O.4 Experiment on Improvement of Arroyo Zacateligue Sanitation Environment

O.4.1 Background

Rivers and streams in Granada have been contaminated seriously. Illegal dumping and littering into the rivers and streams are awful, i.e., tons of house garbage, the leftover, slowly flowing both domestic and industrial wastewater with revolting smell, a hotbed of flies and mosquitoes.

Without any doubt, this has damaged sanitation environment along the rivers and streams seriously. And more, this has been polluting Lake Nicaragua, the nation's largest waster reserve.

To improve this situation, the Arroyo Zacateligue (the Zacateligue River) was chosen as a model river in/along which the experiment (Experiment on Improvement of Arroyo Zacateligue Sanitation Environment) was conducted.

For the experiment, the Granada Municipality nominated six candidate sections of the river. Then, the Study Team made a reconnaissance of these candidate sections in the environmental engineering point of view and conducted a questionnaire survey in February 1997 to check whether the sections were appropriate for the experiment. On the basis of the result of the surveys, the Team had a meeting with counterparts from the Municipality. Then, three sections were selected for the experiment from the point of view that the degree of necessity to be improved, these becomes 6 areas where the collection points (Col Bolson, Arroyo Bolson, Puente Resbalon, Mafulia, Cuiscoma, Talpujera) were established in.

At the beginning of the 3rd work in Nicaragua, in June 1997, the Granada Municipality requested the Team to add one area, Sirena, to the experiment. The team checked the area with the Municipality, then, the Team accepted the request. Accordingly, the number of the areas where were subject to the experiment became seven (7).

O.4.2 Plan of the Experiment

In addition to the principal purposes of the "Experiment on Improvement of Refuse Collection System", the following is also one of the purposes.

To examine the possibility of illegal dumping elimination by providing periodical refuse collection service to the residents along the river.

Although the experiment was almost the same as the "Experiment on Improvement of Refuse Collection System", the experiment included clean-up waste dumped along the Arroyo Zacateligue. This was for increasing awareness of the importance of maintaining the river and awareness of necessity of the residents' cooperation to maintain it.

As for the relevant organizations' roles, refer Table O-11.

O.4.3 Execution of the Experiment

This experiment was executed as the same as the experiment in Eddy Ruiz III, so that, refer the section O.3.3.

However, as this experiment included River Cleansing differing from the experiment in Eddy Ruiz III, it is described below.

River Cleansing

This activities took place by cooperation of the residents with the truck provided by JICA and heavy equipment hired.

1. In July 12, 1997, the first river cleansing program was held in the area named Col Bolson. Around 130 participants (the residents, students, the counterparts and Team member) joined the program.
2. In Talpujera, the river cleansing was held with around 120 people in July 19, 1997.
3. In July 25, it was held with around 80 people in Puente Resbalon.

These programs closely had a relationship with the "Campaign for the Improvement of Municipal Sanitary Environment in Granada" which was one of the pilot projects. As a part of the campaign, a clean-up activity was held on the beach of Lake Nicaragua located at the mouth of the river. This was also carried out successfully with lots of participants. Below are the pictures that record the progress of the works

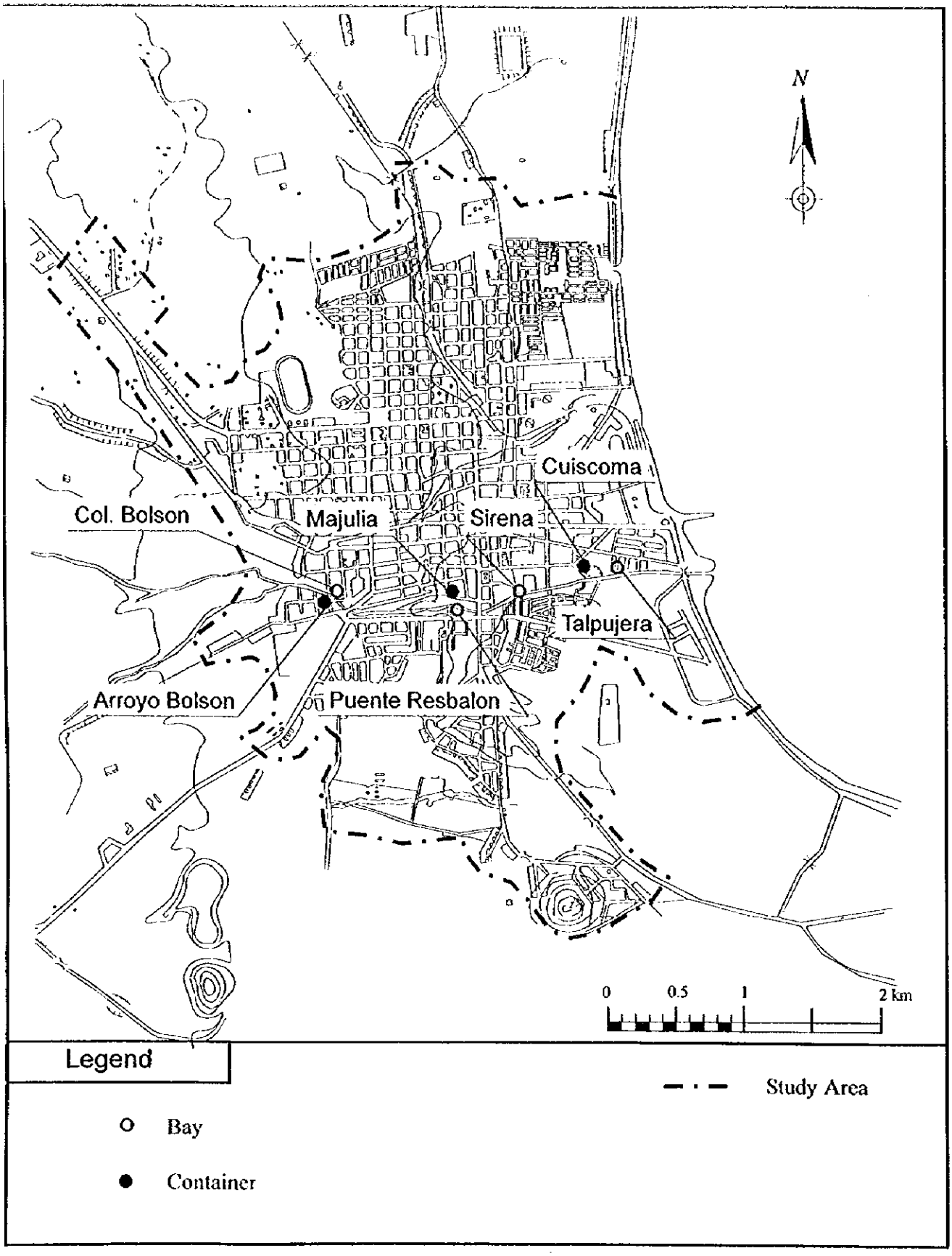

Figure O-15: Location of Experiment on Improvement of Arroyo Zacateligue Sanitation Environment

Plate O-31 : Illegal Dumping in Arroyo (El Bolson)

Plate O-32 : Confirmation of the Collection Points (La Sirena)

Plate O-33 : Postering on the Sign Board (El Bolson)

Plate O-34 : Workshop (Puerto Resbalon)

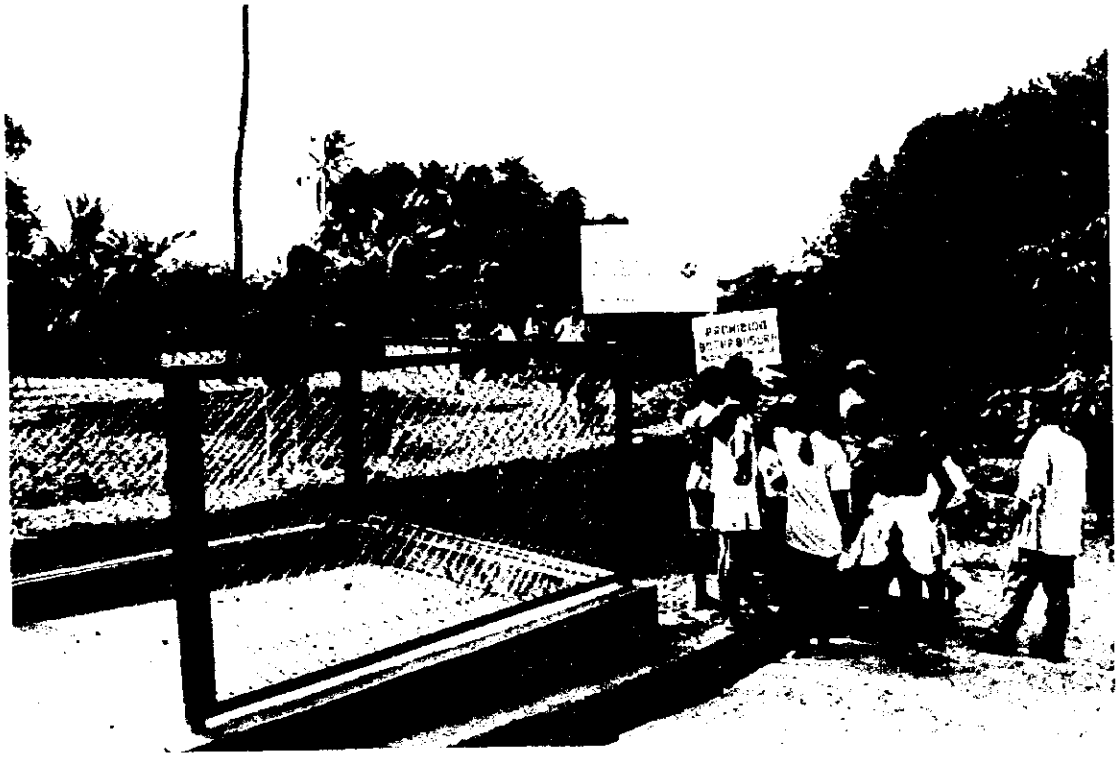

Plate O-35 :Construction of Collection Bay (El Bolson)

Plate O-36 : River Cleansing in El Bolson (Before)

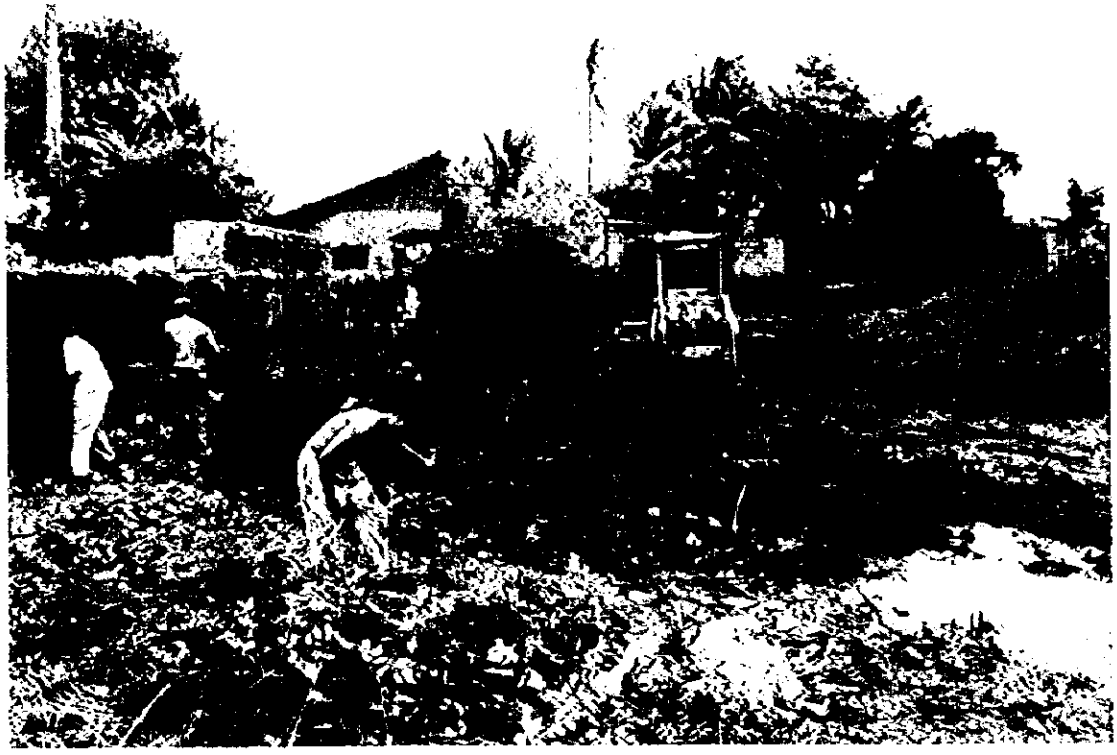

Plate O-37 : River Cleansing in Action (El Bolson)

Plate O-38 : River Cleansing with Community Participation (La Talpujera)

Plate O-39 : With Volunteer Students in Campaign T-shirt (La Talpujera)

Plate O-40 : Collection Bay with Domestic Waste (La Sirena)

Plate O-41 : Waste Collection for Data Gathering (La Sirena)

O.4.4 Findings

According to the questionnaire survey carried out in February 1997 on 60 residents (See Data Book 6), the majority (70%) were not receiving an adequate waste collection service. This led to the illegal dumping to the rivers by 75% of the residents.

However, Granada City started to provide regular waste collection service from May 1997. As a result of conducting another questionnaire survey on 36 residents prior to the experiment, 81% of the residents were receiving waste collection service (See Data Book 6).

With regard to the question on waste collection points, all residents answered they are willing to carry waste to designated collection points within 25m, while the majority (75%) said they would carry waste to collection points within a distance of 50m. The survey also showed that only 19% (7 people) are currently paying the waste collection fee, which amounts to an average of C$3.1/month. The amount the residents are willing to pay for waste collection services averaged C$3.9/month (an average of expenses per house is C$1,006/month).

After providing the refuse collection service and conducting the river cleansing, illegal dumping into the river at the areas was hardly observed. Therefore, it was judged that the illegal dumping into the river by the residents living along it would be eliminated with periodical refuse collection service. Meanwhile, there were a great number of participants for the river cleansing, it was sure that the activities strengthened and increased the awareness of maintaining sanitary environment soundly.

As for the findings about the Point Collection System was the same as in Eddy Ruiz III, so that, refer the section O.3.4.

The result of questionnaire surveys conducted on 36 residents after the experiments showed that:

1. The residents who replied that they are dumping wastes into the river drastically reduced from 75% to 24% (See Figure O-16). This fact indicates that the illegal dumping of the residents living along the river will be prevented if regular waste collection service is provided. Accordingly, the provision of the regular and reliable waste collection service is vital in order to prevent illegal dumping of waste. The active co-operation by citizens in clean-up activities of the Lake shore and Zacateligue river proved that public education programs and campaign for the residents significantly contribute to the elimination of illegal dumping.

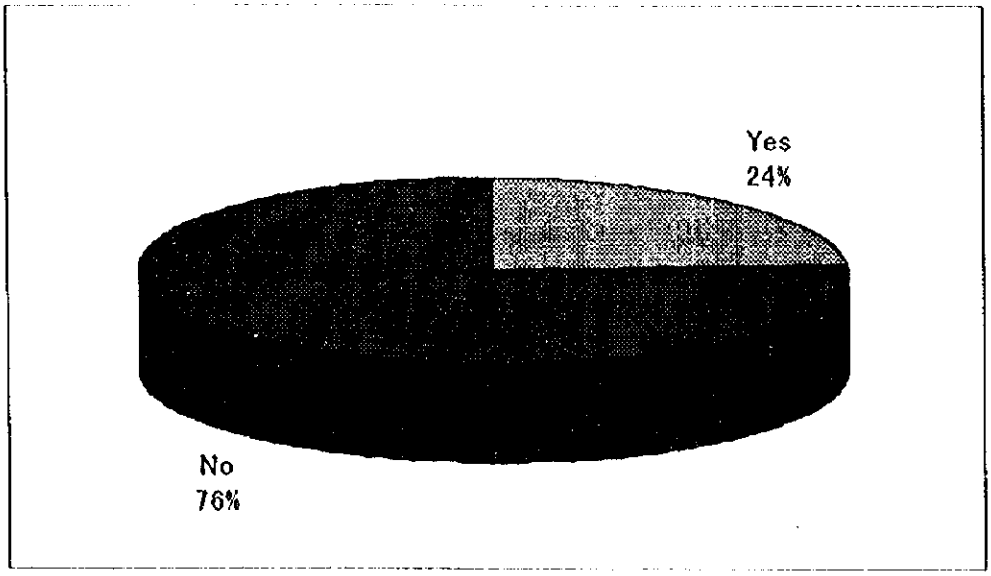

Figure O-16: Illegal Dumping

2. The majority (94%) of residents was content to utilize point collection system (See Figure O-17).

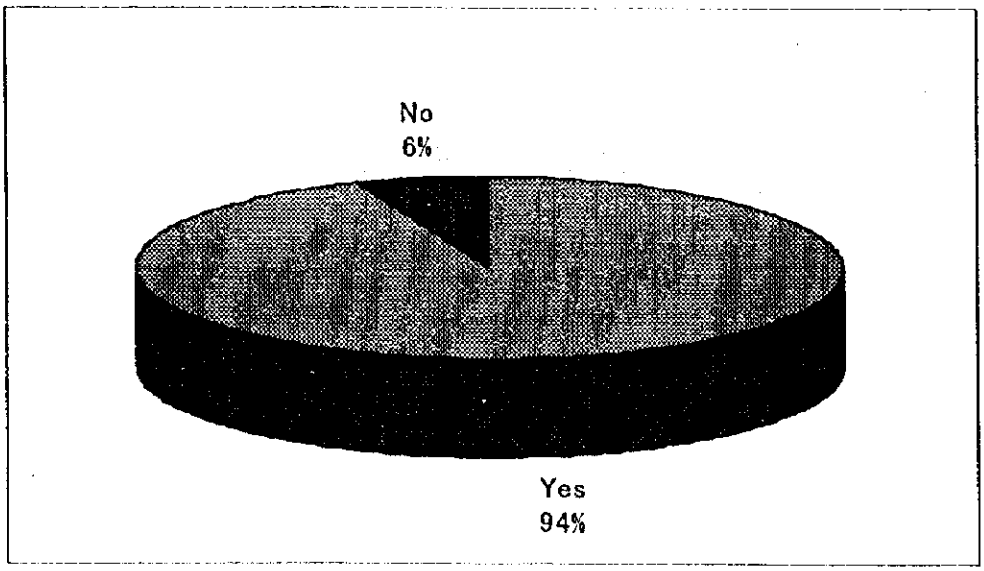

Figure O-17: Use of the Point Collection Service

3. and also, the majority of residents (89%) expressed that the "point collection system" had been positive impact on USE in the areas (See Figure O-18)

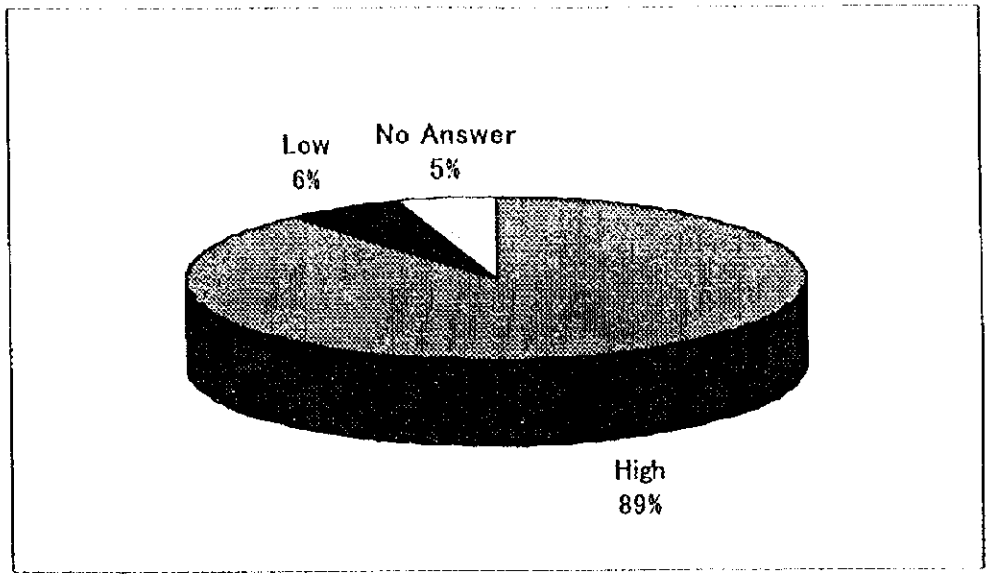

Figure O-18: Utility on the Point Collection System

4. Moreover, ninety seven percent replied that the waste collection bays are effective for the conservation of USE of the community (See Figure O-19).

