2.4.2 Existing Sewerage System

The existing sewerage system in Kisumu comprises two wastewater treatment districts, namely Central Wastewater Treatment District (Central WTD) and Eastern Wastewater Treatment District (Eastern WTD). Figure 2-10 shows the locations of major sewerage infrastructure and the area currently managed by the municipal sewerage system.

(1) Central WTD

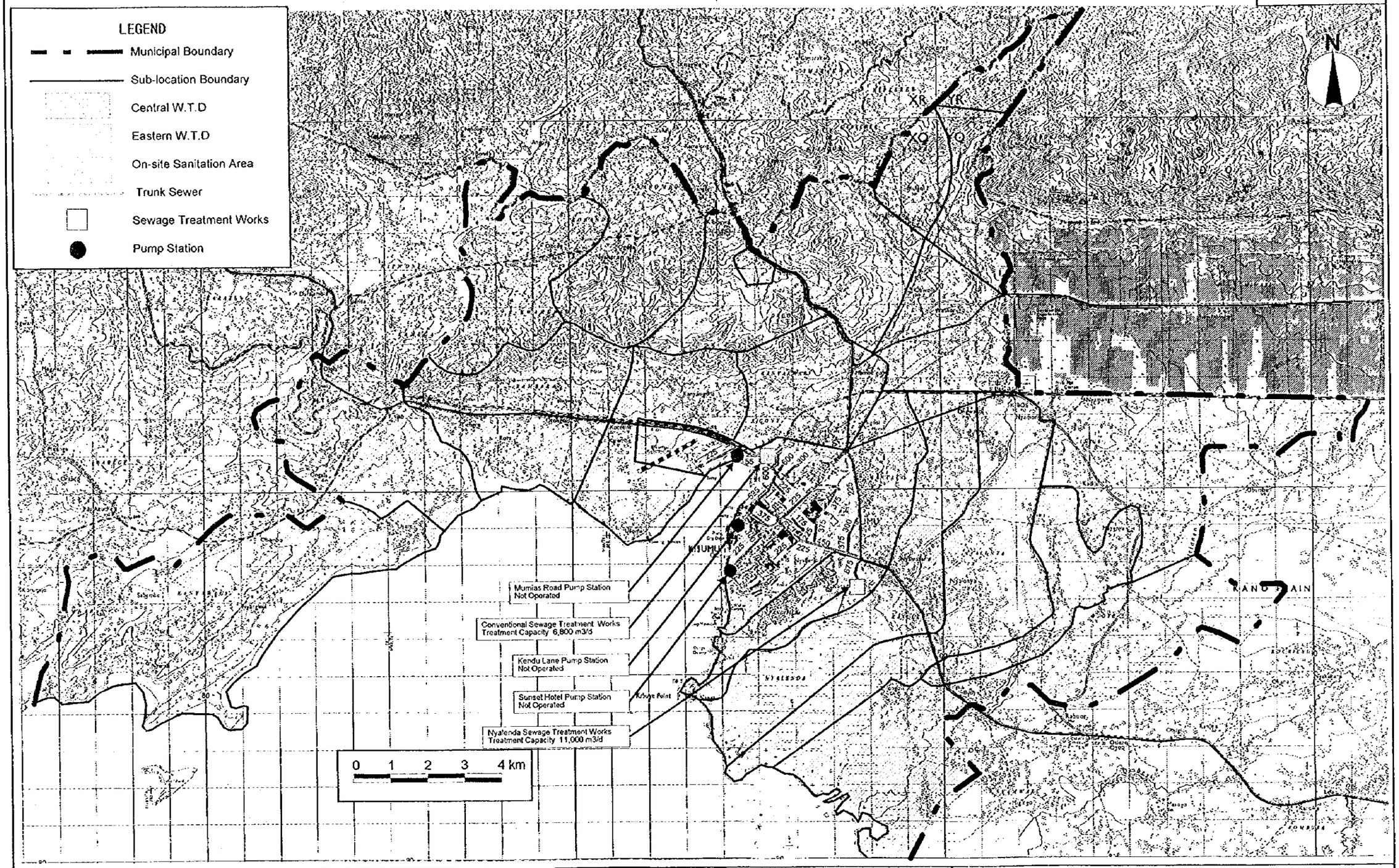
a. Wastewater Collection Facilities

Central WTD collects wastewater generated in the area north-west of the old town by gravity and that generated in low-lying coastal areas along the shore of Lake Victoria through three pump stations, namely Mumias Road, Kendu Lane and Sunset Hotel pump stations. Wastewater collected in this district comprises domestic, commercial, institutional and industrial origins and is conveyed to the Conventional Sewage Treatment Works (Conventional STW) for treatment. The district covers a total area of 390 ha with main sewers 175 to 600 mm in diameter and 8.5 km in total length.

All the sewer mains within the existing sewer networks are concrete pipes with ogee joints except for rising mains which are either uPVC or asbestos cement pipes. The oldest sewers were laid in 1958 and are now almost forty years old. Despite their age, these old sewer pipes are generally in a good condition except for blockage which occurs frequently in certain sections.

All of the three existing pump stations, namely Sunset Hotel PS, Kendu Lane PS, and Mumias Road PS, are currently not being operated. At these stations, broken or worn-out pumps have been left without repair or replacement for many years due primarily to lack of funds. This has resulted in the overflow of sewage at manholes upstream of the respective stations as well as in the direct discharge of sewage to Lake Victoria.

Figure 2 - 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 Exisiting Sewerage System

Records at Conventional STW indicate that the amount of inflow to the STW increases to between 10,000 to 15,000 m^3/d during rainy season, which is more than double the amount of what is supposed to be received (6,000 to 7,000 m3/d) by the STW for treatment. The cause for this seasonal increase is estimated to be the intrusion of storm-water through manholes, broken sewers and faulty connections, and the infiltration of groundwater through pipe fittings and manholes.

Major problems identified for the existing wastewater collection system in Central WTD are summarised as follows:

- Wastewater overflow from manholes or direct discharge to Lake Victoria resulting from the existing three pump stations which are currently not being operated
- Increase of wastewater inflow to the Conventional STW during rainy season

b. Conventional Sewage Treatment Works

This sewage treatment works is sited to the north-west of the town adjacent to the Kasat River. Originally the works was designed to treat 2,270 m^3 per day but was extended to treat a dry weather flow (D.W.F.) of 6,800 m^3 per day (1.5 mgd).

Treatment process comprises screening, grit removal, primary settlement, biological filtration and final settlement of filter humus. The sludge produced is conditioned in cold digestion tanks and dried in sludge drying beds before disposal to the land. It is possible to recirculate filter effluent. Final effluent is discharged into the Kasat River which then flows through the golf course and into Lake Victoria. The mechanical/electrical equipment underwent rehabilitation/replacement under a KFW financed project in 1986. On completion of the project the plant was restored to its design capacity.

However at present the plant is overloaded, hydraulically and in terms of BOD, influent concentrations being in the order of 800 mg/l. This is due to industrial wastewaters which are not pretreated at source.

The works as designed should be capable of producing an effluent up to British Commission Standards of 20mg/l Biochemical Oxygen Demand and 30mg/l Settleable Solids. However analysis of the final effluent show that it rarely falls below 100 mg/l. The plant is therefore in need of rehabilitation to achieve its design standards.

(2) Eastern WTD

a. Wastewater Collection Facilities

Eastern WTD collects wastewater generated in the south-east of the old Kisumu town. Wastewater which is mainly of domestic origin except for that received from the new Nyanza Hospital, is collected and conveyed to the Nyalenda Sewage Treatment Works (Nyalenda STW) by gravity. The district covers a total area of 214 ha with trunk sewer mains 175 to 675 mm in diameter and 8.0 km in total length.

Some of the existing sewers in this district are not properly functioning. The trunk sewer from the Shauri Moyo Estate to Ondiek Highway through Akech Street is collapsed and raw sewage overflows from manholes. Kibos Trunk Sewer is clogged at several locations with stones, rags and plastic bags, and sewage overflows at manholes. Branch sewers in Migosi are not functioning due probably to the blockage resulted from low flow of sewage.

The present average wastewater inflow to the Nyalenda STW is estimated to be 2,000 m^3/d, which is smaller than 20% of its design capacity, 11,000 m^3/d. It is assessed that the lack of an adequate water supply in the Eastern WTD is the main reason for this. The situation has resulted in a low flow with a higher solid concentration in sewer mains. The heavier solids tend to settle down and help forming scum and sludge within sewer mains and manholes, causing blockages. Silting, too, has occurred in large diameter sewers having minimum gradients which reduces velocities. Silting reduces the normal capacity of sewer mains and hinders the smooth passage of larger solids.

