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P.U. Report No. RFS 21

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...tional Reference Centre
Community Water Supply

THE WORLD BANK

ENERGY, WATER AND TELECOMMUNICATIONS DEPARTMENT

PUBLIC UTILITIES NOTES

COUNTRY STUDIES IN

APPROPRIATE SANITATION ALTERNATIVES

Prepared for the World Bank Research Project:

"Appropriate Technology for Water Supply and Waste Disposal in Developing Countries"

March 1979

Central Project Staff
Energy, Water and Telecommunications Department

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COUNTRY STUDIES IN APPROPRIATE SANITATION ALTERNATIVES

Abstract

The empircial data base for the World Bank research project on Appropriate Technology for Water Supply and Waste Disposal in Developing Countries is composed of 34 case studies which were carried out in communities of 11 countries during 1977-78. Countries and communities were selected to obtain a diverse sample of existing sanitation technologies operating under a variety of physical and economic conditions. This report presents the technical and economic information collected by the local field consultants at each site.

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COUNTRY STUDIES

IN

APPROPRIATE SANITATION ALTERNATIVES

PREFACE

In 1976, the World Bank undertook a research project on appropriate technology for water supply and waste disposal in developing countries. Emphasis was directed toward sanitation and reclamation technologies, particularly as they are affected by water service levels and by ability and willingness to pay on the part of the project beneficiaries. In addition to the technical and economic factors, assessments were made of environmental, public health, institutional and social constraints. The findings of the research project and other parallel research activities in the field of low cost water supply and sanitation are presented in the series of publications entitled: "Appropriate Technologies for Water Supply and Sanitation in Developing Countries" of which this report is Volume VI. Other publications in this series are the following:

Volume I	- Appropriate Sanitation Alternatives - A Technical and Economic Appraisal
Volume II	- Appropriate Sanitation Alternatives - A Field Manual
Volume III	- Health Aspects of Excreta and Wastewater Management - A State of the Art Review and Annotated Bibliography
Volume IV	- Low Cost Technology Options for Sanitation - A State of the Art Review and Annotated Bibliography 1/
Volume V	- Socio-Cultural Aspects of Water Supply and Excreta Disposal
Volume VII	- Low Cost Design for Water Distribution Systems

Additional volumes and occasional papers will be published as ongoing research work is completed. With the exception of Volume IV, all publications may be obtained from the Energy, Water and Telecommunications Department, World Bank.

Because of the dearth of published literature on low-cost sanitation alternatives (Volume IV), the bulk of the analysis for the World Bank project was derived from a series of case studies carried out in 34 communities in 11 countries around the world. Countries and communities were selected to obtain

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1/ This publication was prepared by the International Development Research Centre in cooperation with the World Bank and is available from IDRC, Box 8500, Ottawa, Canada K1G 3G9.

a diverse sample of existing sanitation technologies operating under a variety of physical and economic conditions. Local consultants were hired to prepare community sanitation reports evaluating the technical, economic, and social aspects of each system. This Volume summarizes those reports. It presents in a standardized form all of the technical and economic information collected in each case on the water and sanitation technologies in use. It does not include detailed background information on geographical, climatic or other physical features of each site. It also omits much of the social data which is analyzed in Volume V.

In addition to providing background material for the other Volumes, this report gathers together much micro-level data on field experiences with low-cost sanitation technologies. It should be of interest to many administrators and project leaders who are about to embark on the operation of such schemes, as well as to those who are familiar with the particular communities discussed herein.

This report, and indeed the entire World Bank project, would not have been possible without the excellent cooperation and efforts of the many field consultants who built the unique data base of case studies. They are acknowledged individually in the Chapters of this Volume. In addition we wish to recognize the support given to this project by Mr. Yves Rovani, Director, Energy, Water and Telecommunications Department, and the valuable review and direction provided by the Bank staff serving on the Steering Committee for the Project: Messrs. E. Jaycox, A. Bruestle, W. Cosgrove, F. Hotes, D. Keare, J. Linn, R. Middleton, R. Overby, A. Stone and C. Weiss.

CHAPTER I

JAPAN

Japan is one of the most advanced economies of the world and has a gross national product of $555 billion (1976) and a per capita GNP of $4,960 (1976). Although limited in natural resources, Japan's industrial base is well advanced, the major products being machinery and equipment, metal, and metal products, textiles, autos, chemicals and electrical and electronic equipment. With a literacy rate of ninety-nine percent, Japan has one of the best educated populations in the world. Japan's agriculture is also well advanced and is responsible for per acre crop yields which are among the highest in the world. With a population of 113 million (1976), the country has a population density of nearly 300 inhabitants per square kilometer. The major religions are Shintoism and Buddhism.

Japan has realized one of the world's highest average life expectancies; 71.8 years for men and 77 years for women. This high life expectancy is due to the population's keen awareness of the importance of public health, a well-organized medical service, excellent nutrition, and the effectiveness of public health related infrastructure. Public sanitation has undergone substantial improvement in recent decades. Approximately ninety percent of the population use public water supplies, while the rest of the population owns private wells with motored pumps. Probably less than thirty percent of the population is served by public waterborne sewerage systems. Much of the remaining portion of the population is served by publicly operated nightsoil collection and disposal systems. A considerable portion of the population uses flush toilets connected to domestic septic tanks.

A. COMMUNITY SELECTION

The cities of Kyoto, Higashi-Kurume, Hannoh, and Tateyama were selected for study in this chapter. This selection was made to provide a diverse and representative cross-section of Japanese urban commmunities with a variety of sanitation systems. These systems include various combinations of nightsoil collection and water borne sewerage and one system that depends entirely on nightsoil collection. The cities are economically and geographically diverse. Kyoto is an old and important city with a long history of advanced systems of water supply and waste disposal. Higashi-Kurume is a typical satellite city near Tokyo. Hannoh is situated in the nearby mountain ranges where municipal development has not been so rapid. Tateyama was originally developed as a fishermen's village but now supports a substantial summer resort community. It is the most rural and least developed of all the cities studied. The population of Kyoto City is about 1.5 million, while the remaining three cities support populations ranging between 50,000 and 100,000 persons.

The engineering firm of Nikon Suido Consultants Co., Ltd. of Tokyo, Japan was engaged to collect and analyze data on waste technologies employed,

the economic and financial costs of these technologies, community characteristics, local hydrological and other physical characteristics, and the environmental and public health conditions existing in the community.

B. ASSUMPTIONS

In dealing with the data collected and prepared during this study, a number of assumptions have been made. The opportunity cost of capital was taken as 10 percent. The majority of the costs collected during the study originally reflected 1976 prices, and these prices have been adjusted to January 1978 prices using the 1977 inflation rate of 6.4 percent. To convert these figures into current US dollars the exchange rate of January 4, 1978 was used (237 Yen/US$). All income figures have been adjusted to reflect both real economic growth and inflation.

C. COMMUNITY RESULTS: KYOTO

Kyoto is located about forty kilometers northwest of the Osaka Metropolis at the confluence of the Kamo and Katsura rivers. The city lies on an inland plain elevated about sixty-five meters above sea level and surrounded by mountains. While Kyoto is one of the largest modernized cities of Japan, there are no heavy industries located inside the city boundaries. However, Kyoto is well known for its traditional fabric and ceramic products. The city is 2,000 years old and a famous sightseeing center with many tourist facilities. Kyoto enjoys a mild climate with an average annual precipitation of 157 centimeters, and during 1975 average monthly temperatures ranged between a monthly minimum of 0.3 ^{o}C in January to a maximum of 31.^{o}9 C in August.

With a population of 1,461,564 (1976) and an area of 610.61 square kilometers, Kyoto is relatively densely populated at 2,394 persons per square kilometer. In 1976, households numbered 476,978, yielding 3.06 persons per household. Employment statistics indicate that 1.5 percent of the employed population are engaged in agriculture (including forestry and fisheries), 36.7 percent are engaged in manufacturing industries and 60.9 percent are engaged in service industries. The average annual household income is $19,229. Housing costs are summarized in the following table:

Dwelling cost	$74,390/unit
Construction	386/sq.m.
Land cost	404/sq.m.
Average total floor space	72 sq.m./unit
Average site area	115 sq.m./unit

(1) Water Supply

Nearly one hundred percent of households in Kyoto are served with piped water. Ninety-seven percent of the population are served by the publicly owned water supply system which obtains its water from a nearby impoundment. Water quality is good from this source, and average daily per

capita consumption is 437 liters. Water treatment includes flocculation, sedimentation, filtration and chlorination. Based on the above daily per capita consumption, the monthly expenditure per household is $11.2 or less than one percent of household income. The tariff schedule for the Kyoto water supply system has an increasing block structure. Depending upon the diameter of the connection piping, a minimum charge is assessed for consumption under ten cubic meters per month. The minimum monthly charge varies between $1.00 for a thirteen millimeter connection to $27.43 for a seventy-five millimeter connection. Consumption above ten cubic meters per month is charged for on a per cubic meter basis with an increasing rate for greater consumption. Maximum charge indicated is $0.69 per cubic meter for consumption over 10,000 cubic meters. Analysis of the 1976 income statement for Kyoto's water supply authority indicates that the system operates at a loss. For 1976, the deficit was twenty-four percent of operating revenues.

Three percent of Kyoto's population utilizes family owned water supply facilities with individual wells. Water quality for these systems is generally good, but in some cases possible pollution has been indicated by coliform counts. The diameter of these wells is approximately one meter, and the depth varies between six and twenty meters. Costs for installing these well systems, including drilling, casing, pipes, pumps, and taps, are $2,236. There are no water vendors, standpipes, or yard spigots in Kyoto.

(2) Sanitation

Kyoto is served by three different sanitation schemes. Forty percent of the population is served by a conventional sewerage system, forty-two percent by a municipal nightsoil collection system, and the remainder by domestic septic tank units.

(a) Sewerage

The sewerage system features treatment by a conventional activated sludge process and effluent chlorination prior to discharge to a local river. This treatment process includes screening, pre-aeration, grit removal, primary sedimentation, aeration, final settling, and chlorination. The sludge is digested, elutriated, dewatered and incinerated. The ash is deposited in a landfill. Methane from digestion provides a portion of the fuel used for sludge incineration.

Examination of the sewer authority's financial statements indicates that the authority operates at a substantial loss and requires subsidies from other city accounts. These subsidies represent approximately forty-seven percent of total revenues for fiscal year 1976. The sewerage tariff structure utilized in Kyoto is presented below in Table 1.1.

Table 1.1

Sewerage Tariff Structure in Kyoto
(for every two months)
(1978 US$)

Service Charge Class	Minimum Charge		Excess Charge (US$ per cubic meters)			
	Consumption (cubic meter)	Charge (US$)	11 to 60	61 to 100	201 to 1000	More than 1,000
Domestic and Industrial	16 and below	1.01	.13	.17	.23	.25
	17 to 20	1.52				

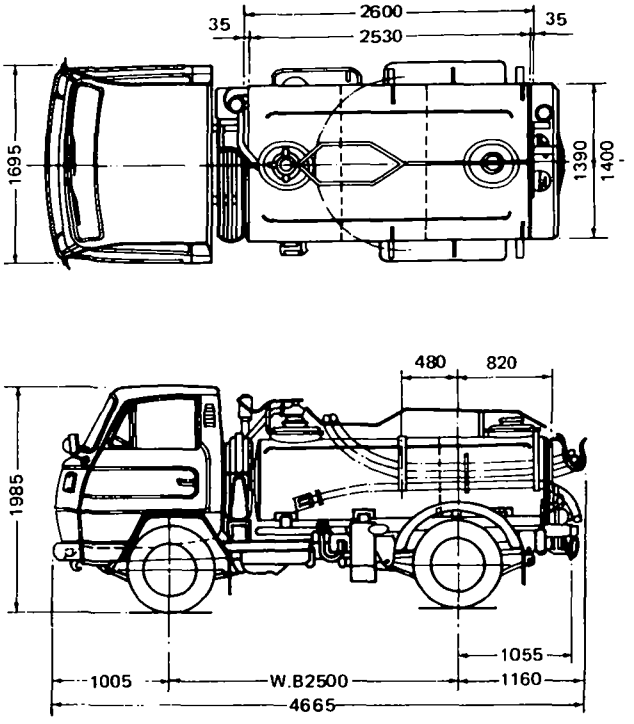
The city of Kyoto provides municipal aid for the installation of a flush toilet at $15.71 per household. In the case of reconstruction, $35.92 is provided, and for a family on relief, $493.84 is provided. In addition municipal loans of $673 are available at no interest and with a term of payment of forty months.

(b) Vacuum Truck Cartage

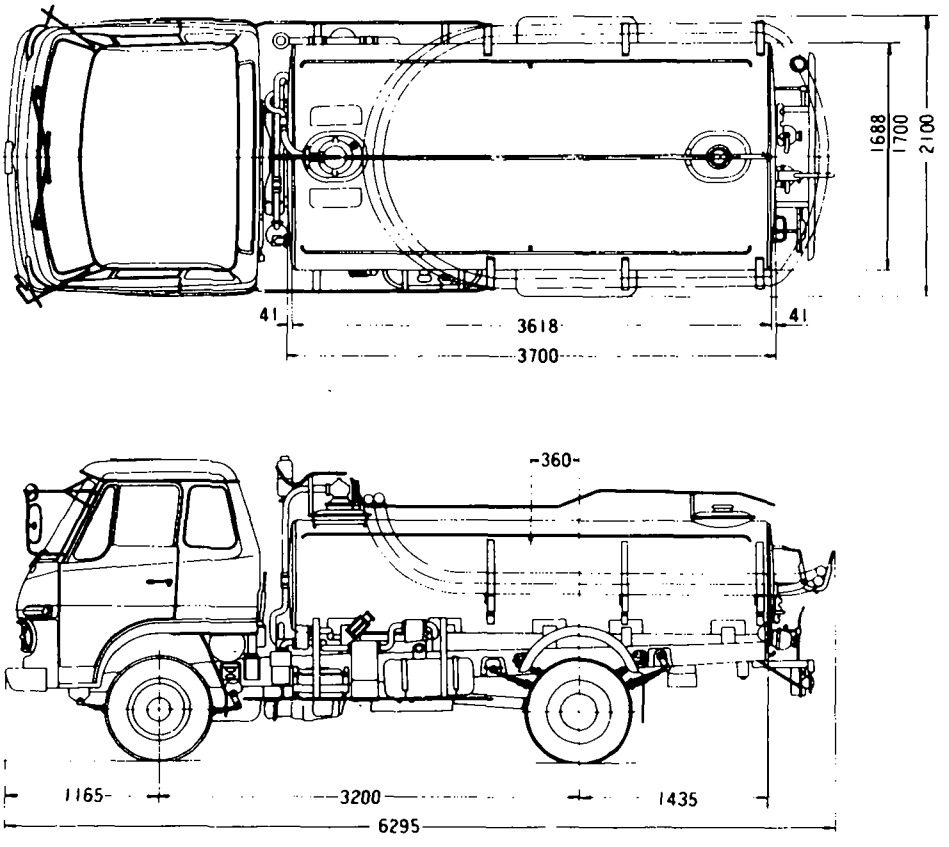
Municipal nightsoil collection serves a population of 605,000 in Kyoto and is conducted by both the municipal agency and other agencies contracted by the municipal authority. Nightsoil collection is provided by the municipal system to a service area of 326.1 square kilometers, or thirty-five percent of Kyoto's total land area. Nightsoil is collected directly from household vaults twice monthly by vacuum trucks. A total of 213 vacuum trucks are used, including vacuum trucks of both two and four ton capacity (see Figure 1.1). No difficulties in recruiting collection personnel are reported. The nightsoil collected by the vacuum trucks is either transported to transfer stations or directly to the sludge digester at the municipal sewerage treatment plant. At the transfer stations, the nightsoil is discharged from the trucks and comminuted, screened, and stored for discharge into municipal sewers during off-peak hours. Once in the sewerage system the nightsoil receives the same activated sludge treatment given to all municipal sewage. Removal of sullage from areas served by nightsoil collection is accomplished through the use of a drainage system maintained by the city. Most drainage canals are concrete lined.

During fiscal year 1975, 411,198 kiloliters of nightsoil (1.86 liters per capita per day) were collected. Seventy-nine percent of the nightsoil was taken to the transfer stations and subsequently discharged into trunk sewers, while twenty percent was taken directly to the digestion tanks at the sewage treatment plants. The remaining one percent was given to farmers for application as fertilizer.

FIGURE 1.1
VACUUM TRUCKS USED NIGHT SOIL COLLECTION IN KYOTO, JAPAN



TWO TON TRUCK



FOUR TON TRUCK

All Measurements in Millimeters

Each household served by the nightsoil collection system is charged according to the size of the household. For households of one or two individuals the monthly charge is $0.96 per household, while for households of three or more individuals the monthly charge is $0.45 per person. Thus the average family pays $1.35 per month for its nightsoil collection service. By contrast, the total cost of off-site investments and operation of the cartage system is $5.06 per household per month. The fee charged to governmental and business offices, schools, etc. is $2.24 per 200 liters of nightsoil.

In addition to the 605,000 individuals served by municipal nightsoil collection, a population of approximately 27,000 (7,974 household vaults) have their nightsoil removed by local farmers who do so to supplement farm sources of nightsoil for meeting agricultural humus and fertilizer needs. Many of these household are inside the service area of the municipal system, while a small percentage is outside of service area. Private arrangements are made between the farmer and household owner, and no fee is charged. Thus, the cost to the individual household for nightsoil collection is eliminated.

(c) Septic Tanks

A population of 226,000 is served by septic tank. Both oxidation and conventional septic tank designs are used. Of the two, conventional septic tanks have proven much less expensive to operate (annual costs per household of $23.6 versus $50.9.) The initial capital cost is equivalent for the two designs: $606.8. Average lifetime for these systems is reported to be 15 years.

Comparative cost data for the three sanitation schemes used in Kyoto are presented below in Table 1.2.

Table 1.2

Annual Household Costs
for Sanitation in Kyoto

	Sewerage System	Cartage System	Septic System
On sites			
Capital	166.1	92.5	223.6
O & M	41.3	18.5	32.8
Water	126.4		84.6
Collection			
Capital	88.9	6.1	9.2
O & M	12.1	35.3	25.0
Treatment			
Capital	147.1	15.3	5.2
O & M	59.4	4.1	9.9
Total	641.3	171.8	390.3

(3) Pollution and Public Health

Health profiles of people served by sewers were essentially the same as those served by nightsoil collection. Sullage from the latter group entering surface streams did not cause measurable stream pollution. However, point discharge of sewerage treatment effluent resulted in local river pollution. (See Figure 1.2)

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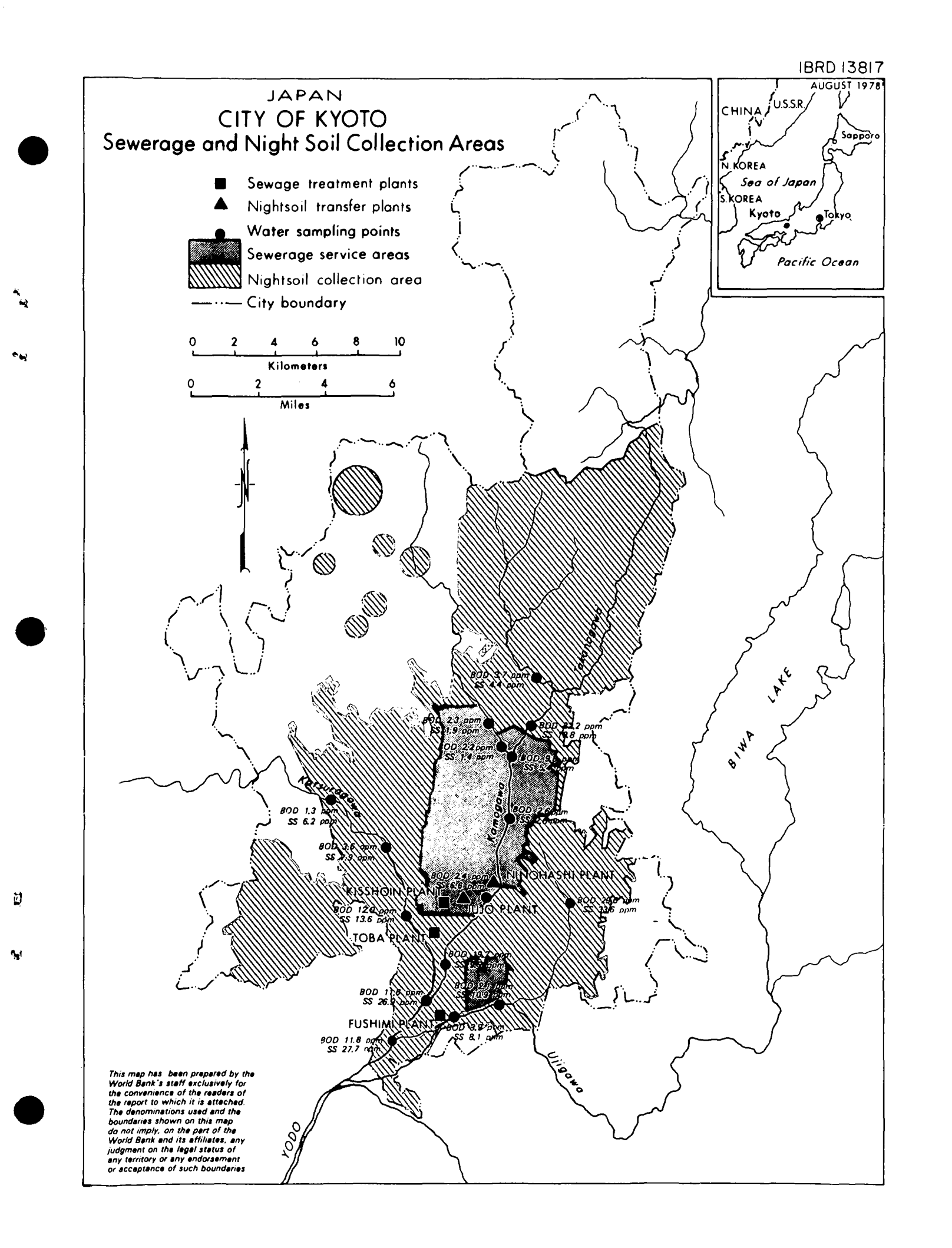
JAPAN
CITY OF KYOTO
Sewerage and Night Soil Collection Areas



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D. COMMUNITY RESULTS: HIGASHI-KURUME

Higashi-Kurume is one of Tokyo's satellite cities and is located twenty-four kilometers northwest of Tokyo at the center of the Musashino plateau, a part of the larger Kanto plain. The Musashino plateau lies forty to seventy meters above sea level. The city has an average annual temperature of 14.4°C and an average annual precipitation of 150 centimeters.

With a population of 102,921 and an area of 12.98 square kilometers the population density is high, 7,929 persons per square kilometer. Statistics indicate that there are 33,211 households, or 3.10 persons per household. Only four percent of the employed population are engaged in agriculture and related activities, thirty-six percent are employed in manufacturing, and sixty percent are employed in service industries. The average annual per capita income is $2,802, or $8,686 per household. Ninety-three percent of the city area is classified residential, while only seven percent is classified as commercial and quasi-commercial. There are no prominent industries in Higashi-Kurume. Dwelling costs and characteristics are summarized in the following table:

Dwelling cost	95,118 $ per unit
Construction cost	428 $ per square meter
Land cost	612 $ per square meter
Average total floor space	68 square meter per unit
Average site area	108 square meter per unit

(1) Water Supply

One hundred percent of the population is served by piped water, with ninety-eight percent of the population served by a publicly operated water supply system. The sources of water for the public system are local groundwater aquifers (47%) and a larger metropolitan water supply system (53%). The only treatment which water extracted from local aquifers requires is chlorination. The average incremental cost for water has been calculated to be $0.79 per cubic meter. The average per capita consumption of water is 268 liters per capita per day or 830 liters per household per day. This translates into an average monthly water bill of $5.71 per household, or less than one percent of household income. The tariff schedule for the Higashi-Kurume water supply system has an increasing block structure. Depending upon the diameter of the connection piping, a minimum charge is assessed for consumption under twenty cubic meters. The minimum charge varies between $2.69 for a thirteen millimeter connection and $152.64 for a seventy-five millimeter connection. Consumption above twenty cubic meters is charged for on a per cubic meter basis with an increasing rate for greater consumption. Maximum charge in $0.81 per cubic meter for consumption greater than 2,000 cubic meters. An analysis of the water authority's income statement for FY 1975 indicates that the system operates with substantial subsidies from other city accounts (16% of total revenues).

(2) Sanitation

(a) Sewerage

A conventional sewerage system with sewage treatment provides service for forty-seven percent of the population of Higashi-Kurume. Approximately forty-six percent of the population is provided nightsoil collection by a municipal system, and the remainder of Higashi-Kurume's households use domestic septic tanks. The sewered area of the city covers 3.5 square kilometers, or twenty-seven percent of the city's total area. As in Kyoto, the sewerage system includes a conventional activated sludge treatment process. Average sewage flow is reported to be 408 liters per capita per day. Only two percent of the flow is industrial. Financial statements of the sewer authority indicate that the authority operates at a loss, requiring revenues from other city accounts. These extra revenues account for fifty-nine percent of total revenue. Amounting to $135 per household, municipal aid is provided for construction of a flush toilet. Municipal loans are also available for the purpose of installing a flush toilet; these loans amount to $90 at seven percent interest and with a term of payment of forty months.

(b) Vacuum Truck Cartage

Vacuum truck cartage serves a population of 46,400, and for fiscal year 1975, 19,703 kilometers of nightsoil, or 1.16 liters per capita per day were collected. Collection is accomplished through four deputed agencies, and the institution responsible for disposal is a corporation organized by four cities including Higashi-Kurume. The design capacity of the plant utilized is 400 kiloliters per day. The process for collection and disposal includes the suction from storage vaults, transportation via vacuum trucks and the subsequent discharge into a disposal plant for treatment. This service is provided free of charge to the individual households.

(c) Septic Tanks

A population of 7,200 is served by domestic septic tank systems. The septic tanks are of either an oxidation type or a more conventional septic tank design. These systems are pumped empty twice yearly by the same vacuum trucks used in the nightsoil collection system. As with nightsoil collection, the service is funded by general city revenues.

The costs associated with the sewerage and cartage systems are presented below in Table 1.3. Septic tank costs are approximately the same as in Kyoto.

Table 1.3

Annual Household Costs for Sewerage and Cartage Systems in Higashi-Kurume

(1978 US$)

	Sewerage	Cartage
On sites		
Capital	153.4	118.2
O & M	37.6	18.8
Water	71.3	
Collection		
Capital	36.2	3.8
O & M	3.9	16.5
Treatment		
Capital	55.4	16.9
O & M	42.6	18.0
Total	400.4	192.2

E. COMMUNITY RESULTS: HANNOH

Hannoh is a rural city located at the west end of the Kantu plain and at the southeast foot of the Chichibu mountain range. The city is about forty-eight kilometers from Tokyo and has an elevation ranging between 100 to 800 meters above sea-level. The western half of the city is a forested area and is the core of the Okumusashi natural park. The eastern half of the city is primarily residential, containing only a few factories which have been established in the area in recent years. The Iruma and Kuma rivers run through the city. Limited meterological data is available. However, in 1975 annual precipitation was 136 centimeters and temperature ranged from a minimum of -5.5^{o}C in January to a maximum of 35^{o}C in July.

Hannoh's 1975 population was 55,924. With an area of 134 square kilometers, the city exhibits a relatively low population density of 417 persons per square kilometer. The city contains 14,889 households, with an average of 3.75 persons per household. Eighty-two percent of the urbanized area is classified as residential, while eighteen percent is either commercial or industrial. Out of an employed population of 25,630, six percent are employed in agriculture, forty-four percent in manufacturing and fifty percent in service industries. The average annual household income is $9,176. Average dwelling costs and features are presented in the following table:

Dwelling cost	54,933 $/unit
Construction cost	415 $/sq.m
Land cost	199 $/sq.m
Average total floor space	70 sq.m/unit
Average site area	130 sq/m/unit

(1) Water Supply

Eighty-seven percent of Hannoh's population is served by a publicly operated water supply system. The city's water is taken from a local river and undergoes treatment by flocculation, sedimentation, filtration and chlorination. The per capita water consumption is 271 liter's per day. The remainder of the population is served by domestic wells. Ground water quality is generally good. The average incremental cost of water has been calculated at $.85 per cubic meter. The schedule of water tariffs in Hannoh exhibits an increasing block structure. The minimum charge for consumption of 20 cubic meters or less is $3.14. The tariff for consumption from 20 cubic meters to 60 cubic meters is $0.18 per cubic meter, while consumption over 60 cubic meters is billed at $0.20 per cubic meter. Based on the average water consumption and the above tariff structure, the monthly cost of water to a household is $5.27 or one percent of household income.

Sanitation System

Only fifteen percent of the population of Hannoh (13,500 inhabitants) are served by flush toilets and water-borne sewerage; fifty percent of the population depend on nightsoil collection; six percent own domestic septic tanks; the remaining twenty percent are farmers living apart from the municipal nightsoil collection system and utilize their domestic nightsoil as fertilizer.

(1) Sewerage

Sewage is treated by activated sludge and effluent chlorination. The average volume of sewage is 542 liters per capita per day. Municipal aid is available for construction of a flush toilet for the amount of $13.46 per household, and loans are available for $540 per household. The loans are made at eight percent interest over twenty-four months. The sewerage tariff structure is provided below. An average household pays $6.15 per month for sewerage service.

Table 1.4

Sewerage Tariff Structure in Hannoh (for every two months)
(1978 US$)

Class	Minimum Charge Consumption (cu m)	Minimum Charge Charge (US$)	Excess Charge Consumption (cu m)	Excess Charge Charge $
Domestic and Industrial	20 and below	1.62	21 to 60	.11
			61 to 200	.13
			201 to 1,000	.18
			more than 1,000	.22

(2) Vacuum Truck Cartage

A population of 33,000 is served by the nightsoil collection system. A system of household vaults is utilized, and collection frequency is once per month. The collected nightsoil is discharged at the sewerage treatment plant. Collection charges are listed below (Table 1.5). Nightsoil from 5,300 people is collected by farmers for fertilizer. There is no charge for this collection. Comparative costs for these systems, are presented below in Table 1.6.

Table 1.5

Nightsoil Collection Tariffs
in Hannoh
(1978 US$)

Distance from treatment plant	Charge
Less than 12.5 km	fixed: .80 $/household poll : .76 $/person /36 liter
12.5 km and over	fixed: .98 $/household poll : .98 $/person .80 $/36 liter *

* in the case of Hotel, private septic tank, etc.

Table 1.6

Annual Household Costs for Sewerage and Cartage in Hannoh (1978 US$)

	Sewerage	Cartage
On sites		
Capital	146.0	113.3
O & M	45.5	22.7
Water	112.8	-
Collection		
Capital	58.5	7.5
O & M	13.3	43.2
Treatment		
Capital	96.0	18.7
O & M	89.4	5.0
TOTAL	561.5	210.4

F. COMMUNITY RESULTS: TATEYAMA

Tateyama is a resort town approximately one hundred kilometers southeast of Tokyo metropolis and is the center of the Minami-Base Quasi-National Park. The city has a beautiful coastline extending about thirty kilometers and includes a fishing harbor in the Tateyama bay. In 1975 annual precipitation was 192 centimeters; and the average minimum monthly temperature was 0.5°C in January, while the average monthly maximum was 30.1°C in August.

The city has a population of 57,000, 110 square kilometers of city area, and an average population density of 520 persons per square kilometer. There are 17,379 households in the city with an average of 3.3 persons per household. Of the employed population of 27,335, twenty-two percent work in agriculture (including fishing), eighteen percent in manufacturing and sixty percent in service industries. The average annual household income is $7,548. Housing costs and characteristics are summarized below.

Dwelling cost	51,629 $/unit
Construction cost	359 $/sq.m
Land cost	153 $/sq.m
Average total floor space	80 sq.m/unit
Average site area	150 sq.m/unit

(1) Water Supply

Seventy two percent of Tateyama's population is served by the public water supply system. The public system's sources for water include both groundwater aquifers and local rivers. Groundwater undergoes only chlorination prior to distribution, while river water is treated by flocculation, sedimentation, either rapid or slow sand filtration, and finally chlorination. Average consumption is 208 liters per capita per day. The program of water tariffs is presented below, in Table 1.7.

Table 1.7

Water Tariff Structure in Tateyama
(1978 US$)

		Excess Charge				
Class	Minimum US$ Charge	1 to 16 (cubic meters)	17 to 40	41 to 80	81 to 120	more than 120
Domestic	2.15	.18	.40	.47	.51	.56
Institution	2.15	.18			.40	
Public bath	2.15			.27		
Under temporary contract	2.15			.56		

Based on the average consumption, monthly household water charges should average $5.94, or less than one percent of household income.

(2) Sanitation

Tateyama has no sewers and approximately eighty percent of the population are served by public nightsoil collection. Ten percent depend on domestic septic tanks. The remaining portion of the population are mostly farmers who use their own nightsoil as fertilizer. The average amount of nightsoil collected by the municipal system is 1,546 kiloliters per month, or .403 kiloliter per year per capita. This nightsoil is collected and transported by vacuum trucks to a treatment plant which includes primary treatment, separated sludge disgestion and secondary treatment by trickling filter. Biogas is produced at the treatment plant and used for office heating and fruit culturing. The sludge is distributed as fertilizer free of charge.

Nightsoil collection is provided to households for $0.74 per capita per month, and the service is provided to hotels, private septic tanks, etc. for $0.02 per liter. Examination of the financial statements of the municipal nightsoil collection agency indicates that the agency operates consistently at a loss.

Septic tanks are either of the oxidation type or of a more basic septic design.

Data on system costs are presented below, in Table 1.8.

Table 1.8

Annual Household Costs for Cartage in Tateyama
(1978 US$)

On sites	
Capital	106.3
O & M	20.0
Collection	
Capital	3.3
O & M	21.2
Treatment	
Capital	8.9
O & M	16.8
TOTAL	176.5

(3) Public Health

Public health records indicate that although there is no waterborne sewerage system, Tateyama shows no observable public health effects.

CHAPTER II

KOREA

South Korea is one of the most rapidly growing economies of the developing world. Over the past 15 years, Korea has maintained an annual GNP per capita growth rate of fifteen percent p.a. and has been transformed from one of the poorest developing countries into a semi-industrialized, middle income nation. Per capita income has grown from less than $100 in 1961 to approximately $700 in 1976. The country covers 98,873 square kilometers, approximately forty-five percent of the Korean peninsula. Its population is estimated at 35 million (1975), yielding an average population density of 353 persons per square kilometer. Increasing amounts of Korea's resources have been allocated to the education sector, and a complete system of public education from primary to university level now exists with increasing penetration into rural areas. The estimated literacy rate in 1970 was over ninety percent. Religious influences include Confucianism, Buddhism, Christianity, and Shamanism. However, Confucianism has had the greatest impact on social values. The topography of Korea is rugged with low-lying mountains. Most of the country has been denuded of forest cover by the ravages of war and centuries of exploitation. The climate is characterized by long, cold winters, and short, hot, humid summers. Most of the rainfall occurs in the summer months.

Korea is not well-endowed with natural resources and has developed export-oriented,light manufacturing enterprises. Industrial and manufacturing activities have been concentrated in the areas of electronics, footwear, fertilizer, cement, petrochemicals and electrical applicances. Growth in these activities has been spectacular with a concomitant shift in economic importance from the agricultural to the manufacturing sector. As a result, agriculture's share of South Korea's GNP has declined from forty-four percent in 1961 to twenty percent in 1976. Accompanying these changes has been a substantial increase in urban income relative to rural income; and a significant migration to urban areas has followed, frequently severely stressing urban infrastructure. Although agricultural land is severely limited in Korea, the agriculture sector has exhibited impressive gains in productivity, primarily through water management, application of chemical fertilizers, and the development of local adaptations of high yielding varieties of rice. However, cultivation is still relatively unmechanized and concentrated in small family owned plots. The gap between rural and urban income is significant, and the Korean Government has responded by establishing industrial estates outside existing urban concentrations and by encouraging the location of factories in other rural areas. Another instrument supported by the Government for reducing rural/urban disparities has been the New Community Movement. Broadly, the objective of the movement is to galvanize villages into improving their own living environment and productivity.

Korea has achieved a high level of public health relative to other developing countries. Life expectancy is approximately sixty-five years.

Although Korea possesses relatively sophisticated medical personnel and technology in its major urban areas, these resources are not distributed throughout the rural areas. Tuberculosis is the most widespread disease and principal cause of death. Endemic diseases include cholera, typhoid fever, dysentery, leprosy and diphtheria. An extremely high incidence of parasitic infections has been documented among the population. Sanitation has been a serious problem in Korea and is thought to contribute greatly to this high incidence of parasitic infections. There are few water-borne sewerage systems in Korea, and human excreta disposal is largely through the use of pit or vault privies and nightsoil collection systems. Direct agricultural application of nightsoil is widespread. A related health problem is that of potable water supply. A large portion of the Korean population is served by wells. It is estimated that in 1973 only forty-three percent of the population were served by piped, centralized water systems: seventy-one percent of the urban population and ten percent in rural areas. The Korean Government has placed increasing emphasis on the improvement of sanitation. Urban water supply and nightsoil treatment systems have increasingly been financed. Efforts in the rural area have been concentrated in New Community Movement which has promoted the development of sanitary water supplies through community self-help projects.

A. COMMUNITY SELECTION

The study communities were selected so as to illustrate both nightsoil utilization and a central system for nightsoil collection and disposal. Included are Chuncheon City, a city of 141,000 inhabitants, and two small rural villages, Yusan 4Ri and Yipyung 1Ri. These communities utilized pit privy or vault household systems in conjunction with private or public nightsoil collection and agricultural reuse of wastes. They are of particular interest because they lie within the basin of the Han River which supplies Seoul with drinking water.

The individual community studies were conducted by Professor Dong Min Kim of Seoul City University. In addition, Dr. Young Soon Kim of the Department of Epidemiology, School of Public Health at Seoul national University, conducted a public health survey of these communities. Special emphasis was placed on the public health implications of fertilizer reuse.

B. ASSUMPTIONS

A number of assumptions have been made for data analysis. The opportunity cost of capital was taken as fourteen percent. The majority of the costs collected during this study originally reflected 1976 prices, and these prices have been adjusted to January 1978 prices using the 1977 inflation rate of 10.1 percent. To convert these figures into current U.S. dollars, the exchange rate of 484 won/US$ was used. All income figures have been adjusted to reflect both real economic growth and inflation.

C. AGRICULTURAL USE OF NIGHTSOIL

Direct agricultural use of nightsoil is prevalent throughout Korea particularly in rural areas. Depending on the accessibility of agricultural areas, varying proportions of urban nightsoil also find use as fertilizer. The Korean Government encourages farmers to use organic fertilizer. There are regulations prohibiting the use of untreated nightsoil as fertilizer, but these regulations are not enforced. Farmers recognize the value of organic manure and generally realize that, in the long run, application of organic manure will be more beneficial for increasing crop yields than the application of chemical fertilizers. These benefits include both the fertilizer values of added nitrogen, phosphorous, potash, CaO, MgO, and SiO_2 and the improvement or maintenance of soil conditions. Soil particle structure is loosened through the addition of nightsoil so as to facilitate moisture and nutrient retention and to provide for the soil microbes which fix nitrogen.

In Korea nightsoil is either applied directly to the soil (regardless of the legality of the practice) or composted with animal waste, straw, grass and other materials to produce an organic fertilizer. Although organic fertilizer is considered by a farmer to be much more valuable than nightsoil, it is not bought and sold in the market. A farmer must make the organic fertilizer necessary for his own use. The mix suggested by Korean agricultural services is forty-eight percent by weight of rice straw or grass, four percent poultry manure, one percent chemical nitrogen fertilizer, forty-three percent nightsoil, and four percent $Ca(OH)_2$. Water is added as required to soak, and anaerobic composting for ninety days follows.

Raw nightsoil is applied only to upland crops and orchards, while organic fertilizer may also be applied to wet rice paddies. Korean farmers generally apply both organic and chemical fertilizers to their holdings. Organic fertilizer or uncomposted nightsoil is applied as a base fertilizer before crop planting, while chemical fertilizer is applied during the growing season. There is little substitution between these two types of fertilizer, although chemical fertilizer prices have risen substantially in recent years. The recent rise in farm labor prices has also substantially increased the cost of organic manure production. According to the Korean National Agricultural Economic Research Institute, the imported value of organic fertilizer is approximately $0.009 per kilogram. This value is based on the estimated labor costs of making organic fertilizer. The values of organic and chemical fertilizers used on the average farm are estimated to be approximately equal. Tables 2.1 and 2.2 present the nutrient values of nightsoil and organic manure.

Table 2.1

Nutrient Composition of Nightsoil (for 100 kg. nightsoil)

N	:	570 g
P_2O_5	:	130 g
K_2O	:	270 g

Source: Kim, K, S. and et al., New Fertilizer Science. Hyangmoon Sa, Seoul, 1972, P. 252.

Table 2.2

Nutrient Value of Organic Manure (% of weight)

Total nitrogen	1.19%
Total Carbon	11.7%
P_2O_5	0.34%
K_2O	4.32%
CaO	0.38
MgO	0.65%
SiO_2	19.0%

Source: S. K. Lee, Institute of Agricultural Science, Office of Rural Development, Suwon, South Korea.

D. COMMUNITY RESULTS: CHUNCHEON

Chuncheon City is located eighty kilometers northeast of Seoul in the North Han river valley. With a population of 141,000 (1976), it is a regional center and capital of the Kangwan Province. Only six percent of household workers are engaged in agriculture, and the vast majority of the population is involved in commercial and industrial employment. A number of light industries are present, including textiles, food processing, lumber and forest products, electronics, and chemicals. Average household size in Chuncheon is 4.85 people, and average annual household income is $2,178. The city has a population density of 420 persons per square kilometer.

The average household dwelling in Chuncheon is constructed with cement, gravel, sand, and/or concrete block. Roofing materials are either asbestos cement slate or tile. The average size of a household dwelling is fifty square meters, and average dwelling cost, including materials and labor, is $2,619.

(1) Water Supply

Chuncheon city has a public water supply system with a capacity of 20,000 cubic meters per day. Total population served is 112,400 (eighty percent of the city's population) through 12,100 service connections of which eighty-nine percent are metered. Assuming twenty percent losses, eighty-six percent of delivered water is used for residential purposes, eleven percent for commercial purposes and the remainder for other miscellaneous purposes. With the exception of houses in high altitude areas of the city where system pressure may be insufficient and cost of service unnecessarily high, all subscriptions for water supply are permitted as long as the requesting households are in service areas and are legal buildings. The water source for the system is an impounded local river, and the water undergoes a treatment process of grit removal, coagulation, sedimentation, rapid sand filtration, and chlorination. Treated water is stored in elevated tanks from which it is distributed throughout the network by gravity. Although the water supply authority is part of the city governmental organization and all personnel are civil servants, the water supply system operates under a special program of independent subsidies from the national government without any budgetary transfer to or from city government. The water tariff schedule is presented below in Table 2.3. With an average per capita consumption of 143 liters per day, average monthly household water costs are $1.39, or less than one percent of total household income.

Table 2.3

Water Tariff Schedule in Chuncheon

	Basic Charge per Month		Excess Charge per Month	
	Basic Consumption (cubic meter)	Basic Charge (dollar)	Consumption (cubic meter)	Charge (dollar per cubic meter)
Residential Use	1-10	0.64	11-30 31-50 51 or more	0.07 0.08 0.09
First Class Commercial (tea house, cabaret,hotels, etc.)	1-30	3.52	31-50 51-10 101 or more	0.14 0.20 0.27
Second Class Commercial	1-20	2.35	21-50 51-100 101 or more	0.16 0.17 0.27

Those households not served by public water supply have domestic wells equipped generally with hand pumps.

(2) Sanitation

Chuncheon City has no city-wide conventional water-borne sewerage system, and the few flush toilets and domestic septic tank units found in the city represent only a negligible proportion of the total household systems. Thus, the typical household toilet system in Chuncheon is an indoor concrete vault privy. These household privies are either attached directly to the dwelling or built as separate structures, usually near the household entrance gate. The vaults have an approximate capacity of one half cubic meter and have exterior manholes to facilitate nightsoil collection. The privy superstructure is built of concrete block, concrete, white plaster, and corrugated asbestos-cement slate roofing; the average size is 1.1 x 1.2 x 1.8 meters.

