ANNEX

ANNEX

I. State of the Art in Soil Treatment Technology

I.1 State of the Art in Other Countries

A subleaching system in which household waste water travels through trenches from each individual household has long been employed in the United States in regions where the construction of large sewage systems is unfeasible. A typical example, is called the septic tank and soil Infiltration system. This system assumes filtration, bacterial breakdown and chemical absorption in the process of soil percolation, after oils and large solid particles are removed by flotation and sedimentation in the septic tank. Since such systems are strongly reliant on nature's own purifying powers, excessive loads and/or improper maintenance management often cause pipe clogging and groundwater contamination; therefore, the U.S. Environmental Protection Agency (EPA) and other institutes have been continuously researching and studying proper design, construction and management for over ten years.

Here is a brief introduction of the state of the art in the U.S..

1) Structure of the Septic Tank and Soil Percolation System

   In the U.S., about 98% of individual household waste water treatment employs a septic tank as the first treatment, followed by a soil Infiltration trench as the second treatment. A typical system is shown in the previously mentioned Fig. S8.A.1. A septic tank consists of one or two tanks, with rectifying plates attached at the inlet and outlet. Unprocessed waste water enters the tank; where components with a light specific gravity, oil and so-called 'scum' float, while large, heavy solid particles settle to the bottom of the tank and become sludge. The discharge from the tank contains floating pollutants which have been discharged, as is, from the center of the tank.

   The second step in the usual type of on-location waste water treatment provides water to a trench constructed underground, causing Infiltration through the soil. Fig. S8.A.3 shows a cross section of this soil trench.

2) Soil Infiltration and Proper Load

The first condition for design of a proper soil Infiltration system is to set a proper load. Determination of the proper load from the results of measurement of soil Infiltration may be considered one method. The auger percolation test has been provided as a simple, inexpensive on-location test procedure. It measures the speed at which water drops in auger holes filled with water to a depth of several feet. If the test is standardized, it is quite effective in indicating the permeability characteristics of a given location.

Fig. S8.A.4 shows the relationship between the results of the Infiltration test and possible long term load. In the Fig., the ordinate shows the load in units of gallons/sq. ft./day (1gal/sq. ft. - 40.75l/sq. m). The abscissa shows the time required for water to drop one inch in the Infiltration tests, in one minute units. Lyon's curve is an analysis which only considered the area of the bottom of the trench as the effective Infiltration area, but has been revised to consider not only the bottom, but also the sides of the trench as effective in Infiltration. Fig. S8.A.5 shows the revised Lyon's curve.

The U.S. Public Health Service has declared standard waste water volume to be 50gal/day·room (=567.8l/day·room), and design values can be computed by combining this value with the revised Lyon's curve.

I.2 Consideration of Proper Load in Soil Treatment

When processing domestic waste water with the soil Infiltration system, the most important thing is to maintain proper balance between the quantity and quality of the waste water to be treated and the soil Infiltration. The following items should be investigated in advance when domestic waste water will be treated by soil Infiltration.

Quality of waste water

Design volume

Preprocessing and its effects

Water quality: 1) SS volume
2) Volume of organic substances

And, when special waste water is introduced, it is necessary to determine whether or not it contains harmful substance.

Soil quality
Landscape conditions
Type and structure
Infiltration
Percolation capabilities
Retention capabilities
Other

1) Reciprocal Relationships and Soil Infiltration

The following items should be evaluated from the perspective of waste water treatment to maintain soil Infiltration.

(1) Waste water should be introduced into the mid-soil, well away from the surface.

(2) The waste water introduced infiltrates through the soil by gravity, and reaches groundwater after traveling a certain distance.

(3) The groundwater absorbs this incoming water into its flow at a certain speed.

2) Infiltration

The following conditions influence infiltration:

(1) Surface Characteristics

Special attention to the density of the soil surface is necessary during construction when soil treatment utilizes trenches, as well as the presence and type of vegetation, and soil particle formations and density.

(2) Type and Structure of Soil

The size of soil particles is most closely related to effluent blockages. Also, Infiltration capabilities are noticeably influenced by the characteristics of the soil structure. Since strata having ideal uniformity are generally rare, Infiltration capabilities can vary considerably even in the same region.

(3) Physical Chemistry Factors

Temperature, distribution of particle diameter, chemical properties of particles, the number of colloid particles, the erosion and absorptivity of particles.

(4) Biological Factors

Due to the structure of biological layers which are generally active close to the surface of the soil, forming an organic substance which both prevents blockages when the sanitary sewage load is proper, and at the same time is essential in the function of breakdown and purification of organic substance.

II. Lagoon Process

II.1 Characteristics of the Lagoon

The word 'lagoon' originally meant a small bog area; but in the field of waste water treatment, whether natural or manmade, the definition means a pond-like facility to process organic waste water by means of the purifying action of microorganisms, during relatively long term retention.

There are various types of lagoons which are often defined by plant configuration. Generally they are classified by means of the principal microbial purification mechanism, as shown in Tab. S8.A.1.

These lagoons each have their own unique characteristics, with little in common. As a rule, however, similar characteristics are as follows.

A relatively large land area is required, but construction costs are inexpensive since it is a non-mechanical facility.

Controls are few, therefore maintenance management is easy and inexpensive.

Retention time is long, and therefore changes in waste water volume and quantity are rare; while there is great resistance against sudden influxes of any toxic agents. However, once the treatment function deteriorates, recovery is protracted.

Apart from aeration lagoons, treatment mechanisms are complex; systems research and analysis lags; and feasible design standards and operations guidelines have not been established.

Treatment capabilities may vary seasonally due to environmental factors such as temperature and amount of sunlight.

There are concerns that trouble may be caused in the surrounding areas due to the stench of hydrogen sulfide and the production of harmful insects such as mosquitoes.

In spite of the many problem points mentioned above, in view of the low construction costs and the ease of maintenance, lagoon treatment may be described as an excellent treatment technique. In the United States, where land for such treatment sites is in surplus, lagoons are being widely employed principally at small volume treatment plants. E.g., 30% of secondary sewage processing plants in the U.S. are lagoons. It is also common in the industrial waste water field, where the canning industry engages in seasonal operations. The lagoon system is rarely used in Japan, because treatment sites are situated close to cites; due to land use conditions, and the impact on residential areas. In the future, however, the lagoon might prove valuable for small scale plant waste water and for small villages in the mountains or near the shore where it is necessary to establish treatment techniques with easy maintenance.

II.2 Stabilization Pond

Lagoons where the photosynthetic action of algae plays a role in the purification mechanism are generically termed stabilization ponds. The stabilization pond is a treatment technique which uses the natural self purification action of a natural body of water, virtually as is, it is only because the self purification mechanism is complex that analytical research lags, while there are many conflicting arguments about techniques.

II.2.1 Oxidation Ponds and Facultative Ponds

Stabilization ponds are subcategorized into oxidation ponds and facultative ponds depending on the water depth and the presence of an anaerobic layer.

An oxidation pond is a small lagoon with a depth of less than 0.5m and the distribution of matter within the pond is kept relatively uniform by indirect mixing, such as fluid circulation, etc. The BOD material in the effluence is oxidized and dissolved by aerobic micro organism in the same manner as the activated sludge system, and the oxygen consumed in the process is provided mostly from the photosynthetic action of algae. Dissolved BOD is removed with a fairly high efficiency, but the treated water contains a high concentration of algae.

A facultative pond is deeper than an oxidation pond, 1.0-2.5 m deep. The layer near the surface, like the oxidation pond, has an aerobic environment for photosynthesis, the bottom layer, where sunlight barely reaches, is an anaerobic environment. BOD material in sewage is primarily broken down by the aerobic microbes in the surface layer. Organic solids, and algae produced in the surface layer, are broken down by fermentation by the anaerobic microbes in the bottom layer, especially the bottom of the pond. Since both aerobic and anaerobic reactions are occurring simultaneously in the same pond, the pond is called a facultative pond. The concentration of algae contained in the treated water is not as high as in the oxidation pond. Most stabilization ponds in the U.S. are classified as facultative ponds.

II.2.2 Microbial Reactions in Stabilization Ponds

1) Photosynthesis and Symbiosis

The purification action of micro organism in stabilization ponds may be described as the symbiotic action of aerobic microbes and algae. I.e., aerobic microbes use the oxygen generated by the photosynthesis of algae to break down BOD materials, while the algae, on the other hand, use carbon dioxide, the product of oxidation, for photosynthesis. Thus, both symbiose with each other, exchanging oxygen and carbon dioxide, and organic effluent is purified in the process.

A characteristic of removal of organic substance by biologic processes, is that the organic substance are concentrated in living cells, while some organic substance are transformed into relatively harmless gases such as CO_2 or CH_4. In the above mentioned symbiotic system, aerobic micro organism oxidize organic agents into carbon dioxide, and if all the required oxygen is provided by photosynthesis, the reaction of the complete symbiotic system is simply to concentrate BOD materials in the cells of aerobic microbes and algae, and virtually no gaseous reactions can be expected. The reactions shown in Table S8.A.2 are calculated with glucose ($C_5H_{12}O_6$) instead of the BOD materials in sewage. In this case, the reaction of the complete symbiotic system converts organic carbon into inorganic while oxygen does not take part in the reaction. The theoretical COD is equal for the organic agents of the reaction system (glucose) and the organic agents of the ecosystem (aerobic micro organism cells and algae cells - sludge).

In the foregoing theory, hypothetically, the algae photosynthesize to produce as much oxygen as needed for aerobic oxidation. But there is no such assurance in the actual stabilization pond. Since the algae can photosynthesize independently of the incoming BOD volume, as long as there are sufficient light and inorganic salts, the theoretical COD may increase as a result of the reaction of the complete symbiotic system. In fact, in stabilization ponds where sufficient algae removal is not likely, and long term BOD measurement is an indicator, sometimes that of the treated water is higher than the original. This is the source of the controversy over the stabilization pond as a water treatment technique.

2) Anaerobic Fermentation in the Facultative Pond

The stench of hydrogen sulfide, and the rise of scum which accompany anaerobic reactions on the bottom of the facultative pond are regarded as a nuisance in operations management, yet fill an extremely important position among the purification processes. Settling suspended solids in the influx water and microorganisms produced in the surface layer, e.g. algae, decompose into methane and carbon dioxide by anaerobic fermentation. At this point, the first gasification of incoming BOD material takes place (See Fig.S8.A.6).

Hendricks posited that photosynthesis takes place in response to the need for oxygen for the micro organism oxidation of soluble organic substance, and calculated the theoretical change in organic substance in the stabilization pond. The result makes it clear that in the symbiotic system of micro organism oxidation and photosynthesis in the upper layer, the COD component of the waste water merely changes qualitatively, but no quantitative change occurs, and the decrease in COD is mainly due to the anaerobic fermentation reaction in the bottom layer. (See Fig. S8.A.7).

II.2.3 Design Data and Standards

Feasible design procedures have not been established for stabilization ponds because the purification mechanisms are complex. Oswald calculated the oxygen volume per unit water area produced by photosynthesis from the radiant strength of sunlight, and suggested a computation procedure to determine the required pond area for a physical equilibrium between oxygen volume and BOD load. This design procedure, has remained unpopular, but is a basic theory of oxygen equilibrium, and even now seems to be in the main stream of stabilization pond design. In Fig. S8.A.8 the stabilization pond of the Sunnyvale treatment plant, which receives domestic waste water, and domestic waste water from the summer season only, is designed on the basis of oxygen equilibrium, as clearly shown by the design data in Table S8.A.3.

Because photosynthesis is proportional to water area, in the design procedure for a stabilization pond which is based on oxygen equilibrium, the BOD water area load is treated as the most critical design factor, while retention time (days) also has an effect on the treatment process (Fig. S8.A.9), and so is perceived as another critical design factor.

Because the functions of the stabilization pond are greatly dependent on climate factors, it is impossible to provide nationwide design standards. Fig. S8.A.4 shows design standards for secondary sewage treatment facilities in several states of the United States. There are no such design standards for industrial waste water, but Fig. S8.A.5 shows average experimental data for stabilization ponds of several types of industry.

II.2.4 Structural Considerations

1) Configuration and Layout of Ponds

Any configuration is acceptable as long as no dead water area or shortflows are produced. There are many instances where multiple ponds are constructed to make effective use of land area. Fig. S8.A.10 shows both parallel and serial layouts, and in the latter instances, function differentiations may be planned, e.g. making the last pond an algae settling pond, etc.

