	0	0	0	0	0	256	345	131	131	8	8
5	775	2,176	286	7,849	11	14,241	0	14,513	0	8,506	0	1,964	0	0	0	0	0	0	10	144	0	0	0	0
6	196	2,161	552	8,190	75	14,104	0	14,302	0	8,295	0	1,753	0	0	0	0	0	0	130	130	0	0	137	137
7	20	1,970	1,054	9,033	0	13,893	0	14,091	0	8,084	0	1,542	0	0	0	0	0	0	0	0	0	0	312	312
8	232	1,991	474	9,296	60	13,742	0	13,880	0	7,873	0	1,331	0	0	0	0	0	0	27	27	0	0	156	257
9	1,195	2,974	200	9,285	343	13,874	0	13,669	0	7,662	0	1,120	0	0	0	0	0	0	0	0	0	0	208	254
10	320	3,083	49	9,123	0	13,682	0	13,458	0	7,451	0	909	0	0	0	0	0	0	0	0	0	0	301	345
11	444	3,316	114	9,026	727	14,178	0	13,247	0	7,239	0	698	0	0	0	0	0	0	2,443	2,443	0	0	8	142
12	100	3,205	609	9,424	361	14,329	0	13,036	0	7,028	0	487	0	0	0	0	0	0	297	2,529	65	65	0	0
13	44	3,037	1,598	10,811	261	14,378	0	12,825	0	6,817	0	276	0	0	0	0	0	0	0	2,318	47	47	30	30
14	40	2,866	543	11,143	75	14,242	0	12,614	0	6,606	0	64	0	0	0	0	0	0	7	2,114	2	2	0	0
15	72	2,727	719	11,651	0	14,031	0	12,403	0	6,395	0	0	0	0	0	0	0	0	369	2,271	39	39	0	0
16	839	3,355	1,185	12,625	0	13,820	0	12,192	0	6,184	0	0	0	0	0	0	0	0	14	2,074	93	93	0	0
17	104	3,249	368	12,782	473	14,082	0	11,981	0	5,973	0	0	0	0	0	0	0	0	0	1,863	360	360	0	0
18	531	3,569	609	13,179	220	14,091	0	11,770	0	5,762	0	0	0	0	0	0	0	0	235	1,887	13	162	0	0
19	128	3,486	670	13,638	533	14,413	0	11,559	0	5,551	0	0	0	0	0	0	0	0	0	1,676	4	4	0	0
20	100	3,374	351	13,779	928	15,130	74	11,421	0	5,340	0	0	0	0	0	0	0	0	75	1,540	60	60	0	0
21	352	3,515	25	13,592	302	15,221	27	11,238	0	5,129	0	0	0	0	0	0	0	0	34	1,364	19	19	121	121
22	348	3,652	617	13,998	0	15,010	80	11,107	0	4,918	0	0	0	0	0	0	0	0	7	1,159	185	185	11	11
23	683	4,124	188	13,975	622	15,421	15	10,911	0	4,707	0	0	0	0	0	0	0	0	0	948	56	56	14	14
24	675	4,588	719	14,483	209	15,419	100	10,808	0	4,496	0	0	0	0	0	0	0	0	0	737	211	211	156	156
25	216	4,593	65	14,338	276	15,483	0	10,597	0	4,285	0	0	0	0	0	0	0	0	10	536	13	13	25	25
26	8	4,390	0	14,127	116	15,388	19	10,405	0	4,074	0	0	0	0	0	0	0	0	334	660	60	60	0	0
27	160	4,339	0	13,915	242	15,419	0	10,194	0	3,863	0	0	0	0	0	0	0	0	3	452	63	63	0	0
28	1,031	5,159	0	13,704	343	15,551	0	9,983	0	3,652	0	0	0	0	0	0	0	0	20	262	60	60	0	0
29	1,255	6,203			455	15,795	0	9,772	0	3,441	0	0	0	0	0	0	0	0	0	51	0	0	0	0
30	615	6,607			75	15,658	0	9,561	0	3,230	0	0	0	0	0	0	0	0	0	0	0	0	173	173
31	204	6,600			26	15,473			0	3,019			0	0	0	0			802	802			173	173

As the calculation result, necessary leachate adjustment pond (or sand sedimentation tank) is approximately 15,800 m³.
However, leachate can be storaged inside the sanitary landfill site of which capacity is 4400m³.
Therefore, actually necessary capacity of the pond is approximately, 12,000 m³

Table X.2.11(1) Leachate Generation Quantity due to Average Daily Precipitation for Past 20 Years at the City Owned Site.