Major problems identified for the existing wastewater collection system in Eastern WTD are summarised as follows:

- Wastewater overflows due to collapsed or clogged sewer mains
- Low wastewater flow resulted from inadequate water supply

b. Nyalenda Sewage Treatment Works

The existing plant provides preliminary, secondary and tertiary treatment to an inflow predominantly domestic in origin but including that 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 parallel pairs. The treated final effluent is discharged to an adjacent watercourse, from whence it percolates to the lake via the Nyalenda papyrus swamp. The present estimated inflow of 2000 m^3/d is very low compared to the design capacity of

11,000m^3/d. This low flow combined with high evaporation rates due to the geographical location of Kisumu results in very low effluent flows. The present flows are so low that it is not necessary to operate all three parallel streams at once. Two streams could be closed and all the present influent treated in one stream.

2.5 AREA SELECTED FOR FEASIBILITY STUDY

The extent of the study area selected for this Feasibility Study is shown in Figure 2-11.

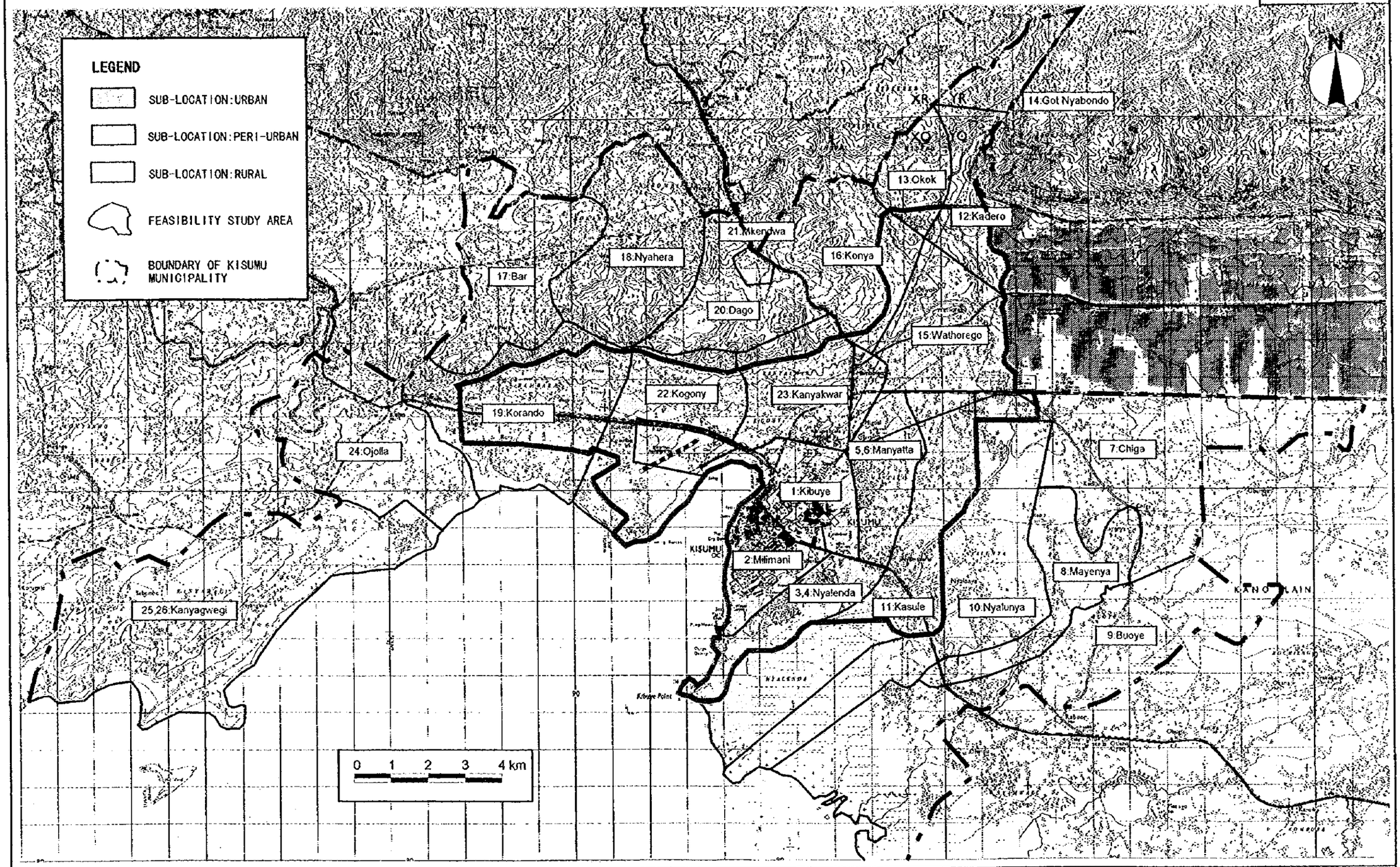
The area is 87.7 km2 in total extent and located in the middle of the Kisumu municipality's administrative area, covering virtually all of the inhabitable areas within the Sub-locations classified as "Urban" and "Peri-urban" areas. At the fringe, it also covers part of the Kadero and Konya Sub-locations and a small fraction of the Okok , Nyalunya and Chiga Sub-locations, all of which are "Rural" by area classification.

Table 2-5 presents the extent of the Feasibility Study Area and the coverage by each Sub-location and land use category.

The JICA Master Plan envisages that the Feasibility Study Area, although in area-wise it is only 30 % of the total municipal area of 296.5 km2, will accommodate approximately 80 % of the total municipal population in the year 2005 with an average population density of 47 persons/ha.

The Master Plan also envisages that the extension of the municipal water supply system to areas beyond this Feasibility Study Area is not an economical solution, as the population density in those areas is estimated to remain very low in the future. For this reason, the Master Plan recommended that those rural areas be provided with rural water supply schemes based on local groundwater, which will be completely separate from the municipal water supply system.

Figure 2-11



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 Location of Feasibility Study Area

Table 2-5 Extent of Feasibility Study Area and Coverage by Sub-location and Land Use

Sub-location	Category	Area km²	Planning area for Piped Water Supply, km²							
			Residential	Commercial	Industrial	Agriculture	Wet	Hilly	Airport	Total
Kibuye	Urban	11.5	4.7	1.3	4.1				1.4	11.5
Milimani	Urban	5.5	3.8	1.7						5.5
Kanyakwar	Urban	10.4	8.1	0.4						8.5
Nyalenda	Peri-urban	6.8	6.8							6.8
Manyatta	Peri-urban	7.3	7.3							7.3
Kasule	Peri-urban	17.5	8.9		0.7					9.6
Wathorego	Peri-urban	7.6	7.2	0.4						7.6
Korando	Peri-urban	20.2	10.2	0.4	1.5					12.1
Kogony	Peri-urban	12.8	7.2		1.3				1.8	10.3
Konya	Rural	13.3	2.6	0.2						2.8
Chiga	Rural	24.5		0.2	0.2					0.4
Mayenya	Rural	11.6								0.0
Buoye	Rural	23.6								0.0
Nyakunya	Rural	17.4			1.3					1.3
Kadero	Rural	6.9	3.3							3.3
Okok	Rural	4.0	0.7							0.7
Got Nyabondo	Rural	4.5								0.0
Bar	Rural	12.1								0.0
Nyahera	Rural	16.7								0.0
Dago	Rural	11.0								0.0
Mkendwa	Rural	1.1								0.0
Ojolla	Rural	17.5								0.0
Kanyagwegi	Rural	32.7								0.0
TOTAL		296.5	70.8	4.6	9.1	0.0	0.0	0.0	3.2	87.7

CHAPTER 3

POPULATION, WATER DEMAND AND WASTEWATER GENERATION

3. POPULATION, WATER DEMAND AND WASTEWATER GENERATION

3.1 POPULATION AND POPULATION SERVED

3.1.1 Population

JICA Study Team in consultation with the Kisumu Municipal Council reviewed the "Kisumu Structure Plan 1983-2013" and made modifications to the land use envisaged by the plan, with a view to reflecting the latest conditions. The modified land use plan for the year 2015 is shown in Figure 3-1. Table 3-1 presents the extents of areas allocated for each land use category after the modification.

Table 3-1 Summary of Land Use in 2015

Land Use Category	Residential	Agricultural	Industrial	Commercial	Airport	Hilly Land	Wetland and Open Land	Total
Area (km^2)	73.8	164.0	9.1	5.1	3.2	18.0	23.3	296.5

Apart from the land use, the JICA Study Team in collaboration with the KMC classified each of the 25 Sub-locations which comprise the municipal area into one of the following three area categories.