[captions: (a) series layout (b) parallel layout (c) series-parallel layout]

2) Water Depth

The depth of an oxidation pond is less than one meter, while a facultative pond is 1-2.5 meters deep. When water depth is less than one meter, adherent algae flourish and not only block the flow of water, but are also a cause of floating particles in the treated water.

3) Intake and Discharge Procedures

There are two intake procedures; the single point intake mode uses a spray to the center of the pond with pump pressure; the multipoint intake mode uses overspills from a dam. The latter is superior because the BOD load is distributed evenly over a pond. Similarly, there are single point and multipoint discharge modes. In either case, an overspill mode with no scum accumulation is best.

[captions: (a) single point intake and discharge (b) multipoint intake, single point discharge (c) multipoint intake and discharge

4) Pond Dike Structure

The slope of the pond dike is determined from the perspective of soil dynamics and the prevention of erosion. The value of the general horizontal-vertical ratio is usually from 6:1 to 2:1. Algae will flourish near the dike, and become a source of stench and harmful insects, so it is best to select a construciton material which will minimize these.

5) Recirculation of Treated Fluids

Recirculation of treated water in the stabilization pond has two objectives: 1) inoculating intake water with algae and 2) equal distribution of the BOD load. An axial pump with load head high volume is usually used for recirculation.

6) Rapid Air Mixture System

Intermittent mixing and stirring was formerly employed in oxidation ponds, but most recently, aeration mixing in the facultative pond has been emphasized. There are two objectives in aeration mixing.

(1) Supply of supplementary oxygen when photosynthesis declines or even stops in winter and at night.

(2) To remove oil layers forming on the surface, and to facilitate photosynthesis by breaking up thermal stratification.

In the aeration mode, there are two modes, air bursts, and mechanical, but, except for the lateral shaft type machine, generally neither system is economical in shallow ponds.

TABLES

Tab.S8.1.1 Treatment facilities for domestic waste water system

	City name	Sewers	Flow method	Treatment method
Domwstic sewage system	San lorenzo	Yes	Sprinkler system	Lagoon treatment 1st pond anaerobic 2nd 3rd pond aerobic unit; 200l/person/day BOD 54g/person/day
	San bernardino Ypacarai Capat Aregua	No		Individual house hold treatment. Septic tanc + perccoation tank

Tab. S8.1.2 Treatment Facilities for Industrials and Others

	Name of Establishment	Location	Type	Discharge Location	Treatment Facilities	Treatment System	Considerations
Tourism Related	Club Nautico Puerta Del Lago	San Bernadino	Club	Septic Tank	Available	Septic Tank ($27m^3$)	No drains
〃	Country Golf Club	〃	Club	Lake	Available	Septic Tank. Permeation Tank	
〃	Hotel Casino	〃	Hotel	Septic Tank	Available	Siorage Tank $210m^3$ Septic Tank $54m^3$ Sprinkler	104 Rooms
〃	Centro Militar Naval y Aereo	〃	Club	Lake	Available	2 Septic Tanks $80m^3$ Torage Tank	–
〃	Hotel Balneario	〃	Hotel & Restaurant	Unknown	Available	Septic Tank $27m^3$	Sprinke - Well Water use of Cleanser
〃	Hotel Del Lago	〃	Hotel	Unknown	Available	2 Septic Tanks $32m^3 \times 2$ Permeation Tank	No. of Rooms: 24
〃	Country Club Lago Azul	〃	Club	Lake	Available	2 Septic Tanks 2 Permeation Tanks	Due to the Poor Results of Permeation Discharge into Lake
〃	Hotel Aquario	〃	Hotel	Unknown	Unknown	–	–
Industry Related	Sebastian Caboto	Ypacarai	Tannery	Ipuku River	None	–	–
〃	Etrete S.R.L.	〃	Brewery	Ipuku River	Available	Lagoon	At present not in operation Scheduled to resume next year
〃	Ceramica Santa Terega	〃	Brick Kiln	Brook& Lake	None	–	–
〃	La Inoustrial del Norte S.A.	〃	Vegetable Oil Processing Plant	Brook& Lake	None	Daily Effluent Output 50m3 Since Taere is no Permeatin Facility, dried by Boiler Heat	(Oil Leftover sold to Soap Factory)
〃	Matiadero Municipal	〃	Abattoir	Ipuku River	None	Since the River Water is drawn in the left overs flow directly into the River	–
〃	Mautic for S.R.L.	〃	Tannery	Ipuku River	Available	Passer Through Lagoon	Use of Tanned Leather
Public Facility	Hospital Del Quenado	Capiata Aregua	National Hospital	Tukiri River	Available	Septic Tank 5×10×6m×3und	Established 1986. Cancer and Plastic Surgery Treatment
Inoustry Related	La Industrial Aregua S.R.L.	Aregua	Oils Soap Processing	Brooks & Lakes	Available	Lagoon, or direct discharge	–
〃	Costa Fleita	〃	Abattoir	Tukuri River	None	–	Moved 3 years ago from Are Gu
〃	Ghun	〃	Hatchery	Unknown	Available	Septic Tank Permeation Tank	Poultry Excretia being sold as Low Fooder
〃		〃	Shoe Factory	—	—	–	Out of Production for 7 years
〃		San Sernadino	Coffee factory	Brooks & Lakes	Available		At present not in Operation Resumes from March
〃	Capsa	Capiata	Vegetable Oil Plant	Tukuri River	Available	Discharge Purification Treatment Plant	Not in Operation
〃	Aceitera	Itagua	Vegetable Oil Plant	Tukuri River	Available	Purification Treatment	Not in Operation
Tourism Related	Club Nautico San Bernadino	San Bernadino	Club	Lake	Available	Septic Tank $22m^3 \times 2$ Permeation Tank $32m^3 \times 2$	Roko is present at the mouth of the Lake

Tab. S8.3.1 Treatment volume from the bottom of infilthation trench filter beds and soil permeability from evaluation of facilities.

Soil	Infilthation (cm/s)	Treatment volume (m^3/day m^2)
Gravel, Coarse sand	<4.2×10^{-2}	Unsatisfactory
Corse sand～Fine sand	8.5×10^{-3} 4.2×10^{-2}	0.050
Silt, Loamy sand	2.8×10^{-3} 8.5×10^{-3}	0.034
Sandy loam, Loam	1.4×10^{-3} 2.8×10^{-3}	0.025
Loamy poras, Silty loam	7.0×10^{-4} 1.4×10^{-3}	0.019
Silt loam	3.5×10^{-4} 7.0×10^{-4}	0.008

Tab. S8.3.2 Removal ratio

Period	13 October 1988 ～		
	Water quality		Removal rate
Samples	Raw water	Treated water	Treated water
BOD	660.0	87.3	86.7
COD	2149.1	150.0	93.0
NH_4-N	135.0	131.4	2.7
T-N	1852.0	1847.0	2.7
T-P	22.1	15.0	32.1

Tab. S8. 3. 3 Data of CEC, PAC

	Demention	No. 1	No. 2	No. 3
C E C	meq/100g	16. 3	2. 6	9. 4
P A C	mg/100g	500	90	270
Water content	%	1. 9	0. 5	1. 3

※ sumple No. 1 6. July. 1988 River Pirayu Concrete Bridge (Planosol)
No. 2 7. July. 1988 River Pirayu Leftbank (Regosol)
No. 3 22. July. 1988 Aregua Police station (Acrisol)

Tab. S8.4.1 Result of test

DATE	DESCRIPTION	SENASA (mg/l)						INTN (mg/l)					
		TN	SS	ST	BOD	COD	TP	TN	ST	SS	BOD	COD	TP
30 JAN 1989	INFLOW	1,277	540	5,538	10,138	4,044	10			1,395	2,040	3,306	
	OUTFLROW	1,272	260	1,362	7,809	2,451	6			758	900	1,487	
21 FEB 1989	INFLOW	865	670	3,922	5,042	6,447	20			538	3,474	2,800	
	OUTFLROW	789	413	1,776	4,168	5,980	18			367	2,283	2,400	
Average of removal rate(%)		4.6	45.1	65.2	20.2	23.2	25.0			38.7	45.1	34.7	

Tab. S8.5.1 Lagoon tipe and merits, demerits

	Merits	Demerits	BOD removel rate	Reaction to flow and load movement	Handling Maintenance				Treatment Effectiveness	Construction cost
					Technical difficulting	Techincal Authontetion Level	Number of test pointe	Necessary of hight technology		
Oxidation ditch	No need for first sedimentation Flow and load movement is strong Low pollution outbreak Good handling operation	Space is large Foul odor problem Existence of pollution carry-over	>90%	Reaction is possible	Not difficult	Authorized	Low	Sughtly necessary	Quite	Middle
Aerated lagoon	There is only an aerated lagoon and the mentenance management is good Return sludge is not neccessary Good bacteria treatment	Compared with oter method, there is a need for a space larger than that in oxidation ditch Exxclusion of algae is necessary Existence of problems with evapo-transpiration amount and flying send accumulation	>90%	Adequate reaction is possible	Not at au difficult	Authorized	Very low	Not necessary	Quite	Low
Oxidation pond	There is not much variation in equipment type, the maintenance cost is low, and monitoring is good Good bacteria triatment	A space evev larger than that for aerated lagoon method is neccessary onother same as above for aerated lagoon method	>90%	Adequate reaction is possible	Not in the least difficult	Authorized	Almost none	Not at au necessary	Adequate	Low

Tab. S8.A.1 Lagoon types and characteristics

	Stabilization pond		Anaerobic pond	Aerated lagoon
	Oxidation pond	Facultative pond		
Depth (m)	0.2～ 0.4	1～ 2.5	2.5～ 4	2 ～ 4.5
Retention time(day)	2～ 6	7～ 30	30 ～ 50	2 ～ 10
BOD (g/m^2 day)	10～ 20	2～ 10	20 ～100	
BOD (Removal rate %)	80 ～ 95	35～ 75	50 ～ 70	
Anaerobic or aerobic	Aerobic	Aerobic	Aerobic	Aerobic
Reaction of photosynthesis	○	○	×	×

Tab. S8. A. 2 Removal reaction of Glucose in symbiosis

	Cyton	Microbiological reaction
Aerobic bacteria	$C_6H_7O_2N$	$C_6H_{12}O_6 + 0.67NH_3 + 2.67O_2$ $\rightarrow 0.67C_5H_7O_2N + 2.67CO_2 + 4.67H_2O$
Alga	$C_8H_{14}O_3N$	$0.31NH_3 + 2.51CO_2 + 1.41H_2O + light$ $\rightarrow 0.31C_8H_{14}O_3N + 2.67O_2$
Symbiotic reaction		$C_6H_{12}O_6 + 1.08NH_3$ $\rightarrow 3.26H_2O + 0.67C_5H_7O_2N + 0.16CO_2 + 0.31C_8H_{14}O_3N$ Sluge

Tab. S8. A. 3 Design load at Sunnyvale

Square area	1,700,000m²
Depth of water	1.3m
Aerator	24set
Load of BOD	
Winter	1,500kg/day
Summer	6,400kg/day
Oxigen supply capacity	
Winter:Photosynthesis	1,590kg/day
Summer:Photosynthesis	3,500kg/day
Aerator	2,700kg/day
Total	6,200kg/day

Tab. S8. A. 4 Design standard of Sewerage for Oxidation Ponds in U. S. A

	North state	Middle state	South state
Load of BOD(g/m^2·day)	2.4	3.7	5.5
Detention period (day)	125	65	31

Tab. S8. A. 5 Data averages for oxidation ponds for industrial wastr water

	Depth of watre (m)	Load of BOD (g/m^2·day)	Detention time(day)	Removal of BOD (%)
Food processing	0.9	8.2	70	80
Canned industry	1.8	15.7	37.5	98
Chemical	1.5	17.8	10	87
Paper manufactre	1.5	11.8	30	80
Petrochemical	1.5	3.2	25	76
Dainy produchts	1.5	2.6	98	95
Textile industry	1.2	18.7	14	45
Oils and fats	1.3	4.0	48	76

