DRAFT

REPUBLIC OF KENYA

MINISTRY OF LOCAL GOVERNMENT
ON BEHALF OF
NYERI MUNICIPAL COUNCIL

KfW Kreditanstalt für Wiederaufbau
(KfW ASSISTED)

NYERI WATER SUPPLY FEASIBILITY STUDY

PRE-FEASIBILITY REPORT

Volume I : Main Report

JBG Gauff Ingenieure

FRANKFURT AM MAIN, GERMANY
AND
NAIROBI, KENYA

JANUARY 1996

NYERI-A1

EXECUTIVE SUMMARY

1. Previous Report for this Study

A Situation Assessment Report was submitted in July 1995 at the end of the first stage of this study. The principal findings of that Report are summarised starting from page 1-2 of this report.

2. Scope of this Report

The principal intent of this Report is to outline the scope and essential features of the possible development options for the Nyeri Water Supply, to compare them, and arrive at a recommended project. The selected project will be detailed and refined in the next study stage, and be reported on in the Feasibility Report. This report also includes an analysis of the sanitation, socio-economic and environmental impacts of the proposed project.

3. Availability of Records

The drawings which had not been available during the Situation Assessment from the Water Ministry and from the previous consultant for the Nyeri Water Supply, were obtained in late December 1995, and those records have been taken into account in this report.

4. Present Land Use

The present principal development centres are the Nyeri Central Business District (CBD) and the former "satellite townships" of Ruringu and Kamakwa which have grown to essentially link up with the CBD. Another principal population centre is Mathari to the northwest of the CBD, which has grown around the Catholic mission and associated institutions.

Kiganjo is separated from Nyeri town by the Amboni river valley. The road between them is winding, giving an impression of a greater distance between the two water supply areas than the actual 3 km separation. Kiganjo is the railway station for Nyeri and the area zoned for industrial development. To the north of Kiganjo is a new "slum" settlement called Chaka, and to the south a significant population centre called Kirichu. Around Kiganjo are significant educational institutions.

Place names can be referred to in the figures on pages 1-8 and 1-9.

The principal influences on land use are rainfall, topography, and large land holdings. Within close proximity of the Nyeri CBD to the north and west are very large farms, which limit the extent to which urban development has been able to move in those directions. Suburban development has taken place to the south and east, by developers buying out small scale farmers. Roads run along the ridges between valleys and are a focus of development. Valleys, even close to the CBD, are largely undeveloped.

Kiganjo and associated areas have developed on a long narrow ridge between the deep Amboni and Nairobi river valleys. The most northern parts of the Municipality (Njengu, Nyaribo and Ngonde) are essentially dry and either forested or with low populations.

Pictures of principal areas are on pages 2-8 to 2-19.

5. Expected Future Land Use

There is no recent overall urban development plan for Nyeri, so projections are based on field observations and discussions with relevant officials.

Nyeri town is expected to grow towards and beyond Kamakwa, along the road to Nairobi, in areas adjacent to the Nyeri-Othaya road, and on the road to the sewage works. Outside the old town borders, mixed development of all types of premises is expected rather than specific types of premises in one area, but with a higher predominance of lower cost properties nearer the main roads. Slum development is expected to be in the Chania river valley, although gradually pushed further from the CBD than at present. The location of expensive small holdings to the south, and large holdings to the north, are expected to limit the physical extents to which Nyeri town can grow. Development is also expected to be constrained by the rugged terrain and limited access to areas in valleys.

With adequate water supply, industrial development is expected to take place in Kiganjo and this is expected to be a driving force for urban growth, largely around Chaka (informal housing) and in the area between Kiganjo and Kirichu. The growth of horticultural production to the north is rapidly transforming Kiganjo into a more significant agricultural marketing centre than Nyeri, due to closer proximity and better communications. The land in this area is also cheaper, flatter and more readily available to prospective purchasers.

Illustrations of present and projected land use are on pages 3-7 to 3-9.

6. Proposed Service Area

With a few exceptions it is recommended that the project service area to be the same as the present reticulation area.

Expansions of the present service area are recommended for parts of Mathari, Gitathi-ini (near Kamakwa), and along the Nyeri - Othaya and Nyeri - Nairobi roads. These are areas seen as being central to the expected trend of urbanisation.