Area under opr A 1 = 41,400 m²
Area operated A 2 = 0 m²
Treatment cap Q = 195 m³/d
Max leachate generatio 1,699 m³/d
Necess adjust Pond Vlm 2,639 m³
Site inside storage vl 0 d/y
Evaporation ratio 4.7 mm/d
Sinking coefficient

Year : 1993
Observation Station
PUNO / CO-708 LAT. : 15° 50' "S" DPTO. PUNO
Lxquant/y= 27,973 m³/y LONG : 70° 01' "W" PROV. PUNO
ALT : 3812 m DIST. PUNO

C_1=	0.89		0.91		0.83		0.21		0		0		0		0		0		0.76		0.48		0.61	
C_2=	0.89		0.91		0.83		0.21		0		0		0		0		0		0.76		0.48		0.61	

	January		February		March		April		May		June		July		August		September		October		November		December	
Day	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm	Leacht. quat	Pond vlm
1	435	435	63	2,027	612	1,151	26	39	0	105	0	0	0	0	0	0	0	0	0	0	41	41	195	195
2	37	277	807	2,639	214	1,170	0	0	0	0	0	0	0	0	0	0	0	0	251	251	44	44	0	1
3	284	366	0	2,445	144	1,119	0	0	0	0	0	0	0	0	0	0	0	0	0	56	0	0	129	129
4	15	186	184	2,434	936	1,860	11	11	0	0	0	0	0	0	0	0	0	0	169	169	0	0	0	0
5	0	0	44	2,284	52	1,717	236	236	0	0	0	0	0	0	0	0	0	0	239	239	0	0	0	0
6	0	0	0	2,089	210	1,733	155	195	0	0	0	0	0	0	0	0	0	0	11	56	0	0	276	276
7	0	0	0	1,895	11	1,549	0	1	0	0	0	0	0	0	0	0	0	0	41	41	958	958	85	167
8	96	96	0	1,700	188	1,543	251	251	0	0	0	0	0	0	0	0	0	0	0	0	88	852	177	177
9	0	0	11	1,517	66	1,414	0	56	210	210	0	0	0	0	0	0	0	0	199	199	685	1,343	37	37
10	0	0	0	1,322	144	1,364	582	582	18	34	0	0	0	0	402	402	0	0	85	89	88	1,236	586	586
11	0	0	0	1,127	0	1,169	0	388	0	0	0	0	0	0	648	856	295	295	15	15	44	1,086	206	598
12	0	0	85	1,018	0	974	0	193	0	0	0	0	0	0	0	661	48	148	0	0	383	1,275	18	421
13	332	332	0	823	0	780	0	0	0	0	0	0	0	0	0	466	0	0	37	37	88	1,169	0	227
14	81	218	41	669	0	585	0	0	0	0	0	0	0	0	0	272	0	0	0	0	258	1,232	0	32
15	114	138	0	474	0	391	0	0	0	0	41	41	0	0	0	77	0	0	0	0	0	1,037	0	0
16	520	-520	0	280	15	211	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	843	33	33
17	648	973	0	85	0	16	0	0	0	0	0	0	0	0	0	0	11	11	4	4	0	648	33	33
18	48	827	313	313	118	118	0	0	0	0	0	0	0	0	317	317	99	99	0	0	103	557	0	0
19	107	739	22	141	140	140	18	18	0	0	0	0	0	0	11	133	103	103	516	516	0	362	0	0
20	77	622	147	147	136	136	0	0	0	0	0	0	0	0	7	7	92	92	287	609	0	168	987	987
21	29	457	92	92	0	0	22	22	0	0	0	0	0	0	11	11	15	15	413	827	0	0	7	800
22	169	432	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	632	0	0	0	606
23	811	1,048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	438	11	11	0	411
24	884	1,737	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	243	0	0	0	217
25	188	1,731	1,699	1,699	140	140	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0	0	0	22
26	678	2,214	0	1,504	214	214	0	0	0	0	0	0	0	0	0	0	0	0	11	11	125	125	940	940
27	280	2,300	203	1,512	7	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	752
28	48	2,153	0	1,318	0	0	140	140	15	15	0	0	0	0	0	0	0	0	0	0	0	0	7	565
29	450	2,408		1,123	578	578	251	251	0	0	0	0	0	0	0	0	0	0	103	103	0	0	147	518
30	118	2,331		928	0	384	243	299	0	0	0	0	0	0	0	0	0	0	166	166	0	0	206	530
31	22	2,159		734	18	208			0	0			0	0	0	0			0	0			29	365

Table X.2.11(2) Leachate Generation Quantity due to Average Daily Precipitation for Past 20 Years at the JST Surveyed Site.

Area under opr A 1 = 44,900 m²
Area operated A 2 = 0 m²
Treatment cap Q = 211 m³/d
Max leachate generatio 1,842 m³/d
Access adjust Pond Vlm 2,862 m³
Site inside storage v! 0 d/y
Evaporation ratio 4.7 mm/d
Sinking coefficient
C_1 = 0.89 0.91 0.83 0.21 0 0 0 0 0 0.76 0.48 0.61
C_2 = 0.89 0.91 0.83 0.21 0 0 0 0 0 0.76 0.48 0.61

Year : 1993
Observation Station
PUNO / CO-708 LAT. : 15° 50' "S" DPTO. PUNO
Lysimeter/y= 30,338 m³/y LONG : 70° 01' "W" PROV. PUNO
ALT : 3812 m DIST. PUNO