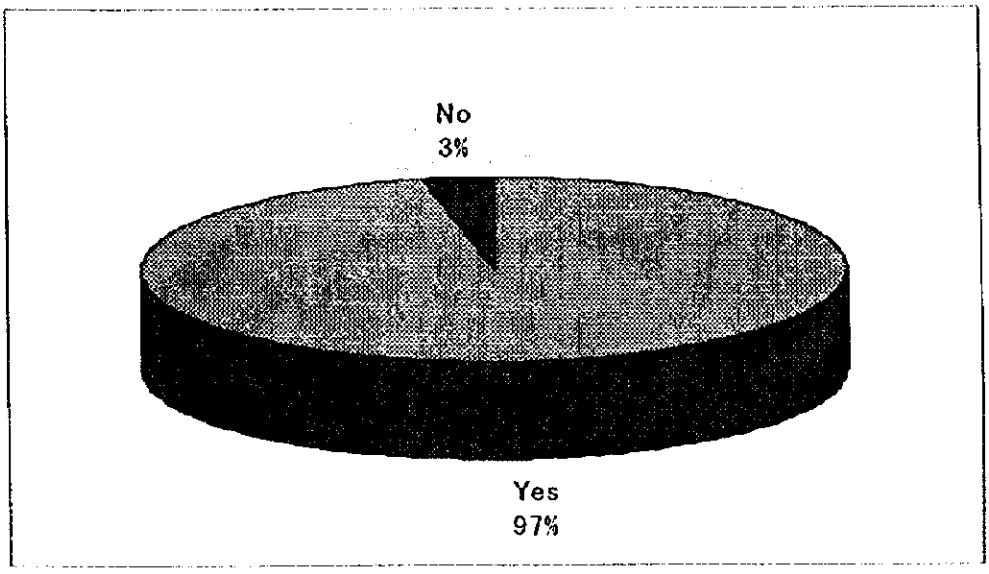

Figure O-19: Positive Impact of the Collection Bays and Containers for USE

5. The amount residents are willing to pay (WTP) for waste collection services remained the same as before the experiment with the average of 3.3 Cordoba/month. Although the residents replied that they are willing to pay dropped from 94% to 89%, no significant change could be observed(See Figure O-20).

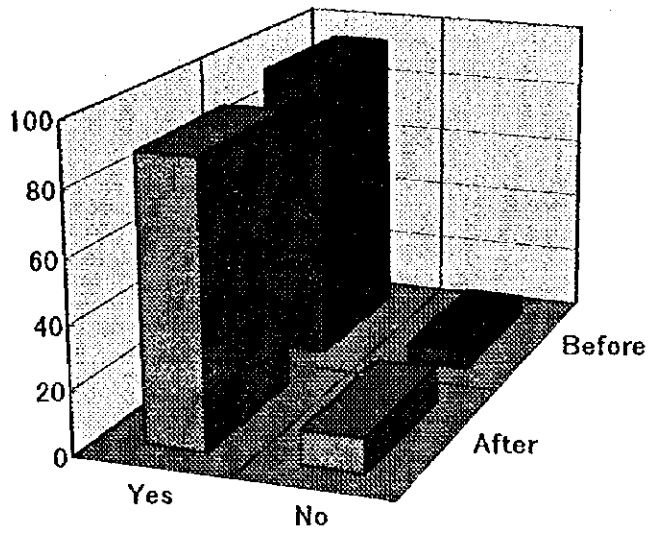

Figure O-20: WTP 1

Namely, in accordance with WTP, fourteen percent answered they may pay below C$2 for the service, of fifty-three percent for below C$4, of seventeen percent for below C$6, and only three percent for below or above C$10 (See Figure O-21).

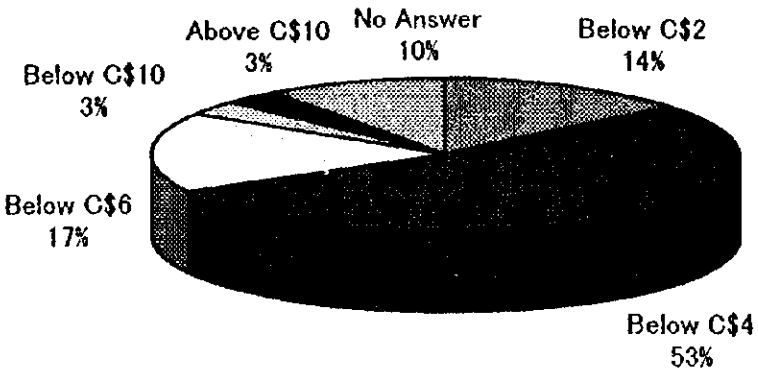

Figure O-21: WTP 2

6. This illustrates that the conclusion regarding point collection system, waste collection bays style, and cost sharing of waste collection fee are the same as that of the experiment on improvement of refuse collection system.

O.5 Experiment on Sanitary Landfill Operation at La Joya Disposal Site

O.5.1 Background

One of the most critical environmental problems in Granada is open dumping practices in the present municipal disposal site La Joya. La Joya disposal site stands upstream of the underground water flow, which serves as potable water sources of the City. Underground water contamination by the present disposal site La Joya is highly anticipated. Consequently, it is considered that construction of new final disposal site for Granada is an urgent issue. The M/P for Granada City might propose a project of constructing a new landfill and implementing appropriate operation of sanitary landfilling therein.

The experiment aims:

- to examine the workability of the sanitary landfill operation system to be proposed in the M/P; and
- to obtain basic data for the preliminary design for the F/S of the new final disposal site of the municipal solid waste.

Meanwhile, the experiment aims to gain citizens' understanding and consensus for the necessity of a new SW disposal site, in this connection it is necessary to demonstrate appropriate operations of sanitary landfill to be implemented in the new landfill site, before its construction.

O.5.2 Plan of the Experiment

The improvement plan comprises:

1. Accumulation of presently scattered waste dumps in one place through excavation and bull-dozing, shaping the accumulated waste heaps in a form of stable embankment, and covering with soil to form a landfill and compacting the landfill in order to minimize generation of leachate and to maintain lorries' access to the landfill face to continue the sanitary landfill operation;
2. Construction of ditches in order to minimize the rainwater intrusion in the landfill and the access road;
3. Installation of landfill gas exhaust pipes;
4. Installation of fence around the site; and
5. Implementation of sanitary landfill operation;

O.5.3 Execution of the Experiment

Implementation flow chart of the pilot project as shown in Figure O-22.

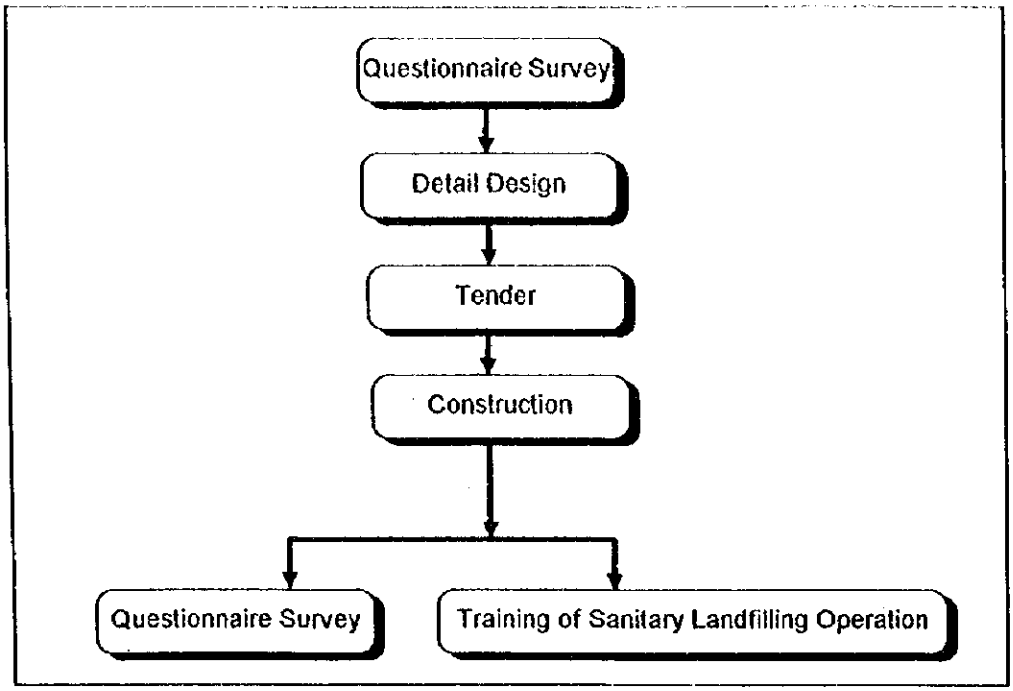

Figure O-22: Implementation Flow Chart of Pilot Project

a. Questionnaire Survey

Prior to the experiment, 24 concerned people (mayor, 5 municipal councilors, 3 newspaper journalists, 2 MARENA employees, 13 residents' representatives) were invited to see the prevailing conditions in the La Joya disposal site and were asked to answer questionnaires.

a.1 Questionnaire Survey (before)

The results of the questionnaire survey showed the majority (57%) to be ignorant of how wastes generated daily are disposed of. With regard to the conditions in the disposal site, 96% answered the site emits offensive odor, 88% stated the site is a detriment to the surrounding environment, pollutes the air, and is a breeding ground for insects (e.g., flies), 83% pointed out how scattered the wastes are, and 54% indicated how dusty the site is.

Table O-13: Profile of Interviewees

Number of interviewees	24
Effective answer	24
Average age	41

Table O-14: Results of the Survey

Question		Answer		Ratio (%)
Do you know where and how to dispose municipal solid waste?		Yes No NA	9 12 3	50 38 12
What do you think about the final disposal site after your visit?				
a.	The waste is scattered in and around the disposal site, unhygienic.	Yes	20	38
b.	Bad odor, unhygienic.	Yes	23	96
c.	Clouds of dust, unhygienic.	Yes	13	54
d.	To many flies, unhygienic.	Yes	21	88
e.	Too noisy and with vibrations.	Yes	4	17
f.	Too , many fires and smoke.	Yes	5	21
g.	Not aesthetic.	Yes	21	88
h.	Causes the debasement of the environment and the area around the disposal site.	Yes	21	88
i.	The contamination of the water due the disposal site is a serious concern.	Yes	21	88
j.	The contamination of the air due the disposal site is a serious concern..	Yes	23	96
k.	Others (please specify)		5	21

a.2 Questionnaire Survey (after)

The Experiment on Sanitary Landfill Operation at la Joya Disposal Site resulted in a considerable improvement of the site. To quantitatively evaluate the effects of the improvement works, the same group of people who responded to the questionnaire survey prior to the beginning of the experiment were, once again, invited to the disposal site to see its newly improved state. As before, the group was asked to fill in a questionnaires. The results of this questionnaire survey outlined that:

The Experiment on Sanitary Landfill Operation at La Joya Disposal Site resulted in a considerable improvement of the site. To quantitatively evaluate the effects of the improvement works, the same group of people subjected to the questionnaire survey prior to the commencement of the experiment were, once again, invited to the disposal site to see its newly improved state. As before, the group was asked to answer questionnaires.

The results of this post-experiment questionnaire showed that:

1. All residents agreed that the disposal site was improved (See Figure O-23).

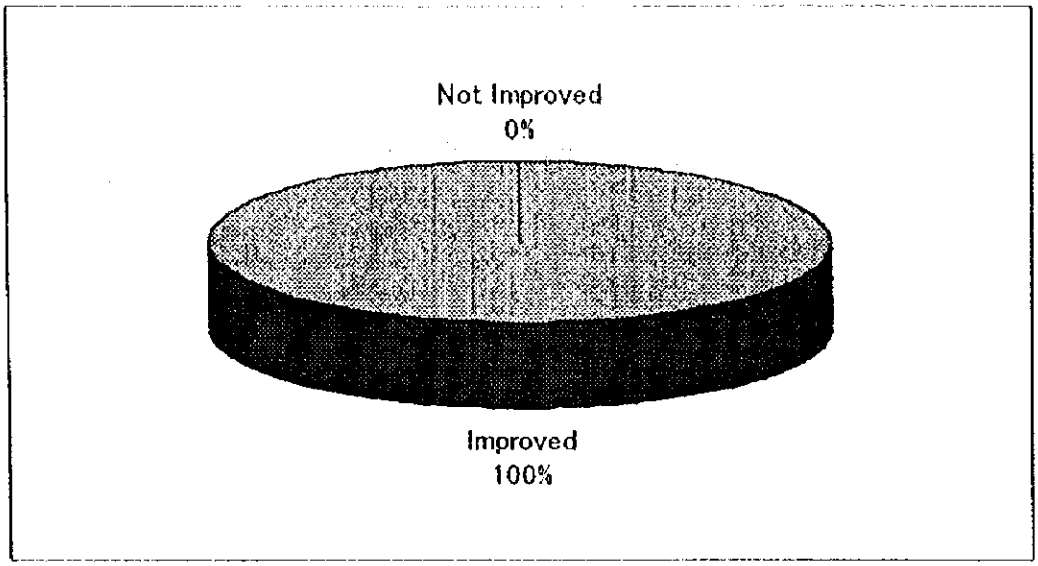

Figure O-23: Level of Environmental Improvement in La Joya

2. Furthermore, majority of negative impacts were relieved in high standard. For example, all of the questionnaire answered that the project has already terminated the major environmental problems in La Joya as ill odor, vermin and waste scattering (See, Figure O-24, Figure O-25 and Figure O-26) .

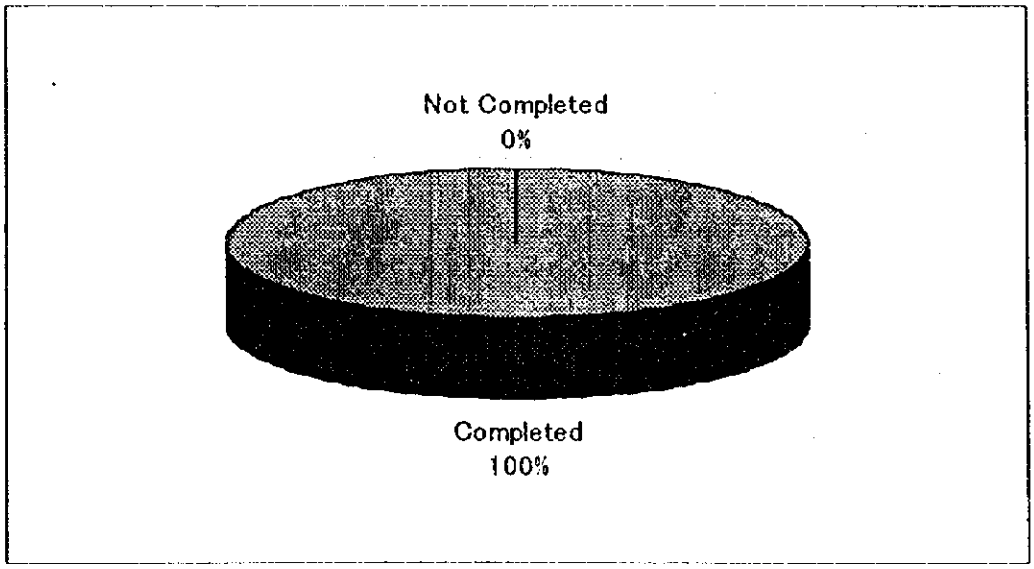

Figure O-24: Termination of Ill Odor

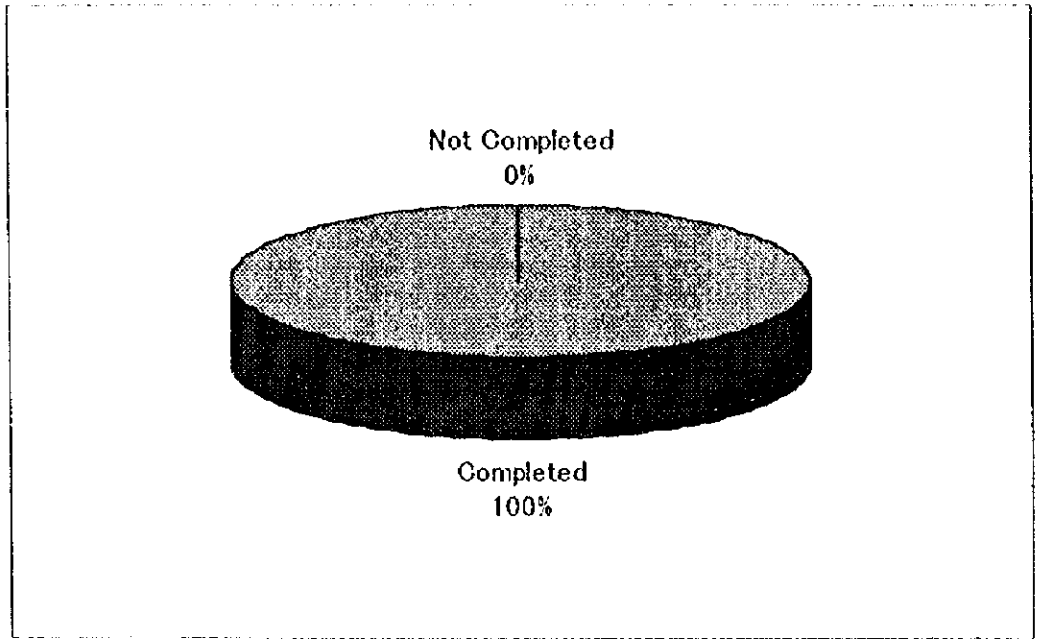

Figure O-25: Termination of Vermin & Improvement of Environmental and Air pollution

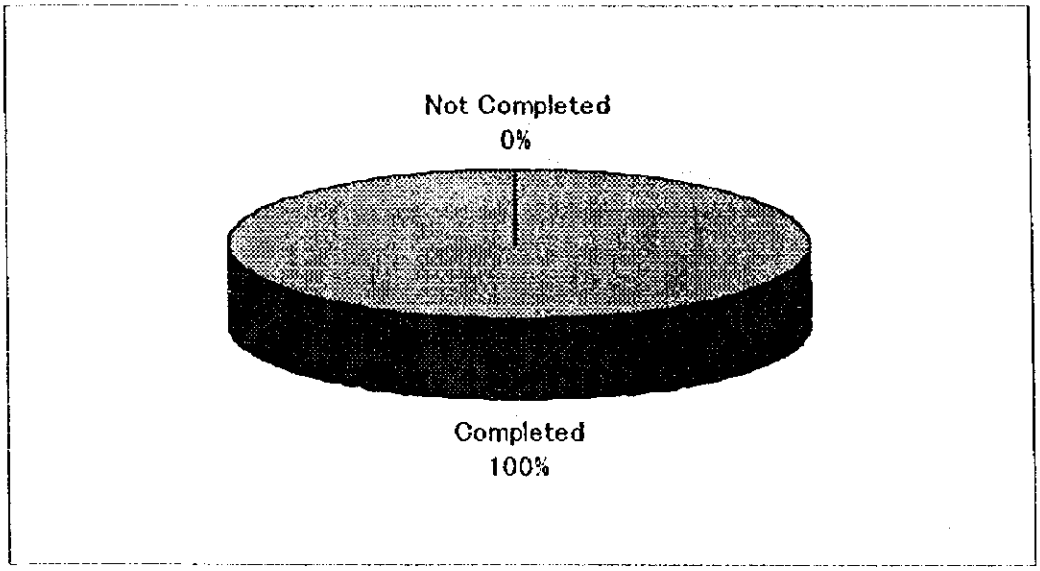

Figure O-26: Termination of Waste Scattering

3. Regarding the respective environmental negative impact, although twenty eight percent of the people concerned pointed out that the issue related to dust remained unsolved (See Figure O-27).

