CHAPTER 5

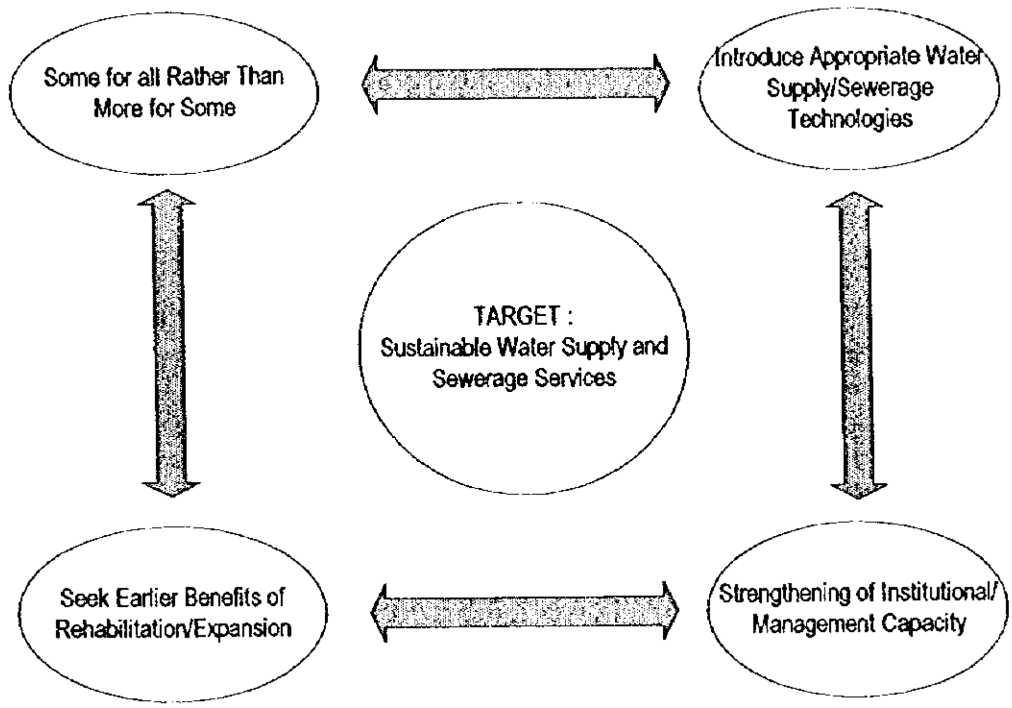
PLANNING POLICIES AND ASSUMPTIONS

5. PLANNING POLICIES AND ASSUMPTIONS

5.1 PLANNING POLICIES

5.1.1 Basic Concept

The basic concept adopted in this Study for the development of a water supply and sewerage master plan is shown below.



5.1.2 Logistics and Phasing

Phasing the construction of a project is desirable for many reasons. Investments can keep pace with demand, local construction capacity can be maximised, and risk associated with uncertainties in future projections can be minimised by rescheduling construction either forward and backward.

It is recommended that Master plan be implemented in two phases. It should comprise components for medium-term improvements and for long-term improvements. Medium-term improvements will be included in Phase I. Target year for Phase I of the project will be the year 2005 considering the following:

- variation of demand and available water sources for medium-term improvements
- time required for design and construction
- investment efficiency
- time required for strengthening of organisation

To cope with the urgent need of potable water, rehabilitation/augmentation of the existing works should be included in Phase I.

Phasing of the water supply service area will not be considered in order to deliver safe water to as much population as possible. However, it is not desirable to lay all distribution mains at one time due to the time required for construction and considering investment efficiency. Under these conditions, communal taps, along with individual house connections, will be provided over an expanded service area to deliver water to as much population as possible.

Implementation of the Master Plan will require a series of institutional and management improvements. It is clear that the residents in Kisumu will not be able to enjoy the benefit of improved services without a major breakthrough in this area.

5.2 LAND USE AND MUNICIPAL POPULATION

5.2.1 Land Use

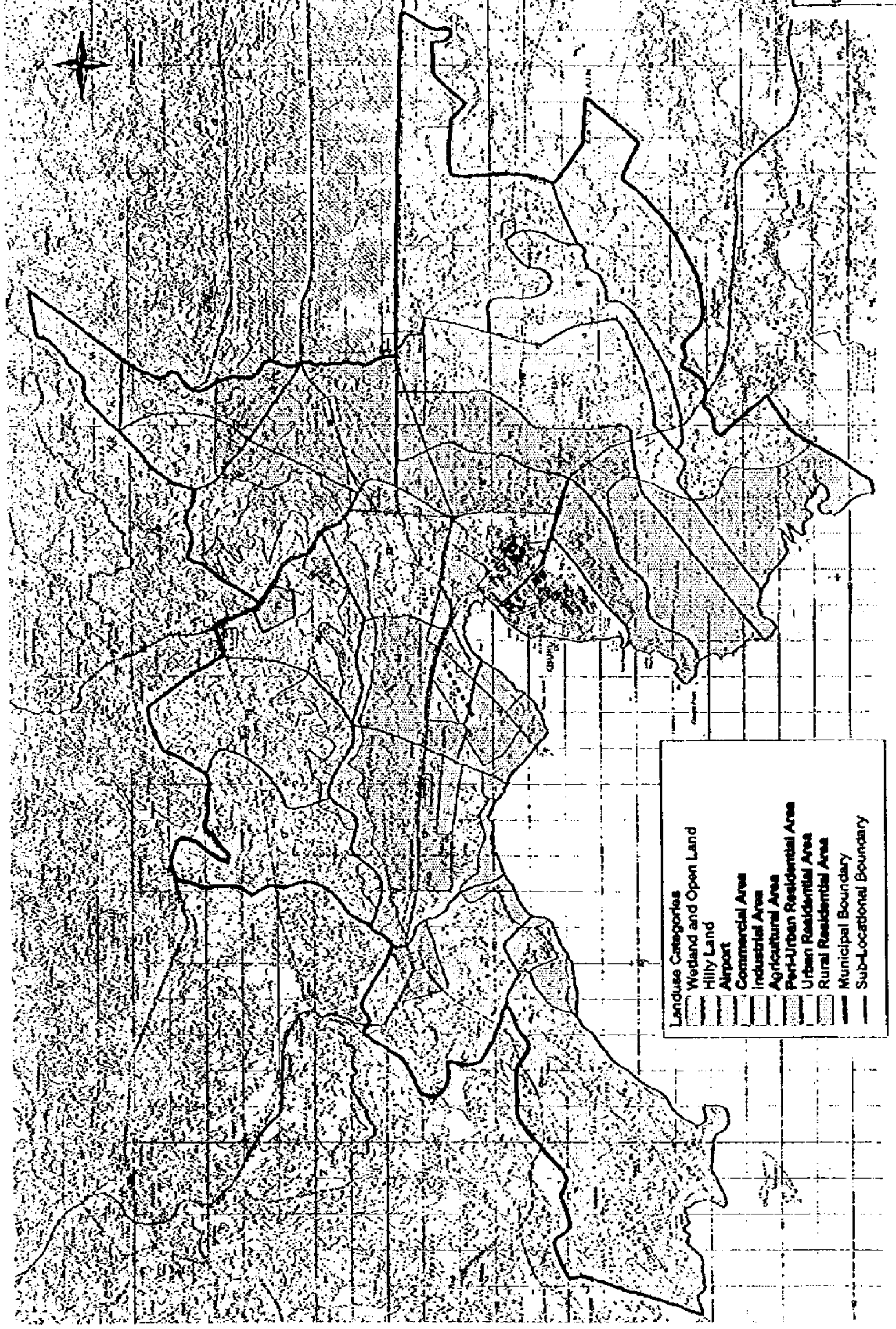
JICA Study Team in consultation with the Kisumu Municipal Council reviewed the "Kisumu Structure Plan 1983-2013" and made modifications to the land use envisaged by the plan, with a view to reflecting the latest conditions. The modified land use plan for the year 2015 is shown in Figure 5-1. Major modifications made to the plan are as follows:

- Ojolla and Korando Sub-locations are categorised as agricultural areas instead of residential area as envisaged in the plan.

- Areas in Kasule and Nyalunya Sub-locations which are envisaged as agricultural areas in the plan will be developed as residential areas.

- Existing slum areas on the eastern fringe of the town will further develop towards the east.

Figure 5-1



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 : Modified Land Use Plan for 2015

Table 5-1 presents the extents of areas allocated for each land use category after the modifications.

Table 5-1 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

5.2.2 Municipal Population

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 from the 1969, 1979 and 1989 census were analysed and the future population growth rates were estimated 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 5-2 and 5-3 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 will increase to 526,195 by 2005 and to 869,166 by 2015, the target year of this Master Plan at an overall average annual population growth rate of 4.77 % between 1989 and 2015. The projected populations and their distribution over the municipal area are graphically presented in Figures 5-2 and 5-3.

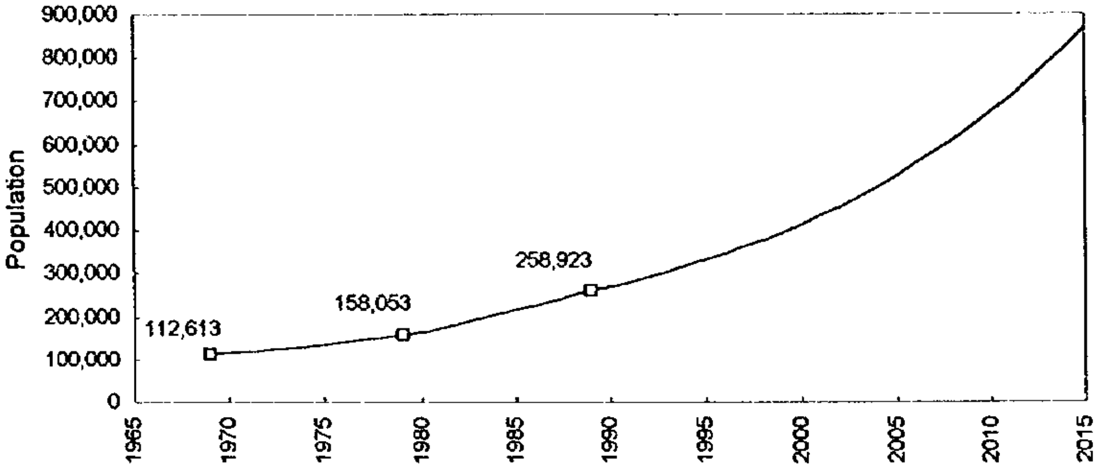
Table 5-2 Past Trend of Population Growth

SUBLOCATION		Category	1969 CENSUS population	Population growth rate %	1979 CENSUS population	Population growth rate %	1989 CENSUS population	Estimated population growth rate %
1	Kibuye	Urban					30,074	1.34
2	Milimani	Urban	32,431	2.17	40,188	1.34	15,856	1.34
3	Nyalenda B	Peri-urban					17,276	4.66
4	Nyalenda A	Peri-urban	12,046	6.11	21,788	5.83	21,109	4.66
5	Manyatta A	Peri-urban					37,913	6.80
6	Manyatta B	Peri-urban	7,942	11.22	23,008	8.52	14,225	6.80
7	Chiga	Rural	6,680	-1.78	5,582	1.64	6,571	1.64
8	Mayenya	Rural					4,168	4.78
9	Buoye	Rural	3,949	2.56	5,084	4.78	3,942	4.78
10	Nyalunya	Rural	4,070	0.21	4,155	6.30	7,656	6.30
11	Kasule	Rural	3,949	0.89	4,317	1.94	5,230	2.28
12	Kadero	Rural					2,951	-1.06
13	Okok	Rural					2,719	-1.06
14	Got Nyabondo	Rural	3,393	4.75	5,397	-6.60	2,726	-6.60
15	Wathorego	Peri-urban	7,676	1.38	8,800	1.68	4,951	2.00
16	Konya	Rural	2,637	5.03	4,309	5.04	7,045	5.03
17	Bar	Rural	-		-		6,075	2.00
18	Nyahera	Rural	-		-		7,717	2.00
19	Korando	Peri-urban	7,934	-1.66	6,708	7.15	13,382	5.00
20	Dago	Peri-urban	1,677	4.92	2,711	2.76	3,558	2.74
21	Mkendwa	Rural	317	3.00	426	3.33	591	3.32
22	Kogony	Peri-urban	3,913	5.83	6,897	4.66	10,879	6.00
23	Kanyakwar	Urban	5,014	3.61	7,147	9.19	17,215	7.35
24	Ojolla	Rural	3,274	2.10	4,031	2.62	5,221	2.61
25	Kanyagwegi	Rural	5,711	2.77	7,505	2.78	9,873	2.78
Total population			**112,613**	**3.45**	**158,053**	**5.06**	**258,923**	

Table 5-3 Projected Population Growth Rates

	Sub location	Category	Estimated Frowth 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

Figure 5-2



Year	Population	
1969	112,613	Census
1979	158,053	Census
1989	258,923	Census
1997	363,157	
2000	415,868	
2005	526,195	Phase I
2010	672,999	
2015	869,166	Phase II

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 : Summary of Projected Population