	January		February		March		April		May		June		July		August		September		October		November		December	
Day	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm	Leachate quant	Pond vlm
1	472	472	68	2,198	663	1,248	28	42	0	118	0	0	0	0	0	0	0	0	0	0	44	44	212	212
2	40	300	875	2,862	232	1,269	0	0	0	0	0	0	0	0	0	0	0	0	272	272	48	48	0	1
3	308	397	0	2,651	156	1,214	0	0	0	0	0	0	0	0	0	0	0	0	0	61	0	0	140	140
4	16	202	200	2,640	1,015	2,018	12	12	0	0	0	0	0	0	0	0	0	0	184	184	0	0	0	0
5	0	0	48	2,477	56	1,863	256	256	0	0	0	0	0	0	0	0	0	0	260	260	0	0	0	0
6	0	0	0	2,266	228	1,879	168	213	0	0	0	0	0	0	0	0	0	0	12	61	0	0	300	300
7	0	0	0	2,055	12	1,680	0	2	0	0	0	0	0	0	0	0	0	0	44	44	1,039	1,039	92	181
8	104	104	0	1,844	204	1,673	272	272	0	0	0	0	0	0	0	0	0	0	0	0	96	924	192	192
9	0	0	12	1,645	72	1,534	0	61	228	228	0	0	0	0	0	0	0	0	216	216	743	1,456	40	40
10	0	0	0	1,434	156	1,479	631	631	20	37	0	0	0	0	436	436	0	0	92	97	96	1,341	635	635
11	0	0	0	1,223	0	1,268	0	420	0	0	0	0	0	0	703	928	320	320	16	16	48	1,178	224	648
12	0	0	92	1,104	0	1,057	0	209	0	0	0	0	0	0	0	717	52	161	0	0	416	1,382	20	457
13	360	360	0	893	0	846	0	0	0	0	0	0	0	0	0	506	0	0	40	40	96	1,267	0	246
14	88	237	44	725	0	635	0	0	0	0	0	0	0	0	0	295	0	0	0	0	280	1,336	0	35
15	124	149	0	514	0	424	0	0	0	0	44	44	0	0	0	84	0	0	0	0	0	1,125	0	0
16	563	563	0	303	16	229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	914	36	36
17	703	1,056	0	92	0	18	0	0	0	0	0	0	0	0	0	0	12	12	4	4	0	703	36	36
18	52	897	340	340	128	128	0	0	0	0	0	0	0	0	344	344	108	108	0	0	112	604	0	0
19	116	802	24	153	152	152	20	20	0	0	0	0	0	0	12	145	112	112	559	559	0	393	0	0
20	84	674	160	160	148	148	0	0	0	0	0	0	0	0	8	8	100	100	312	660	0	182	1,071	1,071
21	32	495	100	100	0	0	24	24	0	0	0	0	0	0	12	12	16	16	448	897	0	0	8	868
22	184	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	686	0	0	0	657
23	879	1,136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	475	12	12	0	446
24	959	1,884	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	264	0	0	0	235
25	204	1,877	1,842	1,842	152	152	0	0	0	0	0	0	0	0	0	0	0	0	0	53	0	0	0	24
26	735	2,401	0	1,631	232	232	0	0	0	0	0	0	0	0	0	0	0	0	12	12	136	136	1,019	1,019
27	304	2,494	220	1,640	8	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	816
28	52	2,335	0	1,429	0	0	152	152	16	16	0	0	0	0	0	0	0	0	0	0	0	0	8	613
29	488	2,611		1,218	627	627	272	272	0	0	0	0	0	0	0	0	0	0	112	112	0	0	160	562
30	128	2,528		1,007	0	416	264	324	0	0	0	0	0	0	0	0	0	0	180	180	0	0	224	574
31	24	2,341		796	20	225			0	0			0	0	0	0			0	0			32	395

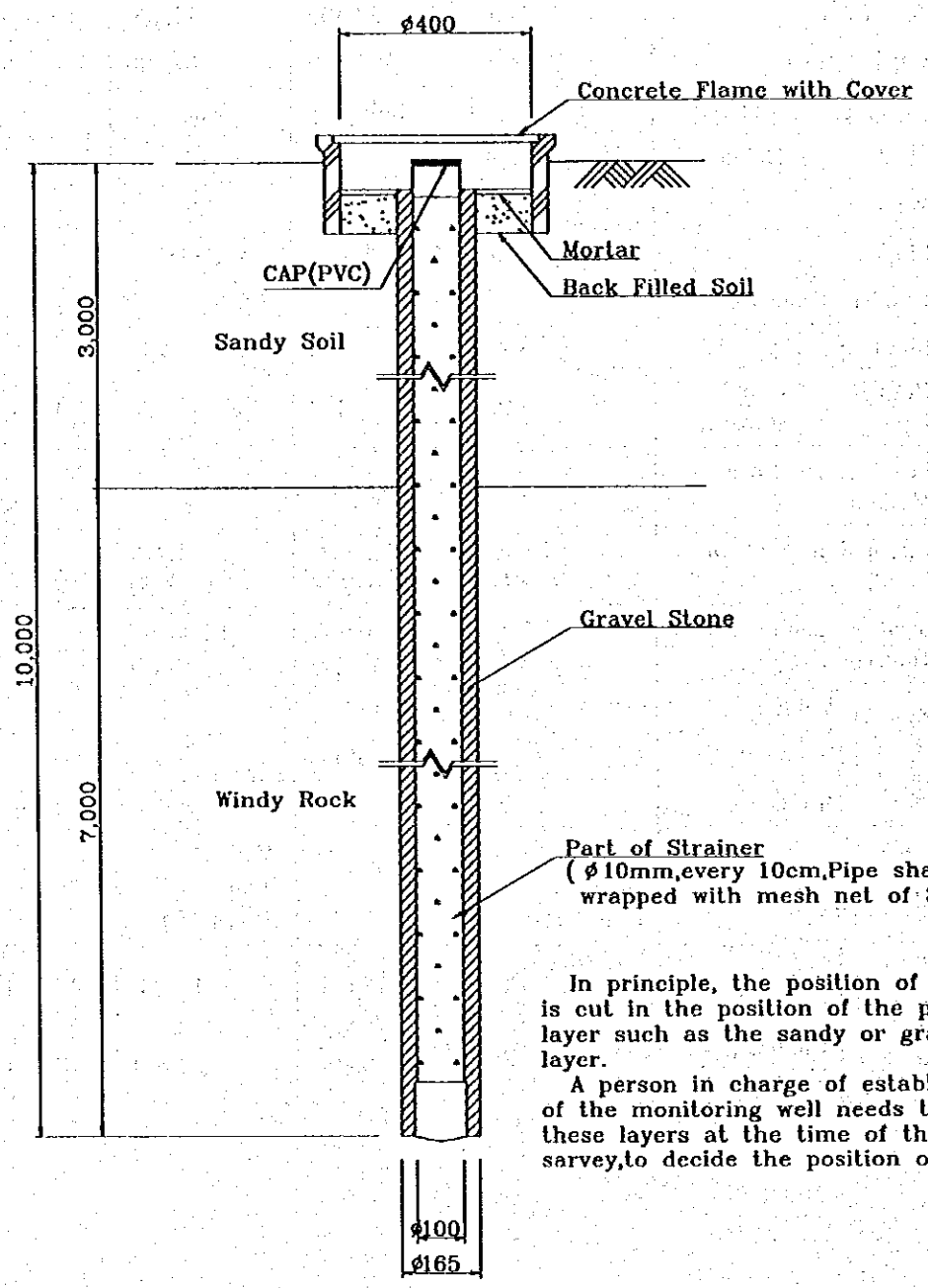
7) Description of the Total Plan of the Facilities