For the Kiganjo area, it is recommended that the dry rural reticulation to the south be treated as a past rather than present service area, since the Council has not physically provided water services to those areas for a considerable period. Recommencing supply to those areas would result in low returns (widely spaced consumers paying lowest tariffs) against high costs and inconvenience (high losses in pipework which has not been in use for long, difficulty tracing old connections, large distances between meters, etc.) It is recommended that that pipework be physically disconnected from the system.

7. Potential for Public Taps

Recent experiences with public taps in two KfW funded water projects have been varied. In Malindi 72 new water kiosks were very successful. In Kericho, out of 7 trial kiosks, only 2 remain in business. The factors seen as influencing the success of public taps are public health awareness (and the related aspect of educational levels), availability of resources to finance an individual connection, and availability of alternative water sources (including potable water from roof catchments).

The expectation is that public taps in Nyeri would not be more successful, and most likely be less successful than in Kericho. There is however the limited need for them in peri-urban trading centres, and in the very low cost housing areas, providing for potable water needs at approximately 5 to 7 l/c/d. Such consumers are expected to choose to meet their other water needs from natural sources. To make the public taps effective, it is considered they would need to either operate on Council subsidised rates, or be unmanned and of the community token water dispenser type.

8. Demand Horizons

Although the Terms of Reference stated the design horizons to be the years 2010 and 2015, it is recommended the latter horizon be revised to 2020. This recommendation is based on the expectation that a "phase 2" project would need to be constructed in time to be commissioned in 2010, and there would then need to be a major feasibility study, design and construction project implementation cycle, which it would be optimistic to expect to be completed within 5 years of the end of "phase 2" construction.

9. Basis of Demand Projections

The per capita demands utilised in demand projections range from 210 l/cap/day (residential high cost) to 55 l/cap/day (temporary low cost residential). These are marginally lower than

the Water Ministry recommended demands, and are as put forward in the Situation Assessment Report.

The present demand has been based on numbers of existing consumers, numbers of residents per connection (as found in consumer sampling during the Situation Assessment), the known numbers of nonoperational connections in reticulated areas which are presently not receiving any water, and the area and population density of areas proposed for incorporation into the supply area.

Expected domestic demand growth has been assessed at the same rate as the population growth rate between 1979 and 1989, as determined in the Situation Assessment, which is 3.7% per annum. Other expected demand growth rates range from 3% per annum (institutional) to 4% per annum (industrial).

10. Projected Average Daily Demand

After consideration of these factors, the expected average daily demands are as follows:

		Units	Average Demands in m^3/day		
			Nyeri	Kiganjo	Total
(i)	Year 2010	m^3/d	16,540	3,050	19,590
(ii)	Year 2020	m^3/d	23,580	4,420	28,000
(iii)	Per capita domestic demand	l/c/d	74	64	72

A graphical presentation of the demand projections is on page 5-13.

Previous demand projections by Sir Alexander Gibb and Partners are generally comparable after removing an allowance for reticulation losses, since their demand figures were all inclusive.

11. Demand Adjustments

For design of facilities, a 25% allowance has been made for demand fluctuations in various seasons of the year (high dry season usage).

Computations in this report assume a successful programme to reduce reticulation losses to 18% by 1997, from the estimate in the Situation Assessment of 35%. Losses would then rise to 22% in 2010 and 25% in 2020, due to continually aging pipework. Should it be indicated that such a programme is not expected, or a programme with lower success expectations is to expected, then these parameters would need adjustment in the Feasibility stage of this study. In addition, very recent indications are that there are significant errors in the clear water bulk metering, leading to an impression of higher water losses at present

than are the actual case. A measuring exercise is now planned as a precursor to the Feasibility Report, and this may lead to a reassessment of the water loss figures.

Daily demand peaking is allowed for at 60%.

12. Developments Options

The Situation Assessment recommended continued use of the Ihwa Intake as the raw water source. The two options then developed for a new project are for the new treatment works to be at the present Kamakwa site ("A") or to be at higher elevation, at a new Kiriti site nearer the intake ("B").

Supply for Kiganjo can be either by a clear water trunk main from Nyeri ("1") or through retention of the separation of the two supplies ("2").