Removal of human excreta from the private vaults is accomplished through both public and private nightsoil collection. The public nightsoil collection system services 21,440 households, seventy-four percent of the population. With the exception of approximately 1,000 individuals served by flush toilets, the remainder of the population collect their own nightsoil for private agricultural use. Public collection of nightsoil from the vaults is by manual and bucket system, carts and vacuum trucks or, where possible, by direct siphoning into vacuum trucks. Approximately eighty percent of the households require hand-dipping and bucket transportation, while only twenty percent can be reached by vacuum trucks. The collected nightsoil is then transported to a recently built treatment plant or sold directly to farmers

for use on vegetable farms or orchards. The treatment plant employs a process of two stage digestion and activated sludge treatment of the supernatant. The design capacity of the plant is one hundred kiloliters per day, enough to serve an estimated 21,817 households. The public system actually serves 21,440 households and collects 103 kl/day. However, only fifty to sixty kiloliters of nightsoil reach the treatment plant each day; the rest is sold directly to farmers at an approximate price of $7.00 per truck.

The sale of nightsoil prior to arrival at the treatment plant arises partly out of the institutional arrangements surrounding the public collection network. The treatment plant is owned and managed by the city under the general budget account, but house to house collection and delivery to the treatment plant is conducted by a private firm which has been awarded collection rights by the city on the basis of competitive bidding. The collection firm collects nightsoil collection charges from the households and uses the revenue for their own operation and management. Additional revenue is provided by sale of nightsoil to farmers. The collection fee charged is $0.07 per eighteen liter bucket. Trucks and buckets are provided by the city, but maintenance and repair costs are borne by the collection firm. There are four trucks utilized, each with a capacity of ten cubic meters. The current collection firm employs fifty-four laborers at a wage rate of $5.75 per day, but the firm is reported to find hiring nightsoil collection workers increasingly difficult at these wage rates because the job is so unpleasant.

Costs for the Chuncheon collection system are presented below in Table 2.4.

Table 2.4

Annual Household Cost for Nightsoil Collection in Chuncheon
(1978 US$)

On-site cost	
capital	20.9
O & M	6.6
Collection	
capital	0.1
O & M	5.7
Treatment	
capital	5.0
O & M	8.1
Total Waste Disposal Cost	46.4
Reuse Benefits Fertilizer	1.2
Net Waste Disposal Cost	45.2

The nightsoil treatment plant was built recently and only began operating in late 1976. Prior to this time, nightsoil was collected by hand and stored in nightsoil tanks located near a local river. The stored nightsoil was then either buried or discharged into the river at times of sufficient flooding so that adequate dilution was accomplished. Considerable portions of aged nightsoil taken from the tanks were also spread by farmers as fertilizer on upland acreage.

In addition to its nightsoil collection system, the city of Chuncheon has a network of open concrete ditches which run along the streets. Individual houses correct their drain pipes to these ditches, but human excreta is not to be discharged into them. The drainage network eventually discharges into a local stream which runs through Chuncheon to the Uiam Dam lake. Before the waste is discharged to the lake, it is stored in a retention pond beside the lake and is pumped into the lake during the flood season to ensure adequate dilution. The city plans to build a sewage treatment plant eventually so that Uiam Dam lake can be used for recreation. There is no sewer charge for households. The sewer network is constructed and repaired by the construction department of the city whenever it is necessary, and the expenses charged to the city's general budget accounts.

(3) Public Health and Environmental Pollution

Limited health facilities are available in Chuncheon: the city contains one hospital with eight doctors, thirty-one medical clinics with thirty-four doctors, four dental clinics with four dentists, five herb medical clinics with five herbal physicians, eight midwifery clinics with eight mid-wives, and one health center with two doctors. There are sixty-seven registered nurses who serve these various facilities. A vaccination program has been conducted in the community, and vaccination statistics for 1974 provided in Table 2.5 indicate the extent of this program. Birth and death statistics are provided in Table 2.6. These statistics are based on a rudimentary public data collection system and must be considered approximate figures. Morbidity statistics are provided in Tables 2.7 and 2.8. These statistics are taken from a survey of Chunseong Gun, the region immediately surrounding Chuncheon City, and these tables contain information derived from both a survey comprised of personal interviews and from subsequent medical examinations. Table 2.9 gives statistics on disease frequencies based on disease type, and Table 2.8 gives disease rates based on age. In addition to these general morbidity statistics, information on prevalence of intestinal helminthic infections is provided in Table 2.9.

Among excreta-related diseases, diarrhoeas, dysenteries, typhoid and helminthic infections predominate. Infectious hepatitis and cholera are also important. Excreta-related diseases may constitute approximately five percent of illness reported to Chun Cheon Hospital and may constitute approximately 0.7 percent of all conditions found by clinical survey of 3,166 people in Chunseong Gun. Gastroenteritis accounts for around nineteen percent of recorded infant deaths.

Table 2.5

Number of Persons Vaccinated by Type of Antigen in 1974 in Chuncheon

	Chuncheon City
Base Population	136,533
Type of Antigen	
Typhoid fever	51,392
Cholera	65,215
Smallpox	7,065
D.P.T.	7,598
D.T.	7,065
Poliomyelitis (Sabin)	3,817
B.C.G.	11,415

Table 2.6

Births and Deaths by Year in Chuncheon

Year	Base Population	Number of Births	Crude B.R.	Number of Deaths	Crude D.R.
1974	130,524	2,950	22.6	516	4.0
1975	130,250	2,713	20.8	540	4.1
1976	140,521	2,388	17.0	735	5.2

Table 2.7

Morbidity Rate (Number of Sick Persons/1000 Population) by Age and Sex in all of Korea and in Chunseong Gun

Age (Yr.)	Korea, 1971 1/ Whole Country Male	Female	Sep. 1976 2/ Chunseong Gun Male	Female
Under 1	276.1	246.5	500.0	263.2
5-9			361.3	274.3
10-14	117.4	139.9	338.2	282.5
15-19			296.9	285.2
20-24	119.1	128.6	258.6	258.1
25-29			309.7	430.9
30-34	111.1	279.8	444.4	739.7
35-39			477.6	734.9
40-44	109.6	308.2	528.5	708.0
45-49			642.3	706.3
50-54	172.2	444.0	559.5	657.1
55-59			675.7	713.0
60-64	378.7	424.5	693.3	676.1
65+			742.4	774.6
All ages	168.1	237.4	424.6	478.2

1/ Report of Health Interview Survey, Ministry of Health & Social Affairs, 1971 for four weeks.

2/ Interview survey on Chunseong Gun population, the nearest sites of Chuncheon City for four weeks.

Table 2.8: Morbidity Rate by Disease Classification Among Chunseong Gun Inhabitants

Disease Classification	Both Sexes				
	*Interview Number	Survey Rate Per 100	**Medical Number	Examination Rate Per 100	
I: Infectious & parasitic diseases	76	17.2	482	152.3	
004: Dysentery	13	3.3	9	2.8	*3,919 persons interviewed
005: Enteritis & diarrheal dis.	16	4.1	5	1.6	
006: Pulmonary tuberculosis	32	8.2	55	17.4	
010: Other tuberculosis	1	0.3	7	2.2	**3,166 persons examined by two physicians
029: Other viral dis.	-	-	11	3.5	
043: Other helmin.	-	-	10	3.2	
044: All other infectious and parasitic dis.	5	1.3	385	121.6	
II: Neoplasms	-	-	22	6.9	
III: Endocrine, metabolic & nutritional deficiencies	-	-	225	71.7	
IV: Diseases of blood and blood forming organs	-	-	137	43.3	
V: Mental disorders (mostly neurosis)	186	47.5	218	68.9	
VI: Dis. of the nervous system & sensory organs	691	174.3	549	173.5	
VII: Dis. of the circulatory system	88	22.4	145	45.8	
VIII: Dis. of the respiratory system	605	154.4	526	166.2	
IX: Dis. of the digestive system	653	161.3	195	61.5	
X: Dis. of the genitourinary system	117	29.9	161	50.8	
XXII: Dis. of the skin and subcutaneous tissue	268	68.4	338	106.8	
XIII: Dis. of the Musculoskeletal sys. & conn. tissue	79	20.4	218	68.8	
XIV: Congenital anomalies	2	0.5	11	3.5	
XVI: Symptoms and ill-defined conditions	15	3.8	20	6.3	
XVII: Accidents and poisoning	4	1.0	24	7.6	

Table 2.9: Prevalence of Intestinal Helminthic Infection in Korea and Chuncheon by Year, Area, and Species - Species of Intestinal Helminths

Area	Year	Number Examined	Egg Pos. Rate %	A.l. u	A.l. f	Total	H.w.	T.t.	T.o.	E.v.	C.s.	P.w.	T.s.	H.n.
Korea	1974	11,901,236	53.4	7.5	30.7	38.2	0.1	32.0	0.03	Other helminths not calculated				
	1976	6,448,258	39.7	7.1	20.7	27.8	0.03	20.7	0.01	0.09	0.1	0.002	0.007	0.01
Chun Cheon City	1974	19,035	43.9	10.3	15.6	25.9	0.1	27.9	0.03	0.4	0.03	0.005	0.07	0.5
	1976	20,291	33.5	8.5	10.6	19.1	0.009	21.1	0.05	0.1	-	-	0.04	0.1
**Twaegae Dong	1976	215	66.0	17.2	16.7	33.9	2.8	52.1	2.3	0.9	3.3	-	-	-

Source of Data: Semi-annual reports on the results of stool examination of primary school children by Korea Association for Parasite Eradication (KAPE); the fecal examinations were done by celophane thick smear technique. Also cited from "The Second Conference of the Asian Parasite Control Organization", October 21-26, 1975.

**Result of stool examination on general population by the local office of KAPE.

***A.l. = Ascaris lumbricoides, H.w.=hookworm, T.t.=Trichocephalus trichiurus, T.o.=Trochostrongylus orientalis
E.v. = Enterovius vermicularis, C.s.=clonorchis sinensis, P.w.=Paragonimus westermani, T.s.=Taenia species,
H.n. = Hymenolepis nana

Three mosquito-borne diseases are found; Brugia malayi, malaria and Japanese B encephalitis. All these are transmitted in South Korea by clean water breeders and are not related to excreta disposal. Culex fatigens - the dirty water breeder which transmits bancroftian filariasis in some countries - has not been reported in Korea.

Houses in Korea have average rat populations of around four rats per house and around sixty percent of houses have rats. Ratus norvegicus is the most common species and this has health implications since this rat is known to live in sewers and faecally polluted sites and is a major host of Leptospira icterohaemorrhagiae.

Limited pollution studies have also been conducted in Chuncheon. Samples of water from the city's water supply system have proven to be one hundred percent free of coliform bacteria. However, those samples taken from domestic hand pump systems exhibited a fifty-six percent incidence of coliform contamination.

E. COMMUNITY RESULTS: YUSAN 4RI AND YIPYUNG 1RI.

Two rural communities were selected for this study: Yusan 4Ri and Yipyung 1Ri. These two villages are located in the northwestern portion of South Korea in the Ichon Gun and are contained within the drainage basin of the Han River, as is Chuncheon City. They are in close proximity to each other and their drainage flows directly into the Bokhachon stream which in turn drains into the South Han River. The local economy of these two villages is almost entirely agriculturally based; ninety-eight percent of the households of Yusan 4Ri and eighty-six percent of the huseholds of Yipyung 1Ri are directly engaged in farming. Practically all farm households own the land which they cultivate, and average farm size in Yusan and Yipyung is 1.48 and 1.08 hectares, respectively. The majority of the arable land is in rice paddy, much of which is irrigated. Other, mostly upland crops are barley, soybeans, potatoes, peppers, chinese cabbage, and fruits. Since size of holdings is relatively small, these acreages are intensively cultivated with relatively heavy application of fertilizer and labor. The population in Yusan 4Ri and Yipyung 1Ri is, respectively, 285 and 310. Population density is low in these communities, and average household size is 5.3 individuals. The climate of this region is cold, preventing the double cropping prevalent in the more southern parts of Korea. Rainfall is in excess of eighty-nine centimeters per year, but the winters are cold and rather dry.

The average size of a dwelling in Yusan and Yipyung is sixty-six square meters. The construction materials are essentially the same as in more urban areas: cement, gravel, sand, concrete block, and wood with corrugated asbestos, cement slate or tile roofing. However, straw and mud are in some cases used as wall material. The average cost of a dwelling is $1,818.

(1) Water Supply

Water is supplied in Yusan 4Ri by a recently constructed and simple village system. The system was built in 1975 with funding provided

by the national and regional governments and with labor supplied by the village. The water source utilized is local ground water aquifers, and the system consists of two wells with motorized pumps, one distribution reservoir with a chlorinator, distribution piping, and individual water taps. Forty-five households are served. There are no water tariffs collected, and electricity to run the pumps is paid for by profits from the village owned flour milling plant. The system is managed by a six person village committee. There are no regulations or restrictions on subscription and use, and approximate water consumption is 100 liters per capita per day. Prior to construction of this public water system, water was provided by two village wells and by twenty individual household hand-pumped wells.

In contrast to Yusan 4R, Yipyung has no public water supply system. Prior to 1968, all households used village wells. However, five households built their own hand-pumped wells in 1968, and subsequently almost every household has built their own system. Cost of construction, including labor, is estimated at $90. Estimated water consumption is forty liters per capita per day.

(2) Sanitation

There have been no substantial changes in nightsoil disposal practices for centuries in these rural villages. There is no public cartage system, and individual households collect their own nightsoil from their private vault privies. Nearly one hundred percent of all nightsoil is used as fertilizer. In fact, in order to meet their needs orchard owners must buy nightsoil from nearby urban collectors. The going rate is $6.80 per truckload including delivery. The vault privies are constructed with concrete block, concrete, and straw mud. Roofing material is corrugated asbestos-cement slate. A few vaults are sealed and insulated to provide biogas; one family reported that their latrine and kitchen wastes provided sufficient cooking gas to make them completely independent of supplemental gas for nine months of the year. Dimensions for the village vaults are slightly larger than those found in Chuncheon. The reason for the bigger toilet in these rural areas is that the substructure is connected to cattle waste storage so that cow waste can be channelled into the human nightsoil tank. Many of these household systems utilize composting privies, while others utilize vault privies which are emptied to fill separate composting chambers. Nightsoil is never placed directly into flooded paddies unless first composted with other materials to produce an organic fertilizer. Costs for these systems are presented below in Table 2.10.

Table 2.10

Annual Household Waste Disposal Cost for Household in Yusan & Yipyung
(1978 US$)

On site	
Capital	10.30
O & M 1/	13.85
Collection	
Capital	-
O & M	-
Treatment	
Capital	10.23
O & M	-
Total Waste Disposal Costs	34.28
Resource Benefit Fertilizer	30.80
Net Waste Disposal Costs	3.48

1/ Includes repair and emptying.

Both of these villages have concrete-lined open drains constructed under a government self-help projects program. Theoretically, these sewers are used for disposal of sullage and not human excreta. Total length of the sewers is 800 meters in Yusan 4Ri and 320 meters in Yipyung 1Ri. Both empty into rice paddies.

(3) Public Health and Environmental Pollution

The citizens of Yipyung and Yusan are far less privileged than the citizens of Chuncheon as far as access to good quality medical facilities is concerned. Treatment for the less serious diseases can be obtained at the nearby town of I-Chon, but for the more serious health problems a relatively lengthy trip to Soowon City must be made. The medical facilities of I-Chon consist of one general hospital and thirteen medical clinics with only sixteen doctors, two dental clinics with two dentists, four herb medical clinics with four herbal doctors, two midwifery clinics with two midwives, and one health center with two doctors. A vaccination program has been conducted in I-Chon Gun. Number and type of vaccination is presented below in Table 2.11. Birth and death statistics are displayed in Table 2.12.

Table 2.11

Number of Persons Vaccinated by Type of Antigen in 1974 in Yusan and Yipyung

	Hobub Myon (Yusan 4Ri)	Machang Myon (Yipyung 1Ri)
Base Population	6,338	7,573
Type of Antigen		
Typhoid fever	2,954	3,212
Cholera	4,312	3,932
Smallpox	508	496
D.P.T.	200	168
D.T.	508	496
Poliomyelitis (Sabin)	302	318
B.C.G.	361	573

Soruce of Data: Statistical Yearbook of I-Chon Gun, 1975.

Table 2.12

Birth and Death Rates in Yusan and Yipyung

	Year	Base Population	Number of Births	Crude B.R.	Number of Deaths	Crude D.R.
Yusan 4Ri	1976	293	4	13.7	1	3.4
Yipyung 1Ri	1975	290	8	27.6	1	3.4
	1976	297	8	27.0	1	3.4

Morbidity data collected in Yipyung 1Ri and Yusan 4Ri on July 20 and 21, 1977 are presented in Table 2.13. The data were collected by interview, and conditions occurring during the previous week were noted. These statistics have been segregated into age groups and presented in Table 2.14. Those individuals of age 1-10 and those over 30 show markedly higher rates. A special program of stool examination of the general population of Yusan 4Ri and Yipyung 1Ri was conducted for this study, and the prevalance of intestinal helminthic infection revealed by the program is presented in Table 2.9. In addition, Table 2.15 presents data concerning intestinal protozoan infection.

Excreta-related disease may be appreciably more prevalent in rural areas than in urban areas. Prevalences of infection with certain helminths vary approximately in the range twenty-two to sixty-six percent. Ascaris lumbricoides and Trichuris trichura account for over ninety-five percent of all worms isolated. It has been noted that these infections are more prevalent among dry land farmers than among others (either wet land farmers or urban non-farmers), and this may be due to the use of untreated nightsoil as a fertilizer by dry land farmers. Many soil samples on vegetable farms contain Ascaris ova.

Additional information from the I-Chon Gun statistical yearbook indicates that within the Gun (county) of Yusan and Yipyung six cases of cholera were reported in 1969, 1970, and 1971, seven cases in 1972, none in 1973 and 1974, and one case in 1975. When all of this public health information is reviewed, it must be concluded that sanitation related disease is problematic in these two villages.

Limited environmental information consisting of bacteriological examination of drinking water samples has been collected for these two villages. In Yusan 4Ri, where households are supplied with tap water for drinking, all samples were free of coliform bacteria. However, of the hand pumped systems used for wash water, fifty percent were positive for coliform bacteria, and of the open dug wells present sixty-six percent were positive for coliform bacteria. In Yipyung, where there is no public system, eighty percent of the hand pumped wells used for drinking water contained coliform bacteria; and one hundred percent of the open dug wells were contaminated. It is interesting to note that the occurrence of enteritis, dysentery, diarrhea, and food poisoning was much higher in Yipyung than Yusan.

Table 2.13

Morbidity Rate (Number Sick/1000 Population) in Yusan and Yipyung

	Study area, 1977 July							
	Yipyung Ri		Yusan Ri		Chunseon Gun		Country	
Age (Yr.)	Male	Female	Male	Female	Male	Female	Male	Female
Under 1	333.3	235.3	392.9	315.8	430	269	276	246
5-9								
10-14	192.3	181.8	111.1	266.7	317	283	117	140
15-19								
20-24	333.3	272.7	166.7	200.0	284	344	119	129
25-29								
30-34	272.7	416.7	400.0	478.3	461	736	111	280
35.39								
40-44	466.7	500.0	363.6	500.0	585	707	110	308
45-49								
50-54	562.5	600.0	583.3	631.6	611	585	172	444
55-59								
60-64	(No person inteviewed)							
65+	193		191		718	725	388	424
All ages	346.5	391.3	310.7	425.5				

Table 2.14: Morbidity Rate/1000 Persons Interviewed/One Week by Disease Classification (150 and 17) and Sex Among Inhabitants of Yipyung 1 Ri and Yusan 4 Ri

Disease Classifications		Male		Female		Both Sexes	
		Number	Rate	Number	Rate	Number	Rate
I	Infectious Diseases	9	46.6	10	52.4	19	49.5
004	bacillary dysentery and amoebiasis	3	15.5	2	10.5	5	13.0
005	enteritis and other diarrheal diseases	3	15.5	2	10.5	5	13.0
006	tuberculosis of respiratory system	2	10.4	1	5.2	3	7.8
021	other bacterial diseases (food poisoning)	1	5.2	5	26.2	6	15.6
II	Neoplasms	1	5.2	-	-	1	2.6
V	mental disorders (neurosis)	4	20.7	6	31.4	10	26.0
VI	disorders of the nervous system and sensory organs	16	82.9	27	141.4	43	112.0
VII	disorders of the circulatory system	8	41.5	19	99.5	27	70.3
VIII	disorders of the respiratory system	23	119.2	10	52.4	33	85.9
IX	disorders of the digestive system	23	119.2	39	204.2	62	161.5
X	disorders of the genitourinary system	-	-	11	57.6	-	-
XI	complications of pregnancy...	-	-	1	5.2	-	-
XII	disorders of the skin and subcutaneous tissue	7	36.3	8	41.9	15	39.1
XIII	disorders of the musculoskeletal system...	4	20.7	11	57.6	15	39.8
XVI	symptoms and ill-defined conditions	2	10.4	6	31.4	8	20.8

Note: Among those conditions reported in the interview, 72.8% were chronic conditions.

Table 2.15: Prevalence of Intestinal Protozoa Infection by Year and Area

Area	Year	Number Examined	Cyst Posit. Rate%	Percent Positive by Species*					
				E.h.	E.c.	E.n.	G.l.	I.b.	C.m.
Yipyung 1 Ri	1977	44	13.6	-	6.8	3.5	4.5	2.3	-
Yusan 4 Ri	1977	29	13.8	4.5	9.1	8.3	3.4	-	-

* E.h. = Entamoeba hystolytica, E.c. = Entamoeba coli, E.n. = Endolimax nana

G.l. = Giardia lamblia I.b. = Iodamoeba buetschlii C.m. = Chilomastix mesnili

For the study area collected stools were examined by MGL methods; some were also examined by direct smear when the stool volume was not sufficient enough for concentration.

CHAPTER III

TAIWAN

Taiwan is one of the most advanced economies of Asia and has achieved considerable economic growth during recent decades. The per capita GNP in 1975 was $700 with a real per capita growth of four percent. The island is comprised of 35,981 square kilometers, and with a population of 16.1 million (1965) has a population density of 450 persons per square kilometer. The population is well educated with an adult literacy rate of ninety-three percent. Fifty-two percent of the population are urban dwellers. The climate is hot and humid in summer and mild and humid in winter. The average annual rainfall is 254 centimeters. The predominant religion is a combination of Buddhism and Taoism. However, there are over 600,000 practicing Christians in Taiwan, most of whom are Protestants.

Taiwan has undergone rapid industrialization in the past two decades with a corresponding change from an agricultural to an industrialized economy. Due to Taiwan's lack of natural resources, the industrialization has been largely export oriented. Twenty-three percent of the labor force is currently engaged in industry, and principal products are textiles, electronics, light manufactures and cement. In spite of its declining importance relative to manufacturing, agriculture is still important in Taiwan. The one-quarter of the land area which is arable is intensively cultivated with most areas producing two or three crops per year. The major crops are sugar and rice. The soils of Taiwan are not highly productive and are intensively fertilized with both organic and chemical fertilizers.

Taiwan's social infrastructure has undergone significant development in recent years; since 1968, a nine-year free educational system has been in effect. Six years of elementary school are compulsory, and almost ninety percent of all students continue to complete the remaining three years available. Approximately one-third of these graduates continue on to senior high and vocational schools. Taiwan also has an extensive system of universities, colleges, and junior colleges, which currently enroll 300,000 undergraduate and graduate students.

Health facilities are available throughout the country. Serious epidemics and diseases are infrequent in Taiwan. Public health officials have recognized Taiwan's problems of environmental sanitation, and substantial resources have been devoted to their solution. Public water supplies are being extended throughout the country. However, sanitation is still problematic, and open sewers continue to exist in many areas. Traditional methods of sanitation including the collection and direct use of nightsoil as fertilizer are still common.

A. COMMUNITY SELECTION

The communities of Keelung, Pingtung, and Tainan are included within this chapter to document Taiwan's traditional urban nightsoil collection

schemes as well as its well established reuse practices which include aquaculture and biogas generation. Keelung, a large, modern port city provides public nightsoil collection from vaults to twenty-nine percent of its population. In Pingtung, forty-three percent of the population use vault privies which are served by both public and private nightsoil collectors. In addition, biogas units are used domestically in a number of households. In Tainan, another coastal city, nightsoil collected from vaults serving about ten percent of the population supports a thriving aquaculture industry. The Shihlin model sewerage project in Taepei is also included within this chapter to illustrate many of the problems which can arise when implementing a large sewerage project in a developing country.

The majority of field work for this study was done by Mr. Ng Kin Seng, a consulting sanitary engineer with the support of Dr. Lo Mei Chan, Director of the Institute of Environmental Sanitation of the Taiwan Provincial Government. In addition, a summary of the Shihlin model sewerage project was submitted by Mr. S. C. Hsu, Professor of Civil Engineering at Tamkang College of Arts and Sciences, Taiwan.

B. ASSUMPTIONS

In dealing with the data collected and prepared during this study, a number of assumptions have been made. The opportunity cost of capital was taken as twelve percent. Many of the costs collected during the study originally reflected 1975 or 1976 prices, and the prices given in this report, unless otherwise stated, have been adjusted to January 1978 prices using the 1976 inflation rate of 2.8 percent and the 1977 inflation rate of 4.0 percent. To convert these figures into current US dollars the exchange rate of 38NT$/US$ was used. All income figures have been adjusted to reflect both real economic growth and inflation.

C. COMMUNITY RESULTS: KEELUNG

Keelung is located approximately twenty-three kilometers east of Taipei city on the northeast shore of Taiwan. The city is one of Taiwan's major ports and supports an urban population of approximately 341,000 inhabitants (1975). Keelung's topography is extremely hilly, and the altitude ranges between 100 and 1,000 meters. The Keelung River flows through the community with an average discharge of 26.5 cubic meters per second, and groundwater sources are limited in the region. With a mean average temperature in January of 15.3^{o}C and in July of 28.7^{o}C, Keelung's climate is warm and humid. Average annual precipitation is 334 centimeters.

With a total land area of 132.8 square kilometers, Keelung has an average population density of 2,573 persons per square kilometer. Average household size in Keelung is 5.1 persons and average household income is $3,907.0. Because of the city's hilly topography and the scarity of arable land, only 1.7 percent of the Keelung's households are engaged in agriculture. This limited agricultural activity is concentrated in the production of rice, sweet potato, ground nut and fruits. Most of the community is engaged in manufacturing, shipping and service-related activities. In general, there is no difficulty in finding skilled workers such as carpenters, plumbers, and electricians among the population or in finding unskilled workers for sanitation services. Individual housing units vary according to the wealth of the

inhabitants. Dwellings of lower income groups are built of timber with roofing of galvanized metal plates. Houses of wealthier individuals are built of bricks and reinforced concrete.

(1) Water Supply

Keelung has a public water supply system which serves 273,600 people or eighty percent of the population. The regional office of the Taiwan Water Supply Corporation in Keelung is responsible for the system's production, operation, maintenance, and service. However, the head office in Taichong exercises centralized planning, design, control, and supervision over manpower and financial matters. Water production averages 408 liters per capita per day and consumption is 340 liters per capita per day. The water tariff structure is presented in Table 3.1. Based on these tariffs, the average monthly, household water bill is $6.60 or two percent of household income. Those households not serviced by the public system utilize private well systems.

Table 3.1

Water Tariff Structure of Taiwan Water Supply Co.
(1978 US$)

Minimum Units (cubic meters)	8
Minimum water charge	.54

Escalating charges

Units (cubic meters)	Charge $/m^3
20 and below	.07
21 - 30	.10
31 - 50	.12
51 - 200	.15
201 - 2000	.12
2001 and above	.10

(2) Sanitation

Keelung provides public nightsoil collection for 20,000 households (29% of the population). Forty-eight thousand households, seventy percent of the population, are served by private septic tank systems, and one percent of the households collect and use their own nightsoil. Those household served by nightsoil collection have household vaults which are usually constructed of bricks with a volume one half to one cubic meter. For low income groups, the vaults are located outside the household, while they are attached to the house in the more wealthy households. The vaults have a port with cover for collection, and the toilet is normally made of concrete with a simple drop hole without a water seal.

Nightsoil is collected at two week intervals. Removal from the vault is accomplished by either hand-dipping or directly by vacuum truck where accessible. Where not accessible to trucks, buckets are hand carried to intermediate hand drawn carts which are in turn drawn to trucks at predetermined locations. The vacuum trucks transport the collected nightsoil to a recently constructed treatment plant. This plant has a capacity of treating 150 cubic meters per day but now only receives about 90 cubic meters daily, representing one liter per capita per day. Within the plant, the nightsoil is first digested aerobically for about ten days, followed by sea water dilution and treatment by an activated sludge process. The excess sludge is dewatered by solid bowl centrifuge and given to farmers free of charge. Approximately two cubic meters of treated nightsoil are distributed daily in this manner. The treated effluent is discharged directly into the sea; reportedly the quality is satisfactory. Nightsoil collection and treatment are administered by the Sanitation Department of Keelung, and 116 nightsoil collectors are employed by the Department.

A number of problems have been associated with the present night soil collection scheme in Keelung. Most notable is the quality of maintenance and construction of household vaults. Infiltration into the vaults makes necessary more frequent collection of nightsoil. Alternatives for the system under consideration include less frequent nightsoil collection, installation of commercially manufactured vaults, installation of water seal toilet to control odors, and the use of hand operated carts equipped with vacuum pumps for nightsoil collection where vehicular access is not feasible.

Septic tank systems utilize a flush toilet which feeds into tanks of varying designs. The oldest tanks include an interior stone filled chamber which has been omitted in more recently built tanks because it frequently becomes clogged. The most recently built tanks are quite simple and consist of a rectangular tank of approximately 1.5 cubic meter volume with 4 to 6 baffled chambers. The inlets and outlets of the chambers are installed at different levels to avoid short-circuiting. Costs for the current sanitation systems in Keelung City are presented below in Table 3.2.

Table 3.2

Annual Household Waste Disposal Costs
in Keelung
(1978 US$)

	Cartage	Septic: Average for Taiwan
Household Costs		
Capital	9.6	195.4
O & M	2.2	79.6
Water		31.0
Collection		
Capital	1.9	---
O & M	12.2	---
Treatment		
Capital	3.9	---
O & M	2.4	---
Total	32.2	306.0

D. COMMUNITY RESULTS: PINGTUNG

Pingtung is located twenty-five kilometers due east and inland of Kao Hsiung in southern most Taiwan. The city has a total area of 65.07 square kilometers and is characterized by flat terrain with an altitude of less than 100 meters. One small stream known as Wan-Nen Creek meanders through the city and flows southwesterly into the Koa-Ping Creek. The groundwater table is generally within 3.6 meters of the ground surface. The climate is warm with a mean average January temperature of 18.1°C and a mean average July temperature of 28.5°C. The annual precipitation is 207 centimeters.

With a population of 174,891 (1975), Pingtung's population density is 2,700 people per square kilometer. Average household size is 5.28 individuals, and average household income is $4,505. Analysis of employment patterns indicates that twenty-two percent of the working population are engaged in agriculture, fifteen percent in mining and manufacturing, and sixty-three percent in service industries. No information is available on housing costs.

(1) Water Supply

Only 33,363 individuals, nineteen percent of the population, are served by the public water supply system. The remainder of the population is

served by private wells. In addition, those households which utilize the public water system frequently supplement their water supply with withdrawals from domestic wells. Average per capita water consumption from the public water supply system is estimated at 108 liters per day. This low consumption rate is attributable to the additional use of domestic well systems. Use of public water in Pingtung is limited by the systems intermittent supply and frequent low pressure.

(2) Sanitation

Although the city of Pingtung operates a public refuse collection system, there is no public sewerage system. One hundred thousand inhabitants, fifty-seven percent of the population, are served by septic tanks. The remainder of the population is served by nightsoil collection, and of these, 50,000 are served by a public nightsoil collection unit operated by the city of Pingtung. The remaining 24,000 are served by private collectors. Both the septic tank and household vault systems located in the more interior regions of the city are similar in design to those found in Keelung. However, in the outlying regions of the city, pit privies of shallow design and low volume are predominantly used for excreta disposal. Periodic infiltration into these pit privies occurs during rainy periods, and overflow of excreta is common. It is from these outlying areas that nightsoil is collected privately for agricultural use. Collection is free of charge, and due to the limited volume of these pit privies, the usual interval between collection by farmers is four days.

The city of Pingtung employs forty workers to accomplish its public collection of nightsoil. This crew utilizes for collection three 4.2 ton vacuum trucks, each equipped with an additional trailer of 2 ton capacity. Under normal circumstances, one of these trucks is held in reserve, while only two are operated. The vaults are emptied by dipper and bucket at two week intervals. The nightsoil is first loaded into intermediate carts and drawn to predetermined stations for transfer into the vacuum trucks. Approximately forty tons of nightsoil is collected daily and is either taken directly to local farmers or to the municipal treatment plant. The annual household charge for public collection is $0.57. During the rainy season when low-lying areas of the city are easily flooded, three-wheel motorized carts of 1.2 ton capacity are brought into service. The city treatment plant was built in 1972 and has a daily treatment capacity of thirty tons. The plant employs conventional sludge treatment.

Costs for waste disposal in Pingtung are presented below in Table 3.3 Average septic tank costs for Taiwan are presented in the Keelung discussion.

Table 3.3

Annual Household Waste Disposal Costs in Pingtung
(1978 US$)

	Cartage
Household	
Capital	9.6
O & M	2.2
Collection	
Capital	.8
O & M	8.1
Treatment	
Capital	2.4
O & M	2.6
Total	25.7
Reuse	
Fertilizer	1.8
Net Waste Disposal Cost	23.9

(3) Reuse: Agricultural

The majority of the nightsoil collected in Pingtung is used as fertilizer. In addition to the nightsoil collected by private individuals, sixty-two percent of that collected by the public agency, 8,421 tons, was sold to farmers in 1976 at $0.61 per cubic meter. It is standard practice to transport all untreated nightsoil for which there is a demand immediately to the agricultural areas of the Pingtung region. Nightsoil is taken to the treatment plant only when there is an excess above agricultural demand. The peak demand for nightsoil is from November through March. During this period, very little nightsoil is treated by the municipal treatment plant. During the rainy season from May to September, the treatment plant fails to cope with the daily production of nightsoil in the city. The excess is stored in tanks located on the outskirts of the city. When the peak demand period arrives again, the nightsoil previously stored in the tanks is drawn into the vacuum trucks and mixed with freshly collected nightsoil for delivery to farmers for reuse. The fermented nightsoil amounts to approximately one-fifth of that sold to the farmers.

Approximately ten percent of the nightsoil sold to farmers is for banana farming; the remainder is for vegetables. It is estimated that forty tons of nightsoil are needed for fertilizing one hectare of banana

trees at fifteen-day intervals for a period of ten months during the year. Other crops produced in the Pingtung area include rice, sweet potato, Indian corn and soya bean.

(4) Reuse: Biogas

Reportedly, there are thirty family-size biogas plants in operation in Pingtung. The biogas plant design consists of a reinforced concrete digester with an inverted steel lid which acts as a gas holder while resting in a water seal. The digester is a cylinder approximately two meters in diameter and two meters deep. The methane gas generated is transmitted to the kitchen through a pressure hose connected to the outlet pipe at the top of the inverted lid. A control valve is installed at this outlet pipe. The digesters are fueled by both human nightsoil and pig waste. Frequently, the digester is connected to the pig pen by a clay pipe through which the pig waste and wash water are loaded daily. Methane generation is continuous, and the effluent from the digester is temporarily stored in a chamber next to the digester. The digester is emptied twice per year, and the sludge sold.

It was reported that nightsoil from a family of five plus the feces excreted from five hogs is adequate to generate methane gas for cooking purposes for a family of five. Owners of these units reported that they were quite satisfied with the units. However, many complained that the price of pig feed was becoming so high as to make the raising of pigs uneconomical, thus threatening the continued use of their biogas plants. In the Pingtung area between 1963 and 1969, 120 biogas units designed for the utilization of pig waste were constructed, and only thirty units are presently in operation. An analysis of the costs of this system is presented in Table 3.4.

Table 3.4

Net Cost of Household Biogas Unit In Pingtung
(1978 $, lifetime in years)

	Total Cost	Lifetime	Annual Cost
Construction /1	236	20	31.6
Land Cost (15 m^2)	348	infinite	41.8
Desludging Cost (annual)	16.6	-	16.6
Total Cost per Household per year			90.0
Biogas Benefits (12 cylinders of LPG at 6.25)		-	75.0
Sludge Sales (2 carts)		-	11.0
Net Cost per Household per year			4.0

/1 Includes household latrine facilities.

E. COMMUNITY RESULTS: TAINAN

Tainan is located approximately 300 kilometers southwest of Taipei on the west coast of Taiwan. The city is divided into seven districts, of which the Southern District was chosen for study. The total area of the city is 175.64 square kilometers of which 23.2 square kilometers is within the southern district. The total population of Tainan is approximately 500,000. Climatological records (1961 to 1970) reveal a mild and wet climate typical for Taiwan. Mean average January temperature was 16.6°C, while mean average July temperature was 28.8°C. Average annual precipitation was 132 centimeters.

With a population of 84,853 inhabitants, the southern district of Tainan has a population density of 3,657 persons per square kilometer. In 1976, there were 16,736 households with 5.07 persons per household. Average household income is $3,202. Houses are built out of reinforced concrete in the city proper, while in the outskirts of the city, bricks are more commonly used.

(1) Water Supply

Sixty-eight percent of the population of the Southern District are served by piped water. Average piped water consumption was 136 liters per capita per day in 1975. The public water supply is frequently supplemented by domestic wells, thus average total water consumption is somewhat higher.

(2) Sanitation

Of the 84,853 people based in the Southern District, 56,500 (66%) are served by domestic septic tanks. The increasing numbers of septic tanks found in this district reflects increasing income levels in Tainan. There is no public sewer system, but the city of Tainan operates a night-soil collection system which serves 8,000 additional people in the Southern District. The remainder, approximately 20,353 persons, either collect their own nightsoil for farm use or are served by private illegal operators.

The illegal operators start their nightsoil collection in the very early morning and use dippers and buckets for removal in conjunction with ox-carts of three-quarter ton capacity. Nightsoil is collected by both public and private collectors two to three times monthly. The public system which services the entire city (but only six percent of the population) uses thirteen vacuum truck of two to three ton capacity and one hundred laborers. The laborers are paid $80 to $105 per month plus a food subsidy worth about $26 per month. At this wage, no problems with attracting laborers are reported. Approximately ninety tons of nightsoil are collected daily by the public system from the entire city. Nightsoil from both public and private collectors is sold for agriculture and aquacultural purposes. However, the public system sells its nightsoil for $0.65 per ton plus $0.57 per kilometer for transportation costs, while the private collectors sell theirs for $7 per ton, inclusive of transportation costs. The public system is able to sell

eighty percent of its total annual collection of nightsoil. The remainder is taken to "sterilization" ponds where it is left for three weeks without any treatment. It is then transported by vacuum truck to the ocean where it is dumped. This "sterilization" pond is seven to eight meters deep with a capacity of approximately 400 tons and is located several kilometers outside of town. With the substantial black market in nightsoil, the excess capacity taken to the holding pond seems contradictory, but can easily be explained by the seasonal nature of nightsoil use. During November and December, there is little demand for nightsoil. City officials plan to construct a nightsoil treatment plant to replace the "sterilization pond." However, if the rapid switch to septic tank continues, this plant may be unnecessary since during most of the year, it would remain unused. Cartage system costs are presented below in Table 3.5.

Table 3.5

Annual Household Waste Disposal Costs in Tainan

	Cartage
Household	
Capital	9.6
O & M	2.2
Collection	
Capital	2.2
O & M	15.3
Treatment	
Capital	—
O & M	--
Total	28.3
Reuse	
Aquaculture	1.3
Net Waste Disposal Cost	27.0

(3) Reuse: Aquaculture

The Tainan area is known for aquaculture, and it is reported that all of the city's nightsoil is sold for this purpose during ten months of the year (January through October). There are over 5,410 hectares of fish ponds in the Tainan region, of which 440 hectares are located within the

study area of southern Tainan. These ponds are supplied with water drawn from local wells; and depending on the distance of these wells from the sea, the ponds may be either fresh or salt water. There is also reported to be some shallow sea culture in the region. The ponds in the Tainan region can be characterized as follows:

Sea water fish ponds	:	4,195 hectares
Fresh water fish ponds	:	1,124 hectares
Shallow sea culture	:	85 hectares
Other	:	6 hectares

The following types of fish are cultivated in Tainan: Chanos Chanos, Tilapia, Silver Carp, Mud Carp, Common Carp, Mullet and Gold Carp. The typical pond is one hundred meters square and sixty to seventy centimeters deep.

Nightsoil is used as a nutrient for the growth of algae and plankton. In addition to nightsoil, bean cake is used to supply nutrients. Fish rearing usually begins in early March and ends at the end of November of that same year. In the interim period between December and February, the fish ponds are left empty and dry. In December, when the ponds are emptied, young fish which have not been previously harvested are removed from the large ponds and placed in smaller protective ponds. These smaller ponds are surrounded with straw fences so as to protect the young fish from the cold of winter. This function is important since some species are extremely sensitive to temperature. The young fish will be re-introduced into a larger pond in early April after the ponds have been appropriately prepared. The reconditioning of these ponds begins in early March when they are flooded. Prior to flooding, nightsoil and bean cake are placed in the bottom of the pond. The ponds are first filled with only there centimeters of water, and algae soon begins to flourish. As the water evaporates more nightsoil and bean cake, along with more well water, are added to the ponds. After a month, a substantial algal mass has accumulated, and the water level is adjusted to about twenty-five centimeters. The fish are then introduced from the protective ponds into the larger ponds and are first harvested in about one month, depending on the size of the fish when introduced into the pond. Throughout the rearing period of approximately seven months, five or six harvests can be achieved. Nightsoil and bean cake are applied in five or six doses throughout the rearing season to stimulate growth of algae and plankton.

Production quantities and prices for 1976 are presented below in Table 3.6, as are the costs of cultivating the mirror carp in salt water in Table 3.7.

Table 3.6

Production and Prices of Various Fish Cultured in 1976 in Tainan

	Description	Cultured Area (hectare)	Production (ton)	Price (US$/Kg)
1.	Chanos Chanos	4,119		
2.	Tilapia	549		
3.	Silver carp*	(583)	732.4	.29
4.	Grass carp *		80	.84
5.	Common carp*	(15.83)	32	.42
6.	Colden carp*		29	.37
7.	Oystera	74	139	2.24
8.	Tapes	6	10.1	1.05
9.	Dragon beard vegetable	42	3,034	.39
			*of which half exported	

Sources: Aquaculture Department and City Council of Taiwan.

Table 3.7

Estimated Cost for Culturing Chanos Chanos (Mirror Carp) in Salt Water
1976

Capital Cost

	Description	US$
1.	Construction of fish pond (1 hectare) including land cost	4,000
2.	Pump	250
	Subtotal annual cost (capital x CRF, .134) (20 years @ 12%)	569.50

Production Cost

3.	Fingerling	11,000/hectare	580.00
4.	Nightsoil	7.3 tons	10.50
5.	Bean cakes	200 kg	35.00
6.	Ricehusk pellets	700 kg	64.50
7.	Salary: (i) Regular:	0.2 man-year	87.00
	(ii) Casual labor:	male 50 men-day at NT$200/day	263.50
		female 100 women-day at NT$150/day	395.00
8.	Winter protection facilities		13.20
9.	Consumable equipment & tools		13.20
10.	Bund repairs		13.20
11.	Loan interest		13.20
12.	Taxes		118.50
	Subtotal annual production cost		1,606.80
	Grand total annual cost		2,176.30

Yields

13.	Annual yield:	2,500 kg x 45	2,964.50
14.	Profit		788.20

F. COMMUNITY RESULTS: TAIPEI - SHIHLIN MODEL SEWERAGE PROJECT

Due to rapid population growth and industrial and commercial development, Taipei, the capital city of Taiwan, has grown into a large metropolitan region in recent years. There are now about 2.4 million people living in Taipei itself, and 3,000,000 in the Greater Taipei Area. In twenty years, these numbers are expected to double. In spite of its growing prominence as a major urban center, Taipei and the surrounding urban areas have no complete sanitary sewerage system.

Sanitary services are provided for the most part by either vault nightsoil collection systems or by flush toilets connected to septic tanks. The urban drainage system is comprised of a series of sewers and canals which carry human and industrial waste as well as stormwater run off. At present, the daily production of wastewater in the Taipei Area is estimated at 900,000 cubic meters and 200 tons of BOD_5. This waste water load is largely discharged directly into drains or water ways or, in the case of flush toilets, indirectly after it passes through septic tanks, and eventually finds its way into the local river and estuary system. Due to a decreasing demand for agricultural reuse of nightsoil, increasing amounts of untreated night soil have also been discharged in recent years into the local river and estuary system. Consequently, the river system of the Taipei Basin has become so seriously polluted that even water supply sources are endangered. During low flows, the dissolved oxygen is found to be almost non existent in many parts of the river and estuary system. The BOD_5 $20^{o}C$ is sometimes as high as thirty parts per million, especially in the lower Keelung River. The bacteria concentration of local water ways is very high, with the bacteria count at one point in the Keelung River ranging up to 1,100,000 MPN per 100 cubic centimeters.