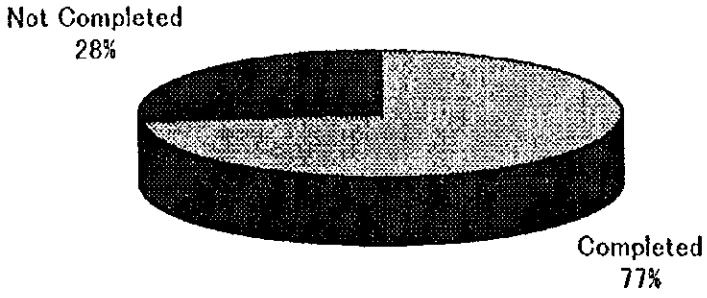

Figure O-27: Relieving of Dust Problem

b. Detail Design

Plans drawn in the 2nd Study Work in Japan are revised to meet the actual situation of the site.

c. Construction

Based on the plans above, the improvement work was contracted to a construction company in Managua, and was launched on June 29, 1997 and completed on August 15, 1997 under the supervision of the Study Team. The outline of the improvement work and its photographic records are shown below.

Table O-15: Outline of Improvement Work

Item	Quantity	Remarks
Waste compilation work	Lump sum	accumulation and compaction
Earth work	14,000 m^3	import of clay and soil
Rain water drainage	Lump sum	
Gas removal	9 Nos.	
Fencing improvement	1,200 m	
Entrance gate	1 No.	
Heavy equipment employed		
Bulldozer (D8 class)	30 days	
Bulldozer (D6 class)	20 days	
Bulldozer (D4 class)	5 days	
Wheel loader	50 days	
Back hoe	15 days	
Dump track	180 days	
Motor grader	20 days	
Water tanker	15 days	

Plate O-42 : Before Improvement

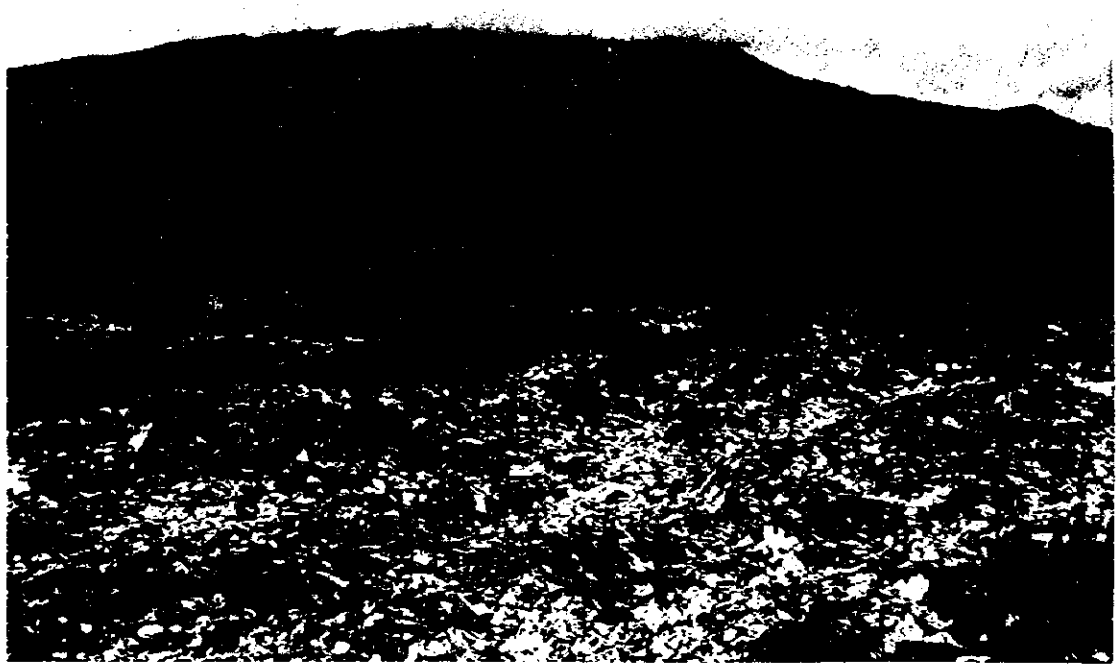

Plate O-43 : Before Improvement

Plate O-44 : Before Improvement

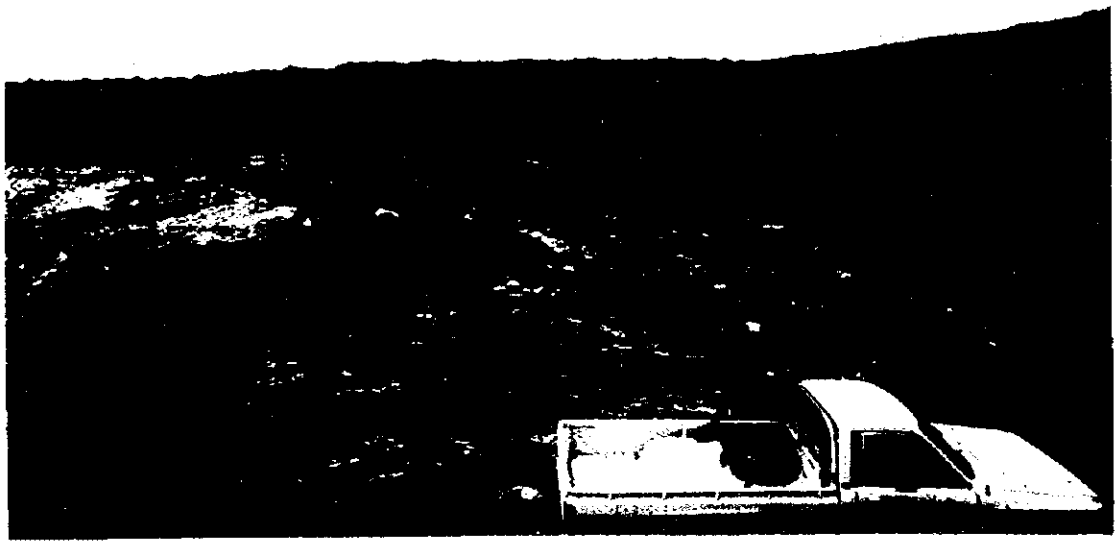

Plate O-45 : Accumulation of Waste

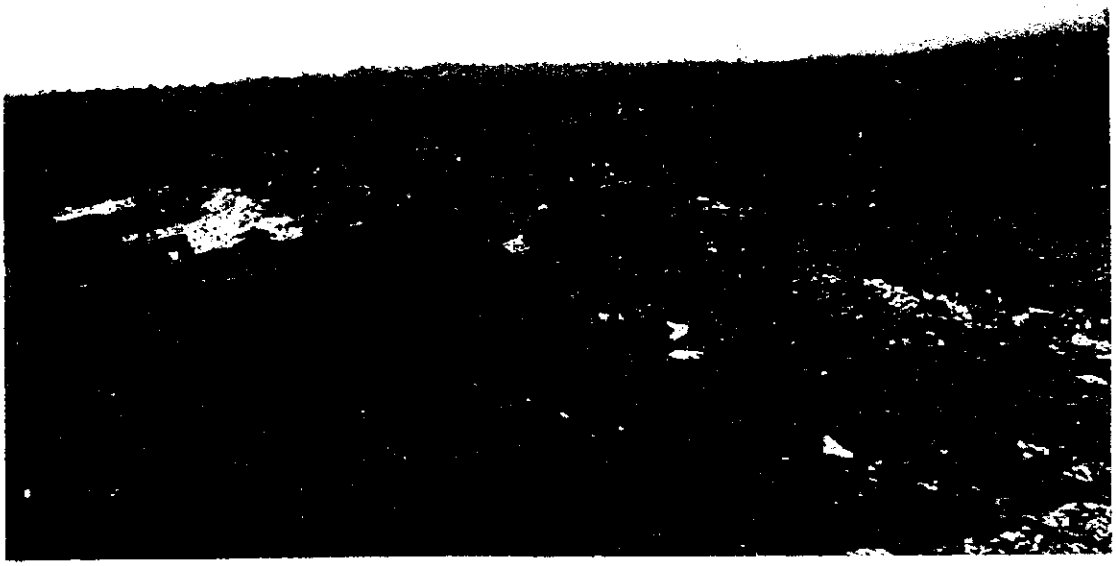

Plate O-46: Accumulation of Waste

Plate O-47: Accumulation of Waste

Plate O-48 : Accumulation Completed

Plate O-49 : Final Covering

Plate O-50 : Final Covering

Plate O-51 : Final Covering

Plate O-52 : Final Covering

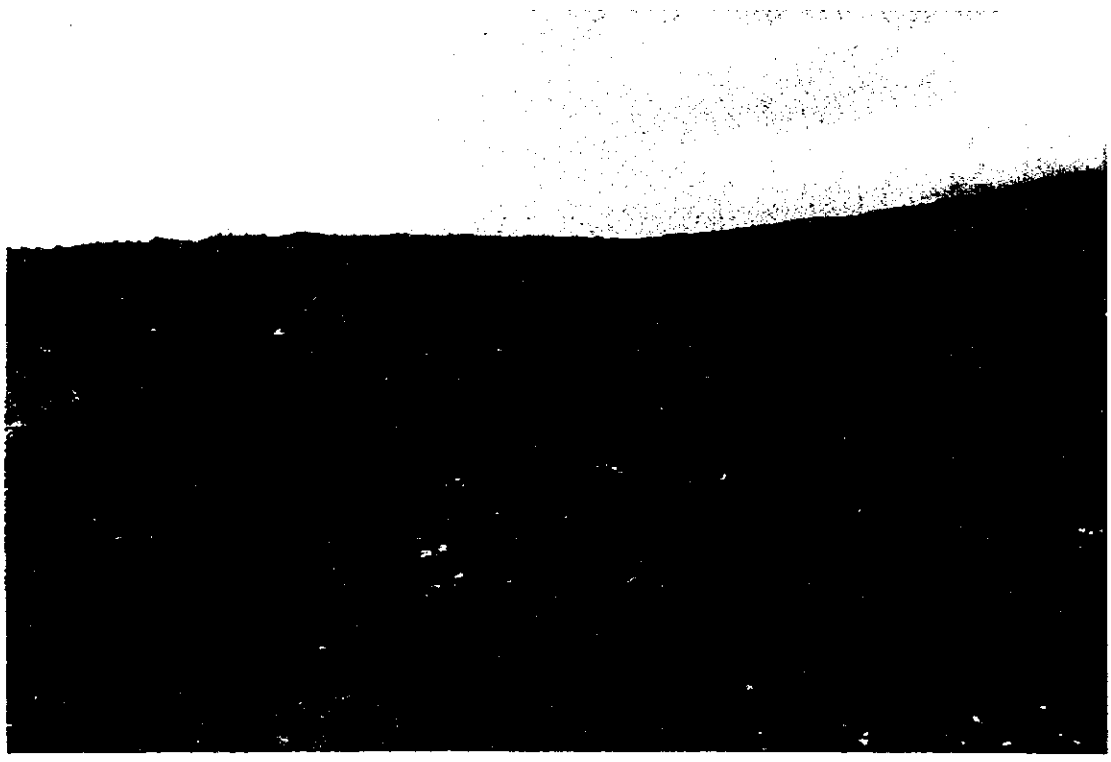

Plate O-53 : Final Covering

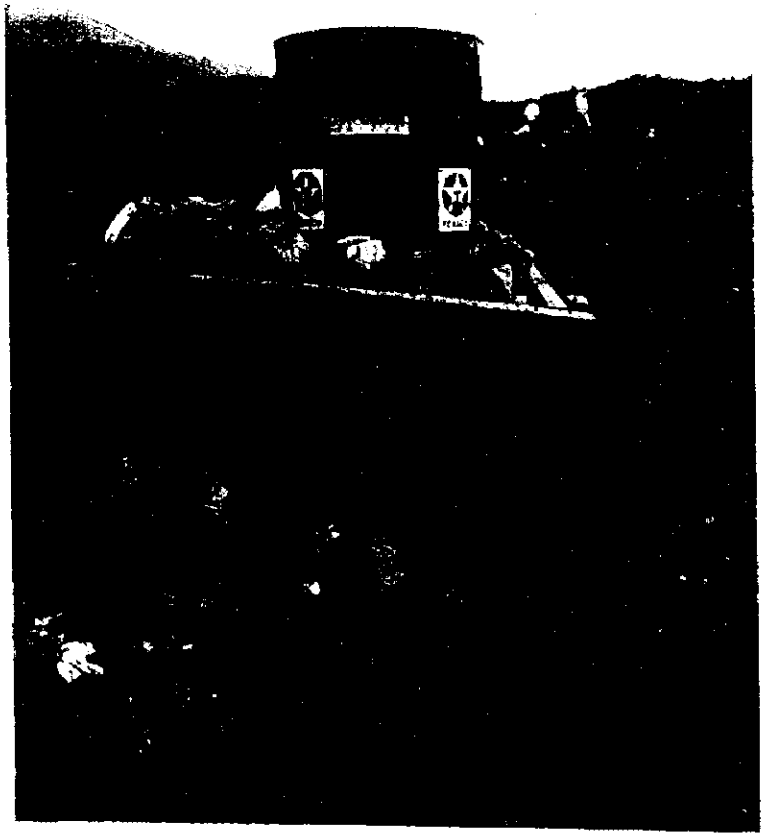

Plate O-54 : Gas Remove Pipe

Plate O-55 : Completed

Plate O-56 : Completed

Plate O-57 : Completed

d. Operation

The municipality of Granada should continue conducting sanitary landfill operation even way after the experiment. Because the Municipality own machinery are limited (i.e., wheel loader and dump trucks), the experiment stockpiled some amount of cover soil in the site and sanitary landfill operation with the Municipality machinery are trained to practice for about a week.

O.5.4 Findings

The results of the Experiment on Sanitary Landfill Operation at La Joya Disposal Site revealed the following.

- The condition of the La Joya final disposal site has improved dramatically by introducing a sanitary landfill operation.
- It is considered that there is less leachate generated, as a result of the outstanding reduction of working face area of the landfill, which used to percolate the ground in the past.
- The amount of the rainwater drained from the disposal site into the crater is reduced drastically by the storm water drainage constructed along the crater.
- As Nicaragua has volcanic activities and its nature of the soil is generally sandy and lava, it required time to find out clay deposit for final coverage and longer transport distance from clay deposit to the site.
- The cover material used in this pilot project was a surface clay layer of a borrow pit. The borrow pit mainly provides granular soil and pumice which are used for roads construction in the City. As the amount of the surface clay material is limited, the acquisition of the clayey material may become a problem for the construction and operation of a new municipal disposal site in the near future.
- In addition to the municipal solid waste, industrial solid waste is disposed of at the present La Joya final disposal site. Among the industrial solid waste, the offensive odor of excreta discharged from chicken farms is extremely potent having a native impact on the surrounding environment. However, the offensive odor will be mitigated to a certain extent if the cover soil is carried out on the same day.

O.6 Experiment on Domestic Waste Water Collective Treatment System

O.6.1 Background

INAA, the authority responsible for sewer services, has a target sewer coverage of 65% in the year 2010 for Granada City. Meanwhile, since many communities do not at present receive any sewer services, domestic wastewater (DWW) is simply discharged onto the roadside or Arroyos and thus debases the sanitary environment of the communities.

This has been supported by a public opinion survey (POS) placed by the Team. The purpose of the POS is to estimate priority of the construction, that is: solid waste (SW), wastewater (WW), water supply (WS) and rainwater (RW).

Four areas has chosen for the sake of the POS: Eddy Ruiz Ⅲ (C1), Adelita I (C2), Adelita Ⅱ (C3) and Escudo(C7) appear on a map attached (see Figure O-28).

The reason why the Team chosen these four was that these areas had not enjoyed adequate services on SW, WW, WS, and RW; and therefore, the POS was expected to reflect what they were suffering most seriously among the four issues above.

155 households was selected within the areas randomly and a questionnaire survey was placed. The number should be equal to 5% of the total households in the survey areas. Our calculation method applied may be shown as below:

A data shown that population of each areas was: 4,997 in C1; 3,992 in C2; 7,789 in C3; and 869 in C7. This led to 17,647 of the total population and divided by 5.7 an ideal average number of household members observed in the districts.

In a mathematical form:

$$C1+C2+C3+C7 = 4,997+3,992+7,789+869 = 17,647$$

Therefore, we may estimate the number of the total households as,

$$17,647 \div 5.7 \times 0.05 \fallingdotseq 155$$

and namely,

$$C1 = 4,997 \times 0.05 \fallingdotseq 45 \text{ sample households}$$

$$C2 = 3,992 \times 0.05 \fallingdotseq 35 \text{ sample households}$$

$$C3 = 7,789 \times 0.05 \fallingdotseq 65 \text{ sample households}$$

$$C2 = 869 \times 0.05 \fallingdotseq 10 \text{ sample households}$$

The questionnaire requires informants put numbers 1,2,3 and 4 on SW, WW, WS and RW to make priority. In addition, for mathematical calculation, a point system has introduced, that is: priority 1 gets 4 points; priority 2 gets 3 points; priority 3 gets 2 points; and priority 4 gets 1 point

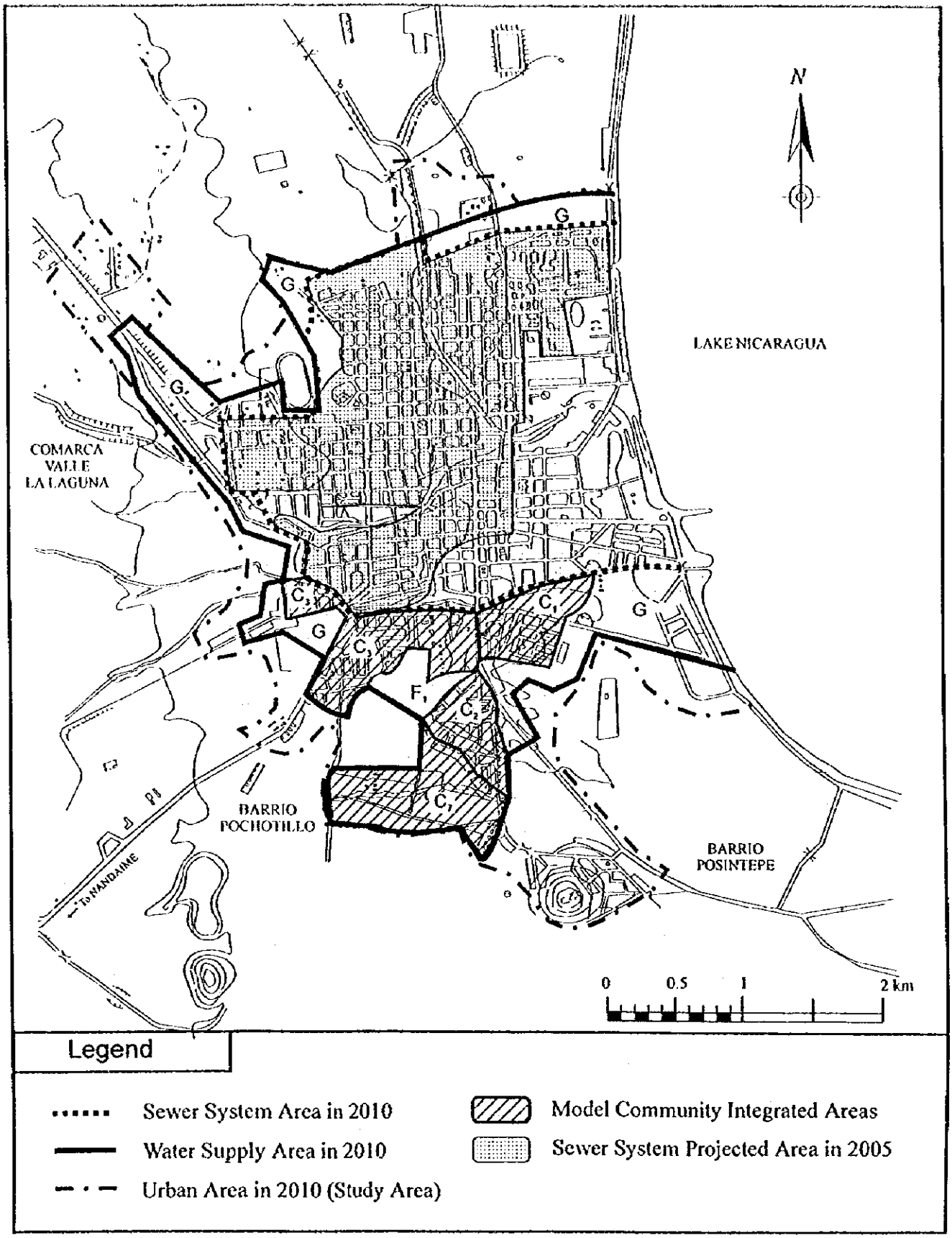

Figure O-28: Locations of the Sampling Areas

Following this method, WW comes to the 1st priority with 491 pt, SW the 2nd with 425 pt, RW the 3rd with 321 pt, and finally, WS the 4th with 308 pt (see Figure O-29).