TableX.2.12 Total Plan of facilities

Name of Landfill Site		City Owned Site(1st Site)	City Owned Site(2nd Site)	JST Surveyed Sites	Total	Remarks
Area (m^2)		19,100	22,300	22,400	63,800	
Capacity(m^3)		85,000	106,500	107,100	298,600	
Embank-ment	Material	Soil	Soil	Soil	—	
	Height	5.0 m (ave).		4.5 m (ave)	—	
Width		7.0		7.0	—	
Slope		V:H=1:2		V:H=1:2	—	
Leachate Collector						
Main Pipe	ϕ 250 (m)	360	300	240	900	
Branch Pipe	Cobble-stone(m)	340	450	450	1,240	
Leachate Treatment Method		Circulation			—	
Circulation Quantity (m^3/d)		1,039 (784)	2,253*1 (1,699)*1	1,219 (919)	—	(20 Max) (20 Ave)
Sand Sedimentation Tank (m^3)		2,200 (0)	10,000 (0)	12,000m^3 (0)		(20 Max) (20 Ave)
Approach Road	Width	8.0m			—	
	Pavement	Crushed Stone			—	
	Distance	300m		1,350m	1,650m	
Environmental Monitoring System		Well 4units 10m, ϕ 150		Well 4unit 10m, ϕ 150		
Impermeable Layer of Clay	Area(m2)	14,800	17,600	14,800	47,200	
	Cubic Volume (m^3)	22,200	26,400	22,200	70,800	

SECTION OF MONITORING WELL

S=1:15



In principle, the position of strainer is cut in the position of the permable layer such as the sandy or gravel sandy layer.

A person in charge of establishment of the monitoring well needs to investigate these layers at the time of the bore hole sarvey,to decide the position of strainer.

Figure X.2.14 SECTION OF MONITORING WELL

REPUBLICA DEL PERU		THE REPUBLIC OF PERU	
NOMBRE DE PLANO		NAME OF DRAWING	
		Section of Leachate Ejection Pipe	
ESCALA	FECHA	SCARE	DATE
1:200	Nov.1999	1:200	Nov.1999
ESTUDIO PARA EL CONTROL INTEGRAL DE LA CONTAMINACION DEL AGUA DE LA BAHIA INTERIOR DE PUNO EN EL LAGO TITICACA EN LA REPUBLICA DEL PERU		STUDY FOR THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERNAL BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU	
JICA - AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON		JICA - JAPAN INTERNATIONAL COOPERATION AGENCY	

(6) Necessary Equipment to be Installed

Necessary equipment for Sanitary Landfill Site are considered as follows,

a. Bulldozer

The main equipment for Sanitary Landfill site for leveling of the hauled wastes and covering by soil after compacting.

b. Backhoe

Used for excavation of the site and picking of soil for covering.

c. Dump Truck

Used for transport of covering soil.

d. Truck Scale

For fundamental data necessary for Sanitary Landfill Site, the equipment for use for weighing of hauled wastes is indispensable.

e. Generator

For use for water drainage and Administration Facilities.

(7) Staff Plan

The present staff for 6 are necessary irrespective to the Alternative Plan for Collection and Transport.

3. IMPLEMENTATION PROGRAM

3.1 CONSTRUCTION WORK OF SANITARY LANDFILL SITE.

The PELT (Special Binational Project for Lake Titicaca) has experiences of civil construction work such as irrigation dams, roads, open channels, etc. Therefore, there is no problem to construct the Sanitary Landfill Site for Peruvian side including the Puno City as technical aspect.