5.3 WATER SUPPLY

5.3.1 Service Area

(1) Municipal Water Supply Area

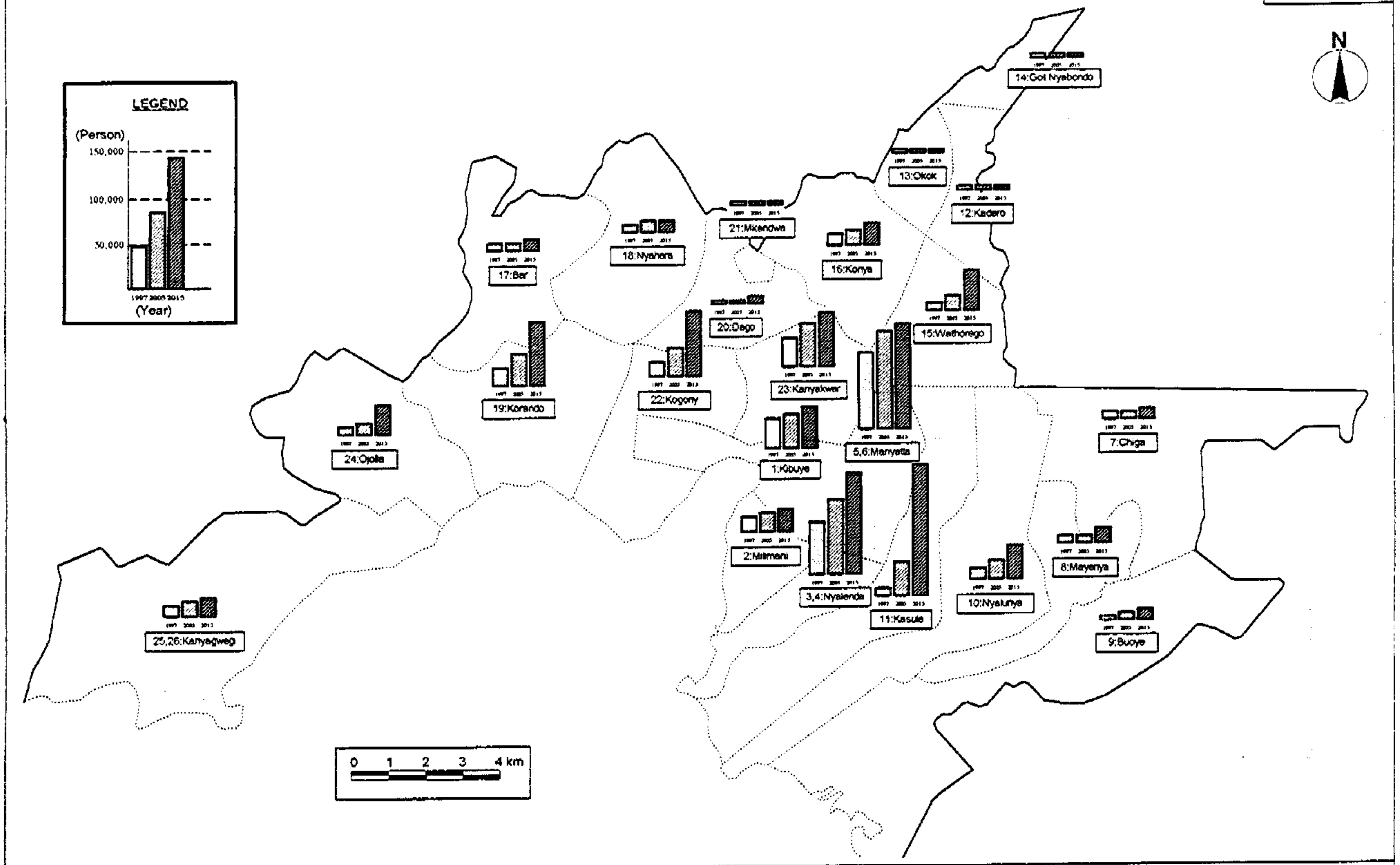
The municipal water supply is planned to supply areas where population density is higher than 40 persons/ha in 2015. With this definition, the municipal water supply system will cover virtually all the sub-locations classified as urban and peri-urban as shown in Figure 5-4. It will also cover part of the adjacent rural sub-locations, such as Konya, Chiga, Nyalunya, Kadero and Okok. Each sub-location is categorised into seven land use types: residential, commercial, industrial, agricultural, wet, hilly and airport areas. It is assumed that wet, hilly and airport areas will be uninhabited. Table 5-4 shows the extent of the proposed service area and coverages by sub-location and by land use category. As shown in the table, the total extent of the proposed service area is estimated to be 87.7 km^2.

(2) Sub-urban Water Supply Area

Sub-urban water supply area is defined as it is basically "the sub-locations which remain outside the propose service area of the municipal water supply". As shown in Table 5-4, following sub-locations will remain outside the municipal water supply system in the future.

- Mayenya
- Buoye
- Got Nyabondo
- Bar
- Nyahera
- Dago
- Mkendwa
- Ojolla
- Kanyagwegi
- Korando (in part)
- Chiga (in part)
- Nyalunya (in part)

Figure 5-3



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KISUMU MUNICIPAL COUNCIL

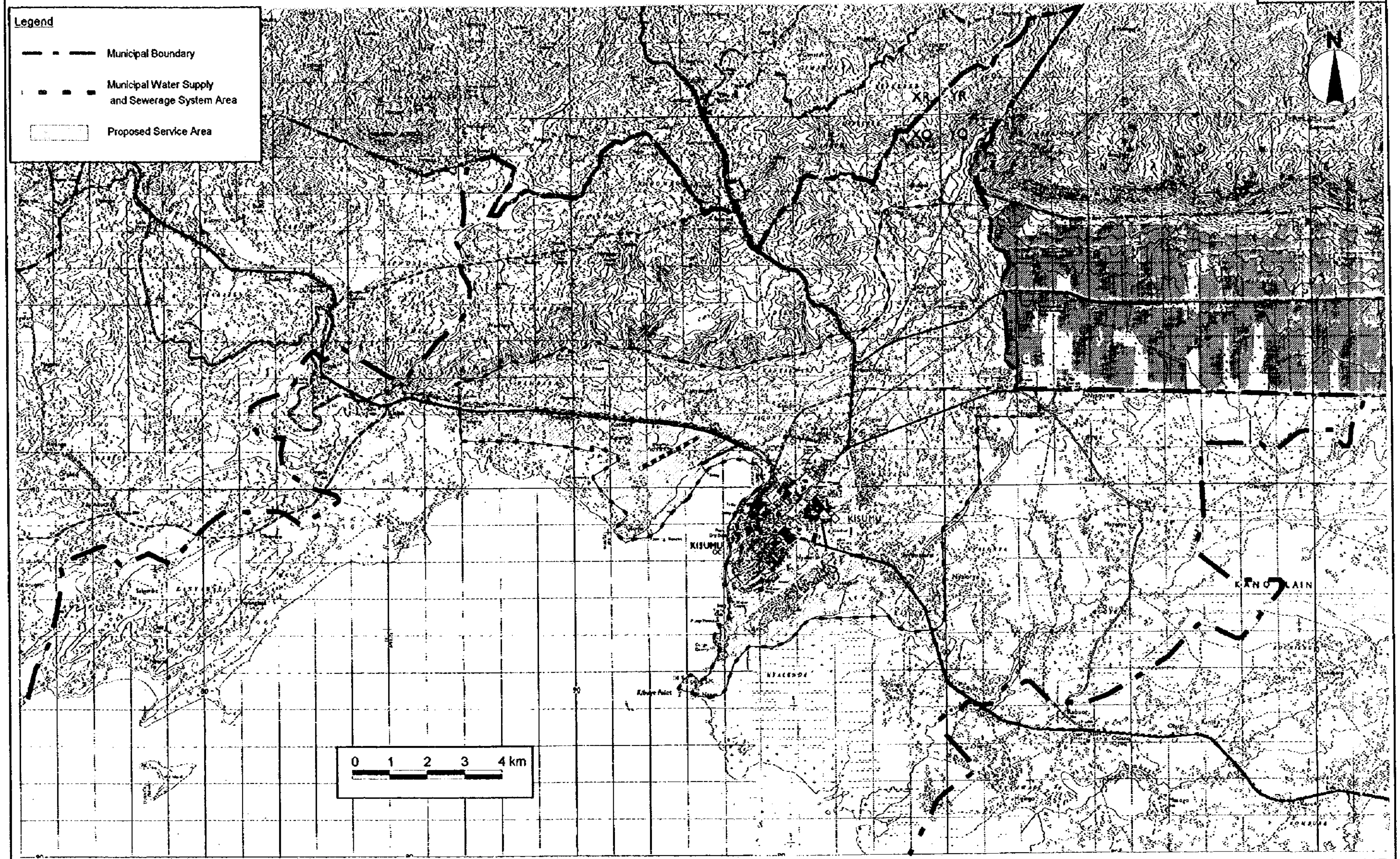
THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM

JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE

Distribution of Projected Population

Figure 5-4



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 Proposed Service Area for Municipal Water Supply System in 2005 and 2015

Table 5-4 Proposed Service Area of Municipal Water Supply

Sub-location	Cate-gory	Area (km²)	Service Area (km2)							
			Resi-dential	Com-mercial	Indust-rial	Agri-culture	Wet	Hil-ly	Air-port	Tot-al
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
Nyalunya	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

5.3.2 Service Population

Future populations who are estimated to live within the proposed municipal water supply system area is shown on Table 5-5. These populations are estimated from the projected total populations in each sub-location shown in Table 5-3 and the coverages by the proposed service area shown in Table 5-4.

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

It was therefore assumed in this Study that all the population within the proposed service area will 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 service population will be equal to the number of the total population in the proposed service area.

Table 5-5 Service Population in Municipal Water Supply System

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

As a result, it is estimated that the municipal water supply area will accommodate a total population of 414, 530 in 2005, or approximately 79 % of the total municipal population 526,195 in that year, and that the coverage will slightly increase to 80 % in 2015.

5.3.3 Water Demand

(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 well 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 5-6 shows the per-capita consumption rates recommended for use by the ministry for different levels of income both in urban and peri-urban areas.

Table 5-6 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 5-7.

Table 5-7 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 and 2015 service populations estimated for each Sub-location shown in Table 5-5 were 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 Tables 5-8 and 5-9 for the years 2005 and 2015 respecticly.

As can be seen in Table 5-8, it is estimated that in 2005 approximately 70 % (289,728) of the total population (414,351) in the municipal water supply area 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 in 2005.

Table 5-9 indicates that the ratio of individual house connection will increase from 70 % in 2005 to 77 % in 2015, comprising 100 % in urban areas and 72 % in peri-urban and rural areas.

The domestic water demand for each Sub-location in the years 2005 and 2015 were then calculated as the products of the numbers of population shown in Tables 5-8 And 5-9 and the per-capita domestic consumption rates shown in Table 5-7. Tables 5-10 and 5-11 presents the domestic water demands estimated for the years 2005 and 2015. The total domestic water demands in the municipal water supply area is estimated to be 24,873 m3/day in 2005 and 41,952 m3/day in 2015.

Table 5-8 Distribution of Service Population Per Service Level in 2005

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 5-9 Distribution of Service Population Per Service Level in 2015

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	42,509	8,502	12,753	21,254	0	0	0	0	0	0	0
	Millimani	22,410	4,482	6,723	11,205	0	0	0	0	0	0	0
	kanyakwar	59,500	11,900	17,850	29,750	0	0	0	0	0	0	0
	Sub-total	*124,419*	*24,884*	*37,326*	*62,209*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Peri-urban	Nyalenda	108,800	0	0	0	10,880	34,816	32,640	0	0	8,704	21,760
	Manyatta	116,800	0	0	0	11,680	37,376	35,040	0	0	9,344	23,360
	Kasule	140,063	0	0	0	14,006	44,820	42,019	0	0	11,205	28,013
	Wathorego	43,919	0	0	0	4,392	14,054	13,175	0	0	3,514	8,784
	Korando	65,282	0	0	0	6,528	20,890	19,585	0	0	5,223	13,056
	Kogony	72,747	0	0	0	7,275	23,279	21,824	0	0	5,820	14,549
	Sub-total	*547,611*	*0*	*0*	*0*	*54,761*	*175,235*	*164,283*	*0*	*0*	*43,810*	*109,522*
Rural	Chiga	338	0	0	0	34	108	101	0	0	27	68
	Nyalunya	3,315	0	0	0	332	1,061	994	0	0	265	663
	Kadero	1,447	0	0	0	145	463	434	0	0	116	289
	Okok	614	0	0	0	61	196	185	0	0	49	123
	Konya	12,884	0	0	0	1,288	4,123	3,865	0	0	1,031	2,577
	Sub-total	*18,598*	*0*	*0*	*0*	*1,860*	*5,951*	*5,579*	*0*	*0*	*1,488*	*3,720*
Total		690,628	**24,884**	**37,326**	**62,209**	**56,621**	**181,186**	**169,862**	**0**	**0**	**45,298**	**113,242**
		690,628	**124,419**			**407,669**			**0**	**158,540**		
			532,088						158,540			

Table 5-10 Domestic and Non-domestic Water Demands in Municipal Water Supply 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 5-11 Domestic and Non-domestic Water Demands in Municipal Water Supply Area in 2015

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	42,509	8,502	12,753	21,254	0	0	0	0	200	120	60	20	-	-	-
	Millimani	22,410	4,482	6,723	11,205	0	0	0	0	200	120	60	20	-	-	-
	kanyakwar	59,500	11,900	17,850	29,750	0	0	0	0	200	120	60	20	-	-	-
	Sub-total	124,419	24,884	37,326	62,209	0	0	0	0	-	-	-	-	-	-	-
Peri-urban	Nyalenda	108,800	10,880	34,816	32,640	0	0	8,704	21,760	120	60	50	-	20	20	15
	Manyatta	116,800	11,680	37,376	35,040	0	0	9,344	23,360	120	60	50	-	20	20	15
	Kasule	140,063	14,006	44,820	42,019	0	0	11,205	28,013	120	60	50	-	20	20	15
	Wathorego	43,919	4,392	14,054	13,175	0	0	3,514	8,784	120	60	50	-	20	20	15
	Korando	65,282	6,528	20,890	19,585	0	0	5,223	13,056	120	60	50	-	20	20	15
	Kogony	72,747	7,275	23,279	21,824	0	0	5,820	14,549	120	60	50	-	20	20	15
	Sub-total	547,611	54,761	175,235	164,283	0	0	43,810	109,522	-	-	-	-	-	-	-
Rural	Chiga	338	34	108	101	0	0	27	68	120	60	50	-	20	20	15
	Nyalunya	3,315	332	1,061	994	0	0	265	663	120	60	50	-	20	20	15
	Kadero	1,447	145	463	434	0	0	116	289	120	60	50	-	20	20	15
	Okok	614	61	196	185	0	0	49	123	120	60	50	-	20	20	15
	Konya	12,884	1,288	4,123	3,865	0	0	1,031	2,577	120	60	50	-	20	20	15
	Sub-total	18,598	1,860	5,951	5,579	0	0	1,488	3,720	-	-	-	-	-	-	-
Total		690,628	81,505	218,512	232,071	0	0	45,298	113,242	-	-	-	-	-	-	-

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	1,700	1,530	1,276	0	0	0	0	4,506	1,196	1,879	8,500	11,575	16,081	23,585
	Millimani	896	807	672	0	0	0	0	2,375	630	991	0	1,621	3,996	5,861
	kanyakwar	2,380	2,142	1,785	0	0	0	0	6,307	1,674	2,630	0	4,304	10,611	15,563
	Sub-total	4,976	4,479	3,733	0	0	0	0	13,188	3,500	5,500	8,500	17,500	30,688	45,009
Peri-urban	Nyalenda	1,306	2,089	1,632	0	0	174	326	5,527	576	538	0	1,114	6,641	9,740
	Manyatta	1,402	2,244	1,751	0	0	187	350	5,934	619	578	0	1,197	7,131	10,459
	Kasule	1,681	2,689	2,101	0	0	224	420	7,115	742	693	980	2,415	9,530	13,977
	Wathorego	527	843	659	0	0	70	132	2,231	233	217	0	450	2,681	3,932
	Korando	783	1,253	980	0	0	104	196	3,316	346	323	2,100	2,769	6,085	8,925
	Kogony	873	1,397	1,092	0	0	116	218	3,696	385	360	1,820	2,565	6,261	9,183
	Sub-total	6,572	10,515	8,215	0	0	875	1,642	27,819	2,901	2,709	4,900	10,510	38,329	56,216
Rural	Chiga	4	6	5	0	0	1	1	17	2	2	280	284	301	441
	Nyalunya	40	64	50	0	0	5	10	169	18	16	1,820	1,854	2,023	2,967
	Kadero	17	28	22	0	0	2	4	73	8	7	0	15	88	129
	Okok	7	12	9	0	0	1	2	31	3	3	0	6	37	54
	Konya	155	247	193	0	0	21	39	655	68	63	0	131	786	1,153
	Sub-total	223	357	279	0	0	30	56	945	99	91	2,100	2,290	3,235	4,745
Total		11,771	15,351	12,227	0	0	905	1,698	41,952	6,500	8,300	15,500	30,300	72,252	105,970

(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 up to the year 2015 at a rate almost equivalent to the future population growth projected for the sub-location.