- **Urban Areas**: old town area which constitutes the core of the Kisumu municipality
- **Peri-urban Areas**: areas around the periphery of the Urban Areas, where a high population growth is expected in the future.
- **Rural Areas**: outside Urban and Peri-urban areas where the future population growth is expected to be slow or even negative

The municipal population in Kisumu was projected up to the year 2015, taking the past trend of the population growth in each Sub-location into consideration. Three population databases, each compiled by the 1969, 1979 and 1989 census were analysed to estimate the future population growth rates for each Sub-location. Where necessary, adjustments were made to the projected growth rates, taking, among others, the following into account:

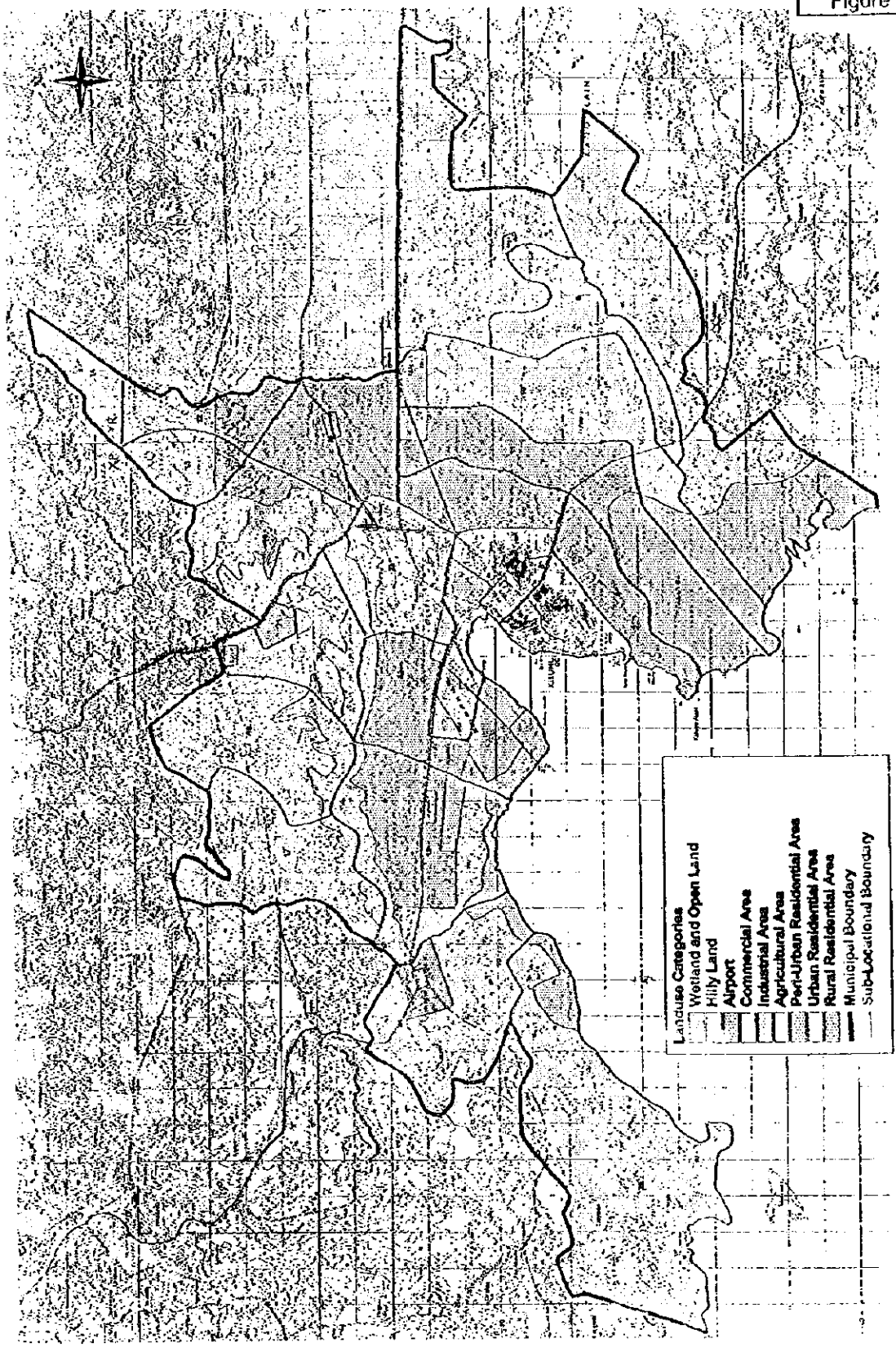
- Kisumu Water Supply and Sanitation Study
- Kisumu Structure Plan 1983-2013

- National Water Master Plan
- Classification of Sub-locations into Urban, Peri-urban and Rural areas
- Sub-location-wise population densities
- Government policies on population

Tables 3-2 and 3-3 present the final estimates of the growth rates and populations for each Sub-location up to the year 2015. It was estimated in this exercise that the total municipal population in 1997 was 363,157, and that it would increase to 526,195 by 2005, the target year of this Feasibility Study at an average annual growth rate of 3.03 %.

The above estimate also indicated that, in the year 2005, the Feasibility Study Area will accommodate a total population of 414, 530, which is approximately 79 % of the total municipal population in the same year.

Figure 3-1



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 : Modified Land Use Plan for 2015

Table 3-2 Projected Population Growth Rates

	Sub location	Category	Estimated Growth Rate (%)	1989 (by Census)	1997	2000	2005	2010	2015
1	Kibuye	Urban	1.34	30,074	33,452	34,814	37,211	39,772	42,509
2	Milimani	Urban	1.34	15,856	17,636	18,354	19,617	20,967	22,410
3	Nyalenda	Peri-urban	4.66	38,385	55,259	63,350	79,552	98,604	108,800
5	Manyatta	Peri-urban	6.80	52,138	83,665	93,604	106,354	114,154	116,800
7	Chiga	Rural	1.64	6,571	7,485	7,860	8,526	9,248	10,032
8	Mayenya	Rural	4.78	4,168	6,056	6,966	8,798	11,113	14,035
9	Buoye	Rural	4.78	3,942	5,726	6,588	8,321	10,510	13,274
10	Nyalunya	Rural	6.30	7,656	12,482	14,993	20,350	27,621	37,489
11	Kasule	Peri-urban	2.28	5,230	8,788	14,738	34,409	71,615	140,063
12	Kadero	Rural	-1.06	2,951	2,710	2,625	2,488	2,359	2,237
13	Okok	Rural	-1.06	2,719	2,496	2,418	2,292	2,173	2,060
14	Got Nyabondo	Rural	-6.60	2,726	1,578	1,286	914	650	462
15	Wathorego	Peri-urban	2.00	4,951	6,489	8,347	14,135	24,745	43,919
16	Konya	Rural	5.03	7,045	10,433	12,088	15,451	19,747	25,239
17	Bar	Rural	2.00	6,075	7,119	7,554	8,340	9,209	10,167
18	Nyahera	Rural	2.00	7,717	9,041	9,594	10,594	11,696	12,913
19	Korando	Peri-urban	5.00	13,382	20,255	24,424	34,352	49,357	72,535
20	Dago	Rural	2.74	3,558	4,418	4,791	5,484	6,277	7,187
21	Mkendwa	Rural	3.32	591	768	846	996	1,172	1,380
22	Kogony	Peri-urban	6.00	10,879	17,787	22,080	32,423	48,234	72,747
23	Kanyakwar	Urban	7.35	17,215	30,360	36,850	47,645	56,089	59,500
24	Ojolla	Rural	2.61	5,221	6,859	8,349	12,633	20,127	33,267
25	Kanyagwegi	Rural	2.78	9,873	12,295	13,349	15,310	17,560	20,141
Total				258,923	363,157	415,868	526,195	672,999	869,166

Table 3-3 Population Projected for FS Area

Category	Sub-Location	1997	2000	2005	2010	2015
Urban	Kibuye	33,452	34,814	37,211	39,772	42,509
	Milimani	17,636	18,354	19,617	20,967	22,410
	Kanyakwar	30,360	36,850	47,645	56,089	59,500
	Sub-Total	81,448	90,018	104,473	116,828	124,419
Peri-urban	Nyalenda	55,259	63,350	79,552	98,604	108,800
	Manyatta	83,665	93,604	106,354	114,154	116,800
	Kasule	8,788	14,738	34,409	71,615	140,063
	Wathorego	6,489	8,347	14,135	24,735	43,919
	Korando	18,230	21,982	30,917	44,421	65,282
	Kogony	17,787	22,080	32,423	48,234	72,747
	Sub-Total	190,218	224,101	297,790	401,763	547,611
Rural	Chiga	252	265	287	311	338
	Nyalunya	1,104	1,326	1,800	2,443	3,315
	Kadero	1,754	1,699	1,610	1,526	1,447
	Okok	743	720	683	647	614
	Konya	5,326	6,171	7,888	10,081	12,884
	Sub-Total	9,179	10,181	12,268	15,008	18,598
Total		280,845	324,300	414,531	533,599	690,628

Table 3-3 Population Projected for FS Area

Category	Sub-Location	1997	2000	2005	2010	2015
Urban	Kibuye	33,452	34,814	37,211	39,772	42,509
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3.1.2 Population Served

(1) Water Supply

"Some for All rather than more for Some" is the basic policy underlying the JICA Study.

