B7 Existing Water Distribution Network Survey

B7.1 Intoroduction

B7.1.1 General

The present water supply for Kisumu Town is operated and maintained by Kisumu Municipal Council. The first system was established in 1920s when Kajule Water Treatment was constructed. Kajulu Treatment Works is situated about 11km north of the Town at the side of the Kibosu river. The Works comprises of a river intake, formed by a concrete weir across the river, sedimentation tanks and 5 rapid gravity pressure filters. Water is fed to the service reservoir at Kibuye under gravity via a 150mm steel / AC main. Rehabilitation works have been carried out since 1920. The second system was established in 1956 when Lake Water Treatment Works was constructed. Lake Water Treatment Works is situated on the edge of Lake Victoria south west of the Town. The Works comprises on intake on the bank of the lake, water is pumped via low lift pumping station to the Treatment Works. Treated water is pumped for storage and distribution.

B7.1.2 Purpose of the Survey

Purpose of the survey is to determine the status of the existing Kisumu Municipality Water Supply System with regard to Water Production, Leakage and Pressure distribution with the System, and to carry out condition survey of existing Distribution Network and Meter Condition Survey.

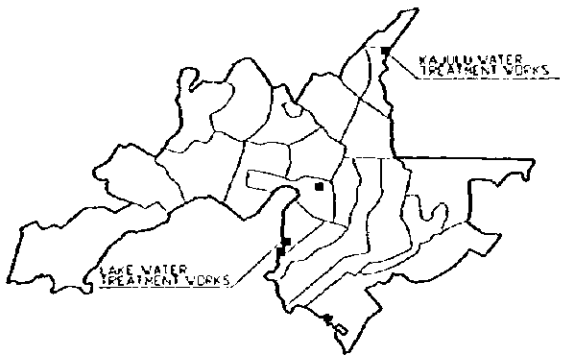
B7.2 Water Production Survey

B7.2.1 Methodology

(1) Location of Treatment Works

The water production survey was carried out at two sites of the water treatment works; the one named Lake Water Treatment Works is located on the edge of Lake Victoria south west of the Town, the other named Kajulu Water Treatment Works is located about 11 km north of the Town at the side of Kibosu River. Fig B-2 shows the locations.

Fig B-2 Location Map

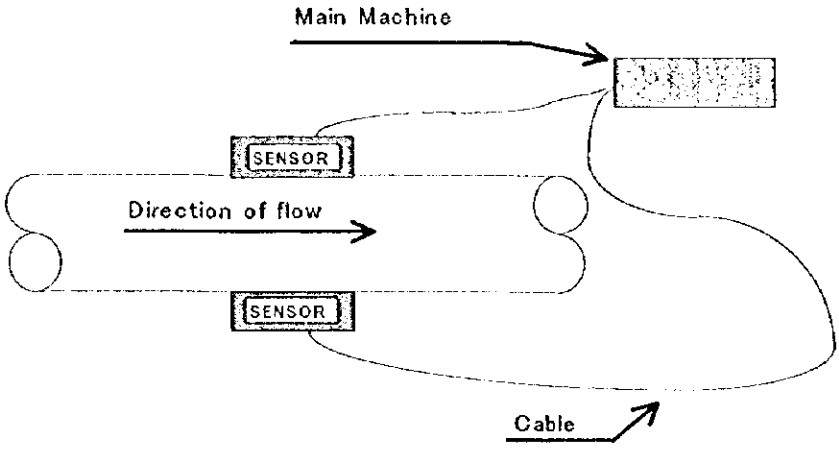


(2) Measuring Method

Water production measurements were carried to determine the bulk supply into the system by using a device named "**Krohne Ultrasonic Flow Meter**". This meter is "clamp on" one, giving an hourly flow which is automatically printed out and can accurate to $\pm 5\%$ if the internal pipe diameter and material is known accurately and if there is no turbulence in the pipeline.

This meter measures a flow of pipe water like as follows;

Fig B-3 Ultrasonic Flow Meter



Measuring items are as follows;

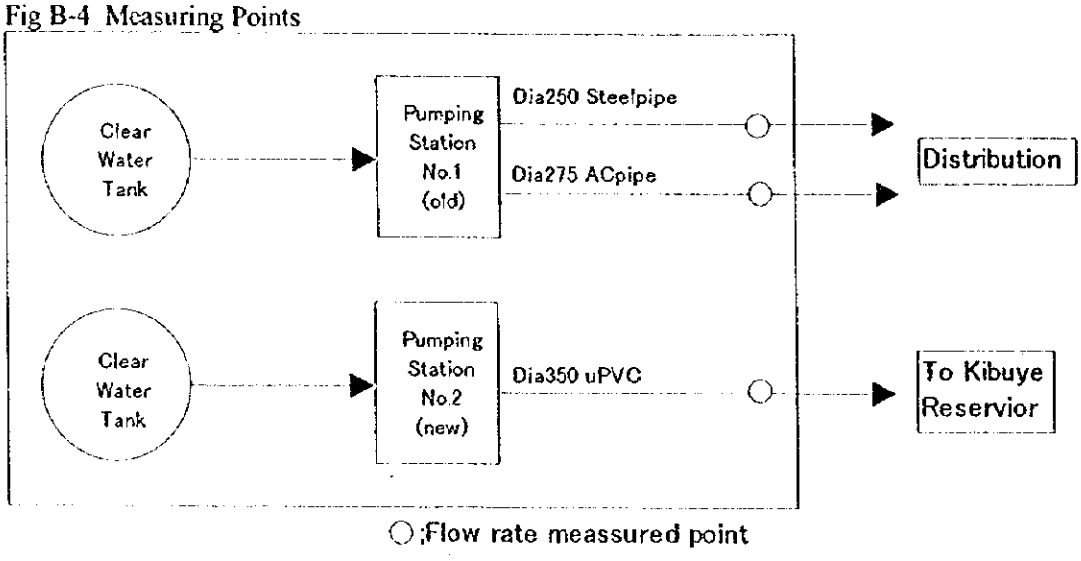
- Flow of rate (m^3/h)
- Duration of measuring : For more than seven days
- Frequency of sampling: 1 hour interval

B7.2.2 Results of Survey

(1) Lake Water Treatment Works

The water is distributed to the system by pumping from two pumping stations which are located within the Treatment Works. Measured points are as follows;

Fig B-4 Measuring Points



Pumping Station No.1(OLD) has 6 Nos. duty pumps and no stand by pump. Three of them feed water to a 275 mm dia. AC rising main. The others feed water to a 250 mm dia. steel rising main. However, at the time of carrying out the survey one pump on each rising main was out of order for the last one year.

Pumping station No.2(NEW) has 8 Nos. duty pumps and no stand by pump, which feed water to a 350 mm dia. uPVC raising main. However, at the time of carrying out the survey 6 pumps were only operational.

The survey results in each pipe are shown in Fig B-5, Fig B-6 and Fig B-7.

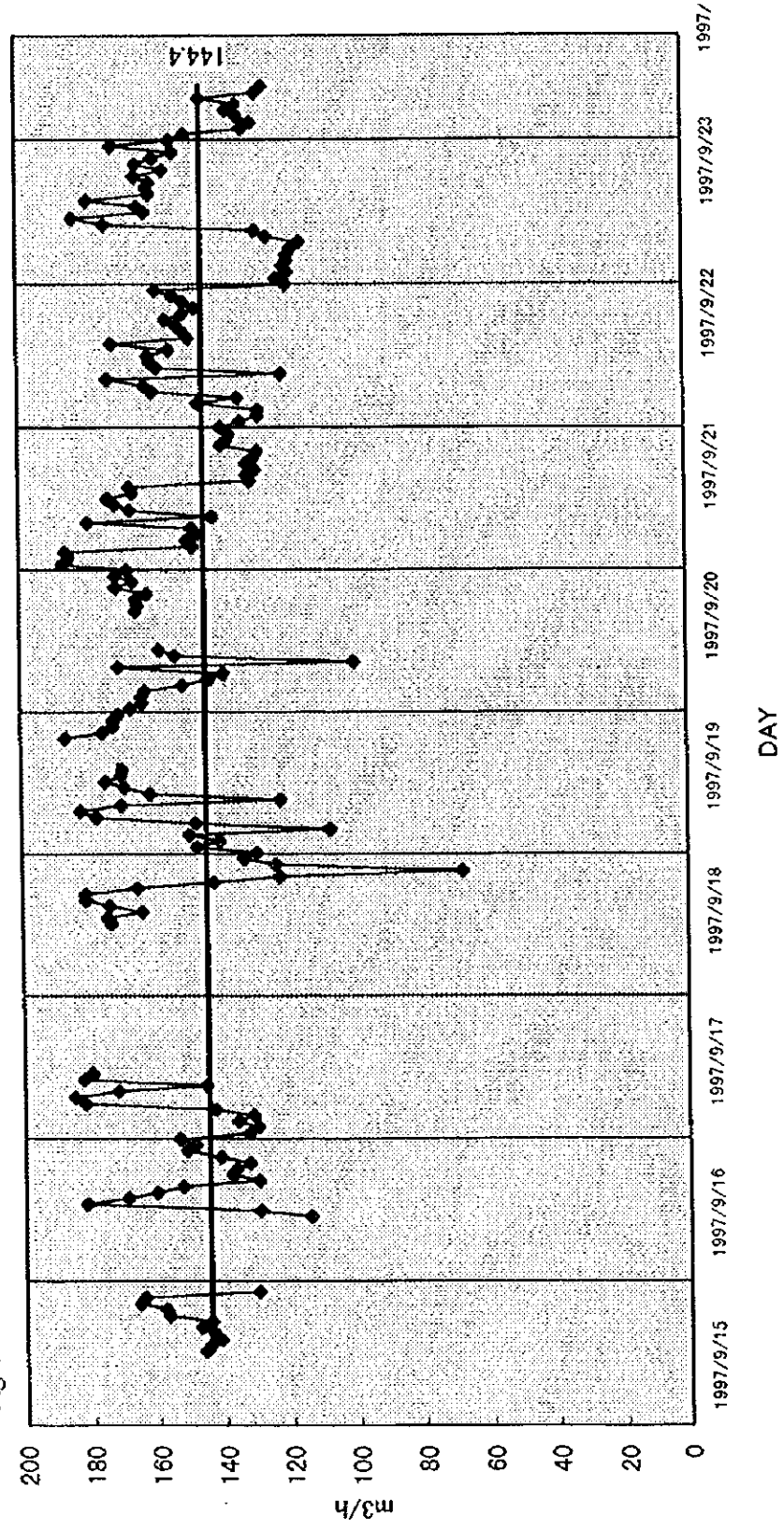


Fig B-5 Result of 250 SP

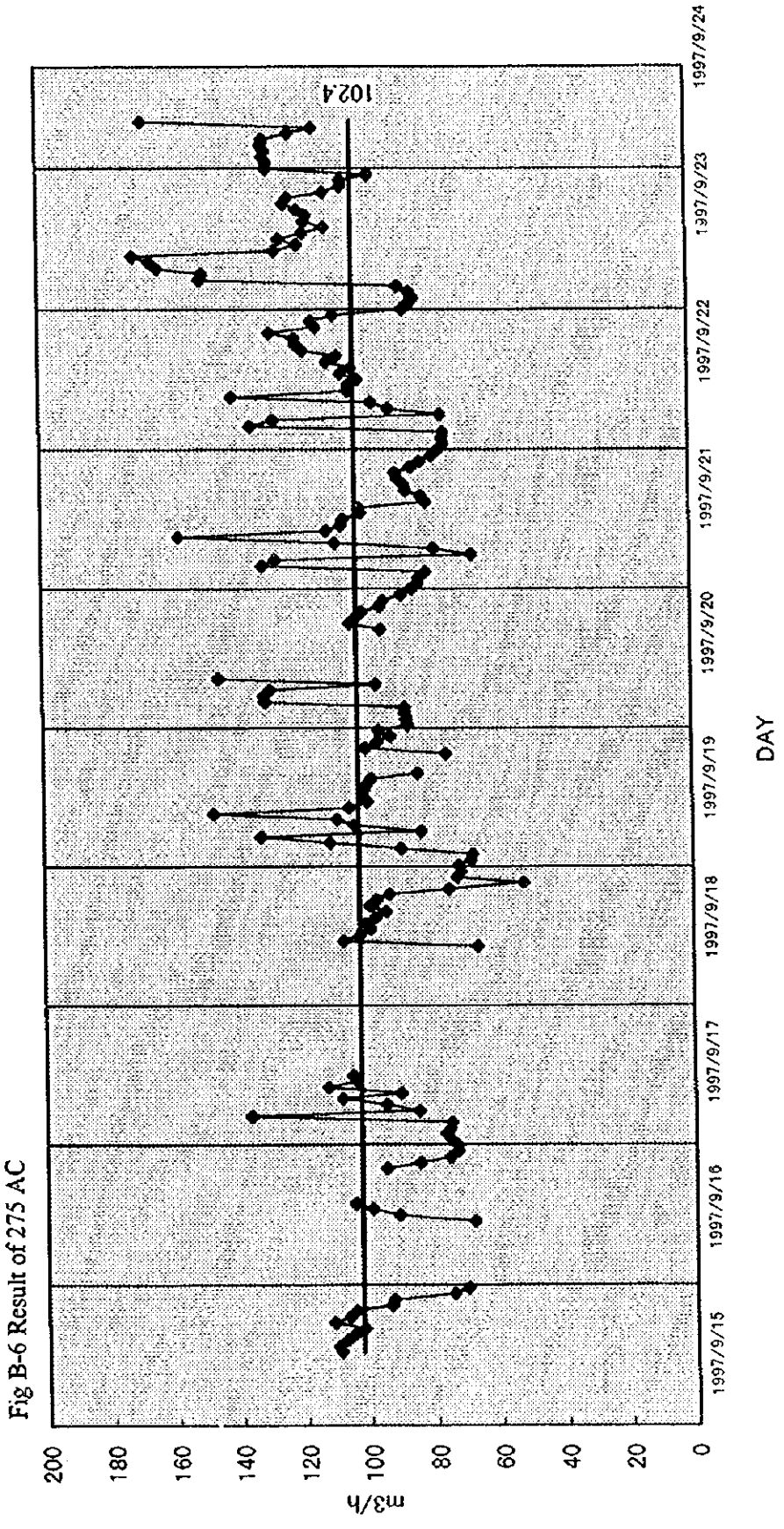


Fig B-6 Result of 275 AC

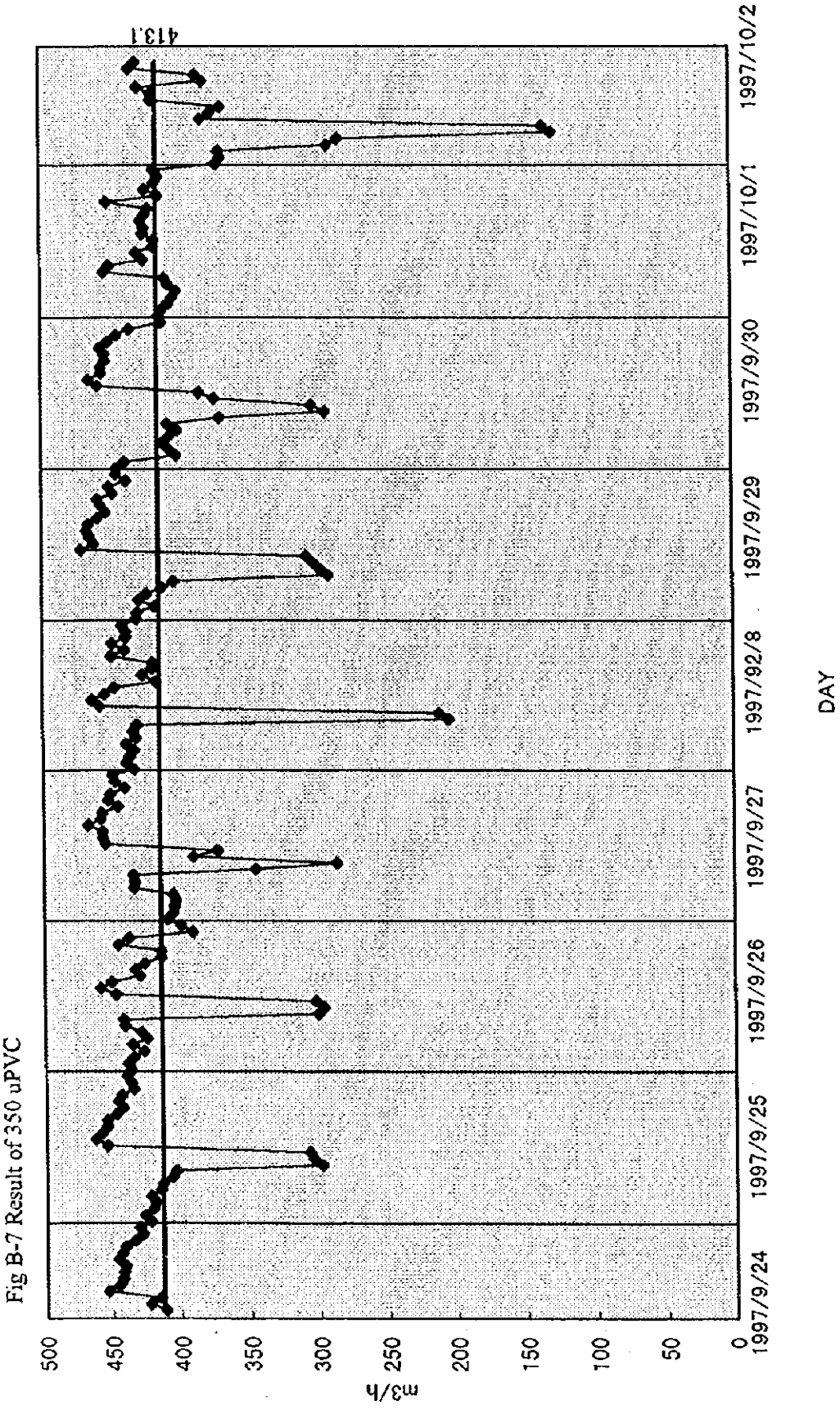


Fig B-7 Result of 350 uPVC

As shown in figures above, duration of missing line means that the rate of flow could not be measured because of lack of power supply. Average flow rate was calculated by way of summation of the flow rate's value divided by total number of the flow rate. Average flow rate is shown in Table B-3.

Table B-3 Average flow rate

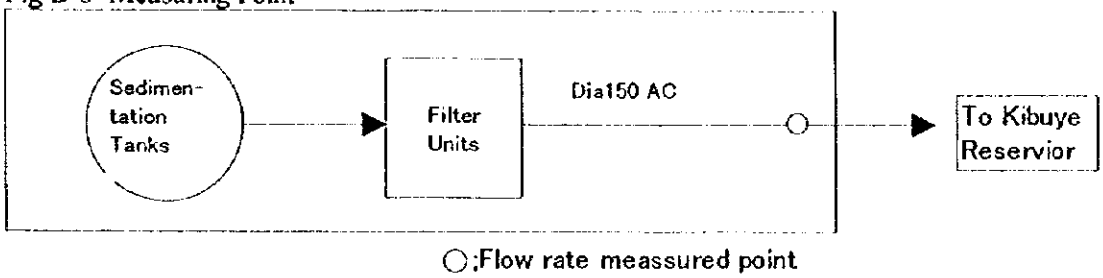
Measured pipe	Average flow rate (m3/h)	Period of measurement
250 SP	144.4	9/15 - 9/24
275 AC	102.4	9/15 - 9/24
350 uPVC	413.1	9/24 - 10/2
TOTAL	659.9	

Measured average production per day in **Lake WTW is 15,800 m^3/day.**

(2) Kajulu Water Treatment Works

Water from Kajulu WTW is fed to the service reservoir at Kibuye under gravity via 150 mm AC main, approximate length 10 km. Measured points are as follows;

Fig B-8 Measuring Point



At the time of survey, two pressure filter units were out of order but were repaired during the course of the flow measurement survey.

The survey results are as follows;

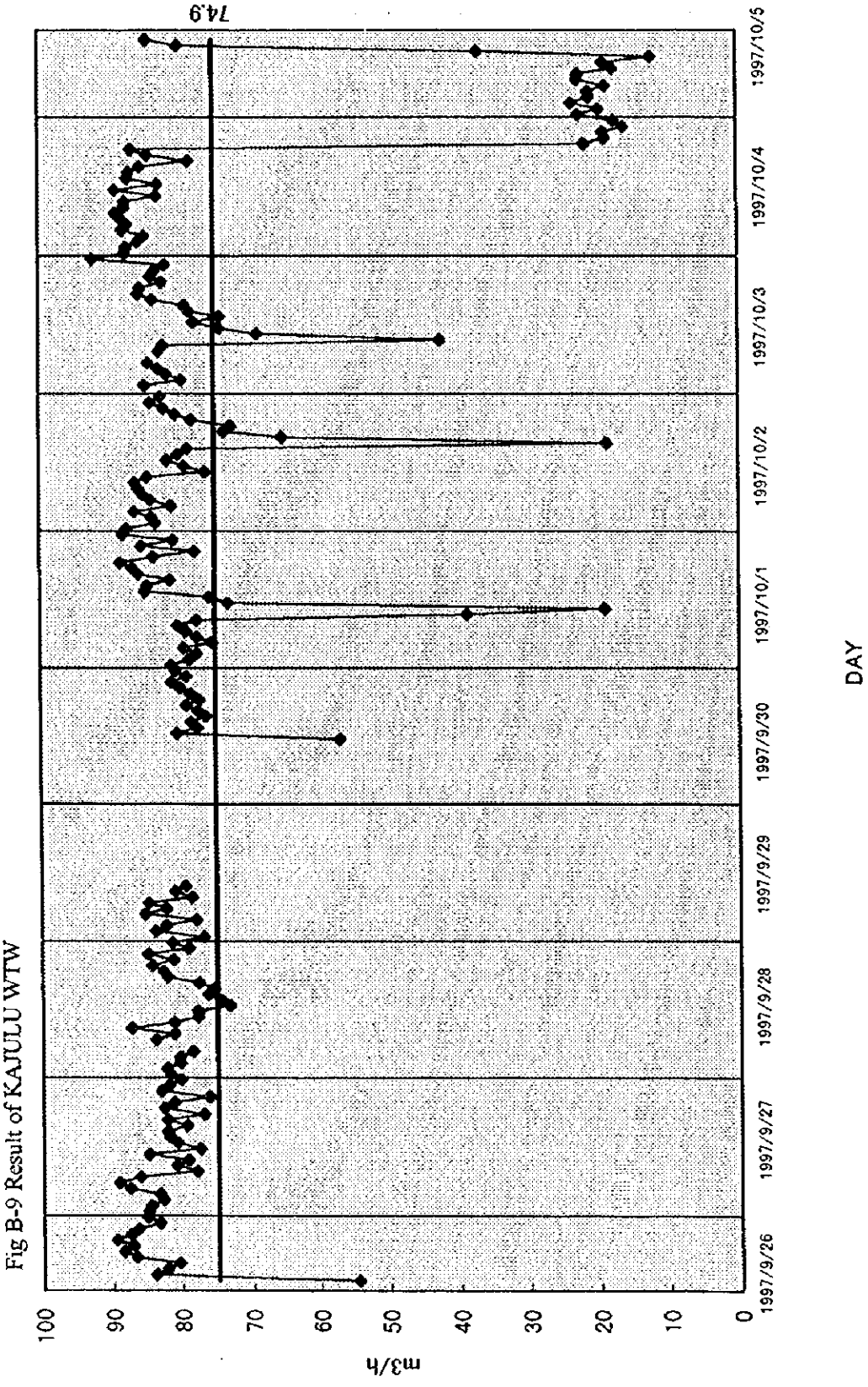


Fig B-9 Result of KAJULU WTW

Calculation of average flow rate is the same as that of Lake WTW.