Recognizing the severity of the problem in 1967, the Government of Taiwan requested assistance from the United Nations Development Program Special Fund (UNDP/SF) for sewerage planning in the Greater Taipei Area. With their support, an international consulting engineering firm was engaged to develop a sewerage plan for the Greater Taipei Area. The scheme eventually chosen was that of a regional system of separate sanitary sewers consisting of primary facilities (main trunk sewers, pump stations, treatment facilities and outfalls) and secondary sewers which would be connected to the local collection systems. Houses and buildings were to be connected directly to local street sewers. In order to proceed at a feasible rate of construction of local sewers and connection to individual households, the construction of the system was segregated into several stages.

However, because of lack of actual experience in sewerage system planning in Taiwan and also because there was no governmental agency or organization that had the capability of implementing and carrying out the proposed Master Plan, it was recommended that a small model project be undertaken as a part of the first stage program. It was hoped that the model project would enable the development and demonstration of the skills in organization, financing, design and construction necessary to implement the

larger master plan. The Shihlin area of Taipei was chosen for the model project, and planning for the project began in 1972 with the creation of the Taipei Area Sewerage Engineering Department (TASED). The outcome of this model project illustrates well the problems associated with the implementation of such a project in a developing country.

Shihlin District is located at the northern part of the Taipei City. The total area of the district is approximately 6,500 hectares of which a large portion is comprised of steep hillsides or mountains. The mountainous portion is not amenable to large scale development, and only comparatively small communities are found there. In the northern portion of the district lies a large flat plain on which most of the development in Shihlin has occurred.

At the northwest tip of the plain is the Shihlin old town, which is composed of a mixture of highly populated residential and commercial areas. The inhabitants, mostly natives, are employed either in downtown Taipei or within Shihlin. The rest of the plain is a huge rural area in which many new residences have been built recently along with a number of institutes, colleges, and museums. The total population of the district is estimated at 90,000. Industries located on the plain include a paper mill, several textile mills, and a number of chemical plants.

Four hundred and thirty-four hectares of the Shihlin District were chosen for inclusion within the model project. The area was located primarily in the flat land portion of the district and included the Shihlin Old Town. Land use in the model area was thirty-four percent residential and ten percent commercial or industrial. Other land use included parks, schools, and other miscellaneous categories. Population density for the Shihlin old town was estimated at 400 persons per hectare, while the density in the newer regions was estimated to be 500 persons per hectare.

(1) Previous Sanitary Facilities

Human excreta have been traditionally disposed of in the project area by nightsoil collection services operated mostly by the city authority. The nightsoil was stored at individual households in a Benjoe, a vault type toilet, until it was dipped out by nightsoil scavengers into wooden buckets of about twenty-five liter capacity which were carried in pairs by means of a shoulder yoke to tank trailers. Until recently, the collected nightsoil was disposed of either through direct sale to farmers for agricultural use or by discharging it into reinforced concrete maturation tanks for storage during low demand periods of the year. However, with the increase in the availability of chemical fertilizers at reasonable prices, and with increasingly unfavorable reaction by the public towards vegetables raised with raw nightsoil, the demand for nightsoil has decreased sharply since 1959, and increasing amounts have been dumped into nearby rivers, creeks and ditches in recent years.

In addition, a large number of flush toilets have been installed recently in the houses equipped with septic tanks. Unfortunately, these

facilities have not operated satisfactorily because of poor design and construction. The reduction in organic matter is negligible, and normally the BOD_5 in the tank effluent is still over 500 parts per million. The effluent, rich in sulfide and many other unstable materials, is blackish in color and offensive in smell, particularly during the summer season.

The project area previously had a drainage system of open or partly covered drains but had no sanitary sewerage system. The major portion of the drainage system was constructed ten years ago and was located in or near the highly developed areas of the District. The drains carried not only storm water but also all the municipal liquid wastes, with the exception of the human excreta carried by vacuum trucks. Most of the existing drains were concrete lined open ditches, placed between the edge of the pavement and the sidewalk. Gutters and curbs were provided only along the main streets in the most recently built up commercial sections. These drains were covered, and small elliptical openings were provided between the concrete cover plates to allow the surface run-off to pass through. Only a few drains had sufficient cross section to carry both storm water and liquid waste flow, and an accumulation of sludge and silty mud within the drains was common. In the newly developed residential areas, the situation was even worse. Houses were built without any adequate facilities to dispose of the wastes, and domestic sewage flowed into nearby irrigation channels and down through the open fields until it finally reached the Keelung River.

(2) System Design

The model project was intended to provide a full service, separated sewerage system to the project area. The final design of the project included the construction of laterals along roads, streets, and lanes with appropriately spaced outlets for house connections. These laterals ultimately converged on four sub-mains which in turn converged on a temporary sewerage treatment plant. Lift stations were needed at points where an extremely deep trench was unavoidable. Minimum burial depth for pipes was set at 1.5 meters under primary and secondary roads, 1.0 meter under ordinary roads, 0.75 meters under small roads and .60 meters under lanes and alleys. To reduce the length of the house connection pipe and to avoid adding further congestion to the underground structures, two parallel sewer pipes were specified for streets wider than twelve meters in City planning areas, and for streets wider than fifteen meter in non-City planning areas. A minimum pipe diameter of twenty centimeters was selected.

(3) Sewer Construction

Construction of this sewerage system in such a densely populated area proved to be a difficult task for the Taiwanese contractors. All submains and laterals were designed to be laid beneath city streets and under such existing facilities as water pipes, underground cables, storm drains, and gas pipelines. Also, great care was required not to disturb and damage nearby buildings or structures. In order to accomplish this, a number of construction methods were employed, including open-dig construction, jacking, and tunnelling.

Open-dig construction was the most primitive method used. Traffic was badly affected in areas where it was employed; and although the method is simple, contractors did not lay the sewer pipes as specified. Because the contractors had little prior experience in constructing sanitary sewers, no special attention was given to the slope of the sewer. Previously, these contractors had constructed only storm drains where slope was not as important. In addition, the contractor neglected to install a rubber gasket and did not perform the leak test before back filling. Consequently, groundwater infiltration and/or sedimentation within the sewers is inevitable. According to observations made at a number of manholes, the majority of the constructed sewers are now carrying primarily groundwater rather than sewage.

A jacking method, introduced into Taiwan by the Japanese, was also used during construction. This method had the advantage of not disturbing the above-ground traffic. However, other difficulties were associated with its use in the Shihlin project. Again, due to lack of understanding of the function of the sanitary sewer by the contractor and construction supervisor, the slope of the sewer after completion was not as specified during design. Sedimentation inside the pipe can be expected due to insufficient slope since the center line of the sewer was not always properly aligned, resulting in both vertical and horizontal crooks in the piping. A steel sleave seal is used when pipe is laid with this method. However, the seal was not made watertight, and infiltration of the groundwater or leakage of the sewage is probable.

Tunnelling was accomplished by using a mini-tunnelling machine imported from Great Britain. In the Shihlin project area, 1,800 meters of the sub-main was constructed by this method. However, according to field observations, the method failed badly since very little of the work done by this method was considered functionally acceptable as early as two years after completion. The only merit that could be found was that traffic was not interrupted during the sewer construction. TASED did not have its engineer study thoroughly all the engineering information about this method and did not send its engineer to Great Britain to observe the actual operation of the equipment. Furthermore, geologic and groundwater conditions in Shihlin proved to be quite different from those in London. Due to the carelessness of the contractor and the construction supervisor, the sewers constructed by tunnelling were found to be badly aligned, both vertically and horizontally. One section of the sewer was laid in such a way that the downstream end was higher than the upstream end. Because no screw was used to lock concrete arches in place and because of unexpected settling of the surrounding soil, connecting arches have either separated or occassionally collapsed entirely.

It has been universally admitted that the construction phase of this project was quite an ordeal for the Shihlin community. Traffic was severely disturbed, and interference with other services was widespread. Almost no available space was found under numerous streets due to utility pipelines and wire conduits. Coordination with the other utility agencies involved proved to be quite difficult, and the expense of moving obstructions

was extremely high. Due to general construction and dewatering practices, land subsidence occurred on occasion, and damage to some buildings and other structures resulted.

(4) House Connections

The final stage of the Shihlin model project was the connection of individual dwellings and buildings to the sewer system. The problems associated with this task were enormous. In the Shihlin project area, there were 13,500 sewerable dwellings; and with single unit garden houses, attached apartments and aggregate shops, old brick houses and shacks present, the types and distribution of these dwellings were very complicated. With the exception of a few newly developed areas, the majority of the city buildings were built so closely together and irregularly that space for house connections was limited. In some cases, a single connection was not possible due to the lack of available space and the presence of multiple household drainage systems. Frequently, a central, wet well was required to collect wastewaters from several nearby houses prior to connection to the sewer.

In almost all of the buildings in Shihlin, sullage was discharged into open ditches from an outlet underneath the ground floor or at the foot of the surrounding walls. The location of these discharge outlets was not consistent and depended upon the locations of the sanitary fixtures in the buildings. It was common for each building to have several outlets with different sizes and locations. These outlets had to be centralized before connection to the sewer system. In addition, some fifteen percent of the total buildings had roof drains which were not separated from the sanitary sewers, and separation of these two drainage systems was required before connection to the sewer. Twenty percent of the dwellings had insufficient or no sanitary facilities at all; some lacked washing sinks, and others used only pit privies. Such sanitary and drainage facilities had to be modified before connection could be made to the sewerage system. These modifications frequently required substantial damage to or complete replacement of the ground floor of the affected dwelling. The expenditures for the modifications were generally at the household's expense.

Construction of the house connections was to be carried out by the house owner with the assistance of the city government whose responsibility it was to contract the plumbers and to inspect the plumbing work after completion. However, it was feared that if the construction of house connections was left entirely to the initiative of individual house owners, few would connect in view of the high cost in time and money required. Therefore, the city adopted a policy of both persuasion and coercion. Financial subsidies were employed as well as the promulgation of a sanitary waste water disposal ordinance.

Implementation of the connection work was carried out in four stages:

(a) Demonstration stage

If an application for connection was filed within six months of the official announcement of the availability of sewerage

service, fifty percent of the expenditure would be subsidized by TASED. The subsidy could only be used to pay half of the total expenditures of constructing the connection between the building outlet and the sewer, and the total amount of the government subsidy could not exceed $39 per dwelling. A complete subsidy was provided to indigent households for house connections including the expenditures for any necessary improvements or alterations of the existing sanitary facilities in the dwelling.

(b) Self-motivated connection stage

If an application for connection were filed between six months and one year after the announcement of the availability of the sewerage system, TASED provided free of charge, engineering services including design, contracting, and final inspection of the works but did not provide any subsidy to the dwelling owner.

(c) Persuasion connection stage

One year after the announcement of the availability of the sewerage system, TASED would contact those house owners who had not yet filed their applications for connection. House owners would have to contract a licensed plumber for the design and construction, and the design had to be approved by TASED.

(d) Enforced connection stage

For those house owners who were not connected after the persuasion stage, TASED would require connection to the sewers using the "The Taipei Area Sewerage Construction Administration Ordinance."

The Shihlin sewerage system was officially announced ready for house connections in October, 1976. Table 3.8 shows the number of connections achieved during the period of late 1976 through 1977. Only twenty percent of the sewerable dwellings had completed connections to the new sewerage project fourteen months after it was completed.

Table 3.8

The Applications Submitted and Connections Completed in 1977 in the Shihlin Project Area

Item	Current Dwellings	Application Submitted	Percentage Submitting Application	Connection Completed	Percentage of Completion
Current Occupant	13,500	2,838	21	2,310	17.1
New Construction	1,135	1,132	99	799	70.4
Construction under plan	1,440	1,398	97	53	3.7

These statistics clearly indicate that TASED's connection program was not successful although considerable attention was given to this phase of the operation. Cooperation from the household owners was not good. The physical systems required for connection were too complicated, and when the expense of connecting was realized, the general public lost interest in the project.

Examination of those houses which were sewered reveals that they are primarily those buildings in which connection is easily accomplished, such as apartments and garden houses. In apartments, separate drainage systems were already in the building and only connection of the outlet from the septic tank to the sewerage system was required. The construction was easy and the expense relatively low. In the case of garden houses, plenty of space was available for connection and the owner normally could afford the extra expense. According to the sewerage ordinance, septic tanks were required in newly constructed houses only if household sewage was not to be removed by the sewerage system. The savings achieved by omitting the septic tank for newly constructed houses was far greater than the expenditures required for the house connection. Thus, these buildings were successfully sewered. Expenditures required for a normal four story apartment were approximately $10, and the expenditure required for a garden house range between US$1.40 and US$10.5. In those areas like Shihlin, where connection required breaking the floor slab to connect sewerage pipes in the rear of the building to the new outlet in front of the building, connections were very difficult and required expenditures normally in excess of US$15.0.

(5) Impact of the Shihlin Model Project

Although the Shihlin sewerage system has been completed for more than two years, the purposes for which it was built have not been achieved. People in the Shihlin area do not enjoy the benefits of a sewerage system.

On the other hand, they feel lucky that they have been able to recover from the disaster experienced during construction of the system. Wastewater continues to flow openly in the area and very little improvement in environmental sanitation was achieved when compared to the capital investment.

The project illustrates well the complications which can arise when implementing large sewerage projects in areas previously unfamiliar with such systems. Acceptance of the system is not assured, and special care must be taken to ensure the affordibility of the system for the intended user. Proper construction and operation are in doubt, and frequently adequate institutions do not exist for management.

CHAPTER IV

INDONESIA

Consisting of over 3,000 islands, the archipelagic nation of Indonesia forms the natural barrier between the Indian and Pacific oceans and extends from the mainland of Southeast Asia to Australia. The largest five islands are Sumatra, Java, Kalimantan, Sulawesi, and Irian Djaja. With an approximate population of 135 million, Indonesia is the fifth most populous nation in the wold. Nearly two-thirds of this population live on the islands of Java, Madura, and Bali. However, these islands represent only seven percent of Indonesia's total land area, and thus these islands are among the most densely populated land areas of the world. The many islands of Indonesia are characterized by highly varied landscapes. Physical features include gently rolling hills or mountains covered by thick forests or dense tropical vegetation, large areas of dry flat-lands and vast tidal swamps extending inland large distances. Indonesia's climate is tropical and marked by heavy rainfall, high humidity, and low winds. Average annual rainfall is 400 centimeters, and daily high and low temperatures range between 30^{o}C and 70^{o}C.

Indonesia contains large timber resources and rich deposits of petroleum, gas, tin, bauxite, copper, nickel, and iron ore. However, with a per capita GNP of $165 (1974), Indonesia's economy remains primarily agricultural. Sixty-one percent of the labor force is engaged in agriculture and eleven percent of the land is cultivated. Subsistence farming is the dominant form of agriculture. Six percent of the labor force is engaged in industry, with the major products being textiles, food and beverages, light manufacturers, cement, and fertilizer.

Indonesia 's population consists of diverse ethnic groups numbering over three hundred. However, the vast majority of the population is of Malay origin, and there are substantial groups of Indian and Chinese extraction. Approximately ninety percent of the population is Muslim, five percent is Christian, and three percent is Hindu. In spite of the rapidly growing urban population, the majority of the Indonesian population (82% according to the 1971 census) lives in rural areas. The literacy rate in Indonesia is estimated at forty percent, and a system of public education from primary to the university level is now being established.

Public health conditions in Indonesia are poor, and a wide range of tropical diseases is found throughout the islands. Malaria is most widespread, but tuberculosis is generally considered the greatest cause of death. Cholera, typhoid, dysentery, and parasitic diseases transmitted by water are endemic. Many cases of paratyphoid and infectious hepatitis have been reported in recent years from Java and Sumatra. In 1974, Indonesia had the highest reported number of cases of and deaths from cholera in the world. In addition, infant mortality and malnutrition, especially in the semi-urban

areas, is extremely high. 1/ The national figure for infant mortality is around 126 deaths per 1,000 live births, but in some of the slums of Jakarta and Surabaya this rises to nearly 200 deaths per 1,000 births, and around half of all children five years old or younger show signs of growth stunting and malnutrition. Population per physician is about 27,000 (1971) compared to 4,800 for India and 2,700 for the Phillippines.

Inadequate provisions for water supply and poor sanitation facilities undoubtedly aggravate health conditions in Indonesia. Among the urban population thirty-one percent are estimated to have access to piped water supply. The remainder of the population is served by wells and direct extraction from rivers, the purity of which is almost always in doubt. The urban population served by sewerage systems is very small. Only small portions of five cities in Indonesia (Banduny, Medan, Kosyakarta, Surakarta, and Surabaya) are sewered, and most of these have no sewage treatment facilities. Human wastes are mainly discharged into septic tanks, latrines, surface drainage ditches, or directly into streams and rivers and constitute a major health hazard especially through their affect on water supplies. In rural areas pit latrines are prevalent; water-seal latrines are a common variation of the pit latrine throughout rural Indonesia. Where fish ponds are abundant, people prefer to use them as the receiver for human excreta and consequently build latrines directly over these ponds. Water is supplied to the rural population entirely from well systems and direct withdrawal from bodies of surface water.

In response partly to the desperately poor sanitary conditions and inadequate water supply and partly to the general lack of housing and infrastructure, the Government of Indonesia has instituted its Kampung Improvement Program (KIP) to address these problems in the poorest portion Indonesia's urban areas. The program was inaugurated in the First Five-Year Development Plan (1969-1974) to improve the physical infrastructure of some of the worst kampungs in Jakarta. In the Second Five-Year Development Plan (1974-79), the program was expanded to include a number of other large urban areas. The program attempts to deal with the minimum infrastructure needs of large numbers of urban poor at a reasonable cost. The KIP attempts to spread limited investment funds over a large number of people by upgrading community infrastructure in low-income areas thereby encouraging the residents themselves to upgrade their dwellings as improvements are made in their environment. Projects undertaken by this program include the provision of water supply and waste disposal services and the construction of drainage systems, streets, and better housing.

A. COMMUNITY SELECTION

Two kampungs in Jakarta, Kayu Awet and Manggarai Barat, and two kampungs in Surabaya, Tambaksari and Darma, were chosen for investigation

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1/ World Bank Report No. 1184a-IND, Indonesia: Appraisal of the Second Urban Development Project, Sept. 24, 1976.

in this chapter. These communities represent typical sanitation patterns for Indonesian urban areas. In addition, in order to present rural sanitation practices, particularly fish pond latrines, a rural community in West Java, Ciputut, was included.

Jakarta is the largest city and capital of Indonesia. With a 1976 population of close to six million and annual average per capita GNP of about $160 (1971), the city is one of the largest and poorest in the world. Physically the city spreads over 560 square kilometers. The urbanized area of Jakarta was approximately 12,000 hectares in 1969 and is estimated to have grown to about 17,000 hectares by 1976. Based on census figures, the rate of growth for Jakarta was 4.6 percent per annum between 1961 and 1971, 2.1 percent due to natural increase and 2.5 percent due to migration. The Jakarta City Government (DKI) has estimated that the present rate of population growth is even higher, 5.7 percent per year.

While the disparity between income levels in Jakarta and surrounding rural areas is substantial and provides sufficient motivation for migration to Jakarta by rural residents, the urban setting awaiting recent immigrants is appalling. The existing housing and infrastructure is grossly inadequate. The poorest residents of the city generally live in outer kampungs without surfaced roads and footpaths, along the railway lines of the inner city, and around the main markets. Many of them are recent migrants and live in tents and shacks alongside the more permanent homes of earlier settlers. A 1969 survey of Jakarta housing conditions demonstrated the poor quality of Jakarta's housing: sixty-five percent had no private toilet facilities, eighty percent had no electricity, and ninety percent had no piped water. Permanent houses with solid walls, cement floors, and tile roofs constituted twenty-four percent of the total housing stock; temporary houses of bamboo matting walls, earthen floors, and thatch roofs comprised forty-four percent; and semi-permanent structures having some combination of temporary and permanent materials accounted for the balance (32%).

Kampungs Kayu Awet and Manggarai Barat are typical examples of the poorer, but not necessarily poorest, kampungs of Jakarta. Both have been improved under the Kampung Improvement Program. In Kaga Awet most of the inhabitants use individual latrines, including many with water seals, and are relatively better off than those in Manggarai Barat. In Manggarai Barat most people use public baths and communal latrines with septic tanks.

Surabaya is the second largest city in Indonesia and the major port for East Java, Madura and South Kalimantan. In recent years Surabaya's status as a port and commercial city has grown substantially, and as a consequence its population has grown from a over 1,000,000 in 1961 to approximately 1.7 million permanent and over 400,000 temporary residents in 1975. This is a rate of growth of approximately 4.5 percent per year. Many of the migrants have clustered in the center of the city, exacerbating the pressure on the already over-strained system of municipal services, especially water supply.

Surabaya's population of approximately 2.1 million is concentrated in the eleven old kecamatans (sub-districts) that formed the city before an expansion of its boundaries in 1965. The recent expansion of its population has involved the annexation of five rural kecamatans that effectively tripled the area of the city. The old area holds eighty-five percent of the population although it comprises only twenty-three percent of the area of the present city. Only nine kelurahans (localities) have a population density of over 400 persons per hectare and six more have densities of over 300 persons per hectare. However, in individual kampungs within the central area which serve as the receiving ground for temporary migrants especially from East Java and Madura, the density is much greater, up to 1,000 persons per hectare.

The physical infrastructure of the city is inadequate for its rapidly expanding population. The piped water system presently serves only about twenty-two percent of the population. In the new kecamatans piped water is rarely available. Approximately forty-five percent of the population is supplied by water carriers with thirty-three percent served by private shallow wells. As in Jakarta, Surabaya has no city-wide municipal sewerage system and only about one-half of the population is served by public or private septic tanks (although they are legally required). Almost all of the remaining population uses rivers or fish ponds. The Kampung Improvement Program has been expanded to include the city of Surabaya. However, the program has been limited in scope mostly to isolated road construction or drainage projects.

Kampungs Tambaksani and Darma represent significantly different community income levels in Surabaya. Tambaksani is a relatively low income area. Water is supplied by public hydrants, and sanitation facilities are public or private latrines. Private latrines are either simple pit privies or water seal latrines. Darma is a high income area, water supply is provided by house connection, and flush toilets and septic tank systems are found in many homes.

This chapter is based on community studies conducted for the World Bank during the period of September 1977 to March 1978 by the principal investigator Mrs. S. S. Soesanto, by Dr. B. A. Kawangian and by the research team of Mr. I. B. I. Gotama and Mrs. A. Lubis, health controlers; Mr. Soenarjo, economist; and Mrs. S. S. Santoso, sociologist. All personnel are from the Health Ecology Research Centre of the Indonesian National Institute of Health, Research and Development. The research team selected thirty households from each community upon which data collection efforts were concentrated. The following community discussions are based on information obtained from these selected households.

B. ASSUMPTIONS

A number of assumptions have been made for data analysis. The opportunity cost of capital was taken at twenty percent. To convert these figures into U.S. dollars, the exchange rate of 415 rupiahs/US$ was used.

C. COMMUNITY RESULTS: KAYU AWET

Kampung Kayu Awet is located in central Jakarta and has a population of 404. There are forty-six households, with an average of 8.8 individuals, and the Kampung has a population density of 40,726 persons per square kilometer.

Thirty-three percent of the houses are of permanent brick construction, while the remaining sixty-seven percent are of semi-permanent brick, bamboo, and wood construction with earthen floors. The estimated lifetime is ten to forty years for the more permanently constructed homes and four years for the semi-permanent construction. The survey of thirty selected households indicated that twenty-seven percent of household wage earners were employed by the Government or army, thirteen percent had a trade or commercial occupation, and thirty-three percent were in various other occupations. The remaining twenty-seven percent were unemployed or retired. Forty percent of the population is under fifteen years of age. No seasonal employment exists for this community, and no skilled laborers live within the communities. However, skilled laborers are readily available from surrounding areas. The literacy rate is estimated to be forty-six percent for adult males and thirty-eight percent for adult females. Sixty-one percent of the children between the ages of seven and fifteen attend school. The weather conditions experienced in Kayu Awet are similar to those of the larger Jakarta metropolitan area. Average monthly rainfall is 16.5 centimeters, and the lowest monthly rainfall occurs in July, averaging 3.5 centimeters. Temperature is relatively constant in Jakarta with a mean monthly average of 27^{o}C.

(1) Water Supply

Water is supplied to the households of Kayu Awet by shallow dug or drilled wells and public standposts. There are no individual household connections to the public water supply system. Of the thirty households surveyed, twenty-eight (93%) use ground water for all purposes, while two households use groundwater only for bathing and washing and buy city water from vendors for drinking and cooking. Sixteen households have drilled, pumped wells, one of which has an electric pump. The fourteen remaining households use dug wells with buckets which are sometimes connected to windlasses. The dug wells range in depth between six and fourteen meters, and depending on the season of the year and location of the well, the depth to the water table varies between two and thirteen meters. The diameter of the typical dug well is approximately one meter, and the interior wall (casing) is made of brick and cement or concrete pipe. This casing rarely extends below three meters from ground surface; the remaining depth is unsupported. The drilled, shallow wells are also of simple construction with a characteristic depth of between eleven and fourteen meters.

During the rainy season average per capita consumption of water from the dug wells is estimated at 57.3 liters per day, and per capita consumption of water from the drilled, pumped wells is 75.3 liters per day. During the dry season, the water level in these wells is substantially lowered, and withdrawals are reduced to thirty percent of the normal consumption from dug wells and to fifty percent of normal consumption from drilled wells. These reduced discharges are not considered adequate, and, when surveyed, forty-seven percent of the households responded that they had water supply problems. Annuitized capital and annual cost, including labor, for the dug well system is estimated at $16.7, while for the shallow pumped well the cost is $38.0.

(2) Sanitation

There is no sewerage system in Kayu Awet. Sixty percent of the households use pit latrines, thirty-three percent use water seal latrines discharging into pits, and seven percent use water seal latrines which discharge directly into the large, waste water gutter running through the community. A few latrine pits are lined with brick, but most are unlined. The upper portion of the wall is usually made impermeable to water. The superstructure of the latrine is made of wood or brick with a tile or metal roof, and the seat is either a porcelain bowl or made of brick. Dimensions of the pit are approximately one by one by three meters; and when the pit is filled, a new one is dug. A new pit is required every three to four years. This practice can be sustained since most houses have ample space. When surveyed, only ten percent of the households felt that there was a healthier way to dispose of waste. Their primary concern was for a more adequate separation between latrine and water supply. Forty-seven percent felt there was no better method of disposal. The remaining thirty-three percent had no opinion. Costs for waste disposal in Kayu Awet are presented below in Table 4.1.

Table 4.1

Annual Household Costs for Sanitation in Kayu Awet
(1978 US$)

	Water Seal Latrine	Pit Privy
Capital	17.0	5.1
Operation-Maintenance	3.6	-
Inc. Water	2.7	-
Total	23.3	5.1

(3) Public Health

Although no empirical evidence is available, contamination of well water is considered highly probable and likely to result in increased mortality and morbidity. The only health statistics available for the Kampung Kayu Awet are taken from a nearby health center which serves a much larger population of approximately 36,330. The statistics indicate a crude birth rate of twenty per thousand and a crude death rate of five per thousand. 1/ These

1/ These and many of the subsequently quoted crude birth and death rates for the Indonesian communities are significantly below international rates and should be used with caution.

rates are relatively low when compared to the national CBR of forty-five per thousand and CDR of twenty per thousand. The ten most prevalent diseases treated at the health clinic are presented in Table 4.2. Although the reported incidence of enteritis and other diarrheal diseases is relatively low, a much higher incidence rate must be expected since many cases undoubtedly go unreported.

Table 4.2

Ten Most Prevalent Diseases from April to September 1977 and the Proportional Rate at the Johar Baru II Health Center

Diseases	Total	Prop rate
1. Influenza	1221	26.9%
2. Acute respiratory infections	925	20.4%
3. Skin infections and other skin diseases	679	15.0%
4. Bronchitis	459	10.1%
5. Enteritis and other diarrheal diseases	173	3.8%
6. Diseases of the nervous system	162	3.6%
7. Other diseases of digestive system	128	2.8%
8. Tuberculosis	104	2.3%
9. Conjunctivitis	89	2.0%
10. Avitaminosis	84	1.9%
11. Others	515	11.2%

D. COMMUNITY RESULTS: MANGGARAI BARAT

Manggarai Barat is located in south Jakarta and has a population of 262. Economically, the population of Manggarai Barat is less advantaged than that of Kayu Awet. Only twenty percent of the housing can be considered permanent; the remaining eighty percent is of semi-permanent construction. Twenty housing units are converted warehouse space which has been subdivided into individual housing units. The population density of Kampung Manggarai Barat is 49,600 persons per square kilometer. The forty households in the Kampung average 6.6 persons per household. The population growth rate for the community is 5.3 percent, and forty-seven percent of the population is under the age of fifteen. Of the surveyed population (30 households), thirty-three percent are employed by the government or the army, thirteen percent are in trade or commerce, seventeen percent are in miscellaneous other non-laboring occupations, and thirty-seven percent are unemployed or retired. The reported literacy rate is eighty percent for men and seventy-seven percent for women. Seventy-three percent of the children between the ages of seven and fifteen attend school. Weather conditions experienced in the community correspond with those of the larger Jakarta metropolitan area (see previous community).

(1) Water Supply

All of the water is supplied in Manggari Barat by shallow wells. Eighty-three percent of the households use shallow, drilled wells with hand pumps, while the remaining seventeen percent use a single, communal dug well.

Only twenty-four of those households using pumped wells have their own individual well. The remaining households share a shallow pumped well, usually among several households. During the rainy season average consumption of water from the pumped, shallow wells is sixty-three liters per capita per day. During the dry season consumption is curtailed to sixty percent of the rainy season amount. Rainy season consumption from the dug well is fifty-three liters per capita per day and drops to fifty percent of that amount during the dry season. Depth to water table ranges between two and three meters during the rainy season and between fourteen and seventeen meters during the dry season. There is no available quantitative information concerning water quality, but it has been qualitatively described as slightly discolored but with no taste or odor.

The one communal dug well is 18 meters deep and 1.5 meters in diameter. There is a casing made of brick extending 2.5 meters below the surface of the platform. Water withdrawal is accomplished through use of a bucket. Annual cost per household including amortized labor and material expenses is estimated to be $2.89.

The drilled wells in this community extend to depths of sixteen to twenty-four meters, and hand pumps are used for water withdrawal. Annuitized capital and annual maintenance cost per household for these systems is estimated at $16.16.

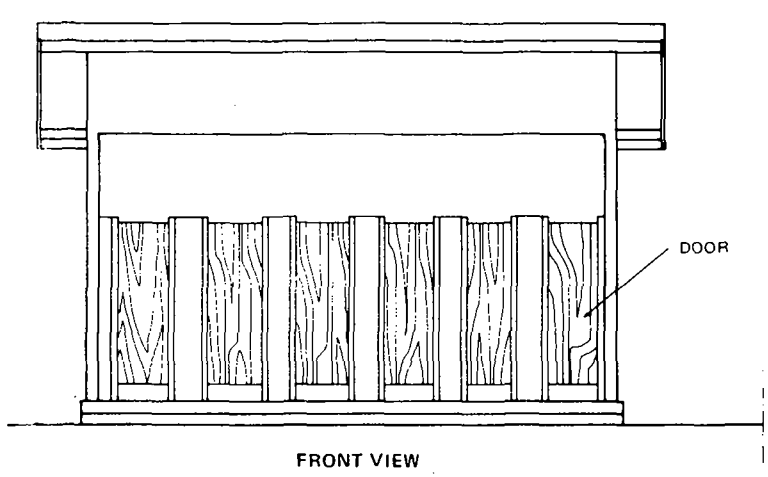
When surveyed, fifty percent of the households stated that they had water supply problems. Problems cited include turbid water from the dug well, loss of time while waiting in the queue to obtain water, and disputes among neighbors over water supply. Seven of the thirty households queried stated that they would like taps in their own house, eleven would like shallow, pumped wells, and twelve had no specific requests. In general, the inhabitants of this community are willing to contribute for the improvement of community water supply; eighty percent of the wealthier households are willing to contribute money.

(2) Sanitation

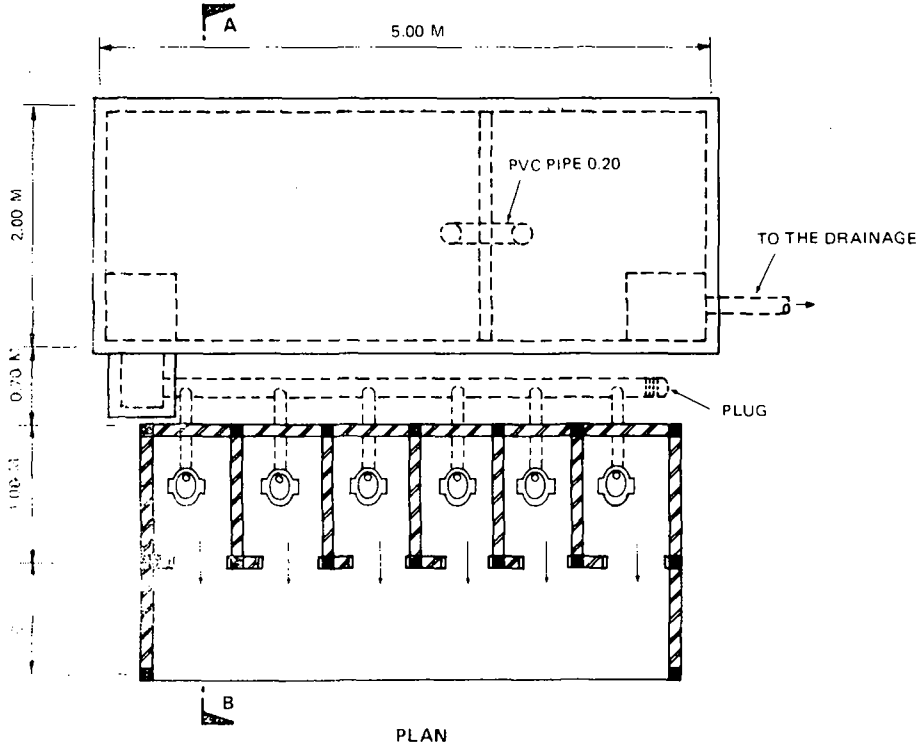
Ninety-three percent of the households surveyed use the one communal latrine (Figure 4.1). This latrine with septic tank was built under the Kampung Improvement Program. The latrine unit contains six toilet stalls, and bathing and washing facilities. The bathing and washing facilities have rarely been used due to a shortage of water. The source of water is a shallow pumped well. Excreta is flushed into a septic tank which in turn is connected to a large drainage field. Due to heavy use, the tank requires desluding once a year. Vacuum trucks are operated by the local government of Jakarta for this purpose.

Coordination and supervision of the operation and maintenance of the public latrine is the responsibility of the head of the neighborhood organization, and a local individual is employed by the neighborhood community to clean and maintain the latrine. To meet this cost and to pay for the yearly desludging, each household using the facility pays $.24 a month. This payment also provides funds for maintenance of the communal well.

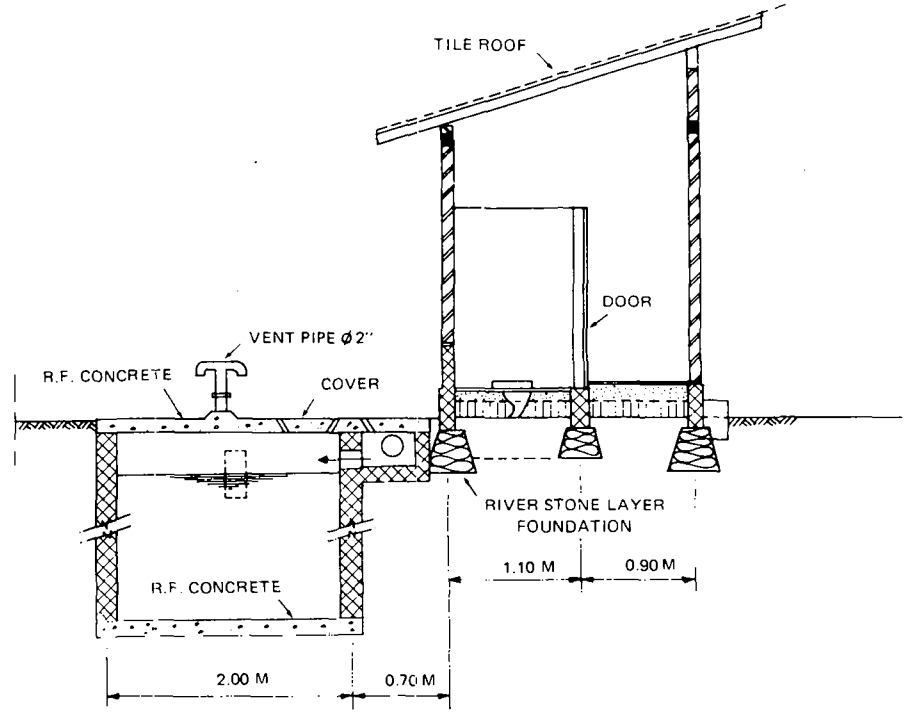
FIGURE 4.1
COMMUNAL LATRINE WITH SEPTIC TANK IN INDONESIA



FRONT VIEW



PLAN



CROSS SECTION A–B

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The remaining seven percent of the households use private water sealed latrines. These latrines are usually attached to the house. Locally made bowls and slabs are used. The pits are lined with brick and manually desludged every two to three years.

Seventeen percent of the households surveyed felt that a better way of disposing of their human waste was desirable. Improvements suggested included the installation of private latrines and an increase in the number of public latrines. However, implementation of these suggestions would be difficult since space is severely limited in this community.

Disposal of household wastewater is accomplished through direct discharge into the gutter built under the Kampung Improvement Program. This gutter also serves as drainage for storm water. Refuse is removed from the community by the vegetable vendor who charges each household $.12 for each collection. Collection occurs every three to five days.

Costs are presented below in Table 4.3 for the communal latrines:

Table 4.3

Annual Cost of Communal Latrine in Manggarai Barat
(1978 US$)

Capital Cost	1,074.0
O & M	45.8
Water	361.4
Total	1,481.2
Per capita cost	2.5
Per household cost (6.6 persons/household)	16.5

(3) Public Health

Limited public health statistics are available for this community, but they are derived from a health center servicing a much larger population. The crude birth rate for the population serviced by the health center is 25.4 per 1000 and the crude death rate is 3.3 per 1000. These are relatively low compared to the national CBR of 45 per 1000 and CDR of 20 per 1000.

All other available health statistics are presented in Table 4.4.

Table 4.4

Five Most Prevalent Diseases from January 1974 to September 1977 at the Manggarai Health Center

Diseases	1974		1975		1976		1977	
	Total	rate %	Total	rate %	Total	rate %	Total	rate %
1. Influenza	679	27.9	2904	40.6	4520	43.4	300	6.3
2. Skin infection	565	23.2	1513	21.1	1350	12.9	2400	50.4
3. Dysentery/ diarrheal diseases	434	17.8	807	11.3	1110	10.6	900	18.9
4. Bronchitis/asthma	552	22.7	815	11.4	1860	17.8	580	12.2
5. Anemia	203	8.4	1115	15.6	1590	15.3	580	12.2
	2433	100.%	7154	100.%	10430	100.%	4760	100.%

E. COMMUNITY RESULTS: CIPUTAT

Ciputat is situated in a rural location near the border of Jakarta and West Java. The total population of the Kampung is 614 inhabitants, and the population density is 516 persons per square kilometer. Average household size is 6.1 persons, and forty-six percent of the population is under the age of fifteen. The population is employed primarily in rural occupations. Ten percent of the homes are of permanent brick construction. Most homes are built of bamboo and wood with relatively little brick included. Adult male and female literacy rates are forty-seven percent and forty-four percent, respectively.

(1) Water Supply

The inhabitants of Ciputat depend on ground water for all their household purposes, and either dug wells or shallow pumped wells are used for extraction. Ninety-seven percent of the households use dug wells, and of those, eighty-seven percent have their own private well. One household (3%) has it own shallow, pumped well. Those households without wells must either use a neighbor's well or take water from the one hundred year old dug well located at the community musholla (small mosque). The capacity of all wells is influenced greatly by the season. Average daily water consumption from a dug well is 60.3 liters per capita, and during the dry season consumption drops to sixty percent of normal. Average per capita daily water consumption from the pumped shallow well is seventy-five liters, and during the dry season consumption drops to seventy-five percent of normal. Construction of dug wells is similar to that of the dug wells found in Kayu Awet and Manggarai Barat. Depth to water table ranges between three to four meters in the rainy season and between five to twelve meters in the dry season.

When surveyed, the majority of the people of Ciputat (67%) stated that they had no water supply problems. This is due to the availability of

the old dug well in the musholla. However, ninety-three percent of the inhabitants stated that they were willing to contribute to an improvement of the community water supply. When queried about the expense in terms of time, labor, and money of the current water supply, fifty-three percent responded that they found it low, forty-seven percent found it reasonable, and no one found the expense associated with water supply high.

(2) Sanitation

There are two methods used for excreta disposal in Ciputat: pit privies and fish pond latrines. Eighty-seven percent of households use fish pond latrines, while the remaining thirteen percent use pit privies. Fish pond latrines are the preferred method of waste disposal. Those households which use pit privies do so ususally because they are located at an inconvenient distance from a fish pond. The ponds are generally ten to one hundred meters from the households which use them.

Fish pond latrines have recieved wide acceptance because they provide to the people of Ciputat both a practical method of excreta disposal and an economic means of increasing fish production. The area of the ponds ranges between 200 and 1000 square meters; depth ranges from 1.5 to 2 meters. The latrines are built by the owner of the pond. One latrine usually serves 2 to 5 families, and there may be several latrines built on a single pond. The structure is made of wood or bamboo, and the platform is generally constructed 1.5 to 2 meters above the water surface. The floor is made of wood or bamboo with an area of one by one meter. The latrine is built approximately two meters from the bank, and a small bridge is built for access. Goldfish, tawes, and fresh water carp are grown in these ponds. Harvesting occurs once or twice a year. The latrines are not used three days prior to harvesting so that the job will not be so unpleasant. Also, once a year the sediment is removed from the bottom of the pond. Use of fish pond latrines have proven to increase significantly the production of fish and thereby warrants the capital expenses and labor associated with the practice.

The pit privies used by those with no convenient access to the fish pond latrines are very simple. The pits are unlined and have the approximate dimensions of 1 x 1 x 2.5 meters, and the slab is made of bamboo. Maintenance of the latrines are poor, and consequently they are not sanitary. The pits fill in three to five years and are then simply covered with soil. Space is ample, and a new pit is dug.

Disposal of wastewater is rudimentary. Normally, people throw water into cesspools or the nearest creek. When soakage pits are used, they are left uncovered and create open breeding places for mosquitoes. Frequently soakage pits are located in close proximity to the household well, and contamination of water supply may result. If the house is near a creek or river, a gutter may be dug to provide drainage into these water courses. However, the gutters are not lined or covered.

(3) Public Health

Limited health data from a nearby health center show crude birth rates and death rates of sixty-seven and forty per thousand, respectively. These are relatively high when compared to the national average of forty-five and twenty per thousand for CBR and CDR, respectively. The eight most prevalent diseases for the health center serving Ciputat are presented in Table 4.5.

Table 4.5

Eight Most Prevalent Diseases
During 1976 and 1978 in Ciputat Health Center

Diseases	1976		1977	
	Total	Prop. Rate %	Total	Prop. Rate %
1. Influenza	912	20.09	1570	25.25
2. Skin infection	1182	26.04	1078	17.34
3. Bronchitis	567	12.49	856	13.77
4. Enteritis/diarrheal diseases	743	16.37	864	13.90
5. Anaemia	387	8.52	449	7.22
6. Tuberculosis	360	7.93	533	8.57
7. Alergy	214	4.71	501	8.05
8. Eye infection	175	3.85	367	5.90
	4540	100%	6218	100%

F. COMMUNITY RESULTS: TAMBAKSARI

Kampung Tambaksari is located within the Surabaya metropolitan area and has a population of 1,739. There are 266 households with an average of 6.5 individuals per household. The population density is 58,160 persons per square kilometer. It is a relatively low income and congested community. Forty-seven percent of all homes are of permanent brick construction, while the remaining fifty three percent are of a less permanent construction, utilizing bricks in conjunction with bamboo and wood. The population of the community is employed in widely differing occupations, with thirteen percent employed in the government or army, thirty-seven percent in trade or commerce, thirteen percent as Becak drivers, seven percent as mechanics,

and twenty-seven percent in miscellaneous other occupations. The remaining three percent are retired or unemployed. The literacy rate is estimated for men at eighty-five percent and for women at seventy-eight percent. Forty percent of the children between the ages of seven and fifteen years attend school. Annual rainfall averages one hundred centimeters in the Surabaya area, and mean monthly temperature varies little with an average of 28°C.