It was therefore assumed in the Study that all the population within the FS Area should be somehow granted an access to the municipal water supply system, even if such an access is an indirect access through a water kiosk, a communal tap or a water vendor. In this context, a broad assumption was made that the number of population served will be equal to the number of the total population in the Feasibility Area.

Table 3-4 presents the distribution of the estimated population served in 2005 by Sub-location and by area classification mentioned in Sub-section 3.1.1.

Table 3-4 Distribution of Population Served in 2005

Area Classification	Sub-location	Population Served in 2005
Urban	Kibuye	37,211
	Millimani	19,617
	Kanyakwar	47,645
	Sub-total	*104,473 (25.2 %)*
Peri-urban	Nyalenda	79,552
	Manyatta	106,354
	Kasulu	34,409
	Wathorego	14,135
	Korando	30,917
	Kogony	32,423
	Sub-total	*297,790 (71.8 %)*
Rural	Chiga	287
	Nyalunya	1,800
	Kadero	1,610
	Okok	683
	Konya	7,888
	Sub-total	*12,268 (3.0 %)*
Total		414,531 (100 %)

(2) Sewerage

Table 3-5 summarizes the population to be served by Municipal Sewerage System under the Phase I Project. It is planned that all the population in the Central and Eastern WTDs who are assumed to consume more than 50 lcd will receive the sewerage service. As shown in the table, the total population served by the sewerage system is estimated to be 133,270 in the year 2005.

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Table 3-5 Population to be served by Municipal Water Supply and Sewerage System in 2005

Urban/ Peri-urban/ Rural	Water Supply Method	Income Level	Unit Water Supply (lcd)	Served By Water Supply System	Served By Sewerage System	On-site Sanitation
Urban	House Connection	High	200	17,993	9,787	8,206
		Medium	120	34,244	18,627	15,617
		Low	60	43,530	23,681	19,849
	Communal Taps	Low	20	8,706	0	8,706
	Sub-total			104,473	52,095	52,378
Peri-urban	House Connection	High	120	28,125	22,143	5,982
		Medium	60	75,440	28,157	47,283
		Low	50	82,719	30,874	51,845
	Communal Taps	High	20	1,655	0	1,655
		Medium	20	18,859	0	18,859
		Low	15	90,992	0	90,992
	Sub-total			297,790	81,174	216,616
Rural	House Connection	High	120	1,158	0	1,158
		Medium	60	3,107	0	3,107
		Low	50	3,408	0	3,408
	Communal Taps	High	20	69	0	69
		Medium	20	777	0	777
		Low	15	3,748	0	3,748
	Sub-total			12,267	0	12,267
Total				414,530	133,269	281,261

3.2 WATER DEMAND

3.2.1 Domestic Water Demand

In order to estimate the future domestic water demand, a survey on the existing water use was conducted by the Study Team. For this survey, the Study Team selected the Milimani area where supply from the municipal water supply system is currently available on a continuous basis, and hence the results of the survey might represent the potential domestic water demands in other areas of the municipal water supply system as well.

The survey indicated that the level of the existing per-capita water use in Milimani is more or less compatible to that recommended in the guidelines prepared by the MLRRWD for design of water supply facilities for various domestic consumption levels. Table 3-6 shows the per-capita consumption rates recommended for use by the ministry for different levels of income both in urban and peri-urban areas.

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Table 3-6 Per Capita Consumption Rates by User Category and Area Classification

User Category	Urban Area (lcd)	Peri-Urban Area (lcd)
Individual House Connections		
High-income	200	120
Medium-income	120	60
Low- income	60	50
Communal taps	20	15

Source : Design Manual by MLRRWD, 1990.

The results of the survey in Milimani indicated that the level of water consumption through a house connection varies to a considerable extent depending on the level of income, and that, even in the urban area, there is a significant number of people who still do not have a direct access to the municipal water supply system but depend their domestic water on a communal tap.

JICA Study Team made minor modifications to the MLRRWD guidelines and developed the future per-capita domestic consumption rates. They are summarized in Table 3-7.

Table 3-7 Modified Per Capita Domestic Consumption Rates by Level of Income and Area Classification (lcd)

User Category	Urban Area	Peri-urban Area	Rural Area
Individual House Connections:			
High-income	200	120	120
Medium-income	120	60	60
Low- income	60	50	50
Communal taps:			
High Income	20	20	20
Medium Income	20	20	20
Low Income	20	20	15

Source : JICA Study Team

The year 2005 population estimated for each Sub-location was then distributed into one of the three income level groups, i.e. high, medium and low, taking the current situations of the Sub-locations and the future land use envisaged by the Kisumu Structure Plan into account. The numbers of population distributed into each income group and service level are shown in Table 3-8. The domestic water demand for each Sub-location in the year 2005 was then calculated as the products of the numbers of population shown in Table 3-8 and the per-capita consumption rates shown in Table 3-7. Table 3-9 presents the domestic water demands estimated for each

Sub-location. The total domestic water demand in the Feasibility Study Area is estimated to be 24,873 m3/day in the year 2005. As shown in Table 3-8, it is estimated in this Feasibility Study that approximately 70 % (289,728) of the total population (414,351) within the municipal water supply system area in the year 2005 will be supplied through an individual house connection with an average consumption rate ranging from 50 to 200 lcd while the remaining 30 % through a communal tap with an average consumption rate of 15 to 20 lcd. The ratio of individual house connection supply is estimated to be 92 % in urban areas and 63 % in peri-urban and rural areas.

3.2.2 Non-domestic Water Demands

Non-domestic water demand comprises institutional, commercial and industrial water demands. The future institutional water demand in each Sub-location was projected to the year 2005 at a rate almost equivalent to the future population growth rate in the Sub-location.

At present, most of the commercial activities in Kisumu are centered around the Milimani area and its surroundings where many banks, supermarkets, hotels and restaurants are located. The future growth is expected to continue towards the north of this central core area. It is expected that Manyatta, Kibuye and Kanyakwar Sub-locations will remain as the center of commercial activities in Kisumu in the year 2005. Although a high population density is expected in Manyatta and Nyalenda Sub-locations, no significant commercial growth is foreseen in these areas.

There has been little expansion in industrial activity in Kisumu in recent years. Currently, industrial activity is dominated by beverages and agro-processing based on tee, coffee, pyrethrum, sugarcane and cotton.

At present, most of the major industries in Kisumu are located in the Kibuye Sub-location. The Kenyan Brewery Limited is one of those industries and is a large user of water from the municipal water supply system. It is expected that the future expansion in industrial activity in Kisumu will be slow and mostly accommodated in the Kibuye Sub-location.

A relatively large growth is expected to take place in the north of the Kasule Sub-location as the future land use plan envisages the development of a new industrial estate in this area.

Table 3-8 Distribution of Population Served Per Service Level

Sub-location		Population Served									
		Total	Distribution per Service Level								
			House Connection						Communal Tap		
			Urban			Peri-urban & Rural			Urban	Peri-Urban & Rural	
			High	Medium	Low	High	Medium	Low	High	High	Medium	Low
			200 lcd	120 lcd	60 lcd	120 lcd	60 lcd	50 lcd	20 lcd	20 lcd	20 lcd	15 lcd
Urban	Kibuye	37,211	6,409	12,197	15,505	0	0	0	3,101	0	0	0
	Millimani	19,617	3,378	6,430	8,174	0	0	0	1,635	0	0	0
	kanyakwar	47,645	8,206	15,618	19,852	0	0	0	3,970	0	0	0
	Sub-total	*104,473*	*17,993*	*34,245*	*43,531*	*0*	*0*	*0*	*8,706*	*0*	*0*	*0*
Peri-urban	Nyalenda	79,552	0	0	0	7,513	20,153	22,098	0	442	5,038	24,308
	Manyatta	106,354	0	0	0	10,045	26,943	29,543	0	591	6,736	32,497
	Kasule	34,409	0	0	0	3,250	8,717	9,558	0	191	2,179	10,514
	Wathorego	14,135	0	0	0	1,335	3,581	3,926	0	78	895	4,319
	Korando	30,917	0	0	0	2,920	7,832	8,588	0	172	1,958	9,447
	Kogony	32,423	0	0	0	3,062	8,214	9,006	0	180	2,054	9,908
	Sub-total	*297,790*	*0*	*0*	*0*	*28,125*	*75,440*	*82,719*	*0*	*1,654*	*18,860*	*90,993*
Rural	Chiga	287	0	0	0	27	73	80	0	2	18	88
	Nyalunya	1,800	0	0	0	170	456	500	0	10	114	550
	Kadero	1,610	0	0	0	152	408	447	0	9	102	492
	Okok	683	0	0	0	65	173	190	0	4	43	209
	Konya	7,888	0	0	0	745	1,998	2,191	0	44	500	2,410
	Sub-total	*12,268*	*0*	*0*	*0*	*1,159*	*3,108*	*3,408*	*0*	*69*	*777*	*3,749*
Total		**414,531**	**17,993**	**34,245**	**43,531**	**29,284**	**78,548**	**86,127**	**8,706**	**1,723**	**19,637**	**94,742**
			95,769			**193,959**			**8,706**	**116,102**		
			289,728						**124,808**			