Average flow rate is 74.9 m3/h, in other words;

Average production per day in **Kajulu WTW** is **1,800 m^3/day**.

(3) Summary

Water production of each water treatment works is as follows;

Table B-4 Measured Production of existing WTW

Water Treatment Works	Water Production (m^3/day)
Lake WTW	15,800
Kajulu WTW	1,800
Total	17,600

B7.3 LEAKAGE SURVEY

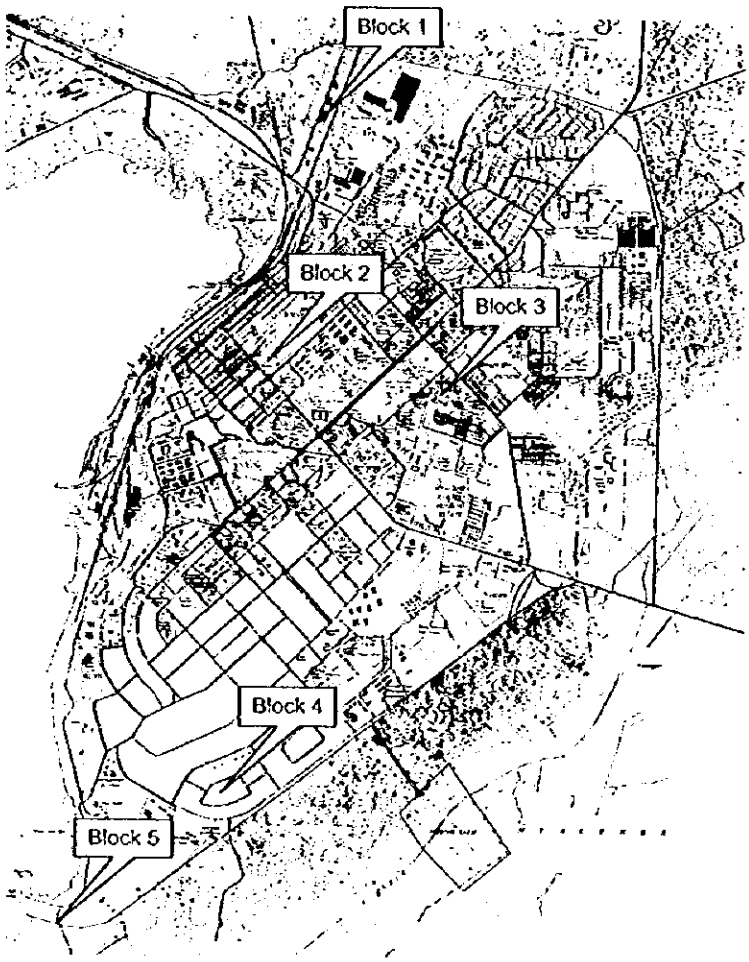
B7.3.1 Location of the survey

The locations of leakage survey were a representative of different parts of the distribution network. The areas were selected as followed;

•	Block1	Industrial area	Subuni Road
•	Block2	Commercial area	Odera Street
•	Block3	Residential area	Ondiek Shopping Center
•	Block4	Residential area	Milimani Estate
•	Block5	Residential area	Ndunga Estate

Fig B-10 shows locations of the blocks.

Fig B-10 Location of Block



B7.3.2 Methodology

In order to assess the magnitude of water losses within the system, Minimum Flow Method and Meter Reading Method were used.

(1) Minimum Flow Method

Minimum Flow method is that minimum flow rate in a 24 hour measurement is assumed to be water loss flow rate because no consumer probably used water at the time when the minimum flow happened. Minimum Flow Method was conducted as follows;

- The block was isolated; only one pipe supplied water to the block and no water exited the block by any other pipe to close valves.
- A device measured flow rate and pressure was set on the inflow pipe.
- Flow rate and pressure were measured.

How to estimate ratio of leakage is as follows;

- Identify minimum flow rate Q_0; Q_0 is supposed to be maximum leakage flow
-
- Identify pressure P_0 when minimum flow rate Q_0 happened
-
- Calculate leakage flow Q_L at any point of pressure measurement Pt using by relations between Q_L and Pt;
- $Q_L = A \cdot Pt^{1/2}$

  where

  A: Constant

  Q_L: Leakage Flow Rate at any time

  Pt: Pressure at any time

  $A = Q_0 / P_0^{1/2}$
- Calculate consumption flow Qc as follows;

  $Qc = Q - Q_L$

  where Qc; Consumption Flow Rate at any time

  Q ; Inflow Rate to the Block at any time

- Calculate Leakage Ratio between Q_L and Q

  Leakage Ratio = $(\int Q_L dt) / (\int Q dt)$

  where;

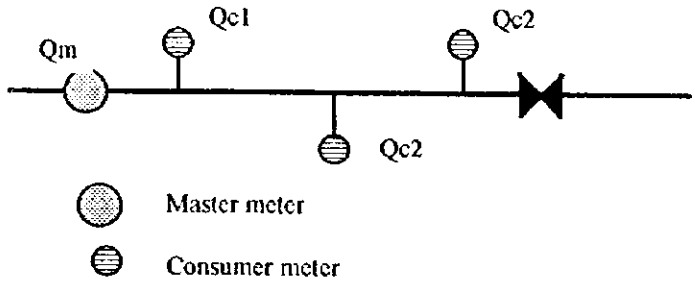
  $\int Q_L dt$: total leakage flow in a day

$\int Q\,dt$: total inflow to the block in a day

(2) Meter Reading Method

Meter Reading method is that the difference of figures between a master meter reading figures and total consumer's meter reading figures should be water losses. The measurement was carried out for 24 hours in some blocks.

Fig B-11 Schematic Meter Reading Method System



$Q_L = Qm - (Qc1 + Qc2 + Qc3)$
where;
Q_L: Total Leakage flow
Qm: Total Inflow rate in Master Meter
Qci: Total Consumption flow at each meter
Leakage ratio = Q_L / Qm

B7.3.3 Results of the survey

The measurement by Meter Reading Method was supplementary carried out. To mention below, the results of some blocks by Minimum Flow Method were extremely high values, so re-survey was carried out by Meter Reading Method whether these results were good or not. Table B-5 shows cases of the survey;

Table B-5 Executed cases of the Survey

	Minimum Flow Method	Meter Reading Method
Block 1	DONE	DONE
Block 2	DONE	
Block 3	DONE	DONE
Block 4	DONE	
Block 5	DONE	DONE

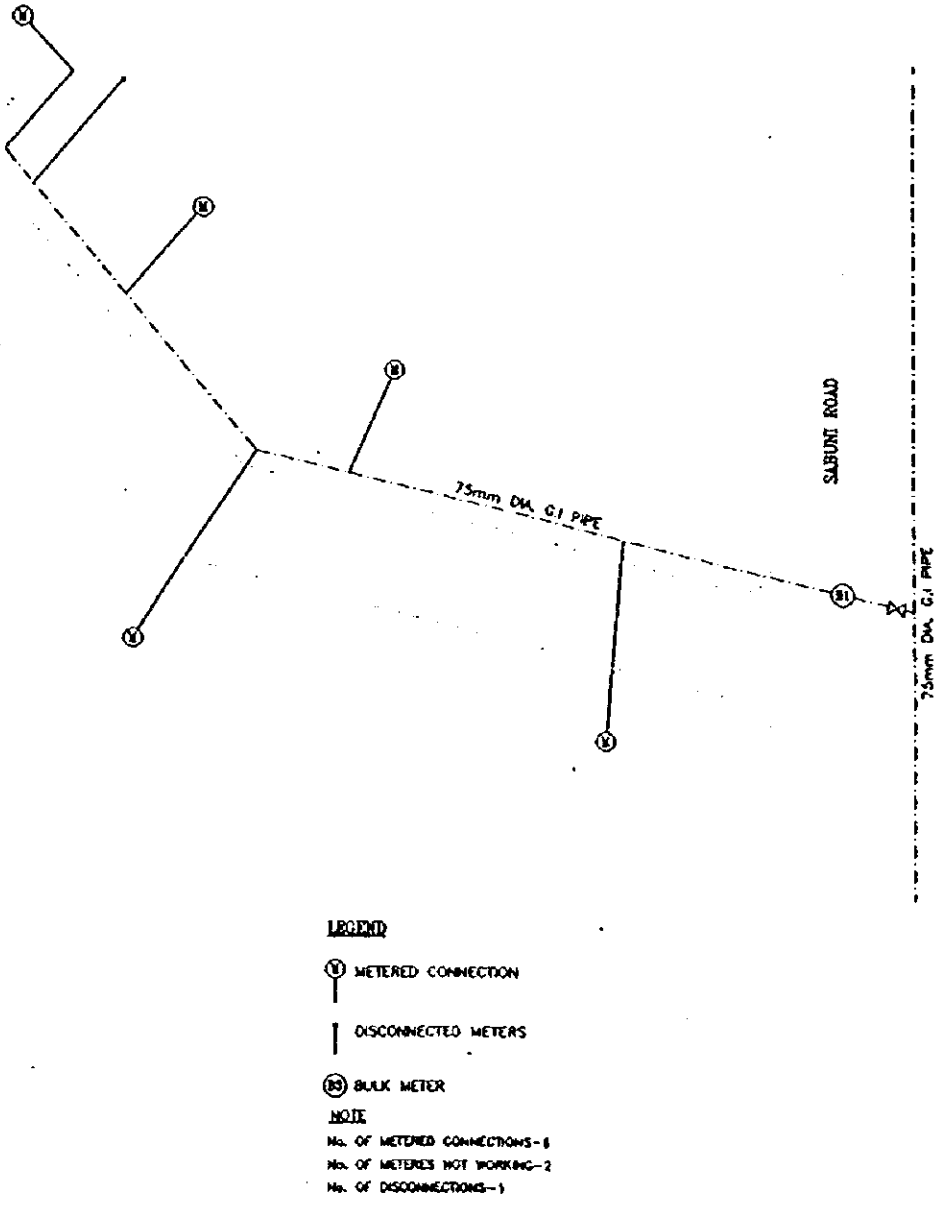
(1) Block 1

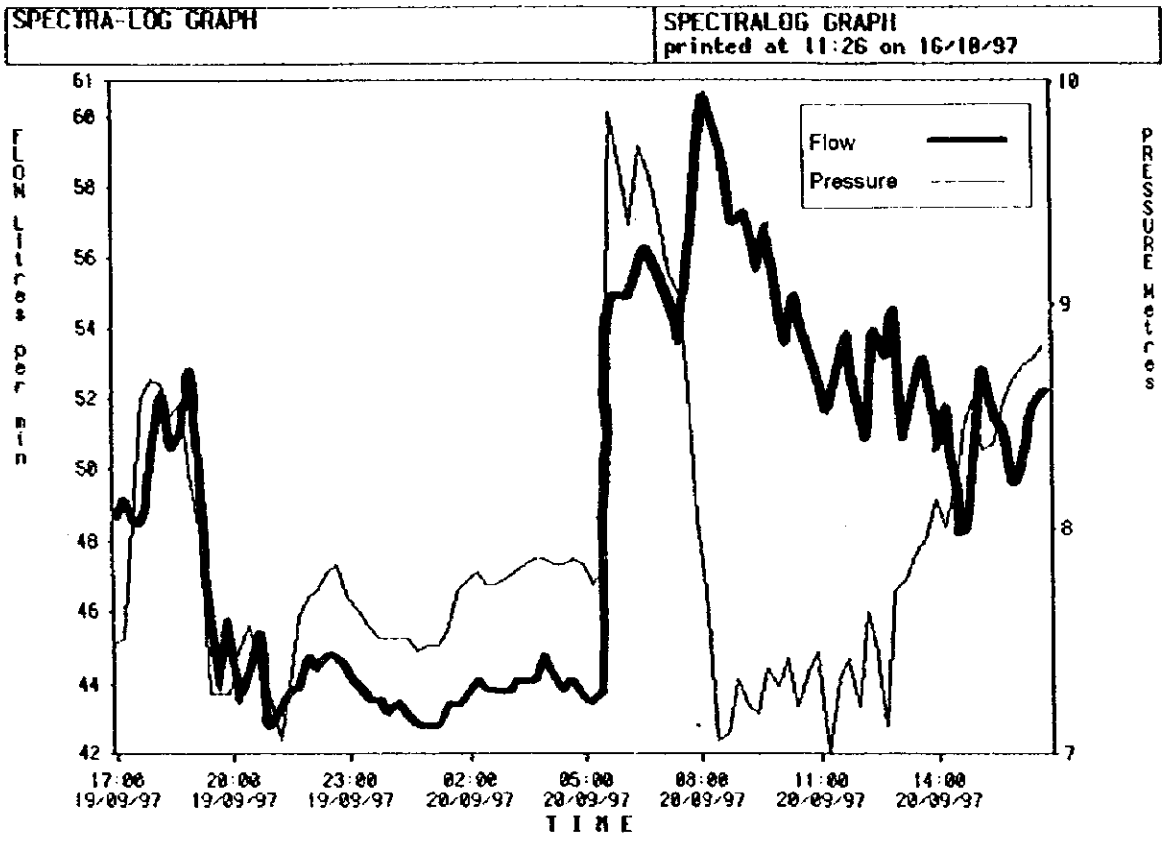
a) Minimum Flow Method

Location, Measured flow rate and pressure, Calculated Q_i and Q are shown Fig B-12,Fig B-13, Fig B-14.

Leakage Ratio is 89%.

Fig B-12 Block1 Location





Flow Minimum 42.76 l/min
The Pressure 7.29 m

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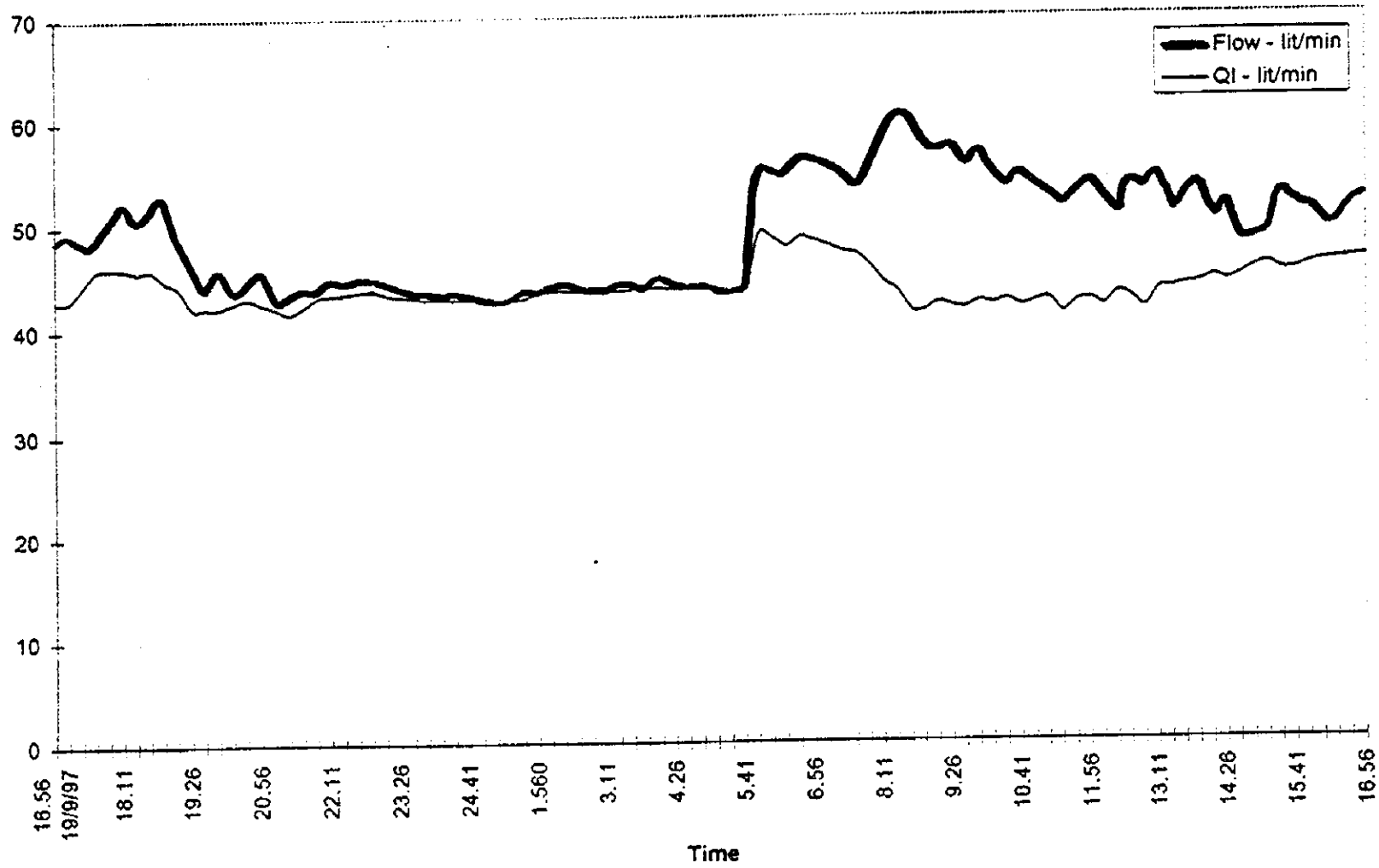


THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Leakage and Pressure Measurements Block 1 Flow Rate Curve-Inflow/Minimum Flow

b) Meter Reading Method

Location is shown in Fig B-15. Table B-6 shows results of meter reading;

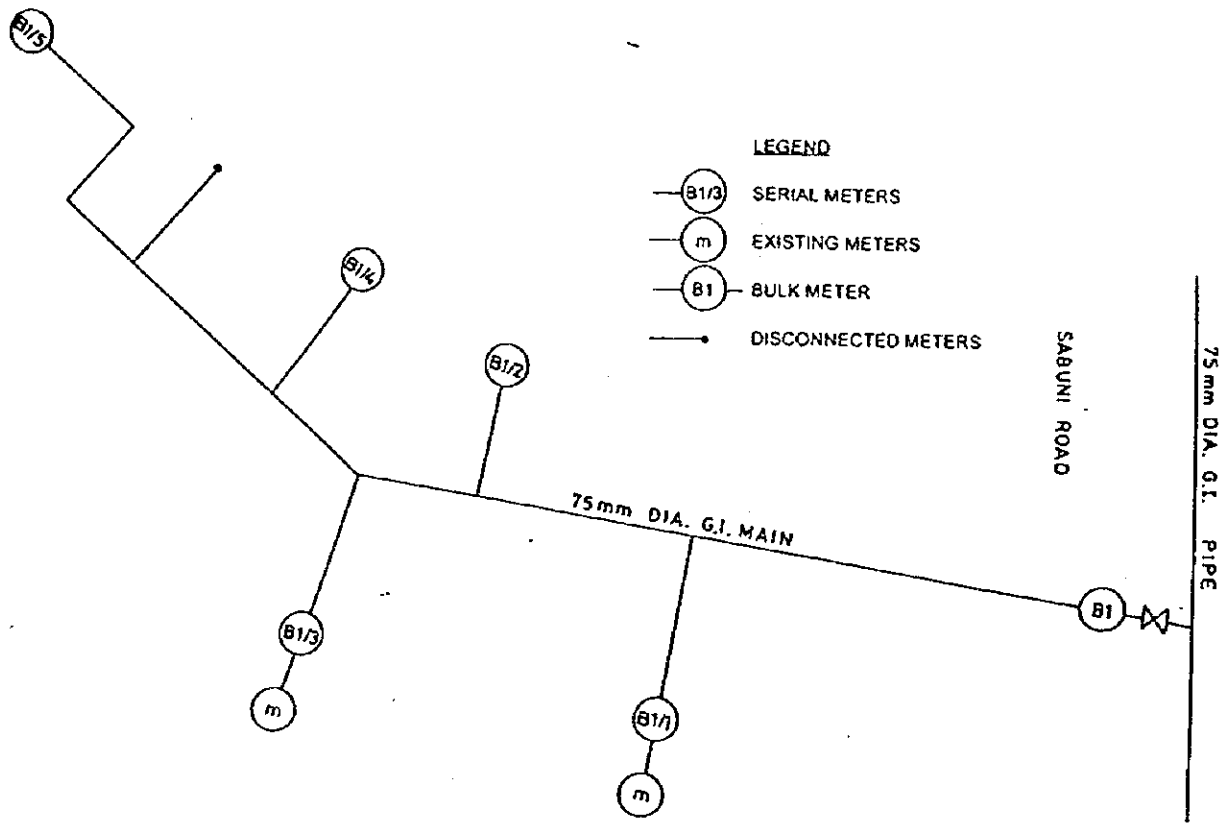
Table B-6 Results of Meter Reading in Block 1

Meter Location	Start Meter Reading	End Meter Reading	Total Consumption m^3	Start Date	Measured period min	Consumption m^3/day
B1	1505.390	1546.220	40.830	97/10/7	1485	39.59
Total						39.59
B1/1	0.289	0.485	0.196	97/10/7	1482	0.19
B1/2	0.008	0.054	0.048	97/10/7	1481	0.05
B1/3	3.831	9.964	6.133	97/10/7	1480	5.97
B1/4	1723.846	1724.751	0.905	97/10/7	1485	0.88
B1/5	2.012	2.089	0.077	97/10/7	1487	0.08
Total						7.16