The following procedure will have to be stepped until the construction work starts for the City of Puno.

(1) Obtaining of land and budget.

(2) Selection of Consultant.

(3) Detailed survey at the site by the consultant including some survey such as geological and topographical.

(4) Environmental Impact Assessment according to the Technical Standard of the DIGESA.

(5) Submission of the documents concerning the construction work to the DIGESA in order to obtain the permission of it.

(6) Detailed design.

(7) Preparation of the Tender Document.

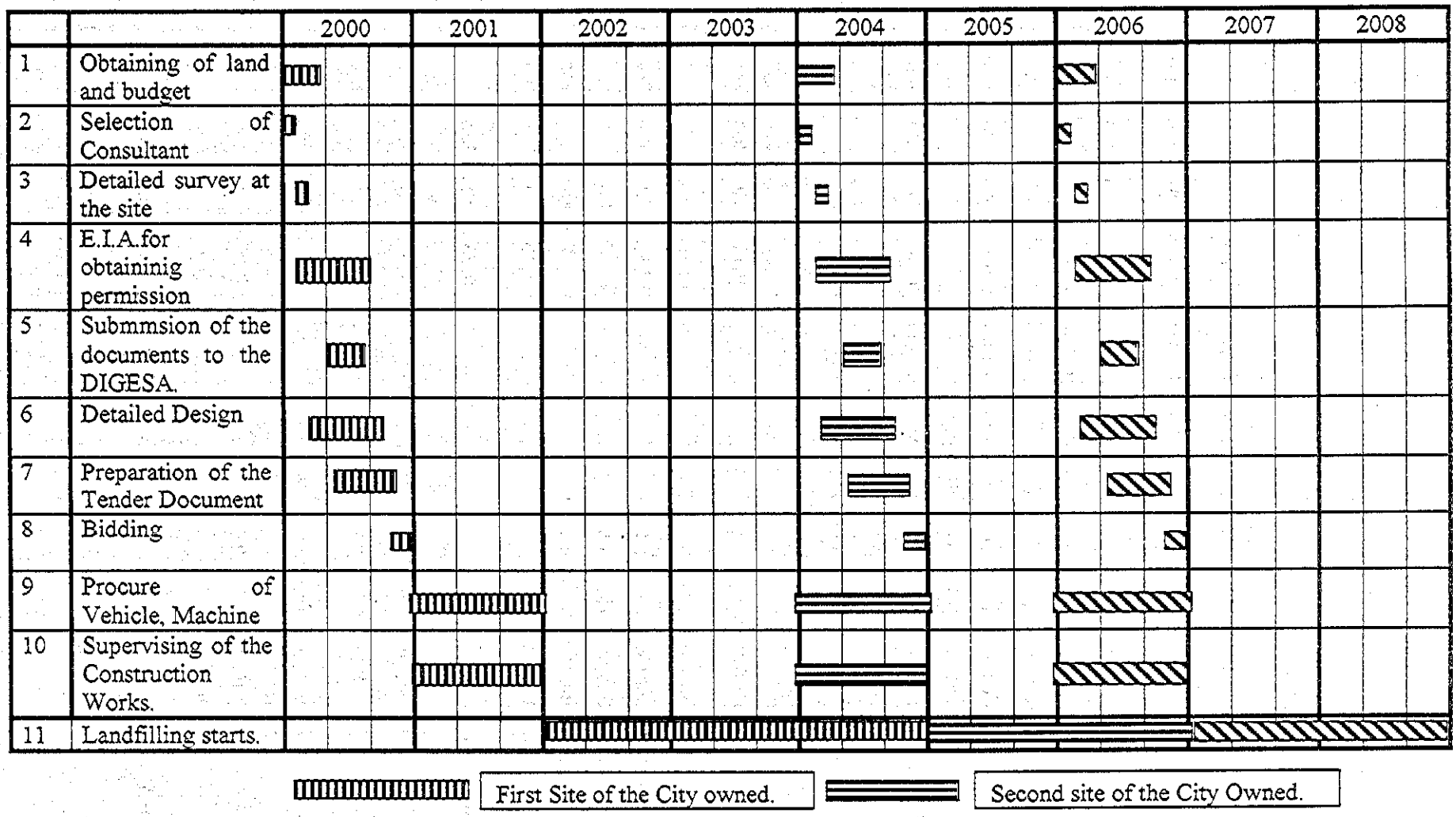
(8) Bidding for the construction work.

(9) Procurement of vehicles and heavy machines

In order to proceed above procedure, one year is absolutely necessary at least. Then, the construction work will be able to start in 2001.

The implementation program is shown in the *Figure X.3.1*

Figure X.3.1 Implementation Program.



4. PROJECT COST

(1) Condition

Condition for cost calculation are summarized as follows,

1) Most costs are expressed under the economic conditions that prevailed in 1998,
2) The construction work is assumed to be contracted to Peruvian general contractors, and the operation and maintenance work is conducted by the staff of the municipality.
3) For the estimation, the costs in Peru are used except that in Japan which is used for leachate collection pipe.
4) The engineering service cost is assumed to be 5 % of the total of direct construction costs.
5) The physical contingency is assumed to be 15 % of the total of the direct construction costs and the engineering service costs.