This gives rise to four options: A1, A2, B1 and B2, with major characteristics as follows:

(i) With all treatment for Nyeri at Kamakwa ("A" options), water supply to western areas (Kamakwa, Kamuyu, Gitathi-ini and Mathari) would all be pumped. Storage would be at three locations - Kamuyu tank serving a western zone (Kamakwa, Kamuyu, Gitathi-ini), a Mathari tank for the Mathari Zone, fed from Kamuyu tank, and all other areas (Central Zone) served from storage at the treatment works. Where Kiganjo is served from Nyeri, a trunk main would start from a Kingongo tank, on the Nyeri - Kiganjo road.

(ii) New treatment works at Kiriti ("B" options) would alter the main aspects of distribution. A clear water trunk main from the new works would run to Kamakwa, branching on the way to Mathari, also branching to supply limited high areas of Gitathi-ini through a small on-line booster pumping installation, feeding the rest of the Western zone (Kamuyu, Kamakwa etc.) directly, and emptying into new storage at the existing treatment site. The Mathari tank would serve all areas north of the Chania river (including the Kingongo tank which would be for Kiganjo) necessitating cutting off of the present two pipes across the river.

(iii) A separate Kiganjo project would be based on abstraction from the Amboni river below Chaka, treatment in the valley, and pumping upto a Chaka tank. Reticulation augmentation would largely consist of a single trunk main from Chaka to Kirichu, ending in a floating head Kirichu tank.

All of these options are based on continued operation of the existing Kamakwa treatment works. The computations for the capacity of new treatment facilities are based on the existing works continuing to produce their design capacity. Should there be indication that these existing works will be augmented in an "Immediate Works" programme, then the design capacity of the new facilities would be reduced in the Feasibility stage of this study.

Schematic layouts of these options are in pages 6-8 to 6-10, and other drawings in pages 6-19 to 6-32.

13. Treatment Processes and Capacity

All proposed treatment works are based on gravity chemical dosing, sinuous flow flocculation channels, horizontal flow sedimentation, and rapid sand filters. The basis of selection is reliability and simplicity of operation. Treatment chemicals are soda ash, alum and sodium hypochlorite, all readily available locally, and simple to dose.

The capacity of new treatment works has been determined inclusive of reticulation losses, seasonal demand fluctuation, and 5% water works usage and losses, with deduction of the capacity of the existing Kamakwa Water Works. This results in the following capacities for new treatment works:

		Treatment Capacity in m^3/day		
		Separate Nyeri	Separate Kiganjo	Combined
(i)	Year 2010	20,600	4,900	25,500
(ii)	Year 2020	32,800	7,200	40,000

The works are in each case to consist of Phase I works, followed by simple augmentation to Phase II capacity.

14. Reticulation

Reticulation, sizing has been carried out with the Consultant's REHM network analysis software. It was found that without extensive duplication of pipework being envisaged in the Phase II works, little would be achieved in having a division between Phase I and Phase II reticulation works. Should this be necessitated by financial constraints, that approach can be reassessed.

Ferrous pipework is proposed in 300 mm dia pipelines and above, the rest being uPVC.

15. Socio-Economic Review

In almost all demographic indicators, Nyeri district scores high in comparison with national averages. Such indicators include literacy, income, owner occupation of housing, standards of housing, and the like.

Businesses have expanded threefold in the last 25 years, but almost exclusively in the commercial rather than industrial sector. Total employment is roughly estimated at 50% of

the population. The outlook for traditional farming and tourism is uncertain, but horticulture and floriculture are beginning to boom in northern parts of the district. Net monthly incomes are estimated at KShs. 1,500 for domestic workers, to KShs. 5,700 for a small scale farmer, and KShs. 100,000 per month for a wholesaler. On average about 50% of income is spent on education, 45% on housing and food, and only 5% on other expenses.

The Council can only charge rates on the 8 sq. km of the old town area (5% of the overall Municipal area), but property values in that area have gone up 3,000% in the last 25 years. Half of this ratable area is occupied by public institutions. These factors have a significant impact on general Council revenue. Land values vary from KShs. 325,000 per 0.1 ha in Ring Road, to KShs. 290,000 in Skuta and Ruringu, down to KShs. 25,000 in Kiganjo.

Urban commercial and industrial activity is expected to be driven to Kiganjo by the much lower land prices, greater land availability, better communications, and better topography.

In 1989, less than 0.5% of the 10 to 14 years age group in Nyeri district were without schooling; overall only 12% of the population had not attended school, which is half the national average. Infant mortality in 1979 was at 6.2% compared to a national average of 10.0%. In the district, 96% of houses had durable roofing materials, and 75% of households had piped water. Nyeri district has few really disadvantaged people at present, but a growth in the proportion of poor people is expected.