Q_L = 39.59 - 7.16 = 32.43

Leakage ratio is **82%**

Fig B-15 Block 1 Location



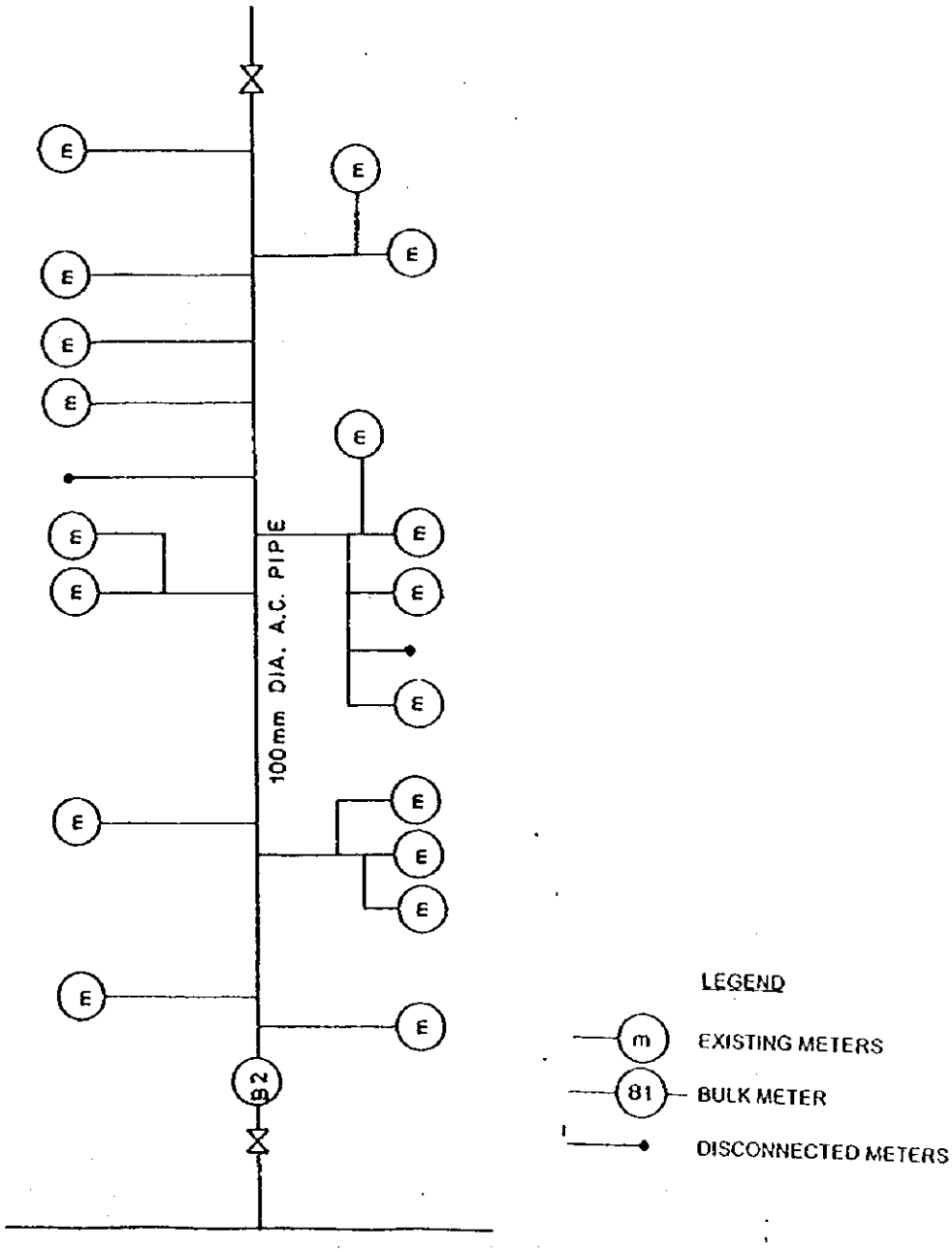
(2) Block 2

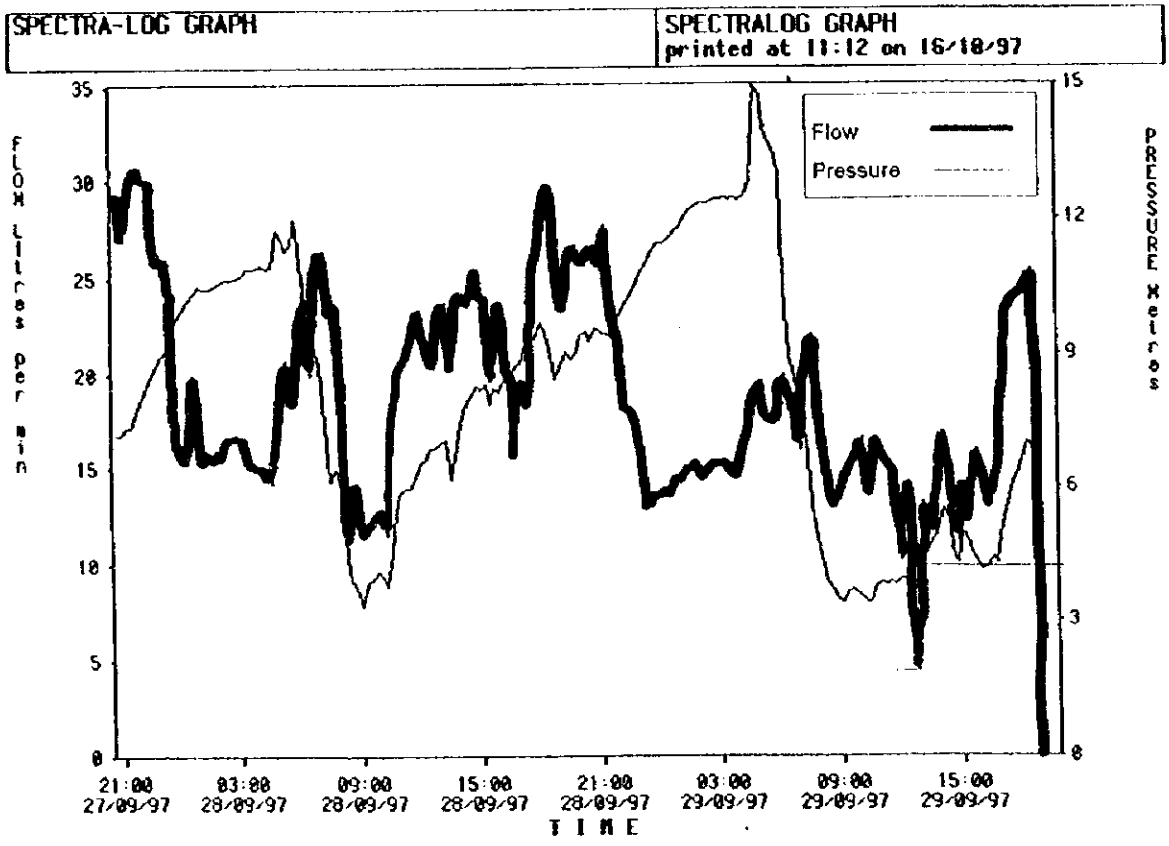
a) Minimum Flow Method

Location, Measured flow rate and pressure, Calculated Q_L and Q are shown Fig B-16, Fig B-17, Fig B-18.

Leakage Ratio is **51%**.

Fig B-16 Block 2 Location





Flow Minimum 4.62 l /min
The Pressure 4.17 m

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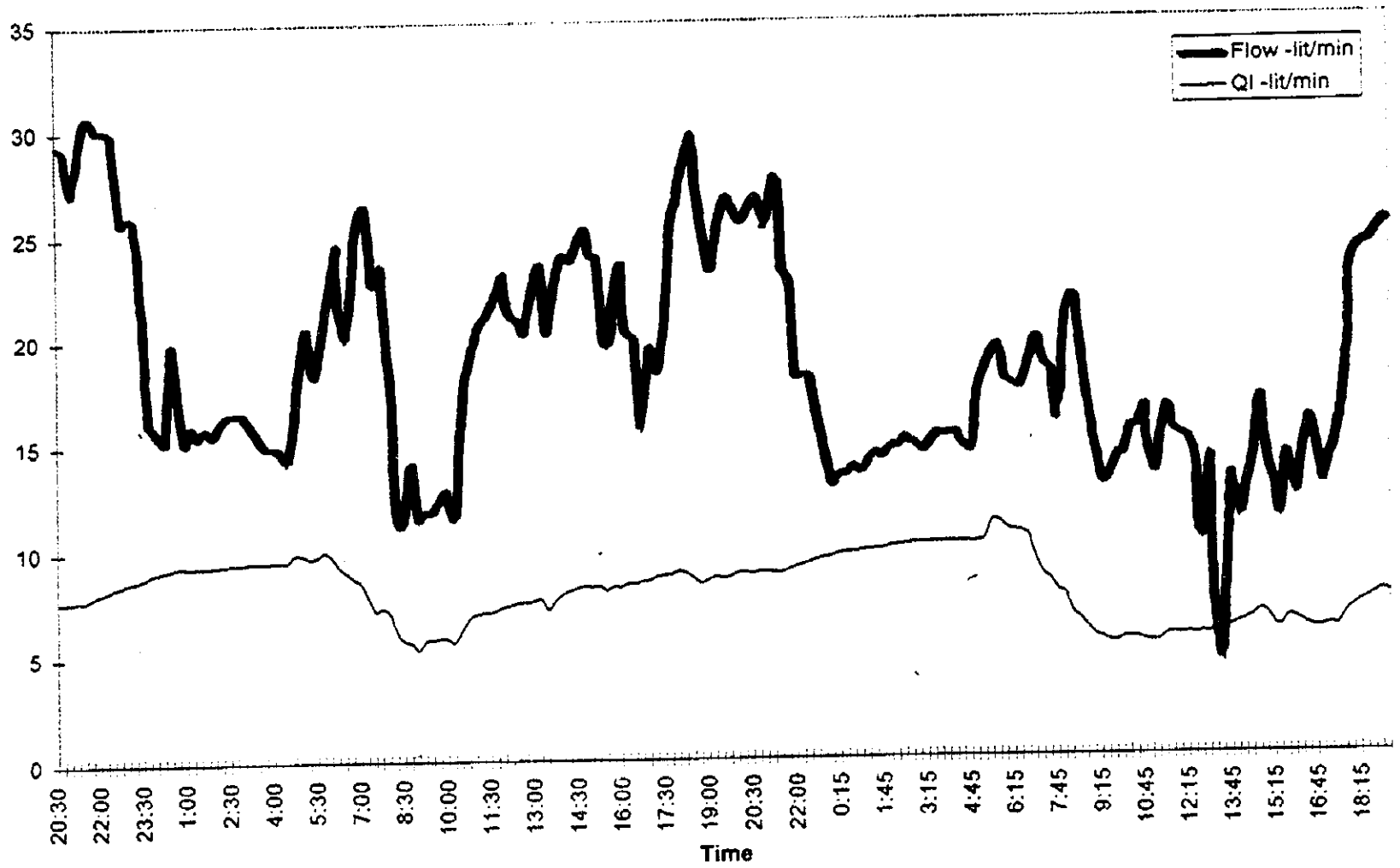
Block 2 - Commercial Area



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Leakage and Pressure Measurements Block 2 Flow Rate Curve-Inflow/Minimum Flow

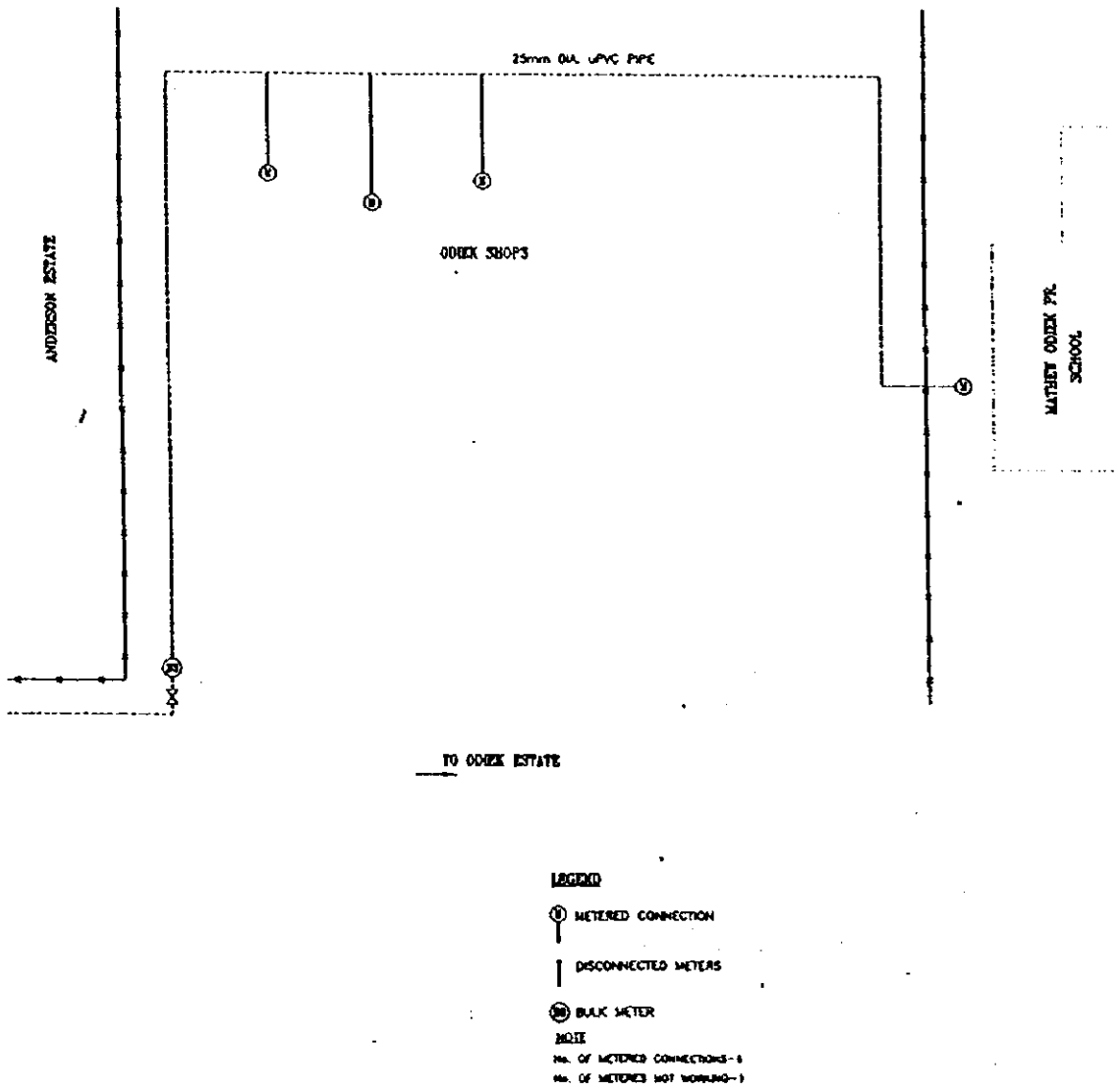
(3) Block 3

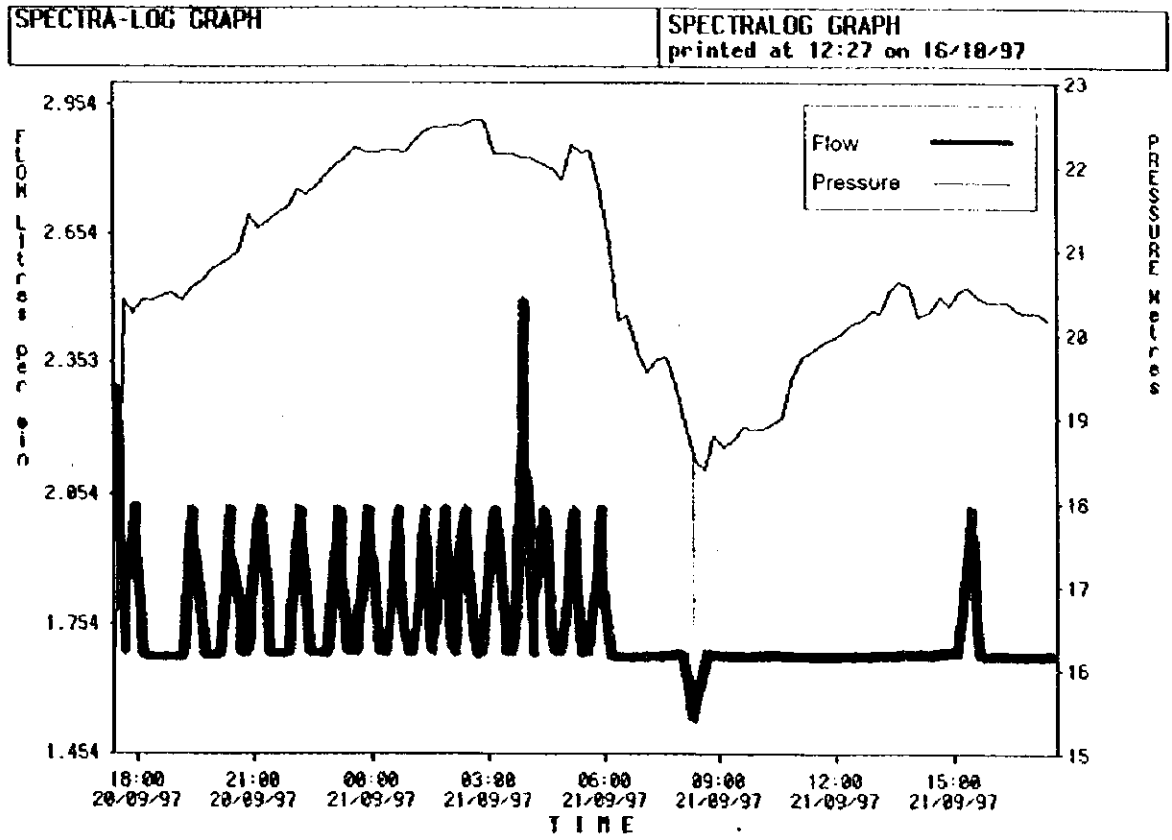
a) Minimum Flow Method

Location, Measured flow rate and pressure, Calculated Q_L and Q are shown Fig B-19, Fig B-20, Fig B-21.

Leakage Ratio is 92%.

Fig B-19 Block 2 Location





Flow Minimum 1.53 l /min
The Pressure 18.55 m

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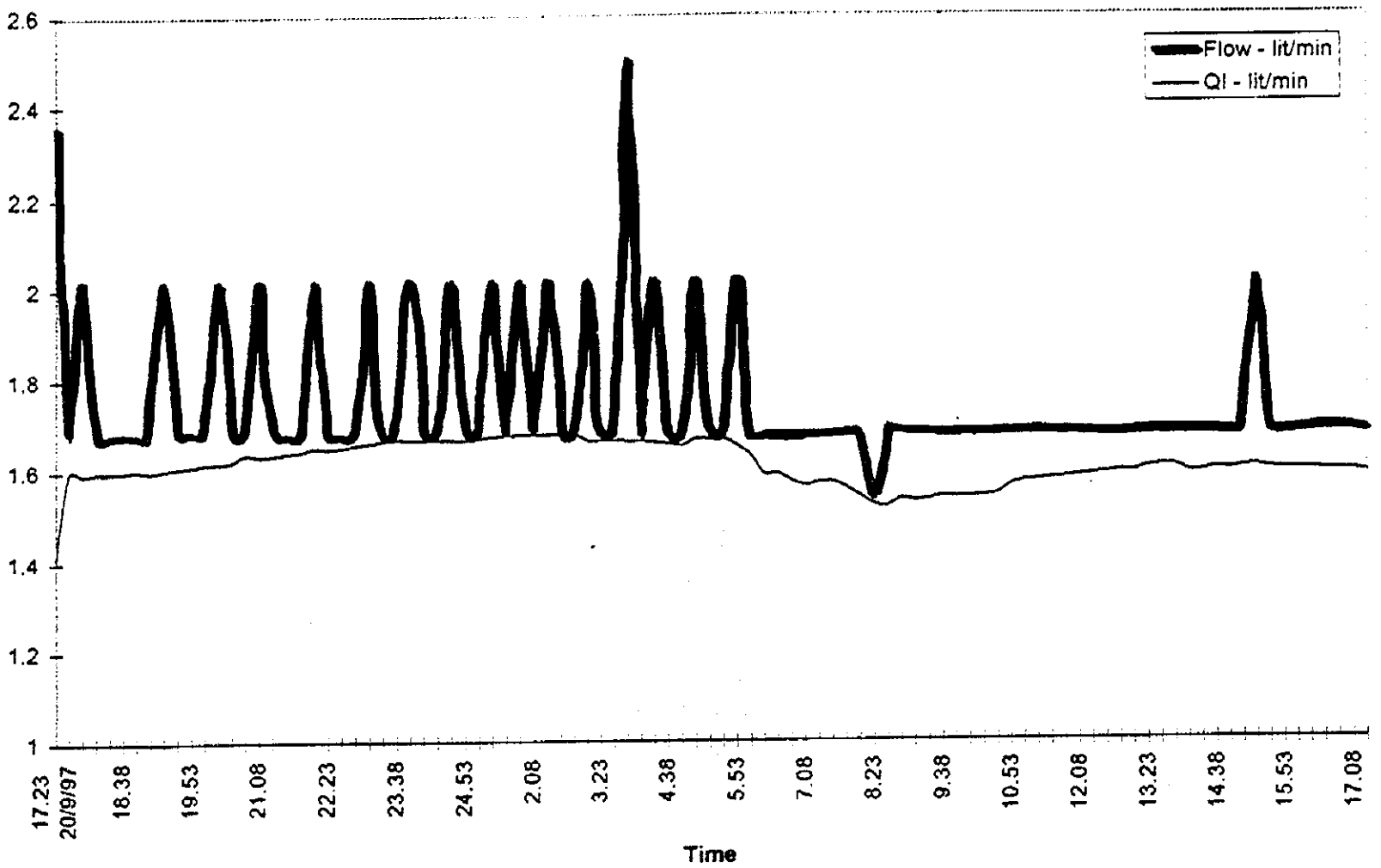
Block 3 - Ondiek



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Leakage and Pressure Measurements Block 3 Flow Rate Curve-Inflow/Minimum Flow

b) Meter Reading Method

Location is shown in Fig B-22. Table B-7 shows results of meter reading;