We may conclude, therefore, that **WW is the residential most concern issue among the four environmental constraints.**

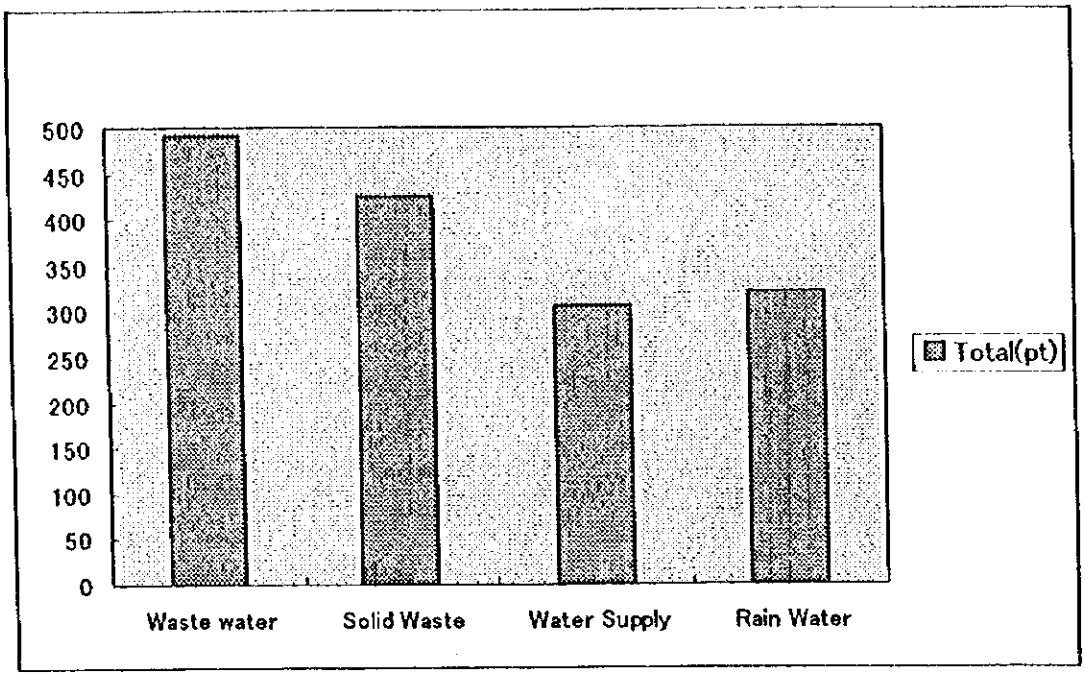

Figure O-29: Priority Order of the Four Constraints

The M/P for Granada City may propose a plan for a community-based integral USE improvement.

In view of the background and POS stated above, the experiment on community cooperation aims:

- to examine the applicability of the technologies proposed (domestic wastewater on-site collective treatment);
- to examine the related institutional system (e.g., operation and maintenance of the system through community participation, technical guidance and advice by INAA, etc.);
- to obtain basic data for the preliminary design for the F/S of the "community-based integral USE improvement"; and
- to raise public awareness for the necessity of community-based approaches for improving the USE.

O.6.2 Plan of the Experiment

The pilot project was basically carried out following the process shown in Figure O-30 below.

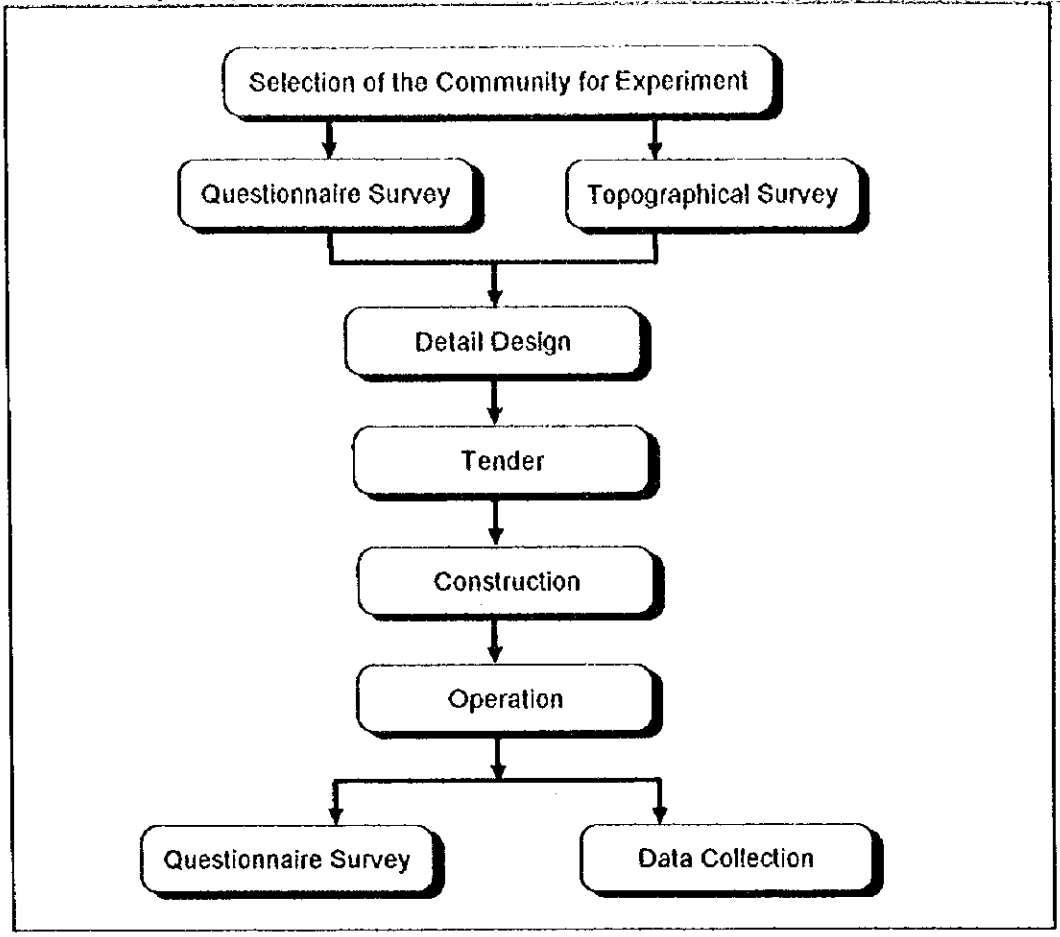

Figure O-30: Implementation Flow of the Pilot Project

a. Selection of a Community for the Experiment

As a result of the discussion with the counterpart, 42 households in Reparto Adelita II were selected from the communities which met the following criteria as a community to carry out the experiment on "on-site collective domestic wastewater treatment". This selection was made on the premise that this treatment system will be applied to the areas where the provision of the sewerage system is difficult in the future.

- A community where the off-site sewerage system is not planned to be established in the present INAA's sewerage plan
- A community where domestic wastewater is discharged into the road at present and the resident's living environment has deteriorated.
- A community where land acquisition for an on-site treatment facility is easy.
- A community where the population density is either equivalent or higher than that of the area presently covered by the off-site sewerage system.
- A community where the served population is small enough so construction will be done within 45 days, as the time is limited for the pilot project implementation. The community should also have a topographical feature of collecting domestic wastewater from the households easy.

O.6.3 Execution of the Experiment

a. Questionnaire Survey

The on-site collective domestic wastewater treatment project was conducted in the Reparto Adelita II as an experiment and the questionnaire survey was carried out on the same people before and after this project, as a means to check the improvement of the USE.

a.1 Questionnaire Survey (before)

The questionnaire survey carried out before the project focused its questions on whether or not respondents think the domestic wastewater flowing on the roads is debasing the environment of the district, and secondly, income and expenditure per month of each household in order to see the possibility of sharing the cost for the on-site wastewater treatment (See Data Book 6 for the questionnaire form). The results are shown below.

Table O-16: Outline of the Sample Household

Total number of sample		42 households
Effective sample		40 households
Population	Adults	143
	Children	132
	Total	275
Water supply	INAA	38 households
	Others	2 households
Mean value of monthly expenses (34 households)		C$998.8
Mean value of monthly income (16 households)		C$ 846.9

Table O-17: Results of the Survey

Question		Answer	Ratio (%)
Q.1	Do you think that DWW worsens the environmental condition of your community?	Yes : 40/40	Yes : 100
Q.2	Reasons worsened		
a.	Gray water runs through the street	Yes :35/40	87.5
b.	Bad odor	Yes :36/40	90.0
c.	Causes flies and mosquitoes to breed.	Yes :37/40	92.5
d.	Causes of the contamination of the river.	Yes :38/40	95.0
c.	Others	NA	-
Q.3	What do you think of the present DWW situation DWW		
a.	No problem	Yes: 0/40	0
b.	One of the causes of environment destruction	Yes : 40/40	100
c.	Others	NA	-

As can be seen above, the majority of the residents in the district believe that the domestic wastewater flowing on the roads is one of the causes for debasing the living environment of the community.

a.2 Questionnaire Survey (after)

As a result of the questionnaire surveys after the construction of the facility conducted with 42 households as before(See Data Book 6 for the questionnaire form).

Table O-18: Results of the Survey

Question		Answer	Ratio (%)
Q.1	Do you think that environmental condition has improved in your community?	Yes : 40/40	Yes : 100
Q.2	Are you satisfied with Waste Water Treatment Service?	Yes : 40/40	Yes : 100
Q.3	Will you carry out the maintenance and operation of the facility?	Yes : 40/40	Yes : 100
Q.4	Will you modify latrine system to flush water toilet?		
a.	Will modify	28/40	67
b.	Wish, but budgetally being disabled to	12/40	33
c.	Will not modify	0/40	0

And all questionnaire indicated that;

1. the USE of the community is improved drastically as 100% of the questionees replied 'Yes' (See Figure O-31) .

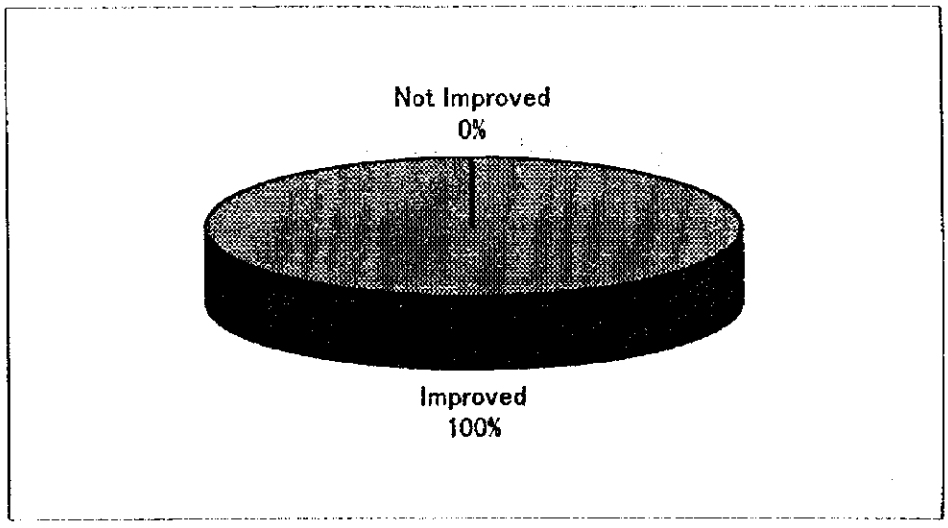

Figure O-31: Improvement of Environmental Condition

2. the domestic waste water treatment facility constructed satisfies them perfectly (See Figure O-32), and

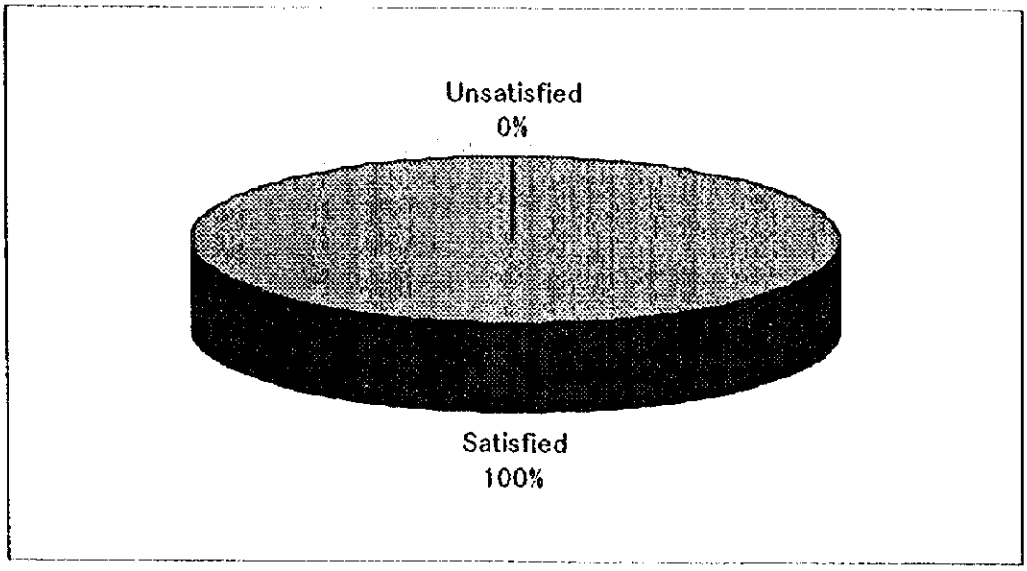

Figure O-32: Contentment on Waste Water Treatment

3. the maintenance and operation of the facility will be carried out by themselves with extra high motivation (See Figure O-33).

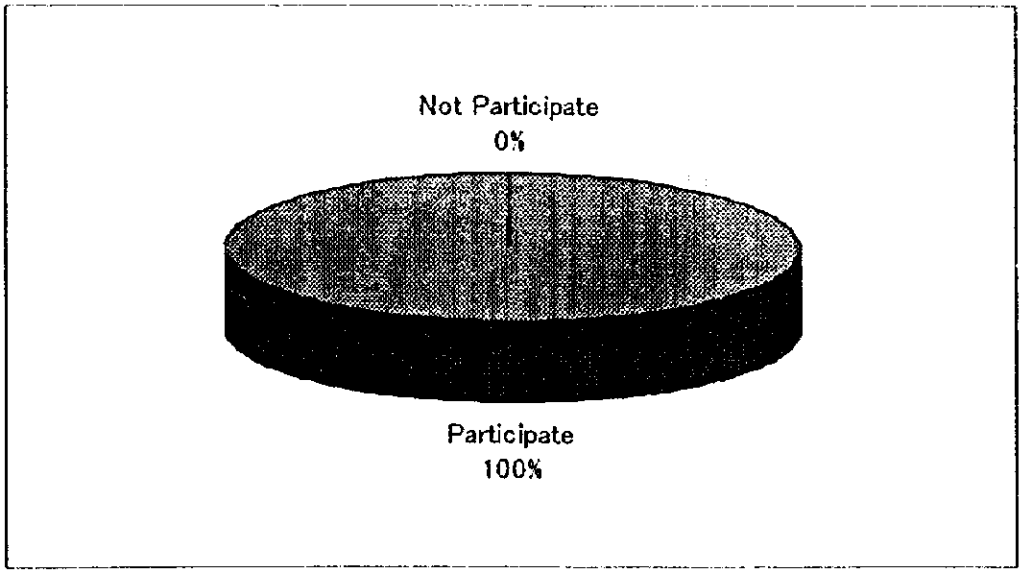

Figure O-33: Participation on the Facility Maintenance & Management

4. Moreover, Majority (67%) of the residents replied that they will remodel their toilets into a flush type of the toilets at their own cost in the future (See Figure O-34).

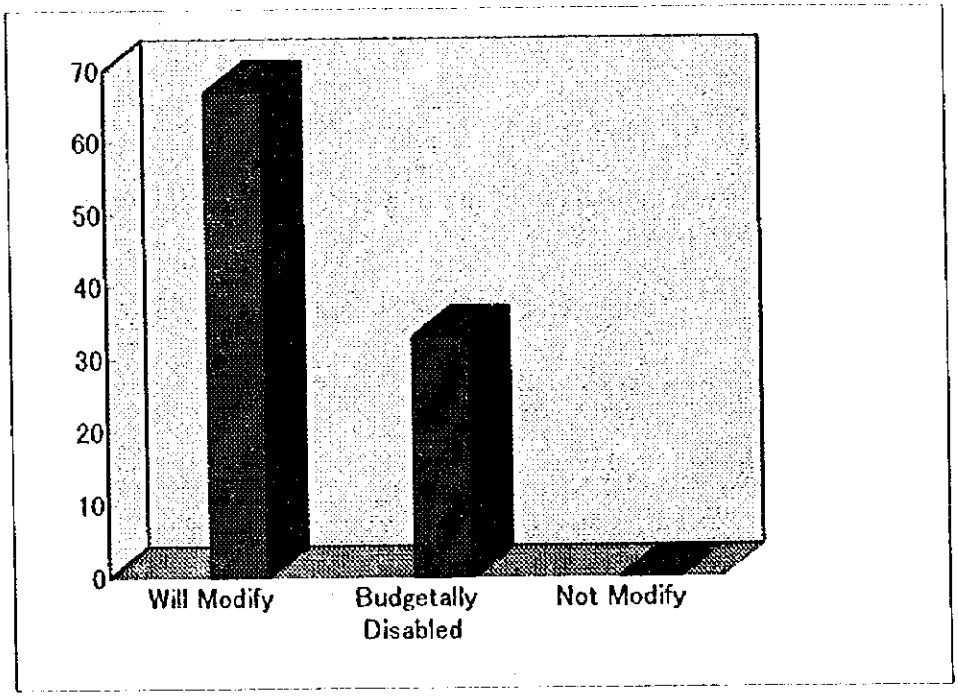

Figure O-34: Latrine System Modification

b. Topographical Survey

Granada municipality carried out topographical survey including profile leveling for the area. The Study Team designed the pipe and the treatment facility utilizing the topographical survey results.

c. Detail Design

c.1 Served Population

The result of the pre-experiment questionnaire survey suggested 7 person/household, served population may reach 294 people in 42 households.

c.2 Treatment Amount

According to INAA, 32 out of 42 households in the project area have a water meter installed. The average amount of water supply for those houses resulted 0.797 m3/day/household from January to June, 1997. The amount of water needed to be treated is basically calculated by multiplying 0.8 as a discharge coefficient and is set as below.

$$Q = 0.797 \times 42 \times 0.8 = 26.8 \rightarrow 27 m^3 / day$$

Table O-19: Served Population and Treatment Amount

Item	Amount
Served population	294 persons
Served number of household	42 household
Treatment amount	27 m^3/day

c.3 Pipeline

The sewer design was carried out by utilizing design parameter in Table O-20, based on the discussion with INAA

Table O-20: Basic Design Conditions

Item	Design Parameter
Type of collection system	Separate system
Pipe material	PVC
Minimum diameter of pipeline	100 (mm)
Formula of flow rate	Manning formula
Roughness coefficient	n=0.01
Maximum veloCity of flow	3.0 (m/sec)
Minimum veloCity of flow	0.6 (m/sec)
Maximum length of manhole to manhole	80 (m)
Minimum earth depth	600 (mm)

The curtailment of construction expenses was considered by installing the pipes parallel to the ground surface gradient. However, if sewer pipes intersect with water supply pipes, the former shall be installed 30 cm below the latter in accordance with INAA regulations.

c.4 Treatment Facility

c.4.1 Intake Water Quality

The inflow water quality of the on-site treatment facility was assumed, based on a water quality surveyed by the Team and existing data, on major pollutant parameters (BOD and SS).