Women in Nyeri Municipality are to a significant extent engaged in self help women's groups, of which there are presently 120 groups with 4,460 active members. These groups engage in providing credit and in commercial activity, and in general provide a means for women to improve their lot.

16. Environmental Impact Assessment

The assessment was carried out over the whole of Nyeri District. The bulk of natural fauna and flora is confined to protected national parks and reserves, and none of the project activities are expected to encroach into such areas.

There are three agro-ecological zones - the upper Highland zone near the mountain forests, with tea, subsistence crops, dairy farming, and fruit orchards, the upper Midland zone in the southern parts of the district, with similar land use, but also with coffee and horticulture, and the drier Lower Highland zone in the north, which has been a ranching, wheat and barley zone, but is increasingly being turned to irrigated horticulture use. Nyeri town is situated on the border between the Upper Midland and Lower Highland zones.

Data on causes of morbidity (illness) and mortality (death) have not been maintained from the 1980s onwards, and individual health facilities were reluctant to release their records, except for one health centre in the CBD. Overall, it was found from a 1995 survey that in Nyeri district only 13.7% of the population reported being sick per annum, which is a relatively low rate. This was attributed to high availability of health care facilities, these

being within 8 km for 94% of the population. Infant mortality was 3.5% in 1989, compared to a national average of 6.2%. Nutrition levels were high, except for the dry northern parts of the districts, and pockets within fertile areas where too much emphasis was being placed on cash crops at the expense of essential subsistence crops.

Records from the 1970s show that water borne diseases such as Gastroenteritis and Typhoid were being reported, but were not the predominate causes of illness. The recent records from the one health centre which released them showed no incidence of a water borne disease being reported in a four month period, but hygiene related illnesses such as diarrhoea and instestinal worms were fairly common.

Natural surface waters were found to be of excellent chemical quality, but all contaminated with faecal coliform. In the high reaches of rivers this contamination is of animal rather than human origin. The Amboni river has higher contamination than the Chania river, and further there is the expectation that significant upstream abstraction from the Amboni river is likely to increase in the coming years. On the Chania river, increasing use of agro-chemicals between the forest and the Ihwa intake, a river distance of 6 km, may be a future problem.

Existing environmental issues in the project area are the beginning of a soil erosion problem due to increasing cultivation of steep slopes, intermittent problems with waste discharges from coffee factories, stone quarrying along river valleys, cultivation of riparian reserves, inadequate refuse collection and drainage, and lack of adequate supplies of potable water.

Negative impacts by the proposed project can be increased soil erosion, dust and noise pollution during construction, and pollution if chemical wastes are improperly discharged in the operational phase. Mitigation should include proper reinstatement after construction and proper arrangements for treatment works waste disposal. Positive project impacts are expected to be on human health, ease of use and effectiveness of sanitation facilities and improved quality of human life. An environmental impact matrix is presented on page 9-12.

17. Sanitation Impacts

Existing sanitation problems are in the large part associated with inadequate water supply and thus ineffectiveness of water borne systems. One small area in the upper CBD does however need sewers; it was originally to have a bus park but is now built up with commercial buildings. Pit latrines are generally deep, clean and inoffensive but where timber floors have been used they need to be replaced by concrete slabs.

Within the project horizon, it is only a small part of Ruringu that may need to be sewered in the near future, and possibly the Kamakwa area and Mathari village later on. Due to their separation from the presently sewered area however, the latter two areas could be provided with a local sewer system, feeding into communal septic tanks, and these sewer systems could be incorporated into the main system at a much later time. On plot systems are expected to continue to be adequate in all other areas.

The design of the existing sewers and sewage works was for the year 2000, but this included some areas which were to be sewered later, and which need not be incorporated into the system since on-plot sanitation can continue to suffice. Overall it is estimated that the Phase II augmentation of the sewage works will be needed by about 2005 and would be adequate for at least 10 years after that, and the trunk sewers will need augmentation by about 2010. This is based on an expectation of adequate water supply and of no major extensions to the sewered area.

18. Need for a Project

The present system can only supply less than half of present water requirements leading to severe water shortages, and in some areas no water supply at all.