FIGURES

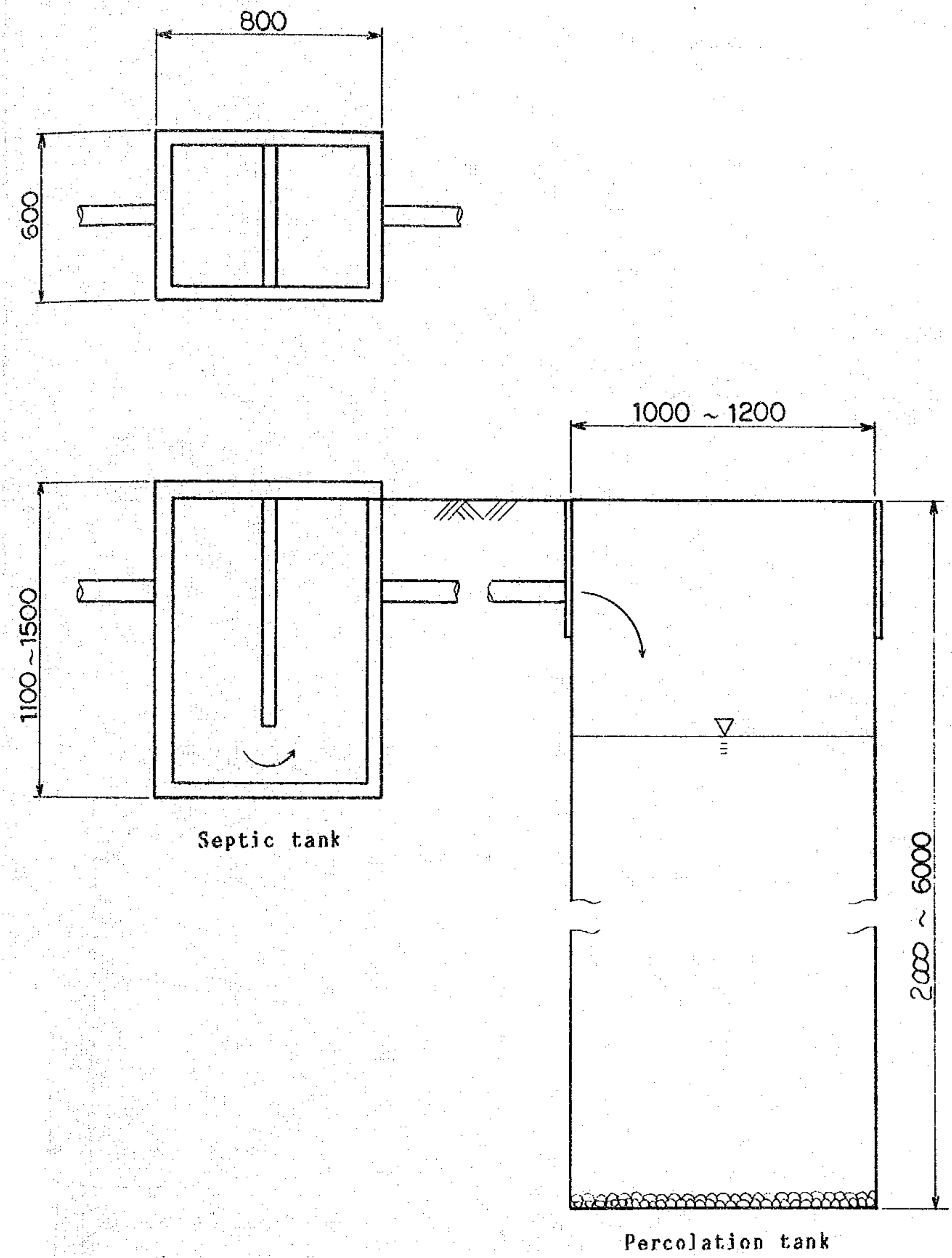

Fig. S8.1.1 Domestic waste water treatment method

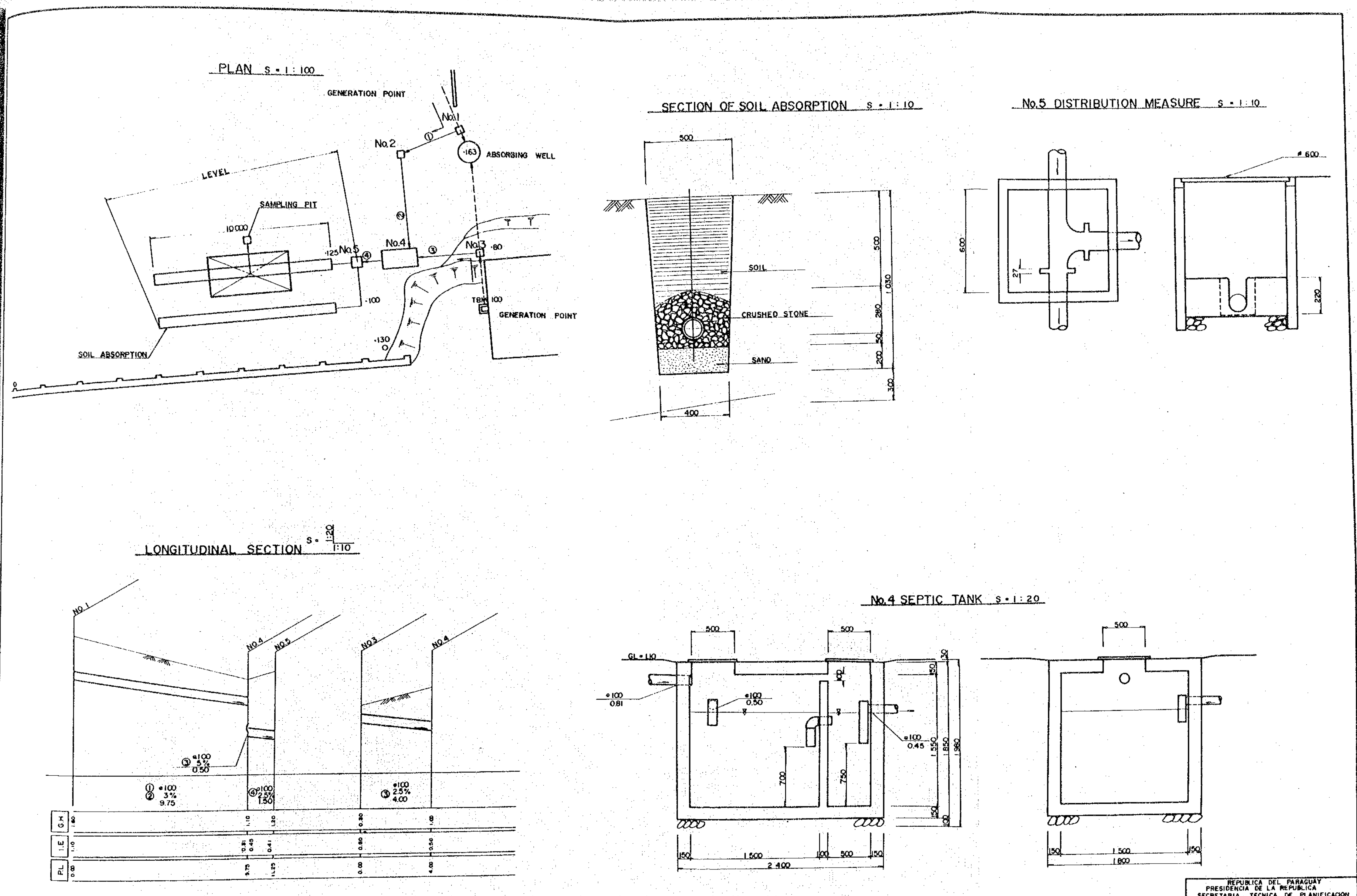

Fig S8. 3. 1 Septic tank and soil absorption system

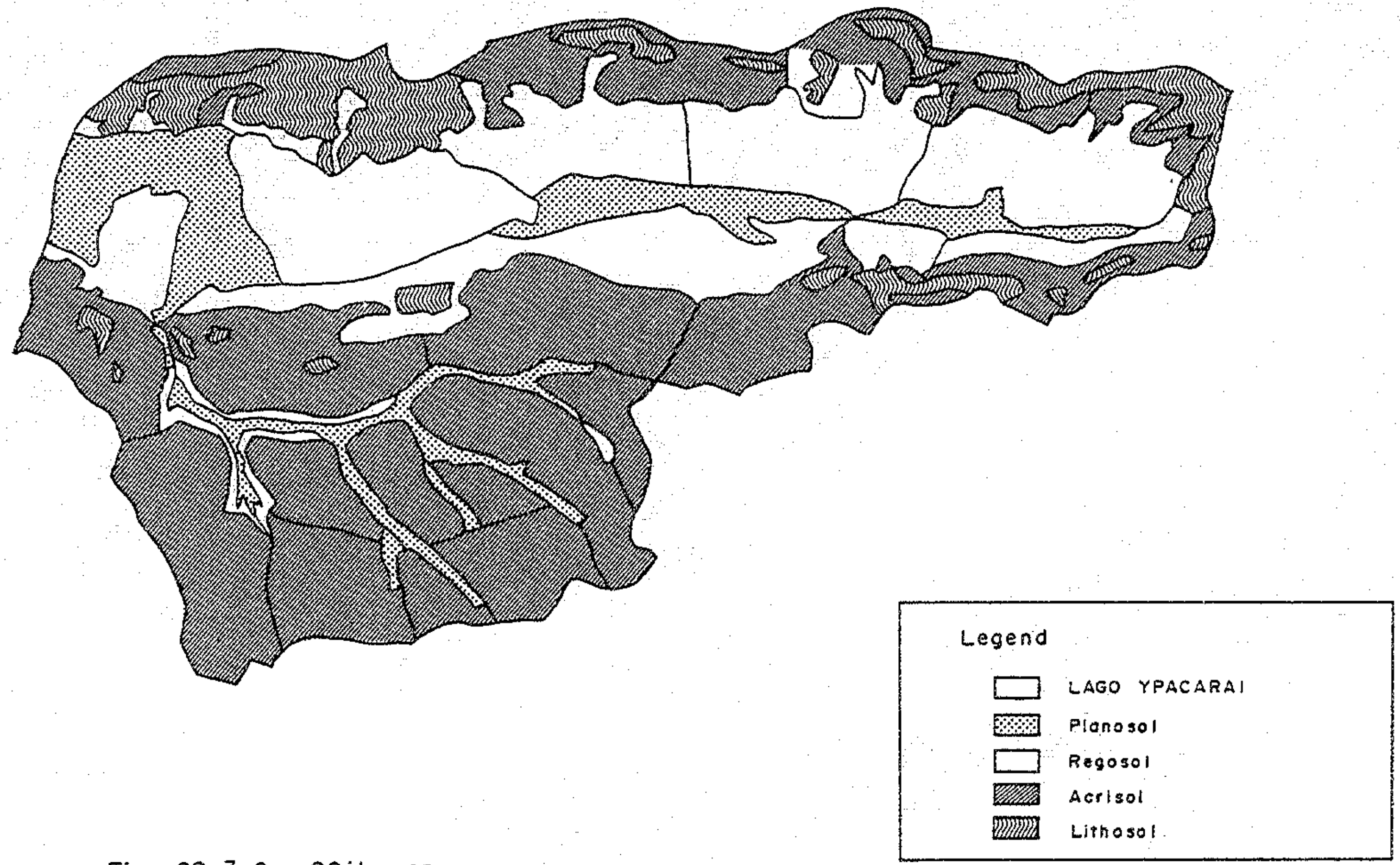

Fig. S8. 3. 2 SOil map

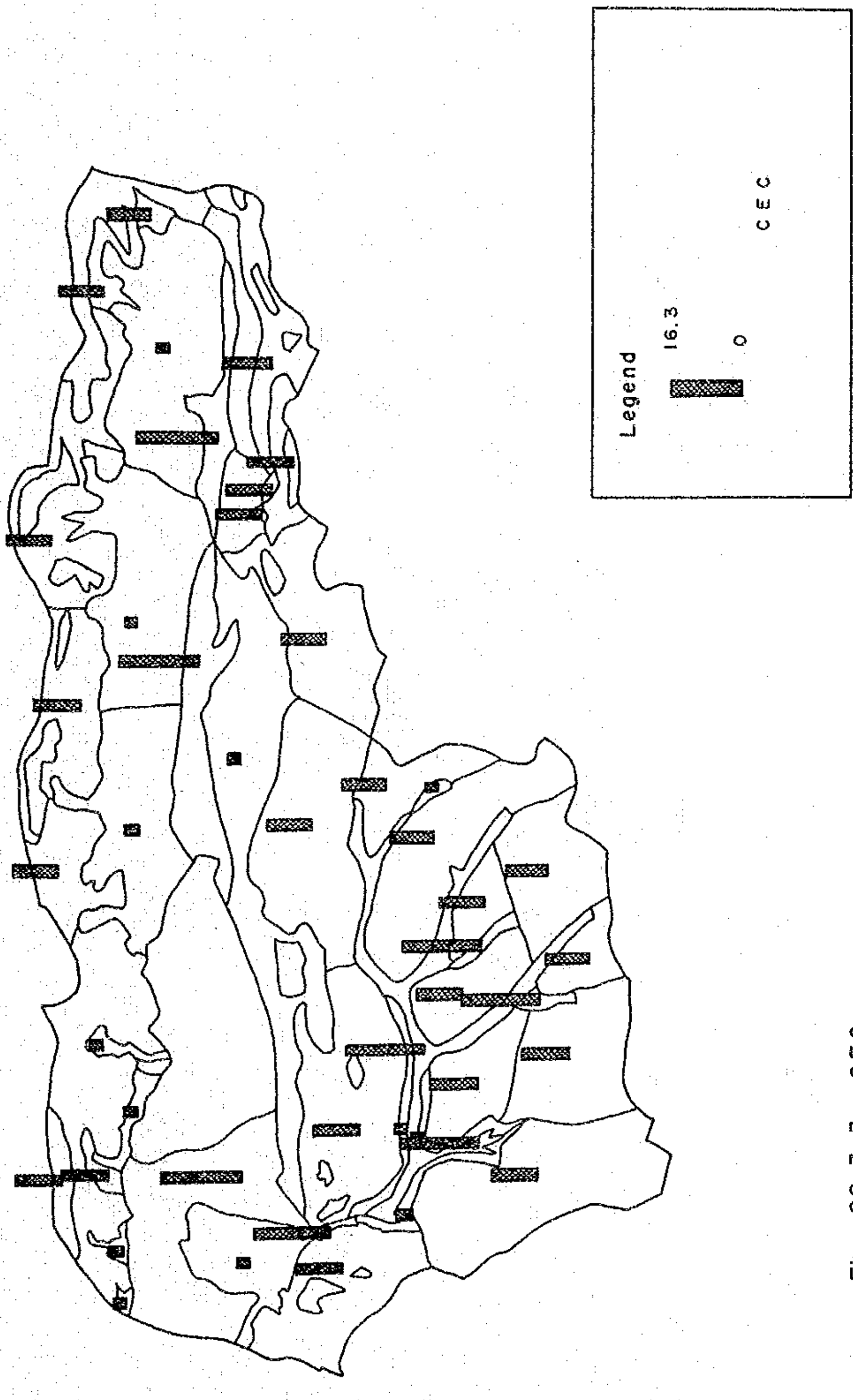

Fig. S8 3.3 CEC map

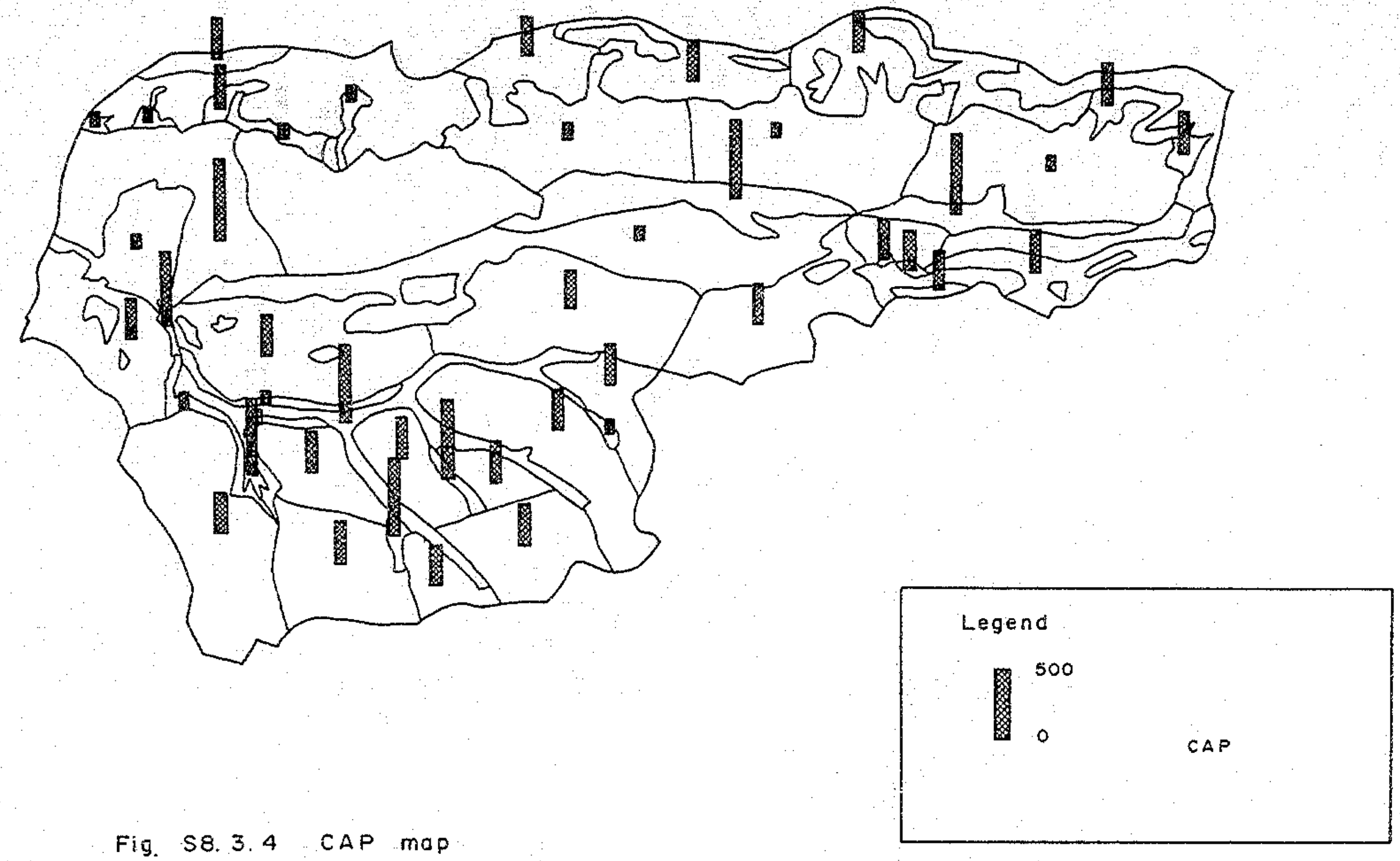

Fig. S8. 3. 4 CAP map