In practice, domestic wastewater currently discharged on the road of project site was sampled and analyzed (which sample is free of excreta). On the other hand, in order that this facility should be designed being able to treat domestic wastewater containing nightsoil in the future, data representing the sewage (containing nightsoil) in Granada was sought and supplied by an Austrian aid project (Biomasa Project).

Table O-21 shows the results of the actual analyses of the quality of domestic wastewater with and without nightsoil.

Table O-21: Measured Water Quality

Item	Concentration	
	without nightsoil	with nightsoil
BOD (mg/l)	146	180
COD (mg/l)	417	526
SS (mg/l)	59	219
T-kN (mg/l)	3.22	19
NO_2-N (mg/l)	0.019	0.006
NO_3-N (mg/l)	0.71	0.419
PO_4-P (mg/l)	6.74	16
Total coliform (NMP/100ml)	1.11 E+05	1.3 E+07
E-coliform (NMP/100ml)	5.12 E+04	4.0 E+06

Table O-21 indicates that even the BOD level in domestic wastewater containing nightsoil is less than 200mg/l. However, the results of the water pollution load survey (WPLS) conducted in Phase I of the Study indicate that sewage in the City of Granada contains 340mg/l of BOD and 570mg/l of SS.

WPLS covered the entire City, the BOD and SS values aforementioned are only the average of the values analyzed in the high income, middle income and low income areas. Hence, the inflow quality necessary to design the treatment facility shall be set as shown in Table O-22, based on the values shown in Table O-21 and the values surveyed in Japan.

Table O-22: Design Indicators of Intake Water Quality

BOD	SS
200 (mg/l)	250 (mg/l)

c.4.2 Treatment Method

There are various systems of treating domestic wastewater. However, to facilitate operation and maintenance easy and so as not to rely on electriCity, the system of "septic tank" with "filter trenches" was adopted for the experiment. The installation of a bulkhead within the septic wall was also designed for the future treatment of wastewater containing nightsoil.

The "filter trench" system involves either the recovery of treated water or the infiltration of treated water into the ground. However, as a pilot project, the former style of the filter trench (treated water recovery) was selected in order to analyze the effluent quality for evaluating a general applicability of the "filter trench" system in Nicaragua. Figure O-35 shows the flow chart of the on-site treatment facility employed in the pilot project.

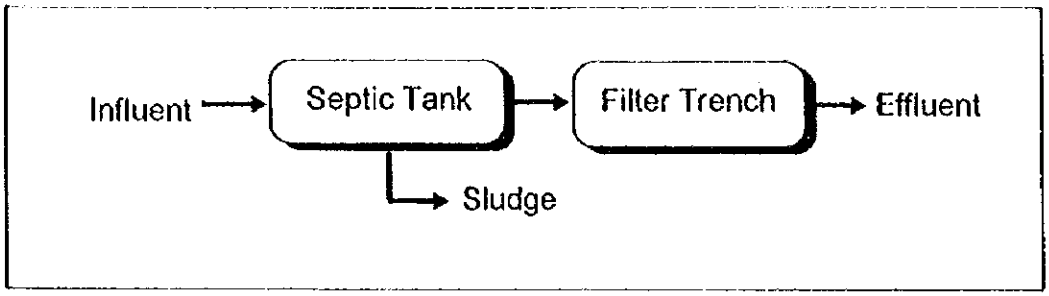

Figure O-35: Flow Sheet of the On-site Treatment Facility

c.4.3 Engineering Calculation

c.4.3.1 Septic Tank

With the septic tank, organic pollutants of influent are removed through anaerobic decomposition. The decomposition capaCity of the tank depends on the detention time.

Detention time could be designed either by conducting laboratory analyses on influent or referring existing data and bibliography.

Detention time of 3 days is employed in the engineering calculation of this experiment, referring that the septic tank in William Fonseca project in the City of Leon established a detention time of approximately 3 days for through a year long experimentation.

The calculation is made as follows:

$$V=Q \times DT=27 \times 3.0=81m^3$$

where,
V = Required volume of septic tank (m3)
Q = Daily average flow (m^3/day)
DT =Detention time (day)

The calculation indicates 81m^3 as the required septic tank volume. However, the septic tank actually constructed was given a 10% allowance, and can therefore accommodate 90m^3.

c.4.3.2 Filter Trench

The design of the filter trench was made taking into account the volume of wastewater that can be treated daily per 1m filter trench. This project adopts the empirical value in Japan (i.e., maximum 200l/m/day for BOD 90mg/l wastewater in Japan).

The biological treatment of organic wastewater can be effectively carried out with the water temperature below 40° C. Since the above mentioned empirical data of filter trench (200l/m/day with BOD 90 mg/l) in Japan abide by the wastewater temperature ranging 15° C to 20° C, the filter trench in Nicaragua with higher temperature could possibly achieve a greater capaCity.

Accordingly, in consideration of climatic conditions (e.g. temperature, humidity, in Nicaragua), there is a need to verify through the pilot project whether the value adopted in Japan, as shown below, is applicable in Nicaragua.

$$L = Q \div 0.2 = 135m$$

where,

L= Required length of filter trench (m)

Q= Daily average flow (m^3/day)

Although the above equation shows 135m as the required filter trench length for the pilot project, the constructed filter trench actually measures 137.5m long.

When a filter trench is used for a long period of time, it becomes clogged with microbe membrane that result from the wastewater decomposition. When this happens, water should not be directed to the trench so that the trench can dry to facilitate the removal of the microbe membrane. Consequently, this project should construct two units of filter trenches of 137.5m, alternately using them for a period of about one year.

c.4.3.3 Pollutant Load Balance

It is assumed that the treatment facilities to be constructed should be capable of removing the following ratios of BOD and SS properties based on the Japanese empirical data, as shown in Table O-23. Based on these ratios, the quality of treated water was estimated and shown in Table O-24. Figure O-36 shows the pollutant load balance.

Table O-23: Removal Ratio

	Septic Tank (%)	Filter Trench (%)	Total (%)
BOD	55	70	87
SS	50	70	85

Table O-24: Influent & Effluent Quality

	Influent	Septic Tank	Filter Trench	Effluent
BOD (mg/l)	200	90	27	27
SS (mg/l)	250	125	38	38

In addition, assuming that 50% of the BOD and 100% of the SS removed is transform to sludge, and the water content of sludge is 99%, sludge generation amount is estimated 49l/day or 18m^3/year based on this assumption .

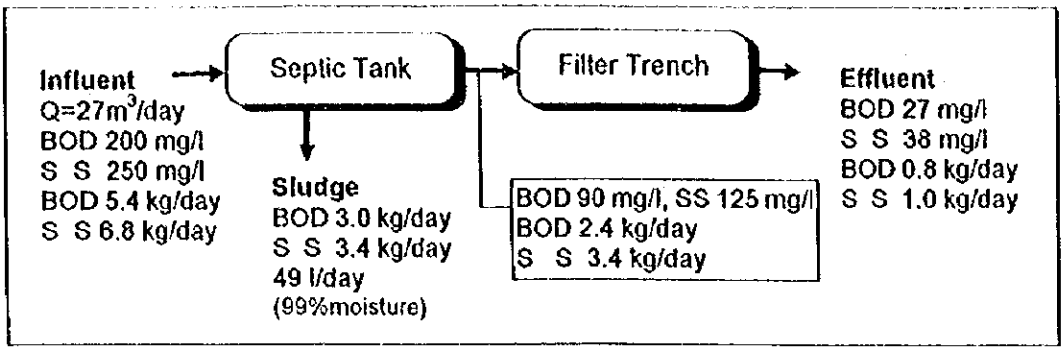

Figure O-36: Pollutant Load Balance Sheet

d. Drawings

Figure O-37, Figure O-38 and Figure O-39 show the general layout of the facilities designed based on the calculations aforementioned (refer to the Annex E for the detailed plans).

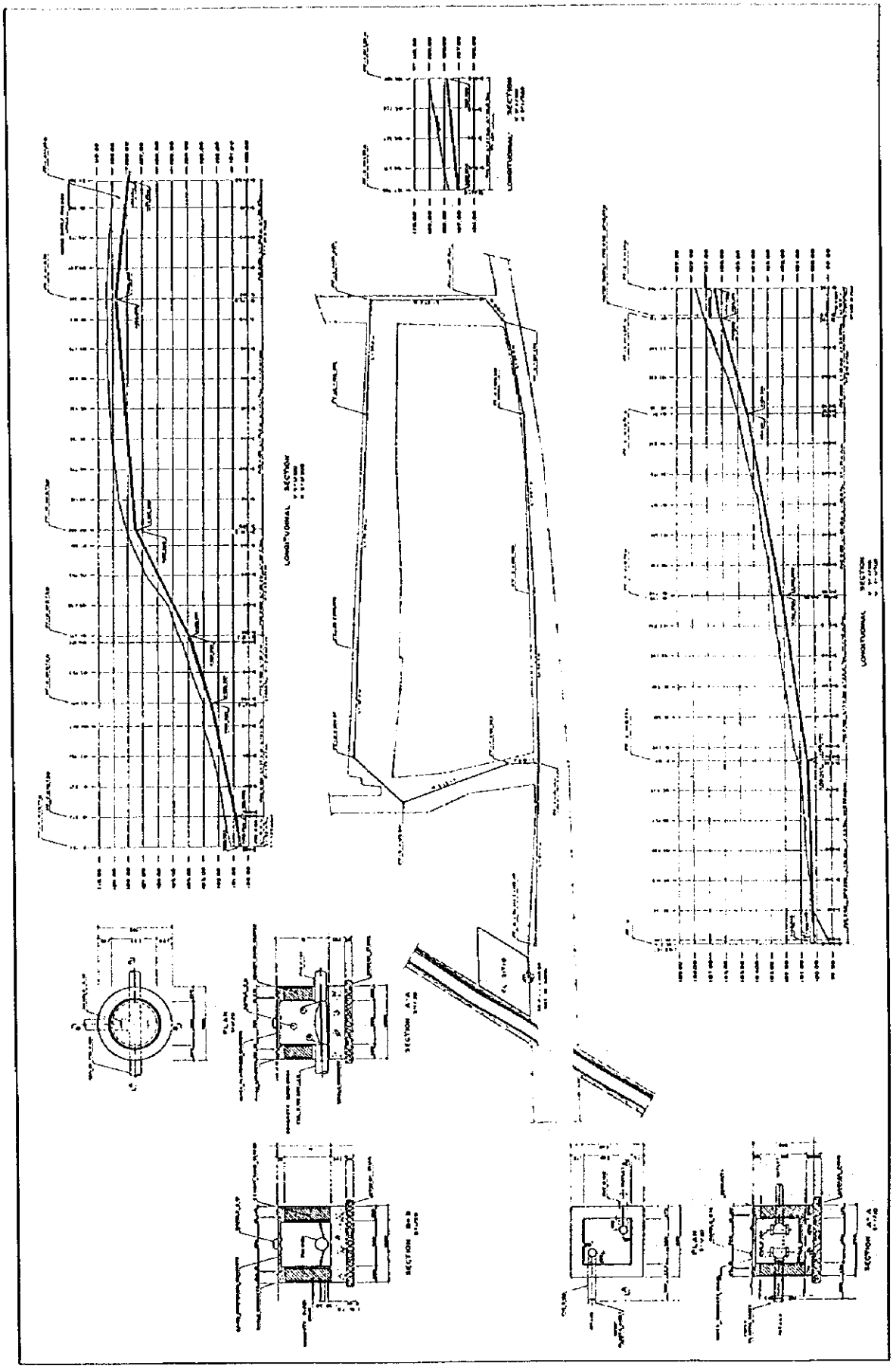

Figure O-37: Pipeline

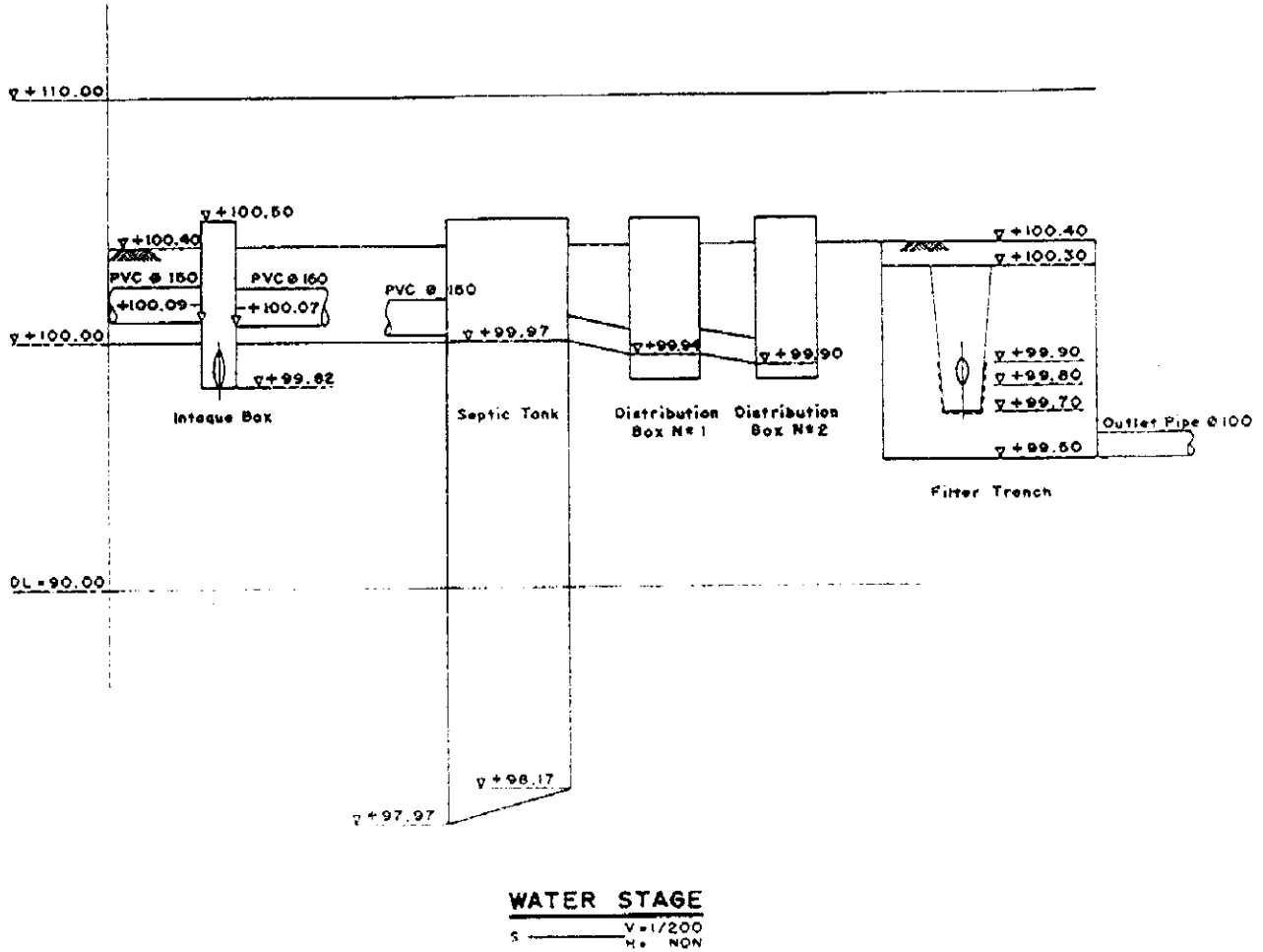

Figure O-38: Water Stage

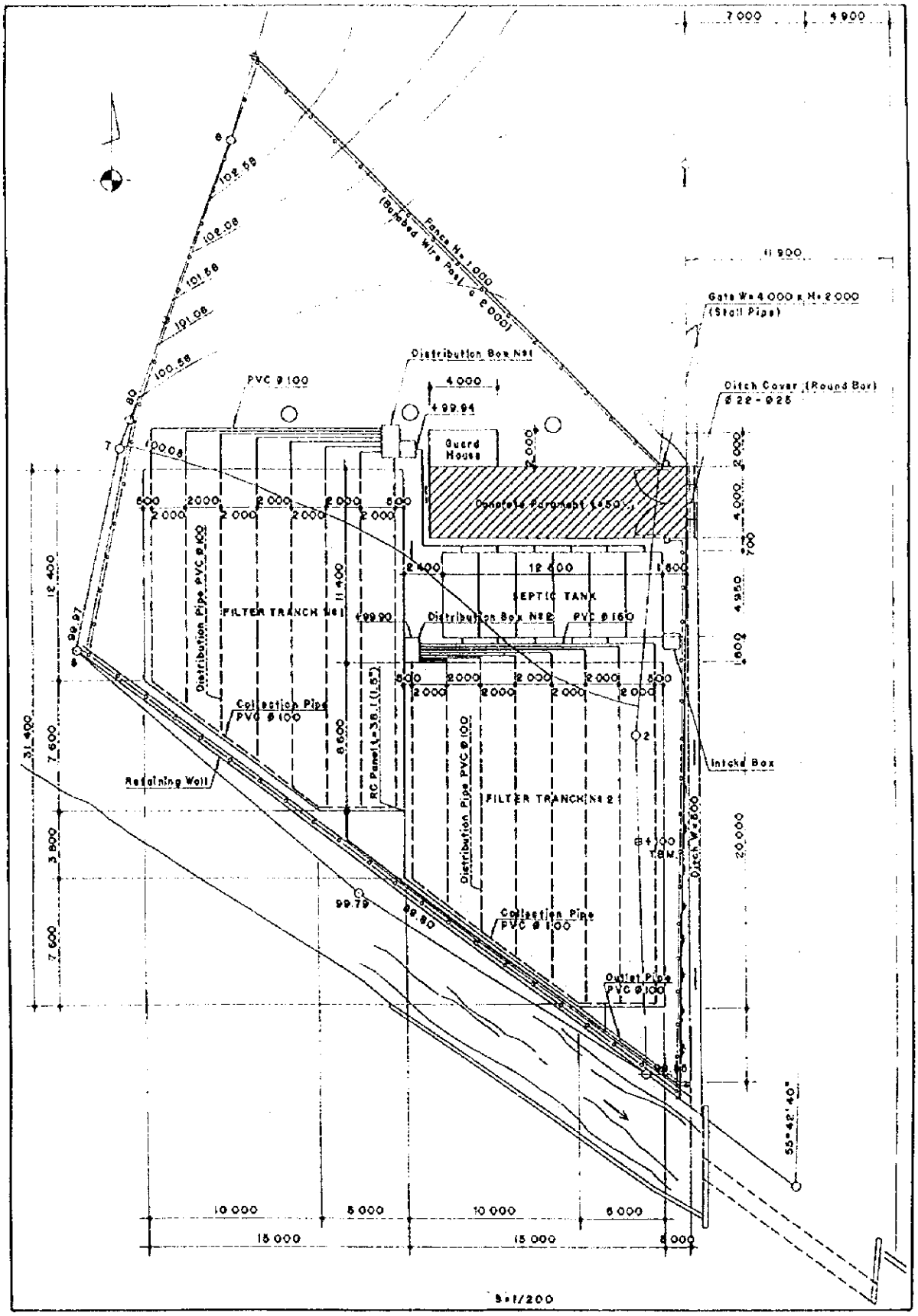

Figure O-39: Facility Layout

e. Construction

The construction of the facilities according to the previously mentioned design layout was contracted to a contractor in Managua. The works started on the 29th of June 1997 and were completed on the 15th of August 1997. After a week of test operation, these facilities were handed over to the INAA on the 25th of August 1997. Parallel to the construction works, domestic connection to the catch pit were implemented by INAA Region IV for every served household, and bathrooms also installed for some households. Below are the pictures that record the progress of the works.