(2) Construction cost	**9,113,000 Soles**
Breakdown;	
1) Direct Construction Cost	7,527,000
2) Land Acquisition Cost	22,000
3) Engineering Service Cost	377,000
4) Contingency	1,187,000
(3) Equipment	**3,738,000 Soles**
1) Vehicles for collection & transportation	1,985,000
2) Heavy machines & dump truck	1,753,000
(4) Operation and Maintenance Cost	**9,682,000 Soles**
1) For collection & transportation	6,900,000
2) For final disposal	2,782,000
GRAND TOTAL	**22,533,000 Soles**

(not including IGV)

5. MANAGEMENT OF THE PROJECT

5.1 COLLECTION AND TRANSPORTATION.

Table X.5.1 shows the necessary maintenance items for the activity of the collection and transportation.

Table X.5.1 Items to be Managed for the Collection and Transportation.

Items	Contents	Remarks
Establishment of necessary budget	Obtain of necessary budget for procurement of equipment and employment.	
Allocation of the staffs	Allocation of the staffs for work places	
Allocation of the procured vehicles and tools	Allocation of procured vehicles for the necessary collection routes and zones.	
Daily check of efficient for the waste collection and transportation	Check the daily work for all the actual result of SW collection and transportation.	
Preventive maintenance	Execution of preventive maintenance for vehicles periodically.	
Supplement of spare parts and consumables	Spare parts and consumables shall be checked and supplied periodically, always arrange the organization of the city that is able to supply them.	
Complaint processing	The city always has to arrange an organization and staffs to cope with the complaints from the inhabitants.	

5.2 FINAL DISPOSAL.

As the management of the sanitary landfill site, three aspects are required. First one is the preparation work to the construction, secondary, the management of the site under use, and the last one is management of the site after use. It is natural that all of the items shall be met with the DIGESA TECHNICAL STANDARD. The *Table X.5.1* shows the main contents of the Technical Standards for the maintenance.

Table X.5.2 Items to be managed for Sanitary Landfill Site.

	Items	Contents	Remarks
Preparation Work	Make of the Prerequisites	According to the DIGESA TECHNICAL STANDARD.	
	Geological Survey	-Confirmation of the permeability of the candidate site and ground water level changes through the year. -Physical and mechanical soil test shall be conducted in order to get the embankment slope and character of covering soil and so on.	
	E.I.A.	-As the result of I.E.E., hardly found out of environmental issue in this project under the present conditions. If it is conceivable that such as the city planning is changed, reconfirmation of IEE and take measures for items concerned if any.	
Under use of the site.	Items under use of the site.	The following items shall be managed in accordance with the Technical Standard. -Control and registration of the carry-in of wastes. -Discharges. -Spread and compaction -Covering -Drainage of superficial waters, gases and leachate. -Control of the contamination of underground water. -Control of Burning of Wastes -Control of Vectors and Rodents -Control of the segregation -Measures of security and contingencies plan -Corrective Work	
After use	Items after use of the site.	The following items shall be managed in accordance with the Technical Standard. -Final covering and maintenance of the covering soil. -Future Use of the Landfill Area.	In case of the rainfall is over 300 mm/year at the site, final covering soil shall be clay.

6. PROJECT EVALUATION

6.1 TECHNICAL ASPECT

(1) Collection and Transportation

1) Since the waste collection method is not technically special but ordinary, the proposed Project is possibly implemented without any problem.

2) The frequency of collection in the north and south sides of C zone is twice a week, three times a week as in the central City. The area of collection is also expanded.

The plan for expansion of collection services is projected as follows;

Comparison of data in 1998 and 2008 for expansion of services

(1998)

a. Expenses for collection service of waste per ton

936,482 soles/year÷360 days=2601soles/d
2,601÷35.5ton/day=73.3 soles

b. Number of residents receiving service per a Municipality's staff

35,500kg/d÷0.62kg/capita day=57,250person
57,250÷109person=525person

c. Number of residents receiving service per a collection vehicle

57,250 person÷4 vehicles=14,313 person

(2008)

a. Expenses for collection service of waste per ton

1,301,000 soles/year÷360 days=3,614soles/d
3,614÷58.3 ton/day=62.0 soles/ton

b. Number of residents receiving service per a Municipality's staff

58,300 kg/d÷0.41kg/capita day=142,195 person
142,195÷160person=889person

c. Number of residents receiving service per a collection vehicle

142,195 person÷9 vehicles=15,800 person

Accordingly, it is apparent that

- The expenses for collection services per a ton of Waste are reduced by 20%.
- The number of residents receiving benefit of services by Municipality's staff are increased by about 70%.
- The number of residents receiving services by collection vehicles are increased 10%.

TRAFFIC

Number of trips of collection vehicles shows increase as follows; those figures are comparatively small to the total numbers of traffic in the City. Accordingly, the increase of number of collection vehicles does not affect the environment in this connection.

1998	4 units operating	Total 8 trips per day
2008	9 units operating	Total 25 trips per day

(2) Final Disposal

Comparison Table is shown in *Table X.6.1* that shows the difference between the present disposal site situation and the planed sanitary landfill site situation. Items designated in the *Table X.6.1* are indispensable to make good environmental condition and to comply with the Standard. As result of implementation of below items, present situation of the site will be improved as environmental aspect.

However, as for the initial investment, the facilities have to be in accordance with the standard and as for the maintenance for the present site, the covering soil of only once is implemented in 4 months from 3 months, that changes to daily covering. Then necessary budget for initial investment and operational cost increase. In order to obtain this increase, improvement of the budget is required.