(1) Water Supply

Water is supplied to the population of Tambaksari by a public hydrants, shallow pumped wells, and dug wells. All households have access to multiple sources of water. Due to the previous use of this area as a cemetery, households use water taken from local wells only for domestic purposes such as cleaning and washing. Only city water is used for drinking and cooking, and it is generally boiled before use. Prior to September 1977, a member of the community personally invested in the installation of a public hydrant. In order to recover his capital costs, this individual is authorized to sell water to the population of the community. The hydrant is located centrally within the Kampung, and water is sold from the hydrant directly or through vendors to the community. The flow of the hydrant is very low; and to overcome this problem, an electric pump has been installed. To improve water distribution, a reservioir with a three cubic meter capacity has also been installed. With an average daily discharge of eleven cubic meters, this hydrant serves approximately 4,500 people (2.4 lcd). Water is sold by the owner of the standpost to consumers for $.024 per forty liters ($0.60 per cubic meter). The owner, in turn, pays the local government enterprise $.096 per cubic meter. Capital costs for the system are $1,927.

For their second source of water, households use either dug or pumped shallow wells. Of the thirty households surveyed, only one was found to use a pumped well; the remaining twenty-nine used dug wells which average, one meter in diameter and three to eight meters in depth. A brick and cement or concrete casing is installed to a depth of no more than three meters, and water is drawn by rope and bucket. Water level in the wells varies with the season. During the rainy season the depth to water varies between one and four meters; while in the dry season, the depth varies between two and seven meters. The water from these wells is reported to be clear with no taste or odor. During the rainy season, water consumption from the dug wells is 62.5 liters per capita per day. During the dry season, consumption drops to fifty percent of rainy season consumption.

Of the thirty household surveyed as to water supply needs, eleven households stated that they would prefer a public tap, one household wanted a house connection, and eighteen would state no preference.

(2) Sanitation

The people of Tambaksari use either public or individually owned latrines for excreta disposal. Twenty-three percent of the households surveyed used the public latrine, while seventy-seven percent use private household latrines.

Household latrines are of two types: pit privies (74%) and water sealed latrines (26%). The pits are approximately two meters deep and one square meter in area. The pits are lined with brick or a wicker work of bamboo. Depending upon the wealth of the owner, this lining wall may extend the entire depth of the pit or support only the upper portion of the pit. In most cases, the pit is directly covered by a concrete slab upon which a superstructure is built. Some slabs are laterally displaced and connected to the pit with clay or concrete pipes, thus requiring some degree of water flushing, but there is no water seal present (Figure 4.2). The height of the superstructure is usually between 2 and 2.5 meters. The walls are made of metal, wood, or wicker work of bamboo, and there may or may not be a tile or metal sheet roof. Depending on the size and number of users, the pit usually fills within two or three years. Sludge is then manually removed using bucket and rope. Odor is a problem with these pit privies.

Water seal latrines are constructed much in the same fashion as the pit privy (Figure 4.2). The water seal effectively eliminates much of the odor and prevents insects from entering the pit. Consequently, many of the water sealed latrines are attached directly to the house. The pit normally needs to be emptied every two or three years.

A public latrine was built in this community in 1972 and is used by those people who live close by and do not have their own latrine. A fee of $.01 is charged for each use. The number of users far exceeds the actual capacity, and cleanliness is consequently a problem. On occasion sludge overflows from the receiving tank due to excessive use. One member of the community is assigned to clean the latrine every day, but odor is still a problem and is noisome to those who live nearby.

The public latrine flushes into a septic tank system. Water is supplied from a nearby dug well and stored in a tank adjacent to the latrine. The septic tank requires desludging every two years. However, a vacuum truck cannot enter the alley to empty the tank.

When the surveyed population was asked if they felt there was a better or healthier way to dispose of human excreta, only one household replied affirmatively, suggesting an improved public latrine for use by the lower income households. Twenty households responded that there was no better method of disposal, and nine households offered no opinion.

Costs for the communal and water seal latrine are presented below in Table 4.6.

FIGURE 4.2
POUR FLUSH OFF-SET PIT LATRINE AND WATER-SEAL LATRINE

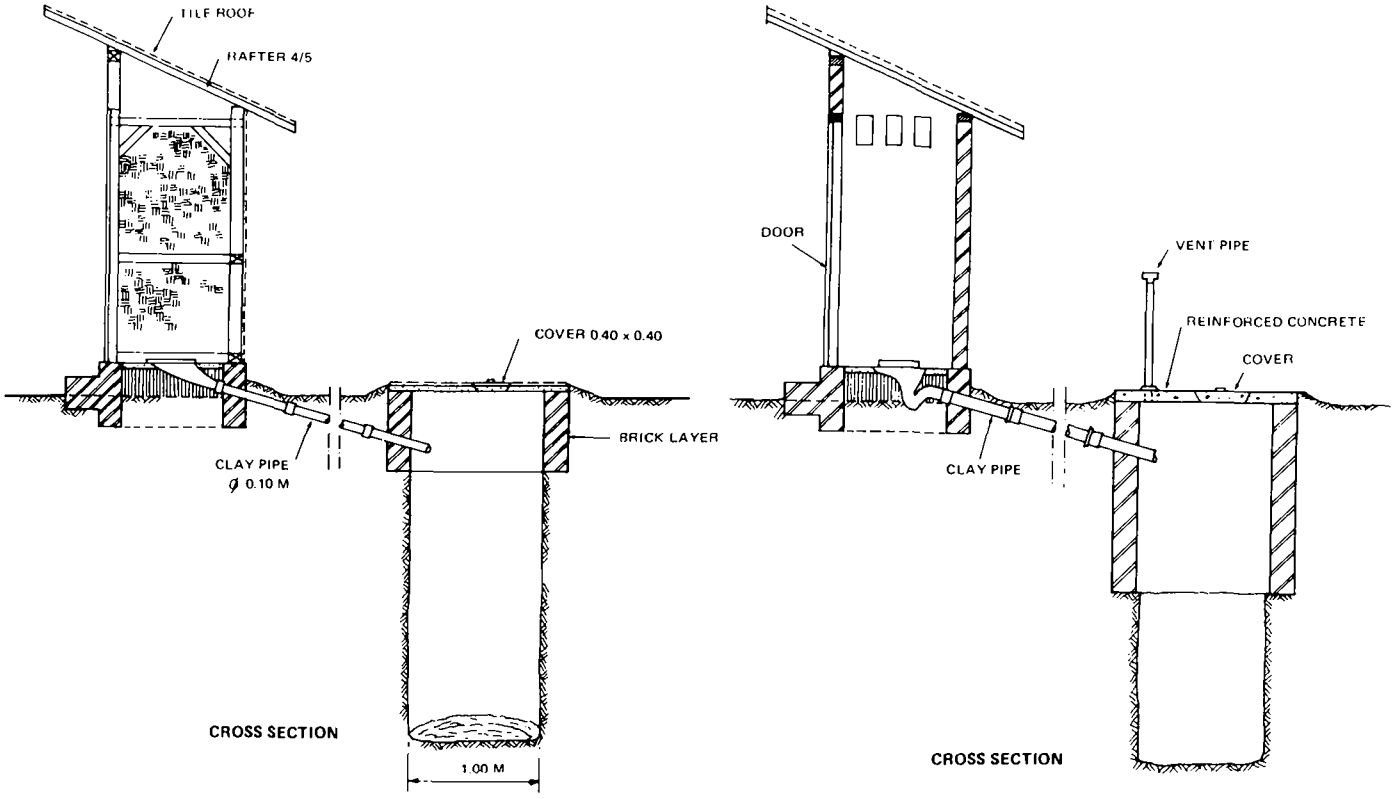

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Table 4.6

Annual Cost of Waste Disposal Tambaksari
(1978 US$)

	Water Seal Latrine	Communal Septic Tank
Capital	17.3	346.4
O & M	2.4	36.1
Inc. Water	3.2	26.4
Total	22.9	408.9
Cost per Capita	3.5	8.2

Public Health

The only health statistics available are for the entire city of Surabaya. They are presented below in Table 4.7 and 4.8.

Table 4.7

Ten Most Prevalent Diseases Among Polyclinic Patients in Surabaya
1976/1977

No.	Diseases	Total New Patients	Percentage
1.	Influenza	47,714	13.75
2.	Enteritis and diarrheal diseases	32,442	9.35
3.	Other skin infections	31,129	8.97
4.	Skin infections, cellulitis etc.	28,755	8.28
5.	Acute nasopharingitis	28,113	8.10
6.	Other respiratory diseases	24,755	7.13
7.	Bronchitis	18,796	5.42
8.	Pharingitis and acute tonsilitis, hypertropia at tonsil and adenoid	18,640	5.37
9.	Arthritis and rheumatism, except polyarthritis	16,013	4.61
10.	Eye infections	11,173	3.22
11.	Other diseases	89,574	25.81
		347,104	100.00%

Table 4.8

Major Causes of Death in Surabaya 1976

No.	Causes of Death	Total	Percentage
1.	Pneumonia	2,282	20.4
2.	Senility without mention of psychosis ill defined and unknown causes	2,141	19.1
3.	Birth injuries post natal asphyxia atelectusis	991	8.8
4.	Rheumatic fever	581	5.2
5.	Bronchitis	279	5.2
6.	Other diseases peculiar to early infancy and immaturity unqualified	500	4.4
7.	Cirrhosis of liver	431	4.1
8.	Gastritis, duodenitis, enteritis, colitis except diarrhea of the new born.	400	3.5
9.	Tuberculosis of respiratory system	382	3.4
10.	Nephritis and nephrosis	223	2.0
11.	Other diseases	2,679	23.9
		11,189	100.0%

Source of data: Division of CDC
Municipal Health Service, Surabaya.

G. COMMUNITY RESULTS: DARMO

Kampung Darmo is an elite, high income area of Surabaya. The total population is 1,503, and the population density is 9,108 persons per square kilometer. There are 300 households in the community with an average household size of 5.0 individuals. Many of the wage earners are employed in high income jobs: thirty-seven percent in the army or government; ten percent in trade and commerce; thirty percent in miscellaneous other professions; and the remaining twenty-three percent are retired or unemployed. The housing of Darmo is generally well spaced and soundly constructed. Seventy-seven percent are of permanent brick construction. Thirty-two percent of the population are under eighteen years of age. The literacy rate for men is eighty-five percent and for women seventy-eight percent. Eighty-four percent of the children under sixteen years of age attend school. Weather conditions are identical to those of Tambaksari.

(1) Water Supply

Most households, have individual or shared house connections which are used for all their water needs. Of the thirty households surveyed, forty percent have house connections which are solely used by the household; seventeen percent have house connections but must share with neighbors; and thirteen percent get water for cooking and drinking from a neighbor's house

connection but otherwise take water from a private dug well. However, there are low income households in the community which must take water from dug wells or buy it from vendors. Of the remaining thirty percent of the surveyed population which have no access to city water through house connections, seventeen percent take water from dug wells for all purposes, while thirteen percent use dug wells only for washing and cleaning water and buy water from vendors for drinking and cooking.

Water consumption in this community is relatively constant. For those with access to house connections, average daily per capita consumption is 194 liters. For those low income households which must depend on dug wells, daily per capita consumption averages 59.6 liters. Due to infiltration from a nearby river, the water levels in the dug wells of this community fluctuate to a much smaller extent than in the wells of the other urban communities studied. Consequently, the average consumption from these wells only decreases to seventy-five percent of normal during the dry season.

Construction of dug wells in Darmo is similar to that found in the other communities studied. The wells are of three to four meters in depth and approximately one meter in diameter. Depth to water table is 1.5 to 2 meters. The wells are partly lined with brick and cement or concrete pipe to a depth of one meter. Buckets are used to withdraw the water which is usually turbid but which has no taste and odor.

Among both income groups in Darmo, there is little perceived problem with water supply. Among those with house connections, there are no problems unless the system fails. Water pressure is usually adequate. Those that use dug wells seem to be satisfied since water levels are relatively unaffected by periods of drought. When asked if they thought their water supply was expensive, eighty-seven percent felt the expense was low, while thirteen percent (low income households) found the expense "fair". All but the poorer thirteen percent are willing to contribute to water supply improvement.

The water tariff for the city water supply system is presented below in Table 4.9.

Table 4.9

Household Water Tariff in Surabaya

Class I and II street	$.07 per cubic meter
Class III and IV street	.06 per cubic meter
Class V street	.05 per cubic meter

minimum usage of five cubic meters applied

(2) Sanitation

Depending on the level of household income, several different methods of excreta disposal are employed. The higher income households use either, flush toilets or pit privies. The lower income group who live

along the local river use latrines which are built out into the river on stilts. Fifty-seven percent of those surveyed use flush toilets, seven percent use pit privies, and thirty-six percent use on overhanging latrine.

High income households with water seal toilets have water closets and bathrooms in the main household building. The water seal bowl flushes into a septic tank with dimensions of one by one by three meters (Figure 4.3). These tanks are made of a water tight brick or concrete and are covered and vented. Internally, the tanks are separated into two separate compartments connected by a single length of PVC pipe, and tank effluent drains directly into community drainage channels. The tanks require emptying every three to five years. If the houses are located on a major street, this can be accomplished through the use of a vacuum truck. Otherwise, a laborer must be hired to empty the tank manually and dump the sludge in the nearby river.

The overhanging latrine built by lower income groups stands out in the river on four columns. The areal dimension of the latrines is approximately one square meter. These platforms have wooden walls but are commonly without roofing.

Costs for septic tank systems are presented below in Table 4.10.

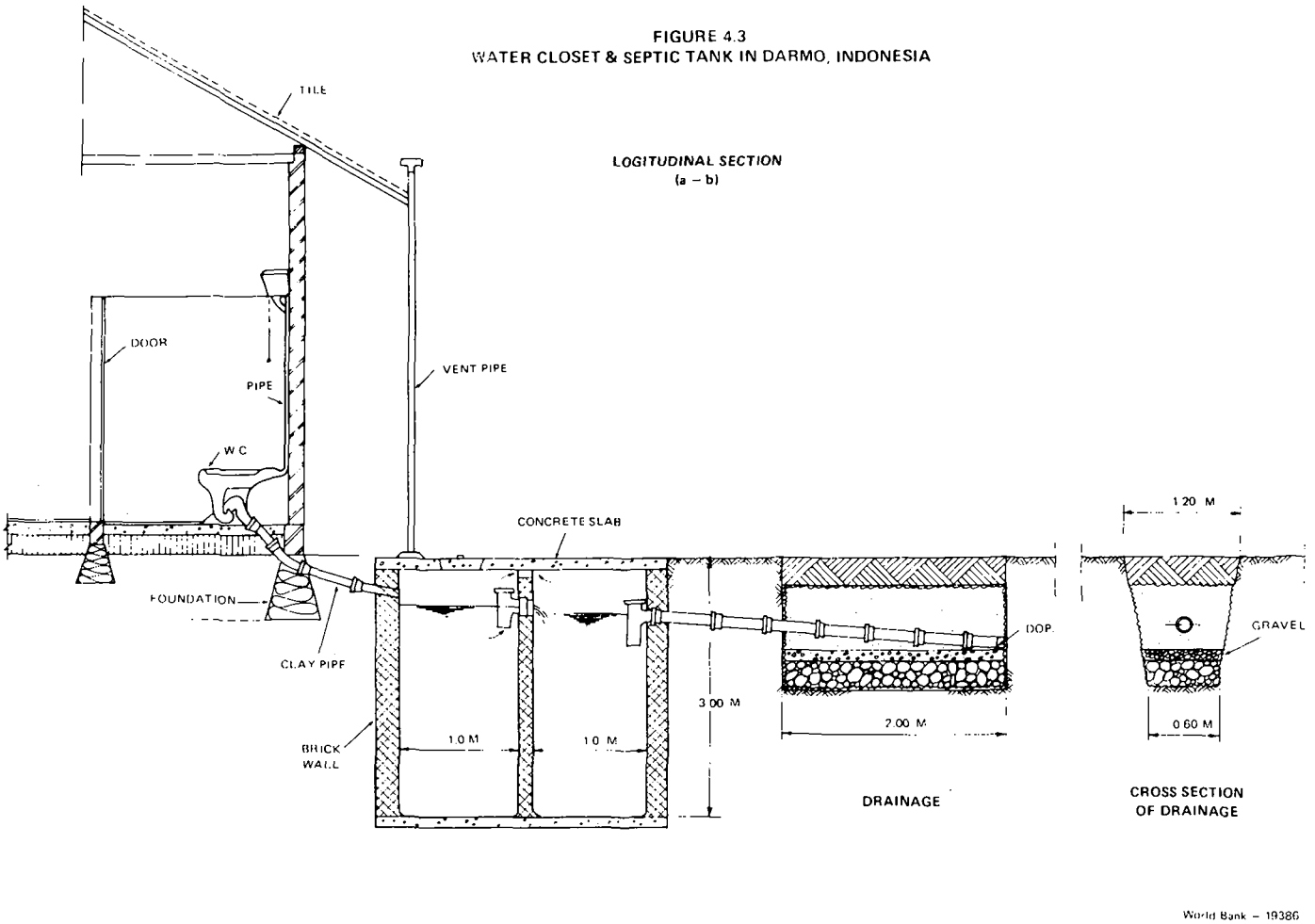
Table 4.10

Annual Costs Per Household
for Septic Tank System in Darmo
(1978 US$)

Capital Costs	36.2
O & M	3.4
Inc. Water	5.4
Total	45.0
Cost per capita	9.0

Sullage in Darmo is disposed of by the higher income households by diverting the water into government constructed, lined gutters. The lower income group throws its water into self made ditches which drain directly into the river. Solid waste collection is also available in Darmo. It is arranged by a Kampung official and costs $.72 per month for each household.

FIGURE 4.3
WATER CLOSET & SEPTIC TANK IN DARMO, INDONESIA



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(3) Public Health

The only available health statistics are those from the entire city of Surabaya (see previous community). Due to the relatively high economic status of Darmo residents, the health conditions are certainly better than in Tamabaksari and most likely better than that of most of Surabaya.

CHAPTER V

MALAYSIA

Malaysia, with an estimated population of 12.1 million (1975) and an area of approximately 333,000 square kilometers, is a federation of thirteen states occupying two distinct geographical regions which are separated by 645 kilometers of the South China Sea. West Malaysia, or Peninsular Malaysia, consists of the eleven states located on the Malaysian Peninsula. It borders Thailand on the north and Singapore on the South. Flanked on the east and west by coastal plains, a long, narrow and steep mountain range runs down the center of the Malaysian peninsula. Approximately eighty percent of Peninsulan Malaysia is covered by tropical jungle, with the remainder of the area occupied by rubber plantations and other agricultural land. East Malaysia consist of the States of Sarawak and Sabah on the northwest coast of the island of Borneo. East Malaysia is comprised of coastal plains which extend from the sea and merge into jungle covered hills and mountains in the interior. The climate is tropical with high humidity and temperature. Malaysia experiences both a southwest monsoon with heavy, unpredictable rains from April to mid-October and a northeast monsoon characterized by more predictable rains. Average annual rainfall is 250 centimeters, but there is considerable geographic variability.

Malaysia maintained an average GNP growth rate of six percent per annum during the last decade. In 1974 per capita income was estimated to be US$600. The agricultural sector accounts for thirty percent of Malaysia's GNP and fifty percent of its employment. Principal products are rubber, palm oil, timber, cocoa, rice, pepper, and pine. In addition to agricultural products, tin is a major export item. The industrial sector is largely undeveloped.

Malaysia's population is comprised of three major ethnic groups. According to the 1970 census, ethnic composition was forty-seven percent Malay, thirty-four percent Chinese, and nine percent Indian. A variety of tribal groups make up the remaining portion of the population. The official religion of Malaysia is Islam, and most Malays are Muslims. The Chinese population follow Buddhism, Confucianism and Taoism, while most Indians are Hindus. Malaysia's population is primarily rural with twenty-nine percent living in urban areas. Education is available at all levels in Malaysia, and schooling is compulsory between the ages of six and fifteen. The literacy rate is estimated at sixty-eight percent. Public health standards have improved over recent years, but tuberculosis and poor nutrition are still major problems. Life expectancy is sixty-two years.

Water supply and sewerage services are not adequate in Malaysia. However, of these two services, provision of water supply is much more advanced. Over fifty percent of the population of Malaysia is served through piped water supply systems. In Peninsular Malaysia and in Sabah State, water systems generally provide service on a regional basis rather than to just a

single community. These systems, which serve almost all urban areas and adjacent towns and villages, have enabled rural communities to benefit from water systems they otherwise would be unable to support. Metered deliveries generally are provided to individual dwelling units, with public standposts representing a relatively small proportion of the total number of connections. In Sarawak State, where some eighty percent of the population live in small communities with poor communications, water supply systems serve individual communities only. The concept of beneficiaries paying for water service through an adequate tariff is well established in Malaysia, and water tariffs generally are sufficient to meet operating costs and debt service and yield a small surplus.

Few sewerage systems and sewage disposal facilities exist in Malaysia. According to the 1970 Census, only 20.6 percent of the population was provided with flush systems discharging either to communal or municipal sewers or, to individual disposal systems. The remaining populations were served by bucket (nightsoil) collection, pit latrines or open drains. Of the urban areas, only the cities of Kuala Lumpur and Georgetown (Penang State) have sewers; a total of 350,000 people or nine percent of the 1970 urban population of 3.7 million persons benefit from this service. However, with the increase in the provision of water supply systems and expansion of the areas where piped water supply services are made available, the waste water disposal problem is rapidly increasing. Pollution of the water sources is already occurring in many instances. These poor conditions are mitigated by frequent and substantial rainfall. Domestic wastes represent only part of the problem; land development, industry and mining operations also are major contributors to water pollution.

A. COMMUNITY SELECTION

The communities of Malacca, Alor Star, and Kuala Trengganu were chosen for study within the Malaysia chapter. The population in the communities ranges between 90,000 and 160,000, and none has a sewerage system. Sanitation in Malacca is provided by bucket latrines, septic tanks, and pour-flush latrines. In Alor Star, bucket latrines and low-cost septic tanks are the principal means of providing for excreta disposal. Septic tanks and Siamese latrines are primarily used in Kuala Trengganu. In addition to the analysis of existing systems, the Malacca community study includes an analysis and cost comparison for two hypothetical systems, a sewerage system and an improved nightsoil cartage system. The Alor Star community discussion also includes a description of an operating family biogas unit.

The field work for this study was done by Mr. Ng Kin Seng, a consulting sanitary engineer.

B. ASSUMPTIONS

No shadow pricing is necessary for foreign exchange or unskilled labor in Malaysia. The opportunity cost of capital was assumed to be twelve percent. Unless otherwise stated, all costs are at 1978 prices, and the conversion rate between the Malaysian and United States dollars is M$2.35 = US$1.00.

C. COMMUNITY RESULTS: MALACCA

Malacca is located on the western coast of the Malaysian Peninsula approximately 145 kilometers south of Kuala Lumpur. It is the capital city of the Malaysian state of Malacca, one of the poorer states on the Malaysian Peninsula. The city is situated on the coastal plain bordering the Straits of Malacca and is divided into an eastern and western portion by the Malacca River which flows in a southerly direction through the center of the city. There is a low range of hills to the north of the city; but apart from small isolated hills within the city, the land is generally flat and low-lying. Drainage areas are not clearly demarcated by ground contours. The Malacca River drains a catchment of 350 square kilometers, and has a mean annual discharge of 1.6 cubic meters per second. The average measure of BOD for the river is 2.31 milligrams per liter. The water table is about one meter below ground level. Average annual rainfall is 200 centimeters, and the mean annual temperature is 26.4°C.

The city of Malacca has an estimated population of 90,000 (1977) and a population density of 8,270 persons per square kilometer. The average household size is 6.4 persons, and average annual income per household is $3,355. However, the poorest twenty percent of Malacca households earn an average of $797 per year. In 1970, the adult literacy rate was sixty-five percent. Sixty-one percent of the children between the ages of five and nineteen attend school. House construction varies from simple wood structures to more sophisticated brick structures. The cost of a typical brick house (135 square meters) is $7,000 excluding land.

(1) Water Supply

A centrally administrated water supply system provides piped water to eighty-six percent of the population of Malacca, mostly by house connection. This sytem is comprised of eleven smaller sub-units which have been built over the last seventy years. The system services not only the city of Malacca but also portions of the larger state of Malacca. The source of water for the integrated system is surface water which is taken either through impoundment or direct withdrawal from streams or rivers. Treatment varies from simply chlorination to more sophisticated processes of floculation and filtration prior to chlorination. Average daily consumption for the system is 207 liters per capita. The water tariff schedule is presented below in Table 5.1. The average annual household water bill is $12.72, or less than one percent of annual income. Examination of income statements for 1975 indicates that the water authority meets all costs through water charges and other fees rather than through subsidies from other government accounts. The individuals not served by house connections are served by open wells from which water is drawn by bucket. The quality of well water is doubtful, and there are reports of substantial contamination. There are a few stand pipes in Malacca supplying a very small portion of the population.

Table 5.1

Water Tariff Schedule for a Residential House in Malacca

Water Consumption	Water Tariff
Up to 8.3 cubic meters	Minimum charge of $1.06
8.3 to 16.7 cubic meters	$0.15 per cubic meter
16.7 to 25 cubic meters	$0.17 per cubic meter
more than 25 cubic meters	$0.19 per cubic meter

(2) Sanitation

The present sanitary arrangements throughout the Municipality consist of bucket latrines, septic tanks, pour-flush toilets and direct discharge to rivers. The wastes from kitchens and baths (sullage) are discharged to open surface water drains. About forty-one percent of the population are served by septic tanks, forty-nine percent are served by bucket latrines, and ten percent are either using private pits or discharging directly to rivers.

(a) Bucket Latrines

Fifty percent of the population of Malacca is served by a bucket collection system operated by city authorities. The household bucket latrines in use in Malacca are separate wooden structures located in the rear of most homes. Scavengers empty household buckets into intermediate sized rubber buckets which are carried on the shoulder. The household bucket is removed and replaced before and after collection through the rear opening at the lower part of a latrine. This opening is covered with a plate made of rubber or galvanized metal. Nightsoil is collected daily except on the outskirts of town where collection occurs on alternate days. Collection usually begins at dawn and ends by about 9:30 a.m. in town. However, in rural areas, collection of nightsoil may take until 1:00 p.m. This mode of operation seems to be satisfactory to most users in the rural areas.

When intermediate buckets are full, they are taken to nearby collection centers. Each center is equipped with several wooden racks in which the imtermediate buckets are placed. The buckets remain at the collection center until a nightsoil truck comes to decant them. The nightsoil is taken to a trenching ground approximately twelve kilometers from town. Five trucks are used for this purpose. At the trenching ground, the nightsoil is discharged into a previously excavated trench which is approximately 1.2 meters wide and 1 meter deep. The nightsoil is discharged as evenly as possible to within ten centimeters of the ground surface, after which a layer of saw dust is spread on the surface to keep away flies and to absorb moisture. The city authority charges individual households a fee for the service which is intended to recover all costs.

The city authorities have no intention of making any improvement in the bucket system since they hope it will be abandoned in the years to come. However, the problems associated with the system are numerous. The galvanized plate covering the opening in back of the latrines frequently drops off, and consequently, most latrines are open in the rear. Household buckets are not washed after decantation of nightsoil into intermediate buckets, and odor quickly becomes a problem. In Malacca, a number of houses do not have a back lane, and collection has to be accomplished through entering the front door of the home. The wooden racks where the intermediate buckets are kept prior to decantation into collection trucks are the source of offensive odors, and the buckets are easily seen inside the rack. Since no shelter has been provided for these racks, they weather badly; their lifetime is approximately one year. It has been suggested that hand carried buckets and collection racks be replaced by hand drawn carts which are to be emptied directly into the collection trucks. Costs for the bucket latrine system are presented in Table 5.2.

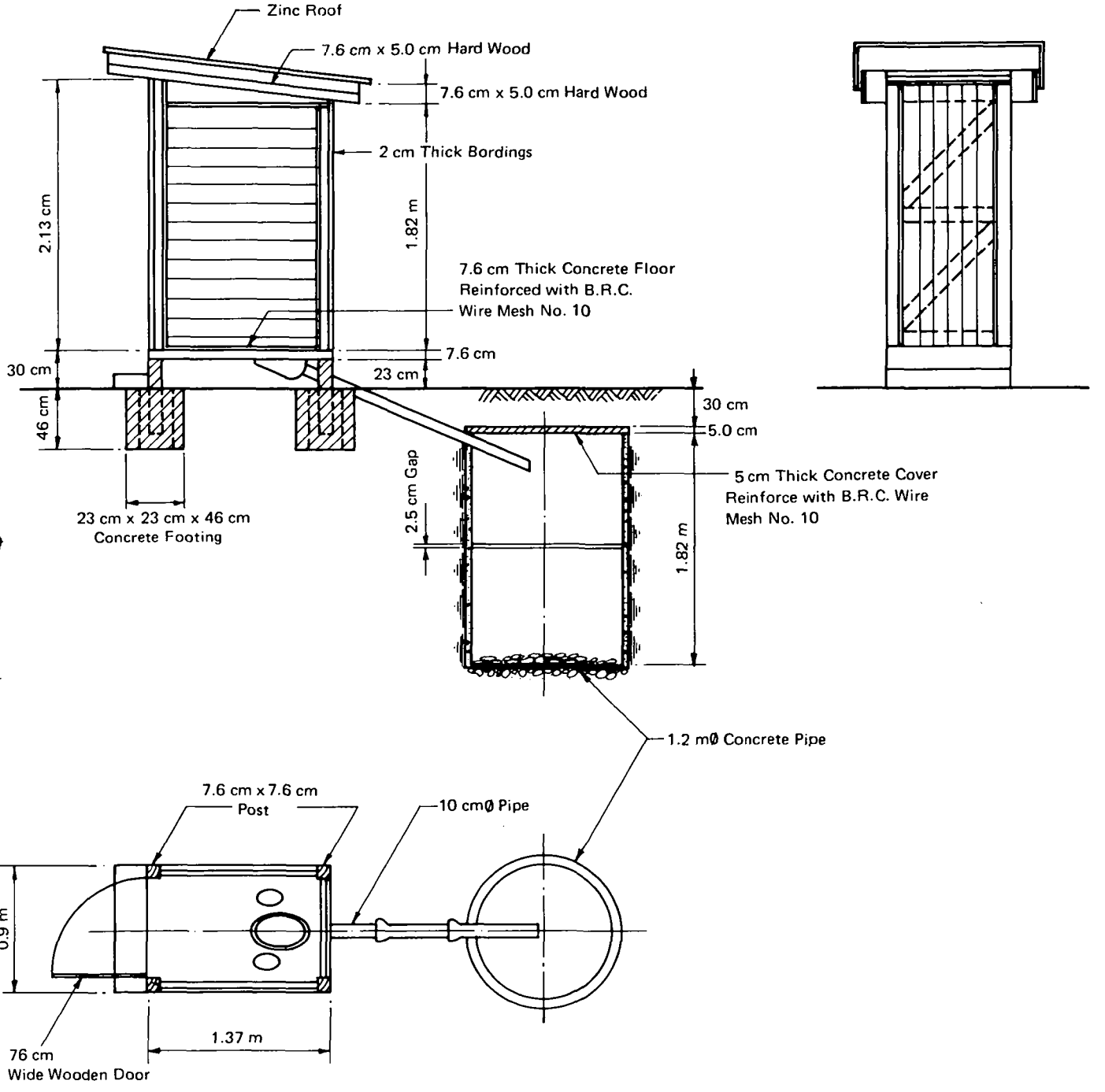
It is interesting to note that the total cost of the bucket collection system is significantly higher than that of the vault collection system used in Taiwan (see Chapter III). A study of the two systems reveals that the frequency of collection plays a very important role in their total cost. The frequency of collection in Taiwan is generally twice a month, but in Malaysia, nightsoil is collected daily or at the least on alternate days. The main difference between the two systems lies mainly in the ability to store nightsoil in household vaults. The bucket system requires more frequent collection, and as a result, the manpower required is ten times more than that needed to serve an equal population in Taiwan. Because wages are lower in Malaysia, the total labor cost of its bucket system is only double that of Taiwan (see Improved Nightsoil Collection System in subsequent section).

(b) Pour Flush - Soak Away Latrine

The local municipality is determined to do away with the bucket system by replacing it with pour flush, soakaway latrines. By-laws have been gazetted which require that by September 1978 all of the existing bucket latrines must be converted to poor flush soakaway latrines, or otherwise the sanitation charges imposed on them would be trebled. Restaurant or food shops will not be licensed if bucket latrines continue to be used.

The pour flush latrine advocated by town authority consists of a wooden latrine structure in which a water seal bowl is connected by a ten centimeter diameter pipe to a laterally displaced soakaway pit. The floor of the latrine is a concrete squatting plate. The soakaway pit consists of a two meter long section of a 1.2 meter diameter concrete pipe installed vertically in the ground. Infiltration occurs through the base of the pit. These latrines require approximately two liters of water for flushing (see figure 5.1). With the extremely high water table in Malacca, infiltration from the pit is very slow. Frequently, the soakaway pits cannot accommodate the load discharged into them; they fill, and overflowing occurs. In fact, it is common for infiltration into the pit rather than out of the pit to occur due to the high water table.

FIGURE 5.1: POUR–FLUSH–SOAK–AWAY LATRINE IN MALACCU, MALAYSIA



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Although the town council has been encouraging the bucket latrine users to have their bucket latrines converted to pour flush soakaway latrines if they cannot afford to use septic tanks, the response is generally poor based on the number of conversions. So far, only approximately 150 soakaway latrines have been constructed during the past two years (1977 and 1978). It is estimated that the cost of conversion is on the order of $130, and they may be too expensive for many households. The lack of conversion of some bucket latrines may be due to other constraints rather than financial difficulty. The lack of sufficient space at the household site is a definite handicap for the conversion.

(c) Septic Tanks

Septic tanks serve 41,000 persons in Malacca. They are desired by those who can afford the additional cost for more convenience and aesthetic improvement. However, their operation is rarely satisfactory because the high water table prevents the infiltration of tank effluent. Often a reverse flow back into the tank is observed in the effluent pipe. Although the quality of septic tank effluent is generally not satisfactory, this is not a decisive factor in selecting septic tanks for use since the convenience provided by the indoor plumbing facilities overrides all other factors. The problems arising from poor operation of septic tanks do not really bother the users but rather become community environmental problems. The use of septic tanks is now on the increase, particularly in new housing estates.

(3) Comparison between a Conventional Sewerage System and Improved Night Soil Cartage System

For purposes of providing cost comparisons, two hypothetical sanitation schemes were designed and costed for the city of Malacca. One system is an improved nightsoil cartage system similar to those found in Taiwan and Korea, using carts and vacuum trucks; the other is a fully designed conventional sewerage system.

(a) Improved Nightsoil Cartage System

The household unit consists of a water sealed, concrete bowl housed in a detached, concrete superstructure with corrugated asbestos sheet roof. Beneath the bowl is a watertight vault with an exterior withdrawal pipe. Collection from vaults is done twice a month by three-fourth ton intermediate hand-drawn vacuum carts. The intermediate vacuum carts are designed to be accessible to household vaults through the back lanes. Their size is governed by the width of the back lane. When the intermediate cart is full, it is drawn to a transfer station where a larger vacuum truck comes to empty the nightsoil and deliver it to biogas tanks and then stabilization ponds.

(b) Sewerage System

The system consists of flush toilets discharging to a sewer system which conveys the excreta to a sewage treatment plant. Pumping stations are necessitated by the flat land. The sewage treatment plant consists of grit channels followed by an aerated lagoon and stabilization ponds.

Vitrified clay, reinforced concrete and asbestos cement pipes are used for the sewers, and asbestos cement pressure pipes are used for the force main, with steel pipes used at river crossings. The sewers are laid on a granular bed on a prepared trench bottom and given concrete protection as necessary. For sewers up to sixty centimeters in diameter, manholes constructed of precast concrete installed on an in situ concrete base are provided at intervals not exceeding seventy-six meters. In the case of larger diameter sewers, manholes are to be constructed in situ of reinforced concrete at intervals not exceeding 122 meters. Heavy duty cast iron manhole covers capable of withstanding traffic loadings shall be provided in roads, and medium duty cast iron covers would be used elsewhere. Also, included are provisions for laying laterals from the sewer to the curtilage of each property served, as well as end spare junctions inserted in the sewers to provide for future connections. During the course of construction, it is necessary to remove and relay all electricity cables and water supply distribution mains which obstruct the proposed sewer lines.

Estimates of sewerage capital cost have been based on recently tendered rates for work of a similar nature in Kuala Lumpur, Malaysia. Estimates of costs of mechanical plant and equipment have been based on budgetary quotations received from manufacturers, and include cost for transportation to and installation on site. Sewer system installation cost has been worked out from a recent successful tender for constructing a work site in Kuala Lumpur. This work site is similar to the Central Town of Malacca not only in topography but also in population density. The sewer system cost of the latter has been calculated proportionately on a per-acre basis.

The total waste disposal costs of the water borne sewerage system and improved nightsoil cartage system, as well as the existing bucket collection system, are shown in Table 5.2. The conventional sewerage system has an on-site cost which is seven times greater and a total cost which is nearly five times greater than that of the improved cartage system. The cartage system would cost about the same as the existing bucket system, although it represents a big improvement in household convenience and community health.

Table 5.2

Annual Household Costs for Sanitation in Malacca
(1978 US$)

	Bucket Latrine	Improved Cartage	Conventional Sewerage
On-site			
Capital	16.8	13.5	98.9
O & M	4.5	7.8	10.3
Water	-	-	34.2
Collection			
Capital	2.6	3.9	56.9
O & M	23.5	19.9	25.1
Treatment			
Capital	1.0	7.3	8.2
O & M	1.9	1.4	9.3
Total	50.3	53.8	242.9

(4) Solid Waste Collection

Solid waste is collected from house to house by handcart. After the cart is filled, it is drawn to a public dustbin for unloading. A lorry wagon empties the dustbin and delivers the solid waste to a tipping ground located about five miles from the city. This is a low-lying area, and land is reclaimed by this controlled tipping. About sixty tons of refuse are collected daily. The population served is estimated to be 90,000.

D. COMMUNITY RESULTS: ALOR STAR

Alor Star is located approximately 480 kilometers north of Kuala Lumpur. The city is situated on a flat plain and surrounded by large acreages of cultivated paddy. The population is 106,000, and population density is 8,000 per square kilometer. The population growth rate is estimated at 3.1 percent. Average household size is 6.1, and average annual household income is $3,000. The adult literacy rate is sixty-five percent, and sixty-one percent of the children between the ages of five and nineteen attend school. Housing is similar in cost and type of construction to that found in Malacca. Average annual rainfall for the Alor Star region is 220 centimeters. Temperature is relatively constant throughout the year with a mean 27°C.

(1) Water Supply

Fifty percent of the population are served by piped water from the community water supply system. Average water consumption is 180 liters per capita per day.

(2) Sanitation

There are three methods of waste disposal practiced in the community: bucket collection, low-cost septic tank latrine or septic tank, and direct discharge into rivers or streams. Fifteen percent of the population are served by the bucket collection system, and sixty-five percent use low cost septic tanks. The remaining twenty percent still discharge their waste into streams or use it for vegetable farming. For religious reasons, Muslim Malays never make use of human excreta, but Chinese farmers occasionally do.

(a) Bucket Latrines

The bucket collection system in Alor Star is nearly identical to that found in Malacca. A similarly structured latrine is used by individual households. An intermediate rubber bucket is used by a scavenger to collect nightsoil from house to house. Collection is conducted fifteen to thirty times a month. Thirty-two laborers, who are each paid $3.00 a day, are employed for that purpose. After the bucket has been filled, it is shouldered to a collecting center where the nightsoil is loaded into trucks. Five trucks and twelve collection centers are used. The nightsoil is transported to a trenching ground fifteen kilometers from town. A total of 1,095 cubic meters of nightsoil is collected annually.

In contrast to the Malacca system, the nightsoil collection service in Alor Star has been operated by a private agency since 1973, when the local municipality decided to contract the service. The duration of contract is three years. Cost data for the bucket system are presented in Table 5.3. It is interesting to note that per household collection costs are lower for this system than for the Malacca one.

Table 5.3

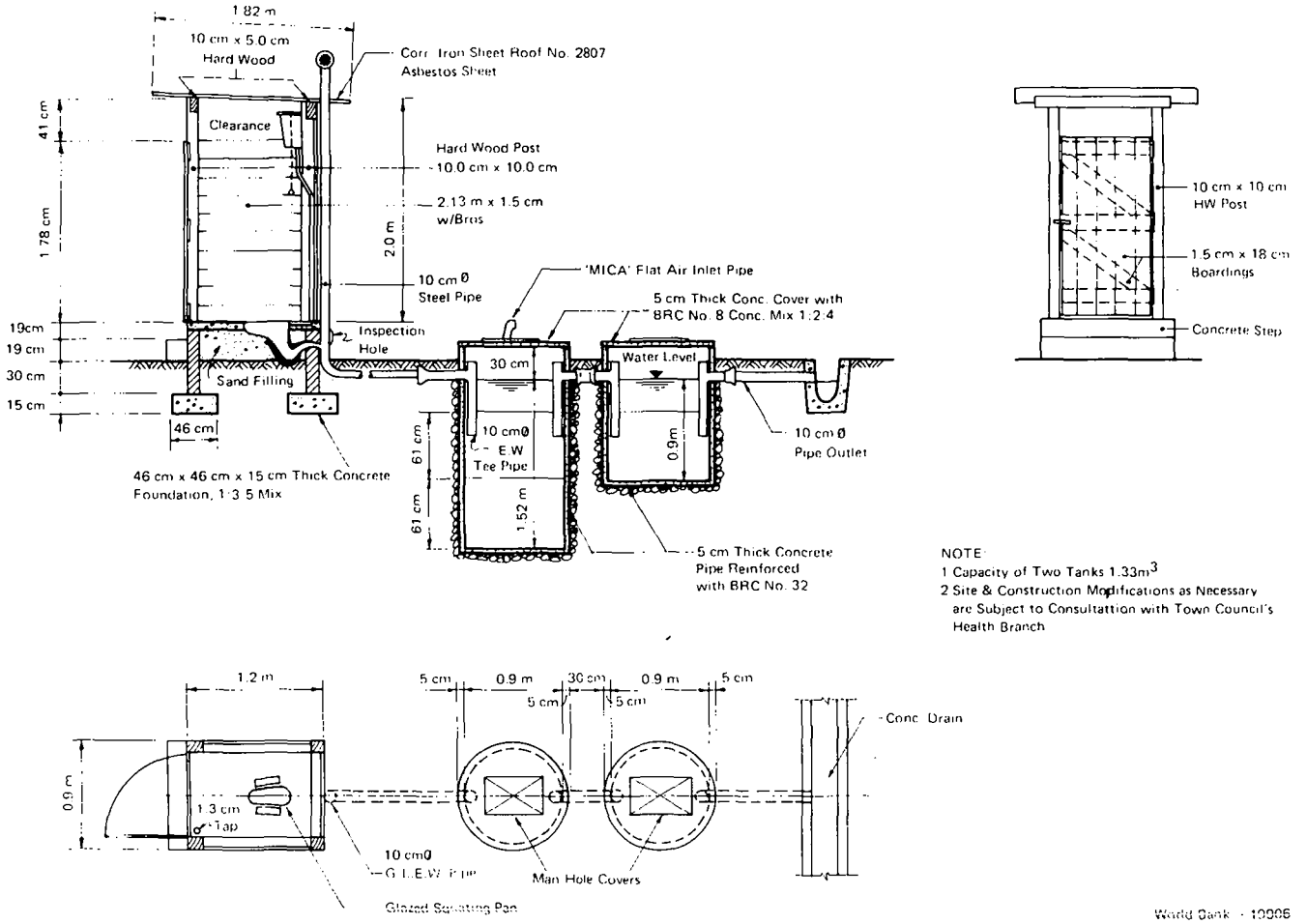
Annual Household Costs for Bucket Latrines in Alor Star
(1978 US$)

On Site		Collection		Treatment		Total
Capital	O & M	Capital	O & M	Capital	O & M	
16.4	7.2	3.3	17.0	1.7	2.6	48.2

(b) Low Cost Septic Tank

Low cost septic tanks are used by 11,500 households (Figure 5.2). Features of the system include water sealed bowl and a water closet. Discharge is into two concrete cylinders linked in series. Effluent from the tanks is discharged into the municipal drainage system. The combined capacity of the two tanks is 1.3 cubic meters. The supposed "low cost" of this unit is

FIGURE 5.2: LOW–COST SEPTIC TANK–LATRINE IN ALOR STAR, MALAYSIA



NOTE
1 Capacity of Two Tanks 1.33m^3
2 Site & Construction Modifications as Necessary are Subject to Consultattion with Town Council's Health Branch

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due to the capability of mass-manufacturing the concrete cylinders involved. However, their use does not leave the option of varying the capacity of the receiving tank according to size of household. If the system is operated correctly, it does provide the advantage of settling the solids from the liquid in two different containers. Many of the septic tank units in Alor Star are not working well, primarily because they are desludged too infrequently with the consequence that in the worst cases, waste merely enters the tanks and quickly passes through with little or no removal of solids. In some instances, it is nearly impossible to desludge these tanks due to insufficient access to areas behind households where the tanks are located.