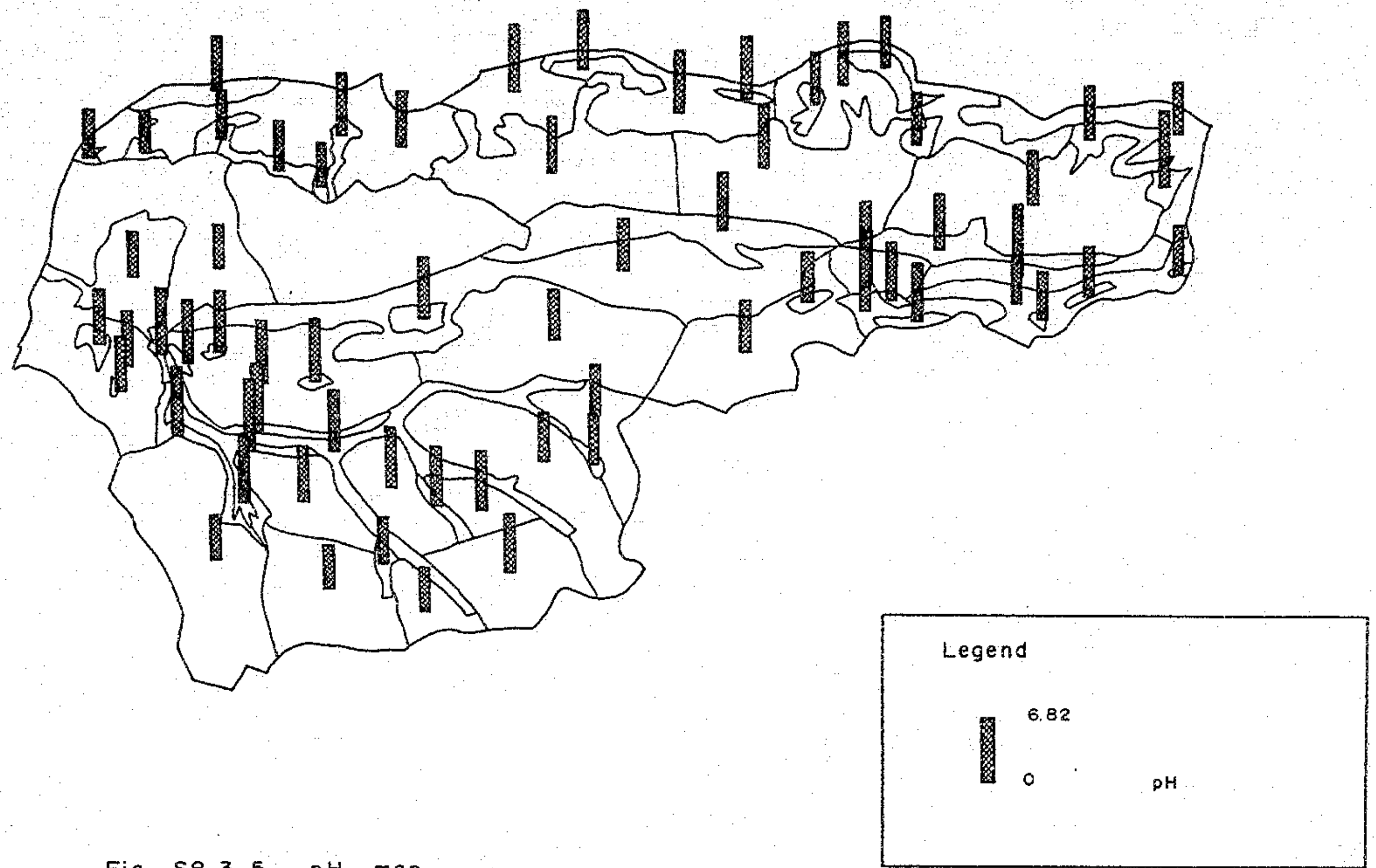

Fig. S8. 3. 5 pH map

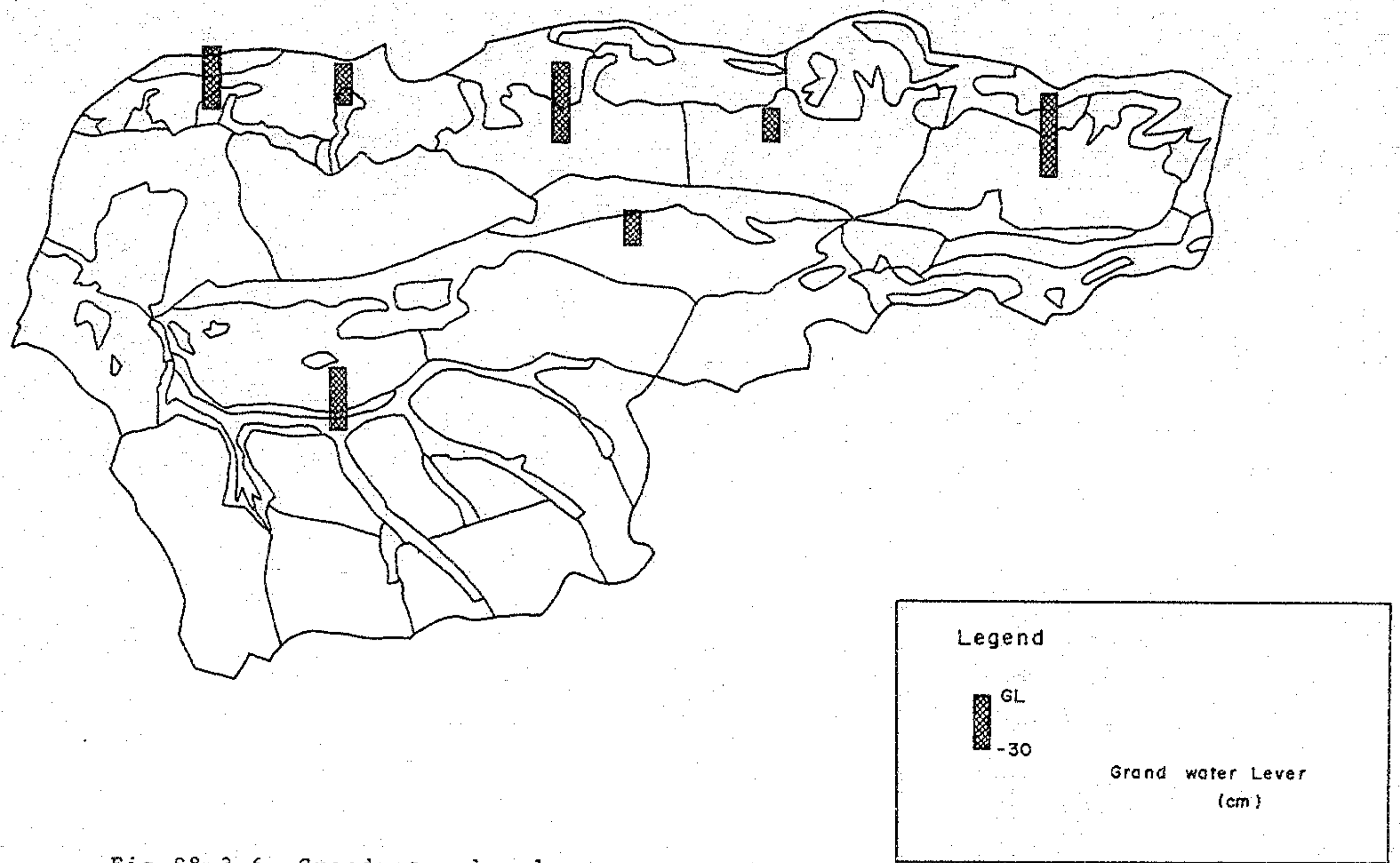

Fig.S8.3.6 Grondwater level map

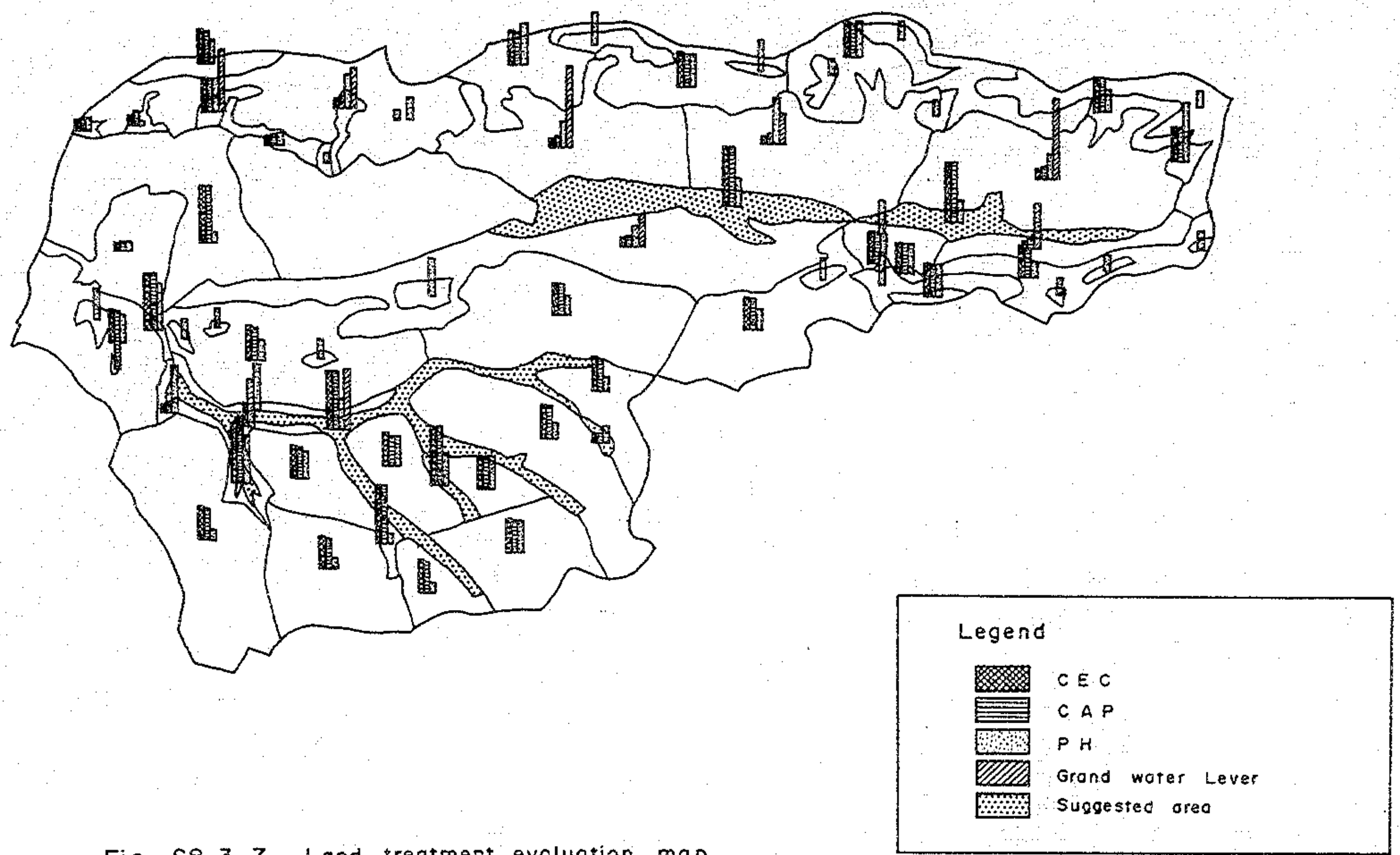

Fig. S8. 3. 7 Land treatment evaluation map

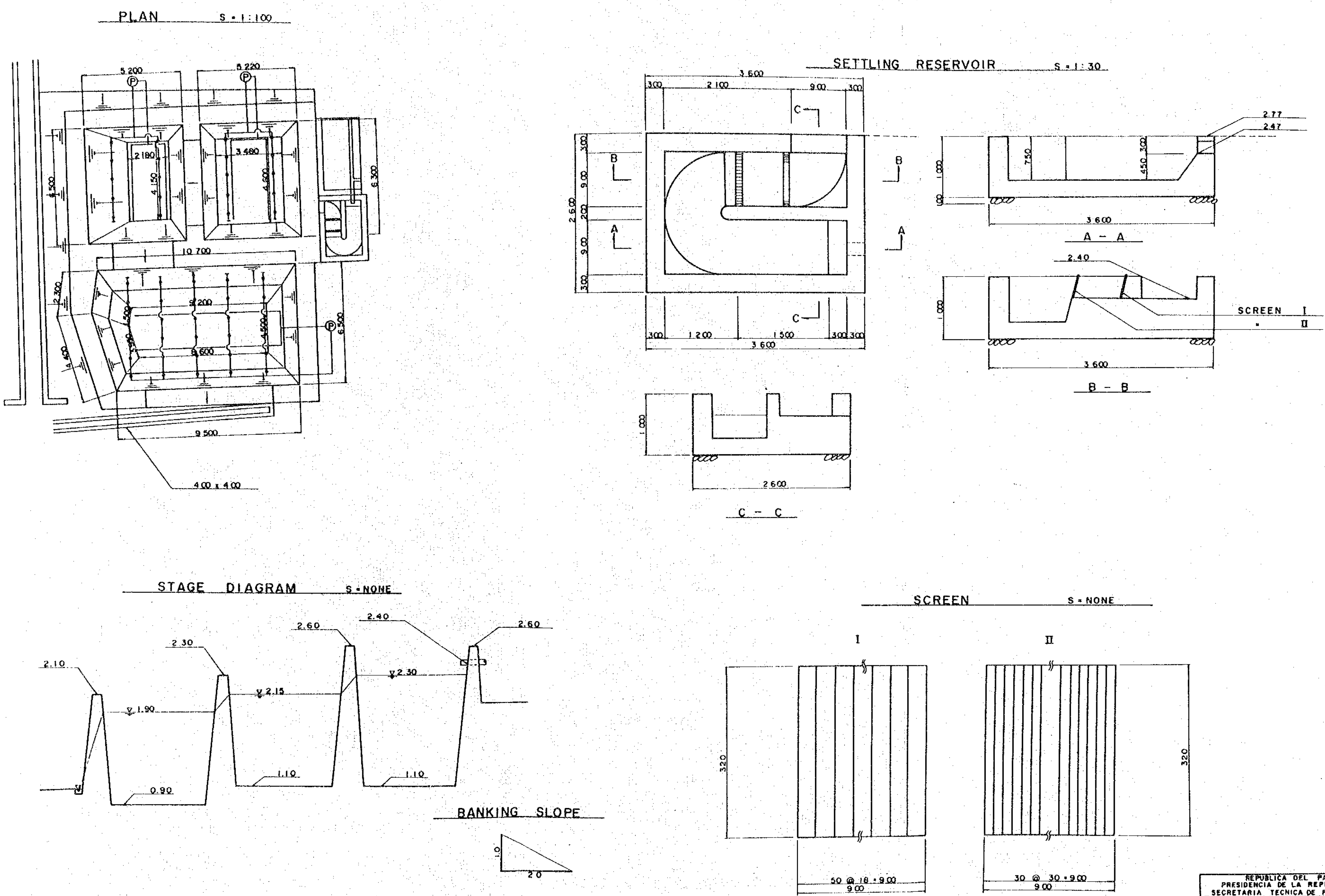

Fig. S8.4.1 Grand plan for oxidation pond

REPUBLICA DEL PARAGUAY
PRESIDENCIA DE LA REPUBLICA
SECRETARIA TECNICA DE PLANIFICACION

WATER POLLUTION CONTROL PLAN FOR THE LAKE YPACARAI AND ITS BASIN

OXIDATION POND SYSTEM

DATE 1989 DWG.NO.

JAPAN INTERNATIONAL COOPERATION AGENCY

No.

NO	NAME	FORM	TOTAL
①	PIPE	2"	36.20 m
②	〃	1 1/2"	88.80 m
③	TUBE	1 1/2" × 2" × 1 1/2"	4
④	〃	1 1/2" × 1 1/2" × 2"	1
⑤	〃	2" × 1 1/2" × 2"	3
⑥	ELDOW	2" × 90°	9
⑦	〃	2" × 45°	10
⑧	〃	1 1/2" × 90°	11
⑨	SOCKET	1 1/2"	2
⑩	CAP	1 1/2"	15