Plate O-58: Before Construction (Treatment Facility)

Plate O-59: Before Construction (Sewer Network)

Plate O-60: Before Construction (Sewer Network)

Plate O-61 : Before Construction (Sewer Network)

Plate O-62 : Site Clearance (Treatment Facility)

Plate O-63 : Construction of Sewer Network

Plate O-64 : Construction of Sewer Network

Plate O-65 : Catch Pit

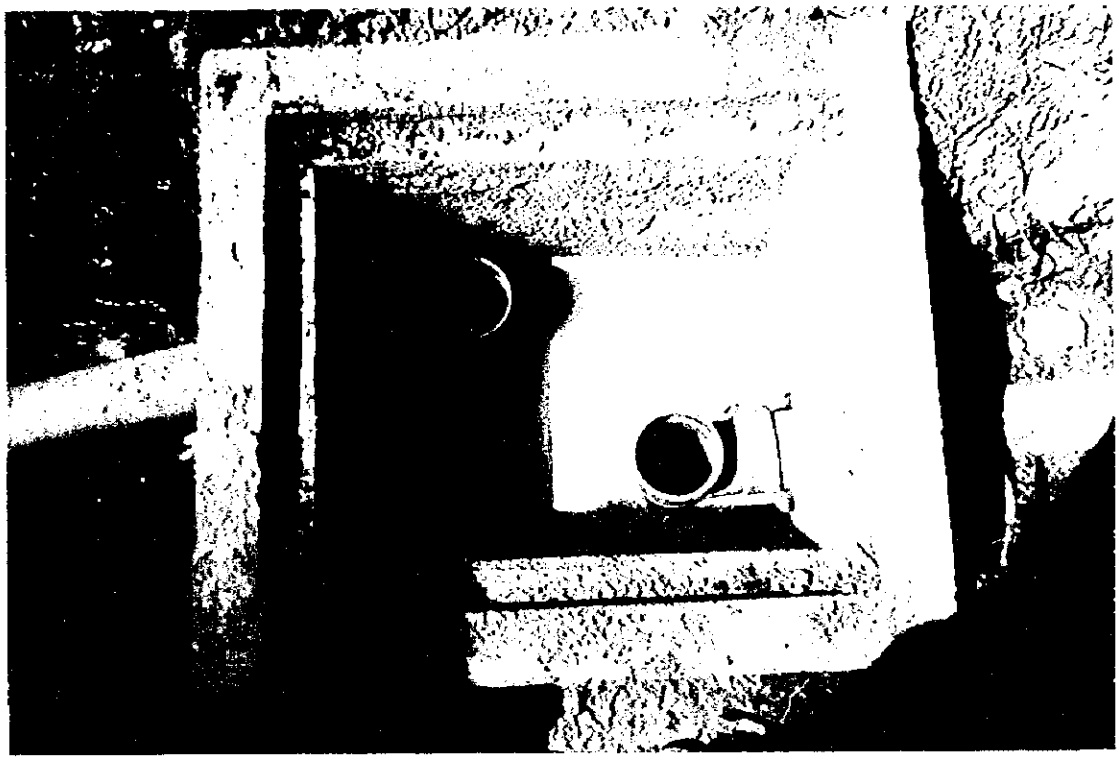

Plate O-66 : Catch Pit

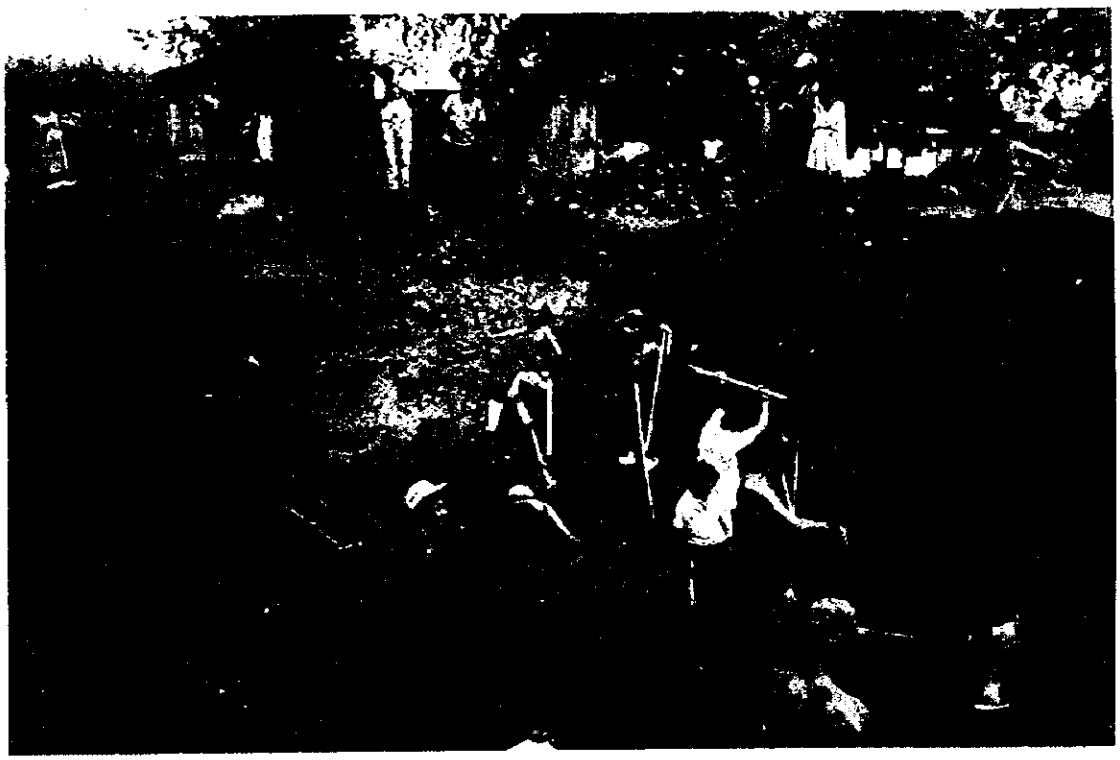

Plate O-67 : Excavation (Septic Tank)

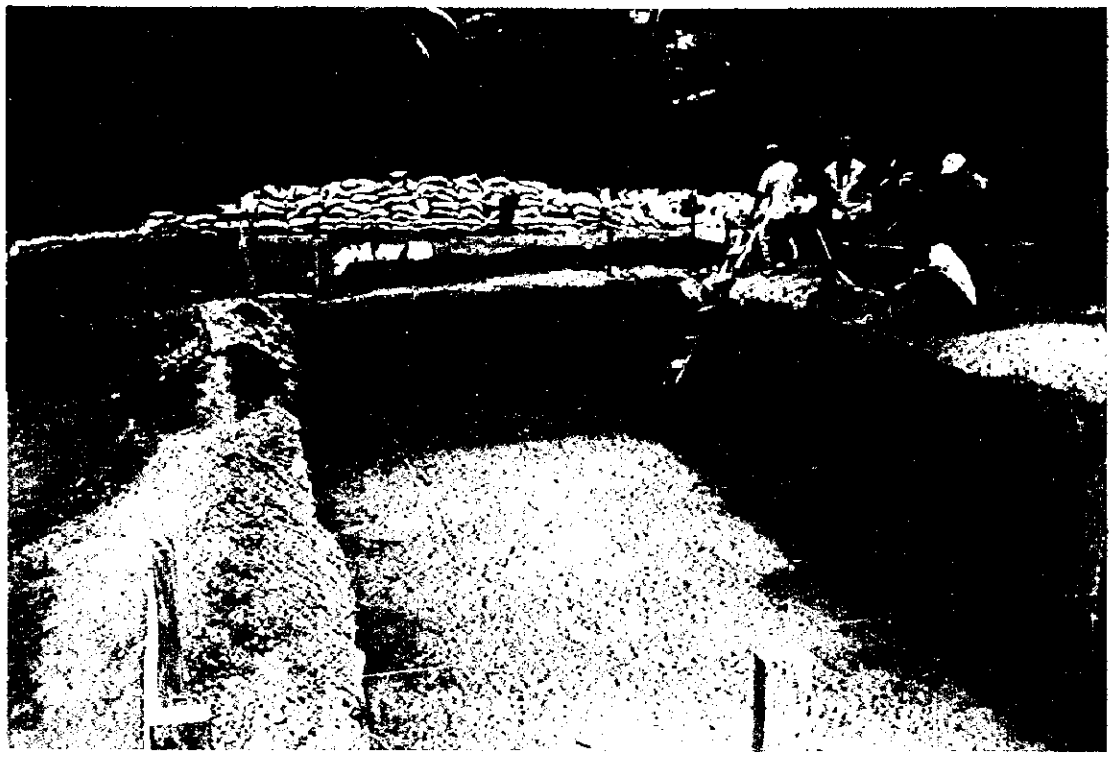

Plate O-68: Excavation (Septic Tank)

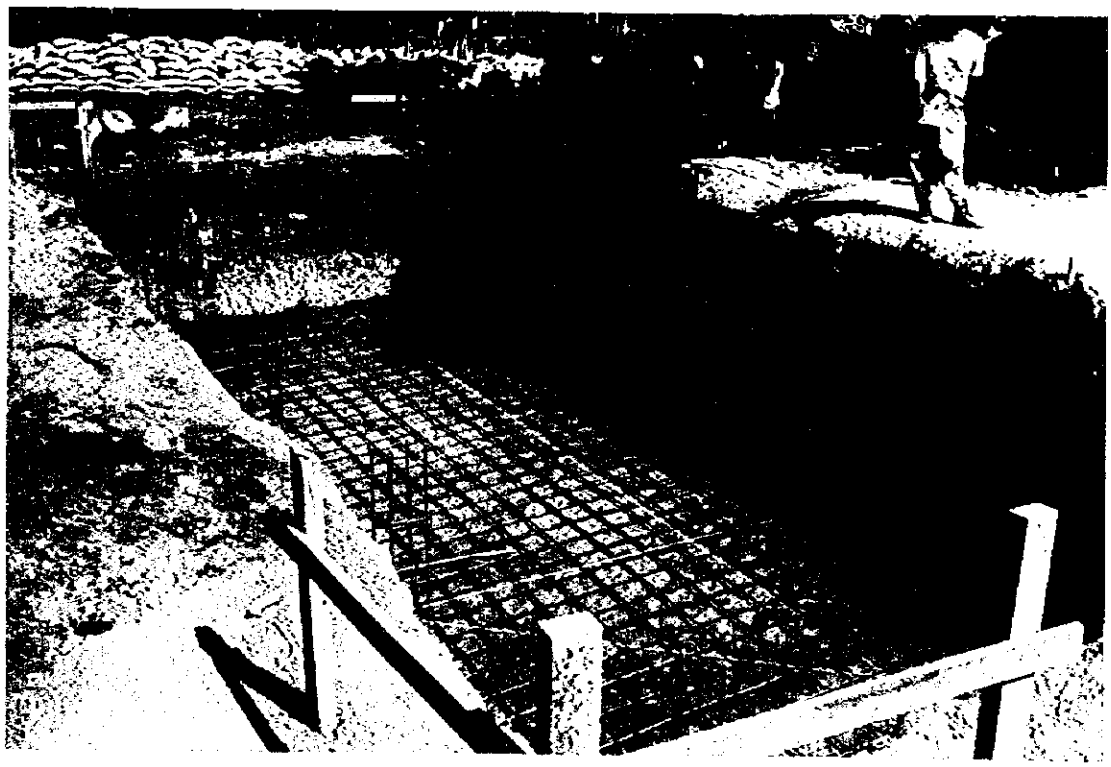

Plate O-69 :Arrangement of Reinforced Bar (Septic Tank)