Some of the effects of this situation are on commercial and industrial development and thus on creation of employment. In a situation of increasing unemployment, social problems and crime are expected to grow. Provision of public services such as running of health facilities and fire fighting services are affected. Although the present incidence of water borne diseases is low, this situation can be expected to deteriorate if adequate potable water is not supplied. Ineffectiveness of water borne sanitation increases the health risks.

Other negative effects of the lack of adequate water supply are in reduced productivity of labour, with time being spent in search of alternative supplies, and in forced idleness due to morbidity. Loss of time in water procurement is felt greatest by women who are expected to fulfill that role. This reduces the time available to them for self improvement activities.

An adequate water supply would have a substantial impact on virtually all sectors of human activity, and generally give rise to an improvement in the quality of life of the population.

A Logical Framework Matrix for the proposed project is presented on Page 11-7.

19. Recommended Project

It is recommended that the project to be implemented should include the Kiganjo area on the grounds that

(i) future physical development especially of industry is likely to be directed towards Kiganjo where there is cheaper and more available land, and better topography and communications,

(ii) the focus of economic activity is moving away from the traditional food/cash crops grown near Nyeri, to horticulture and floriculture in areas to the north, which will give Kiganjo an increasingly greater role than Nyeri as a market centre,

(iii) the financial costs per unit of water produced are lower with project options which include Kiganjo being served from Nyeri, as compared with project options where the supply area covers Nyeri alone,

(iv) of all the project options that have been considered (with or without Kiganjo), the one with the lowest average incremental financial cost per unit water produced, is one of those which include Kiganjo in the new project, and

(v) there is no practicable scenario under which the Council could cease to be responsible for water services in Kiganjo, whether that area is included in this project or not, thus if excluded, Kiganjo could be a drain on resources in attempts to maintain the existing supply in operation.

Including Kiganjo raises the prospective investment costs by Shs. 128 million (DM 3.2 million) in the recommended project option, and would constitute 22% of the investment cost.

The principle aspects of comparison of the project options is presented in Table 1 overleaf.

The options where the scheme is combined to serve both Nyeri and Kiganjo from one source (options A1 and B1) are clearly more favorable than those where the Kiganjo system would be developed as a separate entity (options A2 and B2). Option A1, where all the water is treated at Kamakwa, has the advantage of a lower investment cost and centralised treatment works. Option B1 however, has very limited pumping, leading to a lower financial cost, lower recurrent expenditure, lower maintenance and renewal requirements, and greater security against disruption of water supply through breakdowns of plant and power outages.

Taking the above into consideration, and using the financial cost as the overriding criterion:

the recommended project is **Option B1**

which would involve: new treatment works at Kiriti (nearer the existing intake than the existing treatment works), operated alongside the existing Kamakwa works, and serving both Nyeri and Kiganjo,

at a capital cost of: KShs. 573.5 million [DM 14.3 million]

If these recommendations are accepted, the Consultant will proceed to detail and cost that option to a higher degree, and report on this in the Feasibility Report.

Table 1
PRINCIPLE ASPECTS OF COMPARISON OF OPTIONS RECOMMENDED FOR CONSIDERATION

1. OPTIONS FOR SUPPLYING BOTH NYERI AND KIGANJO

	OPTION A1	OPTION A2	OPTION B1	OPTION B2
	Treatment Works for both Nyeri and Kiganjo at the existing Kamakwa site.	*Treatment Works for Nyeri at the existing Kamakwa site, and separate works for Kiganjo.*	*New Treatment Works for both Nyeri and Kiganjo at the new Kiriti site, and continued use of the existing Kamakwa Works.*	*New Treatment Works for Nyeri at the Kiriti site, continued use of the existing Kamakwa Works, and separate works for Kiganjo.*
Proportion of clear water to be pumped	9%	24%	1%	16%
Number of treatment works sites	1	2	2	3
Personnel requirements	Lowest			Highest
Investment cost for year 2010 works	Shs. 504.2 mio. DM 12.6 mio.	Shs. 532.0 mio. DM 13.3 mio.	Shs. 573.5 mio. DM 14.3 mio.	Shs. 564.2 mio. DM 14.1 mio.
Average incremental financial cost per unit produced	18.14 Shs/m3	24.79 Shs/m3	17.72 Shs/m3	22.82 Shs/m3