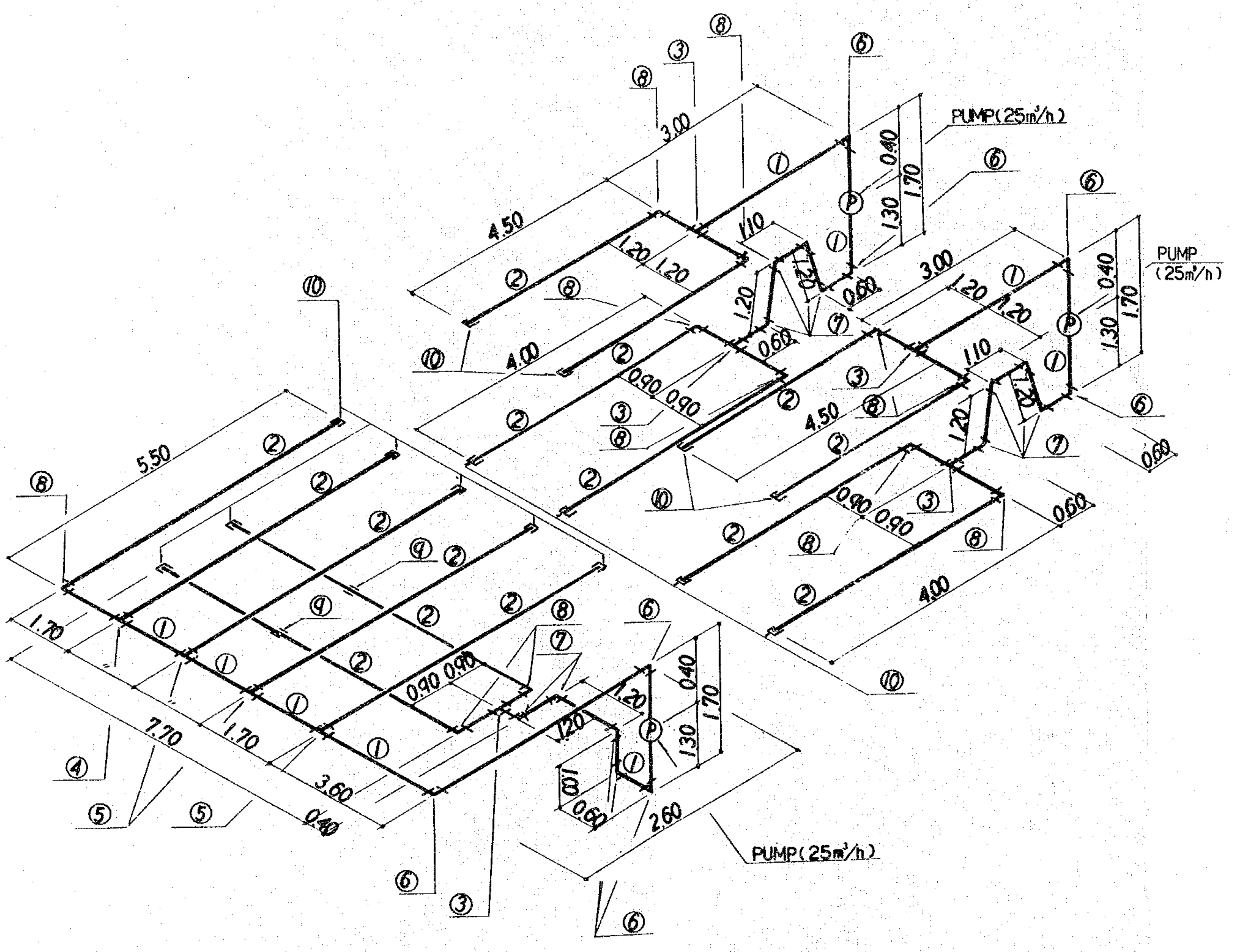

Fig. S8.4.2 Plan for water circuration pipe

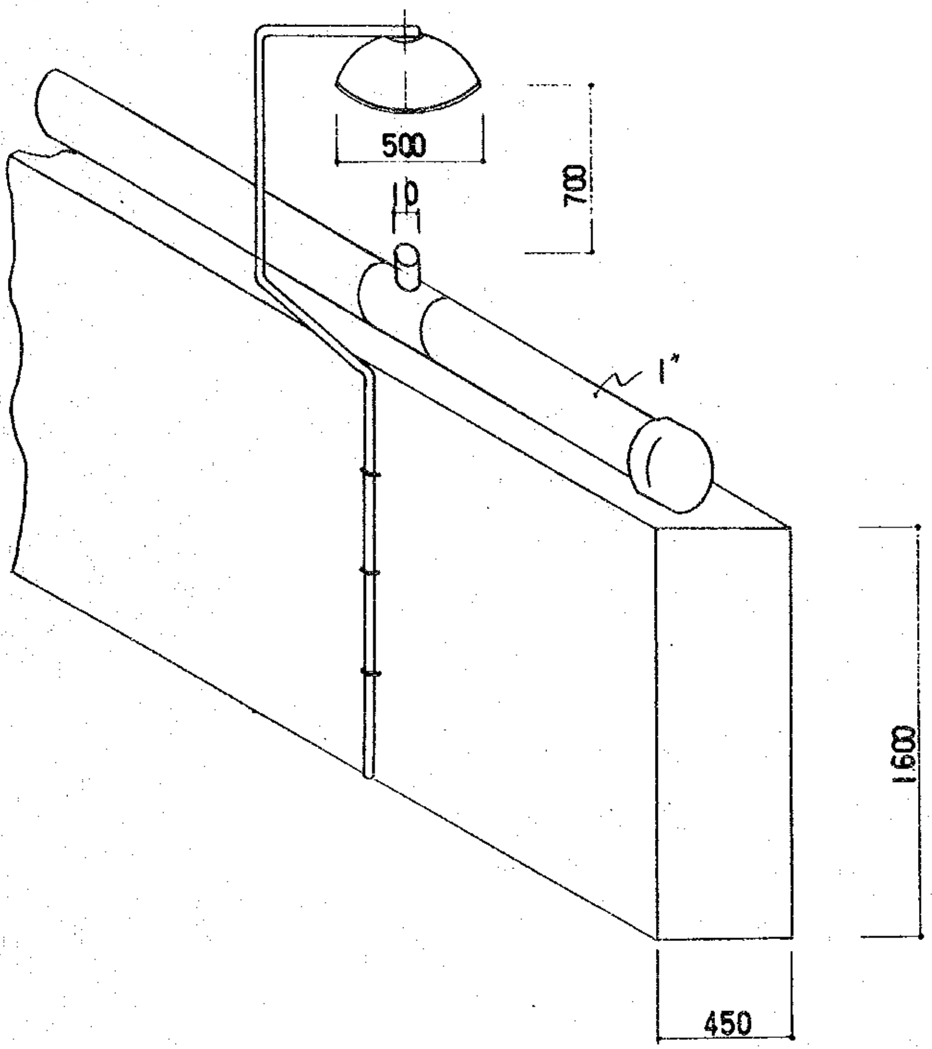

Fig. S8.4.3 Detailed sprinkler system

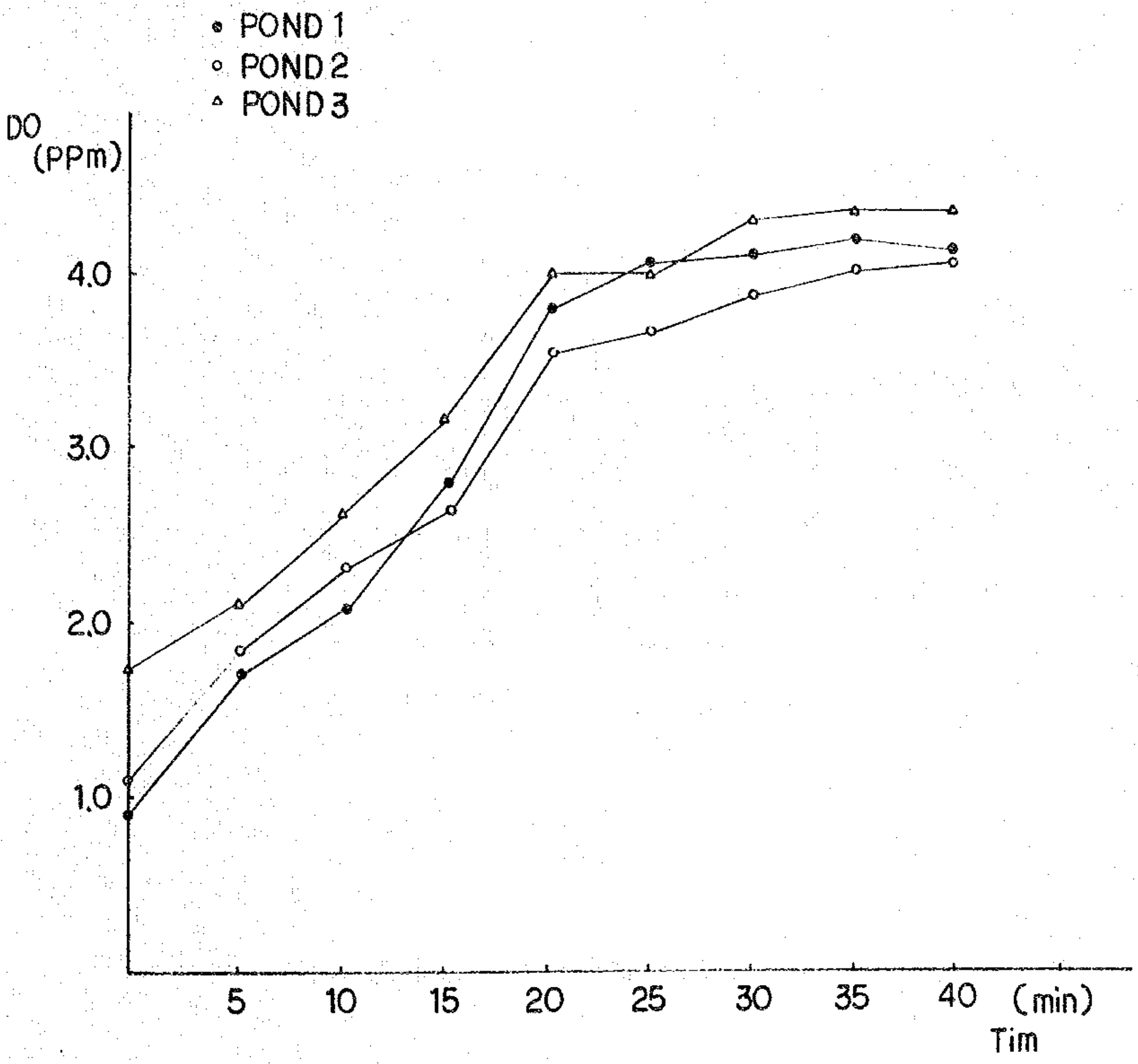

Fig.S8.4.4 Variation of DO in Aregua Oxidation Pond

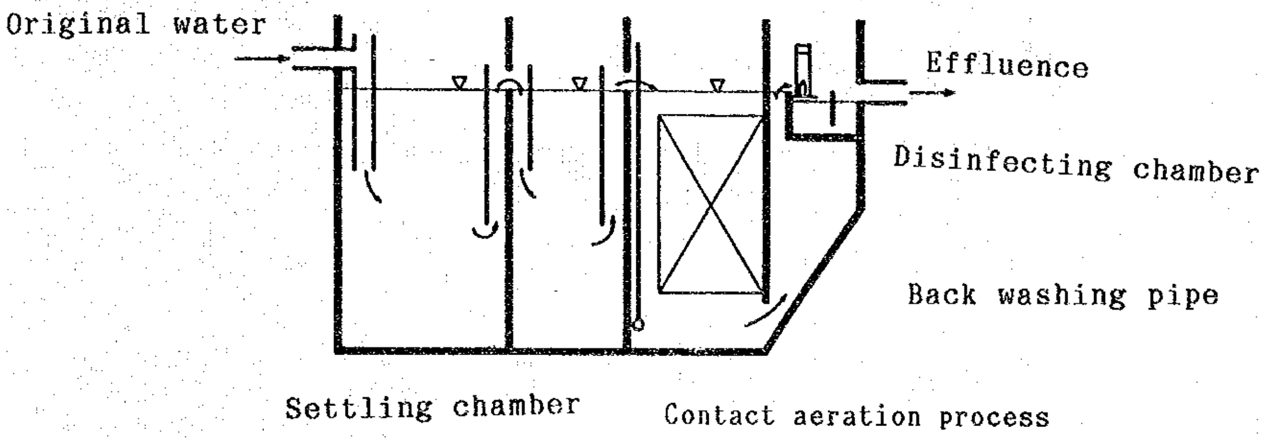

Fig. S8. 5. 1 Combined purification

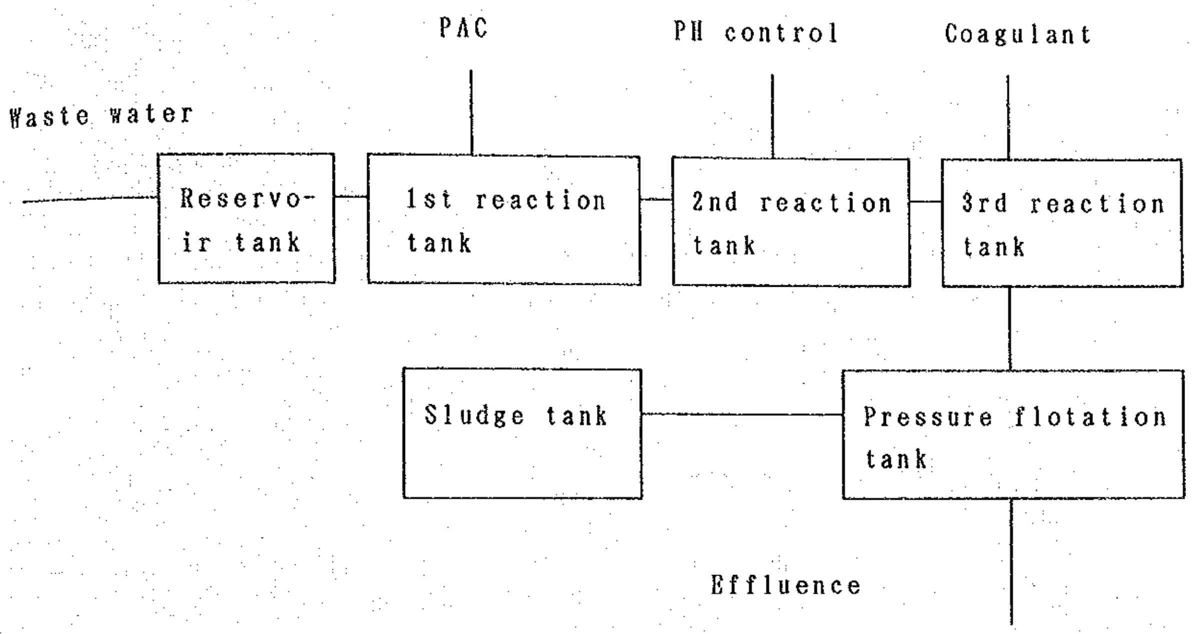

Fig.S8.5.2 One treatment method for Abattoris

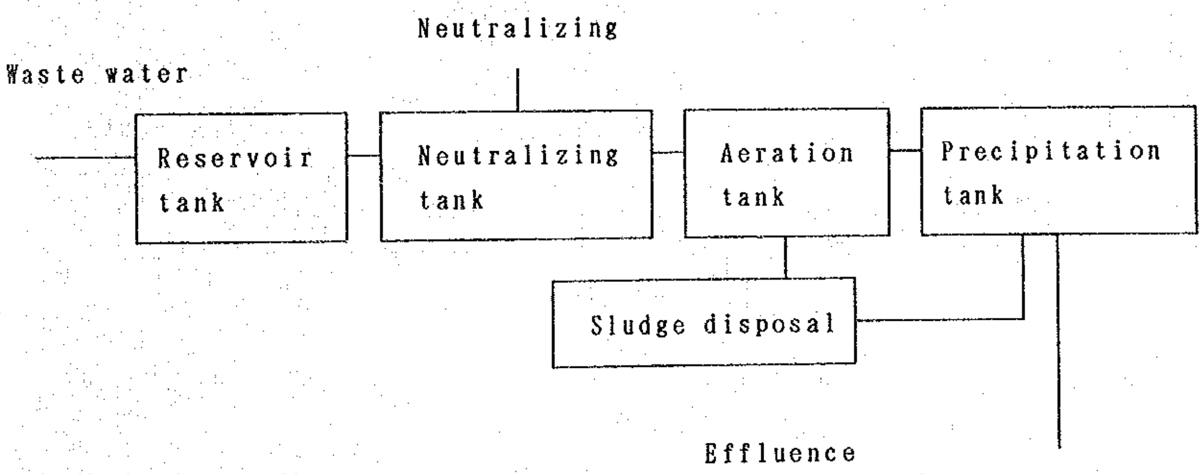

Fig.S8.5.3 One treatment method for Alcohol Facilities

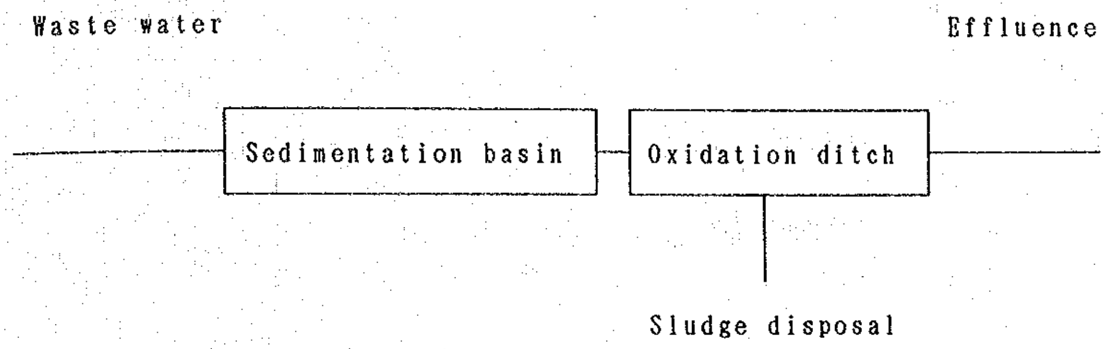

Fig.S8.5.4 One treatment method for Starch Facilities

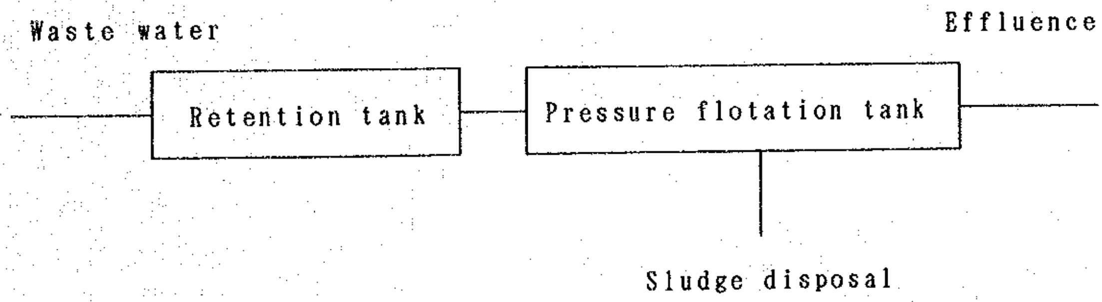

Fig.S8.5.5 One treatment method for Sorp Facilities

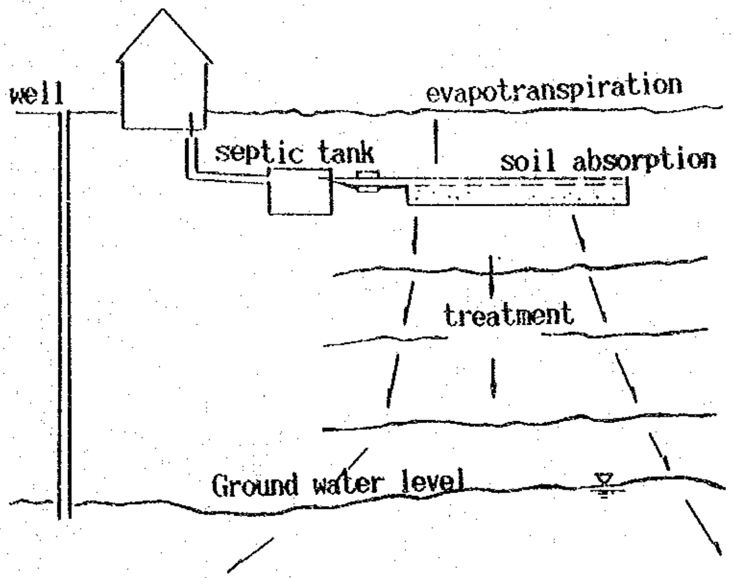

Fig. S8. A. 1 Septic tank and soil adsorption system

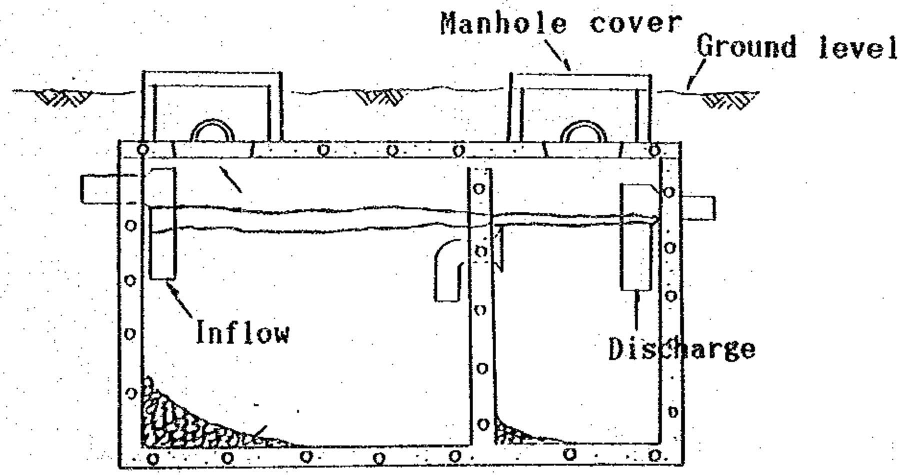

Fig. S8. A. 2 Structure of septic tank

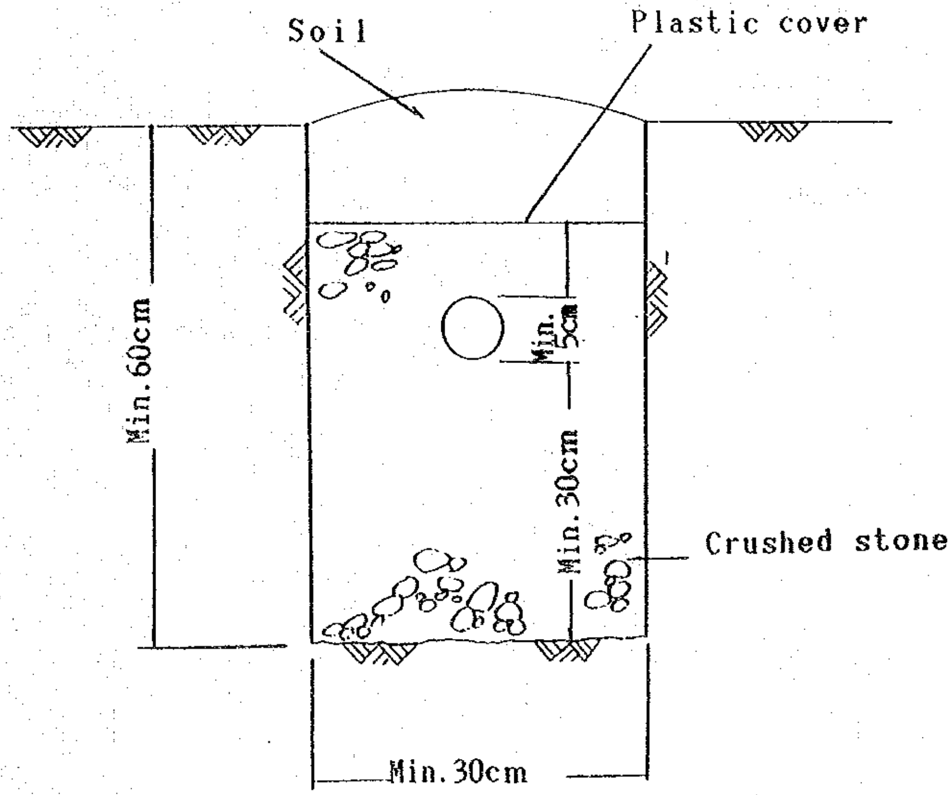

Fig. S8. A. 3 section of trencn adsorption

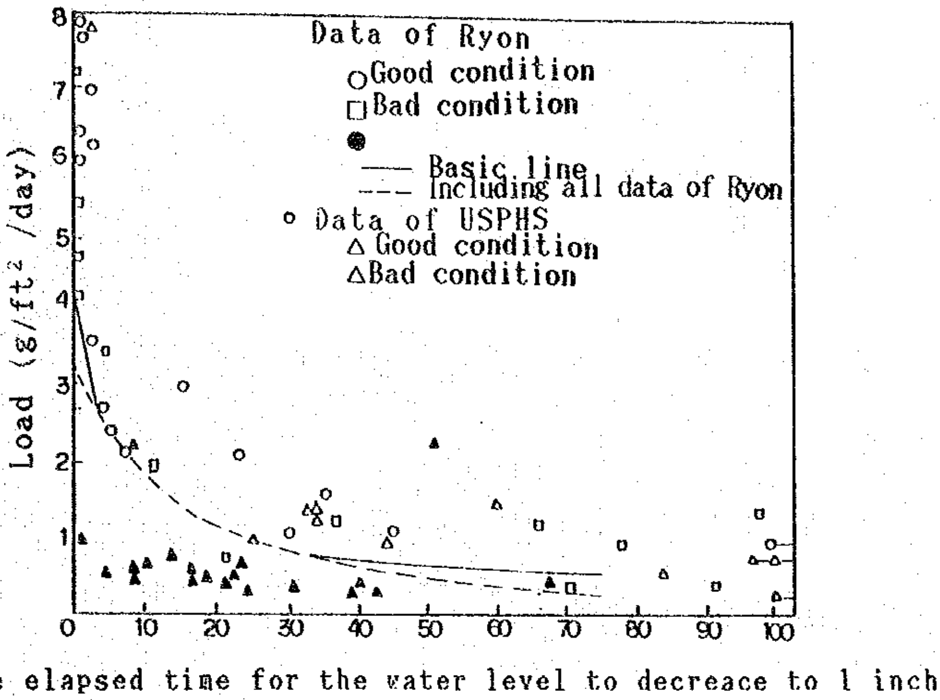

Fig. S8.A.4 Lion's curve

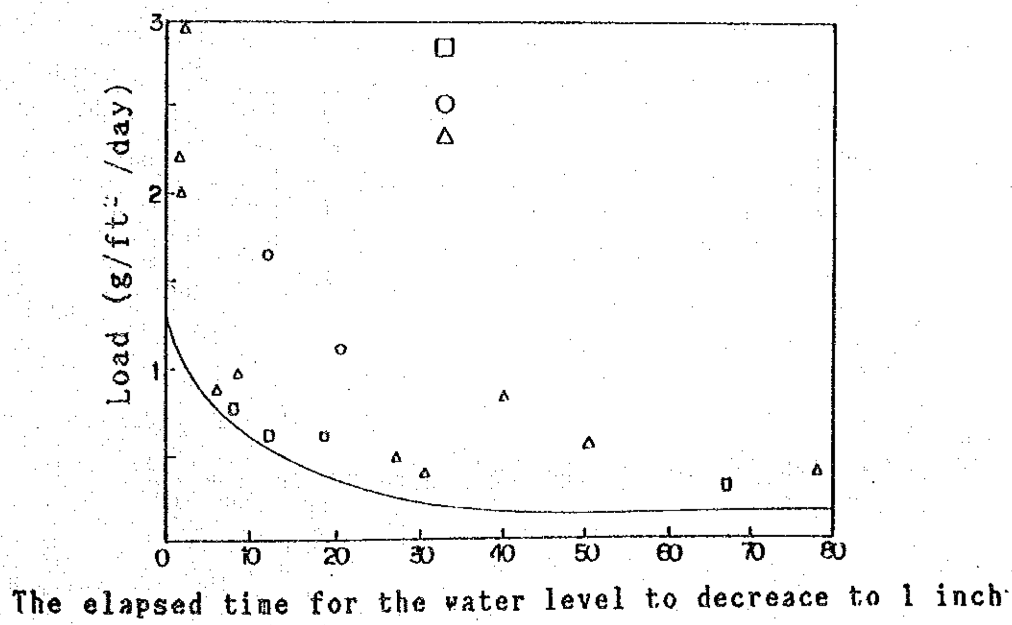

Fig. S8.A.5 Revised lion's curve

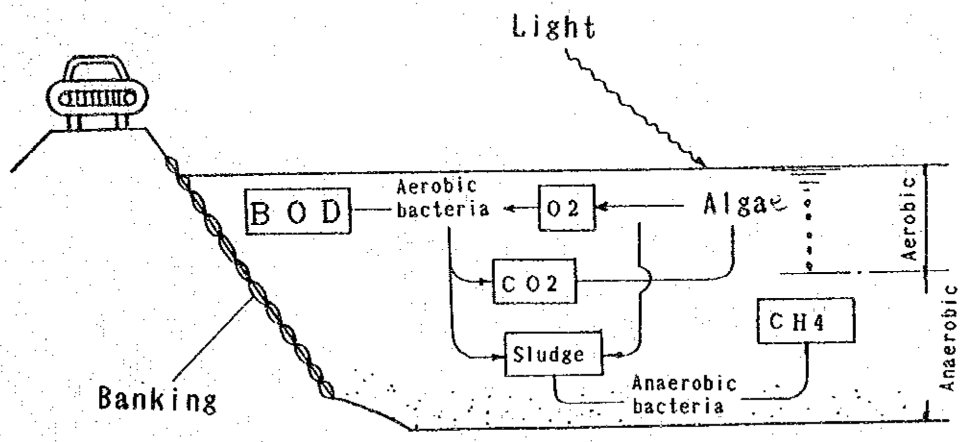

Fig. S8. A. 6 System component of Oxidation Pond

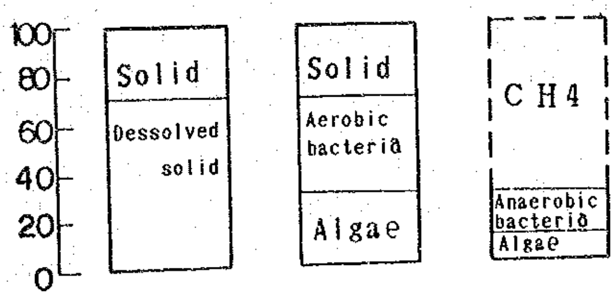

Fig. S8. A. 7 Theory of COD in oxidation pond

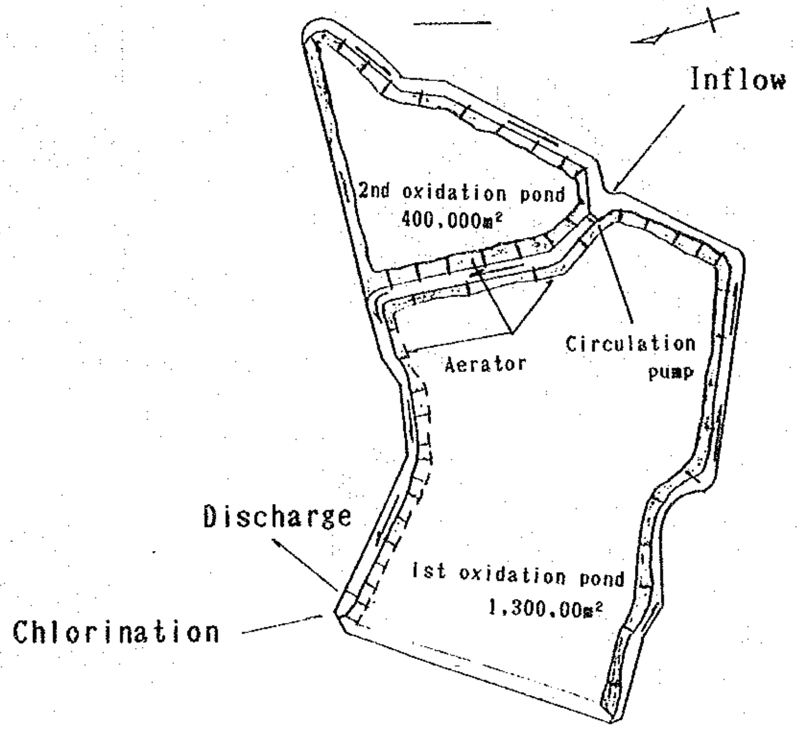

Fig. S8. A. 8 Oxidation Pond at Sunnyvale treatment plant

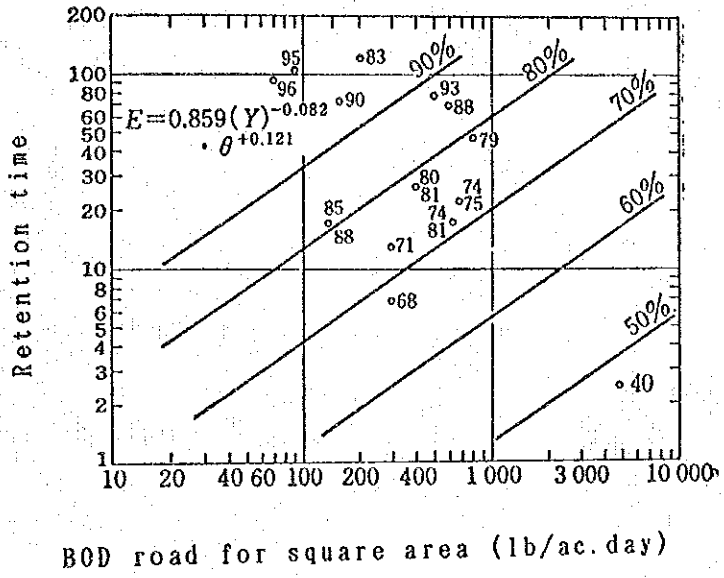

Fig.S8.A.9 Rerationship between retention time and BOD removal ratio for canning industrial waste water

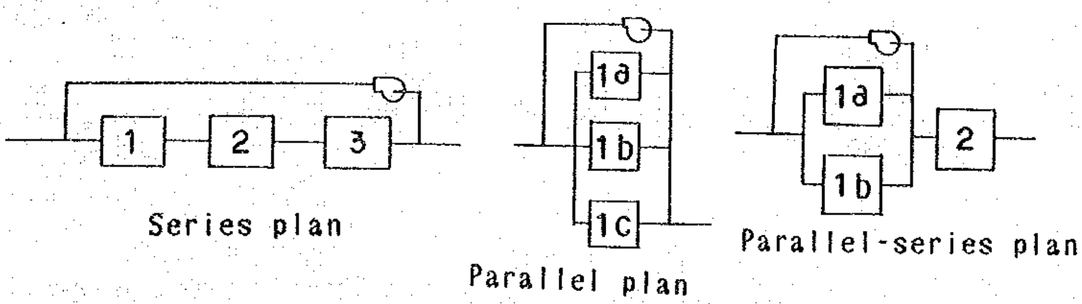

Fig. S8. A. 10 Layaut of multipe ponds

SUPPORTING REPORT IX

WATER POLLUTION CONTROL PLAN

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LIST OF FIGURES

INTRODUCTION