At present, most of the commercial activities in Kisumu are centered around Milimani and its surroundings areas 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. Although a high population density is expected to take place in Manyatta and Nyalenda Sub-locations, no significant commercial growth is foreseen in the future.

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, sugercane 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 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, however, as the future land use plan envisages the development of a new industrial estate in this area.

Tables 5-10 and 5-11 present the non-domestic water demands estimated for each Sub-location in the years 2005 and 2015 respectively. The same tables also present the total water demands estimated for the municipal water supply system. Table 5-12 provides a summary of the estimated total water demands. The total water demands in the municipal water supply system are estimated to be 41,893 m3/day in the year 2005 and 72,252 m3/day in 2015.

Table 5-12 Total Water Demands in Municipal Water Supply System (m3/day)

Year	Domestic Water Demand	Non-domestic Water Demand				Total Water Demand
		Institutional	Commercial	Industrial	Sub-total	
2005	24,873	2,860	5,680	8,480	17,020	41,893
2015	41,952	6,500	8,300	15,500	30,300	72,252

(3) Water Demands for Planning of Water Supply Infrastructure

It is envisaged that the leakage in the distribution system will gradually decrease from 30 % in 1997 to 29.2 % in 2005 and 25 % in 2015, and that this reduction will be achieved by the unaccounted for water reduction programme proposed in Chapter 6 and by exercising utmost cautions during construction of pipelines in the forthcoming rehabilitation and expansion works.

It is also envisaged 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 share of non-domestic water demand (approximately 40 %) among the total water demand as shown in Table 5-12.

Based on the above assumptions, water demands for planning of water supply infrastructure are determined as follows:

Day Average Water Demand

Year 2005	:	41,893/0.708 = 59,171 m3/day
		= 2,465 m3/hour
		= 0.685 m3/sec
Year 2015	:	72,252/0.75 = 96,336 m3/day
		= 4,014 m3/hour
		= 1.115 m3/sec

Day Maximum Water Demand

Year 2005:	59,171 x 1.1= 65,088 m3/day
	= 2,712 m3/hour
	= 0.753 m3/sec
Year 2015:	96,336 x 1.1= 105,970 m3/day
	= 4,416 m3/hour
	= 1.227 m3/sec

Peak Hourly Flow

Year 2005:	59,171 x 2.0= 118,342 m3/day
	= 4,931 m3/hour
	= 1.370 m3/sec

year 2015: 96,336 x 2.0= 192,672 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 treatment capacity required.

5.3.4 Water Quality

Kenyan standards for drinking water quality is presented in Table 5-13 in comparison with the WHO guidelines and Japanese standards. Although several parameters set in the Kenyan standards exceed the recommended values in the WHO guidelines, it is generally compatible to other international standards for drinking water quality. A few areas of concern however are as follows:

- "Total Colonies" which is generally a good parameter for the assessment of impacts on the human health is not specified. As it can easily be tested simultaneously with "Total Coliform Bacteria" which is specified, it is recommended that the parameter be also tested.

- The standards does not include "Trihalomethanes". Since Kisumu uses water from the Lake Victoria which is eutrophic, the chance of formulating trihalomethanes during the water treatment process is relatively high. Thus the inclusion of this parameter in the testing is recommended.

- There is no definite limits for "Turbidity" specified in the standards. It says that turbidity should be preferably one NTU. It is known that turbidity is a parameter which well reflects the effectiveness of water purification process applied, and that the reduction of turbidity leads to the reduction of other undesirable substances. Although the WHO guidelines suggest five NTU, it is recommended that turbidity be maintained at less than two NTU, as is practiced in many countries.

The lack of many water quality testing equipment and apparatus makes it difficult to immediately improve the present water quality management system and the water treatment process. It is recommended that all the necessary water quality testing equipment and apparatus be provided, manuals be prepared and technical training of operators be completed before new facilities proposed in this Study start commissioning.

Table 5-13 Comparison of Drinking Water Quality Standards (1/6)

	Parameter / Constituent	unit	WHO 1993	JAPAN 1993		Kenya 1985
				Maximum	Desirable	
A	**Bacteriological Quality**					
A1	*E. Coli* (or thermotolerant coliform b	*per100 mL*	ND	0		0
A2	Total coliform bacteria	*per100 mL*	ND	0		0
A3	Total colonies (hetotrophic bacteria)	*per 1 mL*		100		
B	**Chemical (of health significance) Quality**					
	Inorganic constituents					
B1	Antimony	mg/L	0.005 (P)			
B2	Arsenic	mg/L	0.01 (P)	0.01		0.05
B3	Barium	mg/L	0.7			1 (tentative)
B4	Beryllium	mg/L	NAD			
B5	Boron	mg/L	0.3			
B6	Cadmium	mg/L	0.003	0.01		0.005
B7	Chromium	mg/L	0.05 (P)	.05 (hexavalent)		0.05
B8	Copper	mg/L	2 (P)			
B9	Cyanide	mg/L	0.07	0.01		0.01
B10	Flouride	mg/L	1.5	0.8		1.5
B11	Lead	mg/L	0.01	0.05		0.05
B12	Manganese	mg/L	0.5 (P)			
B13	Mercury (total)	mg/L	0.001	0.0005		0.001
B14	Molybdenum	mg/L	0.07			
B15	Nickel	mg/L	0.02			
B16	Nitrate (as no3-)	mg/L	50	10 (and nitrite)		10
B17	Nitrite (as no2-)	mg/L	3 (P)			
B18	Selenium	mg/L	0.01			0.01
B19	Uranium	mg/L	NAD	0.01		

ATO - affects appearance, taste and odour
NAD - no available data to specify guideline
(P) - Provisional guideline
(T) - Tentative standard

Table 5-13 Comparison of Drinking Water Quality Standards (2/6)

	Parameter / Constituent	unit	WHO 1993	JAPAN 1993		Kenya 1985
				Maximum	Desirable	
C	*organic constituents*					
	chlorinated alkanes					
C1	Carbon tetra chloride	μg/L	2	2		3 (T)
C2	Dichloromethane	μg/L	20	20		
C3	1,1-dichloroethane	μg/L	NAD	20		10
C4	1,2-dichloroethane	μg/L	30	4		
C5	1,1,1-trichloroethane	μg/L	2,000 (P)			
	chlorinated ethenes					
C6	Vinyl chloride	μg/L	5			
C7	1,1-dichloroethene	μg/L	30			
C8	1,2-dichloroethene	μg/L	50			
C9	Trichloroethene	μg/L	70 (P)			
C10	Tetrachloroethene	μg/L	40			
	aromatic hydrocarbons					
C11	Benzene	μg/L	5	10		10
C12	Toluene	μg/L	700 (ATO)			
C13	Xylenes	μg/L	500 (ATO)			
C14	Ethyl benzene	μg/L	300 (ATO)			
C15	Styrene	μg/L	20 (ATO)			
C16	Benzo(a)pyrene	μg/L	0.7			0.01
	chlorinated benzenes					
C17	Monochlorobenzene	μg/L	300 (ATO)			
C18	1,2-dichlorobenzene	μg/L	1,000 (ATO)			
C19	1,3-dichlorobenzene	μg/L	NAD			
C20	1,4-dichlorobenzene	μg/L	300 (ATO)			
C21	Trichlorobenzenes (total)	μg/L	20 (ATO)			
	Miscellaneous					
C22	Di(2-ethylhexyl)adipate	μg/L	80			
C23	Di(2-ethylhexyl)phthalate	μg/L	8			
C24	Acrylamide	μg/L	0.5			
C25	Epichlorohydrin	μg/L	0.4 (P)			
C26	Hexachlorobutadiene	μg/L	0.6			
C27	Edetic acid (EDTA)	μg/L	200 (P)			
C28	Nitrilotriacetic acid	μg/L	200			
C29	Dialkyltins	μg/L	NAD			
C30	Tributylin oxide	μg/L	2			
C31	Phenolic substances	μg/L		2		2
C32	1,1-dichloroethylene	μg/L				0.3
C33	Tetrachloroethylene	μg/L		10		10 (T)
C34	Tichloroethylene	μg/L		30		30 (T)
C35	Cis-1,2-dichloroethylene	μg/L		40		
C36	1,1,2 trichloroethane	μg/L		6		
		μg/L				
	Chlorophenols					
C37	pentachlorphenol	μg/L				10
C38	2,4,6,-trichlorophenol	μg/L				10

ATO – affects appearance, taste and odour
NAD – no available data to specify guideline
(P) – Provisional guideline
(T) – Tentative standard

Table 5-13 Comparison of Drinking Water Quality Standards (3/6)

	Parameter / Constituent	unit	WHO 1993	JAPAN 1993		Kenya 1985
				Maximum	Desirable	
D	*pesticides*					
D1	Alachlor	μg/L	20			
D2	Aldicarb	μg/L	10			
D3	Aldrin / Dieldrin	μg/L	0.03			0.03
D4	Atrazine	μg/L	2			
D5	Bentazone	μg/L	30			
D6	Carbofuran	μg/L	5			
D7	Chlordane	μg/L	0.2			0.3
D8	Choloroto!uron	μg/L	30			
D9	DDT	μg/L	2			1
D10	1,2-dibromo-3-chloropropane	μg/L	1			
D11	2,4-D	μg/L	30			100
D12	1,2-dichloropropane	μg/L	20 (P)			
D13	1,3-dichloropropane	μg/L	NAD			
	1,3-dichloropropene(D-D)	μg/L		2		
D14	1,4-dichloropropene	μg/L	20			
D15	Ethylene dibromide	μg/L	NAD			
D16	Heptachlor and heptachlor epoxide	μg/L	0.03			0.1
D17	Hexachlorobenzene	μg/L	1			0.01
D18	Isoproturon	μg/L	9			
D19	Lindane	μg/L	2			3
D20	MCPA	μg/L	2			
D21	Methoxychlor	μg/L	20			30
D22	Metolachlor	μg/L	10			
D23	Molinate	μg/L	6			
D24	Pendimethalin	μg/L	20			
D25	Pentachlorophenol	μg/L	9 (P)			
D26	Permethrin	μg/L	20			
D27	Propanil	μg/L	20			
D28	Pyridate	μg/L	100			
D29	Simazine	μg/L	2	3		
D30	Trifluralin	μg/L	20			
	Chlorophenoxy herbicides other than 2,4-D and MCPA					
D31	2,4-DB	μg/L	90			
D32	Dichlorprop	μg/L	100			
D33	Fenoprop	μg/L	9			
D34	MCPB	μg/L	NAD			
D35	Mecoprop	μg/L	10			
D36	Thiram	μg/L		6		
D37	Thiobencarb (benthiocarb)	μg/L		20		

ATO - affects appearance, taste and odour
NAD - no available data to specify guideline
(P) - Provisional guideline
(T) - Tentative standard

Table 5-13 Comparison of Drinking Water Quality Standards (4/6)

	Parameter / Constituent	unit	WHO 1993	JAPAN 1993		Kenya 1985
				Maximum	Desirable	
E	*Disinfectants and disinfectant by-products*					
	disinfectants					
E1	Monochloramine	mg/L	3			
E2	Di- and trichloramine	mg/L	NAD			
E3	Chlorine	mg/L	5 (ATO)			
E4	Chlorine dioxide	mg/L				
E5	Iodine	mg/L	NAD			
	disinfectant by-products					
E6	Bromate	μg/L	25			
E7	Chlorate	μg/L	NAD			
E8	Chlorite	μg/L	200			
	Chlorophenols					
E9	2-chlorophenol	μg/L	NAD			
E10	2,4-dichlorophenol	μg/L	NAD			
E11	2,4,6-trichlorophenol	μg/L	200			10
E12	Formaldehyde	μg/L	900			
E13	MX	μg/L	NAD			
	Trihalomethanes			100		
E14	Bromoform	μg/L	100	90		
E15	Dibromochloromethane	μg/L	100	100		
E16	Bromodichloromethane	μg/L	60	30		
E17	Chloroform	μg/L	200	60		30
	Chlorinated acetic acids					
E18	Monochloroacetic acid	μg/L	NAD			
E19	Dichloroacetic acid	μg/L	50 (P)			
E20	Trichloroacetic acid	μg/L	100 (P)			
	Chloral hydrate					
E21	(trichloroacetaldehyde)	μg/L	10 (P)			
E22	Chloroacetone	μg/L	NAD			
	Halogenated acetonitriles					
E23	Dichloroacetonitrile	μg/L	90 (P)			
E24	Dibromoacetonitrile	μg/L	100 (P)			
E25	Bromochloroacetonitrile	μg/L	NAD			
E26	Trichloroacetonitrile	μg/L	1 (P)			
E27	Cyanogen chloride (as CN)	μg/L	70			
E28	Chloropicrin	μg/L	NAD			

ATO - affects appearance, taste and odour
NAD - no available data to specify guideline
(P) - Provisional guideline
(T) - Tentative standard

(5/6)

Table 5-13 Comparison of Drinking Water Quality Standards

	Parameter / Constituent	unit	WHO 1993	JAPAN 1993		Kenya 1985
				Maximum	Desirable	
F	**aesthetic quality**					
	physical parameters					
F1	Colour	TCU	15	5		15
F2	Taste and odour	TON	acceptable		3	acceptable
F3	Temperature		acceptable			
F4	Turbidity	NTU	5	2	1	(preferably 1
F5	Suspended matter					nil
	inorganic constituents					
F6	Aluminium	mg/L	0.2	0.2	0.2	0.2
F7	Ammonia	mg/L	1.5			0.5
F8	Chloride	mg/L	250	200		250
F9	Copper	mg/L	1.0	1.0		1.0
F10	Hardness, as CaCO3	mg/L	–	300	10 – 100	500
F11	Hydrogen sulfide	mg/L	0.05			
F12	Iron	mg/L	0.3	0.3		0.3
F13	Manganese	mg/L	0.1	0.05	0.01	0.1
F14	Dissolved oxygen	mg/L	–			
F15	pH	mg/L	–	5.8 – 8.6	about 7.5	6.5 – 8.5
F16	Sodium	mg/L	200	200		200
F17	Sulfate	mg/L	250			400
F18	Total dissolved soilds	mg/L	1,000	500 (TS)	30 – 200	1,000
F19	Zinc	mg/L	3	1.0		5.0
F20	Magnesium	mg/L				nil
F21	Calcium	mg/L				
F22	Silicate	mg/L				
F23	Langelier index				>-1 near 0	
	organic constituents					
F24	Toluene	μg/L	24 – 170			
F25	Xylene	μg/L	20 – 1,800			
F26	Ethylbenzene	μg/L	2 – 200			
F27	Styrene	μg/L	4 – 2,600			
F28	Monochlorobenzene	μg/L	10 – 120			
F29	1,2-dichlorobenzene	μg/L	1 – 10			
F30	1,4-dichlorobenzene	μg/L	0.3 – 30			
F31	Trichlorobenzenes (total)	μg/L	5 – 50			
F32	Synthetic detergents	μg/L	–	200		
F33	Permanganate Consumption	mg/L		10	3	
	disinfectants and disinfectant by-products					
F34	Chlorine	μg/L	600-1,000		1	200 – 500
F35	2-chlorophenol	μg/L	0.1 – 10			
F36	2,4-dichlorophenol	μg/L	0.3 – 40			
F37	2,4,6-dichlorophenol	μg/L	2 – 300			

ATO – affects appearance, taste and odour (P) – Provisional guideline

NAD – no available data to specify guideline (T) – Tentative standard

Table 5-13 Comparison of Drinking Water Quality Standards (6/6)

	Parameter / Constituent	unit	WHO 1993	JAPAN 1993		Kenya 1985
				Maximum	Desirable	
G	**radioactive constituents**					
G1	Gross alpha activity	Bq/L	0.1			0.1
G2	Gross beta activity	Bq/L	1			1
H	**Chemicals not of health significance at normal water concentrations**					
H1	Asbestos					
H2	Silver					
H3	Tin					

ATO - affects appearance, taste and odour
NAD - no available data to specify guideline
(P) - Provisional guideline
(T) - Tentative standard

5.4 WASTEWATER MANAGEMENT

5.4.1 General

As discussed in Section 5.3.3, it is envisaged that Kisumu, in order to cater for its increasing population and commercial/industrial activities in the future, will require much more water than it currently consumes. And if this requirement is met, there will be a significant increase in wastewater as well.