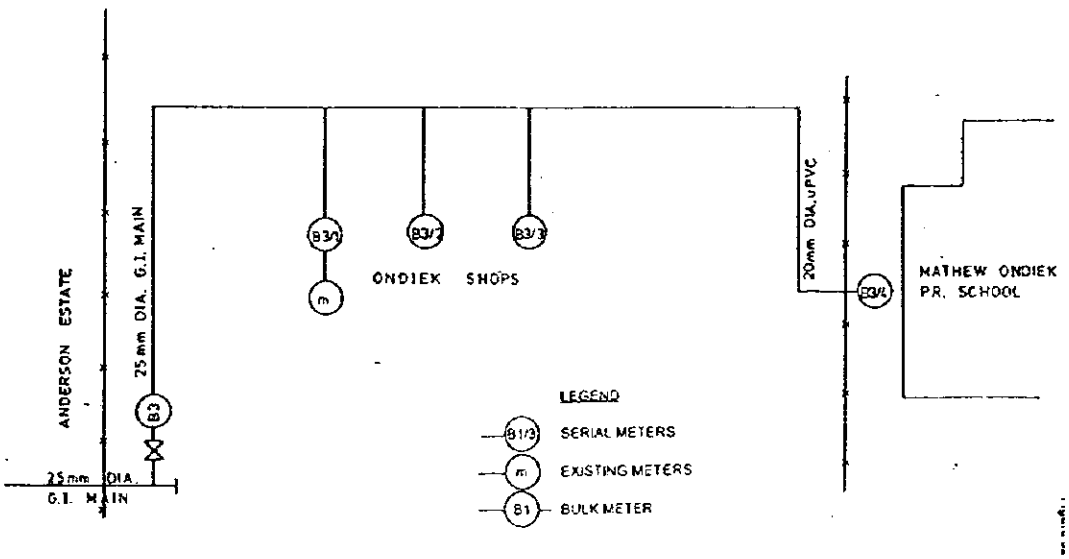
Table B-7 Results of Meter Reading in Block 1

Meter Location	Start Meter Reading	End Meter Reading	Total Consumption m^3	Start Date	Measured period min	Consumption m^3/day
B3	30.012	32.953	2.941	97/10/7	1510	2.80
Total						2.80
B3/1	1.889	2.396	0.507	97/10/7	1508	0.48
B3/2	3.151	4.379	1.228	97/10/7	1510	1.17
B3/3	0.058	0.087	0.029	97/10/7	1500	0.03
B3/4	2.055	2.122	0.067	97/10/7	1500	0.06
Total						1.74

$Q_L = 2.80 - 1.74 = 1.06$

Leakage ratio is **38%**

Fig B-22 Block 3 Location



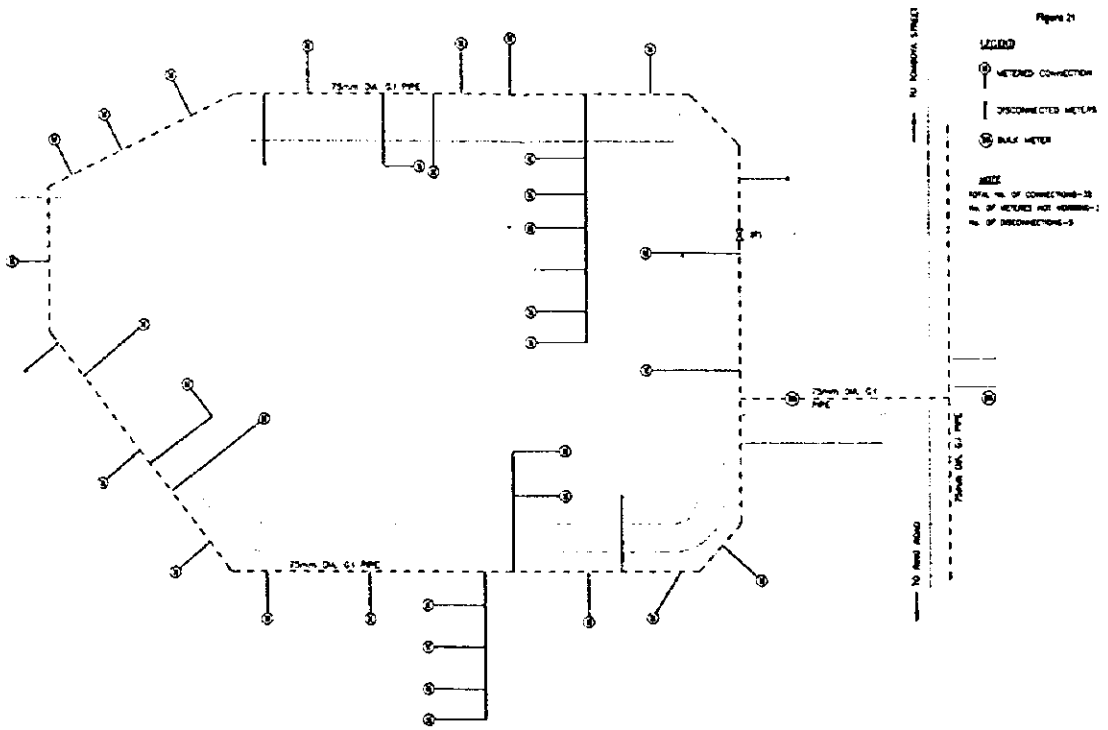
(4) Block 4

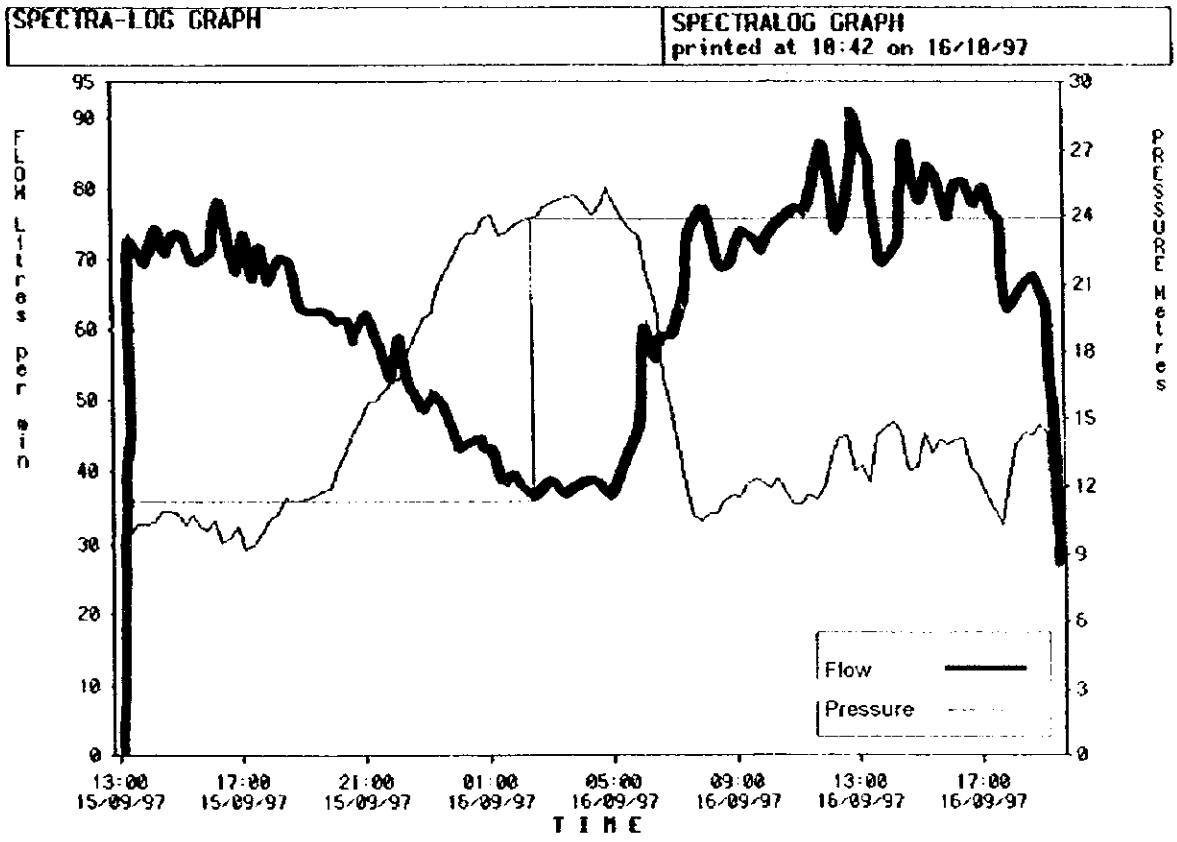
a) Minimum Flow Method

Location, Measured flow rate and pressure, Calculated Q_L and Q are shown Fig B-23, Fig B-24, Fig B-25.

Leakage Ratio is **44%**.

Fig B-23 Block 4 Location





Flow Minimum 36.00 l /min
The Pressure 24.00 m

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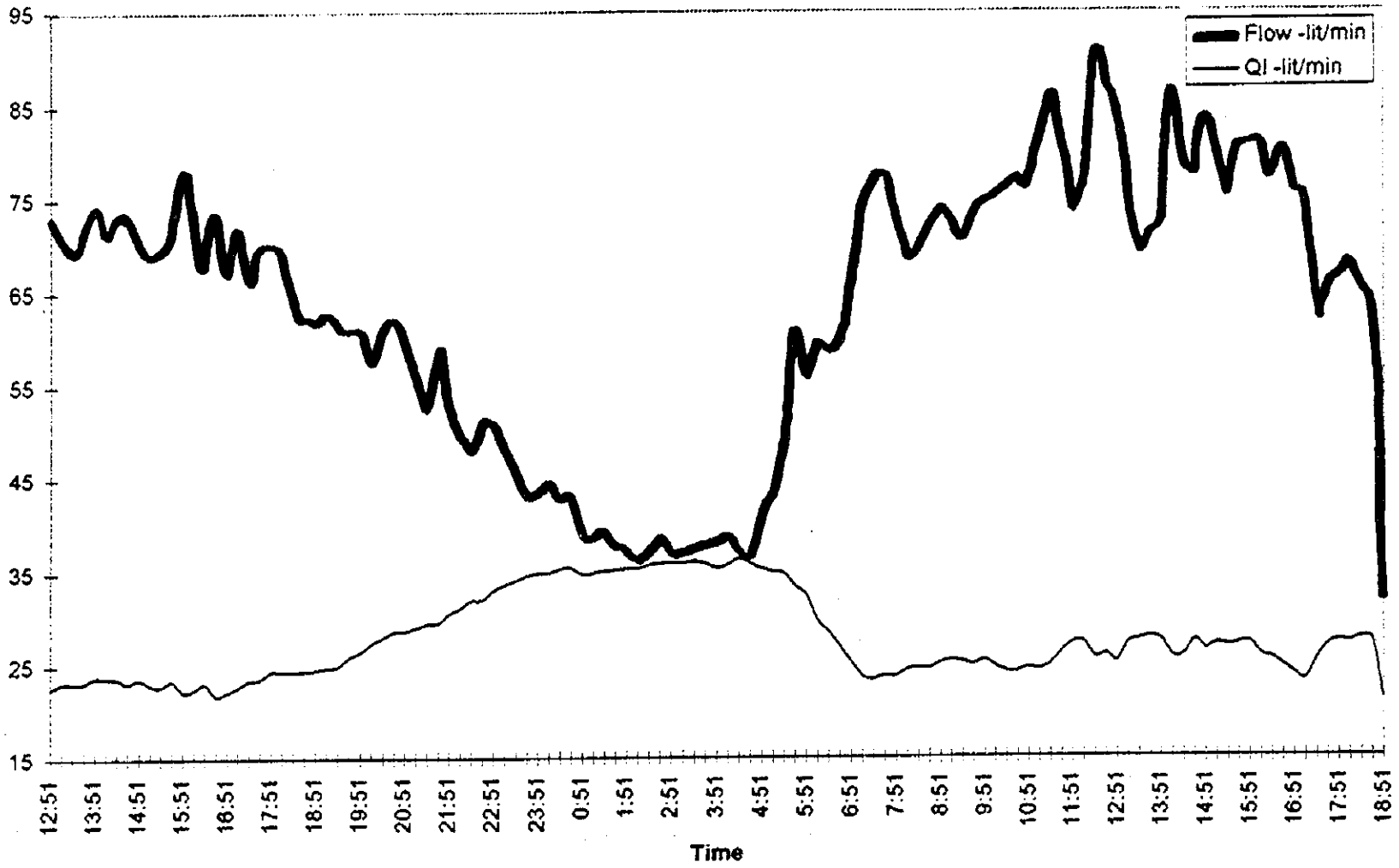
Block 4 - Milimani



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Leakage and Pressure Measurements Block 4 Flow Rate Curve-Inflow/Minimum Flow

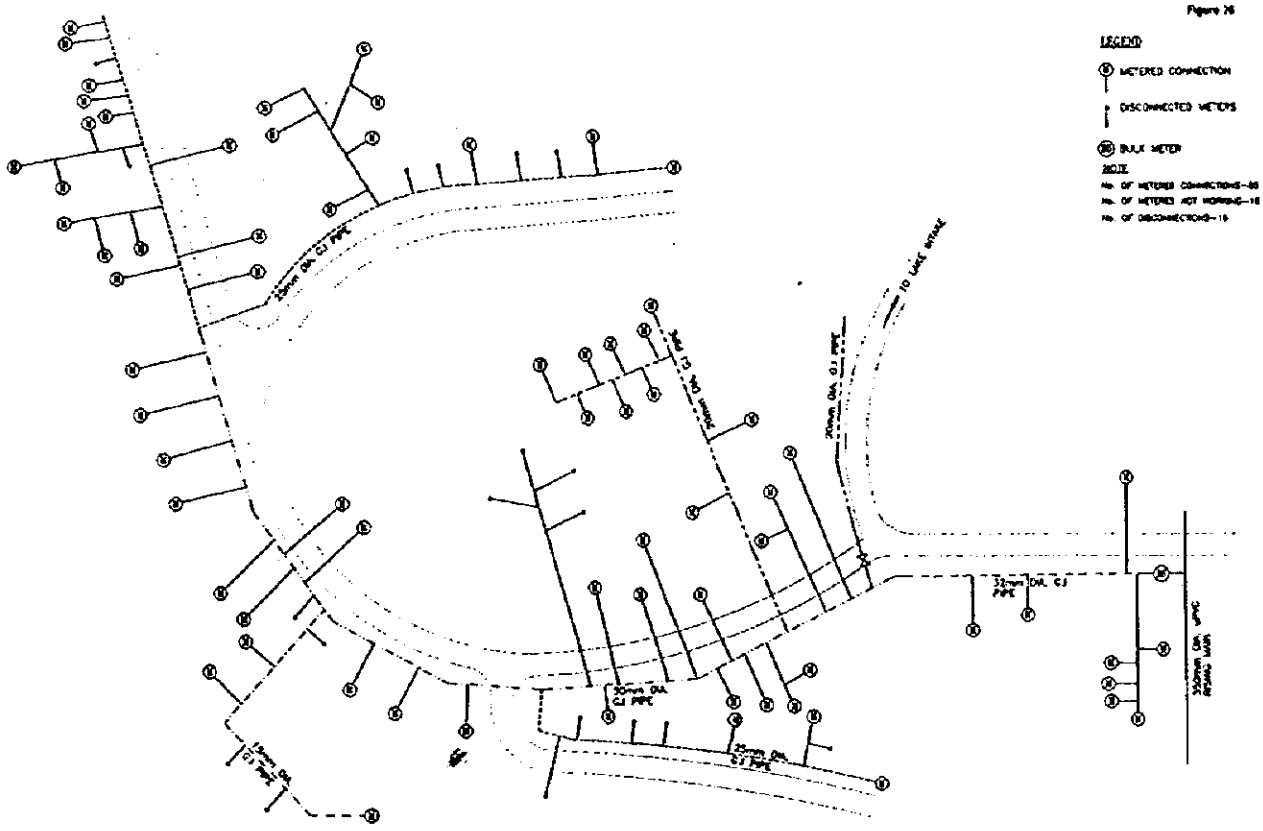
(5) Block 5

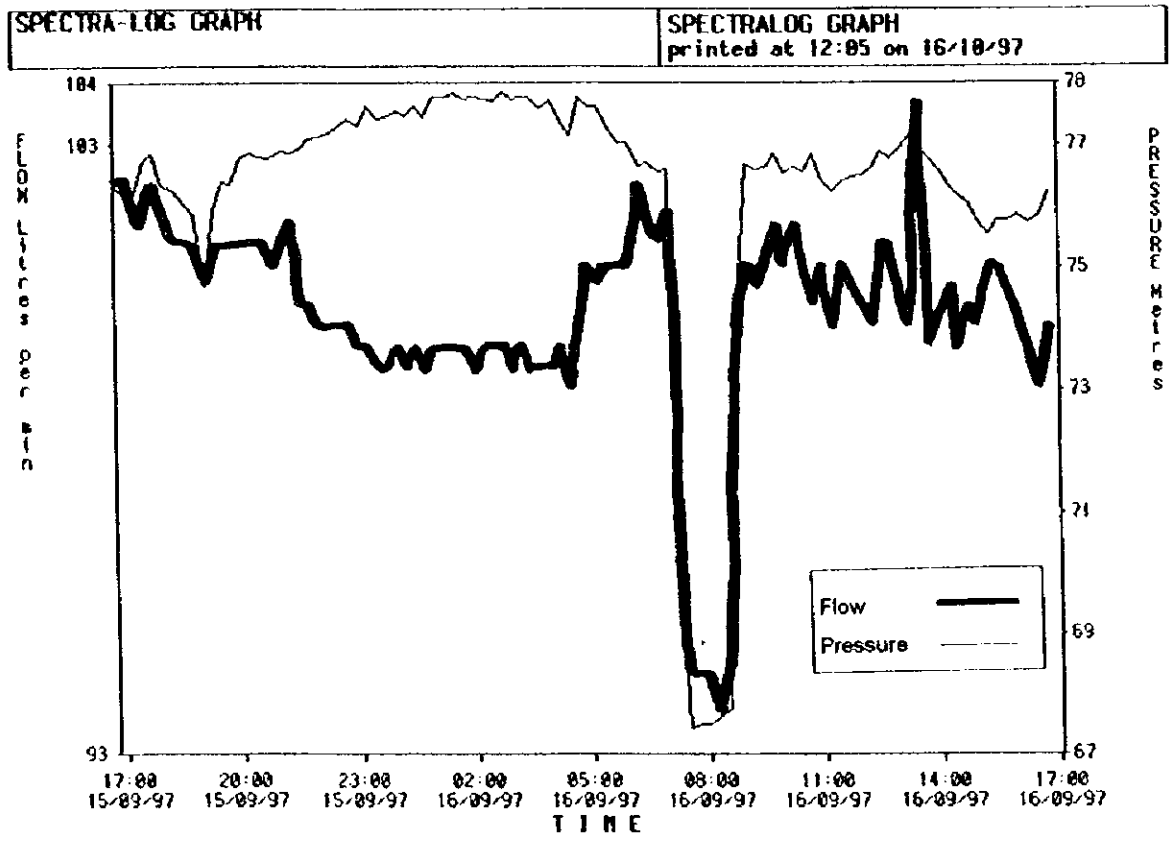
a) Minimum Flow Method

Location, Measured flow rate and pressure, Calculated Q_L and Q are shown Fig B-26, Fig B-27, Fig B-28.

Leakage Ratio is 98%.