This report describes in detail the water pollution control plan which is a part of a study on Lake Ypacarai and its Basin.

Lake Ypacarai, located about 30km east of Asuncion, is mainly a sightseeing and recreation site at present. However, the Paraguyan Government has a strong intention to use this Lake as a water supply source for neighboring areas, where potable water demand will increase in future. The government also intends to continue to develop the Lake's sightseeing and recreational charactor. Moreover, it is believed that there is a potential need for rivers within the Lake basin to also exist as aquatic recreational sites.

To answer the above-mentioned needs for Lake Ypacarai and the inflow rivers, it is necessary to establish a goal for water quality conservation which corresponds with the usage objectives, and to design a plan which is able to succeed based on the measures relating to the natural and socioeconomic conditions of the Lake basin and Paraguay.

Water quality of the Lake and the rivers is always fluctuating due to many factors, and the fluctuation range is sometimes wide. Therefore, it is necessary to continue long-term observation and research on many items, within a wide geographic area.

In this study, we were obliged to create a water pollution control plan only after a one-year field survey and a half-a-year examination, due to the restriction of time. Consequently, the plan presented in this report is just a tentative one and must be corrected in accordance with the results of the research and investigation which should be continued, hereafter.

CHAPTER 1

THE PRESENT POLLUTION SITUATION IN THE LAKE AND ITS BASIN

1.1 Relationship between Human Activity and Environmental Change

Fig. S9.11 shows the relationship between human activity and environmental change with a focus on water pollution.