Table 3-9 Domestic and Non-domestic Water Demands in FS Area in 2005

Sub-location		Population Served								Per Capita Consumption						
		Total	Distribution as per Service Level							Distribution as per Service Level						
			House Connection			Water Kiosk				House Connection			Water Kiosk			
						Urban	Peri-Urban & Rural						Urban	Peri-Urban & Rural		
			High	Medium	Low	High	High	Medium	Low	High	Medium	Low	High	High	Medium	Low
Urban	Kibuye	37,211	6,409	12,197	15,505	3,101	0	0	0	200	120	60	20	-	-	-
	Millimani	19,617	3,378	6,430	8,174	1,635	0	0	0	200	120	60	20	-	-	-
	kanyakwar	47,645	8,206	15,618	19,852	3,970	0	0	0	200	120	60	20	-	-	-
	Sub-total	104,473	17,993	34,245	43,531	8,706	0	0	0	-	-	-	-	-	-	-
Peri-urban	Nyalenda	79,552	7,513	20,153	22,098	0	442	5,038	24,308	120	60	50	-	20	20	15
	Manyatta	106,354	10,045	26,943	29,543	0	591	6,736	32,497	120	60	50	-	20	20	15
	Kasule	34,409	3,250	8,717	9,558	0	191	2,179	10,514	120	60	50	-	20	20	15
	Wathorego	14,135	1,335	3,581	3,926	0	78	895	4,319	120	60	50	-	20	20	15
	Korando	30,917	2,920	7,832	8,588	0	172	1,958	9,447	120	60	50	-	20	20	15
	Kogony	32,423	3,062	8,214	9,006	0	180	2,054	9,908	120	60	50	-	20	20	15
	Sub-total	297,790	28,125	75,440	82,719	0	1,654	18,860	90,993	-	-	-	-	-	-	-
Rural	Chiga	287	27	73	80	0	2	18	88	120	60	50	-	20	20	15
	Nyalunya	1,800	170	456	500	0	10	114	550	120	60	50	-	20	20	15
	Kadero	1,610	152	408	447	0	9	102	492	120	60	50	-	20	20	15
	Okok	683	65	173	190	0	4	43	209	120	60	50	-	20	20	15
	Konya	7,888	745	1,998	2,191	0	44	500	2,410	120	60	50	-	20	20	15
	Sub-total	12,268	1,159	3,108	3,408	0	69	777	3,749	-	-	-	-	-	-	-
Total		414,531	47,277	112,793	129,658	8,706	1,723	19,637	94,742	-	-	-	-	-	-	-

Sub-location		Day Average Demand												Day Maximum Demand
		Domestic Water Demand								Non-domestic Water Demand				Total	
		House Connection			Water Kiosk				Sub-total	Institutional	Commercial	Industrial	Sub-total		
					Urban	Peri-Urban & Rural									
		High m3/day	Medium m3/day	Low m3/day	High m3/day	High m3/day	Medium m3/day	Low m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day	m3/day
Urban	Kibuye	1,282	1,464	930	62	0	0	0	3,738	545	1,371	5,510	7,426	11,163.8	17,345
	Millimani	676	772	490	33	0	0	0	1,970	287	723	0	1,010	2,980.3	4,630
	kanyakwar	1,641	1,874	1,191	79	0	0	0	4,786	698	1,756	0	2,454	7,239.9	11,248
	Sub-total	3,599	4,109	2,612	174	0	0	0	10,494	1,530	3,850	5,510	10,890	21,384.0	33,224
Peri-urban	Nyalenda	902	1,209	1,105	0	9	101	365	3,690	341	470	0	811	4,500.9	6,993
	Manyatta	1,205	1,617	1,477	0	12	135	487	4,933	456	628	0	1,084	6,017.1	9,349
	Kasule	390	523	478	0	4	44	158	1,596	148	203	416	767	2,363.0	3,671
	Wathorego	160	215	196	0	2	18	65	656	61	83	0	144	799.8	1,243
	Korando	350	470	429	0	3	39	142	1,434	133	182	891	1,206	2,640.0	4,102
	Kogony	367	493	450	0	4	41	149	1,504	139	191	772	1,102	2,605.9	4,049
	Sub-total	3,375	4,526	4,136	0	33	377	1,365	13,813	1,278	1,757	2,079	5,114	18,926.7	29,406
Rural	Chiga	3	4	4	0	0	0	1	13	1	2	119	122	135.3	210
	Nyalunya	20	27	25	0	0	2	8	83	8	11	772	791	874.5	1,359
	Kadero	18	24	22	0	0	2	7	75	7	10	0	17	91.7	142
	Okok	8	10	10	0	0	1	3	32	3	4	0	7	38.8	60
	Konya	89	120	110	0	1	10	36	366	33	46	0	79	444.9	691
	Sub-total	139	186	170	0	1	16	56	569	52	73	891	1,016	1,585.1	2,463
Total		7,113	8,822	6,918	174	34	393	1,421	24,876	2,860	5,680	8,480	17,020	41,895.8	65,092

Table 3-9 presents the non-domestic water demands estimated for each Sub-location in the year 2005. The same table also presents the total water demand estimated for the Feasibility Study Area in the year 2005. Table 3-10 shows a summary of the water demands. The total water demand in the Feasibility Study Area in the year 2005 is estimated to be 41,893 m3/day

Table 3-10 Total Water Demand in FS Area in 2005 (m3/day)

Domestic Water Demand	Non-domestic Water Demand				Total Water Demand in 2005
	Institutional	Commercial	Industrial	Sub-total	
24,873	2,860	5,680	8,480	17,020	41,893

3.2.3 Water Demands for Planning of Water Supply Infrastructure

The JICA Master Plan envisions that the leakage in the distribution system will gradually decrease from 30 % in 1997 to 29.2 % in 2005 and 25 % in 2015. It is also envisaged in the Master Plan that the peak day and peak hour factors in Kisumu will be as low as 1.1 times and 2.0 times of the average day demand respectively, given the relatively large proportion of non-domestic water demand in relation to that of domestic water demand.

Day Average Water Demand in 2005 : 41,893/0.708 = 59,171 m3/day
= 2,465 m3/hour
= 0.685 m3/sec

Day Maximum Water Demand in 2005 : 59,171 x 1.1 = 65,088 m3/day
= 2,712 m3/hour
= 0.753 m3/sec

Peak Hourly Flow in 2005 : 59,171 x 2.0 = 118,342 m3/day
= 4,931 m3/hour
= 1.370 m3/sec

Peak hourly flow will be used for the planning of distribution pumps and pipelines while day maximum demand will be used for planning of distribution reservoirs and clear water transmission pumps and pipelines. For the planning of water treatment works, an allowance of 5 % will be added to the day maximum water demand to compensate water losses at the works. For water intake and raw water transmission facilities, another 3 to 5 % allowance for water losses will be added to the required treatment capacity.

3.3 WASTEWATER GENERATION

3.3.1 Domestic Wastewater Generation

Domestic wastewater to be generated in 2005 is estimated as shown in Table 3-11. In this estimate, it is assumed that the whole amount of water which is domestically consumed will be generated as wastewater. The only exception for this is that large domestic users who consume 200 lcd of water are assumed to generate 190 lcd of wastewater.

Table 3-11 Domestic Wastewater Generation (DWWG) in 2005

Urban/ Peri-urban/ Rural	Water Supply Method	Income Level	Unit DWWG (lcd)	DWWG (m^3/d)	Management Methods	
					Sewerage System (m^3/d)	Individual Treatment (m^3/d)
Urban	House Connection	High	190	3,419	1,860	1,559
		Medium	120	4,109	2,235	1,874
		Low	60	2,612	1,421	1,191
	Communal Taps	Low	20	174	0	174
	Sub-total			10,314	5,516	4,798
Peri-urban	House Connection	High	120	3,375	2,657	718
		Medium	60	4,526	1,689	2,837
		Low	50	4,136	1,544	2,592
	Communal Taps	High	20	33	0	33
		Medium	20	377	0	377
		Low	15	1,365	0	1,365
	Sub-total			13,812	5,890	7,922
Rural	House Connection	High	120	139	0	139
		Medium	60	186	0	186
		Low	50	170	0	170
	Communal Taps	High	20	1	0	1
		Medium	20	16	0	16
		Low	15	56	0	56
	Sub-total			568	0	568
Total				24,694	11,406	13,288

As can be seen in the above table, it is planned that 11,400 m3/d or approximately 46 % of the total domestic wastewater (24,700 m3/d) will be collected by the municipal sewerage system in the year 2005.