2. OPTIONS FOR SUPPLYING NYERI ONLY

	OPTION A	OPTION B
	Treament Works at Kamakwa.	*New Treatment Works at Kiriti, and continued use of existing Kamakwa Works.*
Investment cost for year 2010 works	Shs. 413.3 mio. DM 10.3 mio.	Shs. 445.4 mio. DM 11.1 mio.
Average incremental financial cost per unit produced	21.04 Shs/m3	18.31 Shs/m3

<1> *Kenya Shillings converted to DM at the current rate of 1 DM = KShs. 40*

<2> *Financial costs at 10% discount rate, and upto the year 2010*

NYRCOMP1.XLS Sheet1 04/03/96 09:17

DRAFT

REPUBLIC OF KENYA

MINISTRY OF LOCAL GOVERNMENT
ON BEHALF OF
NYERI MUNICIPAL COUNCIL

KfW Kreditanstalt für Wiederaufbau
(KfW ASSISTED)

NYERI WATER SUPPLY FEASIBILITY STUDY

PRE-FEASIBILITY REPORT

Volume I : Main Report

Gauff Ingenieure JBG

FRANKFURT AM MAIN, GERMANY
AND
NAIROBI, KENYA

JANUARY 1996

NYERI A1

NYERI WATER SUPPLY FEASIBILITY STUDY

Index

Volume I : Main Report

Preface : Executive Summary

Section	Contents	Page
1.	**INTRODUCTION**	**1 - 1**
1.1	Study Stages	1 - 1
1.2	Scope of this Report	1 - 2
1.3	Situation Assessment Findings	1 - 2
1.4	Availability of Existing Records	1 - 7
1.5	Illustrations in this Report	1 - 7
2.	**PRESENT LAND USE**	**2 - 1**
2.1	General	2 - 1
2.2.	Central Areas	2 - 1
2.3	Western Suburbs	2 - 3
2.4	Chania River North Bank	2 - 4
2.5	Eastern Suburbs	2 - 6
2.6	Kiganjo	2 - 6
2.7	Other Areas	2 - 7
3.	**PROJECTIONS OF LAND USE CHANGES**	**3 - 1**
3.1	Physical Development Planning	3 - 1
3.2	Expected Land Use Changes	3 - 2
3.3	Overall Expectations	3 - 5
4.	**PROPOSED SERVICE AREA AND LEVEL**	**4 - 1**
4.1	Service Area	4 - 1
4.2	Potential for Public Taps	4 - 3
4.3	Service Levels	4 - 5
5.	**DEMAND FORECASTS**	**5 - 1**
5.1	Horizons	5 - 1
5.2	Present Demand from Existing Consumers	5 - 1
5.3	Present Demand in Proposed Supply Area	5 - 3
5.4	Demand Growth Factors	5 - 7

Index (Cont'd)

Section	Contents	Page
5.5	Future and Ultimate Demands	5 - 11
5.6	Adjustments to Average Demands	5 - 14
6.	**PROJECT OPTIONS**	**6 - 1**
6.1	General	6 - 1
6.2	Earlier Studies	6 - 1
6.3	Supply Zones	6 - 3
6.4	Treatment Works Location	6 - 4
6.5	Basic Project Options	6 - 6
6.6	Treatment Works Process Selection	6 - 12
6.7	Sizing of Treatment Works Components	6 - 13
6.8	Storage	6 - 17
6.9	Reticulation	6 - 19
7.	**COMPARISON OF OPTIONS**	**7 - 1**
7.1	Technical Comparison	7 - 1
7.2	Construction Costs	7 - 5
7.3	Financial Comparison	7 - 5
7.4	Conclusions	7 - 6
8.	**SOCIO-ECONOMIC REVIEW**	**8 - 1**
8.1	Introduction	8 - 1
8.2	Historical Perspective	8 - 1
8.3	Demography and Demographic Indication	8 - 3
8.4	Property Values and Development Patterns	8 - 5
8.5	Living Standards and the Poor	8 - 6
9.	**ENVIRONMENTAL IMPACT ASSESSMENT**	**9 - 1**
9.1	General	9 - 1
9.2	Topography and Geology	9 - 1
9.3	Climate	9 - 2
9.4	Flora	9 - 3
9.5	Fauna	9 - 3
9.6	Land Use and Tenure	9 - 4
9.7	Human Health	9 - 5

Index (Cont'd)