The Spanish goverment founded Asuncion in 1537. Next to the lake, the city of San Bernardino was founded in 1881. Therefore, basic changes in the basin area began in the 20th century. From the Pirayu river valley to the lake itself was grassland, but this was enlarged when a big part of the forest in the area was cleared away to create arable land for farming.

Paraguay's population is relatively small since it hasn't reached 4 million. However, around 20% of this population is concentrated in the National Capital region. Thus, the population per square kilometer is only 7.5 overall, but in the cities it is almost 2,000. Furthermore, the population increase is 2.54% overall, but in Asuncion and its neighboring cities, San Bernardino and Luque, it is extremely high, between 7 and 8%. With such a high population density around the Lake basin, various problems in the living environment have arisen.

Figs. S9.12 and S9.13 show the difference in distribution condition of the cities and arable land between 1965 and 1988. During these past 23 years, the vast growth of the cities is quite apparent.

Due to deforestation in the mountain regions, much of the vegetation has been lost. During frequent intense rainstorms lasting for several hours and dumping as much as 80 to 120mm of rain on the area, large amounts of sand and mud are washed away, thus promoting the scale-down of lake and marsh area. Arable land created through deforestation has been degraded by plunder farming. The humus layer is suddenly lost, and year by year the layer of topsoil becomes thinner and thinner. The lack of forests has also reduced the amount of water flowing into the rivers and the water's quality.

When the area around the National Capital was no longer able to produce vegetation, it was converted into housing developments, giving origin to