Fig B-26 Block 5 Location





Flow Minimum 93.60 l /min
The Pressure 67.75 m

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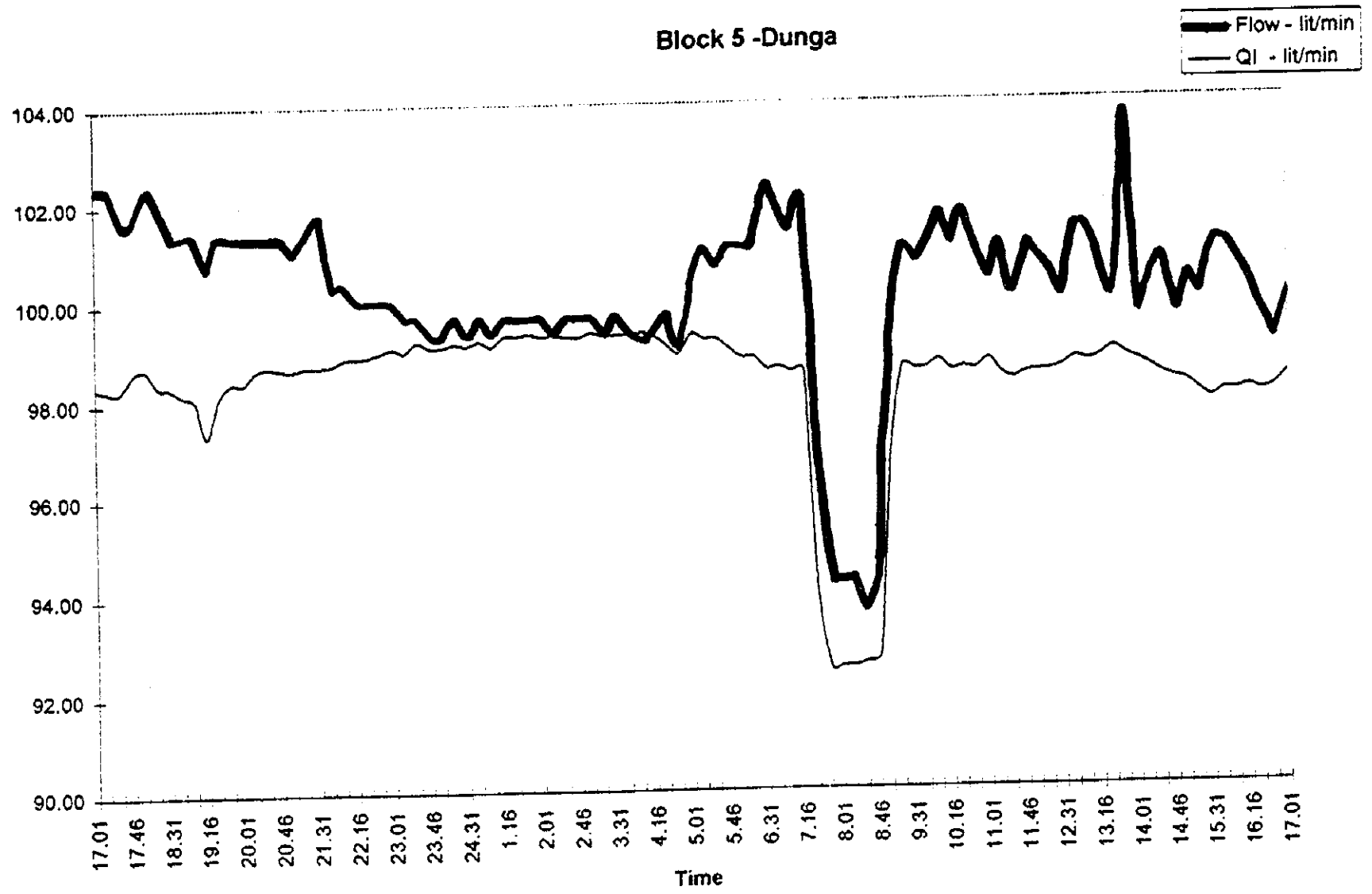


THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Leakage and Pressure Measurements Block 5 Flow Rate Curve-Inflow/Minimum Flow

b) Meter Reading Method

Location is shown in Fig B-29. Table B-8 shows results of meter reading;

Table B-8 Results of Meter Reading in Block 1

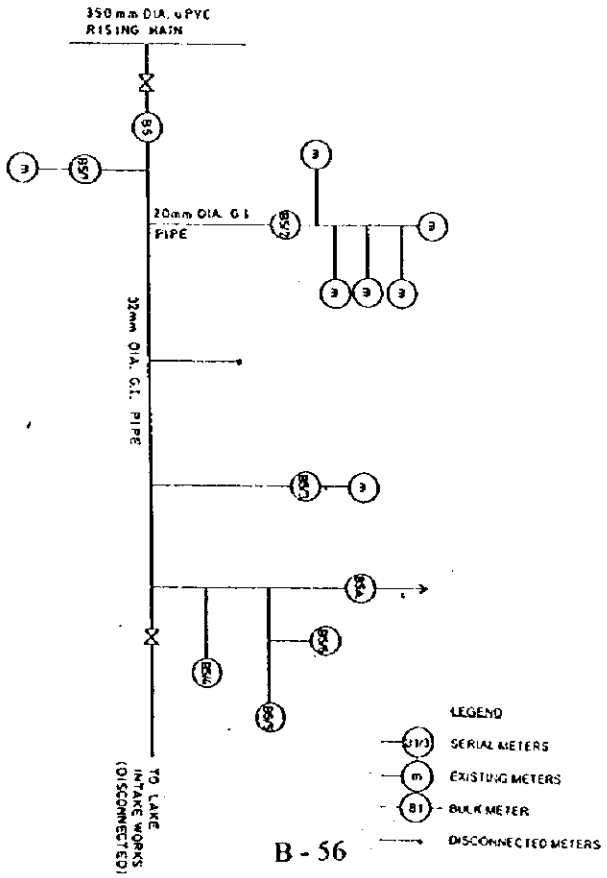
Meter Location	Start Meter Reading	End Meter Reading	Total Consumption m^3	Start Date	Measured period min	Consumption m^3/day
B5	5463.280	5606.545	143.265	97/10/5	1465	140.82
Total						140.82
B5A	3091.385	3159.237	67.852	07/10/5	1475	66.24
Total						66.24
B5/1	18.422	26.561	8.139	97/10/5	1460	8.03
B5/2	11.781	22.986	11.205	97/10/5	1460	11.05
B5/3	4.314	7.090	2.776	97/10/5	1460	2.74
B5/4	1.754	4.630	2.876	97/10/5	1465	2.83
B5/5	0.853	1.466	0.613	97/10/5	1460	0.60
B5/6	2574.868	2576.092	1.224	97/10/5	1460	1.21
Total						26.46

$Q = 140.24 - 66.24 = 74.00$

$Q_L = 140.82 - 66.24 - 26.46 = 48.12$

Leakage ratio is **65%**

Fig B-29 Block 5 Location



B7. 3.4 Summary

Survey results are shown in Table B-9.

Table B-9 Summary

Block	No. of	Leakage Ratio (%)		Remarks
	Connections	Minimum Flow Method	Meter Reading Method	
B1	5	89	82	Industrial
B2	17	51	-	Commercial
B3	4	92	*38	Residential
B4	27	*44	-	Residential
B5	66	98	65	Residential

Note: Average leakage ratio is considered to be between the figures with *mark.

B7.4 CONDITION SURVEY OF THE EXISTING DISTRIBUTION PIPE

B7.4.1 General

A condition survey has been carried out on the existing distribution pipe network.
The purpose of this survey was to record all components of the system, generally as follows;

- Pipe location
- Pipe diameter (Nominal) 80mm diameter and above
- Length of pipe
- Material of pipe
- Year of construction
- Location of bulk meters, Valves, hydrants, air valves and other appurtenances
- Updating of 1:2500 scale existing drawings

B7.4.2 Methodology

In order to identify mains on the ground, node points were adopted which were transferred to 1:2500 scale maps.

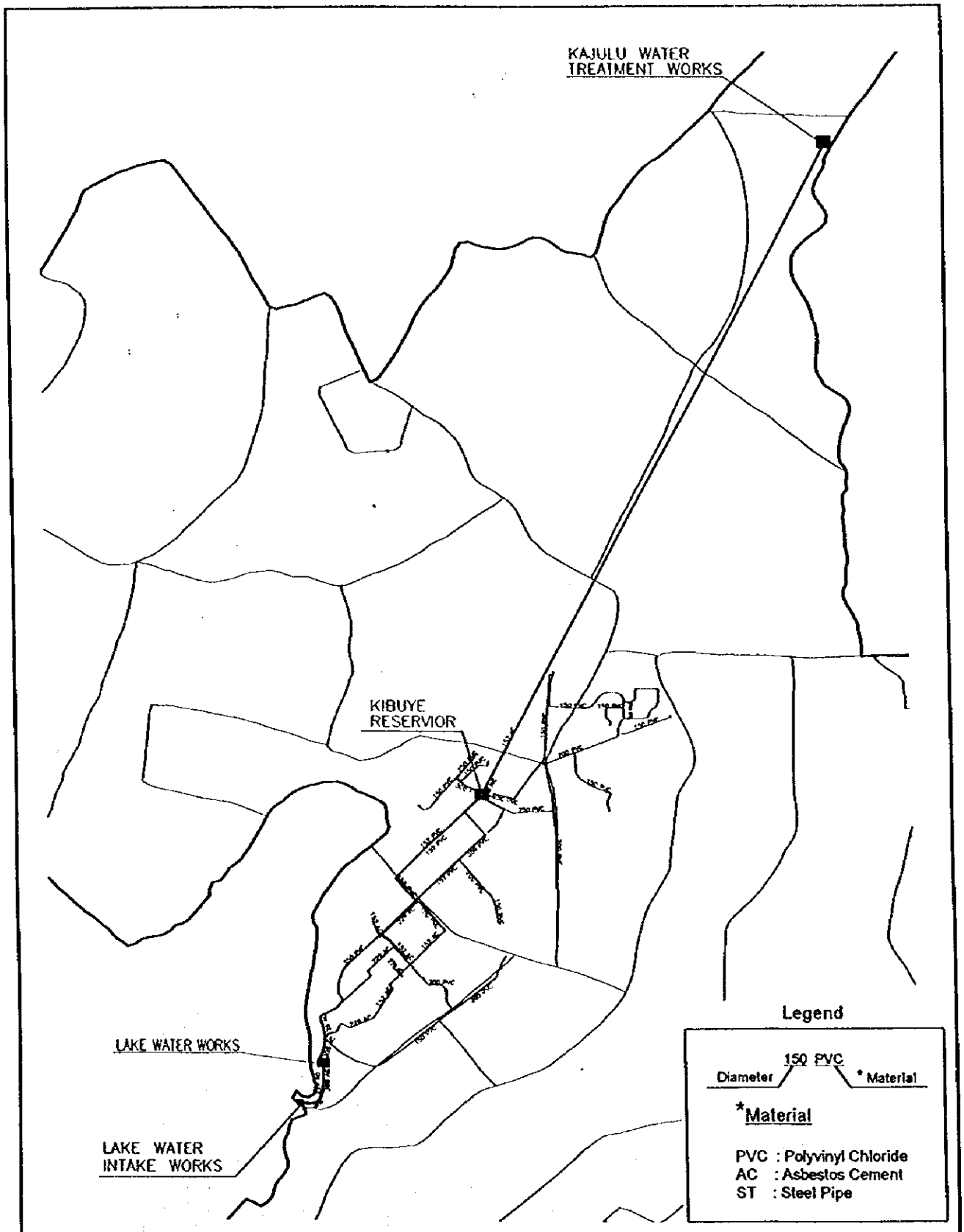
Casual labourer were engaged to manually excavate the junction points in the distribution net work and notes made by a engineer in the field about the status of appurtenances, size of pipe etc.

The data obtained in the field has then been transferred to the 1:2500 drawings.

During the entire period of investigation, liaison was maintained with the staff of the KMC such as General Manager, Water Works Superintendents, Operator, Meter Reader, Line Patrollers.

B7.4.3 Results of the Survey

Results are shown in Fig B-30 and Table B-10.



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Existing Distribution Main equal to150mm and over

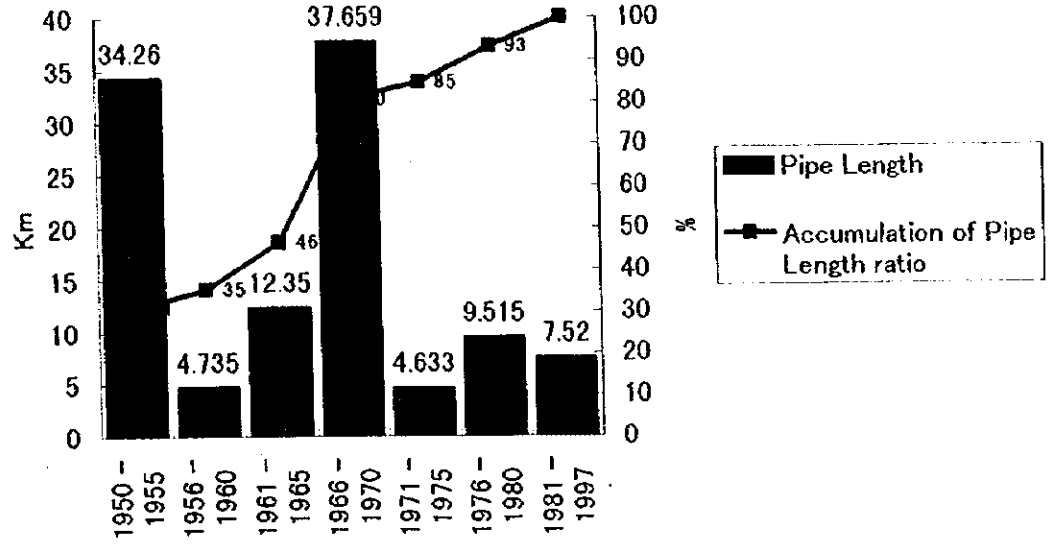
Table B-10 Summary of Existing Distribution Mains in Municipal Water Supply System

Diameter	Material	Length, m							
		1950-1955	1956-1960	1961-1965	1966-1970	1971-1975	1976-1980	1981 Onwards	Total
350 mm	GMS				450				450
350 mm	uPVC	130				1,050	3,890		5,070
300 mm	AC	1,330							1,330
300 mm	uPVC								580
250 mm	uPVC						2,280		2,280
225 mm	AC	4,575							4,575
200 mm	uPVC					2,223	240		2,463
150 mm	AC	15,070							15,070
150 mm	GMS				4,090			5,720	9,810
150 mm	uPVC			1,760		1,360	2,250		5,370
125 mm	GMS				1,580				1,580
100 mm	AC	2,155	1,310		360				3,825
100 mm	GMS	220			5,470				5,690
100 mm	uPVC			2,090			285	1,000	3,375
80 mm	AC	3,610	525		630				4,765
80 mm	GMS	7,170	2,900		25,079			800	36,254
80 mm	uPVC			8,500			570		9,070
TOTAL		**34,260**	**4,735**	**12,350**	**37,659**	**4,633**	**9,515**	**7,520**	**111,567**
Percentage of Total length		31%	4%	11%	34%	4%	9%	7%	100.0%

Material	350 mm	300 mm	250 mm	225 mm	200 mm	150 mm	125 mm	100 mm	80 mm	TOTAL	%
uPVC Pipe	5,070	580	2,280		2,463	5,370		3,375	9,070	28,208	25.3
AC Pipe		1,330		4,575		15,070		3,825	4,765	29,565	26.5
GMS Pipe	450					9,810	1,580	5,690	36,254	53,784	48.2
TOTAL	5,520	1,910	2,280	4,575	2,463	30,250	1,580	12,890	50,089	111,557	100.0

As shown in Fig B-30, existing pipe is concentrated in the center of old town (Kibuye and millimani). On the other hand, Fig B-31 shows relation between pipe construction year and length of pipe. The ratio of pipe length laid by the year of 1970 reached to 80%.

Fig B-31 Pipe Length and Construction Year



B7.5 Service Meter Survey

Sampling survey of service meter condition was carried out. Results are shown in Table B-11 and Table B-12.

Table 5-1-1 Service Meter Condition Survey

Survey Items		Surveyed on 1997/9 Number of Meters	Component %
No. of household visited		309	
Meter condition	Working	192	62.1
	Wrong or no working	117	37.9
	Total	309	100.0

Table 5-1-2 Service Meter Accuracy Survey

Surveyed through 1997/10/5 - 1997/10/6

Location	Consumption (m3)		Difference		
	Test meter	Existing meter	m3	%	%
	A	B	A - B	B/A x100	Simpl average
Industrial area Sabuni Road B1/3- Afro meat factory	6.109	5.169	0.940	84.61	
Industrial area Sabuni Road B 1/1- Grada Agencies	0.289	0.270	0.019	93.43	
Ndunga estate B 5/3 - Building under construction	2.776	2.460	0.316	88.62	
Ondieki Estate B 3/1 - Butchery	0.506	0.392	0.114	77.47	
Total	9.680	8.291	1.389	85.65	86.03

Note: Location of each number (eg. B1/3) is referred to O3.2 Results of Survey

APPENDIX-C

EXISTING WASTEWATER MANAGEMENT FACILITIES

APPENDIX C
EXISTING WASTEWATER MANAGEMENT FACILITIES
TABLE OF CONTENTS

C Existing Wastewater Management Facilities

C1 Introduction

The data and information on the existing wastewater management system are summarized to evaluate the system for future use and to formulate a future physical plan. The existing wastewater management system in Kisumu Municipality is a combination of sewerage system, composed of sewers and pump stations and sewage treatment works, and on-site wastewater treatment system. Important findings on pre-treatment facilities for industrial wastewater are also explained.

C2 Wastewater Collection Facilities

C2.1 Trunk Sewers

All sewers within the existing sewer net works are concrete pipes with ogee joints except for the rising mains which are either uPVC or asbestos cement. The first sewers were laid in 1958, thus the oldest sewers are around forty years old, but collapses are rare and sewers appear to be in sound condition. However, blockages are very frequent in certain sections to cause sewage overflowing the streets.

The capacity of existing trunk sewers in Central and Eastern WTD was calculated based on the information of pipe diameter, invert level and ground surface level collected from the previous F/S report and of pipe length read directly from the drawings in the F/S. For calculation, the Manning equation is used for gravity sewers with "n" value of 0.015. The results are shown in Table C-1 and C-2 for Central and Eastern WTD, respectively. The capacity of existing sewers will be examined to be able to cover the future design flow rate, the detail will be given in Appendix H.

In addition to the information of existing sewers collected from the previous F/S report, the following data and information on the existing sewers were collected by the longitudinal surveys conducted by the JICA Study Team. The collected data and information is pipe location, pipe diameter, pipe length, ground level, invert level and manhole cover level. The sewer pipes are 225 to 450 mm in diameter and 10.33 km in total length:

- Sewers from the municipal slaughter house to the Kibos trunk sewers
  (diameter 225 mm, length 3.82 km)
- Kibos trunk sewer

(diameter 225 mm, length 2.77 km)
(diameter 300 mm, length 1.87 km)
(diameter 400 mm, length 0.69 km)

- Sewers along the Ring road (from Kisumu Christian Center to Nairobi roads)
(diameter 225 mm, length 1.18 km)

Based on the information collected, the capacity of above sewers is calculated as shown in Table C-3. The results indicate that these sewers do not have enough capacity required for the flow of the year of 2015 as summarized in Table C-4. In addition, some part of the sewers, which installed at shallower depth under the ground or installed above the ground level, do not have a function as trunk sewers, means that branch sewers cannot be connected with the sewers without any pump system.

Therefore, these sewers are judged not to treat as trunk sewers for future use, and the figures of existing trunk sewers mentioned in Section 4.3.2 (2) Eastern WTD excludes those of sewers. Some part of the sewers will be used as branch sewers in future.

C2.2 Pump Stations

Existing three pump stations, Sunset Hotel P.S., Kendu Lane P.S., and Mumias Road P.S., are not operated due to the broken pumps without any repairs. This resulted in sewage overflows at manholes upstream of the stations or direct charge to Lake Victoria. These pump stations are necessary to be rehabilitated urgently to improve the living environmental conditions and dispose the health hazards smoothly.

C3 Sewage Treatment Works

C3.1 Conventional Sewage Treatment Works

Conventional Treatment Works with a treatment capacity of 6,800 m^3/d was initially completed in 1957 and once rehabilitated in 1987. It provides primary and secondary treatment to an inflow comprising of domestic, commercial and industrial wastewater. At present the mechanical/ electrical equipment is in need of rehabilitation/replacement, and the Conventional Treatment Works has experienced frequent stoppages due to failure of mechanical and electrical facilities. The Works is not operated properly during the night time due to the absence of operating staff.

The sewage treatment works has been subjected to severe over-loading in terms of sewage

volume and loads, the quality of effluent is more than 100 mg/l in terms of BOD. The inlet, primary sedimentation tanks and humus tanks will need to be expanded to cope with the flows proposed in 2015. The bio-filters are the limiting component at present, with three not functioning and the remaining three filters operating at approximately twice the design loading, thereby achieving a very much reduced BOD removal rate. In order to preserve the quality of effluent below 50 mg/l BOD it is necessary to rehabilitate the existing sewage treatment works and to introduce adequate non-structure measures to control the industrial wastewater, which is the major pollution load contributor.

In addition to treating wastewater the existing works contain sludge digestion and drying facilities. The facilities convert the liquid sludge removed from the wastewater to a dry cake form which is then sold as an agricultural fertilizer. A schematic layout is shown in Fig. C-1.

C3.2 Nyalenda Sewage Treatment Works

This STW treats about 2,000 m^3/d of sewage, which is only about 20 % of the design wastewater treatment capacity and provides preliminary, secondary and tertiary treatment to an inflow predominantly domestic in origin but including effluent from the New Nyanza Hospital. The works consists of an inlet works with screening and grit removal, 3 No. facultative ponds in parallel and 6 No. maturation ponds arranged as three (3) parallel pairs. The treated final effluent is discharged to an adjacent watercourse, from whence it percolates to the lake via the Nyalenda papyrus swamp. A schematic layout is shown in Fig. C-1.

C4 On-site/Community Wastewater Treatment Facilities

Following on-site wastewater treatment systems such as septic tanks, pit latrines and bucket latrines are commonly used not only in rural area but also in urban and peri- urban areas.

Septic tanks are used in the low density residential areas in Milimani area and at certain institutions. Septic tanks operate satisfactorily in the area. Emptying sludge service for septic tanks are provided by the municipality.

Pit latrines are commonly used in the peri-urban and rural area in the municipality. Pit latrines of various designs are used as follows:

- Pit with a slab at ground level and a superstructure of timber poles and iron sheets without a roof or ventilation to the pit;
- Pit raised above ground level and a superstructure of timber/iron sheets with a roof.

The raised slab prevents surface water from entering the pit and provides extra pit volume; and

- Ventilated improved pit with a raised slab and sound superstructure. Pits were seen with a manhole for emptying by a vacuum tanker or manually.

In areas prone to flooding, a common problem is collapse of pit latrines. This is probably due to their poor construction in unstable soils and the problem can be overcome with lining of the pit and raising the floor slab to prevent surface waters entering the pit.

Another common problem is that of high ground water level that reduces the available pit volume and increases the frequency of emptying the pits or digging new pits. Contamination of the groundwater is a serious consequence especially in areas where shallow wells and boreholes are used for local water supply. Emptying of pits in many areas is not possible by vacuum tanker due to the limited or no access to the sites.

Bucket latrines are used in a very limited area. A daily collection service are still operated by the Municipality, and the waste is disposed to Nyalenda STW. But daily collection service becomes difficult to operate without any proper vehicle or manpower.

In rural area where population density is low, the on-site facilities function well. However, in high population density area, especially in informal settlements, combination of poor state of pit latrines, poor drainage and lack of proper solid waste disposal leads to a deteriorate the sanitary environment and significant increase in water borne diseases such as malaria and diarrhea. In those areas, wastewater from washing, cooking, bathing is usually discharged into the nearest drainage channels. In case that drainage channels are not well defined, this leaves stagnant pools of wastewater. The close proximity of pit latrines can cause the contamination of shallow wells which constitutes the main water supply.

C5 Industrial Wastewater Pre-treatment Facilities

A questionnaire survey on existing industries was carried out with assistance of WSD, in which industrial wastewater pre-treatment facilities were one of the questions.

The only pre-treatment of industrial effluent appears to be at Kicomi Textile Factory. The treatment of the final effluent is by settlement tank, this does not however remove toxic substances, such as sodium sulphide, copper and chromium which are used in the drying process, high temperatures and high pH values were also observed in the effluent. These substances cause poor bio-filter performance in the Conventional Treatment Works.

Pre-treatment of the textile factory waste would allow the Conventional Treatment Works to produce a satisfactory BOD. The most effective ways of dealing biologically with textile wastes are by activated sludge and oxidation ditches (aerated lagoons).