Against this background, the ultimate objectives of wastewater management in Kisumu will be to maintain living environments and to protect Lake Victoria from degradation of its water quality.

5.4.2 Wastewater Management Methods

There are a variety of methods for disposal of wastewater. They are used either on a stand-alone basis or in combination, taking amongst others the following into consideration.

- Extent of water supply area and water distribution
- per capita water consumption rates
- Ability to pay
- groundwater conditions
- current wastewater practises

(1) Sewerage System

Sewerage system is an ideal but most expensive way of managing wastewater. It consists of sewers, pump stations and a sewage treatment works. Generally, it is applied in areas where residents consume water at a rate of 100 lcd or more. This is because sewerage system requires a relatively large quantity of water to transport domestic sewage from households to the sewage treatment works.

(2) Shallow Sewers

This method is similar to sewerage system but less expensive. The advantage of this method is that it can be applied in high population density areas where residents consume water even at a smaller rate of 50 to 60 lcd. Compared with sewerage system, however, almost twice the number of households must be connected to a sewer to increase the flow. This requires part of sewer pipes to be installed within private properties, and thus community participation is essential for this method to work.

(3) On-site Sanitation

On-site sanitation is generally applied in areas where residents use less than 20 lcd of water. In these areas, neither sewerage system nor shallow sewer can be used, since water available for disposing sewage is too small for either of these methods to work properly.

Ventilated Improved Pit (VIP) Latrines and septic tanks are most popular on-site sanitation facilities. Single-pit VIP latrines are recommended for low population density areas. Double-pit VIP latrines are recommended for areas of a relatively high population density. Where groundwater level is high, single-pit latrines should be raised above the ground or double-pit latrines should be provided. These modifications provide extra storage, prevents groundwater seepage into the pit and prolong the time between emptying or relocating the pit.

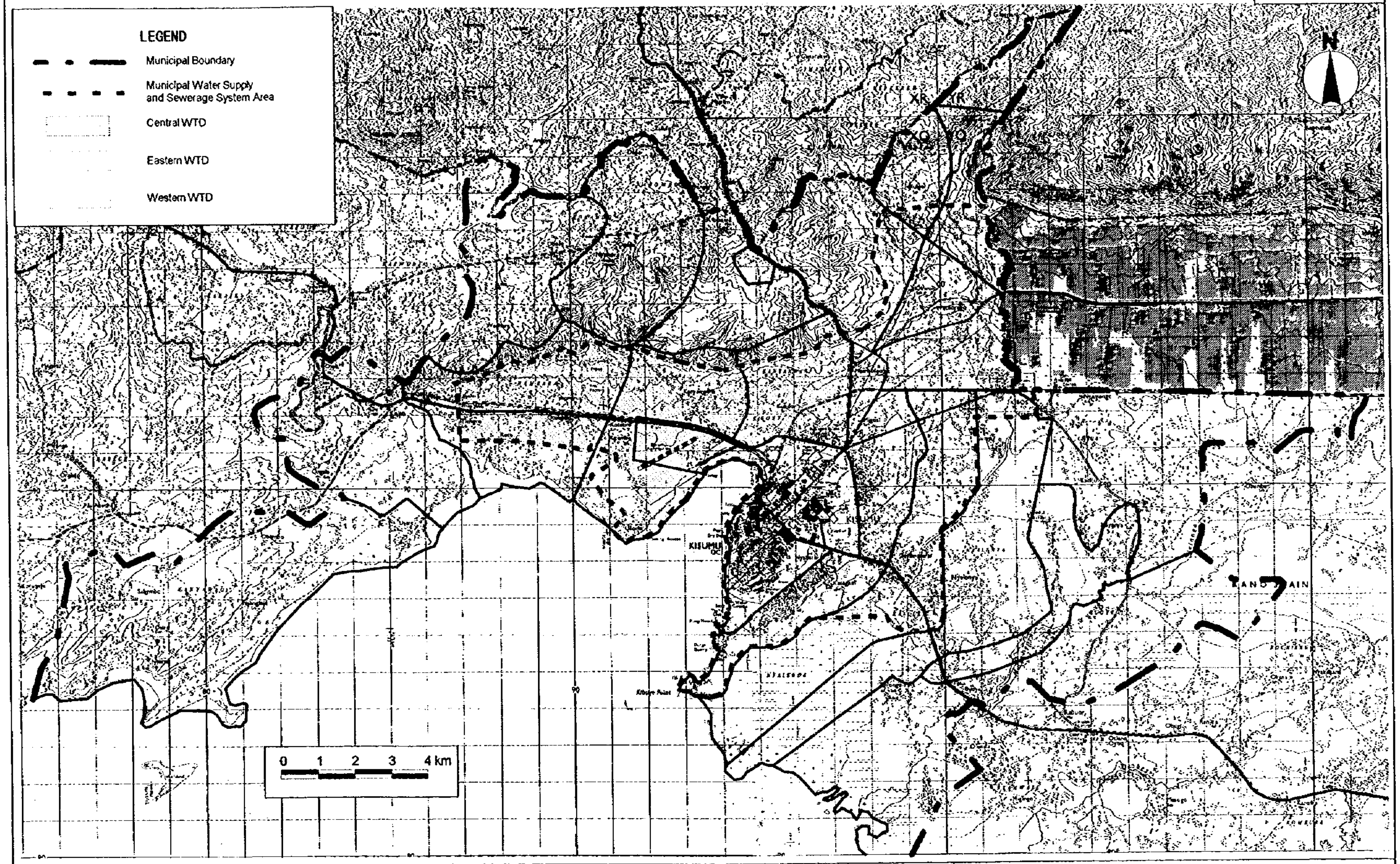
Septic tanks are convenient but more expensive than VIP latrines. Compared with a VIP latrine, a septic tank requires a wider extent of land for construction and maintenance. It requires regular emptying and hence the presence of suitable access for vacuum vehicles is necessary for a successful operation. It also requires suitable soils for disposal of effluent through soak pits and percolation trenches.

5.4.3 Service Area and Population

The area proposed to be covered by the municipal sewerage system in 2015 is shown in Figure 5-5. This area is delineated based on the assessment of the projected water demands in Section 5.3.3. It is estimated that with the combination of sewerage system and shallow sewers, the proposed service area will be able to collect more than 80 % of wastewater to be generated within the municipal water supply system in 2015.

The proposed service area is divided into three wastewater treatment districts, namely Central, Eastern and Western Wastewater Treatment Districts (WTDs), taking topographic conditions, locations of existing trunk sewers and sewage treatment works, future water supply service area and future land use plan.

Figure 5 - 5



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 Proposed Service Area for Municipal Sewerage System in 2015

Table 5-14 below presents a summary of the projected service area and population for each of the years 2005 and 2015.

Table 5-14 Sewerage Service Area and Service Population

WTD	Service Area (km2)		Service Population	
	Year 2005	Year 2015	Year 2005	Year 2015
Central	4.4	4.4	23,992	29,896
Eastern	14.5	20.6	109,277	185,070
Western	0	26.4	0	158,880
Total	18.9	51.4	133,269	373,846

Source: JICA Study Team

5.4.4 Wastewater Generation

(1) Domestic Wastewater Generation

Domestic wastewater generation volumes are estimated for different domestic water consumption rates as shown in Table 5-15. They are basically the same as the projected per capita consumption rates, except that wastewater generation from a household who consumes 200 lcd is assumed to generate 190 lcd or 95 % of water consumed.

Table 5-15 Domestic Wastewater Generation VS Water Consumption

Water Supply Methods	Urban/ Peri-urban/ Rural	Income Level	Water Consumption Rate (lcd)	Wastewater Generation Rate (lcd)
House Connection	Urban	High	200	190
		Medium	120	120
		Low	60	60
	Peri-urban and Rural	High	120	120
		Medium	60	60
		Low	50	50
Communal tap	Peri-urban and Rural	High	20	20
		Medium	20	20
		Low	15	15

Source : JICA Study Team

Table 5-16 Domestic Wastewater Generation within Municipal Water Supply Area and That to be Collected by Sewerage System

Urban/ Peri-urban/ Rural	Water Supply Method	Income Level	Unit DWWG (lpcd)	2005				2015			
				Populatiuon		DWWG		Populatiuon		DWWG	
				Total	Sewerage System	Total	Sewerage System	Total	Sewerage System	Total	Sewerage System
Urban	House Connection	High	190	17,993	9,787	3,419	1,860	24,884	24,884	4,728	4,728
		Medium	120	34,244	18,627	4,109	2,235	37,326	37,326	4,479	4,479
		Low	60	43,530	23,681	2,612	1,421	62,210	62,210	3,733	3,733
	Communal Taps	Low	20	8,706	0	174	0	0	0	0	0
	Sub-total			104,473	52,095	10,314	5,516	124,420	124,420	12,940	12,940
Peri-Urban	House Connection	High	120	28,125	22,143	3,375	2,657	54,761	54,761	6,571	6,571
		Medium	60	75,440	28,157	4,526	1,689	175,235	100,472	10,514	6,028
		Low	50	82,719	30,874	4,136	1,544	164,283	94,193	8,214	4,710
	Communal Taps	High	20	1,655	0	33	0	0	0	0	0
		Medium	20	18,859	0	377	0	43,810	0	876	0
		Low	15	90,992	0	1,365	0	109,522	0	1,643	0
	Sub-total			297,790	81,174	13,812	5,890	547,611	249,426	27,818	17,309
Rural	House Connection	High	120	1,158	0	139	0	1,857	0	223	0
		Medium	60	3,107	0	186	0	5,917	0	355	0
		Low	50	3,408	0	170	0	5,568	0	278	0
	Communal Taps	High	20	69	0	1	0	0	0	0	0
		Medium	20	777	0	16	0	1,482	0	30	0
		Low	15	3,748	0	56	0	3,773	0	57	0
	Sub-total			12,267	0	568	0	18,597	0	943	0
Total				414,530	133,269	24,694	11,406	690,628	373,846	41,701	30,249

Table 5-16 presents a summary of the estimated total domestic wastewater generation in the municipal water supply system and the wastewater to be collected by the municipal sewerage system. It is estimated that the municipal sewerage system will collect 46 % (11,406/24,694) of the total domestic wastewater to be generated within the municipal water supply system in 2005, and that the ratio will increase to 73 % (30,249/41,701) in 2015.

(2) Non-domestic Wastewaters Generation

Non-domestic wastewaters comprise wastewaters to be generated from institutional, commercial and industrial activities. The first two are estimated from the projected water demands multiplied by ratios of 0.80 and 0.85 respectively. Wastewater from general industries is assumed to be 80 % of the projected water demand. Wastewater from large industrial users is estimated through interviews with factories and from the results of previous studies. Table 5-17 below presents a summary of the estimated industrial wastewater generation within the municipal water supply system.

Table 5-17 Industrial Wastewater Generation

Area	Type of Industry	Year 2005		Year 2015	
		Water Demand (m3/day)	Wastewater Generation (m3/day)	Water Demand (m3/day)	Wastewater Generation (m3/day)
Urban	Large Industry	3,100	2,770	2,800	2,550
	General Industry	2,410	1,930	5,700	4,560
Peri-urban and Rural	Large Industry	0	0	800	640
	General Industry	2,970	2,380	6,200	4,960
Total		8,480	7,080	15,500	12,710

Table 5-18 shows a summary of the estimated wastewater generation and the wastewater to be collected by the municipal sewerage system in each of years 2005 and 2015.

Table 5-18 Wastewater Generation and Wastewater to be Collected by Municipal Sewerage System

Category of Wastewater	Year 2005		Year 2015	
	Wastewater Generation (m^3/d)	Wastewater to be Collected by Sewerage (m^3/d)	Wastewater Generation (m^3/d)	Wastewater to be Collected by Sewerage (m^3/d)
Domestic	24,690	11,410	41,700	30,250
Non-domestic				
Institutional	2,290	1,750	5,200	5,120
Commercial	4,830	3,920	7,055	6,990
Industrial	7,080	6,140	12,710	12,710
sub-total	14,200	11,810	24,965	24,820
Total	38,890	23,220	66,665	55,070

As can be seen in the above table, it is estimated that the municipal sewerage system will be able to collect approximately 60 % (23,220/38,890) of the total wastewater generation within the municipal water supply system in 2005, and that the percentage will increase to 83 % (55,070/66,665) in 2015.

5.4.5 Water Quality

(1) Industrial Effluents

Industries discharging large volumes of wastewater and of high concentration compared with domestic sewage, will significantly increase the concentration of wastewater inflow to the sewage treatment works. Those industries can opt to discharge into public sewers. However, if they would like to discharge into public sewers, they need to pretreat their wastewater to an extent which will depend on the wastewater quality and quantity. This restriction arises from the need for the treatment plant to satisfy effluent standards.

Reduction of industrial wastewater loads into the sewerage system will reduce the pollutant loads discharged into the Lake Victoria and protect the sewage treatment works from harmful chemicals. Table 5-19 shows the standards for industrial effluents in Kisumu proposed by the Study Team.

The future industrial loads on treatment works have been calculated assuming that the present day discharges will comply with the proposed trade effluent standards. General industrial effluents have been estimated at having the following estimated qualities: BOD 500 mg/l; SS 600 mg/l ; and the absence of substances which would adversely affect biological treatment processes, and thus they are reflected in the proposed effluent standards..