Table X.6.1 Comparison Table between Present site and Planned Site.

	Items	Present site situation	Planed site situation	Remarks
Facilities	Embankment	Established with soil	Planed with soil in accordance with the Standard.	
	Open channel for superficial water	Soil Open Channel is established	Soil Open Channel is planed.	
	Leachate Collector	No installation	HDP Pipe of ϕ 250 × 2 routes are planed in each site.	
	Gas drainage	As for closed site, the drainage was established, the site under use has no gas drainage.	Gas drainage is planed in accordance with the Standard.	
	Impermeable layer with clay at the bottom	No installation	1.5m of thickness of the impermeable layer is planed in accordance with the Standard.	
	Leachate treatment	No installation	Circulation system is adopted which is designated in the Standard.	
	Fence	Installed	The height of 1.8 Fence is planed.	
	Administration House	No installation	200 m^2 of administration house is planed for scaling of hauled waste.	
	Truck Scale	No installation	30 ton truck scale is planed.	
	Monitoring Well	No installation	4 Monitoring well are planed for each	
Operation	Covering soil	One time / 3 months is carried out.	Daily covering and Final covering is planed.	
	Final Covering Soil	Executed	Execution is planed.	

6.2 FINANCIAL ASPECT

1) Conditions for Finance Analysis

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

(a) Inflation estimation is omitted

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

(c) Revenue of solid waste project will grow with

i) the increase of Puno household

ii) the increase of solid waste charge with economic growth

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

iii) the increase of collection rate of waste handling charge

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

iv) the implementation of environment fee, so to speak environment fee for "save Lake Titicaca" for tourists

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

v) the contribution by PRONAA

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

vii) the contribution by the state government

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

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

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

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

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

(i) All facilities and equipment will be sold out at the remaining value in 2008F/Y

2) Financial Viability of Proposed Project

(i) Results of Financial Viability

In Chapter VI of master plan, the following three cases were recommended to increase the revenue for solid waste management in Puno.

Case6: Waste handling charge is 48soles/household/yr and environment fee is 1.4$/day/person under the condition that the expenditure for engineering service is covered by a contribution of Peru government.

Case7: Waste handling charge is 64soles/household/yr and environment fee is 1.1$/day/person under the condition that the expenditure for engineering service is covered by a contribution of Peru government.

Case8: Waste handling charge is 48soles/household/yr and environment fee is 1.2$/day/person under the condition that the expenditures for engineering service, heavy machines, and vehicles are covered by a contribution of Peru government.

The viabilities of these cases were analyzed for the term by 2025yr that is a target year of master plan. Therefore, these viablilities should be estimated again for the term by 2008yr that is a target year of feasibility study.

In the *Table X.6.2*, the results of financial viability analyses on the three cases are shown.

Table X.6.2 Results of Financial Viability

	Waste Handling Charge	Environment Fee	FIRR
	soles/household/yr	$/day/person	%
Case 6	48	1.4	0.7
Case 7	64	1.1	1.3
Case 8	48	1.2	15.4

From the results of financial viability, the following facts can be said.

- Environment fee of Case 6 should be raised to make FIRR (0.7%) surpass 7% at F/S stage.
- Environment fee of Case 7 should be raised to make FIRR (0.7%) surpass 7% at F/S stage.
- Environment fee of Case 8 seems suitable, because FIRR (15.4%) exceeds 7% of interest rate of soft loan. However, P/L of Case 8 is negative, environment fee must be therefore raised to make P/L positive at F/S stage.

3) Financial Plan

(i) Calculation for Acceptable Financial Plan

Table X.6.3 Recommendable Combinations

	Waste Handling Charge	Environment Fee	FIRR	P/L	Revenue Balance
	soles/household/yr	$/day/person	%	1,000 soles	1,000 soles
Case 9	48	2.1	13.6	9	1,466
Case 10	64	1.8	14.2	214	1,670
Case 11	48	1.4	21.1	140	1,596

*1: Engineering service of Case9,10 are covered by a contribution of Peru government.

*2: Engineering service, heavy machines, and vehicles of Case11 are covered by a contribution of Peru government.

*3: P/L stands for Profit –Loss.

Based on the results of analyses shown in the *Table X.6.3*, Case9,10,and 11 are recommendable for the target year of 2008yr. Reasons in detail to choose Case9,10,and 11 are descried as follows:

Reason1: FIRRs are over 7% of discount rate.

Reason2: P/Ls are positive.

Reason3: Compared with accommodation charge in Puno, 1.4-2.1 $/day/person for an environment fee seems acceptable.

(ii) Implementation of Financial Plan

In the *Table X.6.4*, advantages of each case are described.

TableX.6.4 Advantage of Each Case

	Waste Handling Charge	Environment. Fee	Advantage
	soles/household/yr	$/day/person	
Case 9	48	2.1	If the priority of citizens is higher than the one of tourist, and if heavy machines and vehicles are not covered by a contribution, Case 9 is the most suitable.
Case 10	64	1.8	If the priority of tourist is higher than the one of citizens, and if heavy machines and vehicles are not covered by a contribution, Case 10 is the most suitable.
Case 11	48	1.4	If the expenditure of engineering service, heavy machines, and vehicle is covered by a contribution of Peru government, Case 11 is the most suitable.