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
A-1	K18		175	17.9	1.11	0.027	92	1,180.300	1,182.624	
		K17	7"				92	1,178.651	1,181.100	
	K17		175	-8.8			94	1,178.651	1,181.100	
		K16					186	1,179.481	1,179.576	
	K16		175	41.6	1.69	0.041	78	1,179.481	1,179.576	
		K15					264	1,176.234	1,178.509	
	K15		175	10.2	0.84	0.020	115	1,176.234	1,178.509	
		K14					379	1,175.061	1,176.985	
	K14		175	11.3	0.88	0.021	103	1,175.061	1,176.985	
		K13					482	1,173.896	1,175.766	
A-2	K13		225	8.3	0.89	0.035	50	1,173.896	1,175.766	
		K12	9"				50	1,173.482	1,175.766	
A-3	K12		225	2.7	0.51	0.020	75	1,173.482	1,175.766	
		K11	9"				75	1,173.278	1,175.156	
	K11		225	4.1	0.63	0.025	85	1,173.278	1,175.156	
		K10					160	1,172.927	1,174.699	
	K10		225	4.4	0.65	0.026	78	1,172.927	1,174.699	
		K9					238	1,172.586	1,174.394	
A-4	K9		225	3.6	0.59	0.023	103	1,172.586	1,174.394	
		K8	9"				103	1,172.217	1,174.090	
	K8		225	3.7	0.60	0.024	91	1,172.217	1,174.090	
		K7					194	1,171.876	1,173.480	
	K7		225	3.8	0.60	0.024	75	1,171.876	1,173.480	
		K6					269	1,171.592	1,172.566	
	K6		225	3.5	0.58	0.023	80	1,171.592	1,172.566	
		K5					349	1,171.312	1,172.261	
	K5		225	4.9	0.69	0.027	70	1,171.312	1,172.261	
		K4					419	1,170.967	1,172.261	
	K4		225	2.8	0.52	0.021	107	1,170.967	1,172.261	
		K3					526	1,170.672	1,171.956	
	K3		225	4.0	0.62	0.025	88	1,170.672	1,171.956	
		K2					614	1,170.321	1,171.194	
	K2		225	7.3	0.84	0.033	20	1,170.321	1,171.194	
		K1A					634	1,170.175	1,171.042	
	K1A		225	8.4	0.90	0.036	35	1,170.175	1,171.042	
		K1					669	1,169.882	1,170.737	
	K1		225	11.6	1.05	0.042	95	1,169.882	1,170.737	
		T36					764	1,168.782	1,169.670	

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
A'-1	T41A		375					1,171.309	1,171.804	
		T41						1,170.873	1,171.956	
	T41							1,170.873	1,171.956	
		T40						1,170.431	1,171.956	
	T40							1,170.431	1,171.956	
		T39						N/A	N/A	
	T39							N/A	N/A	
		T38						1,169.544	1,170.584	
	T38							1,169.544	1,170.584	
		T37						1,169.062	1,169.822	
	T37							1,169.062	1,169.822	
		T36						1,168.782	1,169.670	
To Sewer A-5										
A-5	T36		375	3.7	0.84	0.092	42	1,168.782	1,169.670	
		T34	15"				42	1,168.626	1,169.365	
	T34		375	16.0	1.74	0.192	61	1,168.626	1,169.365	
		T33					103	1,167.648	1,168.603	
A-6	T33		375	11.8	1.49	0.165	80	1,167.648	1,168.603	
		T32	15"				80	1,166.700	1,168.146	
	T32		375	6.8	1.13	0.125	88	1,166.700	1,168.146	
		T31					168	1,166.100	1,167.384	
	T31		375	4.4	0.91	0.101	75	1,166.100	1,167.384	
		T30					243	1,165.767	1,167.689	
A-7	T30		375	11.4	1.47	0.162	100	1,165.767	1,167.689	
		T29	15"				100	1,164.624	1,165.860	
	T29		375	37.3	2.66	0.293	100	1,164.624	1,165.860	
		T28					200	1,160.891	1,162.202	
	T28		375	14.4	1.65	0.182	108	1,160.891	1,162.202	
		A63					308	1,159.336	1,160.678	
	A63		375	25.4	2.19	0.242	42	1,159.336	1,160.678	
		T26					350	1,158.269	1,159.764	
	T26		375	33.6	2.52	0.279	58	1,158.269	1,159.764	
		T25					408	1,156.319	1,158.088	
	T25		375	32.0	2.46	0.272	42	1,156.319	1,158.088	
		T24					450	1,154.974	1,156.106	

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
A-8	T24		525	45.5	3.67	0.795	37	1,154.974	1,156.106	
		T23	21"				37	1,153.289	1,154.887	
	T23		525	42.3	3.54	0.767	45	1,153.289	1,154.887	
		T21A					82	1,151.387	1,153.516	
B-2	M8		225	6.0	0.76	0.030	62	1,177.213	1,178.222	
		M7	9"				62	1,176.843	1,178.239	
	M7		225	6.0	0.76	0.030	62	1,176.843	1,178.239	
		M6					124	1,176.472	1,178.264	
	M6		225	6.2	0.77	0.031	60	1,176.472	1,178.264	
		M5					184	1,176.102	1,177.956	
	M5		225	6.2	0.77	0.031	60	1,176.102	1,177.956	
		M4					244	1,175.732	1,177.779	
	M4		225	6.2	0.77	0.031	60	1,175.732	1,177.779	
		M3					304	1,175.361	1,177.192	
	M3		225	6.2	0.77	0.031	60	1,175.361	1,177.192	
		M2					364	1,174.991	1,176.591	
	M2		225	18.0	1.31	0.052	64	1,174.991	1,176.591	
		M1					428	1,173.841	1,175.064	
	M1		225	69.0	2.57	0.102	46	1,173.841	1,175.064	
		A18A					474	1,170.669	1,173.480	
	A18A		225	16.0	1.24	0.049	22	1,170.669	1,173.480	
		A18					496	1,170.318	1,172.870	
	A18		225	24.4	1.53	0.061	95	1,170.318	1,172.870	
		A17					591	1,167.996	1,169.822	
	A17		225	35.7	1.85	0.074	60	1,167.996	1,169.822	
		A16					651	1,165.853	1,168.298	
B-3	A16		300	16.1	1.50	0.106	62	1,165.853	1,168.298	
		A15	12"				62	1,164.856	1,167.079	
	A15		300	5.6	0.89	0.063	85	1,164.856	1,167.079	
		A14					147	1,164.378	1,167.232	
B-4	A14		300	37.2	2.29	0.162	73	1,164.378	1,167.232	
		A13	12"				73	1,161.659	1,164.336	
	A13		300	22.7	1.79	0.126	60	1,161.659	1,164.336	
		A12					133	1,160.299	1,163.117	
	A12		300	22.4	1.77	0.125	60	1,160.299	1,163.117	
		A11					193	1,158.952	1,162.355	
B-5	A11		300	9.9	1.18	0.083	75	1,158.952	1,162.355	
		A10	12"				75	1,158.211	1,160.678	
	A10		300	17.9	1.59	0.112	115	1,158.211	1,160.678	
		A9					190	1,156.157	1,157.478	

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
B-6-1	A9		300	10.6	1.22	0.086	45	1,156.157	1,157.478	
		A8	12"				45	1,155.682	1,157.173	
	A8		300	11.6	1.28	0.090	104	1,155.682	1,157.173	
		A7					149	1,154.478	1,155.649	
	A7		300	11.4	1.27	0.089	102	1,154.478	1,155.649	
		A6					251	1,153.316	1,154.887	
B-6-2	A6		300	4.6	0.80	0.057	60	1,153.316	1,154.887	
		A5					60	1,153.042	1,156.959	
	A5		300	6.0	0.92	0.065	60	1,153.042	1,156.959	
		A4A					120	1,152.682	1,155.954	
	A4A		300	4.9	0.83	0.059	32	1,152.682	1,155.954	
		A4					152	1,152.524	1,155.192	
	A4		300	5.8	0.90	0.064	65	1,152.524	1,155.192	
		A3A					217	1,152.149	1,153.973	
	A3A		300	11.6	1.28	0.090	31	1,152.149	1,153.973	
		A3					248	1,151.789	1,153.016	
B-8	A3		375	1.5	0.53	0.059	52	1,151.789	1,153.016	
		A2	15"				52	1,151.710	1,154.430	
	A2		375	2.8	0.73	0.080	60	1,151.710	1,154.430	
		A1					112	1,151.542	1,152.274	
	A1		375	3.5	0.81	0.090	44	1,151.542	1,152.274	
		T21A					156	1,151.387	1,153.516	
To Sewer A-9										
A-9	T21A		525	3.6	1.03	0.224	32	1,151.387	1,153.516	
		T21	21"				32	1,151.271	1,152.296	
	T21		525	2.4	0.84	0.183	32	1,151.271	1,152.296	
		T20					64	1,151.195	1,153.058	
	T20		525	2.3	0.83	0.179	50	1,151.195	1,153.058	
		T19					114	1,151.079	1,153.820	
	T19		525	2.1	0.79	0.171	41	1,151.079	1,153.820	
		T18					155	1,150.991	1,152.754	
	T18		525	2.8	0.91	0.197	85	1,150.991	1,152.754	
		T17					240	1,150.756	1,153.820	
	T17		525	3.1	0.96	0.208	35	1,150.756	1,153.820	
		T16					275	1,150.649	1,152.906	
	T16		525	2.3	0.83	0.179	67	1,150.649	1,152.906	
		T15					342	1,150.497	1,153.668	
	T15		525	2.3	0.83	0.179	30	1,150.497	1,153.668	
		T14A					372	1,150.427	1,152.144	

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
	T14A		525	1.8	0.73	0.158	10	1,150.427	1,152.144	
		T14					382	1,150.409	1,152.144	
	T14		525	2.3	0.83	0.179	92	1,150.409	1,152.144	
		T13					474	1,150.195	1,152.144	
	T13		525	4.4	1.14	0.247	25	1,150.195	1,152.144	
		T12					499	1,150.085	1,152.144	
A-10	T12		525	3.0	0.94	0.204	103	1,150.085	1,152.144	
		T11	21"				103	1,149.772	1,152.144	
	T11		525	2.0	0.77	0.167	91	1,149.772	1,152.144	
		T10					194	1,149.592	1,152.144	
	T10		525	2.4	0.84	0.183	104	1,149.592	1,152.144	
		T9					298	1,149.345	1,151.382	
	T9		525	33.0	3.13	0.677	102	1,149.345	1,151.382	
		T8					400	1,145.983	1,150.620	
A-11	T8		600	2.9	1.01	0.287	81	1,145.983	1,150.620	
		T7	24"				81	1,145.751	1,151.382	
	T7		600	-29.0			96	1,145.751	1,151.382	
		T6					177	1,148.531	1,151.534	
	T6		600	2.4	0.92	0.261	112	1,148.531	1,151.534	
		T5					289	1,148.263	1,150.620	

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
C-1	KA6		225					1,174.378	1,176.833	
		KA5	9"					1,172.597	1,174.507	
	KA5							1,172.597	1,174.507	
		KA4						1,165.743	1,167.630	
	KA4							1,165.743	1,167.630	
		KA3						1,157.906	1,159.551	
	KA3							1,157.906	1,159.551	
		KA2						1,153.264	1,155.164	
	KA2							1,153.264	1,155.164	
		KA1						1,150.764	1,152.144	
	KA1							1,150.764	1,152.144	
		T5						1,148.263	1,150.620	
To Sewer A-12										
A-12	T5		600	2.5	0.94	0.266	102	1,148.263	1,150.620	
		T4	24"				102	1,148.004	1,150.315	
	T4		600	2.2	0.88	0.250	120	1,148.004	1,150.315	
		T3					222	1,147.745	1,150.011	
	T3		600	3.0	1.03	0.291	44	1,147.745	1,150.011	
		T2					266	1,147.614	1,150.620	
	T2		600	2.6	0.96	0.271	80	1,147.614	1,150.620	
		T1A					346	1,147.402	1,149.197	
D-1	197		300	3.3	0.68	0.048	50	1,156.415	1,158.094	
		196	12"				50	1,156.249	1,158.480	
	196		300	3.7	0.72	0.051	45	1,156.249	1,158.480	
		99					95	1,156.082	1,158.538	
	99		300	3.6	0.71	0.050	46	1,156.082	1,158.538	
		98					141	1,155.915	1,159.212	
	98		300	3.3	0.68	0.048	60	1,155.915	1,159.212	
		83					201	1,155.715	1,159.296	
	83		300	3.3	0.68	0.048	41	1,155.715	1,159.296	
		82					242	1,155.579	1,159.536	
	82		300	3.3	0.68	0.048	49	1,155.579	1,159.536	
		81					291	1,155.417	1,159.576	
	81		300	3.9	0.74	0.052	49	1,155.417	1,159.576	
		80A					340	1,155.225	1,159.700	
	80A		300	1.9	0.52	0.037	24	1,155.225	1,159.700	
		80					364	1,155.180	1,159.060	

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
D-2	80		300	3.3	0.68	0.048	50	1,155.180	1,159.060	
		X15	12"				50	1,155.013	1,157.768	
	X15		300	3.5	0.70	0.050	50	1,155.013	1,157.768	
		X14					100	1,154.840	1,157.690	
	X14		300	3.1	0.66	0.047	42	1,154.840	1,157.690	
		X13					142	1,154.708	1,157.649	
	X13		300	3.6	0.71	0.050	30	1,154.708	1,157.649	
		X12					172	1,154.600	1,157.120	
	X12		300	3.3	0.68	0.048	60	1,154.600	1,157.120	
		X11					232	1,154.400	1,157.390	
	X11		300	3.3	0.68	0.048	40	1,154.400	1,157.390	
		X10					272	1,154.267	1,157.706	
	X10		300	3.3	0.68	0.048	50	1,154.267	1,157.706	
		X9					322	1,154.100	1,157.816	
	X9		300	3.2	0.67	0.047	65	1,154.100	1,157.816	
		X8					387	1,153.893	1,157.863	
	X8		300	3.3	0.68	0.048	58	1,153.893	1,157.863	
		X7					445	1,153.700	1,156.618	
	X7		300	3.4	0.69	0.049	45	1,153.700	1,156.618	
		X6					490	1,153.545	1,156.165	
	X6		300	3.2	0.67	0.047	47	1,153.545	1,156.165	
		X5					537	1,153.396	1,156.375	
	X5		300	3.7	0.72	0.051	54	1,153.396	1,156.375	
		X4					591	1,153.195	1,154.997	
	X4		300	3.3	0.68	0.048	42	1,153.195	1,154.997	
		X3					633	1,153.055	1,154.031	
	X3		300	40.3	2.38	0.168	45	1,153.055	1,154.031	
		X2					678	1,151.242	1,152.742	
	X2		300	36.4	2.26	0.160	60	1,151.242	1,152.742	
		X1					738	1,149.056	1,150.839	
	X1		300	47.8	2.59	0.183	20	1,149.056	1,150.839	
		X1A					758	1,148.100	1,150.029	
	X1A		300	15.5	1.48	0.104	45	1,148.100	1,150.029	
		T1A					803	1,147.402	1,149.197	
To Sewer A-13										

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
E-1	KK6		600				86	N/A	N/A	
		KK5	24"				86	N/A	N/A	
	KK5						92	N/A	N/A	
		KK4					178	N/A	N/A	
	KK4						88	N/A	N/A	
		KK3					266	N/A	N/A	
	KK3						90	N/A	N/A	
		KK2					356	N/A	N/A	
	KK2						70	N/A	N/A	
		KK1					426	N/A	N/A	
	KK1						14	N/A	N/A	
		T1					440	1,147.409	1,150.011	
To Sewer A-14										
A-13	T1A		600	-1.0			7	1,147.402	1,149.197	
		T1	24"				7	1,147.409	1,150.011	
A-14	T1		600	30.4	3.28	0.928	10	1,147.409	1,150.011	
		S4	24"				10	1,147.105	1,149.858	
	S4		600	32.9	3.41	0.965	190	1,147.105	1,149.858	
		S3					200	1,140.850	1,143.000	
	S3		600	4.3	1.23	0.349	124	1,140.850	1,143.000	
		S2					324	1,140.317	1,141.476	
	S2		600				100	1,140.317	1,141.476	
		S1					424	N/A	N/A	
F-1	SA12						88	N/A	N/A	
		SA11					88	1,144.900	1,146.300	
F-2	SA11						92	1,144.900	1,146.300	
		SA10					180	1,144.543	1,146.150	
	SA10						54	1,144.543	1,146.150	
		SA9					234	1,144.162	1,146.062	
	SA9						77	1,144.162	1,146.062	
		SA8					311	1,143.571	1,146.180	
	SA8						60	1,143.571	1,146.180	
		SA7					371	1,142.473	1,143.880	
	SA7						59	1,142.473	1,143.880	
		SA6					430	1,141.888	1,143.090	
	SA6						71	1,141.888	1,143.090	
		SA5					501	1,141.274	1,142.679	

Table C-1 Inventory of Existing Trunk Sewer in the Central WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
	SA5						84	1,141.274	1,142.679	
		SA4					585	1,140.156	1,141.910	
	SA4						38	1,140.156	1,141.910	
		SA3					623	1,139.767	1,141.535	
	SA3						*32*	1,139.767	1,141.535	
		SA2					*655*	N/A	1,141.231	
	SA2						*28*	N/A	1,141.231	
		SA1					*683*	1,138.832	1,141.261	
	SA1						*28*	1,138.832	1,141.261	
		SA1A					*711*	1,138.349	1,140.929	
	SA1A						*74*	1,138.349	1,140.929	
		SA1B					*785*	1,137.100	1,140.960	

Table C-2 Inventory of Existing Trunk Sewer in the Eastern WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
A-1	B10		175	15.6	1.03	0.025	102	1,168.413	1,169.822	
		B9	7"				102	1,166.825	1,167.603	
	B9		175	12.9	0.94	0.023	78	1,166.825	1,167.603	
		B8					180	1,165.816	1,167.384	
	B8		175	17.1	1.08	0.026	90	1,165.816	1,167.384	
		B7					270	1,164.274	1,166.165	
	B7		175	10.4	0.84	0.020	35	1,164.274	1,166.165	
		B6					305	1,163.911	1,165.860	
A-2	B6		175	14.7	1.00	0.024	50	1,163.911	1,165.860	
		B5	7"				50	1,163.177	1,164.793	
	B5		175	12.0	0.91	0.022	68	1,163.177	1,164.793	
		B4					118	1,162.360	1,162.812	
A-3	B4		225	3.5	0.58	0.023	92	1,162.360	1,162.812	
		B3	9"				92	1,162.037	1,162.507	
	B3		225	2.7	0.51	0.020	107	1,162.037	1,162.507	
		B2					199	1,161.750	1,162.507	
	B2		225	3.4	0.57	0.023	104	1,161.750	1,162.507	
		B1					303	1,161.400	1,163.117	
	B1		225	5.5	0.73	0.029	20	1,161.400	1,163.117	
		N6					323	1,161.290	1,162.812	
A-4	N6		225	11.3	1.04	0.041	77	1,161.290	1,162.812	
		N5	9"				77	1,160.421	1,161.288	
	N5		225	25.4	1.56	0.062	90	1,160.421	1,161.288	
		N4					167	1,158.135	1,162.964	
	N4		225	28.2	1.64	0.065	75	1,158.135	1,162.964	
		N3					242	1,156.017	1,157.173	
	N3		225	33.8	1.80	0.072	68	1,156.017	1,157.173	
		N2					310	1,153.716	1,155.954	
	N2		225	10.0	0.98	0.039	108	1,153.716	1,155.954	
		N1					418	1,152.631	1,153.668	
A-5	N1		N/A	6.4			14	1,152.631	1,153.668	
		W24					14	1,152.542	1,154.303	
A-6	W24		375	27.7	2.29	0.253	63	1,152.542	1,154.303	
		W23	15"				63	1,150.795	1,151.878	
	W23		375	20.4	1.96	0.217	85	1,150.795	1,151.878	
		W22					148	1,149.061	1,150.534	
	W22		375	22.4	2.06	0.227	82	1,149.061	1,150.534	
		W21					230	1,147.225	1,148.746	
	W21		375	20.7	1.98	0.219	76	1,147.225	1,148.746	
		W20					306	1,145.649	1,147.150	
	W20		375	24.8	2.17	0.239	64	1,145.649	1,147.150	
		W19					370	1,144.060	1,145.871	
	W19		375	5.6	1.03	0.114	11	1,144.060	1,145.871	
		W18					381	1,143.998	1,145.671	

Table C-2 Inventory of Existing Trunk Sewer in the Eastern WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
A-7	W18		450	11.0	1.63	0.259	75	1,143.998	1,145.671	
		W17	18"				75	1,143.173	1,144.161	
	W17		450	11.7	1.68	0.267	72	1,143.173	1,144.161	
		W16					147	1,142.333	1,143.083	
	W16		450	11.0	1.63	0.259	76	1,142.333	1,143.083	
		W15A					223	1,141.496	1,142.245	
	W15A		450	6.9	1.29	0.205	12	1,141.496	1,142.245	
		W15					235	1,141.413	1,142.163	
	W15		450	14.2	1.65	0.294	90	1,141.413	1,142.163	
		W14					325	1,140.138	1,141.138	
A-8	W14		675	1.4	0.76	0.273	86	1,140.138	1,141.138	
		W13	27"				86	1,140.019	1,141.019	
	W13		675	1.4	0.76	0.273	87	1,140.019	1,141.019	
		W12					173	1,139.901	1,140.901	
	W12		675	1.2	0.71	0.252	86	1,139.901	1,140.901	
		W11					259	1,139.800	1,140.800	
	W11		675	0.3	0.35	0.126	68	1,139.800	1,140.800	
		W10A					327	1,139.782	1,140.782	
A-9	W10A		675	11.8	2.21	0.791	10	1,139.782	1,140.782	
		W10	27"				10	1,139.664	1,140.664	
	W10		675	1.4	0.76	0.273	89	1,139.664	1,140.664	
		W9					99	1,139.535	1,140.535	
	W9		675	1.5	0.79	0.282	89	1,139.535	1,140.535	
		W8					188	1,139.405	1,140.405	
	W8		675	1.4	0.76	0.273	92	1,139.405	1,140.405	
		W7					280	1,139.275	1,140.275	
	W7		675	1.7	0.84	0.300	90	1,139.275	1,140.275	
		W6					370	1,139.125	1,140.125	
	W6		675	1.2	0.71	0.252	94	1,139.125	1,140.125	
		W5					464	1,139.015	1,140.015	
	W5		675	1.4	0.76	0.273	94	1,139.015	1,140.015	
		W4					558	1,138.887	1,139.887	
A-10	W4		675	1.4	0.76	0.273	100	1,138.887	1,139.887	
		W3	27"				100	1,138.744	1,139.744	
	W3		675	1.4	0.76	0.273	100	1,138.744	1,139.744	
		W2					200	1,138.603	1,139.603	
	W2		675	1.4	0.76	0.273	102	1,138.603	1,139.603	
		W1					302	1,138.461	1,139.461	
A'-1	B52		225	-16.7			20	1,164.612	1,165.860	
		N7	9"				20	1,164.946	1,163.832	
	N7		225	48.1	2.15	0.085	76	1,164.946	1,163.832	
		N6					96	1,161.290	1,162.812	