In spite of the problems associated with their use, the low cost septic tank latrine is considered a rather advanced method of waste disposal, and the municipal council hopes that in the near future all the bucket latrines will be replaced by these septic tank units. However, the council is aware that they are still too expensive for many bucket latrine users.

(3) Reuse: Biogas

A biogas unit has recently been constructed to treat cattle waste in the kampong of Jitra, about thirty kilometers north of Alor Star. The unit was designed to treat waste produced by five cattle, and generates biogas sufficient to cook three meals a day for a family of five members. It operated smoothly for the first two weeks after commissioning; but later excess scum was found on the surface of the unit, and this hindered the release of biogas. When pig waste is used to run the biogas unit, the problem does not exist. It is believed that the cattle waste contains large amounts of grasses that are not easily digested in the biogas unit. The undigested grasses accumulate and float to the top, thereby forming a scum which prevents the biogas from being released to the kitchen through the conveying PVC pipe.

This unit was installed within the compound of a Malay Muslim house. The biogas is fed back to his kitchen for cooking and boiling water. This implies that the gas generated from waste is acceptable by a Muslim. Of course, if the biogas were generated from pig waste, it would become an entirely different issue. It is not known whether biogas produced by human waste would be accepted by the same family.

(4) Solid Waste Collection

Solid waste is collected from house to house by a handcart. When the handcart is full, it is drawn to a public dustbin into which the solid waste is dumped. A lorry or wagon empties the dustbin and delivers the solid waste to a tipping ground located about thirteen kilometers from the Municipal Council. This is a low-lying area, and land is reclaimed by this controlled tipping. About 72,500 kilograms of refuse are collected daily. The population served is estimated to be 110,000.

E. COMMUNITY RESULTS: KUALA TRENGGANU

Kuala Trengganu is located 500 kilometers northeast of Kuala Lumpur on the east coast of Peninsular Malaysia. The city is situated at the mouth

of the Trengganu River. With a catchment area of 3,340 square kilometers, the Trengganu flows from Mount Lawit to the South China Sea with an average discharge of 7.8 cubic meters per second and generally good water quality. The city of Kuala Trengganu has an average elevation of twelve meters above sea level. With a growth rate of 3.2 percent, the population of the city in 1977 was 101,000, and the population density was 7,000 per square kilometer. Average household size is 6.3, and average annual household income $2,800.

(1) Water Supply

An estimated sixty-five percent of the population are served by house connections, with the remainder collecting their water from standpipes. There are no water vendors in the area. The source of the water is the Trengganu River. A water treatment process consisting of flocculation, sedimentation, rapid sand filtration, and chlorination is employed. Average water consumption is 160 liters per capita per day There is one water tariff applied to all domestic consumption: $0.17 per cubic meter. Thus, normal family annual expenditure for water is $62 or 2.2 percent of annual income.

(2) Sanitation

(a) Siamese Latrine (pour flush)

Cities located on the east coast of Peninsular Malaysia are less well developed than those of the west coast with respect to infrastructure facilities, but surprisingly, the local authority in Kuala Trengganu (Municipal Council) did away with the bucket latrines in 1973 by replacing them with Siamese Latrines (pour flush) shown in Figure 5.3. At present, hardly a bucket latrine can be found in the area. The whole conversion project was completed in three years. Interest free loans and removal of sanitation charges after conversion were the incentives given to the bucket latrine users. The former sanitation charge was $1.27 per month per household. At present, about 34,000 persons are served by these Siamese Latrines. The cost of conversion was then about $170.

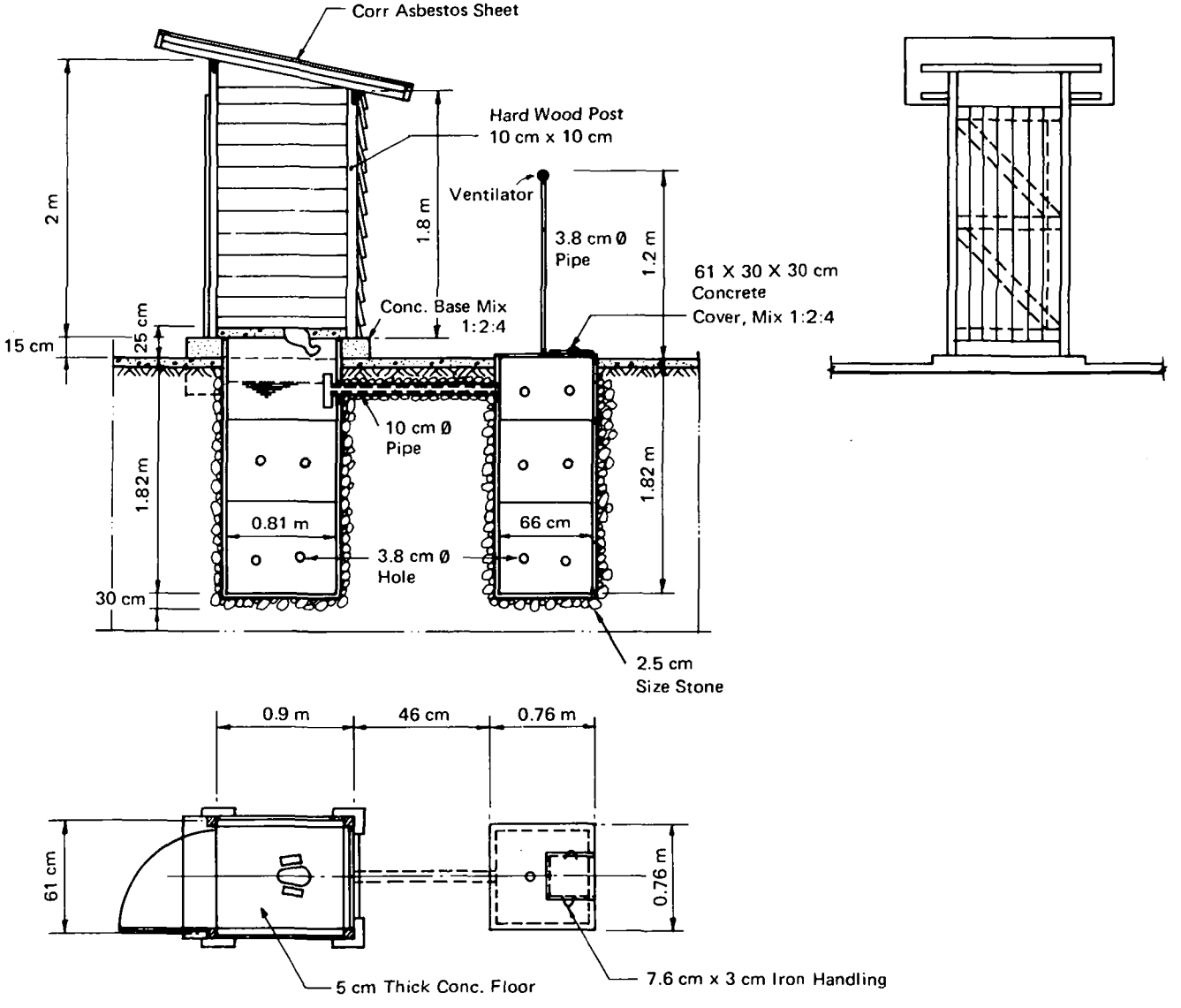
Siamese latrines are commonly used in the southern part of Thailand. The Health Authority brought back this idea after they had paid a visit to the area. These latrines consist basically of a water seal bowl which discharges into a stone lined pit directly beneath the squatting plate. A second pit is dug nearby and connected to the first by a pipe. Both pits act as seepage pits, with the first pit collecting most of the settleable solids. A super-structure of wood is provided. Costs for this system are provided below in Table 5.4.

Table 5.4

Annual Household Costs for Siamese Latrines in Kuala Trengganu
(1978 US$)

On Site			Collection		Treatment		Total
Capital	O & M	Water	Capital	O & M	Capital	O & M	
32.8	—	2.6	—	—	--	—	35.4

FIGURE 5.3: SIAMESE–LATRINE IN KUALA TRENGGANU, MALAYSIA



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(b) Septic Tanks

Septic tanks are used by 9,050 households and by trade premises and government institutions. The users of septic tanks are generally satisfied by the system as its plumbing facilities provide great convenience to users when compared to that provided by bucket nightsoil collection systems. These tanks do not always operate efficiently as they are not desludged properly. The effluent is generally of poor quality, but this does not seem to bother the users. As in Malacca, the pollution becomes more of a community problem than a household problem.

(3) Solid Waste Collection

Solid waste is collected from house to house by a handcart which is then drawn to a public dustbin for unloading. A lorry or wagon comes to empty the dustbin and deliver the solid waste to a tipping ground located about eight kilometers from the Municipal Council. This is a low-lying area and land can be reclaimed by this control tipping. About 60,000 kilograms of refuse are collected daily. Population served is estimated to be 101,000.

CHAPTER VI

SUDAN

Sudan is the largest country in Africa with an area of 2,505,800 square kilometers and a population of 16.4 million. It is geographically diverse and includes a variety of different ecological conditions. From south to north, the country has tropical forests and savanna, swamplands, open semitropical savanna, and sandy and arid hills which gradually give way to the Libyan Desert just north of Kharthoum. The country is transversed by the Nile River and its major arteries. Corresponding to its geographical regions, Sudan's rainfall varies from less than 2 centimeters per year in the north to some 150 centimeters per year along the southern border. According to the season of the year, maximumm daily temperatures range from 29°C to 46°C in most areas of the country. Sudan's geographical diversity is accompanied by a corresponding ethnic diversity. Concentrated in the northern six provinces, seventy percent of the population is Arab or arabized, while in the three southern provinces the remaining portion of Sudan's population shares common genetic and cultural origins with black Africa. The northern population is primarily Muslim, while a variety of indigenous beliefs and practices are followed in the south. Four percent of Sudan's population is Christian and are found primarily in the south.

Population density is low in the rural areas, with the exception of irrigated farm areas along the Nile River. The country has experienced an increasing migration into the cities from the rural areas. The principle urban areas are the triple cities of Khartoum, Khartoum North, and Omdurman, Port Sudan on the Red Sea, and Juba in the south. In spite of the migration to urban areas, eighty-six percent of the laboring population continue to be engaged in agriculture. Principal agricultural products are cotton, peanuts, sesame seeds, gum arabic, sorghum, wheat and sugar cane. Only six percent of the population are engaged in industrial activities with the primary products being cement, textiles, pharmaceuticals, and shoes. Per capita income is $165 per year. The literacy rate is estimated to be between fifteen and twenty percent.

Public health conditions are unsatisfactory in most areas. Malaria, schistosomiasis and tuberculosis are considered the major environmental diseases. Poor nutrition, lack of proper sanitation, difficult ecological conditions, and insufficient medical services are primarily responsible for the high incidence of disease. Sanitation practices are still rudimentary in the Sudan and vary from pit or bucket latrines in most areas to waterborne sewerage systems in a few, small, localized areas in the major cities. The recent population influx into the urban areas has seriously stressed sanitary infrastructure and aggravated urban health problems. Overcrowding and temporary living structures are prevalent.

A. COMMUNITY SELECTION

The communities of Hasaheisa, Faki Hashim, Haj Youssef, and Mahadia were selected for study within this project. Due to the constraints imposed by travel, these communities all lie within the northern regions of the Sudan. However, they were chosen to represent a variety of existing waste disposal techniques. In addition to the collection of technical, economic, and sociological data, laboratory examinations for intestinal parasites of faecal samples collected from selected school populations within these communities were conducted so as to provide information relative to the sanitary conditions of these communities.

This report is based on field studies conducted by Dr. Beshir Mohamed El Hassan of the Faculty of Engineering and Architecture at the University of Khartoum and Mr. Samir El Daher of the World Bank during the period of August to February 1978.

B. ASSUMPTIONS

In dealing with the data collected and prepared during this study, a number of assumptions have been made. The opportunity cost of capital was taken as sixteen percent. Foreign exchange components of all costs have been shadow priced at 1.25 times the official rate. All cost and income data have been adjusted to 1978 U.S. dollars using an exchange rate of 2.87 Sudanese pounds per US$, unless otherwise noted.

C. COMMUNITY RESULTS: HASAHEISA

Situated on the banks of the Blue Nile, Hasaheisa is located about 137 kilometers southeast of Khartoum within the the Gezira Province. The city occupies a narrow piece of land lying between the Blue Nile on the east and the main irrigation canal of the Gezira Scheme to the west. It is an urban community of 24,000 inhabitants and is presently experiencing rapid growth due to the recent establishment of a number of expanding industries. The principal factories are a textile unit employing 3,000, a number of cotton ginneries employing 200, and a variety of small industrial units. There is also reported to be a small but developing agricultural industry. However, fertilizer from organic wastes is not utilized. In 1973 unemployment was approximately five percent. There are seasonal peaks in employment during cotton picking and ginning seasons. These periods prompt seasonal migrations into the area from outlying regions of the province. Average annual household income is $860, with the poorest twenty percent of households averaging $515. The literacy rate is estimated to be seventy percent for men and thirty percent for women. Seventy-five percent of the children attend school. The climate is similar to the Khartoum Province, but with slightly more rain. Average monthly precipitation is thirty millimeters with a dry period from November through April. The maximum monthly precipitation of 1.33 centimeters occurs in July.

The population density of Hasaheisa is 1,200 persons per square kilometer, and the average family size is 6.5. Fifty percent of the houses are constructed with red brick and roofing of either corrugated iron sheets or timber. Forty-five percent are constructed with mud and roofing of straw, bamboo, and grass. Only five percent of the houses are made of reinforced concrete.

(1) Water Supply

Hasaheisa has a central water supply system which services ninety-four percent of the population by house connections. The remainder are served by one village standpost. The source of water is four boreholes penetrating to depths between 85 and 105 meters. Although high in dissolved solids, the water quality from these boreholes is generally good. Due to limited evidence of organic contaminants, water taken from one borehole requires chlorination. Water is pumped from the boreholes to three water towers (average volume forty cubic meters) from which it is distributed to the community. Leakage from the distribution system is estimated at thirty-two percent, and metered consumption averages sixty liter per capita per day. The water tariff is $0.17 per cubic meter, with a minimum monthly charge of $2.87. The tariff rate is applied only on consumption above sixteen cubic meters per month. Average annual household cost is estimated at $34.44, or four percent of annual income. An initial connection fee totaling $32.57 is charged to individual households.

(2) Sanitation

Seventy percent of the population are served by pit latrines, while the remaining thirty percent are served by a bucket night soil collection system. Two different systems of bucket collection operate within the community. The largest system, utilizing 1,221 buckets, is operated by the town council; the smaller system of 641 buckets is operated by the local cotton ginneries. The community system employs forty-three laborers at the minimum wage, and three drivers at $63 per month. Until recently, each laborer manually collected the buckets from this district and emptied them at centrally located containers from which the waste was transferred to trucks and then transported out of town. Recently, however, trucks with carts which allow for more immediate collection have been purchased. There is no reuse of collected waste. It is simply transported to an outlying area and buried in trenches dug daily. The trenches are twelve to fifteen meters in length, one meter in depth, and three quarters of a meter in width.

Fees charged to a household are based on the number of buckets it "maintains", with a rate of $2.87 per bucket per month. The average annual fee charged to a household is $34, or four percent of household income. The system subsidizes purchase of the buckets. Bought from the supplier at approximately $11.50, the buckets are resold to individual households at half price. Each household averages at least two new buckets per year, thereby adding $11.50 to annual household costs. The buckets are housed between collections in small buildings built of brick and located adjacent to each house. Average dimensions are 0.8 x 1.7 x 3 meters, with an interior concrete

stand 0.9 meters in height. A complete analysis of system costs is presented below in Table 6.1. With the growing employment opportunities in this community, it is expected that finding laborers willing to act as collectors will become increasingly difficult, and the abandonment of bucket collection is consequently contemplated. Consideration of the abandonment of the bucket system may also be partly attributable to a desire to eliminate the migration from the south of members of a Christian tribe who are used primarily as night soil scavengers.

Table 6.1

Annual Household Costs of Bucket Collection in Hasaheisa
(1978 US$)

On Site	
Capital	80.5
Collection	
Capital	9.7
O and M	19.4
Treatment	
Capital (land)	.2
O and M	6.7
Total	116.5
Cost Per Capita	17.9

In addition to the pit privies and bucket collection system, septic tanks are used by twenty-eight households, and aqua privies are used by six households.

(3) Public Health

Data on public health conditions are limited in Hasaheisa. Cholera outbreaks have occurred in the past. The community has one hospital. Public health data collected during the project is presented below in Table 6.2 Sample size was 557 school children. The children were primarily from households with bucket latrines.

Table 6.2

Results of Parasitological Examination of Faecal Samples in Hasaheisa

Parasite	Percentage Positive
E. Coli	25.3
G. Lambia	18.0
H. Nana	7.1
E. Histolytica	2.5
S. Mansoni	1.4
E. Vermiculeris	.2
I. Butchili	.2
T. Saginata	0

D. COMMUNITY RESULTS: FAKI HASHIM

Faki Hashim is located on the banks of the Nile River approximately fifty kilometers north of Khartoum and within the Khartoum Province of Sudan. With a population of 4,000 persons (1977), El Faki Hashim is a small semi-rural community. Forty percent of the population are engaged in agriculture, while fifty percent of the population work in Khartoum as laborers and clerks. The remaining ten percent are government officials. The principal agricultural products are fruits, vegetables, and maize; chemical fertilizers (urea) are mainly used by the farmers. In addition, most farmers breed and fatten lambs and goats, and some raise poultry. The average size of a household agricultural plot is one hectare. It is estimated that seventy-five percent of the male population and forty percent of the female population are literate. Ninety-eight percent of the children currently attend school. Thirty year meteorological data for the Khartoum area indicate a dry hot climate. Annual rainfall averages sixteen centimeters, mostly during July and August, with average monthly amounts of fifty-five and seventy-two millimeters, respectively. Mean monthly temperature in January is 23.9^{o}C and in June, 34.4^{o}C.

The population density of Faki Hashim is 1,067 persons per square kilometer. The available land for housing expansion is limited, and expansion occurs at the expense of fertile land. With approximately 500 households in the community, average household size is eight individuals. Average annual income per household is $1,205, and annual household income for the poorest twenty percent of the population is approximately $690. Rate of employment in the area is estimated at ninety-five percent, with most unemployment among recent school graduates. Skilled labor is readily available in the area with the possible exception of mechanics and electricians.

Housing in Faki Hashim follows the typical pattern for Sudan. Seventy percent of the homes is of conventional mud construction. The

walls of these homes are constructed of mud, while the roof is made of local timber, straw, bamboo, and grass. The walls and roof require annual covering with mud and animal manure for protection against rain. Many of the mud houses have surrounding fences of red brick. Thirty percent of the houses are built of more expensive red brick and with a roof of corrugated iron sheets or timber. Less than one percent of the houses are of reinforced concrete construction. Regardless of design, the owner usually participates in the construction of his own home.

(1) Water Supply

Faki Hashim has a central water supply system which distributes water throughout the community. The system is operated by the Public Electricity and Water Corporation (PEWC), and the source of water is a seventy-five meter borehole. The watertable is generally forty-five to sixty meters below the ground surface. The borehole is equipped with an electric pump which raises the water to a one cubic meter water tower. This well system serves not only Faki Hashim but also two other neighboring communities. Ninety-five percent of the houses in Faki Hashim are served by house connections. The remaining households are served by one village standpost. In addition, a few households have shallow well systems which are used only occasionally, primarily when the water supply fails. The quality of the ground water is generally acceptable except for a high salt content about which consumers consistently complain. However, contamination of water does occur in the households as water is drawn into jars and stored for cooling and use during periods of inadequate supply. It has also been reported that people take water (for clothes washing) from the irrigation canals which run through the village. Use of canal water has been attributed to the high salt content of tap water. Children are also reported to drink from, and play in, these canals.

The water distributed by the public system is metered and sold to consumers. The water tariff is $0.14 per cubic meter with a minimum monthly charge of $2.89. The average daily per capita water consumption is fifty liters. The average annual household water charge is $34 or 3.4 percent of household income.

(2) Sanitation

The village is served primarily by pit privies (99% of population) with average pit dimensions of 2 x 1.5 x 10 meters. The latrines are not water sealed or vented; consequently, odors and flies are present. The principal soil type in the village is a soft, expansive clay. As a result, there have been numerous reports of failures and subsequent collapses of latrine walls. However, the reported lifetime for a latrine is 20 years, provided it is well built and not misused. Volume of waste produced has been estimated at 1.3 liters per capita per day. There are a small number of septic tanks and aqua-privies in use in the community: twenty-three individuals are served by septic tank and sixteen by aqua-privies.

(3) Public Health

The village of Faki Hashim has one dispensary which opens between 8 p.m. and 2 a.m. and is run by an assistant doctor.

The results of the parasitological examinations are presented in the following Table 6.3. Sample size was 198 children. The results show significant infection frequencies with a number of parasites. Schistosomiasis is endemic to the area.

Table 6.3

Results of Parasitological Examination of Faecal Samples in Faki Hashim

Parasite	Percentage Positive
E. Coli	37.3
G. Lambia	23.7
H. Nana	7.0
E. Histolytica	1.3
S. Mansoni	5.9
E. Vermiculeris	0.0
I. Butchili	.6

E. COMMUNITY RESULTS: HAJ YOUSSEF

Haj Youssef is an extension of Khartoum north. It is a poor community, and many of the inhabitants are immigrants from other parts of the Sudan or from neighbouring African countries. There are sizeable, illegal squatter settlements on the periphery of the community. In fact, the study community itself was at one time an illegal squatter settlement which the government has now recognized as legitimate. It can be expected that the current illegal settlements will eventually receive similar official recognition. Most of the population works in the Khartoum North industrial area for very low wages. Eighty percent are unskilled workers; the remaining twenty percent can be considered either skilled or professional. The rate of employment is estimated at eighty percent with no substantial seasonal patterns. The average annual income level per household is $690, with the poorest twenty percent of households earning between $340 and $520. Statistics on literacy are not available, but the literacy rate is likely very low. Seventy percent of the children attend schools. The community experiences weather conditions similar to the rest of the Khartoum area. Rainfall occurs only in trace amounts from November through April, and peak rainfall occurs in August, with a monthly average for thirty years of seventy-two millimeters, lowest monthly mean temperature occurs in February with a thirty year average of 25^{o}C; highest monthly mean temperature of 34.4^{o}C occurs in June.

Population in the sample community is 26,000 inhabitants. Population density is 10,667 person per square kilometer in the legal settlement area within the community and 13,333 persons per square kilometer in the illegal squatter area. Average family size is six persons. Housing in the area is almost entirely of mud construction with roofing of cheap, local timber, straw, bamboo and grass. The area of individual housing plots averages two hundred square meters.

(1) Water Supply

Water is supplied to Haj Youssef by two boreholes penetrating to depths of seventy-five and ninety meters. Depth to watertable averages sixty to seventy-five meters. The water is elevated from these boreholes to one elevated tower by two electrically driven pumps. Water is distributed to the more established section of the community by house connections (outside study area) and to the less established study area through sixteen standposts of which nine are currently functional. The sixteen original standposts were designed to serve 18,000 settled people. However, they are now additionally required to serve those individuals residing in the illegally settled areas, with the result that nine operating standposts must serve 26,000 people, or approximately 3,000 persons per standpost! Water is distributed through a system of private vendors. The water authority employs for each standpost a standkeeper who works twelve hours per day at a monthly wage of $23.

Water is sold by the standkeeper to vendors who in turn sell to households. The vendors transport the water on their shoulders or by donkey. Tariff schedules for both the vendors and households are presented below in Table 6.4. Average per capita water consumption for the area is seventy liters per day, and average, annual, household cost for water is estimated at $69, or ten percent of annual income. When compared to the nearby areas serviced by house connections where the annual household bill averages $34, basic costs for water for those who inhabit the poorer area are extremely high. In addition to these costs, those household serviced by vendors must bear the burden of frequently contaminated water.

Table 6.4

Water Tariff Schedule in Haj Youssef
(1978 US$)

Unit Volume	Selling price at Standpost	Re-selling price by vendor
1 Bucket (10 liter)	$.003	Carried only by private individuals
1 Tin (20 liter)	.006	Carried only by private individuals
2 Tins (40 liter)	.009	$.09
1 Barrel (240 liter)	.057	.20

(2) Sanitation

Haj Youssef has no central waste disposal system. In the better established, wealthier areas only 1.3% of population are served by septic tanks and 0.5% by aqua privies. Pit privies are used by the remainder and are the primary means of human waste disposal. However, in the less established areas (sample community) and illegal settled areas, many individuals are not even served by pit privies. Only eighty-four percent of the population of the sample community are estimated to have access to pit privies. The remainder either use shallow ditches or unaltered open areas. The dimensions of the average pit latrine are 2 x 1.5 x 15 meters, while the small ditches serving many households are of one cubic meter capacity. Sanitary conditions are poor in this community. The average cost of a pit privy in Haj Youssef is presented in Table 6.5.

Table 6.5

Annual Household Cost for Pit Privies in Haj Youssef
(1978 US$)

Capital	
Excavation	10.1
Slab	13.4
Housing	12.5
Total	36.0
Cost Per Capita	6.0

(3) Public Health

Due in part to poor sanitation, the public health situation in Haj Youssef is very bad. Although the population is large, there are no health services with the exception of a single dispensary run only by an assistant physician for eight hours daily.

Parasitological examinations of stool samples indicate significant infection rates in Haj Youssef (see Table 6.6).

Table 6.6

Results of Parasitological Examination of Faecal Samples in Haj Youssef

Parasite	Percentage Positive
E. Coli	23.4
G. Lambia	5.1
H. Nana	12.4
E. Histolytica	0
S. Mansoni	.4
E. Vermiculeris	0
I. Butchili	0
T. Saginata	0

F. COMMUNITY RESULTS: AL MAHADIA

Al Mahadia is a northern suburb of Omdurman City and was recently built (early 1960's) to accomodate urban expansion. The population in 1977 was 35,266. Al Mahadia's inhabitants are engaged in urban occupations with one-half of the population employed as laborers and the remaining half as businessmen, teachers, professionals, and government employees. The community can be classified as low to middle income with an average annual household income of $1,722. The poorest twenty percent of the population average an annual household income of $860. The community contains a much smaller squatter area with approximately 1000 inhabitants. There is a low level of unemployment in the area with most of the unemployed found among the young and recent graduates. It is estimated that eighty percent of the men and fifty percent of the women are literate. All of the children attend primary school. The climate is typical of the Khartoum region with meteorological data similar to El Faki Hashim.

The population density of Al Mahadia is 7253 persons per square kilometer, and average family size is seven persons. The housing in Al Mahadia is of the highest standard of all the communities studied. Sixty percent of the homes are built of red bricks, and many are relatively large with several rooms, a veranda, kitchen, and water closet. The average cost of the brick homes is $14,350, and they are usually built by skilled masons, carpenters, and plumbers. The houses are generally owned by the occupant on government land leased for thirty years at $690. In some cases, several low income families may live in a single house, each paying a proportionate share of the rent. The remaining forty percent live primarily in the conventional mud-walled houses. There are only a few homes built of concrete.

(1) Water Supply

Ninety-seven percent of the households in Mahadia are served by house connections, while the three percent of the population which reside in

the illegal squatter area are served by standposts. The sources of water for the system are three local wells and two main lines from the Khartoum and Omdurman system which supply water only during the winter season when sufficient water is not available from local wells. Water from local boreholes is of good quality. The water tariff for the system is $0.14 per cubic meter, with a minimum montly charge at $2.87 for consumption less than twenty cubic meters per month. Average water consumption is estimated at one hundred liters per capita per day, and the average household annual water charge is $36.12, or 2.1 percent of annual income.

(2) Sanitation

Al Mahadia has no public sewerage system, but seventy percent of the population are served by aqua privies. Most of the remaining thirty percent of the inhabitants are served by pit privies, with only a few households using septic tanks. The general design of the aqua-privy tank is that of a three meter cubic container. The walls of the tank are constructed of red bricks of local manufacture, while the bottom and lid are made of reinforced concrete. The container is divided into two compartments. The first compartment is intended for settling, storage, liquifaction, and digestion of night soils. Flow into the second compartment is accomplished through an asbestos pipe or, in times of capacity use, over the top of the separating wall. The inlet pipe to the first container is submerged at least ten centimeters to ensure a water seal and thereby prevent odor and fly problems. Effluent from the second compartment flows through a pipe into a soakaway pit. The soakaway pit is generally 2 x 2 x 2 meters in size, filled with broken bricks, and topped with sand. The pit is usually located in the street next to the fence surrounding the house. In addition to the individual household aqua privies, there are a number of large communal systems in use.

Aqua-privies in Al Mahadia have operating problems. The water level in the first compartment is often not maintained with a resulting loss of the water seal surrounding the inlet and a deterioration of the liquefaction and subsequent processes in the first compartment. Consequently, blocking of the connecting pipes and soakaway pit, filling of the main tank, and odor problems have occurred. Problems resulting from failure to add sufficient water have been compounded by the heavy use of many household aqua-privies due to the crowded housing conditions. Dissatisfaction with the aqua-privies has caused some households to resort to digging pit privies which are used alone or in conjunction with the aqua privy. In addition to the problems with aqua-privies in Al Mahadia, sullage disposal is problematic problem since ponds sometimes form in the streets of the community.

Total annual cost for a household aqua-privy unit in Al Mahadia is $248.2, or $35.5 per capita. These costs can be segregated into annual annuitized capital costs of $243.6 and annual water costs of $4.6.

(3) Public Health

Public health conditions in Mahadia have been characterized as average for the Sudan. There is in the community a hospital for women and children with about 120 beds and one out-patient clinic for men. In addition, there is a dispensary in the community, and much of the population is treated at the nearby Omdurman Central Hospital and private clinics. Data collected during this investigation on intestinal parasites in children are presented below in Table 6.7. The subject population are serviced primarily by aqua-privies.

Table 6.7

Results of Parasitological Examination of Faecal Samples in Mahadia

Parasite	Percentage Positive
E. Coli	22.5
G. Lambia	14.5
H. Nana	11.4
E. Histolytica	0.4
S. Mansoni	0.0
E. Vermiculeris	0.2
I. Butchili	0.6
T. Saginata	0.0

CHAPTER VII

NIGERIA

Nigeria, with a 1978 population of approximately eighty million, is the most populous nation in Africa. Nigeria's total land area is 924,630 square kilometers, and the country is located on the Gulf of Guinea on the west coast of Africa. The country is commonly divided into five geographical regions consisting of a low lying coastal zone, an area of hills and low plateaus immediately north of the coastal zone, the Niger Banne River Valley bisecting the country on an east-west axis, a high central plateau covered by open woodland and savana, and a mountainous region along the eastern border. The climate is tropical but influenced by moist southwest monsoon and dry northeast trade winds. Mean daily maximum temperature in the south is 31.6°C and in the north 35.0°C. Ranging from 200 centimeters annually in the coastal zone to 63 centimeters in the northern area, annual rainfall decreases as one moves northward. There are two rainy seasons in the south, March through July and September through November, and a single rainy season in the north from April through October.

The economy of Nigeria is dominated by the production of petroleum, which accounted for ninety-two percent of exports in 1974. Other industrial products include cotton, rubber, textiles, cement, metal products, and timber. Per capita income was $210 in 1974. The industrial sector employs ten percent of the labor force, while seventy percent work in agriculture. The urban population accounts for only twenty-five percent of the total population. Nigeria is largely self-sufficient in food production, and principal agricultural products are cocoa, rubber, palm oil, yams, cassava, soybean, millet, corn, rice and livestock.

Nigeria is ethnically diverse, with over 200 indigenous languages and dialects. Approximately forty-seven percent of the population are Muslim, thirty-four percent are Christian, and the remainder belong to a variety of traditional religious groups. The adult literacy rate is estimated to be twenty-five percent. Complicated by poor nutrition, water pollution, and poor sanitation, public health is poor in Nigeria. Life expectancy is thirty-nine years. Major diseases are tuberculosis, parasitic infections, malaria, dysentary, and pneumonia. Water supply and waste disposal services are inadequate throughout the country. The principal means of waste disposal are pit latrines and bucket latrines.

A. COMMUNITY SELECTION

The city of Ibadan and the town of New Bussa were selected for inclusion within this chapter. Ibadan is an old urban center with a public water supply and a variety of waste disposal practices including private pit and bucket latrines, communal bucket latrines and aqua-privy units, and flush toilets connected to septic tanks and soakaways. New Bussa is a recently constructed and settled town which has a sewered aqua-privy system.

The fieldwork for this study was conducted by Dr. Kenneth O. Iwugo of the University of Birmingham, England. Dr. Duncan Mara of the University of Dundee, Scotland, and Dr. Richard G. Feachem of the Ross Institute of Tropical Hygiene, London aided in interpreting results and preparing the final report.

B. ASSUMPTIONS

In dealing with the data collected and prepared during this study, a number of assumptions have been made. The opportunity cost of capital was taken as twelve percent, and the opportunity cost of labor was taken as eighty percent. To convert cost data to U.S. dollars an exchange rate of 1 Naira (N) to 1.6 dollars ($) was used. The conversion factor for foreign exchange was 1.19.

C. COMMUNITY RESULTS: IBADAN

Ibadan is located 120 kilometers north of Lagos, the capital of Nigeria, and is the capital of the State of Oyo. With a population of approximately 650,000 inhabitants, Ibadan is the largest pre-colonial city in Africa south of the Sahara. Ibadan is not an important industrial town since much of the industrialization in the Western Region of Nigeria has been concentrated around Ikeja. Ibadan has grown instead into a major commercial city mainly because it is a university town and the administrative capital of Oyo State and because of the enterprising nature of its Yoruba inhabitants. Apart from trading, the principal occupations in the Ibadan area are subsistence farming, pig and goat rearing, poultry raising and fishing. The major agricultural crops are yams, cassava, cow-peas, maize, coco-yams, oranges and bananas. On average each farmer ploughs and plants an area of about six hectares. The use of natural or chemical fertilizers is not widely practiced. The major industries in Ibadan are tobacco processing, food canning, furniture making, tire retreading, beverage manufacture and a variety of civil engineering (construction) industries. There are also several thousand small-scale service industries such as weaving, tailoring, cabinet-making, mechanical equipment repairing, plumbing and bricklaying. Many of these small service industries employ fewer than ten people each. Although precise figures are unavailable, it is estimated that less than thirty percent of the adult population of Ibadan is employed by either the large state industries, civil service or other industrial concerns.

The minimum daily wage for an unskilled worker employed by the public sector in Ibadan is N2 ($3.2). Frequently, the income of the major wage earner in a family is supplemented by earnings from petty-trading undertaken by other members of the family. On this basis, the income levels per household have been estimated at N1000 ($1,600) per annum. The average household size is sixteen since the family group often includes grand parents and relatives. The percentage of the adult population in Ibadan which is literate is probably not greater than thirty percent; more men are literate than women. About forty percent of the children of school age are literate.

Ibadan is situated approximately 200 meters above sea level and has a hot, humid climate. There is little annual variation in temperature, and the annual mean daily minimum and maximum temperatures are 25°C and 31°C,

respectively. The relative humidity is high in the early morning throughout the year but gradually subsides during the day. Associated with the high humidity, the cloud cover over the area is usually extensive. The average annual rainfall during the period 1905-1957 was 122.7 centimeters. Most of the rainfall occurs during the months of March through October. However, the total annual rainfall can vary considerable from year to year, ranging from 83.8 centimeters in 1956 to 160 centimeters in 1957.

There are four major rivers (streams) in Ibadan, namely the Ona, Ojumpa, Kucheti, and Ogbere. The main drainage system in Ibadan is provided by these four rivers/streams together with their very dense networks of tributaries and sub-tributaries, many of which are ephemeral. Flooding is not uncommon, with available records indicating that major floods occurred in Ibadan in 1951, 1955, 1960, 1963, 1968 and 1969. Water quality is generally poor in these rivers, particularly in their lower reaches. Solid wastes are to be seen in the streams, often clogging channels and creating pools which become septic. Vegetation is abundant along the river banks and on sandbars within the streams. Faecal matter along the stream banks is common. The quantity of flow in all streams is small during the dry season and accentuates the grossly polluted conditions of these rivers.

The stormwater drainage system in Ibadan is comprised of a large number of casually constructed open drains and ditches which collect the surface run-off and domestic sullage from the compounds and streets and which discharge into the dense network of streams and rivers. Perhaps in recognition of the dangers to health created by stagnant bodies of water, the residents of Ibadan are conscious of the need for drainage. There are earth and concrete ditches around most of the houses in the Inner Core area and along most of the streets of the Old Town. In some of the newer developments, a complete system of concrete lined surface drains (about ninety centimeters deep and seventy-five centimeters wide) has been installed. Some of these concrete lined drains are at times partially covered by precast concrete slabs to provide better vehicular access.

The watertable in Ibadan is generally at a depth of more than ten meters. Groundwater is not used as a source for water supply except at the nightsoil trenching ground where it is used to wash cartage vehicles.

Housing in Ibadan is constructed mainly of mud, bricks, sandcrete blocks and planks; the roofs are invariably of corrugated galvanized iron sheets. The cost of a plot of land (about 0.1 hectare) is about $3200. A medium sized four bedroom family house, which is built of blocks with a galvanized iron roof and wooden windows, will probably cost between $4800 and $8000 exclusive of the cost of the land. It is estimated that the labor costs of building a mud house would be about $64 per room while the corresponding cost for a brick or block house would be $160. In general the lifetime of a mud house varies from about thirty-five to seventy-five years, while brick or block houses can last for at least seventy years. Housing units are frequently inhabited by extended family groups and may provide shelter for forty or more individuals. Frequently these housing units are constructed as compounds with a surrounding mud wall rather than as individual housing units.

Ibadan is a city which exhibits a dramatic degree of diversity, particularly among its residential areas. The city has a pre-European foundation which has been termed the Inner Core or Old Town of Ibadan. It is marked by densely packed family residences and covers an area of almost 1600 hectares with an average of 25 houses and 400 persons per hectare. In 1969 it had a population of about 500,000 with an annual growth rate of approximately three percent. The Inner Core area has been almost totally unplanned. The original compounds have undergone considerable fragmentation resulting in mainly single-storied houses and mud-walled compounds located in an apparently random pattern through which passage is, for the most part, only possible on foot. The area is, however, served by a small network of public roads. Surrounding the Inner Core are the newer residential areas which have all been built in the twentieth century. In general these areas are similar to modern housing estates elsewhere in Africa and are inhabited by the more affluent residents of Ibadan.

The diverse nature of Ibadan is best summarized by the following quotation from Mabogunje's "Urbanization in Nigeria":

> "Today, and in spite of recent development, Ibadan remains a city with a dual personality. Its pre-European foundation constitutes a significant proportion of the city. Although this has been outstripped by the newer development in terms of area, it still commands attention because of its almost unbelievable density of buildings, their spectacular deterioration and virtual absence of adequate sanitation. Moreover, its inhabitants live apart from the modern immigrants. The differences in their wealth, education, acquired skills, social customs and attitudes emphasize the distance between the sections of the city."

(1) Water Supply

A community water supply system provides for domestic and commercial water needs throughout Ibadan. The source of water is local rivers, and water is extracted by direct withdrawal or from impounded reservoirs. The Eleiyele reservoir and water treatment works, with a capacity of 27,000 cubic meters per day, is the oldest water supply source for Ibadan. A newer system, the Asejiere treatment works, provides additional capacity of 81,000 cubic meters per day and is planned for expansion to 162,000 cubic meters per day to alleviate current shortage.

Water service provided by the Ibadan water system to individual household users varies according to area of the city. Residential land in Ibadan has been classified into four developmental categories by consulting engineers, and these categories with their associated level of water service are presented below:

(a) Category R1: Reservation and housing estate with future development at an average population density of seventy-five persons per hectare. In these areas water is supplied to

each household from the municipal water distribution system. All homes are equipped with the full range of internal plumbing fixtures. In areas where water supply from the distribution network is not continuous, many owners have installed storage tanks to ensure the continuity of their supply during the day.

(b) Category R2: Layout areas with future development at an average of 175 persons per hectare. In these areas water is supplied to each household from the municipal water distribution system. Homes are equipped with modern plumbing fixtures. However, in certain areas multiple dwelling units may be provided with communal toilet and kitchen facilities. Some areas of the city within this classification are at present supplied with water by tanker truck. In some cases the water supply is not continuous, and water is supplied through the distribution system on alternate days only. The use of household storage tanks is less common than in the R1 areas.

(c) Category R3: These are unplanned residential developments within the newer parts of the Inner Core area with an average density of 300 persons per hectare. Water is supplied to some houses via house connections, but standpipes are also a major source of supply. Some houses which are provided with a household water supply have the full range of plumbing fixtures, while in others only a tap is provided. The use of household water storage tanks is not common. The water supply is often discontinuous.

(d) Category R4: This category essentially comprises the older Inner Core area which has a population density of 350-430 persons per hectare. In most respects the Inner Core area is similar to R3 areas except that the standpipe is the major source of water supply for most of the residents. Throughout most of the area water is available only part of the day and in certain areas water is supplied by tanker.

Estimates for existing and projected water consumption for Ibadan are presented in Table 7.1. In addition, estimates of the population served by the various water distribution means and the the associated per capita daily water demand in the Inner Core are summarized in Table 7.2. No exact information is available on water tariffs and metering practices, but the charge for one cubic meter of water has been estimated at $1.6.

TABLE 7.1

Existing and Projected Water Consumption for IBADAN

Land Use Category	Water consumption (liters per capita per day) 1969	1971	1980	2000
R1	150	150	185	260
R2	57	95	120	177
R3*	22	22/57	22/57	22/57
R4 (Inner Core)*	22	22/57	22/57	22/57
Institutional	N/A	7500	7500	7500

* 22 liters per capita per day in areas served by standpipe only; 57 liters per capita per day in areas served by standpipes and comfort stations.

TABLE 7.2

Estimates of Average Per Capita Daily Water Demand
In the Inner Core of IBADAN

Type of Service	Population served	liter per capita per day	Total Water demand (liters per day)
Standpipe	435,673	19	8,277,787
Single tap supply	24,000	26	624,000
Multiple tap supply	8,000	95	760,000

(2) Sanitation

A wide range of sanitation technologies are currently in use in Ibadan. In the Inner Core area pit latrines, bucket latrines, aqua-privies and flush toilets connected to septic tanks are used. Sullage is disposed of in the open surface water drainage system. In addition to these private facilities, there are a few public toilets -- pit and bucket latrines and

aqua-privies. In the other, newer areas of the city flush toilets with septic tanks and soakaways are the main form of sanitation, although there are a few pit and bucket latrines. Sullage is discharged to open surface water drains, although in some of the more recent developments, seepage pits are used. A few of the larger institutional, commercial and industrial concerns have their own small, private sewage treatment works. The Ibadan Wastes Disposal Board (IWDB) is the municipal authority responsible for the administration of sanitary facilities in the city.

(a) Pit Latrines

Pit latrines serve at least 50,000 persons in the Inner Core and similar areas of Ibadan. They consist essentially of a circular pit approximately one meter in diameter with depths of up to four meters. The pit is covered with a concrete squatting plate into which a thirty to forty centimeter diameter hole has been cut. A wooden cover is normally used to close the drop hole.

Pit latrines in Ibadan are generally located either centrally in the compound or immediately adjacent to a dwelling. In addition, they are generally open. In cases where a superstructure is provided, the superstructure is rectangular in shape and consists of casually assembled galvanized iron sheets.