(2) Sewage Treatment Works Effluents

The ultimate disposal location for the sewage treatment works effluent is Lake Victoria and the standards set out below for the effluents are drawn up to prevent pollution of the lake waters and to protect public waters.

- Biological Oxygen Demand (BOD) Concentration -20 mg/l
- Suspended Solids (SS) concentration -30 mg/l
- Faecal Coilform concentration (pond effluents only) -5,000 CFU/100 ml

In the case of pond effluents, the BOD concentration shown above will be applied to filtered samples. Faecal Coliform standards are included in the pond effluent criteria because of existing and future pond discharge to watercourses which, due to their length, may be used by adjacent inhabitants as a potable water source during the periods of shortfall in the municipal water supply. It should be noted that higher standards can be achieved where the final effluents flows through papyrus swamps. This is due to the further "polishing" effected by the papyrus swamps, where there are significant reductions in nutrients, BOD and SS and also destruction of the remaining faecal coliforms.

Table 5-19 **Proposed Trade Effluent Standards to Public Sewers**

Parameter	Concentration (mg/l)
Total Suspended Solids	600
Total Non-volatile Dissolved Solids	3,000
BOD_5 at 20℃	500
COD	1,000
Phenols (total at connection point)	10
Detergents	15
Soaping oils and fats	10
Hydrocarbons	20
Silver (Ag)	0.02
Arsenic (As)	0.02
Barium (Ba)	5
Cadmium (Cd)	0.01
Chloride (Cl^-)	1,000
Cyanide (CN^-)	0.02
Total Cyanide (CN)	1
Cobalt (Co)	0.05
Hexavalent Chromium (Cr^{6+})	0.05
Total Chromium	3
Copper (Cu)	0.5
Mercury (Hg)	0.01
Ammonical Nitrogen	20
Nickel (Ni)	0.5
Free Ammonia	10
Total Kjeldahi Nitrogen	Nil
Nitrite	0.5
Lead (Pb)	2
Total Phosphate	30
Selenium (Se)	0.5
Tin (Sn)	0.5
Sulphite (SO_3^-)	2
Sulphate (SO_4^{2-})	1,000

5.5 ORGANISATION AND PRICING

5.5.1 Organisation

Having examined in detail the overall strengths and weaknesses of the WSD in Kisumu, it is apparent that many of the fundamental requirements are not up to standard. The present WSD is incapable of handling the current situation effectively and efficiently, and would not be able to cope with Phase I. and the subsequent capital works requirements.

The legal framework appears to be in place nationally however, legislation at Local Authority level requires attention. The national institutional framework is generally satisfactory, and it is receiving attention under other intensive studies, which will strengthen the position at KMC.

A planning framework is in place for the organisation of the WSD, but this has to be examined against the findings of this study particularly in respect of an early move to autonomy. Whilst the structure of the WSD provides for most of the future requirements, there is a fundamental weakness which must be addressed with respect to human resources in both the technical and commercial sections.

The major personnel issue is clearly the large number of vacant posts within the organisation, and there must be a planning policy to strengthen the staff, in accordance with the phased development of the water supply and sewerage facilities. In addition, apart from the need to urgently develop an autonomous department within KMC, progression to a commercialised company must be embodied in the overall framework.

It is assumed that an autonomous WSD will be in place by mid 1999, and that it will be sufficiently strong enough for development under the Phase I Management/Institutional improvement programme to a commercial company.

5.5.2 Tariffs

In Kenya where local authorities are water undertakers, tariffs are set by the local authorities with the approval of Ministry of Local Government. The central government policy is to encourage tariffs which are high enough to recover all costs. The reluctance comes from local officials who believe a tariff increase would be unpopular with the people. Given the choice between a service at a reasonable cost and a breakdown in service delivery, the local officials have opted to let the service suffer.

Tariffs in most cities, including Kisumu, have been raised substantially for revenue generation. The present level of tariffs is comparable to those prevailing in Western Europe and North America. The tariffs are sufficient to raise all required revenue if the water departments operate efficiently and revenues are retained by this department and used for delivery of this service.

Further revenue can be raised by three modifications in the tariff structure. At present, the largest users of water pay 50% more per unit of water than those who consume little water. This differential can be increased to generate more revenue from high income households and other users.

The second possible adjustment is in non-domestic tariffs. Industry and institutions pay only 20% more for water than households for the same level of consumption. The tariffs for non-domestic users can be increased further. Industry's own estimates show that the cost of water supplied by the largest users themselves would be double the rates presently paid.

The third issue is the cost of sewerage and water services. At present, Kisumu residents pay 75% of their water bill for sewerage when they have a central sewerage connection. It is not clear if this is sufficient for financing an efficient sewerage system. Effective sewerage collection and treatment is highly desirable for health and environmental reasons. Some cities in Kenya charge more for sewerage than they do for water. Sewerage charges thus can be raised to generate more revenue. In any case, the Department should insure that all subscribers who have sewerage service are actually billed for this service as well as water.

The Study Team has recommended that the present tariff for the minimum level of consumption should be reduced from 180 Shillings/month to 100 Shillings. This will improve affordability for the low income people and will have a small impact on overall revenue.

5.6 PRIORITY PROJECT

Kisumu needs urgent improvements on both water supply and sewerage. The prevailing water crisis and water-related diseases in the town are described elsewhere in this report and newspaper cuttings demonstrating these problems are compiled in Appendix S.

The objective of the Priority Project is thus to address these problems at the earliest timing possible. Realistically speaking, however, this cannot be achieved overnight.

The Project is assumed that a large portion of the cost will be financed by a loan from an international lending agency. This financing arrangement can be initiated only from the beginning of 1999 and most probably takes one year before an agreement can be reached between the Kenyan government and the loan agency. This will be followed by the selection of consultants for detailed designs, which normally takes one year or so. Detailed designs will also takes 10 months or so to complete. Any water supply improvement contracts which involve construction of a new water treatment works and water distribution mains will require at least two years to complete.

All these lead to the conclusion that the physical construction of the Priority Project can be completed only at the end of 2002 at the earliest.

Upon completion, the water supply capacity created by the Priority Project must be able to meet the water demands projected over a few years ahead. This is necessary to leave an adequate time for implementation of the succeeding improvements.

It is thus recommended that the Priority Project be formulated with its target year 2005, and that it should be able to meet the projected water demand in 2005.

CHAPTER 6

WATER SUPPLY AND SEWERAGE MASTER PLAN

6 WATER SUPPLY AND SEWERAGE MASTER PLAN

6.1 WATER SUPPLY SYSTEM

6.1.1 Introduction

The improvement of water supply in the Kisumu Municipality will be achieved through two separate schemes : one being the municipal water supply scheme to be operated by the Kisumu Municipality and the other being rural water supply schemes to be operated by the communities. Rural water supply schemes are small in scale and will rely on local groundwater in the vicinity of communities. These schemes are discussed separately in this chapter.

6.1.2 Development Alternatives for Municipal Water Supply System

(1) Introduction

Analysis and comparison of alternatives for water supply development for Kisumu municipality up to the year 2015 are described in this section. Six technically possible alternatives, each comprising a complete set of facilities from water source to distribution, are developed. These six alternatives were compared in terms of both construction and O/M costs to select the least cost solution.

The method of the analysis used in this section is a comparative evaluation. This does not require the calculation of full costs, but allows the comparison even if costs that are common to all alternatives are disregarded.

(2) Phasing Resource Development

The existing supply capacity in Kisumu is around 18,000 m^3/d. It is planned to increase this by around 10,000 m^3/d under rehabilitation works. This will be followed by creating an additional capacity of around 40,000 m^3/d. The total supply capacity will thus increase to around 70,000 m^3/d in Phase I. This capacity is planned to be completed by the year 2003.

To create the additional capacity of 40,000 m^3/d at the end of Phase I, possible water sources are Sondu, Kibos/Awach and Yala rivers in addition to Lake Victoria which is a possible source for any amount of capacity.

(3) Alternative Water Sources

Evaluation of water sources with respect to available intake rate and water quality is discussed in Chapter 3. Table 6-1 shows a summary of the evaluation. Except for Kibos/Awach River with weir intake, all other water sources have sufficient flow rate for intake to meet the water demand in 2015.

Table 6-1 Available Water Sources

Water Source	Distance To Supply Area	Available Intake Rate		Water Quality	Water Transmission		Location (Within Or Outside Drainage Basin)
		Phase I	Phase II		Distance	Method	
Lake Victoria	Adjacent	Sufficient	Sufficient	Algae COD 7 Mg/L	5 km	Pumping : 80 m Head	Inside
Kibos/Awach River - Weir Intake	11 km	Sufficient	Not Sufficient	Good	11 km	Gravity	Inside
Kibos River - Dam	15 km	Sufficient	Sufficient	Good	12 km	Gravity	Inside
Yala River	34 km	Sufficient	Sufficient	Good	34 km	Gravity	Outside
Sondu River	54 km	Sufficient	Sufficient	Good	54 km	Pumping : 150 m	Inside
Nyando River	21 km	Sufficient	Sufficient	High Nitrogen	21 km	Pumping : 100 m	Inside

Among water sources listed above, Nyando River is excluded from this comparative study since its water quality is unsuitable for human consumption and is expected to worsen due to the presence of industries in its upstream.

Out of the two possible intakes on the Sondu River, one at the downstream at an elevation of 1205 m is considered. Topographical conditions require a three or four-staged pumping against a total head of 150 m. This multi-stage pumping from Sondu River will not be sustainable without assurance of payment for high energy costs and without skilled staff being deployed for complicated operation and maintenance of mechanical and electrical equipment. Since it is considered difficult for the Kisumu Municipality to meet these requirements, Sondu River is also excluded from this comparative study.

Remaining alternative water sources are therefore as follows.

1. Lake Victoria
2. Kibos/Awach River
3. Kibos Dam
4. Yala River

Lake Victoria

Available capacity from Lake Victoria is unlimited and this source can be used either as single source or as a combined source with others. Due to its proximity to supply area, combination of this source with other sources will increase the reliability of water supply system.

Kibos/Awach River

The Kibos/Awach system is the most promising source of river water. Without construction of a new dam, the maximum amount of water which can be extracted from the Kibos and Awach rivers is estimated to be 42,500 m3/day.

Kibos Dam

Construction of the Kibos Dam is discussed in the "Kisumu Water Supply and Sanitation Study, March 1988, Ministry of Local Authorities on behalf of Kisumu Municipal Council, conducted by H. P. Gauff Gmbh". This option proposed to build a dam across the Kibos River at one kilometer upstream of the existing Kajulu intake. After the 1988 Study, the JICA conducted the Study on the National Water Master Plan in July 1992. According to the Study, it was envisaged that 70,000 m3 of water could be abstracted per day by constructing the dam which has 40 m crest height and 7 million m3 of gross storage.

Construction cost was estimated in the 1992 JICA Study at US$23.8 million in 1992 price. This corresponds to US$27.6 million in 1997 price using 3% escalation rate per annum.

Yala River

Yala River option is to augment the low flow during the dry season by a trans-basin diversion from Yala River to Kibos catchment, details are given in Appendix B. Diversion pipe will be 27 km in length and 950 mm in diameter. This pipeline will allow gravity diversion from the Yala River to Kibos catchment without tunnel construction. Total construction cost is estimated at US$18.7 million.

6.1.3 Development of Alternative Cases

Six alternatives are developed using these available water sources. Water sources for each alternative case are as shown on Table 6-2 and the details of each alternative are shown on Table 6-3. Schematics illustrating each of these alternatives are shown in Figures 6-1.

Table 6-2 Water Sources for Each Alternative Case

	Phase I		Phase II	
Cases	Water Source	Intake Capacity (m3/day)	Water Source	Intake Capacity (m3/day)
Case 1	Kibos (RC)	3,000	Kibos (RC)	3,000
	Lake (RC)	27,000	Lake (RC)	27,000
	Kibos	25,500	Kibos	25,500
	Awach	17,000	Awach	17,000
			Lake	42,500
Total		**72,500**		**115,000**
Case 2	Kibos (RC)	3,000	Kibos (RC)	3,000
	Lake (RC)	27,000	Lake (RC)	27,000
	Kibos	25,500	Kibos	25,500
	Awach	17,000	Awach	17,000
			Kibos Dam	42,500
Total		**72,500**		**115,000**
Case 3	Kibos (RC)	3,000	Kibos (RC)	3,000
	Lake (RC)	27,000	Lake (RC)	27,000
	Lake	42,500	Lake	42,500
			Lake	42,500
Total		**72,500**		**115,000**
Case 4	Kibos (RC)	3,000	Kibos (RC)	3,000
	Lake (RC)	27,000	Lake (RC)	27,000
	Kibos	25,500	Kibos	25,500
	Awach	17,000	Awach	17,000
			Yala ->Kibos	42,500
Total		**72,500**		**115,000**
Case 5	Kibos (RC)	3,000	Kibos (RC)	3,000
	Lake (RC)	27,000	Lake (RC)	27,000
	Lake	42,500	Lake	42,500
			Kibos Dam	42,500
Total		**72,500**		**115,000**
Case 6	Kibos (RC)	3,000	Kibos (RC)	3,000
	Lake (RC)	27,000	Lake (RC)	27,000
	Lake	42,500	Lake	42,500
			Yala ->Kibos	42,500
Total		**72,500**		**115,000**