Section	Contents	Page
9.8	Poverty	9 - 6
9.9	Gender Issues	9 - 7
9.10	Surface Water Sources	9 - 7
9.11	Existing Environmental Problems	9 - 8
9.12	Project Impacts	9 - 9
9.13	Mitigation Against Negative Impacts	9 - 10
10.	**SANITATION IMPACTS**	**10 - 1**
10.1	General	10 - 1
10.2	Field Investigations	10 - 1
10.3	On-Plot Sanitation	10 - 6
10.4	Capacity of Existing Sewerage System	10 - 7
11.	**NEED FOR A PROJECT**	**11 - 1**
11.1	Present Situation and it's Effects	11 - 1
11.2	Water Borne Diseases	11 - 1
11.3	Sanitation	11 - 1
11.4	Commerce and Industry	11 - 3
11.5	Public Services	11 - 4
11.6	Labour Productivity	11 - 4
11.7	Quality of Life	11 - 5
11.6	Environmental Quality	11 - 5
11.7	Summary	11 - 6

Annexes

Annex 1	:	Terms of Reference
Annex 2	:	Socio-Economic Review
Annex 3	:	Environmental Impact Assessment
Annex 4	:	Cost and Financial Details
Annex 5	:	Correspondence

1. INTRODUCTION

1.1 Study Stages

This study is divided into three distinct stages, each of which is to be completed and reported on separately, and before proceeding to the next study stage. The study stages and their principal components are as follows:

(a) Assessment of Situation (Inception Report):

An assessment of the existing situation with regard to:

(i) water supply facilities, water connections, and urgent rehabilitation measures.
(ii) water consumption
(iii) water demand and supply capacity
(iv) water production, billing and revenue collection, the necessity for a block mapping and consumer survey
(v) cost of water supply, cost covering tariff
(vi) Municipal budget and water/sanitation expenditure
(vii) a brief description of sanitary facilities including on-lot systems, and necessity for sewer network and sewage works expansion

(b) Pre-feasibility

(i) water consumption, and future demand for the years 2010 and 2015; the need for a project.
(ii) define alternatives for a project
(iii) layouts, preliminary quantities and cost estimates for project alternatives
(iv) recommendations on optimum solutions by technical/economic comparison
(v) implications of project proposals on sanitation situation
(vi) environmental and socio-economic impacts of proposed project
(vii) define project objectives and achievement indicators

(c) Feasibility

(i) preliminary design of selected project alternative, including cost estimates
(ii) detailed elaboration of operation and maintenance (O & M) costs
(iii) economic/financial analysis of the project and its effect on the population
(iv) proposals for tariff structure
(v) guidelines on staffing and personal establishment
(vi) detailed proposals on billing and revenue collection

(vi) proposals for water and sanitation services organisational setup.

Under cover of letter of 14th July 1995, the Situation Assessment Report was submitted to the Client. Although final approval of that report has not been provided, the Consultant was subsequently permitted to proceed to the next study stage, as reported on herein.

1.2 Scope of this Report

This Pre-feasibility Report covers that second stage of the study. It essentially comprises an outline of the development scenarios, and their comparison.

Within the comparison of project alternatives, both technical and financial/economic factors are considered.

This report also provides information on the impacts of the proposed project on the sanitation situation, and also on socio-economic and environmental situations.

The Terms of Reference only required that investigations and development of project alternatives be carried out for the "Nyeri Town" area of Nyeri Municipality, leaving out other areas which are presently served by the Municipal Council's Kiganjo Water Supply, the Aguthi Water Supply (run by National Water Conservation and Pipeline Corporation), Tetu-Thegenge Water Supply (Ministry of Land Reclamation, Regional and Water Development), large holdings and forests outside those supplies, and unserved rural populations.

It has been considered that out of these areas which were to be excluded, Kiganjo required some investigation. In the first place, the Municipal Council is the water undertaker for that service area, and there is no practical scenario under which it is envisaged this would cease to be the case. One may also consider that whereas the Nyeri town and Kiganjo Systems are at present separated physically, they are administered together, and their financial situations are inter-related. Thus the Kiganjo system, whether augmented or not, will continue to have a direct effect on the Municipal Council's water and sanitation services, including any augmented Nyeri town system.

This report therefore includes the study of development scenarios for the Kiganjo system.