For a household of sixteen, the filling time for a pit latrine is estimated to be two to three years. When soil conditions permit, successive pits are constructed as each pit is filled. In many areas, however, the occurrence of rock makes the digging of pits difficult and expensive. The pit latrines are normally constructed and operated in pairs. When one pit is filled, it is sealed and the previously filled second pit is desludged and placed in operation. The pit contents are disposed of on the surface of the ground in the vicinity of the latrine.

The problems encountered with the use of this type of excreta disposal facility result from deficiencies in its design and operation. Due to the variety of ground water levels, soil types, standards of construction and maintenance in Ibadan and considering the large number of such facilities, one would expect a significant number of inadequately functioning installations. Generally, however, pit latrines are well constructed, maintained and operated. Those pit latrines which were used by large households perform least satisfactorily, especially with respect to fly and odor nuisance.

Perhaps the most serious public health and aesthetic problem associated with the use of pit latrines in Ibadan lies with the practice of disposing of the pit contents on the surface of the land in the immediate vicinity of the pit. This practice has probably been adopted because of the small lot sizes which make gardening unattractive and also make it impossible to relocate the latrine each time it is filled.

Estimated costs for pit privies in Ibadan are presented below in Table 7.3.

Table 7.3

Annual Household Costs for Pit Privies in IBADAN (1978 US$)

Total annual costs	$45
Total annual substructure costs	$21
Total annual substructure costs with all labor provided by householder in leisure time	$17

(b) Bucket Latrines

There are 2,604 bucket latrines in the Inner Core area serving an estimated 100,000 people; 2,377 of these are private facilities, and the rest serve government offices, public latrines, and the Nigerian Railways Compound. Private bucket latrines in Ibadan are usually located in the household compound but are separated from the house. The bucket latrines are comprised of a simple superstructure of timber and corrugated iron sheets which houses a wooden or concrete seat under which a thirty-eight liter bucket is placed. The standard bucket is made from galvanized iron and is approximately thirty-four centimeters deep and thirty centimeters in diameter. Each latrine serves thirty to forty individuals.

The household collection of nightsoil is administered by the Liquid Wastes Section of the Ibadan Wastes Disposal Board (IWDB). The employees of this Section consist of 1 superintendent, 10 district supervisors, 1 disposal gang inspector, 1 public facilities inspector, 105 house-to-house night soil collectors, 19 removal laborers, 19 trenching ground laborers and 6 drivers. The contents of the 2604 buckets, totalling approximately sixty cubic meters of night soil, are normally collected every one or two days and transferred to the trenching grounds at Ogbere where the nightsoil is buried in shallow trenches. Collection is accomplished by scavangers who empty the contents of the household buckets into larger pails of forty-five liter capacity which are then transported on foot to transfer depots where they are emptied into larger depot containers.

The transfer depots are merely roadside areas designated as pre-arranged collection centers which the transfer vehicles routinely service. There are currently fifty depots in operation, and most of these are not enclosed. The depot containers, which are provided by the IWDB, have a capacity of one hundred liters. These containers are currently fabricated

from 160 liter metal asphalt drums which are cut to size and fitted with handles. These containers are distributed to the depots between 4 and 6 p.m. each day. The distribution and collection of depot containers are carried out with transfer trucks staffed by four laborers, a driver and a supervisor. At the present time, five collecting or transfer vehicles are available for use. In addition to the transfer vehicles, there is also a collection truck used entirely for the desludging of public aqua-privies and private septic tanks when the prescribed fee is met.

When the nightsoil has been collected from the depot, it is transferred to the trenching grounds. Two trenching grounds are in operation at present; the Ogbere trenching ground and the Railway Quarters trenching ground. The Ogbere trenching ground is the bigger of the two, covering an area of sixteen hectares. The nightsoil is buried each day in shallow hand-dug trenches which are approximately fifty-four centimeters deep, one meter wide and four meters long. Nightsoil is placed in the trenches to a depth of about thirty centimeters, and the trench is then backfilled with soil. The interval between successive trenching operations in the same area is approximately one year.

The water supply for vehicle and container washing and the hygiene of the workers is provided at the trenching ground by two dug wells and a water tanker. The hand-dug wells are each equipped with two small pumps with gasoline engines and two 1.9 cubic meter storage tanks. The capacity of the wells is estimated to be less than six cubic meters per day. A washing slab is provided for the washing of vehicles. The water supply by the tanker is unreliable since the tanker itself is not in satisfactory operating condition.

The bucket latrine system involves human contact with excreta and thereby presents a number public health risks. It has been characterized as the least effective and most undesirable method for excreta disposal of the methods presently in use in Ibadan. A number of features which result in serious public health risk or nuisance have been noted. At the household level, open buckets in unprotected areas, corroded buckets which result in spillage and inadequate cleaning of containers and disposal of washwater are frequently cited as problems. Problems associated with transport of nightsoil to the transfer depot include the use of open buckets, frequent spillage at the depot, and irregularity of household pick-up.

The problems associated with transfer depots are numerous. The present depots are not enclosed and as a result are offensive to the general public. Spillage resulting from the transfer of the contents and handling of the containers, in addition to the nuisance of open containers along public roads and near residences and places of business, result in grossly unsatisfactory conditions. The lack of suitable alternative sites resulting from the congested conditions further intensifies this problem. Laborers are employed to maintain the depot areas, but without properly cleanable surfaces their work cannot be done effectively. Collection from the depot is severely

restricted by the shortage of transfer vehicles. Of the five vehicles which are currently allocated for the conservancy service, only two are in satisfactory working condition. An insufficient number of containers is provided at the transfer depots, and this shortage often results in overfilling and consequent spillage during the handling of the containers.

The trenching method of disposal is probably the most effective operating component of the bucket latrine system, and one which is dictated by tradition and the current absence of suitable and cheaper alternative methods of disposal. However, there are also notable deficiencies in operating practices at the trenching grounds. Most importantly, the existing water supply is inadequate to meet the requirements for vehicle and container washing and for the personal hygiene of the conservancy workers. As a result, the containers are never washed, and in the dry season there is frequently insufficient water for vehicle washing. Protective clothing is not worn by the conservancy workers, resulting in frequent and unavoidable direct contact with human excreta. No medical care nor health education is provided for the conservancy workers.

Annual costs for the bucket latrine system in Ibadan are presented below in Table 7.4.

Table 7.4

Annual Household Cost of Bucket Latrines in IBADAN

(1978 US$)

On-Site	
Capital	21.2
Collection	
Capital	34.1
O & M	73.7
Treatment	
Capital	8.9
O & M	8.8
Total	146.7
Cost Per Capita	3.9

(c) Aqua-privies

In 1969 the Federal Government of Nigeria in association with the World Health Organization initiated a study to develop a Master Plan

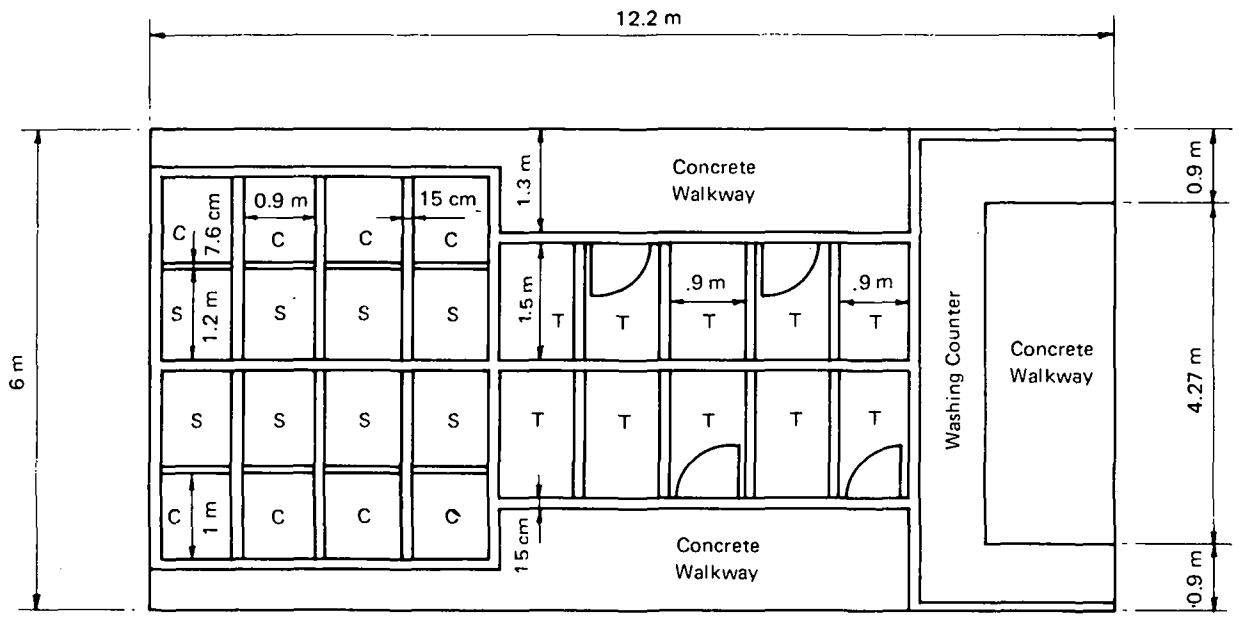
for Wastes Disposal and Drainage within the city of Ibadan. One outcome of this study has been the development of communal aqua-privies, known as "comfort stations", to serve the extended family complexes within the Inner Core area. Most aqua-privy systems found in Ibadan are located in these large, family comfort stations. However, a few aqua-privies have been installed at public locations such as motor parks (truck parks).

Each family comfort station is comprised of aqua-privy toilets, shower rooms, and a laundry. All sullage is discharged into the aqua-privy tank. Since each comfort station is reserved exclusively for the members of the extended family on whose land it is located, the size of the installation varies with the size of the family. At present, there are twenty-four comfort stations in use with approximately 4,000 individuals serviced. Another eight stations are awaiting commissioning, and fourteen are under construction. The WHO target for 1980, which is not likely to be met, is one hundred comfort stations.

Figures 7.1, 7.2, and 7.3 show the basic design features of the aqua-privy unit and comfort station. The size of the aqua-privy toilet compartment at the comfort station averages 1.5 meters long, 1 meter wide and 2 meters high, and each compartment is provided with a water tap at a height of about .75 meters above floor level. An asbestos cement drop-pipe, ten centimeters in diameter and eighty centimeters in length, extends from the concrete squatting slab into the water tight tank. The drop pipe extends about twenty centimeters below the liquid level in the tank, thereby leaving a freeboard of approximately sixty centimeters. Depending upon the number of people served by the comfort station, the tanks may be either two or three chambered. Generally, those tanks serving up to 350 people have two chambers, whereas those serving over 350 people are three-chambered systems. The volume of the aqua-privy tank is usually governed by the population served and the required frequency of desludging. Current design practice allows for approximately five years or more between desluding of the tank. However, it is apparent after the review of the design specification of the existing aqua-privies that this design practice has not been adopted at many of the existing comfort station aqua-privies. The reasons for this may be economic considerations or the provision of insufficient land by the families for construction of the tank. A vent pipe which is about two meters high and has a screened outlet is provided for each chamber of the aqua-privy tank. An effluent pipe leads the effluent from the tank to the soakaway or to the nearest stream or surface water drainage channel. An inspection chamber is generally provided in this effluent line. One precast concrete manhole cover is provided for each chamber of the aqua-privy tank.

Comfort stations are currently built and operated on the principle of self-help. Extended families in the Inner Core donate the land (costing approximately $8,000 per hectare) and make an additional advance contribution of $1,280 - $1,600 for the labor required for the construction of the comfort station. The cost of materials and additional labor are covered by grants from the central government with the Ibadan Wastes Disposal Board acting as the implementing agency.

FIGURE 7.1: TYPICAL LAYOUT OF COMFORT STATION IN IBADAN, NIGERIA



C = Changing Area
S = Shower Unit
T = Toilet Unit

PLAN

NOTE: For Male Section, Partitions between Changing Areas may be Removed to Form a Common Changing Room.

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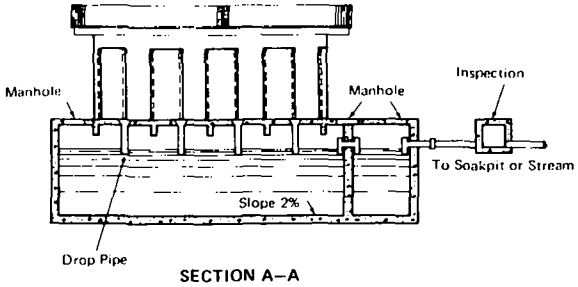
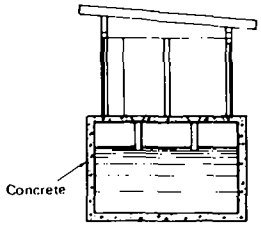
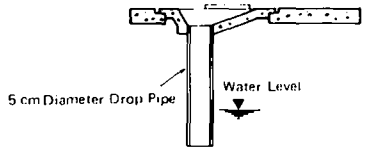
FIGURE 7.2: AQUA PRIVY UNIT IN COMFORT STATION IN IBADAN, NIGERIA



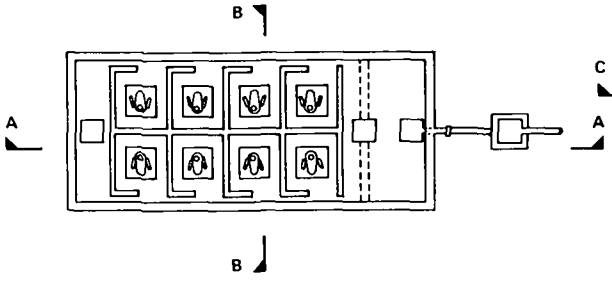
SECTION A–A



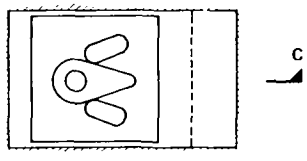
SECTION B–B



SECTION C–C
(N.T.S.)



PLAN



PLAN OF
SQUATTING SLAB
(N.T.S.)

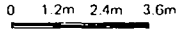


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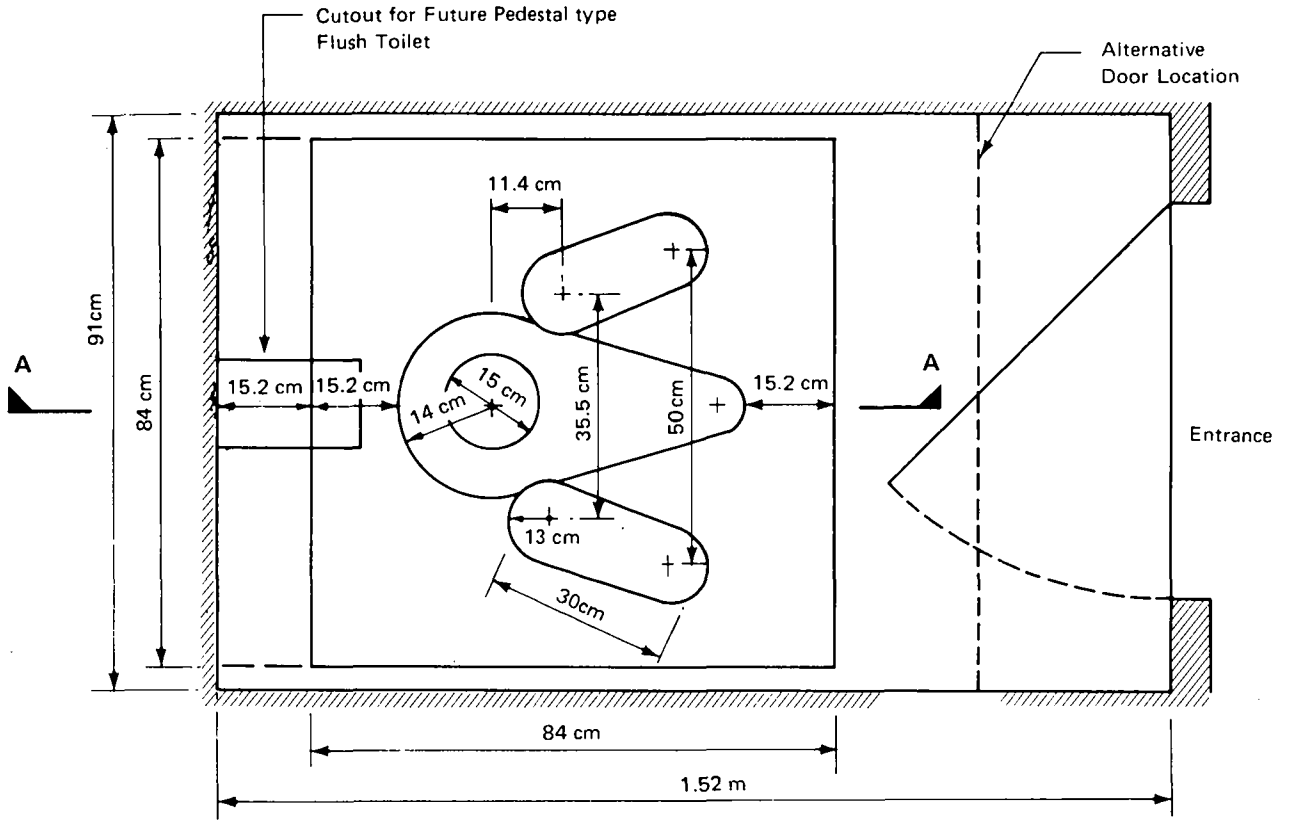
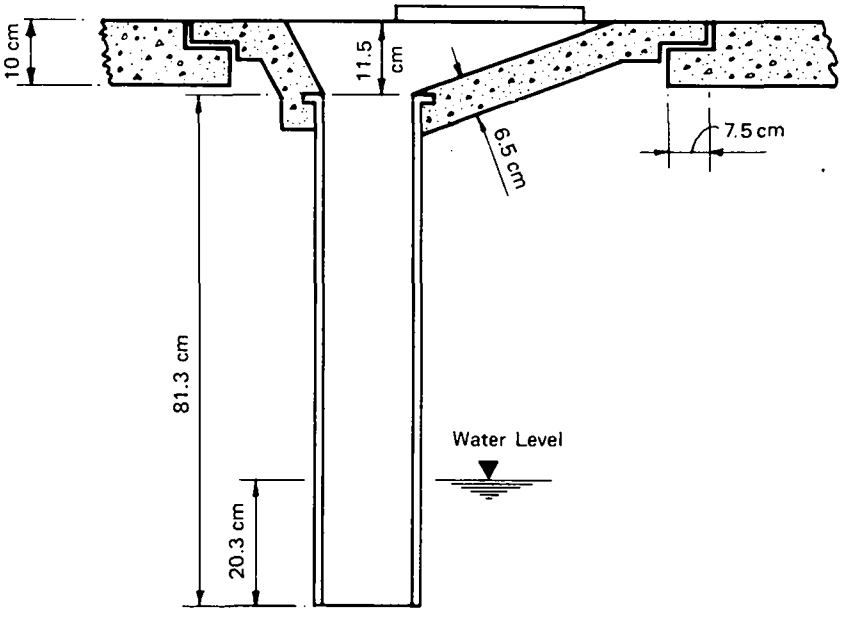
FIGURE 7.3: LAYOUT OF AQUA PRIVY UNIT IN IBADAN, NIGERIA



PLAN



SECTION A–A

Most comfort stations are constructed by contract labor. After construction, the family supplies the attendants to clean and maintain the facilities and is responsible for meeting the costs of electrical and water supply, maintenance, minor repairs, sludge removal and effluent disposal services. The IDWB operates a desludging service. Costs for a comfort station comprised of 28 toilets, 16 showers, and a laundry block and serving 800 people are presented in Table 7.5.

Table 7.5

Costs for IBADAN Comfort Station
(1978 US$)

Capital	3,585.6
less costs of laundry and shower facilities	842.5
	2,743.1
Operations and Maintenance	590.4
Flushing water	1,868.8
TOTAL	5,202.3
Per capita cost	6.50

Although aqua-privies have been well received, and many units operate with a high degree of user care and satisfaction; some problems associated with the construction and operation of comfort stations in Ibadan have been noted:

(i) A major problem associated with the operation of aqua-privies is the soil conditions which are not really suitable for soakaways. This, together with indiscriminate dumping of refuse in the open drains and ditches has led to the ponding of foul water in the vicinity of several Comfort Stations. An associated operational problem has been the breakage of the asbestos cement, effluent pipes.

(ii) Although families are willing to donate land, only a few of the families can raise the advance labor cost of $1,280 to $1,600.

(iii) Vehicular access in the Inner Core area is difficult and at times impossible, and as a result it is not easy to desludge the aqua-privy tanks of some comfort stations with a vacuum tanker truck.

(iv) Water supply in the Inner Core area, as in many parts of Ibadan, is both unreliable and intermittent, and as a result excreta cannot be flushed down the drop-pipe into the aqua-privy tank in many cases. A water storage tank would help alleviate this problem.

(v) Water supply to the comfort stations is metered. In order to economize on water, sufficient water may not be used for flushing or topping up purposes. The laundry room is, as a result, also rarely used.

(vi) The shower rooms measure on average only 1 x 1.5 meters. This small bathing space results in water being splashed out into the corridor which is consequently always wet. As a result doors and door frames in the facility tend to rot more quickly.

(vii) Some families have not been able to afford to recruit attendants to perform routine maintenance at the comfort stations. These stations quickly fall into disrepair.

(3) Solid Waste Collection and Disposal

Solid waste collection and disposal presents one of the greatest environmental problem in Ibadan at the present time. A common occurrence is the presence of large quantities of solid wastes in streams, street ditches, open drains and on open land.

The solid waste collection and disposal program is under the administration of the Ibadan Wastes Disposal Board. Almost all the solid wastes generated in the Inner Core area are collected by the depot method. The depot is comprised of a concrete block (or sometimes a mud block) structure which is about 1 1/2 meters high, 4 meters wide and 3 meters deep. To permit vehicular access, these depots are located at the edges of the few public roads in the area. Residents are expected to carry their wastes in baskets from their homes to the nearest depot. In many cases, the distance between the home and nearest depot is so long that constant use of the depots is discouraged. This results in solid wastes indiscriminately deposited on open pieces of land and in many of the open drains, ditches and streams in the Inner Core area.

In the modern residential areas of Ibadan, curbside pickup is practiced. Dustbins are located either by the front gate or the kitchen door of a house. The dustbins are then collected by laborers who empty their contents into a truck.

There are several disposal sites in operation in Ibadan. With a few isolated exceptions, these disposal sites are located at least seventy-five meters from the nearest dwellings. At all sites, the method of operation is dumping with little or no earth cover, and there is sporadic burning at most of the sites. The problems of fly propagation, rodent harborage and odor do not appear excessive.

D. COMMUNITY RESULTS: NEW BUSSA

New Bussa is a resettlement town built during 1964-68 to accommodate the former residents of Bussa, a town submerged by the impounded waters of Lake Kainji. New Bussa was originally inhabited in 1968 and is located about twenty kilometers west of the Kainji Dam and about five hundred kilometers from Lagos. The nearby Kainji hydro-electric installation is the major source of electricity for Nigeria and several neighboring African countries. Although much of New Bussa is inhabited by the former residents of Bussa, a substantial portion (approximately 25%) of the present population are "immigrants" who are primarily members of the Nigerian Armed Forces or employees of the National Electricity and Power Authority (NEPA) which administers the hydroelectric complex.

Due to its construction as a resettlement town, New Bussa is a reasonably well-planned community. Major public utilities such as water supply and general sanitation are provided for and managed jointly by NEPA and Borgu Local Government Authority. A set of 256 enclosed-family compounds were provided for the resettled inhabitants of Bussa. These enclosed compounds, presently housing between fifteen and forty individuals each, contain a house, water tap in the courtyard, a sewered aqua-privy, and a laundry/shower room. The houses are built of sandcrete blocks with corrugated asbestos sheets for roofing. The sanitation block, which is also built of sandcrete blocks, houses the aqua-privy toilet and the shower compartment. The courtyard water tap is located immediately outside the sanitation block.

(1) Water Supply

Water is presently supplied to New Bussa and its environs by a water treatment plant owned and operated by NEPA. This treatment plant, which has a production capacity of approximately 3.75 cubic meters per minute, extracts its water directly from Lake Kainji. The treatment works consist of five vertical sedimentation tanks (each having an area of twenty square meters) and six pressure filters. The treated water is stored in four storage tanks of 1,800 cubic meter capacity each. Three of these tanks are continuously in use and the fourth is a standby unit. The discharge rate of the distribution pumps is about 200 cubic meters per hour. Total water consumption, which is satisfied by continuous pumping, is approximately 2,700 cubic meters per day. At present individual household connections are not metered and there is no system for charging for the water consumed. The unit production cost of water is not available from NEPA.

This water supply system fails to adequately meet the needs of New Bussa. Supply is intermittent, and a complete loss of supply for periods of

up to four days during the week is common. A new water treatment facility is currently under construction in New Bussa, and it is hoped that the current water shortage will be alleviated when these new waterworks are completed.

(2) Sanitation

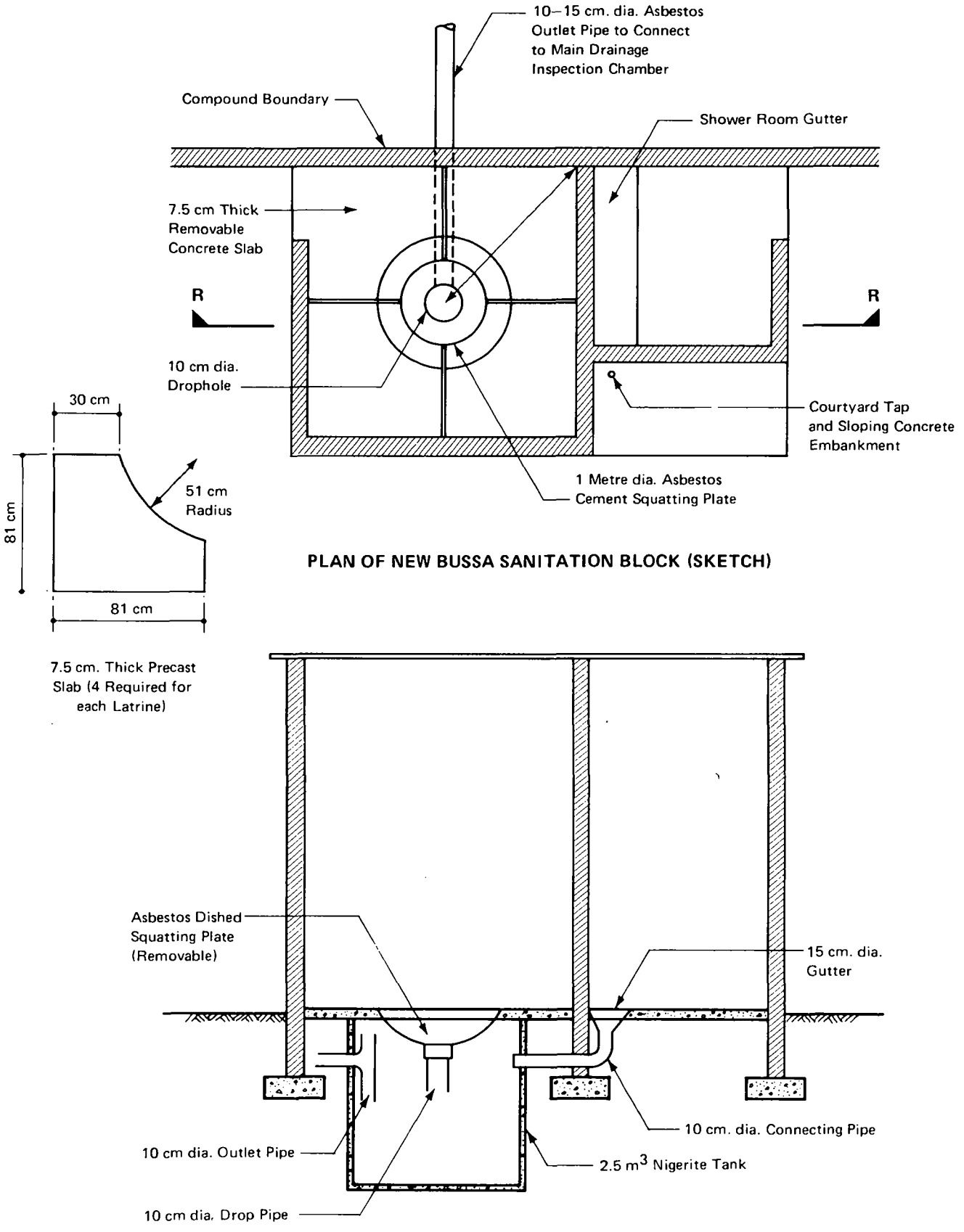
Several excreta disposal techniques serve the population of New Bussa. A sewered aqua-privy system serves most of the resettled residents of old Bussa. A flush toilet system serves most of the employees of NEPA and the members of the Nigeria Armed Forces. Two public latrines are also equipped with flush toilets. Pit latrines are used in some schools and health centers. In addition, some residents serviced by aqua-privies have installed pit latrines as an extra system for the exclusive use of some members of the family or as an alternative system when a shortage of water precludes the use of the sewered aqua-privy.

(a) Sewered Aqua-privies

A sewered aqua-privy system was provided for the resettled inhabitants of old Bussa. The decision to sewer the system was motivated by poor seepage capacity of the soil at the resettlement site. Each of the 256 compounds built during the resettlement program is provided with a sanitation block contiguous to the property line and containing an aqua privy, shower, and laundry. The size of the sanitation block is approximately 3.3 x 2.5 x 2.7 meters high. About two-thirds of the sanitation block is used for the aqua-privy, and the remaining one-third for the shower room. The drain from the courtyard water tap empties into a fourteen centimeter diameter gutter which is located inside the shower room compartment. This gutter drains directly into the aqua-privy tank. The plan of the sanitation block is shown in Figure 7.4.

The aqua-privy consists of a segmented 1.8 square meter precast concrete slab (fifty millimeters thick) placed over a precast "Nigerite" ten-person septic tank (2.5 cubic meter capacity). A circular hole, having an approximate diameter of one meter is cut in the slab to accommodate a circular squatting slab which includes a tapered drop pipe. This ten centimeter diameter and forty-five centimeter long asbestos pipe dips about fifteen centimeters below the water level in the aqua privy tank. Leading from the tank is a ten or fifteen centimeter diameter asbestos cement pipe to carry the effluent. These pipes are located approximately fifteen centimeters below the squatting plate and are L-shaped (instead of the more conventional T shape). They lead into a street junction box (inspection chamber) which is about 0.5 meters square and 0.6 meters deep. These connecting pipes are generally exposed; and due to the grouping of sanitation blocks, pipes from four nearby aqua-privy units connect to a single street junction box. The street junction box is connected to the main sewer line, a fifteen centimeter diameter asbestos cement pipe. The sewer line leads to one of two waste stabilization lagoons located on the eastern and western sides of New Bussa. Concrete manholes with lightweight concrete covers are located at regular intervals of approximately eighty meters along the main sewer lines.

FIGURE 7.4: SANITATION BLOCK IN NEW BUSSA, NIGERIA



PLAN OF NEW BUSSA SANITATION BLOCK (SKETCH)

SECTION R–R (SKETCH)

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Each of the two sewage stabilization ponds at New Bussa covers an area of approximately one hectare. Both are single-cell facultative ponds which receive, in addition to the aqua-privy effluent, effluent from the septic tanks serving the NEPA employees. The influent enters the pond through a ten centimeter diameter asbestos pipe which discharges in the middle of the pond. The end of the pipe is fitted with a T-junction. The outlet of the pond is also a ten centimeter diameter T-shaped asbestos pipe which discharges the partially treated sewage into a local stream. Each stabilization pond is completely fenced and provided a locked gate. Annual household costs for the New Bussa aqua-privy system are presented in Table 7.6.

Table 7.6

Annual Household Cost for Sewered Aqua-Privy System in New Bussa Nigeria
(1978 US$)

On-Site	
Capital	143.7
O & M	32.0
Water	58.4
Collection	
Capital	164.4
O & M	22.0
Treatment	
Capital	96.0
O & M	3.4
Total	519.9
Cost Per Capita	20.8

Of the 256 aqua-privies originally constructed in New Bussa between 1965 and 1968, all are still in operation. Most of the aqua-privy units are kept extremely clean, and odor and fly nuisances are generally absent. Many residents take considerable pride in their aqua-privy systems as evidenced by the provision of additional facilities to enhance the performance of the system. For example, some owners have connected an extra water tap in the aqua-privy compartment so as to avoid the generally disliked practice of having to carry water from the courtyard water tap into the aqua-privy compartment. In some cases, wire gauze or mesh screens have been incorporated into the outlet of the shower room gutter in order to reduce the risk of blockage of the aqua-privy system.

Desludging of the aqua-privies is the responsibility of the owner or users. The aqua privies are desludged manually, and the heavy concrete slabs have to be removed for this purpose. The sludge is generally buried in the courtyard in a ditch dug adjacent to the latrine block. It is unlikely that manual desludging will be replaced by a vacuum tanker service in the near future. The Borgu Local Government Authority currently has no vacuum tankers, and the annual financial allocation for its Health Department which administers the aqua-privy system rarely exceeds $4,800. The capital cost of a vacuum tanker in Nigeria is about $43,200 and annual maintenance cost is about $3,200. Although not completely satisfactory because of small lot sizes, the practice of burying the desludged contents of the aqua-privy tank in trenches dug in the courtyard is therefore likely to continue in New Bussa. If a vacuum tanker service were in operation, the sludge could easily be treated in the waste stabilization ponds. Desludging frequencies and other operational data are presented in Table 7.7 for nine selected aqua privies.

Inspite of this sytem's general success, there have been a number of problems associated with its design and operation. The predominate complaint among the owners of the aqua privies is the shortage of water which is so necessary to operate the system effectively. Water supply in New Bussa is intermittent, and according to residents, odor and fly nuisance occurs during periods of acute water shortage. The aqua privies may also become clogged during periods of water shortage, and as a result some families intensify the use of privately constructed pit latrines.

Design deficiencies at the household site include the lack of strategically placed inspection chambers. Although some of the aqua-privy effluent pipes were provided with inspection chambers in the courtyard before joining the street junction boxes, inspection chambers were rarely provided at locations where the pipes changed directions. As has been indicated, many of the connecting pipes are uncovered and as a result run the risk of being damaged by vehicles or passers-by.

With regard to the collection system, many of the lightweight precast concrete manhole covers have been broken and it is possible to observe that flow in most of the sewers is very low and indeed often non-existent, principally because of the shortage of water. Lumps of excreta and shredded paper which presumably had been used for anal cleansing are frequently seen lying in the sewers. These materials escaped from the aqua-privy tanks partly because of their poor design and partly because of the fractured state of many of the outlet pipes leading from the tanks to the sewers. This deposited material quickly stops the flow in the sewers when water becomes available for topping the aqua-privy tank. Consequently, blocked and overflowing inspection chambers and manholes are a common sight in New Bussa. There is an acute shortage of operational personnel in the Health Department of Borgu Local Government Authority, and as a result no operators have been specifically allocated the duty of clearing the blocked sewers (which could be done by a simple rodding operation).

Table 7.7: Summarized Data on Operation of Aqua-Privies in New Bussa

Household	Occupation and annual salary of head of household	Population served	No. of times tanks desludged since 1968	Average cost of desludging and cost	Religion	Additional facility incorporated by user
A	Town Councillor (N2500)	25 (+50% for visitors)	3	$24 (1976)	Moslem	Pit latrine for contingency
B	Health Officer (N2500)	18 (+25% for visitors)	2	$24 (1975)	Moslem	Pit latrine for contingency
C	Farmer (N700)	40	7	$16 (1975)	Moslem	-
D	Businessman (N1200)	15	1	$ 9.6 (1974)	Christian	Extra tap in toilet and gauze incorporated to bathroom gutter
E	Farmer and tailor (N400)	20	4	$22.4 (1977)	Moslem	-
F	Petty trader	16	1	$ 9.6 (1975)	Moslem	-
G	Mechanic (N900)	14	1	$16 (1974	Christian	-
H	Cobbler (N700)	17	2	$19.2 (1976)	Christian	-
I	Labourer (N700)	18	2	$12.8 (1975	Moslem	Pit latrine for occasional use

In 1977, the Borgu Local Government Authority spent about $4,800 in clearing blocked sewers and replacing broken inspection chamber covers. The sewer clearing operation is carried out by contractors who charge an average of $112 to unblock an inspection chamber. This suggests that the employment of full-time attendants or laborers would be justified since the annual maintenance cost, which is paid mainly to contractors, is sufficient to employ three or four full-time laborers and provide the necessary rodding equipment.

Operation and maintenance of the two waste stabilization ponds are very poor. The edges of the ponds are overgrown with weeds, and scum has accumulated on the surfaces of the ponds. Part of the poor maintenance problem is that no full-time attendants have been allocated to the ponds by NEPA.

CHAPTER VIII

GHANA

Ghana is located on the West Coast of Africa on the Gulf of Guinea. The country has an area of 238,539 square kilometers, and the population was estimated at slightly over ten million in 1977. Ghana is a country of varying topographical and ecological regions. The coastline is backed by low lying, unproductive plains. Inland and particularly to the north is found a belt of tropical rainforests. North of this forested belt are regions of low bush, savana, and grassland plains with altitude ranging between 100 and 400 meters. Similarly, the climate of Ghana varies according to region. The coastal belt is warm and humid, and the north is hot and dry. In the coastal zone annual rainfall is eighty-three centimeters.

The economy of Ghana is primarily agricultural with sixty percent of the working population employed in agricultural pursuits. In 1974, the per capita GNP was $380. The principal agricultural products are cocoa, timber, coconuts, coffee, subsistence crops and rubber. Ten percent of the labor force is engaged in industry with principal products being lumber, minerals, light manufactures, and aluminum. In 1970, twenty-nine percent of the total population lived in urban areas. In recent years the urban population in some of the large urban areas has been growing annually at rates of four to five percent, while growth in the rural areas is estimated at 1.2 percent. The principal religions practiced in Ghana are animism (45%), Christianity (43%), and Islam (12%). The literacy rate is estimated at twenty-five percent.

The water supply and sewerage sector is not well developed in Ghana. Water-borne and sanitation related disease such as guinea-worm, bilharzia, hepatitis, typhoid, dysentary and a whole range of other enteric diseases are prevalent in Ghana, particularly in the rural areas, and average life expectancy is forty-eight years. In 1977, approximately forty-two percent of the total population had access to public water supplies. Ninety-four percent of the urban population was served (half by house connections and half by standpipes) while only twenty percent of the rural population had access to a public water supply.

Water-borne sewerage was first introduced in Ghana in 1958 as part of a newly built industrial township. Since that time a limited number of sewerage systems have been built, but aqua-privies remain the most common form of exreta disposal in newly built urban houses. Private bucket latrines and public toilet facilities continue to serve large segments of the urban population. Excreta disposal in rural areas is accomplished partly through the use of pit privies and occasional septic tanks, but the use of unaltered, open areas still predominates in rural Ghana.

A. COMMUNITY SELECTION

The second largest city of Ghana, Kumasi, was selected for study in this chapter. Kumasi has a large, publicly administered bucket latrine system as well as buckets and aqua-privies in communal latrines.

The field work for this study was conducted by Dr. Kenneth O. Iwugo of the University of Birmingham, England. Dr. Duncan Mara of the University of Dundee, Scotland, and Dr. Richard G. Feachem of the Ross Institute of Tropical Hygiene, London aided in interpreting results and preparing the final report.

B. ASSUMPTIONS

In dealing with the data collected and prepared during this study, a number of assumptions have been made. The opportunity cost of capital was taken as twelve percent. To convert cost data to US dollars an exchange rate of 1 cedis to 0.87 dollar ($) was used. The conversion factor for foreign exchange was 1.75.

C. COMMUNITY RESULTS: KUMASI

Kumasi is located some 270 kilometers north of Accra, the capital of Ghana. It has always occupied an economically strategic position in Ghana as it lies on the major trade routes connecting the northern and southern parts of the country and as it is the political center of the extensive territories controlled by the powerful Ashanti tribe. The establishment of one of Africa's first Technological Universities in Kumasi about twenty-five years ago and the increase in the city's population from 218,172 in 1960 to about 500,000 in 1978 are clear evidence of the city's social and economic importance. The annual population growth rates for Kumasi are estimated to have been 4.5 percent up to 1970, to be 4 percent up to 1980 and to continue at 3 percent until the year 2000, by which time the population is expected to reach one million. These annual growth rates are not only higher than global population growth rates but are also higher than those of many other large West African cities (e.g., Ibadan, Nigeria at 3% per annum). The population density in Kumasi varies from about 6200 persons per square kilometer in the Ridge district to about 62,000 persons per square kilometer in the Fanti New Town and Old Town districts. Average population density for the city is approximately 12,500 persons per square kilometer.

Average annual rainfall in Kumasi is 142 centimeters. Eighty-five percent of the annual precipitation normally falls within the eight months of March through October. On average, rainfall occurs at least once in every three-day period during this wet season. Generally, the rainfall is of short duration and of comparatively high intensity with the result that during much of the year the surface water drains are flushed frequently by run-off. This, of course, is not the case during the dry months when the objectionable effect of the existing arrangements for sullage disposal is most evident.

Except in some of the most recently developed suburban areas of Kumasi, where covered drains are used, surface water is drained away in open channels. In general these channels are concrete-lined and carry sullage as well as the surface water from roads and adjacent properties. There are, however, some parts of the city in which the channels are not lined and are little more than the results of erosion by sullage and surface water run-off.

Because of its good natural drainage characteristics resulting from a topography of valleys and ridges, Kumasi has no serious problem of surface water disposal. Furthermore, because the natural surface gradients are normally relatively steep, small roadside or "sanitary-lane" open-channel drains can provide adequate capacity for the rainfall run-off from quite large areas. Minor floods have been known to occur in Kumasi but they have never created serious problems.

Practically all the water courses of Kumasi are polluted to varying degrees because of the normal practice of disposing of sullage water in the surface water drainage channels. In some water courses the flow is almost entirely sullage from houses. Due to the high density of the development within its catchment area, the River Nsuben, in particular, is grossly polluted. The degree of pollution is highest during the dry season. In spite of the substantial water pollution, little nuisance or health hazard is inflicted upon the residents of Kumasi. This is due primarily to the topography of the city and its resultant development along numerous ridges which serve to separate the water courses from centers of population. The nuisance and health hazard which the polluted streams and rivers may cause are imposed upon those downstream who rely upon the streams and rivers, or shallow wells, for their water supply.

Housing in Kumasi can be categorized into two basic groups according to construction material and period of construction. The typical older house in Kumasi is a single story unit constructed of mudblock walls with corrugated metal sheet roof and arranged with eight or nine rooms around a small courtyard. There is also a small washroom and there may be a bucket latrine. Food preparation and cooking is generally done in the courtyard. Comparatively few of these houses have piped water supply, but most are supplied with electricity. Most commonly, the courtyard is not paved.

Newer houses are generally well constructed with precast concrete blocks and corrugated steel or aluminum sheet roofing. Those houses in the central parts of the city and to the north are frequently constructed as two or three story units with numerous rooms, each accommodating several people. There is usually a communal yard at the back of the house with communal cooking and washing facilities, not more than one water closet and one or two water standpipes.

Additional information concerning housing, number of households and inhabitants, and household income are presented in Table 8.1. This information is extracted from the "Kumasi Land Use Study" carried out in 1975 in the Department of Housing and Planning Research of the University of Science and Technology, Kumasi.

Table 8.1: Housing in Kumasi

Type	Residential areas	Average site area (square meters)	Average ground floor area (square meters)	Site coverage ratio (%)	Average no. of rooms per bldg	Average no. of households per bldg	Average no. of residents per bldg	Room occupancy	Average Income per household ($)	Average condition of structure
Single family	Ridge, Donyame, Kwadaso	2612	279	10.7	5	1	8	1.6	3710	Good
Estate Housing	Asawase, Kwadaso, Estate, North & South Suntreso, Zabon, Zongo	722	196	25	12	5.6	32	2.7	1528	Fair
Traditional compound	Ashanti, New Town, Old Amakom, Abuabo	765	324	42	11	7	27	2.4	994	Fair
Medium rise	Ridge, Mbrom, Old Amakom, Dichemso, Ashanti, New Town, Nhyiaso	1417	297	21	16	7.9	29	1.8	2619	Good

(1) Water Supply

It is estimated that over eighty percent of the population of Kumasi have access to a piped water supply. Previously, a substantial proportion of the population was served by public standpipes which were located in such places as the public sanitary areas. However, there is now a deliberate policy of the Ghanaian government to reduce the use of standpipes by neglecting their repair and maintenancce and, as a result, indirectly force connections to individual houses.