RC : Rehabilitation Works Component

Table 6-3 Detail of Each Alternative Case

Facilities	Location	Phase	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Treatment Works (m³/d)	Kajulu (rehabilitation) E.L.1273 m	I (REH.)	2,800	2,800	2,800	2,800	2,800	2,800
	Lake (rehabilitation) E.L.1140 m	I (REH.)	25,000	25,000	25,000	25,000	25,000	25,000
	Kibuye (Expansion) E.L.1190 m	I	40,000	40,000	40,000	40,000	40,000	40,000
	Kibuye (Expansion) E.L.1190 m	II	40,000	40,000	40,000	40,000	40,000	40,000
	Total (2015 y)		107,800	107,800	107,800	107,800	107,800	107,800
Intake Facilities (m³/d)	Kibos (Rehabili.) E.L.1273m	I (REH.)	3,000	3,000	3,000	3,000	3,000	3,000
	Lake (Rehabili.) E.L. 1134m	I (REH.)	27,000	27,000	27,000	27,000	27,000	27,000
	Kibosu/Awach, Kibos E.L. 1300 m	I	25,500	25,500		25,500		
	Awach E.L. 1300 m		17,000	17,000		17,000		
	Lake E.L. 1134 m	I			42,500		42,500	42,500
	Lake E.L. 1134 m	II	42,500		42,500			
	Kibos Dam E.L.1472 m	II		42,500			42,500	
	Yala River E.L 1777.5 m	II				42,500		42,500
	Kibos River E.L. 1273 m	II		42,500		42,500		42,500
	Kibosu/Awach, Kibos E.L. 1273 m Awach E.L. 1255 m	II						
Transmission or Conveyance Pipe (m³/d)	Kajulu- Clear reservoir L:2.6 km E.L. 1273- 1220 m	I (REH.)	2,800	2,800	2,800	2,800	2,800	2,800
	Lake-Kibuye E.L 1140- 1190 m L :5.0km	I (REH.)	25,000	25,000	25,000	25,000	25,000	25,000
	Kibos/Awach- Kibuye 1300-1190 m L: 5km+5.2+6 (25500+17000m3/d)	I II	42,500	42,500		42,500		
	Lake- Kibuye E.L.1140- 1190 m L : 5.0km	II	42,500		42,500		42,500	42,500
	Kibosu(Dam) E.L. 1300-1190 m L:11.4km	II		42,500			42,500	
	Yala- Kibos E.L.:1777.5-1710 m L: 22.7km	II				42,500		42,500
	Kibos-Kibuye E.L. 1300- 1190 m L:11.4km	II				42,500		42,500
	Kibuye- Kanyakwar L=3.8 km E.L.:1190- 1240 m (Pumping)	I II	5100 5900	5100 5900	5100 5900	5100 5900	5100 5900	5100 5900
	Kibuye - Kogony L=6.0 E.L.:1190- 1240 m (Pumping)	I II	4500 5500	4500 5500	4500 5500	4500 5500	4500 5500	4500 5500
Clear Water Reservoir (m³)	Kibuye E.L.1190, Cap.:6,000	existing	6,000	6,000	6,000	6,000	6,000	6,000
	Kajulu Cap.:1,000	I(REH.)	1,000	1,000	1,000	1,000	1,000	1,000
	Kibuye E.L.1190 Cap.:2,000	I	12,000	12,000	12,000	12,000	12,000	12,000
	Kibuye E.L.1190 Cap.:10,000	II	10,000	10,000	10,000	10,000	10,000	10,000
	Kanyakwar H.W.L 1240 2,500	I	2,500	2,500	2,500	2,500	2,500	2,500
	Kanyakwar H.W.L 1240 m 2,000	II	2,000	2,000	2,000	2,000	2,000	2,000
	Kogony H.W.L. 1240 m 2,000	I	2,000	2,000	2,000	2,000	2,000	2,000
	Kogony H.W.L. 1240 m 2,500	II	2,500	2,500	2,500	2,500	2,500	2,500
	Total		38,000	38,000	38,000	38,000	38,000	38,000
Pumping Station (m³/d)	Lake-Lake TW Q:27,000 L:0.6km EL.:1134-1140 m	I(REH.)	27,000	27,000	27,000	27,000	27,000	27,000
	Lake-Kibuye , Q:25,000, L:6.0km	I (REH.)	25,000	25,000	25,000	25,000	25,000	25,000
	E.L.Difference.:+ 50 m Lake-Kibuye , Q:42,500, L: 5.0km	I			42,500		42,500	42,500
	E.L.Difference.:+ 50 m Lake-Kibuye , Q:42,500, L: 5.0km	II	42,500		42,500			
	E.L.Difference.:+15 m Kibuye-Kanyakwar Q:5100,	I	5,062	5,062	5,062	5,062	5,062	5,062
	E.L.D.:+50 m L:3.8 km Kibuye-Kanyakwar Q:5000,	II	5,275	5,275	5,275	5,275	5,275	5,275
	E.L.Difference:+50 m L:3.8 km Kibuye- Kogony Q:4500,	I	4,486	4,486	4,486	4,486	4,486	4,486
	E.L.Difference:+50 m L:6.0 km Kibuye-Kogony Q:5500	II	5,460	5,460	5,460	5,460	5,460	5,460

Note: REH. - Rehabilitation Works Component

Figure 6-1 (1)

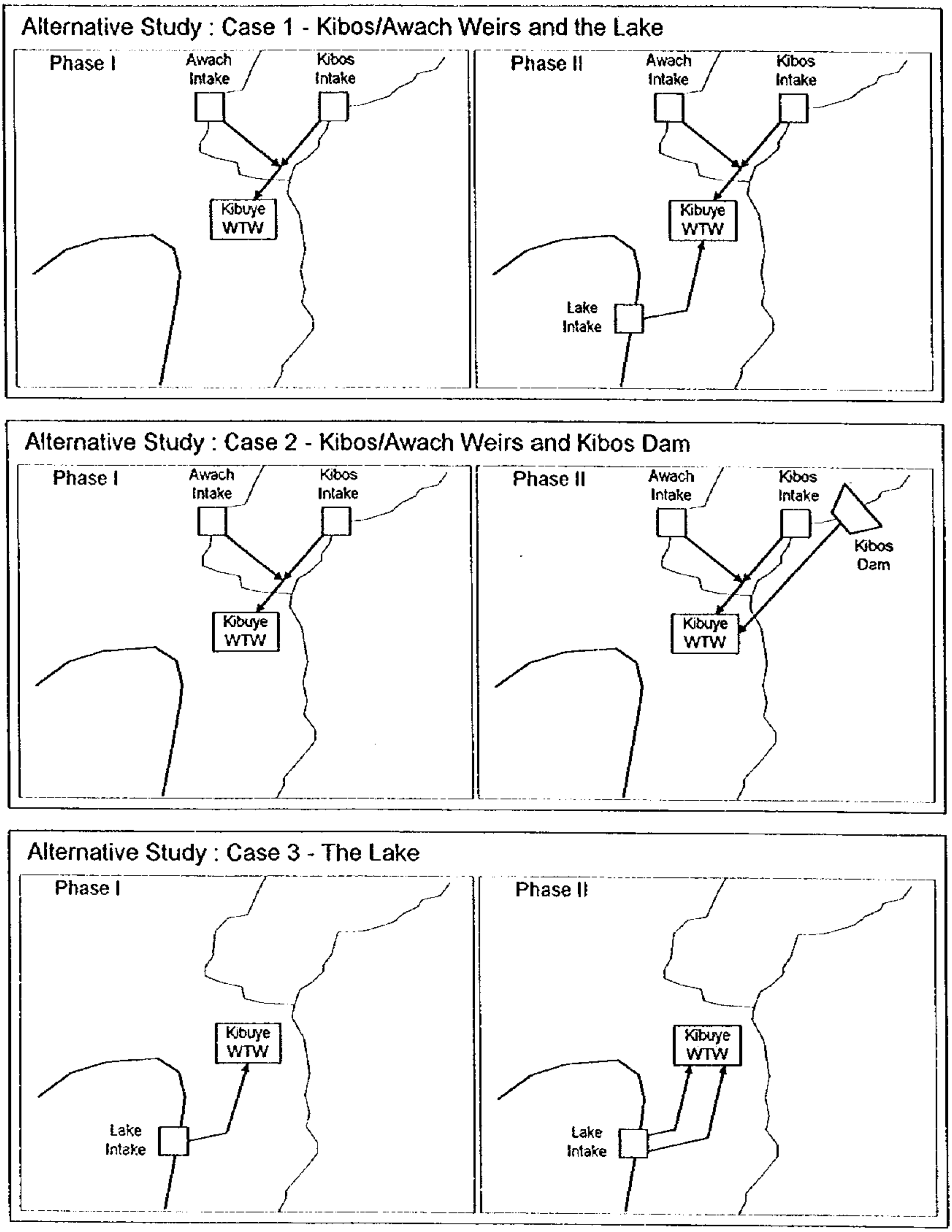


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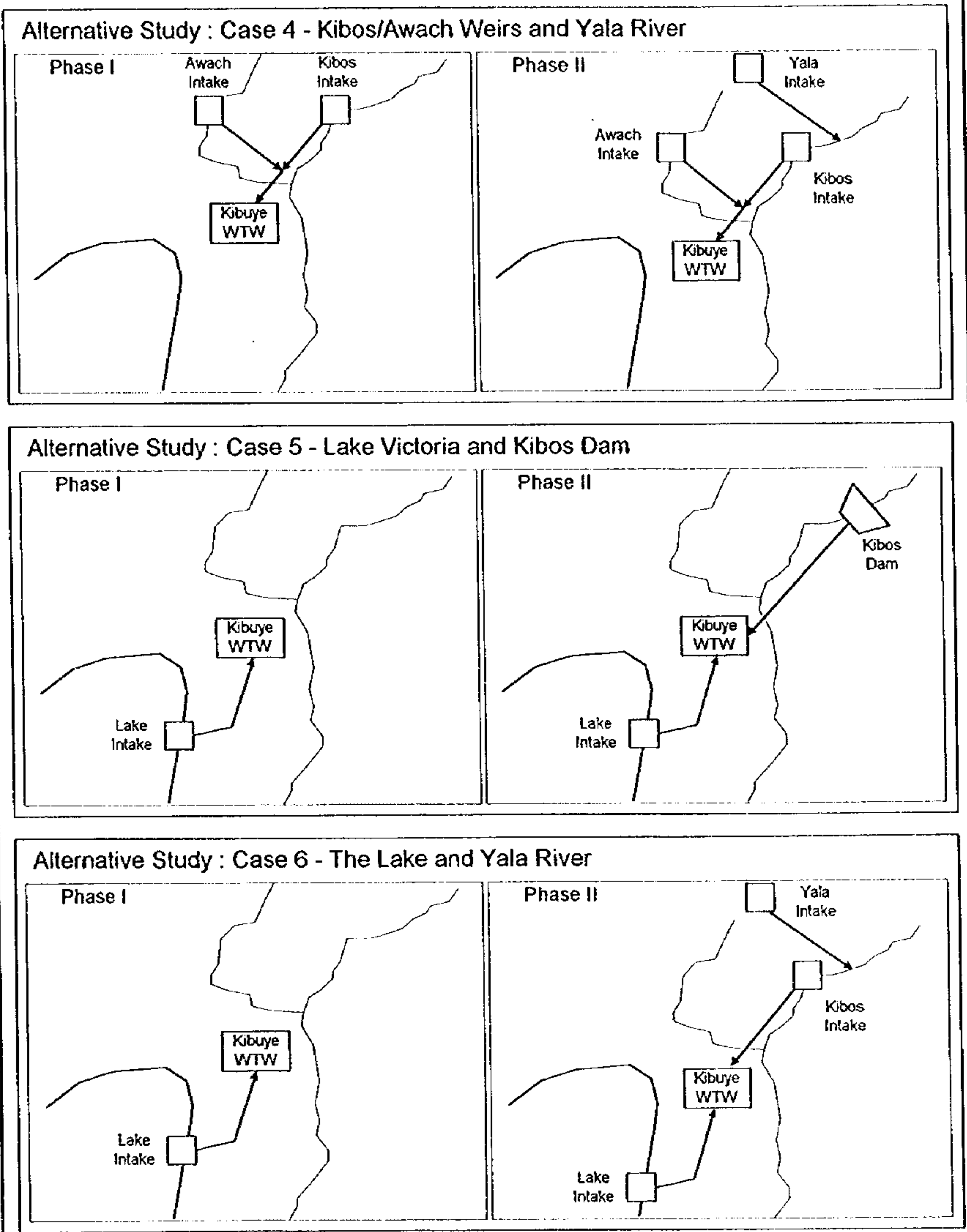
Figure 6-1 (2)



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From the Table 6-2, proposed water sources for Phase I and Phase II are summarized in Table 6-4.

Table 6-4 Summary of Proposed Water Source for Each Alternative Case

Alternative	Proposed Water Source	
	Phase I	Phase II
Case 1	Kibos/Awach River	Lake Victoria
Case 2	Kibos/Awach River	Kibos Dam
Case 3	Lake Victoria	Lake Victoria
Case 4	Kibos/Awach River	Yala River
Case 5	Lake Victoria	Kibos Dam
Case 6	Lake Victoria	Yala River

6.1.4 Comparative Study among Alternative Cases

(1) Comparative Study

For all of the alternative cases, the location of a new water treatment works is fixed at the site of existing Kibuye distribution reservoir. The reasons are:

- Vacant land is available in the premises and in the vicinity of existing Kibuye distribution reservoir. Land space required in the vicinity will be acquired by the municipality.
- The location of Kibuye, because of its high elevation, will enable to supply water by gravity to the most of the supply area.
- The location of Kibuye is in the middle of two major water sources, Kibos/Awach and Lake Victoria. The location, therefore, will have an advantage when an accident occurs at one of the water sources, in which the other source can still meet part of water demand in supply area.
- The location of Kibuye has an advantage in operation and maintenance of treatment works and central distribution reservoir because they will be in the same premises.

Therefore, location of water treatment works is fixed at Kibuye for all alternative cases, and so are the downstream facilities, such as clear water transmission and distribution facilities.

Comparison of alternative cases for the selection of the most preferable case is made by giving weighted points for various parameters. Points are awarded from a scale of 1 to 3 and weight of 1 or 2. Increased weight was given to the following parameters, namely:

* Flexibility of facility design and expansion

* Investment cost
* Operation cost
* Environmental Impacts

For assigning the point to "Investment Cost", preliminary comparison of investment cost is made and the results are shown on Table 6-5. In the comparison, costs that are common to all alternative cases are neglected and only costs of Intake Facilities, Raw Water Pumping Station and Raw Water Transmission Pipeline are compared.

Table 6-5 Preliminary Comparison of Investment Costs

Unit : 1,000 US$

Water Source	Phase I	Kibos/ Awach	Kibos/ Awach	Lake	Kibos/ Awach	Lake	Lake
	Phase II	Lake	Kibos Dam	Lake	Yala	Kibos Dam	Yala
Proposed Facilities for Comparison (not including all proposed facilities)		**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
1 Intake Facilities							
1-a Kibos/Awach River	Phase I	1,820	1,820		1,820		
1-b Lake Victoria	Phase I			3,600		3,600	3,600
1-c Lake Victoria	Phase II	3,600		3,600			
1-d Kibos Dam	Phase II		27,600			27,600	
1-e Yala River	Phase II				2,600		2,600
2 Raw Water Pump Stations							
2-a Lake Victoria Intake	Phase I			2,224		2,224	2,224
2-b Lake Victoria Intake	Phase II	2,224		2,224			
3 Raw Water Transmission Pipeline							
3-a Kibos/Awach I. - Kibuye W.W	Phase I	7,444	7,444		7,444		
3-b Lake Victoria I. - Kibuye W.W	Phase I			2,694		2,694	2,694
3-c Lake Victoria I. - Kibuye W.W	Phase II	2,694		2,694			
3-d Kibos Dam I - Kibuye W.W	Phase II					3,876	
3-e Yala River - Kibos River	Phase II				18,700		18,700
3-f Kibos I. - Kibuye W.W	Phase II						3,876
Total Cost		17,782	36,864	17,036	30,564	39,994	33,694
Phase I		9,264	9,264	8,518	9,264	8,518	8,518
Phase II		8,518	27,600	8,518	21,300	31,476	25,176

Results of comparison of alternative cases are shown on Table 6-6.