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Urban	House Connection	High	190	3,419	1,860	1,559
		Medium	120	4,109	2,235	1,874
		Low	60	2,612	1,421	1,191
	Communal Taps	Low	20	174	0	174
	Sub-total			10,314	5,516	4,798
Peri-urban	House Connection	High	120	3,375	2,657	718
		Medium	60	4,526	1,689	2,837
		Low	50	4,136	1,544	2,592
	Communal Taps	High	20	33	0	33
		Medium	20	377	0	377
		Low	15	1,365	0	1,365
	Sub-total			13,812	5,890	7,922
Rural	House Connection	High	120	139	0	139
		Medium	60	186	0	186
		Low	50	170	0	170
	Communal Taps	High	20	1	0	1
		Medium	20	16	0	16
		Low	15	56	0	56
	Sub-total			568	0	568
Total				24,694	11,406	13,288

As can be seen in the above table, it is planned that 11,400 m3/d or approximately 46 % of the total domestic wastewater (24,700 m3/d) will be collected by the municipal sewerage system in the year 2005.

3.3.2 Non-domestic Wastewater Generation

Non-domestic wastewater comprises commercial, institutional and industrial wastewaters generated by social and economic activities. Table 3-12 presents the non-domestic wastewaters to be generated by each use category in the year 2005.

Table 3- 12 Non-domestic Wastewater Generation in 2005 unit: m^3/d

Non-domestic Wastewater	Municipal Water Supply		Sewerage Service			Out of Sewerage Service
	Water Supplied	Wastewater Generation	Central WTD	Eastern WTD	Total	
Commercial	5,680	4,830	2,130	1,790	3,920	910
Institutional	2,860	2,290	500	1,250	1,750	540
Industrial	8,480	7,080	4,700	1,440	6,140	940
Total	17,020	14,200	7,330	4,480	11,810	2,390

It estimating the above non-domestic wastewater generation, it is assumed that 85 % of commercial water supplied and 80 % of institutional water supplied will be turned out as wastewater. As for industrial water, it is assumed that 80 to 100 % of water used by large factories and 80 % of water used by general factories will be discharged as wastewater.

As shown in Table 3-12 above, it is planned that 11,810 m3/d of non-domestic wastewater or approximately 83 % of the total non-domestic wastewater generation (14,200 m3/d) will be collected by the municipal sewerage system in the year 2005.

Table 3-13 presents a summary of wastewater generation and coverage by the municipal sewerage system in the year 2005. As can be seen in the table, it is estimated that the total wastewater generation will be approximately 38,900 m3/d in the year 2005 and about 60 % of the volume will be collected by the municipal sewerage system.

Table 3-13 Total Wastewater Generation and Coverage by Sewerage System in 2005

Source of Wastewater	Wastewater Generated (m3/d)	To Be Collected by Sewerage System (m3/d)
Domestic Origin	24,700	11,410
Non-domestic Origin	14,200	11,810
Total	38,900	23,220

3.3.3 Design Flows for Planning of Sewerage Infrastructure

Design flows which will be use for the planning of sewerage infrastructure are estimated for each of the Central and Eastern WTDs as shown in Table 3-14 . The estimated design flows include an allowance for groundwater infiltration which is assumed to be 25 % of daily average flow. Daily maximum and hourly maximum flows are estimated by adopting the same ratios as those applied to the estimate of water demand in Sub-section 3.2.3.

Daily Average Flow : Daily Maximum Flow : Hourly Maximum Flow
= 1.0 : 1.1 : 2.0

Table 3-14 Design Flows in 2005 **Unit: m^3/d**

Design Flow	Central WTD		Eastern WTD	
	2005	2015	2005	2015
Daily Average	**12,340**	13,500	**16,690**	28,220
Domestic	2,540	3,110	8,870	14,580
Non-domestic	7,330	7,690	4,480	7,990
Sub-total	9,870	10,800	13,350	22,570
Groundwater	2,470	2,700	3,340	5,650
Daily Maximum	**13,330**	14,580	**18,030**	30,480
Hourly Maximum	**22,210**	24,300	**30,040**	50,790

CHAPTER 4

WATER SUPPLY IMPROVEMENT PLANS AND COSTS

4. WATER SUPPLY IMPROVEMENT PLANS AND COSTS

4.1 IMPROVEMENT PLANS

4.1.1 Description of Proposed Improvement Plans

Figure 4-1 shows the water supply improvement plan proposed under the Phase I Project. The plan is also schematically shown in Figure 4-2.

Once the Phase I Project has been materialised, three water treatment works will be operated within the municipal water supply system. They are the Kajulu, Lake and Kibuye water treatment works.

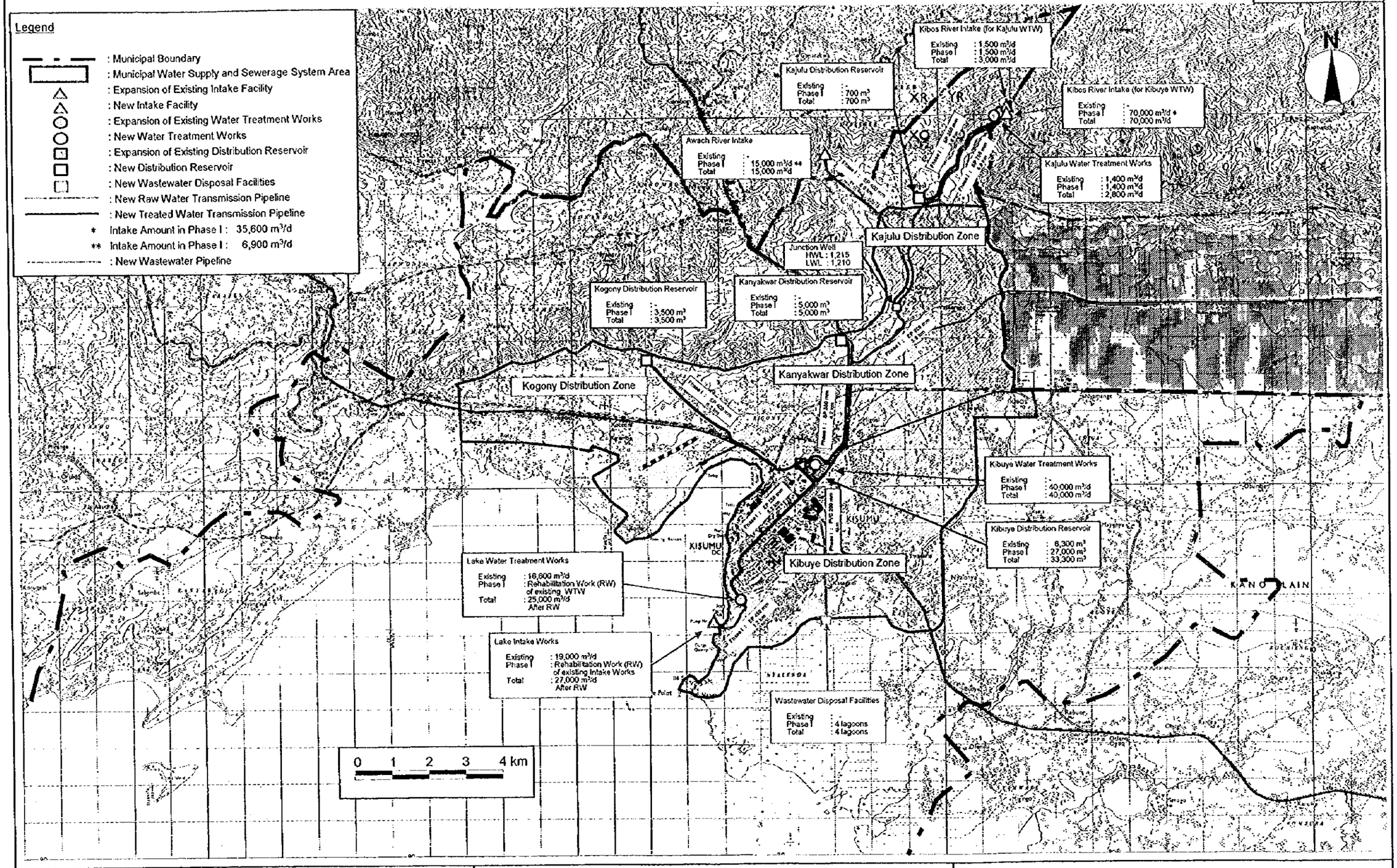
Under the Phase I Project, the treatment capacity of the Kajulu WTW will be doubled from the existing 1,400 m3/day to 2,800 m3/day, and so will be the capacity of the Kibos River Intake from the existing 1,500 m3/day to 3,000 m3/day. Treated water from the works will gravitate to the Kajule Distribution Reservoir through a new 200 mm steel pipeline approximately 3.6 km in length.