Water is supplied to Kumasi by the Owabi and Barikesse water treatment works. The Owabi works started production in 1931-32 and currently has a production capacity of 9500 cubic meters per day. The Barikesse works which was commissioned in 1970/71 has an average current production capacity of about 3200 cubic meters per day. Both works are conventional treatment works having aeration, sedimentation, filtration and chlorination units. With the present estimated population of about 500,000 in Kumasi and assuming twenty-five percent wastage through leakage, this represents an average water consumption of sixty-three liters per capita per day. However, a study conducted for the Kumasi Water Authority has indicated that average water consumption for medium standard housing with metered water cconnection, shower or bath, and a flush toilet is approximately eighty liters per capita per day. Based on this figure, water consumption for low and substantard houses is estimated to be between twenty-seven and forty liters per capita per day, while for the high standard housing areas a consumption of 130 to 150 liters per capita per day is considered reasonable.

A new water rate structure applicable to all cities in Ghana came into force in July, 1977 and is applied to metered connections in Kumasi. This rate structure may be summarized as follows:

(1) Domestic consumers without direct connection: $.42 per house per annum.

(2) Domestic consumers with a direct connection: $.21 per cubic meter with minimum charge of $10.44 per month.

(3) Non-domestic consumers: $.46 per cubic meter with minimum charge of $10.44 per month and a sliding scale for very large consumers.

The total annual operating cost for the year ending June 1977 for both of the Kumasi waterworks was $1,509,513. Assuming that the total average daily operating capacity of both the Owabi and Barikesse works was 41,500 cubic meter per day, the short-run unit production cost of water is $.10 per cubic meter.

(2) Sanitation

Kumasi does not have a central sewerage system. The residential districts of the city may be divided broadly into those with houses equipped

with water closet and septic tanks and those with houses with bucket latrines. Most of the houses constructed in recent years have flush toilets. Many of the residents of the older houses in Kumasi use bucket latrines, and a considerable number depend on public sanitary facilities.

The public sanitary facilities are enclosed areas (ca. 900 square meters) located within densely populated housing estates. Houses, shops and food canteens may be as close as twenty meters from these poorly maintained units. In general, a public sanitary area contains toilet blocks, nightsoil deposit vaults, a refuse disposal enclosure and perhaps shower blocks. The toilet blocks are commonly bucket latrines although aqua-privies and flush toilets with septic tanks are also extensively used. There is no charge for using the bucket latrines and aqua-privy systems, but a charge of 5 peswas (4 cents) is made for using the public flush toilets. The Kumasi City Council is responsible for the administration and operation of all private and public sanitary facilities in Kumasi.

(a) Bucket Latrines

There are eighty-six bucket latrines in the public sanitary areas and an additional twenty-four serving schools in Kumasi. Each latrine contains from ten to fourteen buckets and is designed to serve three hundred people. Thus the approximate total population served by the 110 public and school bucket latrines is 33,000. In addition there are 7635 buckets in private bucket latrines throughout the city, each serving an estimated twenty-five people; that is, an estimated total of 190,875 people use private bucket latrines in Kumasi. Therefore, about forty-five percent of the total population of Kumasi is served by public or private bucket latrines. The design and construction of the bucket latrine system in Kumasi is not significantly different from that which is found in Ibadan, Nigeria. The defaecation unit of the system consists of a twenty-eight liter bucket which is placed in a collection chamber situated immediately below either a pedestal seat or a squatting plate. Pedestal seats are most commonly used in private latrines, while squatting plates are used in the public latrines.

The bucket is usually of galvanized iron, and it is about thirty-eight centimeters in diameter at the top and thirty centimeters deep. The bucket is provided with two handles for lifting and carrying. The pedestal seats or squatting plates are constructed of wood or concrete. The pedestal seats are usually about fifty-four centimeters high and about forty-five centimeters square. The squatting plates are square concrete slabs measuring approximately forty-five centimeters on each side. There is a clearance of about fifteen centimeters between the pedestal or the squatting plate and the top of the bucket. Access to the collection chamber is provided at the back to permit removal and replacement of the bucket by a nightsoil scavenger.

The nightsoil from private bucket latrines is collected daily, usually in the early morning by laborers who empty the contents of the buckets into forty-five liter buckets which they carry on their heads. These buckets are taken to the nearest public sanitary area where they are either deposited or washed into the sanitary area nightsoil holding

vault. Five hundred laborers are engaged to accomplish this task. After the buckets are emptied, they are usually rinsed and then stored in the public sanitary area. The vaults in the public sanitary areas are approximately 3 x 3 x 4 meters in size. The contents of the vaults are removed by nightsoil tankers or suction trucks.

There are currently six nightsoil tankers and seven suction tankers of which only three of each are in working condition. The nightsoil tankers are similar to the suction tankers commonly used for cesspit emptying but are fitted with a large top inlet, a cover plate and a large outlet with a quick-release cover plate.

The approximate quantity of nightsoil collected is about 360 cubic meters per day. Assuming that each bucket is used daily by an average of twenty-five people, the nightsoil volume per capita per day for Kumasi is then about 1.6 liters.

The night soil tankers deliver their contents to the trenching area for discharge and burial in hand-dug ditches. The trenching area is six miles from Kumasi along the Bekwai Road and covers a total area of about twenty-four hectares. A concrete slab covering an area of about 0.4 hectare has been constructed for the washing of the nightsoil tankers. Washwater is obtained from a standpipe located adjacent to the concrete slab and rinses into a ditch which is about 1.8 meters deep and has a surface area of approximately 0.3 hectare. This ditch has no flow outlet, but there are plans to convert it into a series of oxidation ponds which may in the long term also be used to treat nightsoil. The effluent from these ponds will be discharged to the Aboabo river. The desludged contents of septic tanks and aqua-privies are currently being discharged directly into the Aboabo river which is by now grossly polluted.

The Cleaning Section of the City Council's Public Health Department is responsible for the operation of all sanitary services in the city, including the nightsoil and disposal services for both private and public bucket latrines. For the public bucket latrines, no charge is made, but a monthly charge of $1.31 per bucket is made for the private bucket latrines. There are plans to increase this charge to $1.74 when the services which are currently being offered are improved. The construction and operating costs associated with the Kumasi Bucket collection system are presented below in Table 8.2.

Table 8.2

Annual Cost of Bucket Latrines
in Kumasi
(1978 US$)

Household:	capital	$150.1 per bucket
Collection:	capital	$ 21.1
	O & M	$134.2
Treatment:	Capital	$ 4.0
	O & M	$ 50.4
	TOTAL	$359.8

assuming 25 persons per bucket

cost per person: $14.4

The bucket latrine system in Kumasi is presently operating in an unsatisfactory manner. A combination of inadequate engineering design and extremely poor maintenance is responsible for this state of affairs. The greatest public health hazard is caused by the collection of nightsoil from the nightsoil storage vaults in the public sanitary areas. These vaults are generally completely full as the City Council has too few operational tankers to desludge them at the required intervals. As a result the forty-five liter nightsoil collection buckets often have to be left full and unattended for several days on the concrete slab at the storage vault. Although the sanitary areas in Kumasi are relatively well enclosed, the nightsoil storage vaults, and hence the collection of full nightsoil buckets, are not fenced off from the rest of the sanitary area. Thus the vault area, which is liberally contaminated with fresh human excreta, is accessible to domestic animals, rodents, birds, and young children who find the sanitary areas a convenient playing ground.

In addition to the extreme problems found at the collection depots, substantial problems are also associated with the user and disposal stages of operation of this bucket latrine system. Many of the buckets in the public latrine blocks are full as early as 10 a.m., only a few hours after they are emptied, and this clearly demonstrates that the present number of public facilities for excreta disposal in Kumasi is grossly inadequate. The trenching operation also leaves much to be desired. For instance, the trenches are not backfilled with soil after the nightsoil has been poured into them. There is, perhaps, very little public health hazard associated with this at present, since the trenching ground is well isolated from any houses. The pond at the trenching ground which currently receives

the wash water from the nightsoil tankers has no effluent outlet and is also largely unattended; thus in its present state the pond constitutes a potential breeding ground for culcine mosquitoes.

There is little doubt that the provision of more nightsoil collection vehicles and their regular maintenance are major steps that could be taken to improve the operation of the bucket latrine system in Kumasi. Consideration should also be given to the provision of larger nightsoil collection vaults in the public sanitary areas. The vaults should be fenced off from the rest of the sanitary area so as to discourage access to them by the general public, particularly children.

(b) Aqua-Privies

There are about 350 public aqua-privy systems currently in operation in Kumasi, of which 270 are located in the public sanitary areas and 80 in the schools. The aqua-privies serve an estimated population of about 103,500 in Kumasi, or approximately twenty-one percent of the total population.

Most public and school aqua-privy latrine blocks in Kumasi have between 10 and 14 toilet compartments to serve about 300 people, so each toilet is designed to serve between 20 and 30 people. The public aqua-privy systems in Kumasi closely resemble the communal aqua-privy systems described by Wagner and Lanoix. Each aqua-privy toilet consists of a 0.6 meter square concrete squatting plate which is in some cases provided with footrests. The drop-pipe is moulded onto the slabs, and the tank is made of concrete. Water taps are not provided in the aqua-privy toilet blocks; the users are expected to carry water from the standpipes located outside in the public sanitary areas. In some cases long hosepipes have been provided, and these are attached to the standpipes so that they can be used in the toilets. The Cleaning Section of the City Council's Public Health Department operates vacuum trucks for the desludging of the aqua-privy tanks. When the tanks are desludged, their contents are discharged directly into the Aboabo river near the nightsoil trenching grounds.

Similar to the public bucket latrines, public aqua-privies in Kumasi are not operating effectively. These public latrines are overused, and their present state indicates that a much greater number of public latrines needs to be installed. In addition, the current policy of the Ghana Water and Sewerage Corporation to discourage the use of public standpipes by deliberately closing them down or leaving them unmaintained has led to the development of grossly unsatisfactory conditions in the aqua-privy toilet blocks. Most aqua-privy drop pipes are now blocked, and odor and fly nuisance predominates. Many aqua-privies now operate essentially as pit latrines. Even so, the toilets continue to be frequented by the inhabitants of Kumasi.

The Cleaning Department of the Kumasi City Council is currently experiencing a severe shortage of suction tankers and other nightsoil removal vehicles. In addition, vehicle lubricants are in extremely short supply in Ghana at present. These factors have also seriously affected the frequency of desludging of the aqua-privy tanks and the general maintenance of the system.

In addition to the above institutional problems, responsibility for the poor operational performance of the Kumasi aqua-privies must be partially placed with engineering and social design.

The following design and operational modifications would likely contribute to the more effective use of aqua-privies in Kumasi.

(i) The installation of self topping aqua-privy system to aid in the maintenance of a water seal.

(ii) The provision of a water tap in each aqua-privy unit to help to relatively uneducated users understand that there is a difference between an aqua-privy toilet and a pit latrine.

(iii) Provision of suitably located vent pipes of adequate size to further ensure the reduction of odor and fly nuisance in the toilets.

(iv) The incorporation of a hand washing basin in the public toilet block to enhance general personal hygiene and also to assist in maintaining the water seal in the aqua-privy.

(v) The employment of a full time latrine attendant whose duties should include maintenance, cleaning and distribution of toilet paper to users.

(3) Solid Waste Collection and Disposal

A refuse collection and disposal service is operated in Kumasi by the Cleaning Section of the City Council. Twenty-four trucks with an average capacity of nine cubic meters are operated by the council. Approximate daily volume of refuse collected is 690 cubic meters, and all collection trucks are uncovered and of a "tipping" variety. Refuse collection from bins at private residences is restricted to high income residential districts. A monthly charge of $.87 is made for this service. In other areas collection of refuse is from the Public Sanitary Areas and other public refuse repositories. No charge for this service is made. Many of the repositories either have no retaining walls or are in dilapidated condition, and they are seldom completely cleared of refuse. As a result, they invariably look untidy and attract large numbers of birds and rodents.

Disposal of refuse is by controlled tipping. It is tipped and spread, then covered with a layer of sawdust before the next layer of refuse is deposited. Due to the nature of the refuse encountered and the abundance of sawdust for disposal from many local sawmills, this technique has proven satisfactory. It is also useful as a means of land reclamation in the many natural depressions within the city. Various tipping areas are currently in use, and sporadic outbreaks of fire are common in these areas.

References

1. E.G. Wagner and J. M. Lanoix, Excreta Disposal for Rural Areas and Small Communities, WHO 1958.

CHAPTER IX

ZAMBIA

Zambia is located in south-central Africa and has a land area of approximately 753,000 square kilometers and an estimated population of five million. The country is situated on a broad plateau with an elevation of 1,000 to 1,500 meters. The principal rivers are the Zambesi, the Kafue, and the Lunagua. The climate is tropical savanna, modified by high altitude. Average annual rainfall varies from 64 centimeters in the south to 127 centimeters in the north, and a rainy season extends from December to April.

With a per capita GDP $360 (1975), the economy of Zambia is dominated by copper mining. Zambia has traditionally been the third largest copper producer in the world, and copper accounts for forty-three percent of GNP and ninety-eight percent of exports. However, in recent years the Zambian economy has begun to diversify, and the manufacturing and service sectors are gaining importance. Industry now employs fifteen percent of the labor force, and principal products are foodstuffs, beverages, chemicals, textiles, and fertilizers. The agricultural sector employs an estimated eighty-five percent of the labor force but accounts for under eight percent of GNP. The principal agricultural products are maize, tobacco, cotton, groundnuts, and sugar cane. More than ninety-eight percent of the population are of African origin, with the Bantu being the principal tribe. The majority of Zambians adhere to tribal religions, but twenty-five percent of the population are considered Christian. The literacy rate is estimated at twenty percent.

The urban population of approximately two million resides in three cities, the five municipalities, and the thirteen townships, all of which have central water supply systems. Those systems supply in total about eighty-two percent of the urban inhabitants, fifty percent by house connections and thirty-two percent by standpipes. The remaining eighteen percent use private wells, boreholes or streams. The rural population of about three million resides in twenty-seven rural townships (three to four thousand inhabitants each), in 2,300 villages, and in groups of small farms with populations of between 50 and 1000. Water supply is provided to about ten percent of these rural inhabitants through piped systems and to over forty-five percent by boreholes and wells. The remaining forty-five percent use rivers, lakes or shallow wells. There are fifteen sewerage systems in Zambia located in various municipalities, urban townships and in rural townships. In most localities the systems cover only parts of the populated area. It is estimated that about sixty percent of the urban population is connected to waterborne systems. Information about the situation in rural areas is not available. In addition to conventional sewerage systems, aqua-privies, pit latrines, and bucket latrines are used for sanitation. There is a particularly large number of aqua-privies present. Most of which were designed and constructed during the 1950's and early 1960's by the then African Housing Board.

A. COMMUNITY SELECTION

The communities of Lusaka and Ndola were selected for study within this chapter. They were chosen primarily to illustrate the use of aqua-privies and to provide a comparison with other operating sanitation technologies, both high and low cost. In Lusaka, sanitation facilities include flush toilets, aqua-privies, pit latrines, and bucket latrines. In Ndola, flush toilets connected to septic tanks and sewers, aqua-privies, and pit latrines are used. Cost data are presented for comparison of these systems.

The field work for this study was conducted by Dr. Kenneth O. Iwugo of the University of Birmingham, England. Dr. Duncan Mara of the University of Dundee, Scotland, and Dr. Richard G. Feachem of the Ross Institute of Tropical Hygiene, London aided in interpreting results and preparing the final report.

B. ASSUMPTION

In dealing with the data collected and prepared during this study, a number of assumptions have been made. The opportunity cost of capital was taken as twelve percent, and the opportunity cost of labor was taken as sixty percent. To convert cost, data to US dollars an exchange rate of 0.91 Kwacha (K) to 1.0 dollar ($) was used. The conversion factor for foreign exchange was 1.17.

C. COMMUNITY RESULTS: LUSAKA

Located in the southeast portion of the country, Lusaka is the capital of Zambia. The city has a population of 415,000 and sprawls over an area of 360 square kilometers. Economic activity in Lusaka is concentrated in the manufacturing, commercial, and service sectors. In 1968, employment data indicated that 36.8 percent of the population were in manufacturing or small sale industry, 21.3 percent were employed as clerical or sales workers, 13.7 percent were in service and miscellaneous occupations, 13 percent in transportation and communications, 9.7 percent in managerial or professional positions, and 1.7 percent in agriculture or mining. Unemployment was estimated at 3.8 percent. Due to its status as a growing commercial and industrial center, Lusaka has experienced a substantial immigration from outlying rural areas in the past decade. As a consequence, large areas of squatter settlements have been established. In 1976, it was estimated that more than forty percent of the Lusaka's total population lived in squatter areas.

(1) Water Supply

Lusaka has had a piped water supply system since 1954. In 1973, water was supplied by both boreholes (15 mgd) and withdrawal from the Kafue river (10 mgd). The current treatment for water taken from underground sources is chlorination; while river water, due to considerable contamination, is fully treated by sedimentation, sand filtration and chlorination. The system is maintained by the City Council, with the City Engineer in charge.

(2) Sanitation

The sanitation facilities in use in Lusaka are flush toilets, aqua-privies, pit latrines, and bucket latrines. In 1976, thirty-seven percent of the population were using flush toilets, one percent was using aqua-privies, fifty-four percent were using pit latrines; and three percent used bucket latrines. Five percent of Lusaka's population had no access to established means of excreta disposal. Pit latrines predominate in the older townships and several squatter compounds scattered throughout the city. The high income and low density areas of Lusaka are served by septic tanks with soakaway pits, while some post-colonial housing estates and Lusaka's industrial areas are sewered. A site and service scheme recently constructed in Lusaka is also sewered. The use of the aqua-privy system and similar low volume water-borne sanitation systems seems to have been limited to the townships of New Chilenje and some parts of Matero where middle class Africans (clerks, teachers, etc.) lived in the pre-independence era. Of particular interest to this study and discussed in subsequent sections of this chapter are the desludgeable pit latrines and aqua-privies found in Lusaka and nearby towns.

(a) Sewerage System

Lusaka's sewage is treated at seven plants: two of these are conventional sewage treatment plants and five are waste stabilization ponds. The largest plant treats about 20,000 cubic meters per day and currently is being expanded. The degree of treatment obtained at this plant is reasonable, and analysis of the final effluent shows that it meets conventional physiochemical standards. These standards may, however, be unsatisfactory for Lusaka because of the low flow in the effluent receiving stream; moreover, the removal of excreted pathogens is likely to be very poor. The second treatment plant, after a nearly completed expansion, will have a total capacity of 9,000 cubic meters per day. This plant receives most of the industrial effluents in the city. The effluent of the plant in terms of its BOD and suspended solids concentration is poor at the present. The five waste stabilization ponds are located throughout the Lusaka area, and the effluent from these ponds, expressed in terms of BOD and suspended solids, is generally unsatisfactory. Inadequate operation and maintenance account for the deficiency.

(b) Desludgeable Pit Latrines

In the Matero suburb of Lusaka 3,000 desludgeable pit latrines are in operation. These latrines are referred to as aqua-privies in the files of the Lusaka Medical Officer of Health but, upon inspection, are found to be no more than wet pit latrines. They are located in areas where the water table is high and therefore they tend to be naturally wet. Furthermore, it appears to be a common Zambian practice for baths to be taken in latrine blocks in areas where bathrooms are not provided. These two factors are probably responsible for the modification of the conventional pit latrine design to

provide an access for desludging just behind the superstructure. The sketch of the modified pit latrine, which is still erroneously referred to as an aqua-privy, is shown in Figure 9.1.

The shallow depth of these latrines (less than two meters) requires that they be desludged frequently, perhaps even monthly, since the ground is unable to absorb much of the water added to them. However, desludging is rarely done, with the consequence that many of these wet pit latrines are most offensive. Responsibility for desludging is assigned to the Medical Officer of the Health Department in the City Council. This department has only one operational vacuum tanker which is also used to desludge the hundreds of septic tanks located in the high income areas of Lusaka. Since a charge of eleven dollars is made for desludging a septic tank and the desludging of the wet latrines is free of charge, the one vacuum tanker is scarely ever available to desludge the latrines.

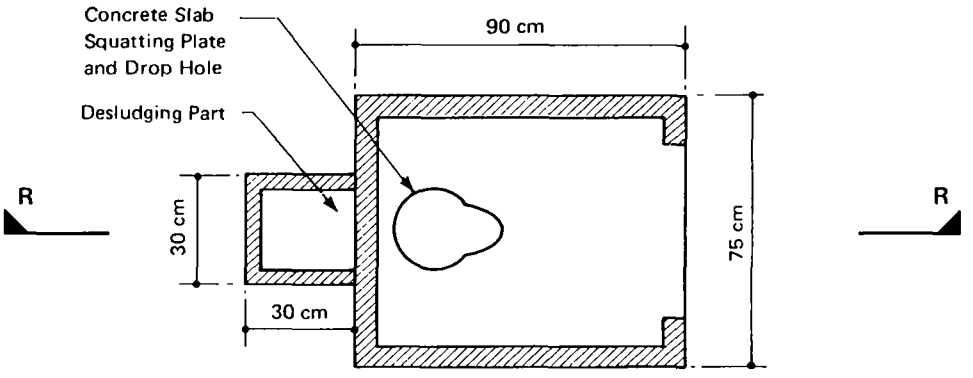
However, some of wet pit latrines were found to be operating satisfactorily with few odor and fly problems, generally in those cases where the family size was about three.

(c) Sewered Aqua-Privies

A total of 532 sewered aqua-privies are in operation in the low-cost housing areas of Chipanda in the Matero township of Lusaka. The Chipanda housing estate was built in 1960, and the houses which the estate contains are generally one or two bedroom homes. In addition to the houses served by the sewered aqua-privy system, some of the more recently constructed houses are served by flush toilets. The ten centimeter diameter asbestos pipes which carry both the effluent from the aqua-privy tanks and the wastes from the flush toilets are all connected to a fifteen centimeter lateral sewer which runs between most of the compounds. The fifteen centimeter sewer in turn is connected to a 22.5 centimeter main sewer. Like all other sewered areas of Lusaka, the main sewers are connected to a sixty-one centimeter trunk sewer which transverses the city from north-west to south-east. This trunk sewer is currently running to capacity over most of its length.

The aqua-privies are located in latrine blocks which are separate from the individual houses and are shared by four contiguous households. Each latrine block is approximately 4.35 by 1.95 by 2.25 meters in size and divided into four equal compartments. Each compartment contains a cast-iron squatting plate and is provided with an external washbasin. There is a common tank underneath the block into which the drop pipes from each of the four squatting plates discharge. The tank also receives sullage from the four washbasins. The estimated dimensions of the tank are 2.5 by 1.95 by 1.2 meters.

FIGURE 9.1: MATERO DESLUDGEABLE WET PIT LATRINE (Often Termed Aqua Privy by Residents and Health Assistants)



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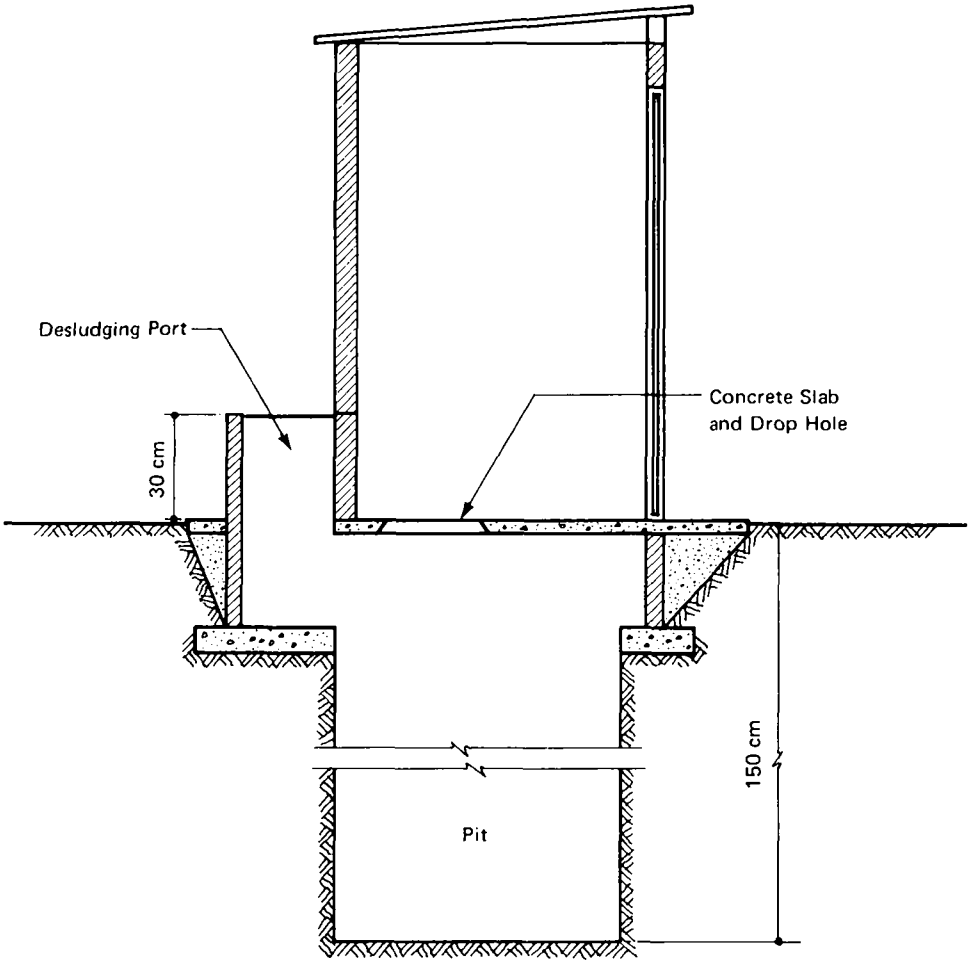
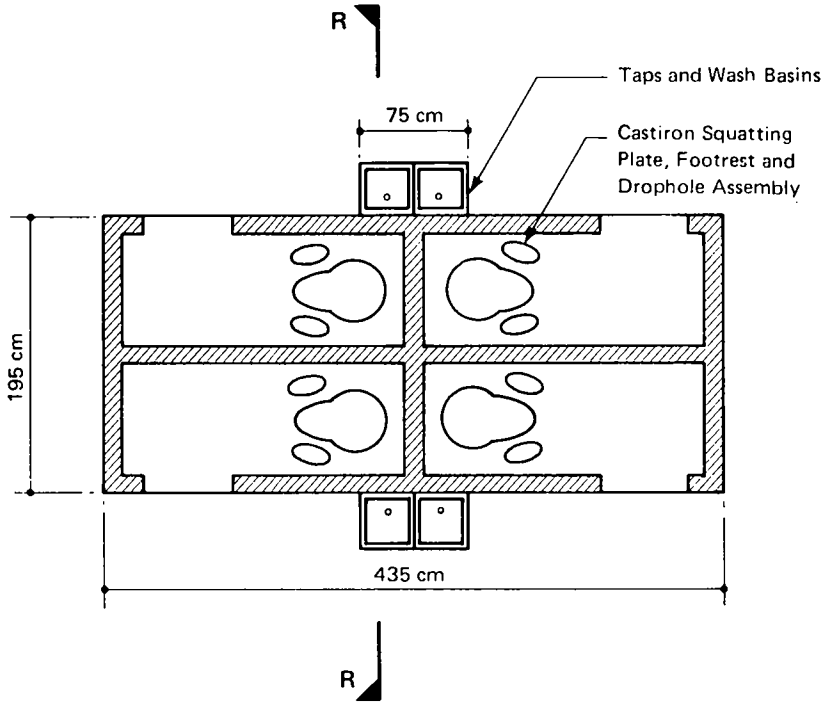


SECTION R–R

World Bank – 19899

FIGURE 9.2: CHIPANDA (LUSAKA) SEWERED AQUA PRIVIES



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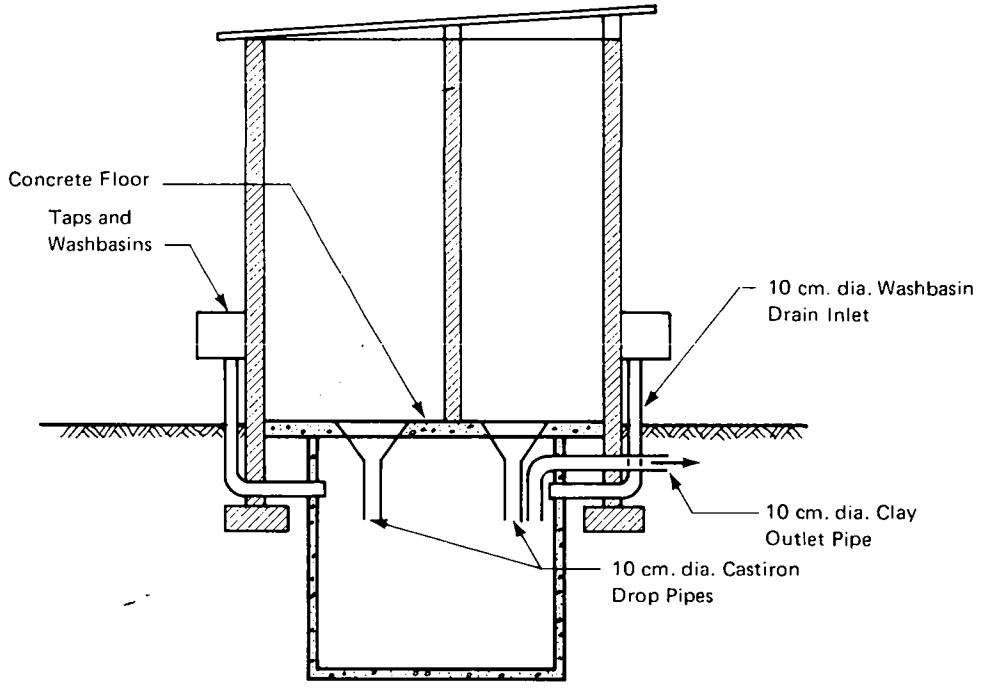


SECTION R–R

World Bank – 19898

The latrine block and aqua-privy details are shown in Figure 9.2. Each aqua-privy unit (one compartment of a latrine block) consists of a sixty centimeter diameter circular cast iron squatting plate which is connected to a forty-five centimeter long cast iron drop pipe. This assembly fits closely into a rectangular ten centimeter thick concrete slab which covers the remaining area of the compartment. Desludging of the aqua-privy tank requires removing this cast iron squatting plate assembly. The water level in the trunk is generally fifteen centimeters below the squatting plate, thus maintaining approximately thirty centimeters of the drop pipe below water level. A ten centimeter diameter clay enamel or asbestos pipe connects the aqua-privy tank to the sewer. The system is made self topping by connecting the drain pipe of the wash-basin to the aqua-privy tank.

Nearly all the aqua-privy units in Chipanda are operating satisfactorily with no odor or fly nuisance. The ten centimeter sewers are rarely blocked. However, the fifteen centimeter lateral and main sewers are blocked on occassion. In many of the aqua privy units, residents have adopted the practice of placing their anal cleansing materials in buckets for subsequent disposal by incineration. As this practice appears to be fairly widespread among users of the aqua-privy system, it can be concluded that the blockage observed in the fifteen centimeter and 22.5 centimeter sewer lines were most probably caused by the anal cleansing materials used in the flush toilets which serve some of the more recent properties in Chipanda.

The major operational problem which has so far been encountered with the use of the sewered aqua-privy system has been the shortage of water in Matero township. In the past the Chipanda area has been without water supply for periods of as long as three days or more, most frequently in the dry season. The aqua-privies have operated unsatisfactorily during those periods, and odor release and fly nuisance are then common in the area.

Although most of the sewered aqua-privies in Chipanda were built in 1960, and according to the City Engineer's operational staff and local residents none of the forty aqua-privies inspected has yet required desludging. Each aqua-privy tank serves four households, i.e. approximately twenty-four people, and the wash basins which drain into the tank are commonly in continuous use; it is not uncommon to find the taps of these wash basins left running either because the tap washers are worn out or because children have intentionally or accidentally left the taps open after use. Furthermore, most residents who use these aqua-privies do not have bathrooms and so they usually have their baths in the latrine blocks. The probable effect of these practices is that the settlement of both the digested and undigested faecal matter in the aqua-privy tank is considerably disturbed and there is a substantial carry over of solids from the tank to the sewer. Thus the solids residence time in the tank is considerably less than would be expected so that desludging at the normal interval of three to five years has not been required. The solids carried over into the sewer are likely to be small in size and generally do not block the sewers which have sufficient flow to prevent deposition of such solids.

In addition to the system in Matero, a sewered aqua-privy system consisting of 102 units is in operation in the New Chilenje township of Lusaka. The external features of the sewered aqua-privy latrine in Chilenje are similar to those which have been described for Chipanda in Matero, with the exception that the Chilenje latrine blocks are larger (2 meters x 0.8 meters). Enough space seems to have been deliberately provided in the latrine block to encourage the users to take their baths there. Unfortunately, the bath water flows into the aqua-privy tank through the wash basin drain. An arrangement whereby the bath water flowed into the aqua-privy tank via the squatting plate drop hole would probably help maintain the cleanliness of the squatting plate. In spite of this, the general design of this system seems to be the most modern found in Lusaka. Each aqua-privy unit (one compartment of a latrine block) consists of a square concrete slab (60 x 60 centimeters) into which has been incorporated an asbestos cement squatting plate and drop pipe assembly. The drop pipe is about forty centimeters long and ten centimeters in diameter. The squatting plate is about forty centimeters long and its maximum breadth is about twenty-five centimeters. The outlet pipe is a ten centimeter diameter asbestos pipe which leaves the tank just fifteen centimeters below the squatting plate and empties through an inspection chamber into a ten centimeter diameter sewer which eventually joins Lusaka's main sewer system. The aqua-privy tank is moulded out of asbestos cement and is about one hundred-twenty centimeters deep. For a single aqua-privy unit the tank is about one hundred-fifty centimeters long and ninety centimeters wide and thus has an effective capacity of about 1600 liters. As in the case of Chipanda in Matero, the system is made self-topping by connecting the drain pipe of the washbasin to the aqua-privy tank.

In general, these aqua-privy units are well maintained and operated with only very slight odor and fly nuisance, and blockage in effluent pipes is rare. Blockages are apparent in some of the inspection chambers, but most of the connecting sewers are clear. Unlike the system in Chipanda, Matero, most of the connecting sewers empty into the fifteen centimeter diameter main sewers after a relatively short distance (less than 50 meters). It must be concluded that this arrangement helps to discourage the blockage of the ten centimeter diameter connecting sewers. When interviewed, most of the residents who use these aqua-privies could not recollect when their tanks were last desludged. Some of these residents have occupied their property since 1964. As in Matero, one possible reason why the aqua-privies have not become blocked despite no desluging over the past ten years is the practice of collecting anal cleansing materials in a separate bucket. In addition, there is very liberal use of water due to an abundance of water available at extremely low cost ($1.10 per month regardless of the quantity used). Some residents have actually connected a hosepipe to the tap and now use considerable quantities of water to flush their aqua-privy after each use. As in Matero, it is probable that a large quantity of finely suspended particles are washed through the system with such large quantities of water.

The apparently successful operation of the Chilenje aqua-privies must be due to a slightly improved engineering design and the pattern of use that has been adopted by the residents. Maintenance of the system by

the responsible authority is no better than elsewhere in Lusaka. The present arrangement whereby the City Engineer's department undertakes the maintenance of the sewers while the Medical Officer of Health's department has the responsibility for the maintenance of the actual aqua-privy unit leaves much room for mismanagement.

(d) Conventional Aqua-Privies

In addition to the sewered aqua-privy units found in the Chilenje township of Lusaka, 153 conventional self-topping aqua-privies are in use in this township. The conventional aqua-privies in Chilenje are similar in most respects to the sewered aqua-privies except that the supernatant liquor from each aqua-privy tank flows through an inspection chamber to a communal septic tank which overflows into a drainfield. Each communal septic tank receives the effluent from twelve to fifteen aqua-privy units.

A considerable number of these aqua-privy units are blocked, and in some cases odor and fly nuisance are apparent. These blockages are thought to result mainly from the method and frequency of desludging the system. Many of the present users recall that in the past it was customary to desludge individual aqua-privy tanks regularly and to desludge the communal septic tanks at monthly intervals. The current practice, however, is to desludge only the communal septic tanks, and with the current shortage of vacuum tankers, the frequency of desludging of the communal septic tanks has now been reduced to once or at most, twice a year.

Two design aspects of this aqua-privy system are worth emphasizing. Firstly, connections of the aqua-privies to sewers when they are eventually built will be relatively easy. Secondly, the effluent is settled twice before it reaches the drainfield. This not only reduces the loading rate on the drainfield but also decreases the possibility of the drainfield becoming clogged by the higher quantity of suspended solids which would have been carried over in the absence of a second settling tank.

In addition to the capital city of Lusaka, a number of nearby towns employ or have employed aqua-privy systems for waste disposal. The nearby towns of Kafue and Kabwe were chosen for inclusion within this chapter to illustrate these systems.

Kafue

Kafue is a growing industrial township located about thirty miles south of Lusaka. The excreta disposal pattern in Kafue is very similar to that of Lusaka in that a small part of the township is sewered but the much larger portion is served by septic tanks and pit latrines. The township's only sewage treatment plant (activated sludge) treats predominantly industrial effluent.

The only aqua-privies located in Kafue are found in the Zambian Railways Cottage housing estate. These systems were built in 1957 and originally numbered about 200, many of which are still in use. The systems are operated and maintained by the Zambian Railways. The conventional non-self topping aqua-privy unit in the Old Cottage Housing estate consists of a seventy-five centimeter circular concrete slab which is about ten centimeters thick. An enamel squatting plate and drop pipe assembly is moulded into the concrete slab. The aqua-privy tank is a perforated 200 liter capacity drum which is slightly displaced from the superstructure and concrete slab assembly. The superstructure is conical in shape with an outward opening door. It has a circular base of about sixty centimeters in diameter which tapers to a diameter of about fifty centimeters at the top, and the height is about 180 centimeters.

The average family size in the Old Cottage estate is four, and the residents water supply is provided by public standpipes. The aqua-privy units inspected during this study were in reasonable condition with little odor or fly nuisance. The major problem with the aqua-privies was occasional blockages in the effluent pipes, but the response of the maintenance staff is reported to be good. Desludging is usually accomplished by digging out the drum and replacing it. The frequency of this operation is very low; desludging has been needed only twice since installation in 1957.

Kabwe

Kabwe is an industrial mining town located about eighty miles north of Lusaka. The excreta disposal pattern in the Kabwe is also reported to be very similar to that in Lusaka. A portion of the town is sewered, but the majority of the population is served by septic tanks and pit latrines.

According to reports available from the National Housing Authority, about 1380 conventional aqua-privies previously operational in the Chimanini and Ngungu townships of Kawbe were converted to flush toilets and connected to the sewers in 1976. The aqua-privy systems of Chimanini and Ngungu townships had been in operation since the 1950's, but the following problems had been associated with their operation:

1. lack of suitable soil conditions for soakaways;

2. blockage of the outlet pipe with anal cleansing materials and household garbage;

3. difficulties in effectively desludging detritus material (e.g. gravel, sand, etc.) which had been thrown down the drop-hole by the residents (presumably by children); and

4. the lack of water taps in or near the toilet block for topping up the aqua-privy tank.

D. COMMUNITY RESULTS: NDOLA

With an approximate population of 250,000, Ndola is the third largest municipality in Zambia. It is located in the Copperbelt Province. Although centered in one of Zambia's principal mining areas, Ndola is heavily oriented towards manufacturing, commerce, and service industries. According to 1968 data, 6.3 percent of Ndola's working population is employed in professional and managerial positions, 16.2 percent in clerical and sales positions, 38.5 percent as craftsmen or production process workers, 1.7 percent in agriculturally related employment, 0.3 percent as miners or quarrymen, 33.9 percent in miscellaneous other occupations and 3.1 percent are unemployed. The annual rate of population growth for Ndola was 9.5 percent for the 1963-69 period and 7.5 percent during 1969-74. Average household size is six. Housing patterns in Ndola follow those of the Copperbelt Province in which the majority of the housing is either company or government owned. According to 1969 census data 33.1 percent is company owned, 40.9 percent is government owned, and 26.0 percent is privately owned. Housing construction is sixty-eight percent burnt brick or concrete block construction and fifteen percent Kimberly brick construction. The remainder is assumed to be of less permanent construction. 1/

(1) Water Supply

Ndola has a central water supply system which uses local rivers as its primary source for water. Service is provided by house connections, yard spigots, and public standpipes.

(2) Sanitation

The pattern for provision of sanitation facilities in Ndola is similar to that in Lusaka. The high-income low-density residential areas, are served by septic tanks with soakaways, while most of the low cost, recently constructed housing estates, some site and service schemes, and industrial areas are largely sewered. Pit latrines predominate in the old townships of Kabushi, Masala, Chifubu and several of the urban squatter settlements scattered throughout the city. Aqua privies (mainly the sewered type) are limited to the Kabushi township area of Ndola.

(a) Pit Latrines

About 30,000 people in Ndola (twelve percent of the city's total population) are served by pit latrines located predominately in Kabushi and Masala townships. Most of the households served by pit latrines obtain their water by public standpipes which are usually located not more than one hundred meters from the household. The design and construction of pit latrines in Ndola (as in many other major cities of Zambia) are standardized and undertaken by the City Council.

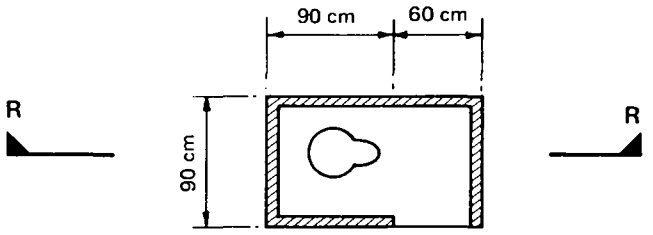
1/ Population growth, employment and housing statistics are taken from Urban Sector Survey of Zambia, World Bank Report No. 490-ZA (1976).

A typical Zambian pit latrine consist of superstructure, a concrete slab squatting plate and the pit itself (Figure 9.3). The superstructure is generally built of concrete blocks or brick and has the following dimensions: length-150 centimeters, breadth-90 centimeters, and height-80 centimeters. The walls are plastered and limewashed. The squatting slab is 120 centimeters wide and 180 centimeters long and has a minimum thickness of 10 centimeters. Locally manufactured five millimeter iron rods are used for reinforcing the slab. A 30 by 22.5 centimeter drop hole is cut into the concrete slab. The pit is usually about 5.4 meters deep and about 90 centimeters square. The cost of excavation is approximately $16.8. In most areas of Kabushi and Masala the water table is more than six meters below ground level.

Most of the pits inspected during this study were found to be well maintained and essentially tidy. None of the squatting plates had been fouled. However, strong odor and fly nuisance was common in most latrines. This was due partly to the small size of the latrine. Furthermore, the pit itself is not vented in any way, and the odor and fly nuisance problem would probably be greatly reduced by incorporating into the pit a 300 centimeter long and ten centimeter diameter vent pipe fitted with a fly trapping gauze. This improvement would add about ten dollars to the construction cost of each pit latrine. Other problems observed by the consultants or emphasized by local maintenance staff included flooding of the pit latrines due to bathing in the latrine block; no bathrooms are provided elsewhere. Also cited was the frequently insufficient notice given by households when their latrines need resiting.

According to design specifications, the average filling time was estimated at ten years. In practice, the filling time is shorter, mainly because many residents deposit their ash and domestic refuse into the pit latrines. This suggest that a compost toilet might well be a socially acceptable sanitation facility in these areas. When a pit latrine becomes full another latrine is built adjacent to it. The superstructures of Zambian pit latrines are usually only thinly plastered so that the blocks and the corrugated iron or asbestos sheets used for the roof can be used again to build the new latrine. The concrete slab is not reused since it is considered that its removal will expose the full pit and this will create a potential health hazard. However, it is clearly possible that the concrete slab can be reused for the new pit latrine if the full pit is backfilled with some of the soil excavated from the new pit.