Table 6-6 Comparison of Alternative Cases

Parameters	Weight	Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Water Source		Phase I	Kibos/ Awach	Kibos/ Awach	Lake	Kibos/ Awach	Lake	Lake
		Phase II	Lake	Kibos Dam	Lake	Yala	Kibos Dam	Yala
Flexibility of Facility Design and Expansion	2	Phase I	6	6	4	6	4	4
	2	Phase II	6	4	4	6	4	4
Reliability of Supply	1	Phase I	2	2	3	2	3	3
	1	Phase II	3	2	3	3	2	3
Control Over Source (Catchment)	1	Phase I	2	2	1	2	1	1
and Transmission	1	Phase II	1	2	1	2	2	2
Speed and Difficulty	1	Phase I	3	3	3	3	3	3
for Development	1	Phase II	3	1	3	1	1	1
Water Quality of Resources	1	Phase I	2	2	1	2	1	1
	1	Phase II	2	3	1	3	3	3
Investment Cost	2	Phase I	6	6	4	6	4	4
	2	Phase II	6	2	6	4	2	4
O/M Cost	2	Phase I	6	6	2	6	2	2
	2	Phase II	4	6	2	6	6	6
Existing Water Rights	1	Phase I	2	2	3	2	3	3
	1	Phase II	3	2	3	3	2	3
Management Area	1	Phase I	3	3	3	3	3	3
	1	phase II	3	2	3	1	1	1
Environmental Impacts	2	Phase I	6	6	6	6	6	6
	2	Phase II	6	2	6	4	2	4
Total point			75	64	62	71	55	63
Rank			1	3	5	2	6	4

Note : Point system ; Very good - 3 points; Good - 2 points; Moderate - 1 point.

Results of comparison of alternative cases are shown on Table 6-6.

Table 6-6 Comparison of Alternative Cases

Parameters	Weight	Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Water Source		Phase I	Kibos/ Awach	Kibos/ Awach	Lake	Kibos/ Awach	Lake	Lake
		Phase II	Lake	Kibos Dam	Lake	Yala	Kibos Dam	Yala
Flexibility of Facility Design and Expansion	2	Phase I	6	6	4	6	4	4
	2	Phase II	6	4	4	6	4	4
Reliability of Supply	1	Phase I	2	2	3	2	3	3
	1	Phase II	3	2	3	3	2	3
Control Over Source (Catchment)	1	Phase I	2	2	1	2	1	1
and Transmission	1	Phase II	1	2	1	2	2	2
Speed and Difficulty	1	Phase I	3	3	3	3	3	3
for Development	1	Phase II	3	1	3	1	1	1
Water Quality of Resources	1	Phase I	2	2	1	2	1	1
	1	Phase II	2	3	1	3	3	3
Investment Cost	2	Phase I	6	6	4	6	4	4
	2	Phase II	6	2	6	4	2	4
O,M Cost	2	Phase I	6	6	2	6	2	2
	2	Phase II	4	6	2	6	6	6
Existing Water Rights	1	Phase I	2	2	3	2	3	3
	1	Phase II	3	2	3	3	2	3
Management Area	1	Phase I	3	3	3	3	3	3
	1	phase II	3	2	3	1	1	1
Environmental Impacts	2	Phase I	6	6	6	6	6	6
	2	Phase II	6	2	6	4	2	4
Total point			75	64	62	71	55	63
Rank			1	3	5	2	6	4

Note : Point system ; Very good - 3 points; Good - 2 points; Moderate - 1 point.

(2) Alternative Selection

As a result of the comparison in Table 6-6, Case 1, Case 2, Case 3, and Case 4 are selected for detailed evaluation considering present value of the alternatives. The calculation of the present values are carried out considering investment and operation costs. However, the costs that are common to all alternatives are disregarded.

(a) Investment Costs

The major components at works to be undertaken under each option and the investment schedule are presented in Table 6-7. All components which are common to all alternatives are excluded such as Water Treatment Works, Distribution and Transmission System of clean water. Investment costs of Intakes, Dam, Transmission Pipes Tunnel, and Pumping Station of raw water are regarded for detail evaluation considering the present value.

Table 6-7 Capital Investment Schedule

CASE 1 :Kibos/Awach Intakes and the Lake (Unit: thousand USD)

		Phase	2000	2001	2002	2003	2004	2005	Total
Intake	Kibos/Awach	I	600	600	620				1,820
	Lake	II				1,200	1,200	1,200	3,600
Pumping Station(RW)	Lake Intake	II				700	750	774	2,224
Transmission Pipe	K/A to Kibuye	I	2,400	2,400	2,644				7,444
	Lake to Kibuye	II				900	900	894	2,694
Total			3,000	3,000	3,264	2,800	2,850	2,868	17,782

CASE 2 :Kibos/Awach Intakes and Kibos Dam (Unit: thousand USD)

		Phase	2000	2001	2002	2003	2004	2005	Total
Intake	Kibos/Awach	I	600	600	620				1,820
Kibob Dam	Dam	II				9,200	9,200	9,200	27,600
Transmission Pipe	K/A to Kibuye	I	2,400	2,400	2,644				7,444
Total			3,000	3,000	3,264	9,200	9,200	9,200	36,864

CASE 3: Lake Only (Unit: thousand USD)

		Phase	2000	2001	2002	2003	2004	2005	Total
Intake	Lake Intake	I	1,200	1,200	1,200				3,600
		II				1,200	1,200	1,200	3,600
Pumping Station(RW)	Pump Station	I	700	800	724				2,224
		II				700	800	724	2,224
Transmission Pipe	Lake to Kibuye	I	900	900	894				2,694
		II				900	900	894	2,694
Total			2,800	2,900	2,818	2,800	2,900	2,818	17,036

CASE 4:Kibos/Awach Intakes and Yala Diversion (Unit: thousand USD)

		Phase	2000	2001	2002	2003	2004	2005	Total
Intake	Kibos/Awach	I	600	600	620				1,820
	Yala Intake	II				850	850	900	2,600
Transmission Pipe	K/A to Kibuye	I	2,400	2,400	2,644				7,444
Yala Transmission Pipe	Yala- Kibos	II				6,000	6,000	6,700	18,700
Total			3,000	3,000	3,264	6,850	6,850	7,600	30,564

(b) Operation Costs

Tentative operation plans are devised for each alternative to calculate the operation costs. The three major operation components are the "Costs of Energy for Pumping", "Water Treatment Chemicals", and "Staff Costs". "Costs of Energy for Pumping" are depending on location of water resource, and "Costs of Water Treatment Chemicals" are depending of water quality of water resource. Proportion of abstract water amount from Lake and Rivers affects both costs. Water abstract amount from Lake and Rivers are shown below.

(m^3/day)

	Case 1		Case 2	Case 3	Case 4
	Normal	Dry Season			
River Water	88,000	45,500		0	88,000
Lake Water	27,000	69,500	27,000	115,000	27,000

In Case 1, Rive Water will be taken as much as possible, (as maximal 88,000 m^3/d), and make up for a deficiency by using Lake Water during dry season. It is assumed for the calculation of annual operation costs that 69,500 m^3/d of Lake water is taken 2 months a year and only 27,000 m^3/d of Lake Water are taken 10 months a year.

Chemicals

The water treatment chemical dosage used depends on the quality of raw water. Sources of water supply need to identified for calculating the costs of chemicals. Study Team collected information on water quality and dosage in the existing treatment works. It is sufficient to provide a breakdown between lake and the rives, because the quality of water from all rivers can be assumed to be the same and therefore subject to same treatment.

The costs of treatment chemicals for 1000 m^3 of ran water are derived from the following assumptions on dosage and prices:

Unit Price	Alum Input (0.58 US$/kg)	Soda Ash Input (0.29 US$/kg)	chlorine Input (291.0 US$/kg)	Total Cost (US$)
Lake Water 1,000 m^3	60 kg	0	6 kg	1780.8
River Water 1,000 m^3	30 kg	6 kg	3 kg	892.1

Power Consumption

Energy for pumping in required when Lake Water is taken for supply water. The amount of electricity that will be consumed after rehabilitation is calculated relation to the pump head, and efficiency of pumps and motors. Power consumption required for pumping to Kibuya Water Treatment Works to feed a 1,000 m^3/d is as follows:

Pump head, m	Water Production	Consumption, kWh/year	Cost, Ksh
80	1,000 m^3/d	171,750	579,013

No pumping would be required for raw water transmission in Case 1 and case 2 when the water is taken from the Rivers.

Staff Costs

"Staff Costs" are considered to be common to all alternatives, and therefore be disregarded for the evaluation.

(c) The least cost Solution

Present value is calculated for comparative purposes by using two discount rates. The least cost solution does not change with the discount rate adopted, but this rate is likely to be a key element in calculating cost of water at the feasibility analysis stage. The project costs under each alternative are presented in Appendix L. The present value of investment and O/M costs for each alternative is summarised below.

(Costs in 1000 US$ in 1977 prices)

	Case1	Case2	Case3	Case4
Discount rate 3%	37,500	51,074	53,311	46,106
Discount rate 5%	46,691	61,220	68,984	55,765

Case 1 is the least cost option. This calls for water abstraction from Kibos/Awach without large investments. Future requirements are met from the lake when the capacity of weirs is used up. The alternative selected thus combines the low cost operating characteristics of river systems with limited investment requirements associated with the lake options.

As shown on the Table, the most preferable case is found to be the Alternative Case 1. This Alternative Case 1 is adopted for the future water supply development plan. Water sources for the Case 1 is as shown on Table 6-8.

Figures 6-2 and 6-3 show the flowchart for the selected alternative for Phase I and Phase II.

Table 6-8 Water Sources for Alternative Case 1

	Phase I		Phase II	
Cases	Water Source	Intake Capacity (m3/day)	Water Source	Intake Capacity (m3/day)
Case 1	Kibos (EM)	3,000	Kibos (EM)	3,000
	Lake (EM)	27,000	Lake (EM)	27,000
	Kibos	25,500	Kibos	25,500
	Awach	17,000	Awach	17,000
			Lake	42,500
Total		**72,500**		**115,000**

Figure 6 - 2

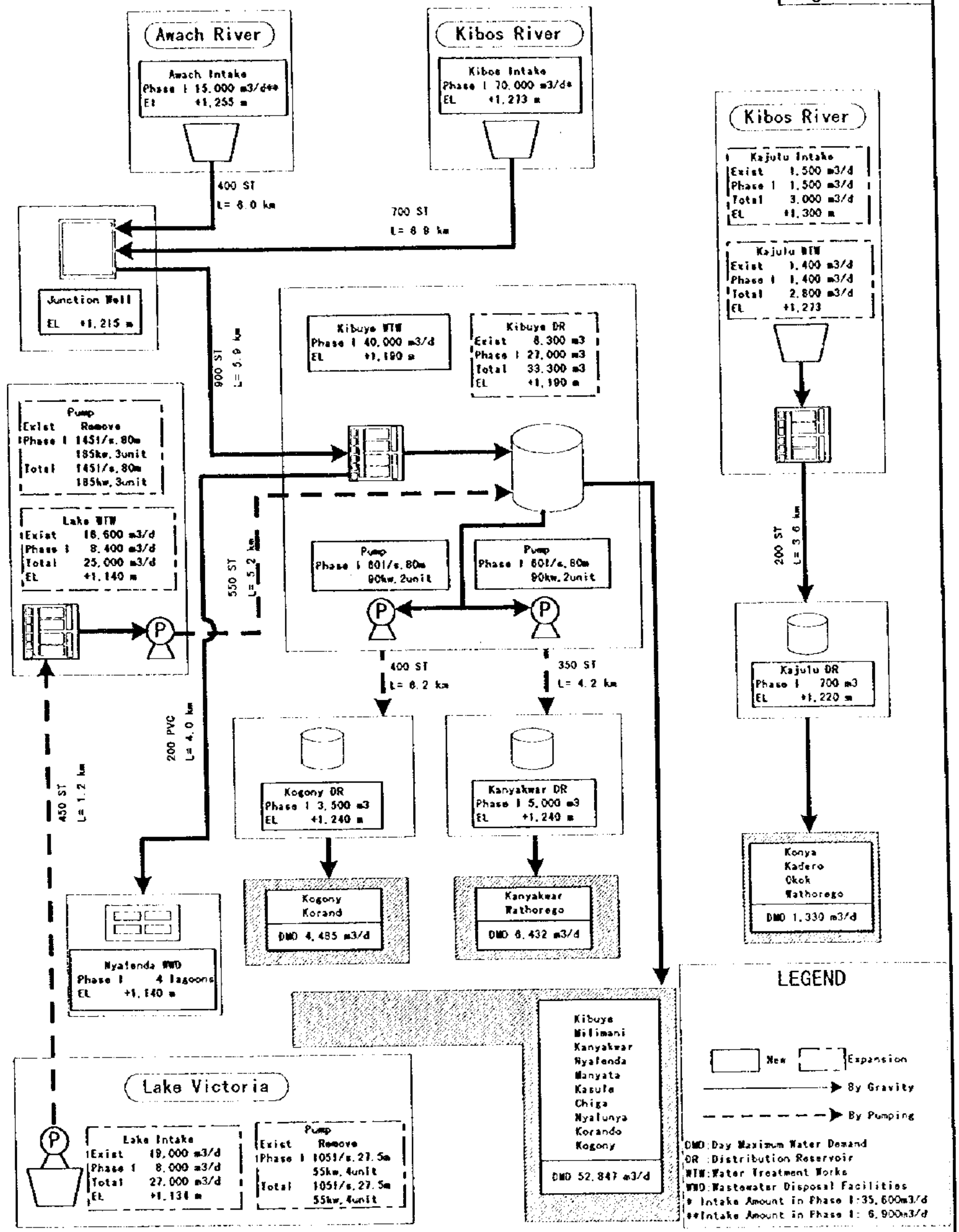

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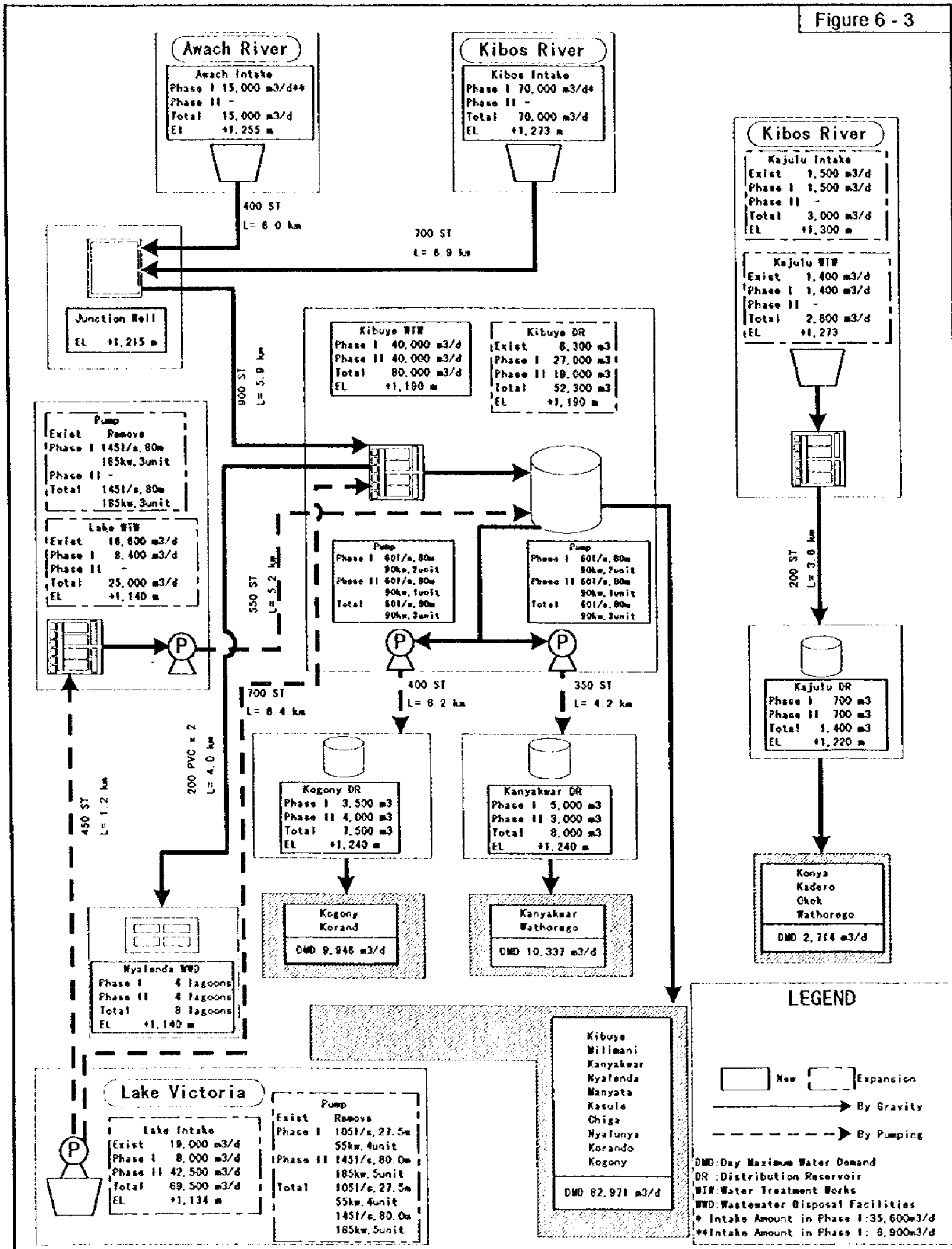
Figure 6 - 3