There are some crucial points to execute Case9,10,11 as follows:

Point1:The present collection rate of the waste handling charge must be increased by 1.46% annually. This method can be executed without a fundamental change of solid waste management in Puno.

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

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

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

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

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

CHAPTER - XI CONCLUSIONS

CHAPTER – XI

CONCLUSIONS

1. INTEGRATED WATER POLLUTION CONTROL PLAN

Based on the discussions in the previous chapters, the Integrated Water Pollution Control Plan for Puno Interior Bay is summarized as follows.

1.1 PROPOSED PLAN

Components of the Integrated Plan are as follows:

(1) External Pollution Load Reduction

1) Wastewater control

a. On-site system (Sanitary toilet)

On-site facility : Pit Latrine (0.7 W × 0.7 L × 1.5 H = 0.74 m^3)
Pit emptying : Small (vacuum) pit emptying machine (500 L/unit)
Sludge disposal : Truck (loading capacity: 2 ton)

b. Off-site system

Wastewater collection system

Sewer Total Length = 136,234 m

Phase 1 (1998-2008)	Length = 23,396 m
Phase 2 (2009-2015)	Length = 46,832 m
Phase 3 (2016-2025)	Length = 66,007 m

Pump Station E.B. EL PUERTO

Submersible pump (5.25 l/s, 8.6 m, 1.2 kW, 1 set (+1))

Wastewater treatment plant

Pump station Submersible pump (200l/s, 8.6m, 30kW, 2 sets (+1))
Aerated lagoon 3 basins

Coagulant dosing equipment

Sedimentation pond 3 basins

Inlets for facultative lagoons

Primary lagoon 1 basin (existing facultative lagoon)

Secondary lagoon 1 basin (existing facultative lagoon)

Outlet facility for the second facultative lagoons

Constructed wetland (Totora) 34 basins (sub-surface flow type)

2) Urban Drainage

Improvement for the drainage channels (5-year return period) : total length = 12 km

- enlargement/lining of the existing channels, construction of additional drainage

(2) Solid Waste Management

1) Removal of illegally dumped Wastes

Complete removal of the wastes by using citizen's voluntary participation.

2) Increase of Collection Rate

	Year	2008	2025
Required Number of Solid Waste Collection Vehicle	12 m^3 compactor	1	2
	4 m^3 compactor	7	15
	6.8 m^3 dump	1	5
	Tricycle	5	5
Manpower		153	204

3) Expansion and Upgrading of Final Disposal Site

Sanitary landfill according to the technical guideline of DIGESA. According to the technical guideline issued by DIGESA, 10 sanitary landfill sites having acreage of 20,000 m^2 - 37,000 m^2 are to be constructed stepwise. At the sites, heavy equipment will be also required.

(3) In-Lake Management

1) Removal of *Lemna*

Target area : the western part of Puno Interior Bay

Regular removal of *Lemna* by a low-draft barge harvesting equipment (harvesting rate: 30~40 t/day) is proposed.

2) Bottom Sediment Cover

The areas for the sediment cover is the western part of Puno Interior Bay where the water depth is smaller than 3.5 m and the equipment can be operated. Possible covering material is silty sand which is distributed along the navigation channel of Puno Interior Bay.

Target area : 2,400,000 m^2 (the western part of Puno Interior Bay)

Covering volume : 720,000 m^3 (covering thickness : 0.30 m)

Covering material : silty sand which is distributed along the navigation channel in Puno Interior Bay

3) Replanting of Reed (Totora)

Target area : along the the western shore of Puno Interior Bay

Major processes of the rehabilitation of Totora are a multiplication of seedling Totora and a planting of multiplied Totora. The seedling Totora should be planted along the western shore of Puno Interior Bay.

- Unit Totora belt : length = 200 m, width = 40 m
- Number of unit : 18 units
- Total of planting area : 14.4 ha

(4) Non-structural Measures

1) Environmental Education and Campaign

The following measures are proposed.

- The **institutional consolidation plan;**
- The **public education program;**
- The **enlightenment campaign (installation of *the Clean Day)*;**
- The **enforcement of environmental regulations.**

(5) Environmental Monitoring

1) Monitoring program for effluents

Food and processing industries (4 workshops)
Slaughter house (1 facility)
Espinar wastewater treatment plant (1 facility)

2) Monitoring program for Water bodies

a. Physical and Chemical Condition

Lake water (7 main points, 5 supplementary points)
Drainage channels (5 points)
Lake sediment (12 points)

b. Biological Conditions

Lake water (Plankton,Benthos and Macrophytes)

1.2 IMPLEMENTATION PROGRAM

Implementation program for the Integrated Plan are summarized in *Table XI.1.1*. Among the proposed components, the sewerage systems improvement, the solid waste management and the environmental monitoring should be implemented as first priority projects in Puno.

Water quality improvement should be begun with the external pollution load reduction. Especially, the sewerage systems improvement is the most effective way in Puno City where domestic and commercial wastewater are major point sources of pollution loads. As on-site treatment of domestic wastewater, sanitary toilet is recommended. But it will take a time that such toilet become popular, and so it is the second priority. Urban drainage should be improved as early as possible in order to prevent the rainwater from overflowing into the sewer network. However its direct effect on the lake water quality improvement is small and it is rather difficult to treat the flooding water directly.