FIGURE 9.3: NDOLA (ZAMBIA) PIT LATRINE



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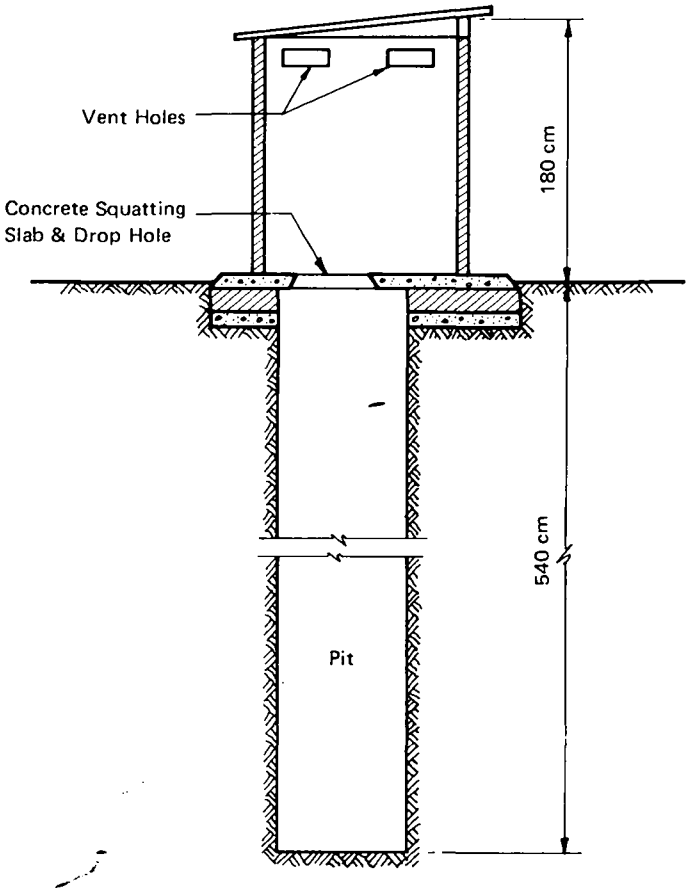


SECTION R–R

World Bank – 19903

The cost of construction and maintenance of pit latrines in Ndola are presented below in Table 9.1.

(b) Sewered Aqua-Privy System

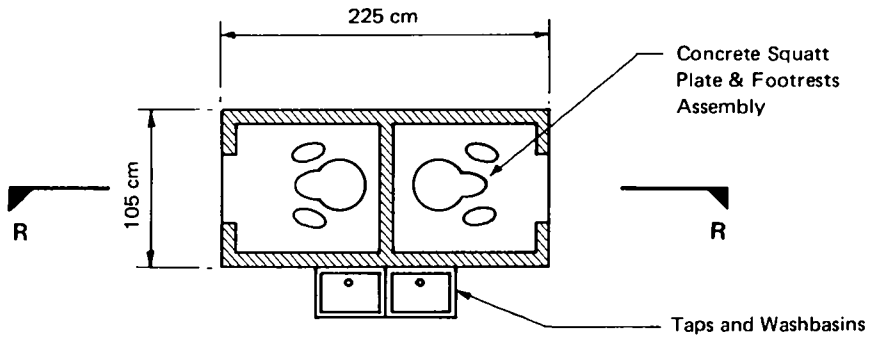
The old township of Kabushi contains the only operational, sewered aqua-privy system in Ndola. Kabushi was built in the early 1950's, and the current population of the township is about 30,000, twelve percent of the present population of Ndola. Housing plot size in Kabusi varies considerably but averages 300 square meters. The average size of a family is six. The excreta disposal systems which are currently used in Kabushi township are pit latrines, sewered aqua-privies, and flush toilets connected to the central sewerage system, but the majority of households are served by either a pit latrine or the sewered aqua-privy unit.

Originally a total of 1422 sewered aqua-privy toilets were built in Kabusi township. However, constant blockage of the systems resulted in the conversion of many of the original aqua-privies to flush toilets. At present, a total of 674 have been so converted while about 748 sewered aqua-privy systems are still operational.

The aqua-privies are located in latrine blocks which are separated from the house and, depending on the arrangement of the houses in a particular area, one, two, or four aqua-privy units may be located in each latrine block (Figure 9.4). The dimensions of a latrine block housing two aqua-privy units are 2.25 by 1.05 by 2.12 meters, and for a latrine block housing four aqua-privy units, 2.25 by 2.10 by 2.12 meters. External washbasins are connected via drainpipes to the squatting plate of each aqua-privy. Inside each unit a shower tap is located approximately 1.8 meters above the squatting plate. For those households in Ndola with either aqua-privies or pit latrines, separate bathing areas are not provided, and it is common for residents to have their baths within the latrine blocks.

Each sewered aqua-privy unit in Kabushi consists of a ten centimeter thick concrete base which has an area of about 2.5 square meters and into which has been set an enamel squatting plate. A thirty centimeter long, ten centimeter diameter asbestos or china clay drop pipe is fixed to the squatting plate. The cylindrical aqua-privy tank is made of abestos cement and has a total capacity of about 250 liters. Regardless of the number of aqua-privy units in a sanitation block, each unit is connected to its own tank. The effluent pipe is a ten centimeter diameter L-shaped asbestos pipe. The pipe is submerged to a depth of about forty-five centimeters inside the tank, thus giving an effective clearance of only thirty centimeters from the bottom of the tank. The effluent pipe is generally connected to a ten centimeter diameter sewer in combination with the effluent pipe from another aqua-privy unit through the use of a T or Y-shaped pipe connection arrangement. These aqua-privy sewers are eventually connected to the main sewerage system of Ndola, and consequently aqua-privy effluent receives the same treatment as conventional sewerage wastes.

FIGURE 9.4: KABUSHI SEWERED AQUA PRIVIES



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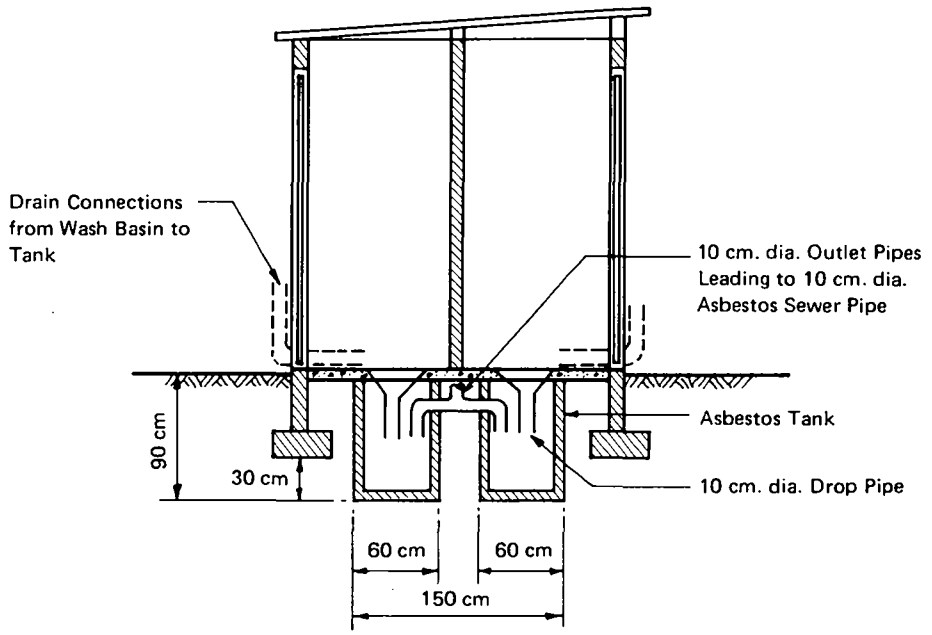

SECTION R–R (After Excavation)

World Bank – 19904

The remaining aqua-privies in Kabushi appear to be operating satisfactorily, in spite of their relatively poor design. One reason for this is the ample supply of water in Ndola and a water tariff schedule for low-cost housing estates which encourages the liberal use of water. Thus, water use is extremely high in Kabushi (200 lcd.). It is common for washbasin taps to be left running, and baths are commonly taken in the aqua-privy block. These practices undoubtedly help in sufficiently flushing the aqua-privy system. In fact, the hydraulic retention time in the small aqua-privy tanks is estimated at four to six hours, and much of the excreta is flushed out into the sewers. Consequently, there has never been a need to desludge these aqua-privy tanks. The effective operation of this aqua-privy system has been further enhanced by the increasingly common practice of depositing anal cleansing materials in a bucket for subsequent removal and incineration. When several of the ten centimeter connecting sewers were inspected during the course of this study, none was found to be completely blocked. However, slight obstructions to flow (due to some household cleansing materials such as sponges, etc.) at fairly frequent intervals were common. Routine maintenance of these sewers is not undertaken.

Costs for the aqua-privy system are presented in Table 9.1. These costs include a prorated portion of the cost associated with the treatment of Ndola's conventional sewerage treatment works and are therefore higher than would be necessary if the system were optimally designed. In spite of this, the total annual household cost of the aqua-privy system is only half that of conventional sewerage. Much of the savings represents the reduction in necessary flushing water.

(3) Conventional Sewerage System

The sewerage system of the city of Ndola covers only a portion of the populated area (3500 hectares and 75% of the population) but is currently being expanded. Average flow is 225 liters per capita per day, and the major construction materials are vitrified clay, reinforced concrete and asbestos cement pipes, and some steel piping.

Ndola sewage is treated at two main treatment works, Kanini and Lubuto. The Kanini treatment works were built in the 1950's and had a design treatment capacity of 18,000 cubic meters per day. It is a conventional trickling filter plant which currently treats 20,000 cubic meters per day. As a result the effluent quality is very poor, and a tertiary treatment stage consisting of upflow sand filters was due to be commissioned in April, 1978. The effluent is discharged into the Kafubu river upstream of the water intake to one of the city's water treatment works. In recent years, there has been a prolific growth of algae at this water intake due mainly to eutorophication caused by the Kanini effluent. A coagulation/flocculation stage is being incorporated into the Kanini works in order to reduce the concentration of phosphate in the final effluent.

The Lubuto sewage works was first commissioned in the mid-1960's and continues to be expanded. The ultimate design capacity is 45,000 cubic meters per day, but the current capacity is only an approximate 30,000 cubic meters per day. The plant is essentially a biological percolating filter. The final effluent, which is satisfactory with respect to BOD and suspended solids, is discharged into the Kafubu river downstream of the intake of the Kafubu waterworks.

Comparative costs of sanitation provided by pit privy, sewered aqua-privy and conventional sewerage systems are presented in Table 9.1.

Table 9.1

Annual Household Cost for Sanitation in Ndola

(1978 US$)

	Pit Privy	Sewered Aqua-Privy	Conventional Sewerage
Household			
Capital	19.0	102.8	105.8
O & M	-	24.2	17.6
Water		7.7	153.3
Collection			
Capital		15.2	23.5
O & M		3.8	5.9
Treatment			
Capital		3.8	5.9
O & M		3.9	5.9
Total	19.0	161.4	317.9
per capita costs	3.2	26.9	53.0

CHAPTER X

COLOMBIA

With an estimated population of 24.5 million (1977), Colombia is the fourth most populous nation in Latin America. The country is located in the northwest corner of South America and bordered by Venezuela, Brazil, Peru and Ecuador. Colombia's 1,140,000 square kilometers of land area can be divided into three principal topographic regions: Atlantic and Pacific coastal lowlands, the central highlands, and extensive eastern plains. Due to significant variations in altitude, the climate is remarkably diverse and varies from tropical heat on the coastal lowlands to cool temperatures in the highlands. Annual precipitation ranges from near desert conditions in the north to over 762 centimeters along the Pacific lowlands. Colombia's population is fifty-eight percent Mestizo, fourteen percent Mulato, twenty percent Caucasian, four percent Negro and eight percent Indian or Negro-Indian. Ninety-five percent are Roman Catholic, and small groups of Protestants and Jews are present. The literacy rate is seventy-three percent. Public health continues to be a problem, with illness and death frequently related to dietary deficiency. Influenza and other respiratory ailments are among the most prevalent health hazards.

With a per capita income of $674 (1976), Colombia has achieved strong economic growth during the period 1967-77 with a significant structural transformation from a predominantly rural, agricultural and largely self-contained economy to a more urban and industrial economy. Industry is the major contributor to the gross domestic product and employs fourteen percent of the labor force. Principle products are footwear, beverages, chemicals, metal products, and cement. Agriculture employs forty-five percent of the working population and produces mostly coffee, bananas, rice, corn, sugarcane, plantain, cotton and tobacco.

The availability of water supply and sewerage facilities in Columbia ranks among the highest in Latin America. However, even though the aggregate growth in services has been fairly rapid during the last ten years, service levels vary substantially according to both family income and size of city. One-fourth of the aggregate urban population still does not have direct access to public water supply, and about sixty percent do not have direct access to public sewerage systems. In rural areas, about thirty-three percent of the aggregate population have access to safe water, while only thirteen percent have access to sewerage. Domestic sewage and industrial wastes are largely untreated. 1/

1/ Paragraph directly quoted from Appraisal Report of Second Cali Water Supply and Sewerage Project, January 8, 1978, Report No. 1679c-CO.

A. COMMUNITY SELECTION

The rural village of Villarrica was selected for study within the Colombia Country Report. The unique approach to rural development followed by the Centro de Investigaciones Multidisciplinarias en Desarollo Rural (CIMDER) in this community was responsible for its selection. CIMDER is a cooperative effort by a group of Colombian agencies and institutions involved in several aspects of the development process. The program has four major components: (a) personal health services, especially primary health care; (b) basic sanitation services (water, excreta disposal and improved housing); (c) health education emphasizing child health care, in-house treatment of patients, treatment of the most common diseases that affect the rural dweller in Colombia, and emergency procedures; and (d) the increase of income through employment generation programs and profit-sharing schemes involving food production and small industry enterprises. This chapter briefly discusses some of CIMDER's efforts in upgrading basic sanitation services.

B. ASSUMPTION

In calculating the latrine costs, unskilled labor was shadow priced at thirty percent of the minimum wage. This reflects the assumption that construction would take place at some time other than the harvest season. The opportunity cost of capital was assumed to be twelve percent. Since no imported materials are needed for the latrines, no foreign exchange shadow pricing was needed. Unless otherwise stated, all costs are at 1978 prices, and the conversion rate between the Colombian and United States dollar is C$36.50 to US$1.00.

C. COMMUNITY RESULTS: VILLARRICA

Villarrica is located in the southern part of Colombia, in the Department of Cauca, some fifty kilometers south of the city of Cali. Natural boundaries are the Cauca river on the south and in all other directions the Cordillera Occidental. A paved highway connects the area with Cali, and good roads form a network of internal communication between the several townships in the area. The terrain is hilly with an average elevation of 1,000 meters above sea level. The total area of the region is about 110,000 hectares. The main watershed in the Villarrica area drains into the Palo River, one of the tributaries of the Cauca River. Hydrological data in the Palo River (1969-74) indicate a maximum discharge of 33.1 cubic meters per second and a minimum discharge of 8.0 cubic meters per second. The area is rich in groundwaters, which are readily accessible. The watertable is only fifty centimeters below ground surface during the dry season and twenty to thirty centimeters below in the wet season. The climate is wet and humid. The mean average temperature is 23.3^{o}C, mean maximum temperature is 31.6^{o}C, and mean minimum is 17^{o}C. Average monthly precipitation is 11.90 centimeters.

The total population of the Villarrica area is 37,000, of which approximately 12,000 are concentrated in the Villarrica township and the remaining are more or less equally dispersed in a number of smaller villages

and farms. Population density for the area is around 297 persons per square kilometer, and for the concentrated population centers, the figure reaches 3,000 persons per square kilometer. CIMDER estimates population growth to be about four percent per annum. The average family size is 5.3 persons. The literacy rate is estimated at seventy-seven percent.

Agriculture is the major source of income for the region. However, there are two distinct economic systems: one is characterized by the capital intensive operations of the large sugarcane plantations and sugarcane mills, and the other is that of the small farmer owning less than two hectares of land with little access to capital or modern technology. Cocoa was for many years the predominant crop of the area, but lately coffee, plantain and especially sugarcane have become important. Seventy percent of the available land is planted with these crops in large farms known as Fincas. On the remaining thirty percent of the land, sembraderos, farmers grow a combination of crops: soy (33%), corn (33%), beans (15%), sugarcane (13%) and others (6%). Produce from the sembraderos is usually consumed by the household, but part is traded in the local Sunday market.

The economically active population in 1974 totalled 14,622 including some children above seven years old who were working. The unemployment rate during the harvest season is low (2%) in comparison with the Colombian urban sector, but adjusting for seasonal variations and other forms of subemployment, the average rate is thirty-five percent. Employment statistics indicate that fifty-six percent of the working population work for wages at agriculturally related jobs, thirty-one percent farm their own or rented land, and thirteen percent are employed in non-agricultural jobs. In 1974, the average annual family income was $365.

(1) Water Supply

Groundwater is the only satisfactory source of drinking water in the Villarrica area. Bacteriological and chemical analysis of surface waters done at the laboratories of the Universidad del Valle have confirmed the inadequacy of all surface waters of the region for drinking purposes. These waters are heavily charged with manganese and iron salts and with the organic wastes from the nearby sugar mills. On the other hand, groundwater is of excellent quality, and the only treatment needed is chlorination.

Most households in the village of Villarrica are either served by the city's aqueduct or by private wells. However, water from the public supply system is considered unfit for drinking and clothes washing purposes due to the high mineral content, which has an unpleasant taste and stains the clothes. Well water is, therefore, preferred. It is interesting to note that in other villages, households which have their own wells often do not drink from them. Instead, there is a group of "prestige wells" from which residents fetch water for drinking. Tests have been performed to determine if there is any difference in the water from well to well, but the results have not yielded any positive evidence. However, people still believe that water from a "prestige" well is better than that from some other but similar well.

As a first step, CIMDER has fostered the improvement of these "prestige wells" by providing manual pumps and improving nearby latrines in those communities where seventy percent of the households have excreta disposal facilities. This practice utilizes village water needs as an incentive for the installation of latrines. To improve the quality of the water in the private wells, a low-cost water chlorinator is made available to the households. The device consists of a nail perforated plastic jar which contains a plastic bag with 250 grams of hypochlorite of calcium and two kilos of sand. The diffusion of the chemical takes place through an array of small holes punctured in the plastic bag. Tests of water quality and residual chlorine have demonstrated that the device is good for a period of 25 days at the end of which the sand should be washed and new chemicals added. Total cost of the chlorinator is US$1.25, of which US$0.25 is the cost of the chemical. CIMDER is also testing a low-cost PVC pump system for installation in community wells. The system consists of a windmill fabricated from fifty gallon plastic barrels cut in half to catch the wind and produce the torque needed to operate a pump.

In a socio-cultural survey randomly applied to twenty-four households in the region, a number of questions were asked about the water supply. All the households questioned fetched water from shallow wells located either within the property or at distances varying from 15 to 500 meters. Nineteen families (80%) utilized a second source of water such as another well, river, or a house connection. One of the families bought bottled water for drinking. In most cases, the average trip to the source took fifteen minutes. Women and children shared the responsibility for carrying the water.

All of the respondents believed that the environment they lived in was a healthy one. The most common reason to support their answer was the absence of disease and their close proximity to the main highway which allowed them to go to the city if anything went wrong. Only three respondents doubted the healthfulness of the water they drank on grounds that it was contaminated from being too close to the latrine. The remaining twenty-one families were quite satisfied with the water, mainly because it was chlorinated, or it was boiled before they drank it.

Eighty percent of the respondents were willing to spend <u>some</u> money to have a better quality water. The same number were also willing to pay in order to have house connections. In nine cases, the source of water was closer than thirty steps from their houses. For those paying for the service (only in Villarrica), monthly charges averaged Col$21.00 (US$0.57/ month).

(2) <u>Sanitation</u>

Prior to CIMDER's work in the area, nine percent of the families (624) disposed of their excreta in flush toilets (the village of Villarrica has an aqueduct and waterborne sewerage), thirty-nine percent (2,737 families) had latrines, and the remaining fifty-two percent had no sanitation facility and used nearby fields. The original latrines were built by the homeowners on their own initative. However, important health aspects such as the location

with regard to water supply were disregarded. Consequently CIMDER, as part of its larger program, has introduced several improvements in dry latrine design, developed a water seal latrine and encouraged the use of both types of latrines. Since the program has started, fifty percent of the dry latrines have been upgraded and about 1,000 water seal latrines have been installed. Three hundred of these have replaced old dry latrines, and seven hundred have gone to families that did not have any prior service. In addition, CIMDER is experimenting with an incinerator latrine. Costs for the pit and water seal latrines are presented in Table 10.1.

(a) Pit Latrine

In those areas where water is scarce, a dry latrine is constructed which consists of: a) pit 1.6 meters deep and 0.96 meters by 0.66 meter in area, lined with bricks (with open joints five centimeters apart to allow for infiltration of the liquids): b) a pitcurb-brocal, 0.5 centimeter high which is required due to high watertable and provides more capacity to the latrine by reducing the depth below ground surface of the pit: c) a concrete slab reinforced with wire mesh; d) a concrete seat and a wood lid, both of which are painted before delivery to make them more attractive to the users; e) the superstructure which may be constructed of three different materials (bricks, wood or bamboo) depending on its availability and the preference of the homeowner and; f) a modern tile roof high enough to permit air circulation. The latrines have a useful life of five years for an average family.

(2) Water Seal Latrine with Soak-away

The water seal latrine has a vitrified-porcelain basin similar to the conventional flush toilet and designed for comfort as well as low-cost. It is currently being installed in those areas where water is available to the householders within a reasonable distance. The latrine flushes with three liters of water which runs off to an absorption pit located either directly underneath the basin or at some distance from it. CIMDER recommends that the pit be located away from the structure and that a register box be added so that it will be possible in the future to redirect the wastes to a second pit. This design feature was instituted after CIMDER found that some villagers constructed a second vault on their own initiative to save the costs and inconveniences associated with relocating the old latrine. The pits are lined with bricks placed five centimeters apart with open joints. Besides the water availability constraint, the other limiting factor for installation of a water seal latrine is the soil permeability required for the infiltration of the waste water. Acceptance of the water seal latrine has been high among users, and all of the twenty-four surveyed households stated that they would like a flush toilet or water seal latrine.

Table 10.1

Annual Household Costs of Sanitation Facilities in Villarrica
(1978 US$)

	Dry Latrine	Water Seal Latrine
Capital	7.1	5.3
O&M	0.5	1.3
Water		3.5
Total	7.6	10.2

CHAPTER XI

NICARAGUA

Nicaragua, with an area of 139,700 square kilometers, is the largest country in Central America. The country has a estimated population of 2.3 million (1976) and a population density of eighteen persons per square kilometer. The country's most salient physiographic feature is the great graben (structural rift or depression) which passes through the southern and western sections of the country. This lowland contains Lakes Managua and Nicaragua, the two largest natural bodies of freshwater in Middle America. The surrounding lowland plains and flanking uplands have highly fertile soil and plentiful rainfall (100-150 centimeters per year) and support a dense population. Approximately three-fourths of Nicaragua's people live on the Pacific side of the country, mainly within these fertile plains and lake lowlands. Nicaragua's population is comprised of several ethnic groups, with seventy percent classified as Mestizo (mixed), seventeen percent as Caucasian, nine percent as Negro, and four percent as Indian. Ninety-five percent of the population are Roman Catholics, and the principal languages are Spanish and English. The adult literacy rate is estimated at fifty-two percent.

With an annual growth of 6.4 percent between 1960 and 1975, the long-term growth of the Nicaraguan economy has been buoyant. The economy of Nicaragua is concentrated in the agriculture sector. Agriculture is responsible for one-fourth of its merchandise exports and employs fifty-three percent of the labor force. Principle products are cotton, coffee, sugar, and meat. Nicaragua's industrial sector is concentrated on processing agricultural products and accounts for ten percent of the GDP. The principal products are processed food, beverages, textiles, chemicals, petroleum and metal products.

The availability of water and sewerage services in the urban areas of Nicaragua compare favorably with those found in other Latin American Countries, but their availability in rural areas ranks poorly with only five countries in the hemisphere having lower levels of services. Of the 1976 urban population, seventy-two percent are estimated to have access to water supply through house connections, thirty-eight percent are served by waterborne sewerage, and thirty eight percent are served by latrines. For the rural population, estimates place service levels for water supply through access to standpipes at six percent and for sanitation through access to pit latrines at eleven percent. 1/

A. COMMUNITY SELECTION

The urban communities of Managua and Masaya and the rural communities of Las Managas and Licoroy were selected for inclusion within

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1/ Statistics taken from World Bank Appraisal report for the Third Managua Water Supply Project.

this chapter. Managua is one of the few urban communities in Nicaragua which have a waterborne sewerage system. A program to provide a package of low cost sanitation through connection to the municipal sewerage and water supply systems has recently been implemented within the community and is documented within the community discussion. The Masaya discussion features an interesting, intermediate sanitation technology known locally as the sumidero (absorption pit). Las Mangas and Licoroy provide examples of communities in which latrines have been installed under the new Rural Sanitation Program.

The field work for this study was conducted by Dr. Mary Elmendorf, consulting anthropologist; Mr. Charles Pineo, sanitary engineer and public health expert; and Mr. Rafael Rodriguez, staff member of the World Bank.

B. ASSUMPTIONS

In dealing the data collected and prepared during this study, a number of assumptions have been made. The opportunity cost of capital was taken as twenty percent. Foreign exchange and unskilled rural labor are shadow priced using factors of 1.5 and 0.5, respectively. Unless otherwise stated, all costs are at 1978 prices and the conversion rate of 7.03 Cordobas per U.S. Dollar is used.

C. COMMUNITY RESULTS: MANAGUA

Managua, the capital of Nicaragua, is located on the edge of Lake Managua in the Central Pacific zone of Nicaragua. The topography of the city is excessively broken with altitudes ranging from 50 to 550 meters above sea level. The city and its surrounding area do not have any significant rivers or streams, and rainfall is removed from the city through infiltration into numerous regional aquifers and by a few ephimeral surface streams. Nevertheless, the area is rich in lakes and groundwater reservoirs. In fact, there are five lakes within the city limits which are fed largely by underground flow. Managua's climate is tropical and characterized by high temperatures and intense sunlight. Two distinct meteoroloical periods are observed during the year: a rainy season from May to October during which ninety to ninety-five percent of the total yearly precipitation falls; and a dry season (November through April) during which rainfall is infrequent and of low intensity and short duration. Annual precipitation varies widely from year to year but averages 110 centimeters. Temperature is basically uniform throughout the year, and mean average temperature is 26.0^{o}C with mean maximum and minimum temperatures of 28.4^{o}C and 25.6^{o}C, respectively.

Managua is a community of 535,400 urban and semi-urban inhabitants and contains seventeen percent of the country's total population and thirty-seven percent of its urban population. The city has experienced in recent years large fluctuations in population due to earthquakes. Large migrations back into the city following recovery from the 1972 earthquake have occurred. Population density for Managua as a whole is currently 147 inhabitants per square kilometer. However, population density for urban Managua is approximately 620 inhabitants per square kilometer. Average household size is six individuals. Thirty-seven percent of Managua's adult population have either

an incomplete elementary education or no formal education at all. However, school enrollment of children in urban Managua is estimated to be as high as one hundred percent.

The city of Managua is the focus of most of the industrial activity in the country. Approximately seventy-five percent of Nicaragua's industrial companies are located in Managua, and the industrial infrastructure of Managua is based on processing agricultural products. Very little secondary sector activities exist, with the possible exception of the construction industry. Heavy industry is yet to be developed. Employment statistics indicate that thirty-six percent of the economically active population is employed in the commercial and personal service sectors, twenty-one percent in restaurants and hotels, nineteen percent in manufacturing, and fourteen percent in the construction and transportation sector. The remainder is employed in a variety of smaller vocational groupings including the public service and agricultural sectors. Average household income is $106 per month.

Housing in Managua can be classified into two categories: single family units in which seventy-three percent of the population live and multi-family units. Most housing units are of a simple, one-room, two-door, rectangular construction with a living area of approximately fifty square meters. The living area is frequently subdivided into two or three rooms using cardboard, zinc sheets, fabric or newspaper. Many houses have a back-yard which is larger than the house itself and where the household kitchen, laundry facilities, and sometimes a well and sanitary services are located. Single family units are typically built with tightly nailed wooden slats and have tin roofs and dirt floors. A few of the more financially advantaged households have brick floors, cement block walls, and "tejas" (cooked mud tiles) for roofing.

The continuous immigration from the rural areas of the country into Managua has resulted in the creation of extensive residential areas of overcrowded, substandard housing. These marginal living areas contain approximately forty percent of Managua's population. However, the percentage of one-family units in these "barrios" is sixty percent less than the average for the entire city. Forty-seven percent of these single-family units are permanent structures, while fifty-three percent are improvised structures. Sixty-five percent of these units have only one room with the dimensions of at most three by four meters. Typically, a family of five will sleep, cook and eat in this one room.

(1) Water Supply

The water authority, Empresa Aguadora de Managua (EAM), operates a system of public water supply which provides water via house connections to ninety percent of Managua's urban population. Groundwater aquifers are the system's source of water, and ninety-three percent of the water used in Managua is pumped from the Mercedes well field or from Lake Asosoca (which is fed directly by inflow of groundwater). The water is of excellent quality and requires only chlorination. Average per capita consumption from public system is 341 liters per day, and all house connections are metered.

The households which are not connected to the public system are located primarily in the marginal barrios of Managua and obtain their water either at a high premium from a private vendor or from a private well. The vendor is usually a neighbor living within a distance of not more than 200 meters who has been able to connect to the public system. People buy water from these ventors and store it in unprotected twenty-two liter barrels. Empresa Aquadora de Managua maintains a policy of providing water to the community entirely through the use of house connections and thereby maintains no public standposts. Vendors charge as much as $1.50 per cubic meter, while the tariff which the vendor must pay is $0.08 per cubic meter. Women and children are usually responsible for carrying the water to the household and accomplish the task by either making numerous trips to the vendor or by using wooden push carts to carry the barrels.

(2) Sanitation

A conventional sewerage system operated by the National Sewer Authority, Departmento Nacional de Alcantarillados (DENACAL), serves seventy-three percent of Managua's population. The remaining portion of the population, concentrated largely in the marginal barrios of city, are served by pit latrines of various, simple designs. Currently, the sewage collected by the system is discharged untreated into Lake Managua. The resulting deterioration in the water quality of Lake Managua has been substantial, and there are now plans to build a primary treatment plant which will include screening and grit removal, sedimentation, chlorination, and sludge storage and dewatering. The volume of sewage collected by the Managua system is estimated to be 67,000 cubic meters per day of which the average domestic flow is 47,000 cubic meters per day, or 170 liters per capita per day.

In order to extend minimum basic sanitation services to the marginal barrios of the city, EAM in conjunction with AID has recently implemented an integrated sanitation project in Managua. Water supply and sewerage facilities have been provided to 5,362 lower income families under a plan which allows for a choice between three levels of service. The three alternatives are: (1) a flush toilet and one patio connection including fifteen meters of pipes; (2) the preceeding facilities plus an additional shower facility; and (3) the preceeding plus additional laundry facilities. Each alternative has been designed to be the least expensive solution for providing these basic services. The water supply connection consists of a surface PVC pipe and a patio tap. The excreta disposal facilities consist of a standpipe porcelain flush toilet with no cover for the bowl or the water tank. When possible both are located outside the house to reduce the costs incurred by the household. Similarly, shower facilities are basic and consist only of a vertical PVC pipe with an inexpensive faucet and shower head and a brick and cement shower platform (2 x 1 meters) surrounded by a one-half meter high brick and concrete wall designed to confine the runoff of shower water. The homeowner builds the type of protective shelter which suits him best. In some cases, home owners have elected to build no protective wall. A towel or sheet is draped around the shower stall if privacy is needed. Laundry facilities consist of a large cement sink with a faucet.

The annual cost per household of Managua's sewerage system including the costs of the proposed treatment facility are presented below in Table 11.1. These costs include on site costs which correspond with alternative (1) of the above discussed integrated sanitation scheme.

Table 11.1

Annual Household Cost of Managua Sewerage
(1978 US$)

ON SITE	
Capital	80.8
O & M	7.1
Inc. Water	10.2
COLLECTION	
Capital	105.1
O & M	2.6
TREATMENT	
Capital	89.8
O & M	28.2
TOTAL	323.8
Cost per Capita	54.0

D. COMMUNITY RESULTS: MASAYA

Masaya is an urban community located on a small volcanic plateau 27.5 kilometers southeast of Managua. The community has a population of approximately 57,000. Seventy percent of these inhabitants live within the urban limits of the municipality, while the remaining inhabitants live in the surrounding semi-rural areas. The population density in the urban area of the community is approximately 4,000 inhabitants per square kilometer, while for the municipality as a whole, the density is 360 inhabitants per square kilometer. Population growth has been a rather steady 3.5 percent per annum, with the exception of post-earthquake years (1972-73) when a significant inflow of individuals affected by the earthquake occurred. The terrain is flat, and Lake Masaya is located nearby. The climate is tropical with a well defined dry season from December through April and a wet season from May through November. The average monthly precipitation is 13.7 centimeters. Temperature averages 27.2°C with mean maximum and minimum temperatures of 29.5°C and 25.5°C, respectively.

Masaya is located within one of the most important agricultural areas in Nicaragua and thereby serves as a commercial center for the region. The principal crops of the area are cotton, sugar, tobacco, coffee, sesame and yucca. No large scale industry exists in Masaya, and there are only ten small industries each employing no more than forty individuals. Much of the urban employment is in the manufacture of handcrafts (ceramics, leather, wood, stone, and vegetable fiber articles) in small family shops which are characterized by the absence of sophisticated facilities, tools, and working capital and which service rather small markets. Employment statistics indicate that thirty-five percent of the total economically active urban population are employed as such artisans while ten percent work as professionals or administrators, seven percent as merchants, two percent as farmers, nine percent in the transportation sector, and twenty-two percent in personal services and other miscellaneous fields. Average household size is estimated to be six individuals, and generally eighty to ninety percent of total household income is derived from the work of the male head of the family, with the wife and children earning the remaining income. Average household monthly income is approximately $256. Approximately eighty percent of the population of Masaya is literate.

Most housing units in Masaya are one-story buildings with approximately fifty square meters in floor area and generally with an additional large patio in the rear. The patio usually serves as the kitchen and laundry area, and fifty percent of the houses have more than two rooms. House construction can be separated into three basic types depending on the materials used. Higher income households use asbestos and cement for roofing, bricks and wood for the walls and cement tiles for flooring. Lower income households use tiles for roofing, cement or mud bricks for the wells, and bricks or wood for flooring. The poorest households use straw and palm branches for roofing, mud and adobe for the walls, and bare dirt for flooring.

(1) Water Supply

A public water supply system is operated in Masaya by DENACAL. The sources for the water are two deep wells located north-west of the city. The only treatment the water requires is chlorination, and distribution is accomplished through a thirty-five kilometer network of iron and asbestos-cement pipes. A total of 6000 houses connection serve nearly sixty-two percent of the population. The remaining number of houses and the nearby rural population obtain their water from private wells and from two public standpipes located on the outskirts of the city. The two public standpipes are intended to satisfy the needs of the Indian and rural population which live in the area surrounding Masaya and come to the standposts with horse drawn carts to retrieve the water. Individual and dug wells are found frequently in private residences, but the water is normally not used for drinking. These wells are usually unprotected, and water is fetched by lowering a bucket into the well. The population is generally aware of the health implications and risks involved if the water is drunk.

A tariff of $0.21 per cubic meter is applied to those households connected to the public system. Average daily consumption is estimated to be 190 liters per capita during the dry season. However, during the wet season average daily consumption drops to 140 liters per capita since people collect rainfall for several uses. Those low and middle income households surveyed during this study reported that their average monthly bills ranged between $2.85 and $4.25, or between one and two percent of total household income. A tariff of $0.14 per 230 liter barrel is applied to water taken from the public standposts. Frequently, this water is in turn sold at a rate of $0.71 per 230 liter barrel in the rural areas.

(2) Sanitation

Masaya has a waterborne sewerage system, but service levels rank much below those of the water supply system. Serving twenty-nine percent of the population, the system is only connected to 2657 households. However, a potential exists for four or five thousand house connections, but high connection costs prevent people from soliciting the service. Connection charges vary according to the appraisal valve of the property and range fronm $65 to $106 per connection. Sewer charges are calculated as thirty percent of household water charges. The sewage collected by the system is treated in an oxidation pond prior to discharge into nearby Lake Masaya.

The remaining population not served but the sewerage systems have has a dry latrine or a sumidero (absorption pit) or simply use nearby fields. The latrines found in Masaya are of varying designs and are generally poorly maintained. The majority of these latrines were installed by the government in the late 1950s and early 1960s. Gradually, as financial resources become available, new latrines are being built to replace these older latrines.

The more financially advantaged households in Masaya which do not have access to the municipal sewers construct absorption pits known locally as sumideros. Sumideros have been installed in a number of cities throughout Nicaragua as an intermediate method for disposing of sewage and waste water. Those pits are two meters in diameter and from five to fifteen necessary to prevent the collapse of walls and are capped with a concrete slab into which a vent is sometimes installed. Sewagte from a flush toilet generally located inside the household is carried via a short drainage pipe into thee pits. The sumidero may be located in the interior patio of the house as in most downtown houses or outside when a front yard exists between the street and the house. The concrete cap is often covered with sod.

These pits are usuable only where the soil is fairly porous and there is no danger of polluting the ground water aquifers which may be used as water sources by other people. In spite of these limitations, the sumidero is widely and succesfully used in Masaya. They are normally designed for use by at least eight people and will last indefinitely if they are used with care. Some of the pits have been in operation for over forty years without any reported desludging. However, when grease-traps are not provided and sticks or heavy papers allowed into the system, the infiltration galleries become clogged and the sumidero fills up very rapidly. A maintenance service pumps the sumidero out at a charge of $21.

When sewerage system is installed in an area previously served only by sumideros, these pits are simply corrected to the collection lines by installing an overflow pipe which drains from the pit directly into the sewer. Thus, an intermediate, retention, chamber is provided in which much of the solids in the sewage is deposited prior to the discharge into the sewers. Consequently, the physical and chemical characteristics of the sewage are substantially altered. The need for treatment in oxidation ponds and total volume of sewage passing through the system are reduced. This reduction in flow permits the installation of smaller diameter sewers. Costs for the sewered sumidero are presented in Table 11.2.

Table 11.2

Annual Household Cost of Sewered Sumidero (absorption pit) in Masaya
(1978 US$)

On Site	
Capital	57.5
O & M	10.7
Water	10.2
Collection	
Capital	52.6
O & M	1.3
Treatment	
Capital	44.9
O & M	14.1
TOTAL	191.3
Cost per Capita	31.9

E. COMMUNITY RESULTS: LAS MANGAS AND EL LICOROY

Las Mangas and El Licoroy are rural villages located in Nicaragua's Region V. Las Mangas, a community of nearly 800 people, is located within a farming area in close proximity to the Pan American Highway. The community lies within the Department of Matagalpa at a distance of approximately 125 kilometers from the capital city, Managua. El Licoroy, a community of 196 people, is located in a more remote area somewhat northwest of Las Mangas in the Department of Esteli. The population densities and average family sizes are 216 persons per square kilometer and 8 individuuals per family for Las Mangas, and 196 persons per square kilometer and 7 individuals per family for Licoroy. The adult literacy rate is reported to be eighty percent for Las Mangas and two percent for Licoroy. Region V is noted for its mountainous terrain and cool climate. Las Mangas and El Licoroy are situated

approximately 800 and 850 meters above sea level, respectively. As in the rest of the country, a well defined rainy season is experienced between the months of April and November, with an average annual precipitation of 80 and 158 centimeters observed in Las Mangas and Licoroy, respectively. Average annual temperature for the two communities is 22.5°C.

The principal economic activity in these two communities is agriculture. In Region V, fifty-three percent of the land area is dedicated to farming, and seventy-two percent of the economically active population is engaged in agriculture, forestry, hunting, and fishing. In Las Mangas the principal crops are rice and cotton; corn and beans are grown on a much smaller scale. These products are cultivated for both trade in the municipal markets and for subsistence. Corn is the major crop grown in Licoroy. In addition, coffee, sugar cane, and some oranges and avocados are grown by a few families. Cattle and poultry raising are minor activities in both communities and are done only on a small scale primarily for household consumption. Employment in both communities is highly seasonal and dependent on the rice crops. In Licoroy, there are only a few companies which employ local labor when the harvest is due. Otherwise, the villagers work on their own small farms. The average household income in these two communities is $115 per month.

The same type of building construction prevails in both villages. Approximately sixty percent of the houses are made of bamboo and adobe with a dirt floor and straw or mud tile roofs. Some thirty percent of the households have wood walls, and ten percent are made of brick. All of these building materials are available locally. The houses ae usually built by the homeowners themselves with the aid of a carpenter. Average lifetime is estimated at forty years provided some periodic repairs are made.

(1) Water Supply

Water is supplied to both of these villages from hand-dug wells or from local streams. In Las Mangas there is one communal well (17 meters deep) equipped with a Batelle pump installed by US AID. The vast majority of households in Las Mangas obtains its water from this well. The water from the one nearby stream is contaminated by the wastes of a slaughterhouse, and the villagers only use this water for washing and bathing. A number of private wells supply a portion of the population living on the outskirts of the village, but most people come to the pumped, communal well for their drinking water. In Licoroy, one hand-dug communal well equipped with a Batelle pump also supplies the population with safe drinking water. However, distance prevents as much as sixty-five percent of the population from regularly obtaining its drinking water from the well. Instead, these households take water from a nearby polluted stream.

Average daily consumption of water in these communities (taken from the wells) is estimated at 8 liters per capita during the dry season and 4.3 liters per capita during the wet season. The difference is obtained by placing receptacles under the roofs to collect rainwater.

(2) Sanitation

Pit privies are the only means of excreta disposal in these two communities. Approximately ninety percent of the households are reported to have pit privies, and these latrines were built in recent years as part of the PLANSAR program (National Plan for Environmental Sanitation in Rural Areas). Prior to the implementation of the PLANSAR project, only thirteen latrines are reported to have existed in these two villages, and most people used nearby fields for excreta disposal.

The PLANSAR program was organized in 1976 under the direction of the Ministry of Health for the purpose of providing water supply and waste disposal facilities to rural communities. The official objectives of PLANSAR are to:

(a) Design and carry out a system for self help with community participation.

(b) Provide minimum environmental services through the installation of sanitary latrines and the improvement of the homes in the same communities.

(c) Carry out a massive vaccination campaign (DPT., polio, measles, small pox, DT y BOG) to protect a population of 13,600 under five years of age.

(d) Provide water supply services for domestic use through simple systems and wells, either hand dug or drilled, for a population of 110,000 people living in 340 communities in a period of no more than four years.

(e) Extend the preventive medicine services and health education to the same population.

(f) Prepare the people needed to carry out the projects and to assure the maintenance and operation of their installation in the future.

Under the PLANSAR Program, during six months in 1977, 1300 pit privies were installed (with community participation) throughout rural Nicaragua. The general design of these pit privies includes a) the pit, the dimensions of which has a protective lining, if necessary, of rocks and concrete; b) a concrete slab reinforced with wire mesh and a concrete seat, both in one piece; c) the housing, (walls, roof and door) any suitable material as available in the different areas annual household. A wood lid is recommended but not provided by PLANSAR. The average annual household cost of such a pit privy as provided in Las Mangas or Licoroy is $26.0.

The essential part of the latrine, the concrete slab and riser or seat, is produced in one plant near Managua under the management of

PLANSAR and transported to the villages where installation of the slab is carried out by the householder over the hole which he has dug. The protective shelter is erected by the householder generally using wood for the frame and zinc sheets for he sides and roof, both provided by PLANSAR.

Although these latrines have recieved wide acceptance in Las Mangas and Licoroy, a number of deficiencies in their design have been noted in both these communities and throughout rural Nicaragua. The concrete slab and riser presently used is the same model that has been used throughout Latin America for at least thirty years. It requires a lid on the riser to keep flies from entering the latrine pit and to contain the odors that are produced in the pit. Many unsuccessful attempts have been made to perfect a lid that is durable and preferably, self-closing. The lid is the first part of the latrine to fail.

Both odor and excessive numbers of flies have been cited as problems and forces individuals to locate their latrine at some distance from the house. Additionally, the location of the household well has controlled to some extent the location of the pit privy. However, community wells are now being installed under the PLANSAR program, and the position of individual household wells is less important. If a water seal latrine such as the Colombian type (see Chapter X) is installed, it is possible to to locate the latrine adjacent to the house. It is logical also to combine bathing and laundry facilities in the same area. These various features might be combined in a single compact unit, if desired. By prefabricating the laundry tray, sink combination, the storage tank for laundry water and storage tank for waste water from the shower and sink (the latter two could easily be built in place with brick and mortar) the costs can be kept to a minimum.

Additionally, the design of the present latrine shelter should be changed so as to enable the use of local materials. With local materials the area of the shelter could be increased slightly to make it more convenient to use in comparison with the present shelter, which is so restricted in size that many people have difficulty using it. The size of the present shelter is dictated by the available size of the zinc sheets. Using local material, according to the wishes of the householder who is installing the latrine, would make it possible to reduce the cost of imported materials (in this case the zinc siding) and of the expensive lumber used for the framing. The savings could be used advantageously in extending the usefulness of the latrine by introducing a water-seal latrine of the Colombian type.

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