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6.1.5 Proposed Municipal Water Supply System

(1) Outline of the Proposed Plan

Table 6-8 below presents an outline of the proposed long-term water supply development plan. The locations of the major water supply facilities proposed under the plan are shown in Figure 6-4.

Table 6-8 Outline of Proposed Plan for Piped Water Supply System

ITEM			1997	PHASE I	PHASE II
Target Year			-	2005	2015
Total Population in the Study Area			363,157	526,195	869,166
Population Served	House Connection	Persons	13,018	272,346	531,784
	Communal Tap	Persons	211,438	142,184	158,844
	Total	Persons	224,456	414,530	690,628
Service Ratio		%	61.8	78.8	79.5
Service Area		km^2	88.0	88.0	88.0
Water Demand	Day Average	m^3/d	11,900*	59,174	96,336
	Day Maximum	m^3/d	N/A	65,091	105,970
Water Source	Kibos (for Kajulu WTW)	m^3/d	1,500	3,000	3,000
	Lake Victoria	m^3/d	19,000	27,000	69,500
	Kibos (for Kibuye WTW)	m^3/d	-	35,600	35,600
	Awach	m^3/d	-	6,900	6,900
	Total	m^3/d	20,500	72,500	115,000
Water Treatment Works	Kajulu	m^3/d	1,400	2,800	2,800
	Lake	m^3/d	16,600	25,000	25,000
	Kibuye	m^3/d	-	40,000	80,000
	Total	m^3/d	18,000	67,800	107,800
Service Reservoirs	Kibuye	m^3	6,300	33,300	52,300
	Kanyakwar	m^3	-	5,000	8,000
	Kogony	m^3	-	3,500	7,500
	Kajulu	m^3	-	700	1,400
	Total	m^3	6,300	42,500	69,200
Raw Water Trans. Mains	ø 200 mm - ø 900 mm	km	0.6	20.6	27.0
Treated Water Trans. Mains	ø 150 mm - ø 550 mm	km	16.0	35.2	35.2
Water Distribution Mains	ø 150 mm - ø 800 mm	km	63.0	112.4	139.9
Service Mains	ø 80 mm - ø 100 mm	km	49.0	379	611

* Water consumption (Not water demand)

N/A : Not Applicable

6.1.5 Proposed Municipal Water Supply System

(1) Outline of the Proposed Plan

Table 6-8 below presents an outline of the proposed long-term water supply development plan. The locations of the major water supply facilities proposed under the plan are shown in Figure 6-4.

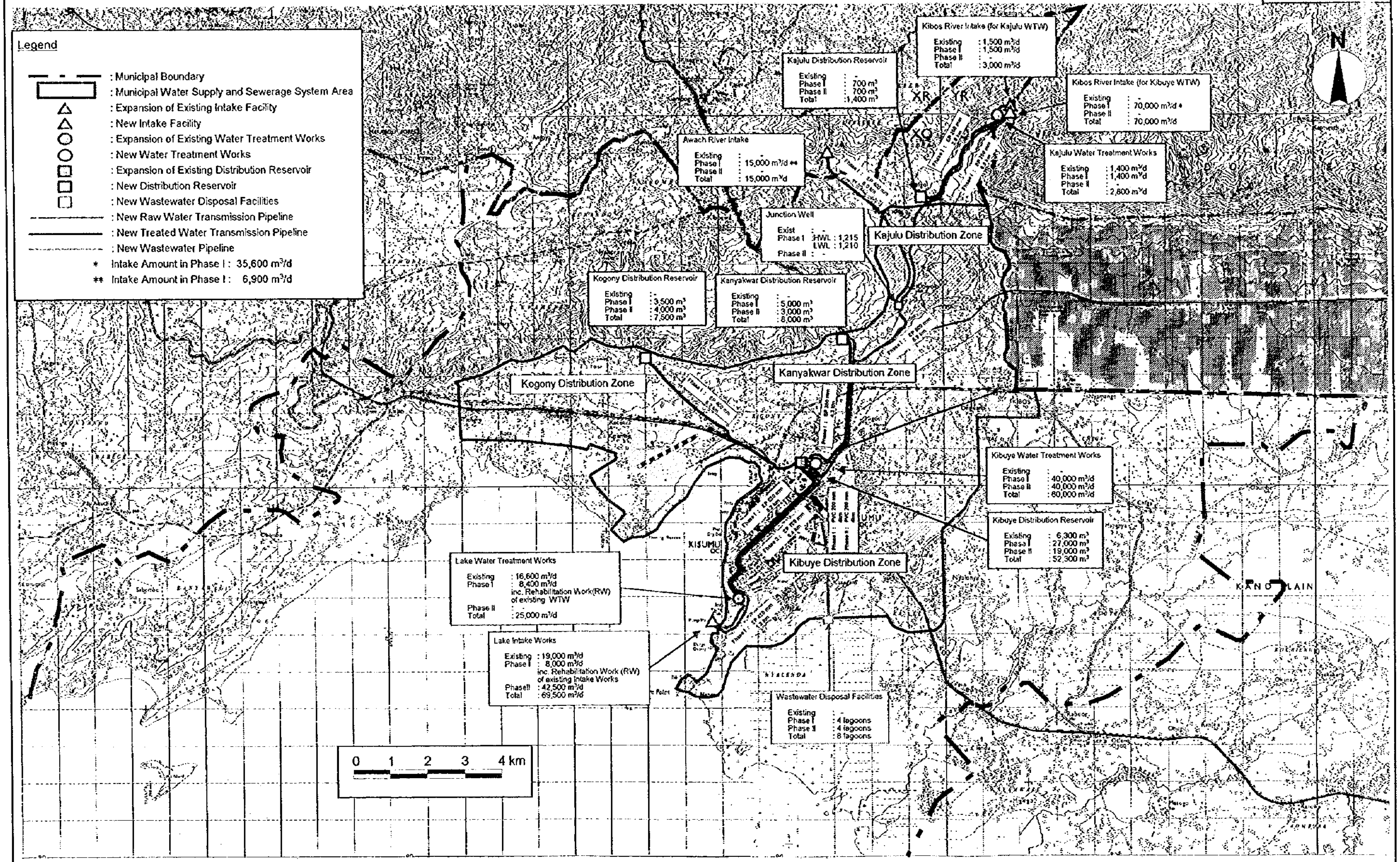
Table 6-8 Outline of Proposed Plan for Piped Water Supply System

ITEM			1997	PHASE I	PHASE II
Target Year			-	2005	2015
Total Population in the Study Area			363,157	526,195	869,166
Population Served	House Connection	Persons	13,018	272,346	531,784
	Communal Tap	Persons	211,438	142,184	158,844
	Total	Persons	224,456	414,530	690,628
Service Ratio		%	61.8	78.8	79.5
Service Area		km^2	88.0	88.0	88.0
Water Demand	Day Average	m^3/d	11,900*	59,174	96,336
	Day Maximum	m^3/d	N/A	65,091	105,970
Water Source	Kibos (for Kajulu WTW)	m^3/d	1,500	3,000	3,000
	Lake Victoria	m^3/d	19,000	27,000	69,500
	Kibos (for Kibuye WTW)	m^3/d	-	35,600	35,600
	Awach	m^3/d	-	6,900	6,900
	Total	m^3/d	20,500	72,500	115,000
Water Treatment Works	Kajulu	m^3/d	1,400	2,800	2,800
	Lake	m^3/d	16,600	25,000	25,000
	Kibuye	m^3/d	-	40,000	80,000
	Total	m^3/d	18,000	67,800	107,800
Service Reservoirs	Kibuye	m^3	6,300	33,300	52,300
	Kanyakwar	m^3	-	5,000	8,000
	Kogony	m^3	-	3,500	7,500
	Kajulu	m^3	-	700	1,400
	Total	m^3	6,300	42,500	69,200
Raw Water Trans. Mains	ø 200 mm - ø 900 mm	km	0.6	20.6	27.0
Treated Water Trans. Mains	ø 150 mm - ø 550 mm	km	16.0	35.2	35.2
Water Distribution Mains	ø 150 mm - ø 800 mm	km	63.0	112.4	139.9
Service Mains	ø 80 mm - ø 100 mm	km	49.0	379	611

* Water consumption (Not water demand)

N.A : Not Applicable

Figure 6-4



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 Water Supply Development Plan in Kisumu up to the year 2015

(2) Major Works Planned for Phase I

Major works included in Phase I and Phase II are described as follows and their outline are shown in Figures 6-5 through 6-10:

a. Phase I

- Rehabilitation of the existing Kibos river intake for the Kajulu WTW which includes an expansion of the intake capacity from the existing 1,500 m^3/d to 3,000 m^3/d.
- Rehabilitation of the existing Kajulu water treatment works which includes an expansion of the treatment capacity from the existing 1,400 m^3/d to 2,800 m^3/d.
- Rehabilitation of the existing Lake intake works for the Lake WTW which includes an expansion of the intake capacity from the existing 19,000 m^3/d to 27,000 m^3/d.
- Rehabilitation of the existing Lake water treatment works which includes an expansion of the treatment capacity from the existing 16,600 m^3/d to 25,000 m^3/d.
- Construction of a new water intake on the Awach river with an intake capacity of 15,000 m^3/d.
- Construction of a new water intake on the Kibos river with an intake capacity of 70,000 m^3/d.
- Construction of a new water treatment works at Kibuye (Kibuye WTW) with a treatment capacity of 40,000 m^3/d.
- Construction of new raw water transmission mains, 400 to 900 mm in diameter steel pipe and 18.8 km in total length from the new water intakes on the Awach and Kibos rivers to the Kibuye WTW.
- Construction of a new raw water transmission main 450 mm in diameter steel pipe and approximately 1.2 km in length from the Lake intake works to the Lake WTW.
- Construction of a 27,000 m^3 distribution reservoir at Kibuye which will increase the total reservoir capacity at this location from the existing 6,300 m^3/d to 33,300 m^3/d.
- Construction of a 700 m^3 distribution reservoir at Kajulu.
- Construction of a 5,000 m^3 distribution reservoir at Kanyakwar.
- Construction of a 3,500 m^3 distribution reservoir at Kogony.
- Construction of a treated water transmission main 200 mm in diameter steel pipe and approximately 3.6 km in length from the Kajulu WTW to the Kajulu Distribution Reservoir.
- Construction of a treated water transmission main 550 mm in diameter and steel pipe approximately 5.2 km in length from the Lake WTW to the Kibuye Distribution Reservoir.
- Construction of a treated water transmission main 400 mm in diameter steel pipe and approximately 6.2 km in total length from the Kibuye distribution reservoir to Kogony Distribution Reservoir.
- Construction of a treated water transmission main 350 mm in diameter steel pipe and

approximately 4.2 km in total length from the Kibuye distribution reservoir to Kanyakwar Distribution Reservoir.

- Construction of wastewater disposal facilities in Nyalenda (Nyalenda WWD), which comprise 4 units of wastewater lagoons and a sludge drying bed.
- Construction of a wastewater disposal main 200 mm in diameter PVC pipe and approximately 4 km in total length from the Kibuye WTW to the Nyalenda WWD.
- Construction of trunk distribution mains, PVC pipes of 160 to 315 mm and steel pipes of 350 to 800 mm in diameter and approximately 49.4 km in total length.
- Construction of secondary distribution mains PVC pipes of 63 to 100 mm in diameter and approximately 330 km in total length.

b. **Phase II**

- Expansion of the intake capacity at the Lake intake works by 42,500 m^3/d which increases the total intake capacity of the works from 27,000 m^3/d upon completion of Phase I to 69,500 m^3/d.
- Expansion of the treatment capacity at the Kibuye WTW by 40,000 m^3/d which increases the total treatment capacity of the works from 40,000 m^3/d upon completion of Phase I to 80,000 m^3/d.
- Construction of a new raw water transmission main 700 mm in diameter steel pipe and approximately 6.4 km in total length from the Lake intake works to the Kibuye WTW.
- Construction of a 19,000 m^3 distribution reservoir at Kibuye which increases the total reservoir capacity at this location from 33,300 m^3 upon completion of Phase I to 52,300 m^3.
- Construction of a 3,000 m^3 distribution reservoir at Kanyakwar which increase the total reservoir capacity at this location from 5,000 m^3 upon completion of Phase I to 8,000 m^3.
- Construction of a 4,000 m^3 distribution reservoir at Kogony which increase the total reservoir capacity at this location from 3,500 m3 upon completion of Phase I to 7,500 m^3.
- Construction of wastewater disposal facilities in Nyalenda (Nyalenda WWD), which comprise 4 units of wastewater lagoons and a sludge drying bed.
- Construction of a wastewater disposal main 200 mm in diameter PVC pipe and approximately 4 km in total length from the Kibuye WTW to the Nyalenda WWD.
- Construction of trunk distribution mains , PVC pipes of 160 mm to 315 mm and steel pipes of 300 to 500 mm in diameter and approximately 27.5 km in total length.
- Installation of secondary distribution mains, PVC pipes of 63 and 110 mm in diameter and approximately 232 km in total length.