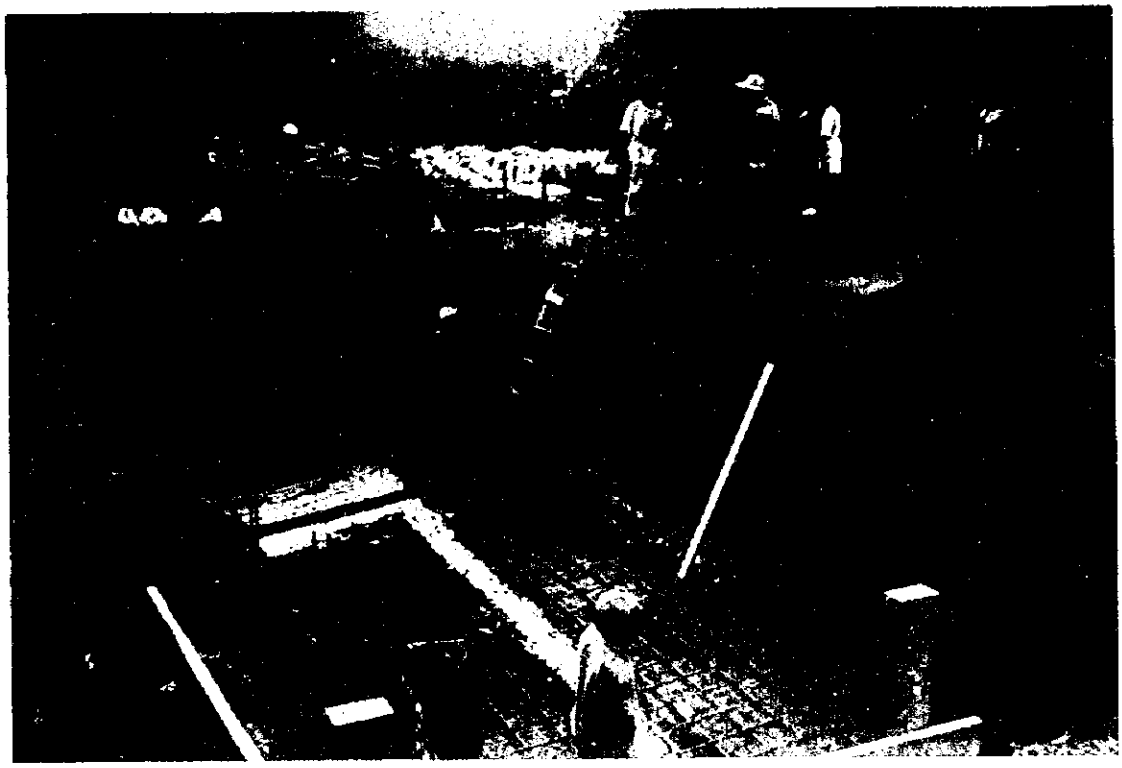

Plate O-70 : Concrete Work of Septic Tank

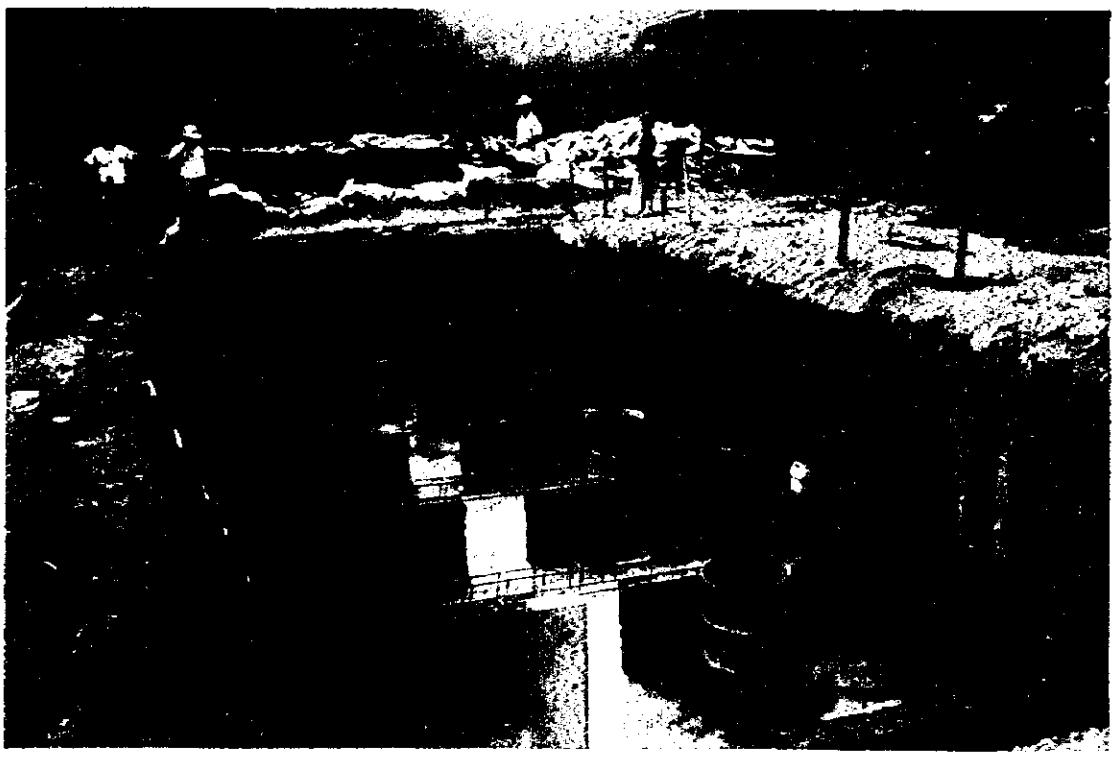

Plate O-71 : Brick Work of Septic Tank

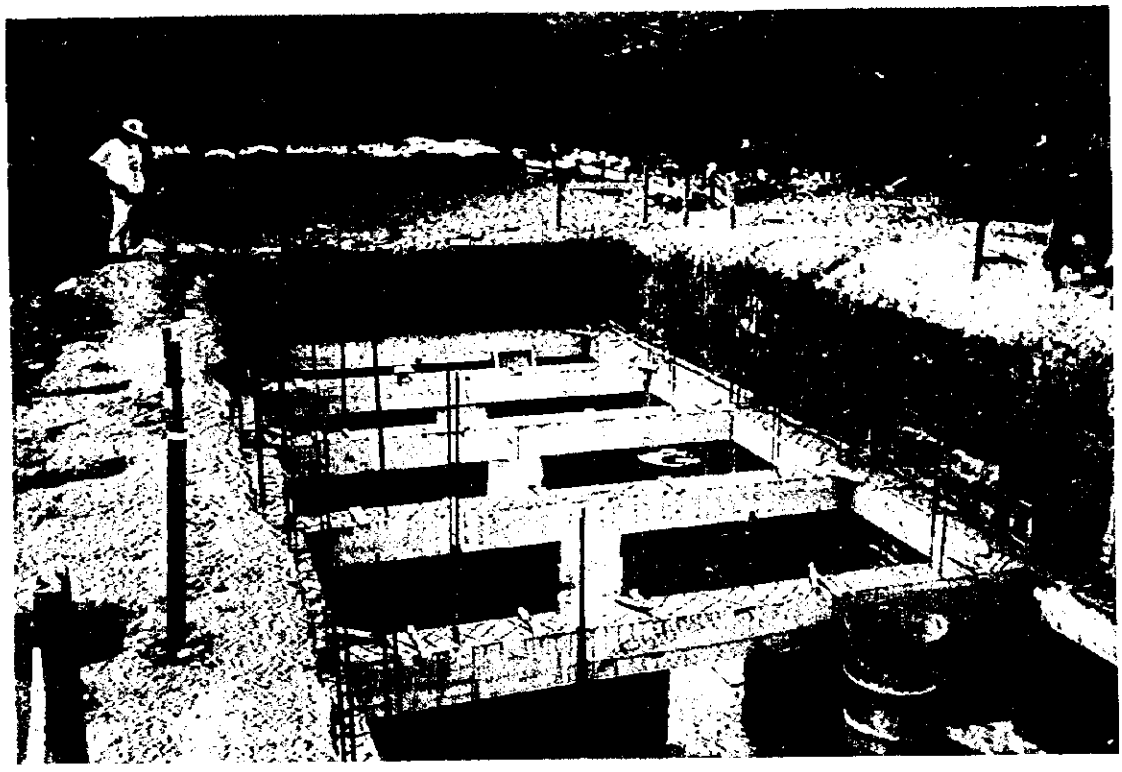

Plate O-72 : Concrete Work of Septic Tank

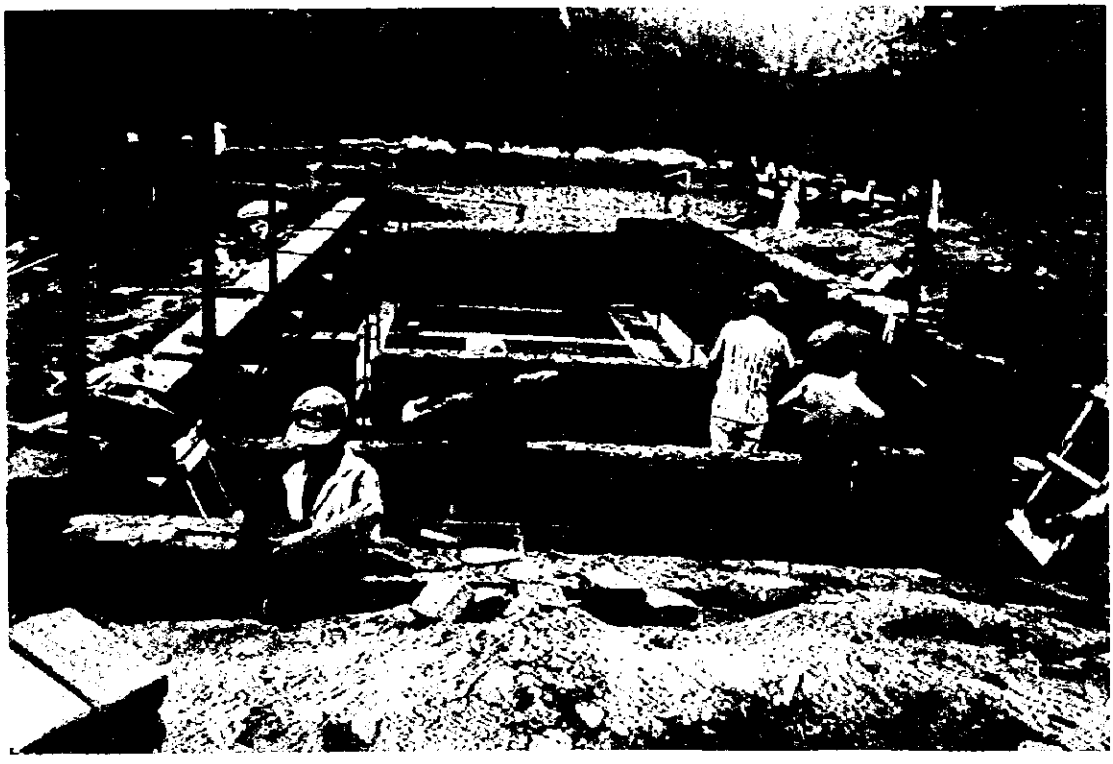

Plate O-73 : Brick Work of Septic Tank

Plate O-74 : Production of Septic Tank Cover

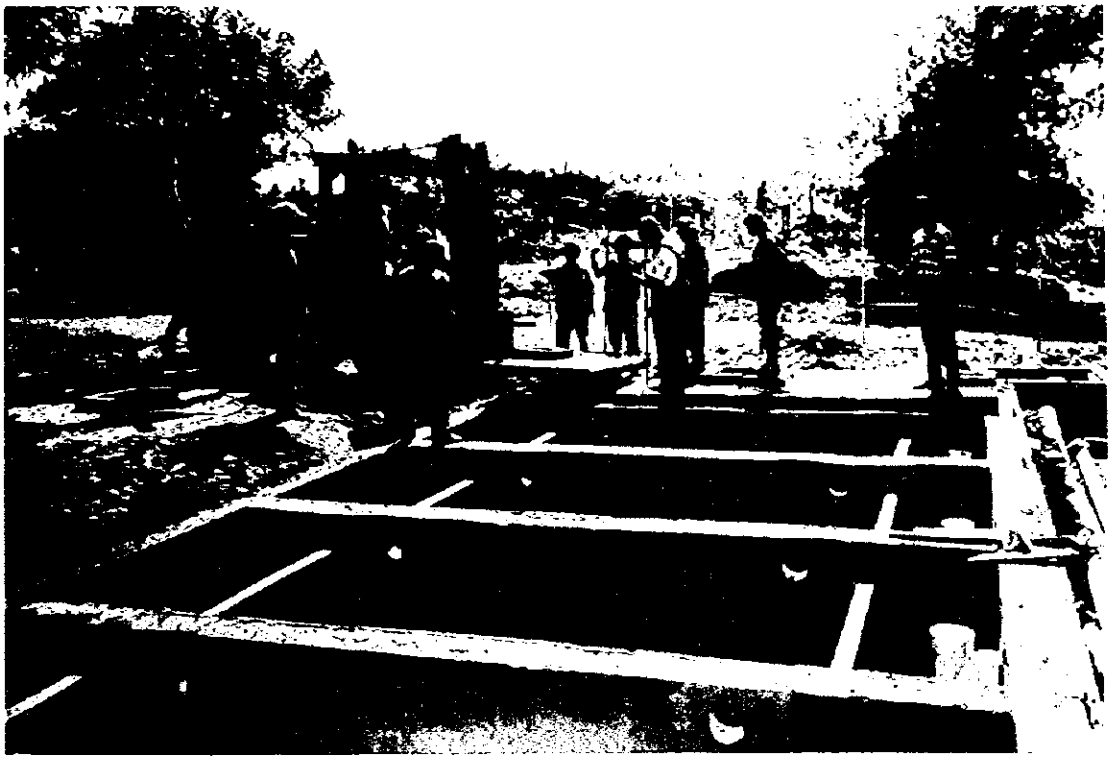

Plate O-75 : Installation of Septic Tank Cover

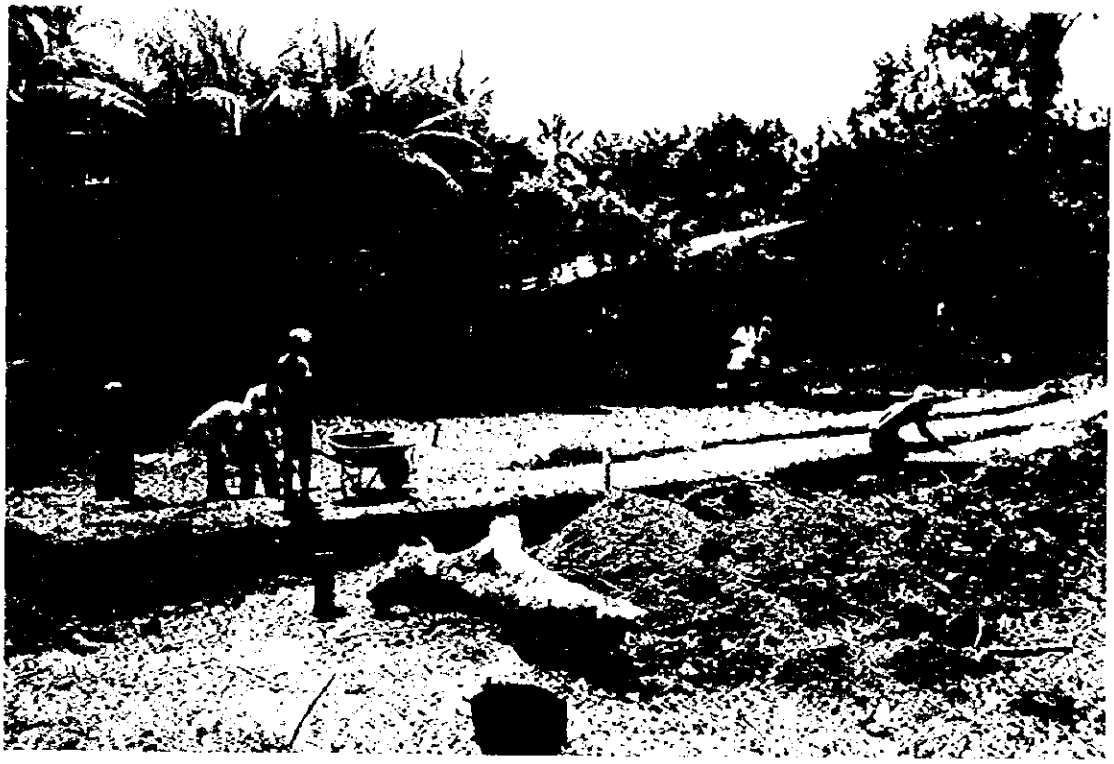

Plate O-76 : Excavation of Filter Trench

Plate O-77 : Excavation of Filter Trench

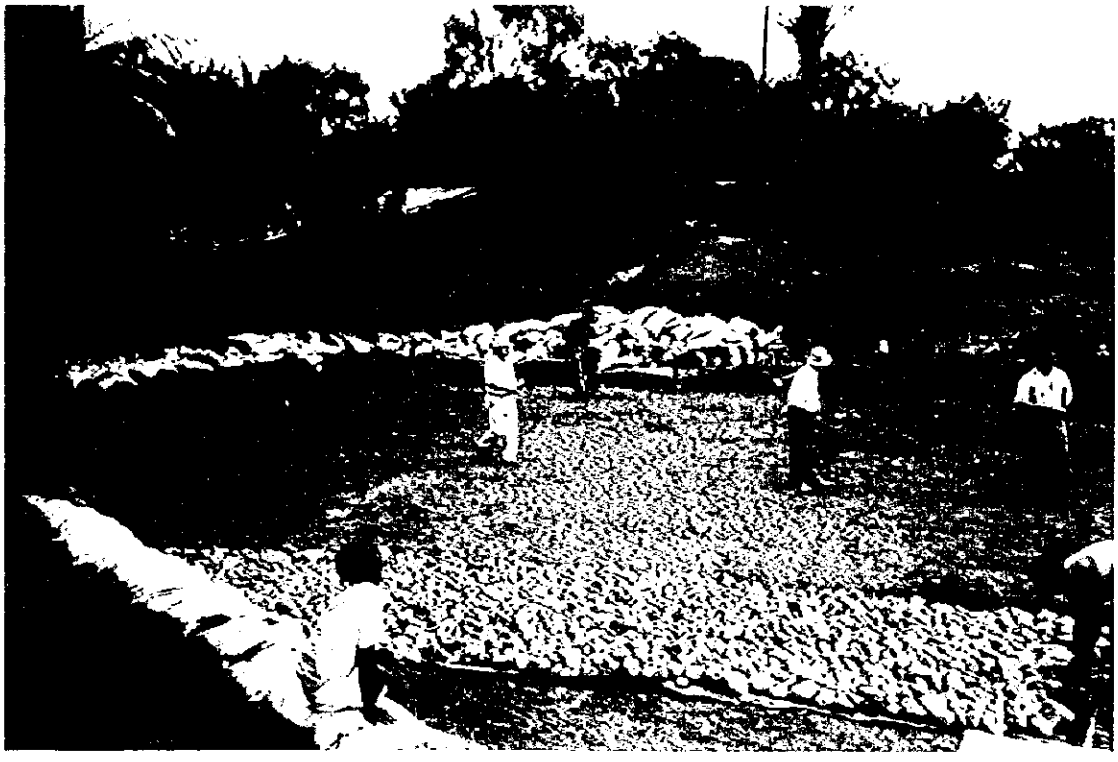

Plate O-78 : Spreading Cobble Stones (Filter Trench)

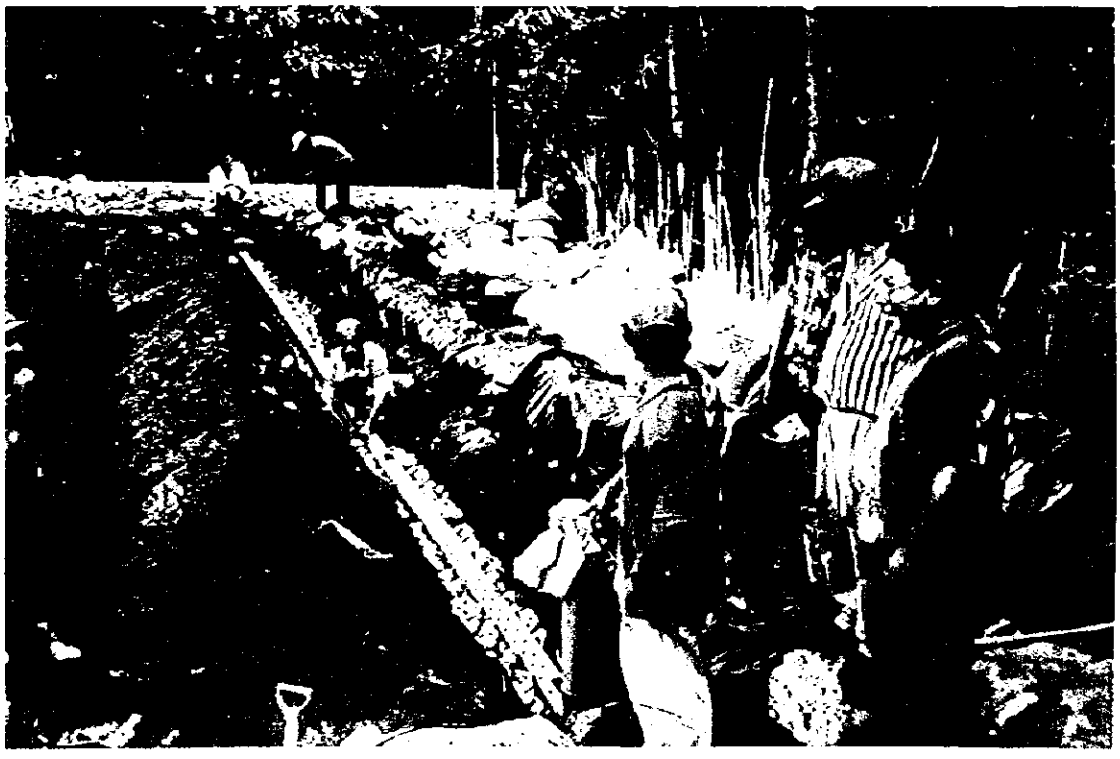

Plate O-79 : Installation of Distribution Pipe

Plate O-80 : Installation of Filter Trench

Plate O-81 : Installation of Filter Trench

Plate O-82 : Spreading Banana Leaves

Plate O-83 : Backfill of Filter Trench

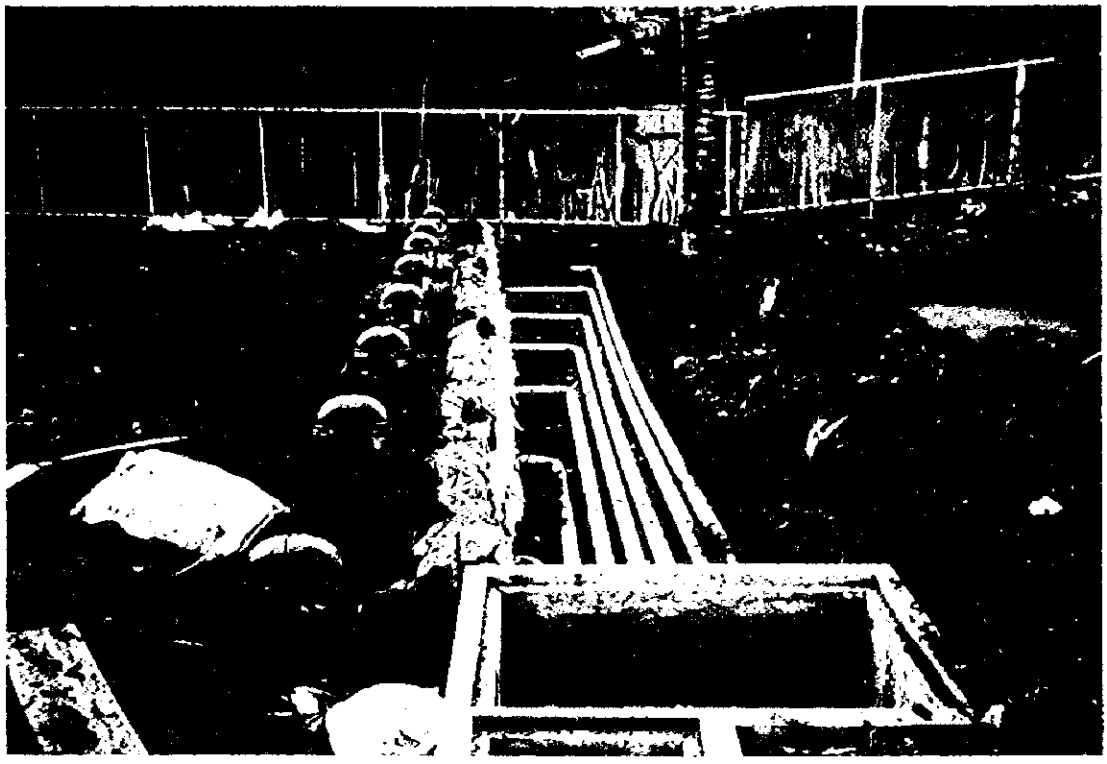

Plate O-84 : Pipe Works for Filter Trench

Plate O-85 : Completed (Sewer Network)

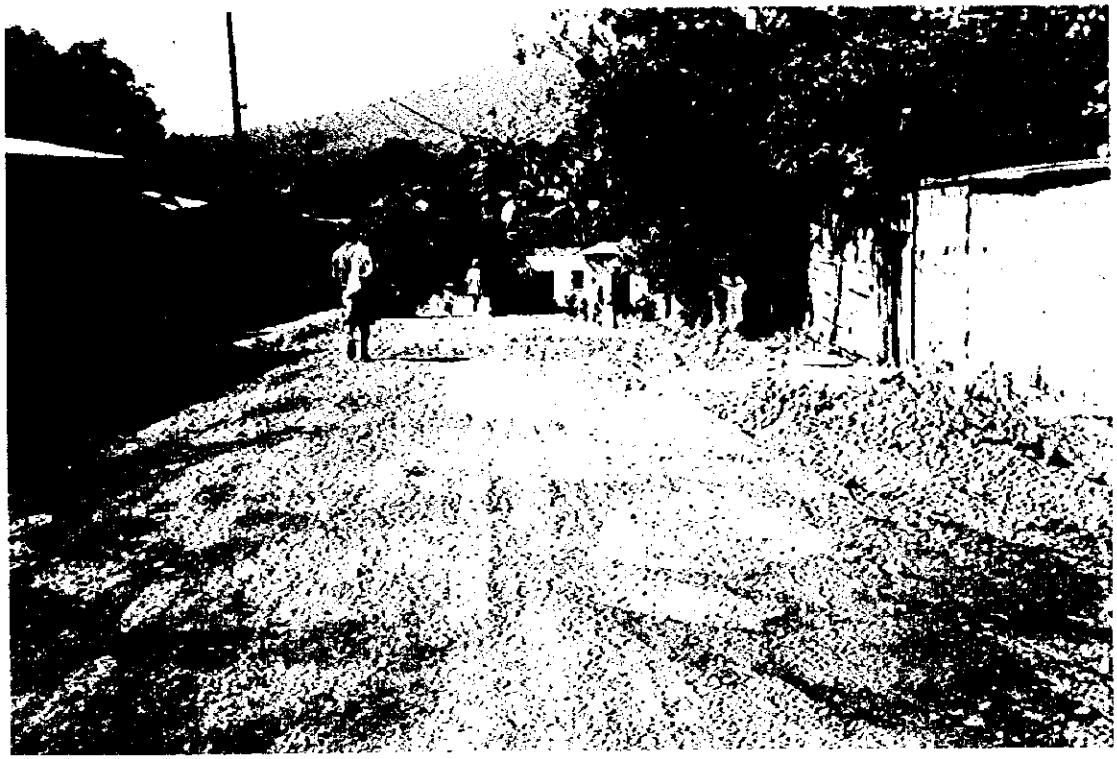

Plate O-86 : Completed (Sewer Network)