Table C-2 Inventory of Existing Trunk Sewer in the Eastern WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
B-1	B14		225	4.6	0.66	0.026	116	1,165.240	1,167.384	
		B13	9"				116	1,164.710	1,167.384	
	B13		225	3.6	0.59	0.023	119	1,164.710	1,167.384	
		B12					235	1,164.277	1,166.012	
	B12		225	8.7	0.91	0.036	95	1,164.277	1,166.012	
		B11					330	1,163.454	1,164.946	
	B11		225	25.5	1.56	0.062	85	1,163.454	1,164.946	
		N6					415	1,161.290	1,162.812	
C-1	CA10		225					1,161.576	1,163.117	
		CA9	9"					1,160.967	1,163.726	
	CA9							1,160.967	1,163.726	
		CA8						1,159.214	1,160.678	
	CA8							1,159.214	1,160.678	
		CA7						1,158.986	1,161.440	
	CA7							1,158.986	1,161.440	
		CA6						1,158.306	1,158.545	
	CA6							1,158.306	1,158.545	
		CA5						1,158.157	1,159.002	
	CA5							1,158.157	1,159.002	
		CA4								
	CA4							0.000	0.000	
		CA3								
	CA3							0.000	0.000	
		CA2						1,157.599	1,156.716	
	CA2							1,157.599	1,156.716	
		CA1						1,157.462	1,157.478	
	CA1							1,157.462	1,157.478	
		C15						1,157.032	1,157.478	
C-2	C16		300					1,158.163	1,158.545	
		C15	12"					1,157.032	1,157.478	
C-3	C15		375	4.7	0.94	0.104	32	1,157.032	1,157.478	
		C14	15"				32	1,156.883	1,156.868	
	C14		375	4.1	0.88	0.097	74	1,156.883	1,156.868	
		C13					106	1,156.578	1,156.868	
	C13		375	3.1	0.77	0.085	106	1,156.578	1,156.868	
		C12					212	1,156.245	1,156.716	
	C12		375	3.2	0.78	0.086	113	1,156.245	1,156.716	
		C11					325	1,155.883	1,156.716	
	C11		375	3.8	0.85	0.094	95	1,155.883	1,156.716	
		C10					420	1,155.523	1,157.326	

Table C-2 Inventory of Existing Trunk Sewer in the Eastern WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
C-4	C20		N/A					1,158.297	1,159.154	
		C19						1,157.785	1,159.154	
	C19							1,157.785	1,159.154	
		C18						1,157.672	1,159.154	
	C18							1,157.672	1,159.154	
		C17						1,156.212	1,157.630	
C-5	C22		N/A					1,157.324	1,157.783	
		C21						1,156.608	1,157.783	
	C21							1,156.608	1,157.783	
		C17						1,156.212	1,157.630	
C-6	C17		N/A					1,156.212	1,157.630	
		C10						1,155.523	1,157.326	
C-7	C10		375	3.9	0.86	0.095	100	1,155.523	1,157.326	
		C9	15"				100	1,155.136	1,156.564	
	C9		375	3.5	0.81	0.090	111	1,155.136	1,156.564	
		C8					211	1,154.746	1,156.106	
C-8	C8		375	3.4	0.80	0.089	114	1,154.746	1,156.106	
		C7	15"				114	1,154.356	1,155.497	
	C7		375	3.7	0.84	0.092	105	1,154.356	1,155.497	
		C6					219	1,153.966	1,155.192	
	C6		375	5.3	1.00	0.111	52	1,153.966	1,155.192	
		C5					271	1,153.688	1,155.192	
	C5		375				27	1,153.688	1,155.192	
		C4A					298	N/A	N/A	
	C4A		375				33	N/A	N/A	
		C4					331	1,153.603	1,154.430	
	C4		375	3.7	0.84	0.092	85	1,153.603	1,154.430	
		C3					416	1,153.289	1,154.430	
	C3		375	2.9	0.74	0.082	32	1,153.289	1,154.430	
		C2					448	1,153.197	1,153.668	
	C2		375	3.1	0.77	0.085	56	1,153.197	1,153.668	
		C1A					504	1,153.021	1,153.516	
	C1A		375	3.4	0.80	0.089	70	1,153.021	1,153.516	
		C1					574	1,152.783	1,153.668	
	C1		375	6.1	1.07	0.119	25	1,152.783	1,153.668	
		N1					599	1,152.631	1,153.668	
D-1	G1		225	5.1	0.70	0.028	59	1,179.586	1,181.466	
		H45	9"				59	1,179.287	1,180.535	
	H45		225	2.0	0.44	0.017	106	1,179.287	1,180.535	
		H44					165	1,179.078	1,180.643	

Table C-2 Inventory of Existing Trunk Sewer in the Eastern WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
D-2	H44		225	8.6	0.91	0.036	102	1,179.078	1,180.643	
		H43					267	1,178.196	1,179.446	
	H43		225	16.2	1.25	0.050	80	1,178.196	1,179.446	
		H42					347	1,176.901	1,178.166	
	H42		225	10.5	1.00	0.040	110	1,176.901	1,178.166	
		H41					457	1,175.741	1,176.982	
	H41		225	12.6	1.10	0.044	110	1,175.741	1,176.982	
		H40					567	1,174.352	1,175.644	
	H40		225				66	1,174.352	1,175.644	
		H39					633	N/A	N/A	
	H39		225				52	N/A	N/A	
		H38					685	1,171.968	1,173.313	
	H38		225				59	1,171.968	1,173.313	
		H37					744	N/A	N/A	
	H37		225				108	N/A	N/A	
		H22					852	1,171.172	1,172.500	
D-3	H22		225	4.2	0.63	0.025	111	1,171.172	1,172.500	
		H21	9"				111	1,170.702	1,172.342	
	H21		225	14.6	1.18	0.047	110	1,170.702	1,172.342	
		H20					221	1,169.092	1,171.122	
	H20		225	14.8	1.19	0.047	111	1,169.092	1,171.122	
		H19					332	1,167.448	1,169.504	
	H19		225	18.4	1.33	0.053	112	1,167.448	1,169.504	
		H18					444	1,165.387	1,167.385	
	H18		225	41.3	1.99	0.079	110	1,165.387	1,167.385	
		H17					554	1,160.842	1,163.117	
	H17		225	51.8	2.23	0.089	110	1,160.842	1,163.117	
		H16					664	1,155.142	1,157.553	
	H16		225	25.4	1.56	0.062	110	1,155.142	1,157.553	
		H15					774	1,152.353	1,154.233	
	H15		225	25.9	1.57	0.063	110	1,152.353	1,154.233	
		H14					884	1,149.505	1,151.625	
	H14		225	13.1	1.12	0.045	128	1,149.505	1,151.625	
		H13					1012	1,147.822	1,149.471	
D-4	H13		300	8.9	1.12	0.079	60	1,147.822	1,149.471	
		H12	12"				60	1,147.286	1,148.955	
	H12		300	6.3	0.94	0.067	100	1,147.286	1,148.955	
		H11					160	1,146.656	1,148.515	
	H11		300	5.0	0.84	0.059	110	1,146.656	1,148.515	
		H10					270	1,146.101	1,148.167	
	H10		300	5.7	0.90	0.063	110	1,146.101	1,148.167	
		H9					380	1,145.472	1,148.402	
	H9		300	4.6	0.80	0.057	106	1,145.472	1,148.402	
		H8					486	1,144.982	1,148.622	
	H8		300	11.4	1.27	0.089	102	1,144.982	1,148.622	
		H7					588	1,143.820	1,147.015	

Table C-2 Inventory of Existing Trunk Sewer in the Eastern WTD

Sewer Line No.	M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Remarks
			mm	o/oo	m/S	m^3/S	m	m	m	
D-5	H7		300	11.3	1.26	0.089	103	1,143.820	1,147.015	
		H6	12"				103	1,142.651	1,145.326	
	H6		300	12.5	1.33	0.094	102	1,142.651	1,145.326	
		H5					205	1,141.375	1,144.067	
D-6	H5		375	1.8	0.58	0.064	104	1,141.375	1,144.067	
		H4	15"				104	1,141.191	1,144.115	
	H4		375	11.4	1.47	0.162	104	1,141.191	1,144.115	
		H3					208	1,140.004	1,144.146	
	H3		375	-64.9			105	1,140.004	1,144.146	
		H2					313	1,146.816	1,142.808	
	H2		375	60.1	3.37	0.373	103	1,146.816	1,142.808	
		H1					416	1,140.629	1,141.702	
	H1		375	4.5	0.92	0.102	110	1,140.629	1,141.702	
		W14					526	1,140.138	1,141.138	

Table C-3-(1) Inventory of Existing Sewer in the Eastern WTD

based on Longitudinal Survey (Slaughter House Sewer)

M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
120A		225	24.8	1.54	0.061	60	1,181.922	1,185.153	1,184.082	2.978	Slaughter
	110A					60	1,180.437	1,182.042	1,182.367		House
110A		225	24.7	1.54	0.061	60	1,180.432	1,182.042	1,182.367	1.357	Sewer
	110A					120	1,178.952	1,180.527	1,180.942		
110A		225	24.7	1.54	0.061	60	1,178.952	1,180.527	1,180.942	1.322	
	110A					180	1,177.467	1,179.062	1,179.417		
110A		225	24.7	1.54	0.061	60	1,177.462	1,179.062	1,179.417	1.347	
	110A					240	1,175.982	1,176.842	1,178.282		
110A		225	17.0	1.28	0.051	60	1,175.982	1,176.842	1,178.282	0.607	
	110A					300	1,174.961	1,176.377	1,176.961		
110A		225	17.0	1.28	0.051	60	1,174.961	1,176.377	1,176.961	1.163	
	110A					360	1,173.940	1,174.522	1,175.990		
110A		225	17.0	1.28	0.051	60	1,173.940	1,174.522	1,175.990	0.329	
	110A					420	1,172.919	1,173.517	1,174.919		
110A		225	17.0	1.28	0.051	60	1,172.919	1,173.517	1,174.919	0.345	
	110A					480	1,171.898	1,172.717	1,173.848		
110A		225	17.0	1.28	0.051	60	1,171.898	1,172.717	1,173.848	0.566	
	110A					540	1,170.877	1,172.035	1,172.927		
110A		225	9.9	0.97	0.039	61	1,170.877	1,172.035	1,172.927	0.905	
	110A					601	1,170.271	1,171.117	1,172.221		
110A		225	9.9	0.97	0.039	60	1,170.271	1,171.117	1,172.221	0.593	
	100A					661	1,169.675	1,170.352	1,171.725		
100A		225	19.9	1.38	0.055	60	1,169.675	1,170.352	1,171.725	0.424	
	100A					721	1,168.479	1,169.557	1,170.429		
100A		225	9.9	0.97	0.039	61	1,168.479	1,169.557	1,170.429	0.825	
	100A					782	1,167.873	1,168.922	1,169.873		
100A		225	9.9	0.97	0.039	60	1,167.873	1,168.922	1,169.873	0.796	
	100A					842	1,167.277	1,168.222	1,168.137		
100A		225	9.9	0.97	0.039	60	1,167.277	1,168.222	1,168.137	0.692	
	100A					902	1,166.681	1,167.762	1,168.681		
100A		225	9.9	0.97	0.039	60	1,166.681	1,167.762	1,168.681	0.828	
	99A					962	1,166.085	1,167.067	1,168.185		
99A		225	9.9	0.97	0.039	60	1,166.085	1,167.067	1,168.185	0.729	
	98A					1,022	1,165.489	1,166.467	1,167.539		
98A		225	9.9	0.97	0.039	55	1,165.489	1,166.467	1,167.539	0.725	
	97A					1,077	1,164.943	1,166.022	1,167.143		
97A		225	198.1	4.36	0.173	55	1,164.943	1,166.022	1,167.143	0.826	
	96A					1,132	1,154.047	1,165.712	1,166.087		
96A		225	####	#NUM!	#NUM!	64	1,154.047	1,165.712	1,166.087	11.412	
	95A					1,196	1,163.627	1,165.252	1,165.927		
95A		225	-54.7	#NUM!	#NUM!	49	1,163.627	1,165.252	1,165.927	1.372	
	94A					1,245	1,166.306	1,165.072	1,165.526		
94A		225	67.8	2.55	0.101	49	1,166.306	1,165.072	1,165.526	-1.487	
	93A					1,294	1,162.985	1,164.462	1,165.885		
93A		225	6.6	0.80	0.032	61	1,162.985	1,164.462	1,165.885	1.224	
	92A					1,355	1,162.585	1,164.437	1,165.155		
92A		225	6.6	0.80	0.032	60	1,162.585	1,164.437	1,165.155	1.599	
	91A					1,415	1,162.192	1,164.181	1,164.892		
91A		225	6.6	0.80	0.032	60	1,162.192	1,164.181	1,164.892	1.736	
	90A					1,475	1,161.799	1,164.048	1,164.549		

Table C-3-(1) Inventory of Existing Sewer in the Eastern WTD
based on Longitudinal Survey (Slaughter House Sewer)

M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
90A		225	-10.1	#NUM!	#NUM!	60	1,161.799	1,164.048	1,164.549	1.996	
	89A					1,535	1,162.406	1,162.743	1,164.006		
89A		225	23.2	1.49	0.059	60	1,162.406	1,162.743	1,164.006	0.084	
	88A					1,595	1,161.013	1,163.148	1,163.613		
88A		225	6.5	0.79	0.031	42	1,161.013	1,163.148	1,163.613	1.882	
	87A					1,637	1,160.738	1,163.183	1,163.338		
87A		225	6.6	0.80	0.032	20	1,160.738	1,163.183	1,163.338	2.192	
	86A					1,657	1,160.607	1,162.484	1,163.507		
86A		225	6.6	0.80	0.032	60	1,160.607	1,162.484	1,163.507	1.624	
	85A					1,717	1,160.214	1,162.568	1,163.314		
85A		225	6.6	0.80	0.032	60	1,160.214	1,162.568	1,163.314	2.101	
	84A					1,777	1,159.821	1,162.313	1,162.951		
84A		225	6.6	0.80	0.032	61	1,159.821	1,162.313	1,162.951	2.239	
	83A					1,838	1,159.421	1,161.808	1,162.221		
83A		225	6.6	0.80	0.032	60	1,159.421	1,161.808	1,162.221	2.134	
	82A					1,898	1,159.028	1,161.513	1,162.128		
82A		225	6.6	0.80	0.032	41	1,159.028	1,161.513	1,162.128	2.232	
	81A					1,939	1,158.759	1,161.353	1,161.689		
81A		225	7.5	0.85	0.034	43	1,158.759	1,161.353	1,161.689	2.341	
	80A					1,982	1,158.438	1,161.058	1,161.478		
80A		225	7.1	0.82	0.033	54	1,158.438	1,161.058	1,161.478	2.367	
	79A					2,036	1,158.056	1,160.888	1,161.056		
79A		225	7.8	0.86	0.034	53	1,158.056	1,160.888	1,161.056	2.579	
	78A					2,089	1,157.643	1,154.248	1,160.723		
78A		225	7.8	0.86	0.034	49	1,157.643	1,154.248	1,160.723	-3.648	
	77A					2,138	1,157.261	1,159.283	1,160.421		
77A		225	7.8	0.86	0.034	60	1,157.261	1,159.283	1,160.421	1.769	
	76A					2,198	1,156.793	1,159.443	1,159.747		
76A		225	-1.3	#NUM!	#NUM!	44	1,156.793	1,159.443	1,159.747	2.397	
	75A					2,242	1,156.85	1,159.57	1,159.65		
75A		225	6.5	0.79	0.031	43	1,156.85	1,159.57	1,159.65	2.467	
	74A					2,285	1,156.57	1,159.17	1,158.89		
74A		225	6.4	0.78	0.031	42	1,156.57	1,159.17	1,158.89	2.347	
	73A					2,327	1,156.30	1,159.23	1,159.92		
73A		225	6.7	0.80	0.032	60	1,156.30	1,159.23	1,159.92	2.677	
	72A					2,387	1,155.90	1,158.79	1,159.76		
72A		225	13.0	1.12	0.044	60	1,155.90	1,158.79	1,159.76	2.637	
	71A					2,447	1,155.12	1,158.83	1,159.81		
71A		225	0.0	0.00	0.000	60	1,155.12	1,158.83	1,159.81	3.457	
	70A					2,507	1,155.12	1,158.52	1,159.90		
70A		225	6.5	0.79	0.031	60	1,155.12	1,158.52	1,159.90	3.147	
	69A					2,567	1,154.73	1,158.65	1,158.84		
69A		225	2.3	0.47	0.019	60	1,154.73	1,158.65	1,158.84	3.667	
	68A					2,627	1,154.59	1,157.66	1,159.04		
68A		225	4.7	0.67	0.027	60	1,154.59	1,157.66	1,159.04	2.817	
	67A					2,687	1,154.31	1,159.37	1,159.72		
67A		225	4.6	0.66	0.026	35	1,154.31	1,159.37	1,159.72	4.807	
	66A					2,722	1,154.15	1,159.61	1,159.40		
66A		225	4.7	0.67	0.027	51	1,154.15	1,159.61	1,159.40	5.207	
	65A					2,773	1,153.91	1,159.03	1,159.51		

Table C-3-(1) Inventory of Existing Sewer in the Eastern WTD

based on Longitudinal Survey (Slaughter House Sewer)

M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
65A		225	4.6	0.66	0.026	50	1,153.91	1,159.03	1,159.51	4.867	
	64A					2,823	1,153.68	1,158.71	1,159.28		
64A		225	2.3	0.47	0.019	44	1,153.68	1,158.71	1,159.28	4.777	
	63A					2,867	1,153.58	1,158.32	1,159.48		
63A		225	2.2	0.46	0.018	50	1,153.58	1,158.32	1,159.48	4.487	
	62A					2,917	1,153.47	1,158.33	1,159.17		
62A		225	2.2	0.46	0.018	51	1,153.47	1,158.33	1,159.17	4.607	
	61A					2,968	1,153.36	1,157.81	1,158.76		
61A		225	2.3	0.47	0.019	56	1,153.36	1,157.81	1,158.76	4.197	
	60A					3,024	1,153.23	1,158.57	1,159.00		
60A		225	2.2	0.46	0.018	50	1,153.23	1,158.57	1,159.00	5.087	
	59A					3,074	1,153.12	1,158.16	1,157.84		
59A		225	2.3	0.47	0.019	52	1,153.12	1,158.16	1,157.84	4.787	
	58A					3,126	1,153.00	1,157.75	1,158.67		
58A		225	2.2	0.46	0.018	50	1,153.00	1,157.75	1,158.67	4.497	
	57A					3,176	1,152.89	1,157.90	1,158.39		
57A		225	2.4	0.48	0.019	50	1,152.89	1,157.90	1,158.39	4.757	
	56A					3,226	1,152.77	1,157.54	1,158.31		
56A		225	2.2	0.46	0.018	60	1,152.77	1,157.54	1,158.31	4.517	
	55A					3,286	1,152.64	1,157.23	1,157.64		
55A		225	2.3	0.47	0.019	60	1,152.64	1,157.23	1,157.64	4.337	
	54A					3,346	1,152.50	1,156.90	1,157.70		
54A		225	2.2	0.46	0.018	50	1,152.50	1,156.90	1,157.70	4.147	
	53A					3,396	1,152.39	1,156.52	1,157.66		
53A		225	2.2	0.46	0.018	60	1,152.39	1,156.52	1,157.66	3.877	
	52A					3,456	1,152.26	1,156.41	1,157.40		
52A		225	4.0	0.62	0.025	60	1,152.26	1,156.41	1,157.40	3.897	
	51A					3,516	1,152.02	1,156.19	1,157.42		
51A		225	4.0	0.62	0.025	60	1,152.02	1,156.19	1,157.42	3.917	
	50A					3,576	1,151.78	1,155.78	1,156.73		
50A		225	3.8	0.60	0.024	63	1,151.78	1,155.78	1,156.73	3.747	
	49A					3,639	1,151.54	1,155.48	1,156.24		
49A		225	3.8	0.60	0.024	60	1,151.54	1,155.48	1,156.24	3.687	
	48A					3,699	1,151.31	1,154.48	1,155.91		
48A		225	-5.8	#NUM!	#NUM!	62	1,151.31	1,154.48	1,155.91	2.917	
	47A					3,761	1,151.67	1,154.70	1,155.42		
47A		225	13.8	1.15	0.046	60	1,151.67	1,154.70	1,155.42	2.777	
	46A					3,821	1,150.84	1,154.43	1,155.14		
47A		225	17.8	1.31	0.052	60	1,151.67	1,154.70	1,155.42	2.777	
	46A					3,821	1,150.60	1,153.85	1,154.90		
		connects to the Kibos Trunk Sewer									

Table C-3-(2) Inventory of Existing Sewer in the Eastern WTD
based on Longitudinal Survey (Kibos Trunk Sewer, Upstream)