Similarly, the treatment capacity of the Lake WTW will be increased by 50 % from the existing 16,600 m3/day to 25,000 m3/day along with the expansion of the Lake Intake Works from the existing 19,000 m3/d to 27,000 m3/d. Treated water from the works will be pumped to the Kibuye Distribution Reservoir through a new 550 mm steel pipeline over a distance of approximately 5.2 km.

Apart from the above two existing water treatment works, a new water treatment works with a capacity of 40,000 m3/day will be constructed at Kibuye immediately adjacent to the existing Kibuye reservoir site. A proposed layout of the treatment works is shown in Figure 4-3. Raw water for the new Kibuye WTW will be taken from the Kibos and Awach rivers at the locations about 15 km to the north of the water works.

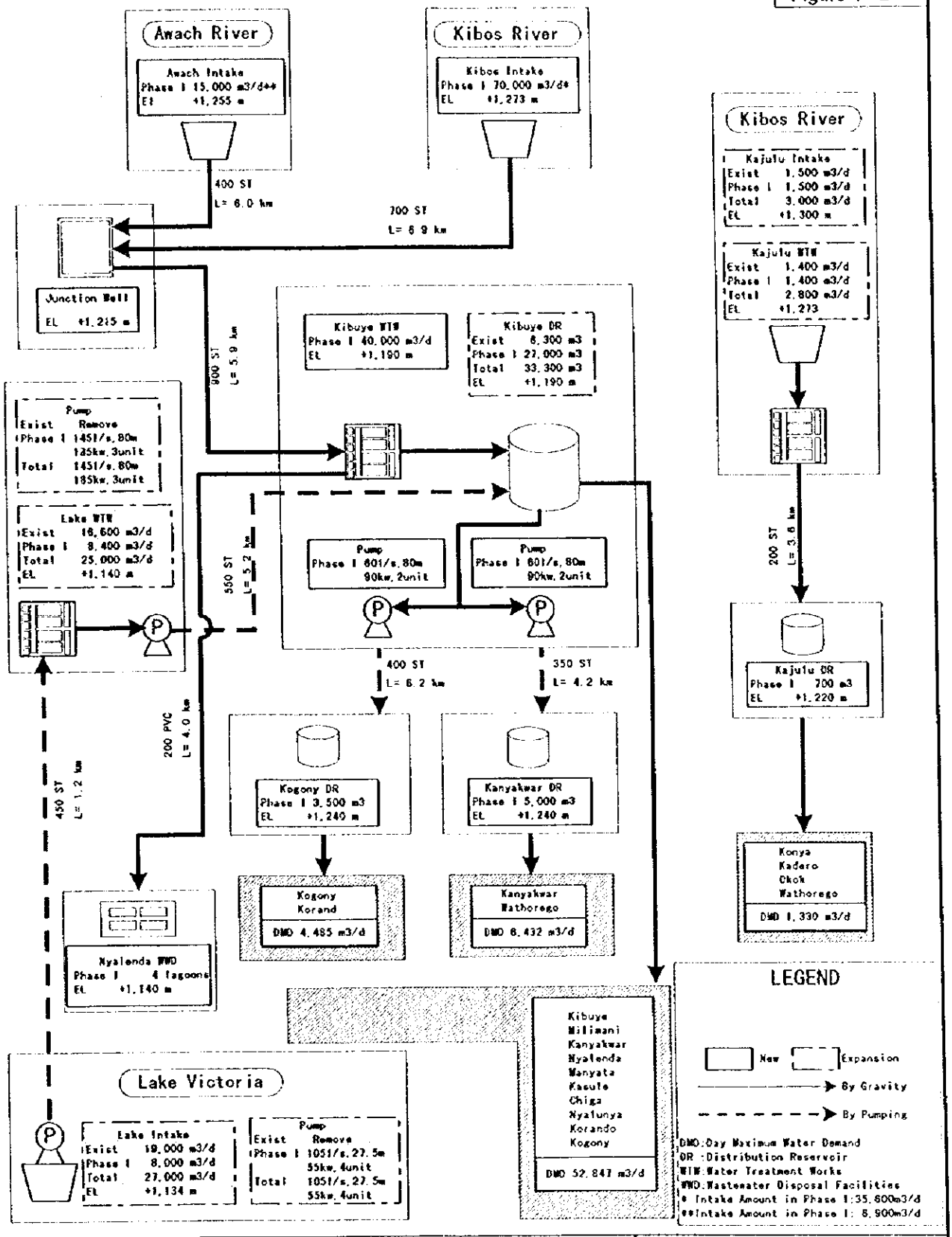
A new water intake will be constructed on the Awach river at about 1.3 km downstream of the confluence where the Joprok and Kepkerer rivers meet. 6,900 m3/day of raw water will be taken from the new intake for treatment at the Kibuye WTW. Water from the new Awach intake will gravitate through a new 400 mm steel pipeline to a junction well to be provided at 6 km to the southeast.

Figure 4-1



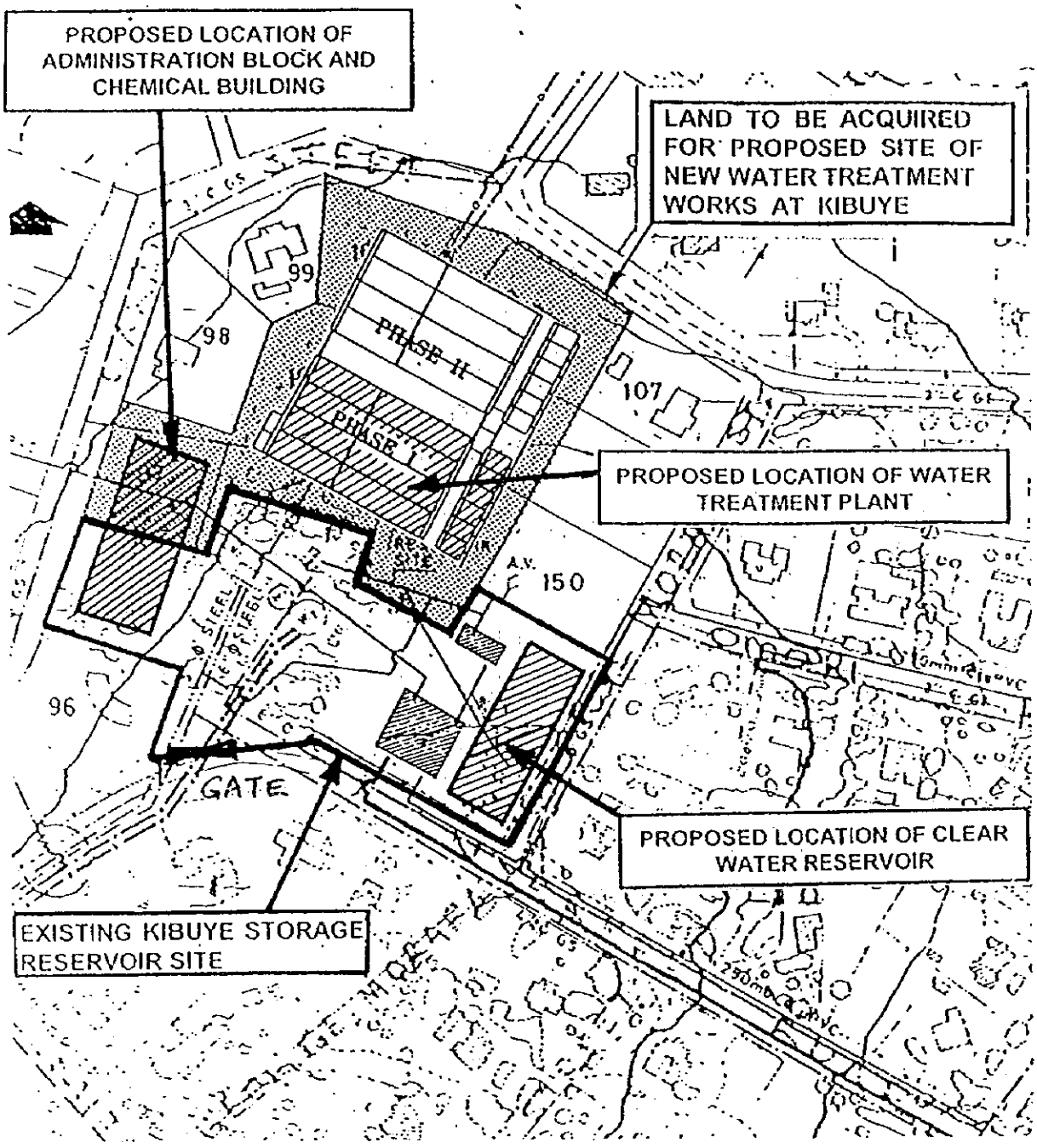
THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Water Supply Improvement Plan Proposed under Phase I Project

Figure 4 - 2



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 Water Supply Improvement Plan Proposed under Phase I Project

Figure 4-3



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 : Layout Plan Proposed for Kibuye WTW

The existing intake on the Kibos river will be renovated and 35,600 m3/day of raw water will be taken for treatment at the new Kibuye WTW. Water from the intake will gravitate through a new 700 mm steel pipeline to the above junction well; will be mixed with water from the Awach river; and will further gravitate to the Kibuye WTW through a new 900 mm raw water transmission main over a distance of 5.9 km.