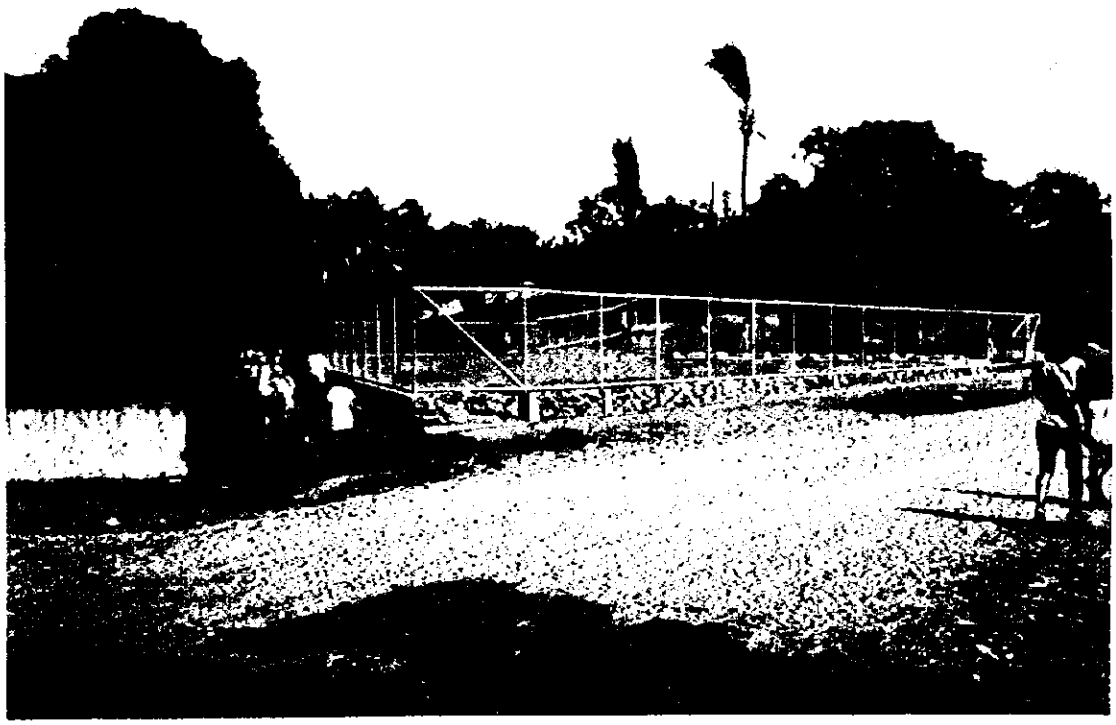

Plate O-87 : Completed (Treatment Facility)

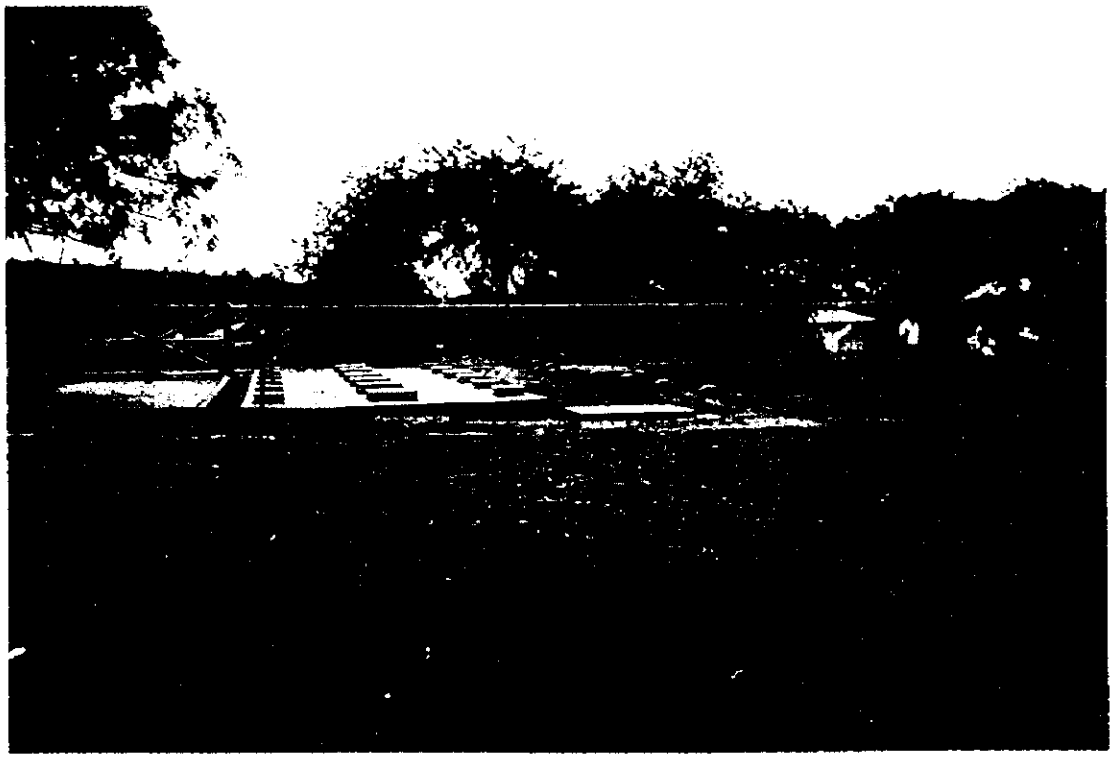

Plate O-88 : Completed (Treatment Facility)

f. Operation

After a week of test operation of the facilities, the facilities are handed over to INAA. Since INAA will assume responsibility for the operation and maintenance of the facility, the important issues with regard to the operation and maintenance of these facilities are explained below:

f.1 Treatment Facility Outline

Domestic wastewater refers to wastewater resulting from daily activities such as cooking, washing, bathing, toilet use, etc. These facilities are for the treatment of such wastewater.

This wastewater treatment process comprises of two stages: a septic tank treatment and then a filter trench treatment in succession.

The septic tank accelerates anaerobic decomposition of the wastewater during detention time. The system establishes about 3 days detention for the decomposition, after which wastewater is directed to the filter trench by gravity.

In the filter trench, wastewater is treated by aerobic bacteria in soil. The project installs two units of filter trench, alternately using them for a fixed period.

Eight numbers of about 20m perforated pipe, which are surrounded with highly porous lapilli (volcanic gravel), are arranged parallel to each other at 2m intervals in the filter trench. The pipes are surrounded with soil containing considerable amount of aerobic bacteria.

These facilities are designed to accommodate a daily inflow of no more than 200 liters of wastewater for every meter of perforated pipe. The bottom and four sides of the filter trench are lined with a vinyl sheet for the collection of treated wastewater.

f.2 Operation & Maintenance of Facilities

The following should be taken into consideration with regard to the operation and maintenance of each treatment facility:

f.2.1 Catch Pit

- Prevent rain inflow to the catch pit. (Rain drain of the house shall not be connected to the catch pits.)
- Prevent the entry of solid materials into the catch pit that is non-biodegradable (i.e. plastic).
- Clean the catch pit more than once a month.

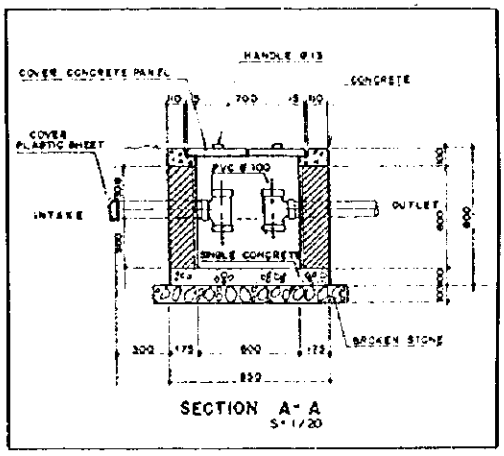

Figure O-40: Catch Pit

f.2.2 Intake Box

- At least once a week, remove waste stuck on the screen and to dry. Then burn or discharge it to a municipal waste collection.
- Clean sand settling basin at least once a week. Sand removed shall be dried and discharged to a municipal waste collection.

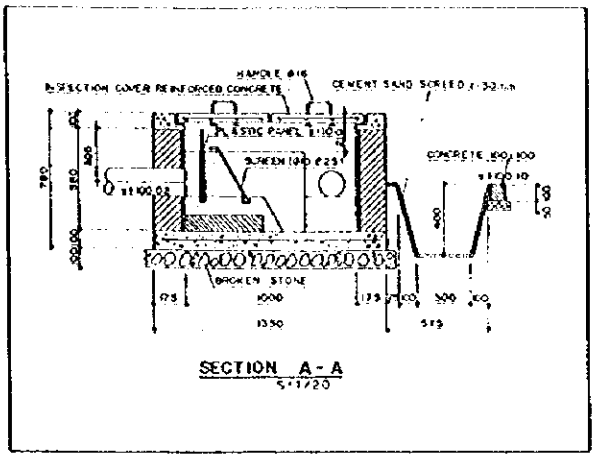

Figure O-41: Intake Box

f.2.3 Septic Tank

- Conduct 24 hour flow survey four times a year to determine flow volume.
- Confirm sludge settling conditions once a month, and remove sludge when necessary.
- Scoop up scum floating in the inflow and outflow sections of the septic tank once a month, and place on central sections to ease the maintenance.
- Sludge should be removed in the dry season, once a year as nominal frequency.
- Regardless of the preceding item, remove sludge before it reaches half the height of the water level in the septic tank, the scum afloat should be removed at the same time.
- Removed sludge should be dried in a place well distanced from people and houses, and then utilize it as compost.

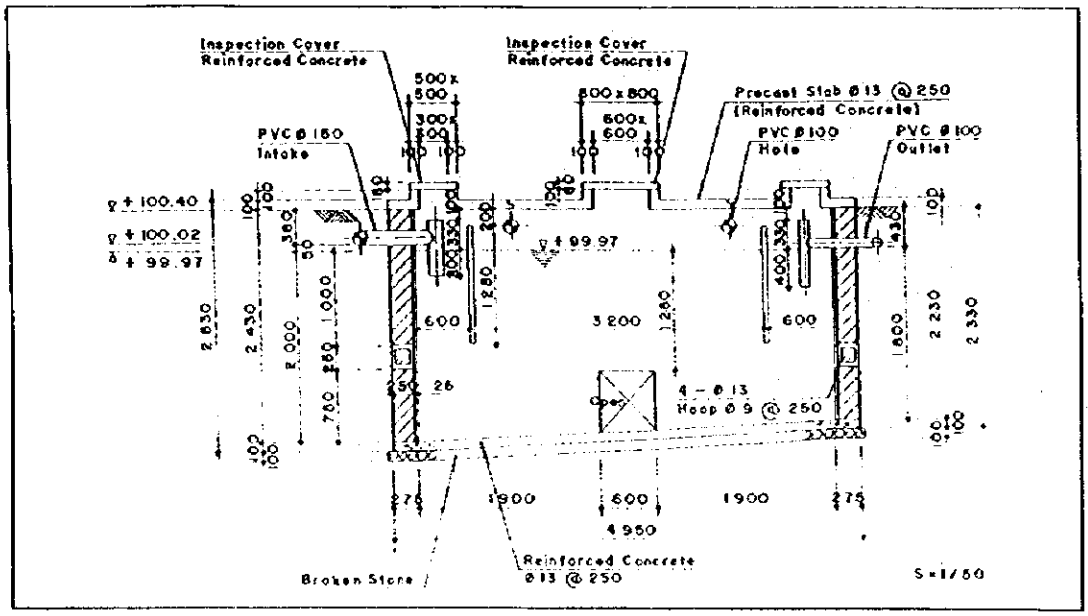

Figure O-42: Septic Tank

f.2.4 Distribution Box

- The switching from filter trench No.1 to No.2 and vice versa shall be principally done once a year, as section c.4.3.2 (Filter Trench) explains the necessity.
- The switching of flow to another filter trench shall be done in the distribution box. The 90° elbow pipe (pipe-A) should be raised placed perpendicular to prevent the wastewater from flowing into the unused filter trench.
- For equal distribution of wastewater into 8 numbers of perforated pipes in a filter trench, the 8 numbers of 90° elbow pipes (pipe-B) shall be rotated and adjusted.
- The 90° elbow pipe (pipe-A) shall be wrapped with nets to prevent solids from entering the filter trench. The solids that get stuck on these nets shall be removed about once a week.
- The distribution box shall be visually inspected more than once a month.

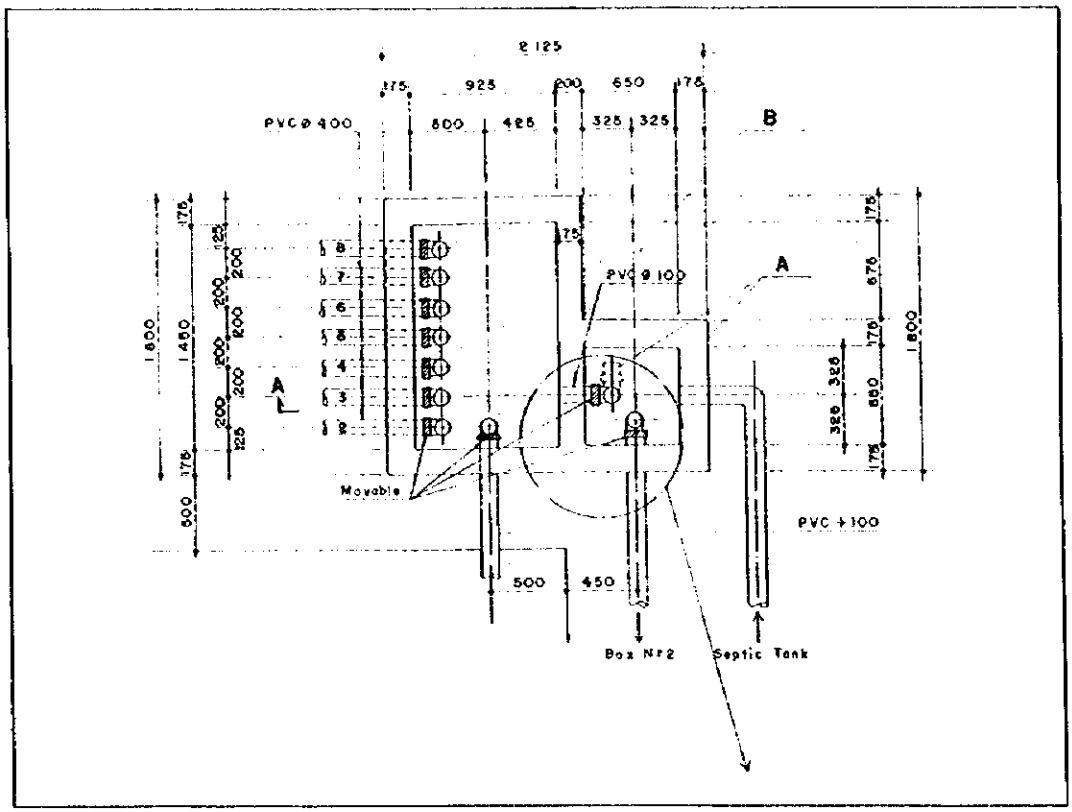

Figure O-43: Distribution Box

f.2.5 Filter Trench

- As a principle, the switching from filter trench No.1 to No.2, and vice versa shall be done once a year.
- Switching of filter trench should be done only after a period that the clogging with microbe membrane in a serving filter trench results in a constant full submerge of distribution box inflow pipe (Figure O-43: pipe-C).

- In case the crown of the distribution box inflow pipe (Figure O-43: Pipe- C) becomes fully submerged in less than a year after the filter trench was used, which could imply a lowering of the filter trench functioning, switching to the other filter trench should be conducted.
- In case the sludge from the septic tank flows into the filter trench, the use of the filter trench in operation at that time shall be immediately stopped and switching shall be carried out. At the same time, the sludge from the septic tank shall be removed.
- Nothing heavier than a person shall be placed on the surface of the filter trench.
- The planting of 2 to 3 meter high orchard is permissible as long as it is not directly planted above the filter trench distribution pipe. However, if such trees are cut down, their roots shall not be pulled out as this may damage the distribution pipe.

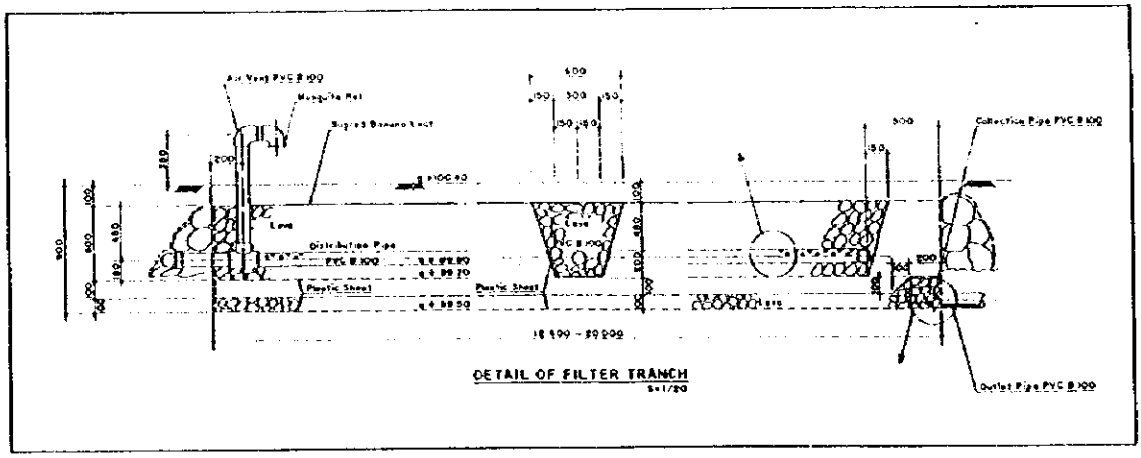

Figure O-44: Filter Trench

f.3 Monitoring Item

In addition to the aforementioned items relevant to facility operation and maintenance, the monitoring of the items shown in Table O-25 is recommended.

Table O-25: Monitoring Item and Frequency

Item		Contents	Frequency
Water quality	Analysis item	Ambient temperature, Water temperature, DO, BOD, COD, SS, pH, Total coliform, E-coliform	3 times/year
	Control point	Intake Box, Distribution Box, Effluent	-
Intake amount*		Water level of intake pipe	daily

Intake amount* : The depth of the influent pipe in the water shall be measured at a fix time and the influent amount shall be estimated from the hydraulic characteristic curve. The details will be stated in the draft final report.

Moreover, the results of the operation of this treatment facilities including the items below, as of the end of September, 1997, shall be reported to the Study Team by October 15, 1997.

- The number of the households connected to the sewerage system by the end of September.
- The contents of the education provided to the residents on prohibition of dumping non-biodegradable i.e. plastics, into the sewer.
- Water quality analyses (items to be analyzed and sampling points are as stipulated in Table O-25. Analysis is required only once).

O.6.4 Findings

a. Construction Cost

The cost required for the construction of this facility, including sewer installation ,amounted to approximately US$ 47,000, that is approximately US$ 160 per recipient. However, this amount includes the cost for acceleration works. Although a detailed cost analysis will be carried out in the 3rd Study Work in Japan, it is estimated that the construction cost can be curtailed up to 70% by carrying out works within the ordinary construction period (and/or speed) in Nicaragua.

The plastic sheet was spread all over in the lower half of the filter trench constructed in this project in order to confirm the effectiveness of the filter trench. However, in the actual use of these facilities, a plastic sheet will not be applied. Instead, the filter trench shall be structured in a manner that will allow treated water to infiltrate to the ground, to considerably minimize the volume of soil excavated and the construction cost as well. Although, a catch pit was installed to every household this time, the same effect can be expected even if one catch pit is installed for every two to three household.

b. Treatment Method

The pilot project adopted a treatment system using a septic tank with a filter trench, and aims to reduce BOD in treated water to 20 to 30 mg/l.

The wastewater quality guideline in Nicaragua (Decreto No.33-95) points out that the quality of water treated in the sewage treatment facilities covering a City less than 75,000 people contains a BOD of less than 90mg/l. Since the standard BOD rate may be achieved through the installation of a septic tank, a follow-up survey on the quality of treated water shall be carried out in the future.

A similar wastewater treatment experiment conducted in Masaya with the assistance of an Australian agency used an imhoff tank combined with wet land treatment. Basically , the concept (first treatment + filter second treatment) of this treatment system is similar to the septic tank + filter trench treatment system adopted by the Study Team.

In the Masaya project, wet land treatment constituted the second treatment process and its installation required an area of $2m^2$/ person.

On the other hand, the filter trench constructed by the Study Team this time requires

$2m^2/200l/day$. And if the wastewater discharge per capita is assumed to about 100l/person/day, filter trench requires an area of $1m^2$/person, half the requirement for the Masaya's case.

However, as is stated above, since the filter trench constructed in the facility by the Study Team this time is used alternately, the spare filter trench is prepared to be able to be used alternately. As a result, the areal efficiency of the filter trench the Study Team has constructed this time is considered to be almost equivalent to the system in the Masaya project.