M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
1B		225	2.7	0.51	0.020	60	1,157.76	1,160.23	1,161.41	2.22	Kibos
	2B					60	1,157.60	1,160.23	1,161.15		Trunk
2B		225	3.3	0.56	0.022	60	1,157.60	1,160.23	1,161.15	2.38	Sewer
	3B					120	1,157.40	1,160.21	1,160.40		
3B		225	2.8	0.52	0.021	57	1,157.40	1,160.21	1,160.40	2.56	
	4B					177	1,157.24	1,160.33	1,160.77		
4B		225	2.6	0.50	0.020	53	1,157.24	1,160.33	1,160.77	2.84	
	5B					230	1,157.10	1,159.92	1,160.45		
5B		225	2.7	0.51	0.020	63	1,157.10	1,159.92	1,160.45	2.57	
	6B					293	1,156.93	1,160.14	1,160.18		
6B		225	2.7	0.51	0.020	63	1,156.93	1,160.14	1,160.18	2.96	
	7B					356	1,156.76	1,160.06	1,160.26		
7B		225	2.7	0.51	0.020	62	1,156.76	1,160.06	1,160.26	3.05	
	8B					418	1,156.59	1,159.45	1,160.11		
8B		225	2.7	0.51	0.020	60	1,156.59	1,159.45	1,160.11	2.61	
	9B					478	1,156.43	1,159.41	1,159.80		
9B		225	2.7	0.51	0.020	26	1,156.43	1,159.41	1,159.80	2.73	
	10B					504	1,156.36	1,159.27	1,159.98		
10B		225	2.7	0.51	0.020	60	1,156.36	1,159.27	1,159.98	2.66	
	11B					564	1,156.20	1,159.63	1,158.45		
11B		225	2.7	0.51	0.020	60	1,156.20	1,159.63	1,158.45	3.18	
	12B					624	1,156.04	1,159.55	1,160.24		
12B		225	2.8	0.52	0.021	60	1,156.04	1,159.55	1,160.24	3.26	
	13B					684	1,155.87	1,159.35	1,160.37		
13B		225	2.7	0.51	0.020	60	1,155.87	1,159.35	1,160.37	3.23	
	14B					744	1,155.71	1,159.39	1,160.22		
14B		225	2.7	0.51	0.020	60	1,155.71	1,159.39	1,160.22	3.43	
	15B					804	1,155.55	1,159.22	1,159.39		
15B		225	12.3	1.09	0.043	60	1,155.55	1,159.22	1,159.39	3.42	
	16B					864	1,154.81	1,158.62	1,158.65		
16B		225	1.2	0.34	0.013	60	1,154.81	1,158.62	1,158.65	3.56	
	17B					924	1,154.74	1,158.33	1,158.26		
17B		225	0.8	0.28	0.011	60	1,154.74	1,158.33	1,158.26	3.34	
	18B					984	1,154.69	1,158.33	1,158.24		
18B		225	-5.2	#NUM!	#NUM!	60	1,154.69	1,158.33	1,158.24	3.39	
	19B					1,044	1,155.00	1,158.07	1,158.38		
19B		225	8.0	0.88	0.035	60	1,155.00	1,158.07	1,158.38	2.82	
	20B					1,104	1,154.52	1,157.87	1,158.41		
20B		225	1.2	0.34	0.013	52	1,154.52	1,157.87	1,158.41	3.10	
	21B					1,156	1,154.46	1,157.80	1,158.21		
21B		225	1.2	0.34	0.013	60	1,154.46	1,157.80	1,158.21	3.09	
	22B					1,216	1,154.39	1,157.46	1,158.16		
22B		225	1.2	0.34	0.013	60	1,154.39	1,157.46	1,158.16	2.82	
	23B					1,276	1,154.32	1,157.48	1,158.00		
23B		225	1.3	0.35	0.014	60	1,154.32	1,157.48	1,158.00	2.91	
	24B					1,336	1,154.24	1,157.41	1,157.94		
24B		225	1.2	0.34	0.013	60	1,154.24	1,157.41	1,157.94	2.92	
	25B					1,396	1,154.17	1,157.09	1,158.03		
25B		225	1.1	0.32	0.013	53	1,154.17	1,157.09	1,158.03	2.67	
	26B					1,449	1,154.11	1,156.87	1,157.61		

Table C-3-(2) Inventory of Existing Sewer in the Eastern WTD
based on Longitudinal Survey (Kibos Trunk Sewer, Upstream)

M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
26B		225	1.2	0.34	0.013	60	1,154.11	1,156.87	1,157.61	2.51	
	27B					1,509	1,154.04	1,156.68	1,157.71		
27B		225	1.3	0.35	0.014	60	1,154.04	1,156.68	1,157.71	2.39	
	28B					1,569	1,153.96	1,156.41	1,157.72		
28B		225	1.2	0.34	0.013	60	1,153.96	1,156.41	1,157.72	2.20	
	29B					1,629	1,153.89	1,156.37	1,157.34		
29B		225	1.2	0.34	0.013	60	1,153.89	1,156.37	1,157.34	2.23	
	30B					1,689	1,153.82	1,156.07	1,157.80		
30B		225	1.1	0.32	0.013	61	1,153.82	1,156.07	1,157.80	2.00	
	31B					1,750	1,153.75	1,157.71	1,157.81		
31B		225	1.2	0.34	0.013	60	1,153.75	1,157.71	1,157.81	3.71	
	32B					1,810	1,153.68	1,157.57	1,157.67		
32B		225	1.3	0.35	0.014	60	1,153.68	1,157.57	1,157.67	3.64	
	33B					1,870	1,153.60	1,157.37	1,157.60		
33B		225	1.2	0.34	0.013	42	1,153.60	1,157.37	1,157.60	3.52	
	34B					1,912	1,153.55	1,157.01	1,157.35		
34B		225	1.2	0.34	0.013	60	1,153.55	1,157.01	1,157.35	3.21	
	35B					1,972	1,153.48	1,156.94	1,157.14		
35B		225	1.2	0.34	0.013	60	1,153.48	1,156.94	1,157.14	3.21	
	36B					2,032	1,153.41	1,157.08	1,157.26		
36B		225	1.2	0.34	0.013	60	1,153.41	1,157.08	1,157.26	3.42	
	37B					2,092	1,153.34	1,156.87	1,157.01		
37B		225	1.2	0.34	0.013	60	1,153.34	1,156.87	1,157.01	3.28	
	38B					2,152	1,153.27	1,156.78	1,157.17		
38B		225	-32.0	#NUM!	#NUM!	60	1,153.27	1,156.78	1,157.17	3.26	
	39B					2,212	1,155.19	1,156.83	1,155.79		
39B		225	43.0	2.03	0.081	60	1,155.19	1,156.83	1,155.79	1.39	
	40B					2,272	1,152.61	1,156.57	1,156.58		
40B		225	8.9	0.92	0.037	63	1,152.61	1,156.57	1,156.58	3.71	
	41B					2,335	1,152.05	1,155.80	1,155.80		
41B		225	25.2	1.55	0.062	63	1,152.05	1,155.80	1,155.80	3.50	
	42B					2,398	1,150.46	1,155.50	1,155.00		
42B		225	-5.7	#NUM!	#NUM!	67	1,150.46	1,155.50	1,155.00	4.79	
	46A					2,465	1,150.84	1,154.43	1,155.14		
	Joint with the Slaughter House Trunk Sewer										

Table C-3-(3) Inventory of Existing Sewer in the Eastern WTD
based on Longitudinal Survey (Kibos Trunk Sewer, downstream)

M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
45A		225	102.1	3.13	0.124	61	1,156.60	1,153.85	1,154.90	-3.00	Joint
	44A					61	1,150.37	1,153.50	1,154.58		with the
44A		225	3.8	0.60	0.024	60	1,150.37	1,153.50	1,154.58	2.88	Slaughter
	43A					121	1,150.14	1,153.29	1,153.94		House
43A		225	4.0	0.62	0.025	60	1,150.14	1,153.29	1,153.94	2.90	Sewer
	42A					181	1,149.90	1,152.95	1,153.82		
42A		225	3.3	0.56	0.022	60	1,149.90	1,152.95	1,153.82	2.80	
	41A					241	1,149.70	1,152.73	1,153.28		
41A		225	3.8	0.60	0.024	60	1,149.70	1,152.73	1,153.28	2.78	
	40A					301	1,149.47	1,152.06	1,153.17		
40A		300	3.9	0.74	0.052	44	1,149.47	1,152.06	1,153.17	2.26	
	39A					44	1,149.30	1,151.49	1,152.80		
39A		300	3.9	0.74	0.052	57	1,149.30	1,151.49	1,152.80	1.86	
	38A					101	1,149.08	1,151.65	1,152.50		
38A		300	3.8	0.73	0.052	60	1,149.08	1,151.65	1,152.50	2.24	
	37A					161	1,148.85	1,151.13	1,152.19		
37A		300	3.8	0.73	0.052	60	1,148.85	1,151.13	1,152.19	1.95	
	36A					221	1,148.62	1,151.03	1,152.10		
36A		300	4.0	0.75	0.053	60	1,148.62	1,151.03	1,152.10	2.08	
	35A					281	1,148.38	1,151.08	1,152.02		
35A		300	3.8	0.73	0.052	60	1,148.38	1,151.08	1,152.02	2.37	
	34A					341	1,148.15	1,151.02	1,151.80		
34A		300	3.8	0.73	0.052	69	1,148.15	1,151.02	1,151.80	2.54	
	33A					410	1,147.89	1,150.90	1,151.69		
33A		300	4.0	0.75	0.053	60	1,147.89	1,150.90	1,151.69	2.68	
	32A					470	1,147.65	1,150.76	1,151.55		
32A		300	3.8	0.73	0.052	65	1,147.65	1,150.76	1,151.55	2.78	
	31A					535	1,147.40	1,150.68	1,151.45		
31A		300	3.8	0.73	0.052	60	1,147.40	1,150.68	1,151.45	2.95	
	30A					595	1,147.17	1,150.71	1,151.37		
30A		300	3.5	0.70	0.050	66	1,147.17	1,150.71	1,151.37	3.21	
	29A					661	1,146.94	1,150.30	1,151.14		
29A		300	3.8	0.73	0.052	55	1,146.94	1,150.30	1,151.14	3.03	
	28A					716	1,146.73	1,150.24	1,150.91		
28A		300	3.8	0.73	0.052	60	1,146.73	1,150.24	1,150.91	3.18	
	27A					776	1,146.50	1,150.29	1,150.60		
27A		300	3.9	0.74	0.052	57	1,146.50	1,150.29	1,150.60	3.46	
	26A					833	1,146.28	1,149.62	1,150.65		
26A		300	4.2	0.77	0.054	12	1,146.28	1,149.62	1,150.65	3.01	
	25A					845	1,146.23	1,149.62	1,150.16		
25A		300	4.0	0.75	0.053	30	1,146.23	1,149.62	1,150.16	3.06	
	24A					875	1,146.11	1,148.88	1,149.31		
24A		300	3.7	0.72	0.051	30	1,146.11	1,148.88	1,149.31	2.44	
	23A					905	1,146.00	1,148.47	1,148.84		
23A		300	3.8	0.73	0.052	60	1,146.00	1,148.47	1,148.84	2.14	
	22A					965	1,145.77	1,148.54	1,148.87		
22A		300	4.0	0.75	0.053	60	1,145.77	1,148.54	1,148.87	2.44	
	21A					1,025	1,145.53	1,148.13	1,148.63		

Table C-3-(3) Inventory of Existing Sewer in the Eastern WTD
based on Longitudinal Survey (Kibos Trunk Sewer, downstream)

M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
21A		300	3.7	0.72	0.051	40	1,145.53	1,148.13	1,148.63	2.27	
	20A					1,065	1,145.38	1,147.48	1,148.06		
20A		300	3.8	0.73	0.052	60	1,145.38	1,147.48	1,148.06	1.77	
	19A					1,125	1,145.15	1,146.80	1,147.36		
19A		300	4.0	0.75	0.053	35	1,145.15	1,146.80	1,147.36	1.32	
	18A					1,160	1,145.01	1,146.52	1,146.76		
18A		300	3.4	0.69	0.049	35	1,145.01	1,146.52	1,146.76	1.18	
	17A					1,195	1,144.89	1,146.43	1,146.76		
17A		300	14.7	1.44	0.102	38	1,144.89	1,146.43	1,146.76	1.21	
	16A					1,233	1,144.33	1,146.31	1,146.58		
16A		300	-2.3	#NUM!	#NUM!	65	1,144.33	1,146.31	1,146.58	1.65	
	15A					1,298	1,144.48	1,146.28	1,146.71		
15A		300	4.6	0.80	0.057	65	1,144.48	1,146.28	1,146.71	1.47	
	14A					1,363	1,144.18	1,146.62	1,147.06		
14A		300	3.8	0.73	0.052	65	1,144.18	1,146.62	1,147.06	2.11	
	13A					1,428	1,143.93	1,147.10	1,147.73		
13A		300	3.8	0.73	0.052	65	1,143.93	1,147.10	1,147.73	2.84	
	12A					1,493	1,143.68	1,145.04	1,146.37		
12A		300	14.0	1.40	0.099	65	1,143.68	1,145.04	1,146.37	1.03	
	11A					1,558	1,142.77	1,143.48	1,144.17		
11A		300	14.1	1.41	0.100	64	1,142.77	1,143.48	1,144.17	0.38	
	10A					1,622	1,141.87	1,143.68	1,143.63		
10A		300	2.1	0.54	0.038	63	1,141.87	1,143.68	1,143.63	1.48	
	9A					1,685	1,141.74	1,143.17	1,143.19		
9A		300	2.2	0.56	0.039	65	1,141.74	1,143.17	1,143.19	1.10	
	8A					1,750	1,141.60	1,142.10	1,142.35		
8A		300	2.1	0.54	0.038	121	1,141.60	1,142.10	1,142.35	0.17	
	7A					1,871	1,141.34	1,141.20	1,142.30		
7A		450	2.1	0.71	0.113	121	1,141.34	1,141.20	1,142.30	-0.63	
	6A					121	1,141.08	1,140.36	1,141.72		
6A		450	2.1	0.71	0.113	121	1,141.08	1,140.36	1,141.72	-1.21	
	5A					242	1,140.83	1,140.05	1,141.93		
5A		450	2.1	0.71	0.113	121	1,140.83	1,140.05	1,141.93	-1.27	
	4A					363	1,140.57	1,139.57	1,141.65		
4A		450	2.1	0.71	0.113	121	1,140.57	1,139.57	1,141.65	-1.49	
	3A					484	1,140.31	1,139.77	1,141.52		
3A		450	2.1	0.71	0.113	121	1,140.31	1,139.77	1,141.52	-1.03	
	2A					605	1,140.06	1,140.13	1,140.06		
2A		450	2.3	0.75	0.119	84	1,140.06	1,140.13	1,140.06	-0.42	Nairobi
	1A					689	1,139.87	1,140.23	1,140.88		Road

Table C-3-(4) Inventory of Existing Sewer in the Eastern WTD
based on Longitudinal Survey

M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
N29		150	5.3	0.54	0.010	61	1,152.573	1,153.413	1,153.893	0.66	Kisumu
	N28					61	1,152.249	1,153.669	1,154.249		Chistian
N28		150	5.3	0.54	0.010	60	1,152.249	1,153.669	1,154.249	1.24	Center
	N27					121	1,151.932	1,153.943	1,154.382		
N27		150	5.3	0.54	0.010	56	1,151.932	1,153.943	1,154.382	1.83	
	N26					177	1,151.636	1,154.206	1,154.736		
N26		150	5.2	0.54	0.010	37	1,151.636	1,154.206	1,154.736	2.39	
	N25					214	1,151.442	1,154.331	1,154.592		
N25		150	5.3	0.54	0.010	51	1,151.442	1,154.331	1,154.592	2.71	
	N24					265	1,151.172	1,154.541	1,154.872		
N24		150	5.3	0.54	0.010	54	1,151.172	1,154.541	1,154.872	3.19	
	N23					319	1,150.887	1,154.771	1,154.837		
N23		150	5.3	0.54	0.010	40	1,150.887	1,154.771	1,154.837	3.71	
	N22					359	1,150.676	1,155.536	1,155.476		
N22		225	10.0	0.98	0.039	32	1,150.676	1,155.536	1,155.476	4.61	
	N21					32	1,150.355	1,155.161	1,155.185		
N21		225	10.1	0.98	0.039	55	1,150.355	1,155.161	1,155.185	4.55	
	N20					87	1,149.802	1,152.030	1,152.552		
N20		225	10.1	0.98	0.039	68	1,149.802	1,152.030	1,152.552	1.98	
	N19					155	1,149.118	1,151.780	1,152.468		
N19		225	10.1	0.98	0.039	48	1,149.118	1,151.780	1,152.468	2.41	
	N18					203	1,148.635	1,151.864	1,152.350		
N18		225	10.1	0.98	0.039	48	1,148.635	1,151.864	1,152.350	2.98	
	N17					251	1,148.152	1,151.865	1,152.202		
N17		225	10.0	0.98	0.039	44	1,148.152	1,151.865	1,152.202	3.46	
	N16					295	1,147.710	1,151.950	1,152.360		
N16		225	83.5	2.83	0.112	39	1,147.710	1,151.950	1,152.360	3.99	
	N15					334	1,144.454	1,151.960	1,152.266		
N15		225	-70.4	#NUM!	#NUM!	39	1,144.454	1,151.960	1,152.266	7.25	
	N14					373	1,147.199	1,151.245	1,151.549		
N14		225	39.9	1.95	0.078	60	1,147.199	1,151.245	1,151.549	3.79	along
	N13					433	1,144.806	1,150.670	1,151.356		the Ring
N13		225	-27.9	#NUM!	#NUM!	58	1,144.806	1,150.670	1,151.356	5.61	Road
	N12					491	1,146.426	1,150.000	1,152.176		
N12		225	42.9	2.03	0.081	55	1,146.426	1,150.000	1,152.176	3.32	
	N11					546	1,144.066	1,149.645	1,151.466		
N11		225	-28.5	#NUM!	#NUM!	57	1,144.066	1,149.645	1,151.466	5.33	
	N10					603	1,145.693	1,149.100	1,149.440		
N10		225	6.5	0.79	0.031	55	1,145.693	1,149.100	1,149.440	3.15	
	N9					658	1,145.333	1,148.700	1,149.000		
N9		225	6.5	0.79	0.031	55	1,145.333	1,148.700	1,149.000	3.11	
	N8					713	1,144.973	1,148.650	1,148.792		
N8		225	6.6	0.80	0.032	56	1,144.973	1,148.650	1,148.792	3.42	
	N7					769	1,144.606	1,147.370	1,144.926		
N7		225	6.5	0.79	0.031	53	1,144.606	1,147.370	1,144.926	2.51	
	N6					822	1,144.259	1,147.255	1,147.409		
N6		225	6.6	0.80	0.032	23	1,144.259	1,147.255	1,147.409	2.74	
	N5					845	1,144.108	1,147.215	1,147.358		

Table C-3-(4) Inventory of Existing Sewer in the Eastern WTD
based on Longitudinal Survey

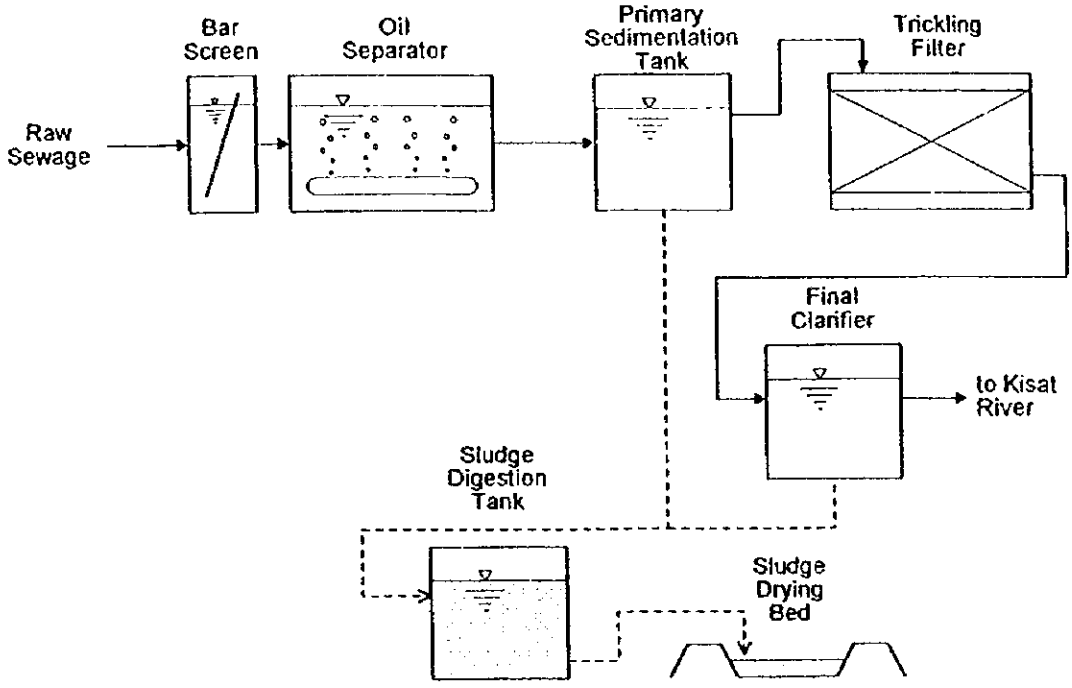
M.H. No.	M.H. No.	Dia.	Slope	Velocity	Capacity	Length	Invert Elevation	Ground Surface Elevation	Manhole Cover Elevation	Earth Cover	Remarks
		mm	o/oo	m/S	m^3/S	m	m	m	m	m	
N5		225	6.6	0.80	0.032	178	1,144.108	1,147.215	1,147.358	2.85	
	N4					1,023	1,142.942	1,143.200	1,144.565		
N4		225	6.5	0.79	0.031	55	1,142.942	1,143.200	1,144.565	0.01	
	N3					1,078	1,142.582	1,143.325	1,143.882		
N3		225	6.6	0.80	0.032	40	1,142.582	1,143.325	1,143.882	0.49	
	N2					1,118	1,142.320	1,142.820	1,143.480		
N2		225	6.6	0.80	0.032	58	1,142.320	1,142.820	1,143.480	0.25	Nairobi
	N1					1,176	1,141.940	1,143.012	1,143.270		Road

Table C-4 Estimated Capacity of Existing Sewers in Eastern WTD

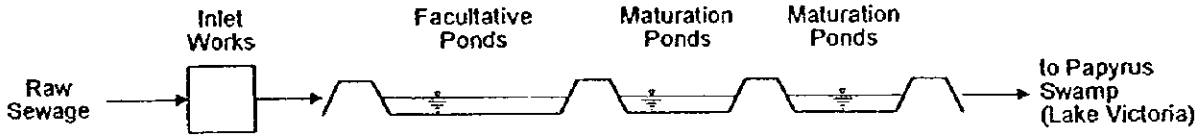
Sewers	Estimated Capacity (m^3/s)	Required Pipe Capacity (m^3/s)
Slaughter House Sewers	0.018 ~ 0.061 (mainly 0.032)	0.038 ~ 0.456
Kibos Trunk Sewers		
Upper Stream Section	0.013 ~ 0.020	0.196 ~ 0.456
Down Stream Section	0.024 ~ 0.113	0.570 ~ 0.628
Ring Road Sewers	0.031 ~ 0.039	0.096 ~ 0.110

Note: Required Pipe Capacity is the design flow rate + allowance(100%)

Figure C-1



Conventional Sewage Treatment Works



Nyalenda Waste Stabilisation Ponds

THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Schematic of Existing STW