It should be noted that both of these two intakes and all of the raw water transmission pipelines which will connect them to the new Kibuye WTW will be sized, from the outset, to meet the raw water requirement of the Phase II Project, which is 85,000 m3/day. A supplementary study on the utilisation of water resources for the Phase II Project was conducted by the JICA Study Team. The study indicated that this provision will enable the Kibuye WTW to receive the full amount of the Phase II raw water requirement (85,000 m3/day) from the Awach and Kibos rivers for a continuous period of 10 months a year and from Lake Victoria for the rest of the year, and that this arrangement will be more economical in terms of capital and O/M costs than in the case where Lake Victoria alone is used. The study also indicated that providing the raw water transmission pipelines with a capacity sufficient to meet the Phase 2 requirement from the outset (under Phase I) will be more economical than providing additional pipelines under the Phase 2 Project. This supplementary study is compiled as Appendix M.

With respect to the water distribution, the entire municipal water supply system area will be divided into four separate distribution zones, i.e. Kibuye, Kanyakwar, Kogony and Kajulu Distribution Zones. In each distribution zone, water will be distributed by gravity from a distribution reservoir which will be located within the zone.

One of the four distribution reservoirs, i.e. the Kibuye Distribution Reservoir is expected to play a fairy important role. The reservoir will receive treated water both from the Lake WTW and from the new Kibuye WTW and blend them with a view to improving the overall water quality of finished water before it is actually distributed into the system. The reservoir will be located on a hill at an elevation of 1,190 m which provides an enough hydraulic head for water from the reservoir to gravitate to the entire Kibuye Distribution Zone. Water from the reservoir will be also pumped to Kanyakwar and Kogony Distribution Reserviors. Each of these reservoirs will be located on a hill at an elevation of 1,240 m so that water from the reservoir can gravitate to the respective distribution zones.

The fourth distribution reservoir, i.e. Kajulu Distribution Reservoir will be constructed in the Okok Sub-location at an elevation of 1,220 m. This reservoir will receive treated water from the Kajulu WTW by gravity and further distribute it to the Kajure Distribution Zone by gravity.

Table 4-1 summarises the population and water demand in each distribution zone in the year 2005. Details are provided in Appendix Q for each distribution zone.

Table 4-1 Population and Water Demand in Distribution Zone in 2005

Distribution Zone	Population	Water Demand (m3/day)			
		Day Average			Day Maximum
		Domestic	Non-domestic	Total	
Kibuye	331,632	19,742	14,271	34,013	52,846
Kanyakwar	33,011	2,819	1,321	4,140	6,432
Kogony	34,762	1,612	1,275	2,887	4,485
Kajulu	15,128	702	153	855	1,329
Total	414,533	24,875	17,020	41,895	65,092

The distribution reservoirs were sized based on the criteria shown in Table 4-2. Trunk distribution mains proposed for each distribution zone are shown in Figure 4-4.

Table 4-2 Criteria Used for Sizing Distribution Reservoirs

Reservoir	Day Max. Demand Phase I	Design Capacity	Required Capacity Phase I	Capacity before Phase I	Capacity Required under Phase I	Construction Capacity Phase I	Capacity after Phase I
	m3/day	hr	m3	m3	m3	m3	m3
Kibuye	52,847	15	33,029	6,300	26,729	27,000	33,300
Kajule	1,330	12	665	0	665	700	700
Kanyakwar	6,432	18	4,824	0	4,824	5,000	5,000
Kogony	4,485	18	3,364	0	3,364	3,500	3,500
Total	65,094		41,882	6,300	35,582	36,200	42,500

Table 4-1 summarises the population and water demand in each distribution zone in the year 2005. Details are provided in Appendix Q for each distribution zone.

Table 4-1 Population and Water Demand in Distribution Zone in 2005

Distribution Zone	Population	Water Demand (m3/day)			
		Day Average			Day Maximum
		Domestic	Non-domestic	Total	
Kibuye	331,632	19,742	14,271	34,013	52,846
Kanyakwar	33,011	2,819	1,321	4,140	6,432
Kogony	34,762	1,612	1,275	2,887	4,485
Kajulu	15,128	702	153	855	1,329
Total	**414,533**	**24,875**	**17,020**	**41,895**	**65,092**

The distribution reservoirs were sized based on the criteria shown in Table 4-2. Trunk distribution mains proposed for each distribution zone are shown in Figure 4-4.

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	m3/day	hr	m3	m3	m3	m3	m3
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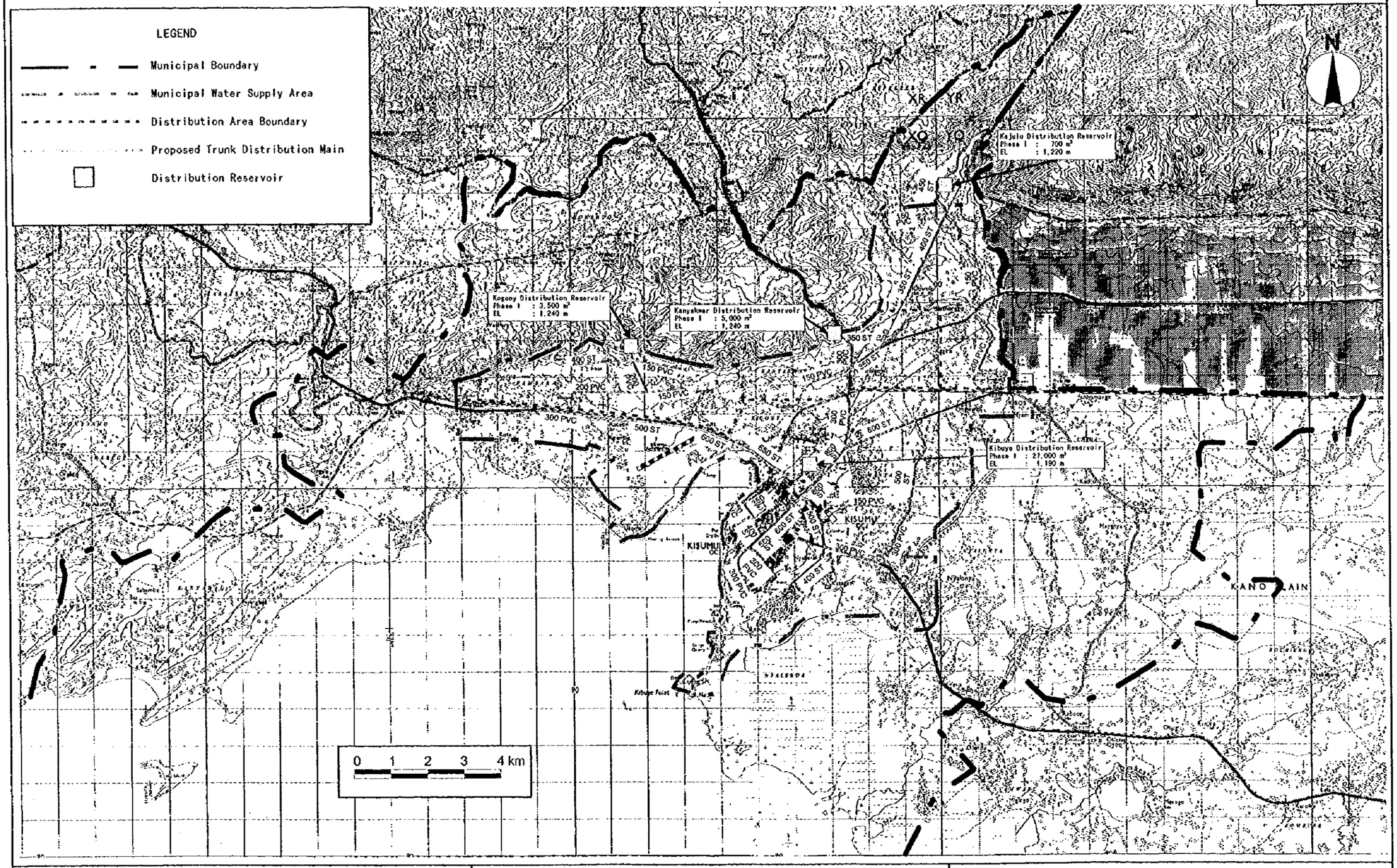
Kogony	4,485	18	3,364	0	3,364	3,500	3,500
Total	65,094		41,882	6,300	35,582	36,200	42,500

Figure 4-4



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 Trunk Distribution Mains Proposed under Phase I Project