1.3 Situation Assessment Findings

1.3.1 Scope of that Report

The first study stage Situation Assessment Report covered the investigation of the existing water and sanitation facilities and services, and the administration and the financing of those services.

The principal aspects of the findings of that study were as follows.

1.3.2 Service Area

The Municipality is 208 km^2 in area but most of this is essentially rural and outside the service area of the Council water and sanitation supplies. Two separate service areas of Nyeri town and Kiganjo exist, the latter downslope and to the east of Nyeri town. Nyeri town is important as an administrative centre with limited industrial activity. Kiganjo is the railway station for Nyeri, and has institutional and some industrial significance.

1.3.3 Raw Water Sources

The Chania river with its headwaters on the Aberdare (Nyandarua) mountains is the present source of water for Nyeri town and has a 98% daily reliable flow of 27,560 m^3/day, against present abstraction of about 6,000 m^3/day. The present source for Kiganjo is the Nairobi river which originates on the slopes of Mount Kenya but is unreliable due to a level of upstream abstraction which almost dries up the river in the dry seasons. The Amboni river also flowing from the Aberdares could be a more reliable source for Kiganjo, having 98% daily reliable flow of about 10,370 m^3/day.

1.3.4 Demography

Boundary changes between the 1979 and 1989 cencii, and the refusal by the Central Bureau of Statistics to release the associated mapping, which for 1989 is reported to have been very detailed, made precise analysis for population growth difficult. The Nyeri Municipal area of 1989 (167 km^2) had 91,539 people, of whom 51,415 were estimated by the Consultant to have been in "urban" areas. Growth rates were estimated at 3.7% for urban areas, 2.2% for rural areas and 3.0% for the Municipality as a whole, but these figures were based on available information and some approximations.

1.3.5 Existing Water Supply Systems

The existing Nyeri Town water supply system is based on gravity abstraction from the Ihwa intake, on the Chania river, 6 km from the treatment works, and on a less important pumped intake on the Chania river, near the town. The treatment works are at Kamakwa and have a nominal capacity of 5,580 m^3/day but have recently produced an estimated 6,500 m^3/day after a leak on the raw water main which was limiting raw water supply was discovered and repaired. The distribution of treated water is essentially by gravity.

Kiganjo has a separate water supply system based on pumping from the Nairobi river, and pumping into distribution. Production has fallen from an average of 1,020 m^3/day in 1991 to 765 m^3/day in 1994. This is due to problems in pump maintenance and increased abstraction from the Nairobi river by upstream users.

The rural areas of small scale farming to the south and west of Nyeri town are served by two rural water supplies. One is the Aguthi Water Supply (NWCPC) which is generally adequate except in the extremities of the distribution, such as near the Nyeri town urban area, where water rarely reaches. The other is the Tetu-Thegenge Water Supply (Water Ministry) which

is wholly inadequate. Some other areas have small water supplies in various stages on implementation. Few heavily populated areas remain outside these supplies. A number of large (mainly institutional) consumers have individual supplies.

1.3.6 Water Consumption and Demand

In the Council records it was found that there were 4,577 registered consumers (both Nyeri and Kiganjo) of which 550 were "inactive" (they had a connection but had closed their account, largely due to lack of water in that area), the balance being 4,027 "active" consumers who had a running account. The Consultant enumerated 3,884 consumers in the meter reading books.

Consumption of water was estimated to be domestic users 42%, institutions 36%, commercial use 19%, and industry 3%.

There were 96 No. large consumers (>100 m^3/month) who consume nearly half the water supplied and generate 60% of the revenue. Most of the large consumers are public institutions. Large consumers accounted for most of the consumption in Kiganjo. On the other hand, small consumers have a higher rate of suppressed demand, thus the large consumers would have a lower proportion of consumption if the supplies were adequate.

The average daily demand at present including 37% water losses for the existing consumers in Nyeri town during peak use seasons was estimated to be 14,000 m^3/day, more than twice the treatment works capacity.

The existing reticulation system was found to be of insufficient size (largest pipes 200 mm dia) and with adequate water production would only assure a few consumers around the treatment works of at least their average daily demand. Large areas were receiving occasional or no water supply.

1.3.7 Billing and Revenue Collection

Based on sampling, over 80% of consumers were found to have functioning meters that were accessible and regularly read, 2% not to have meters at all, and the balance out-of-order meters, buried meters, and properties where access to the meter was often difficult. It was found that the large consumers' meters were all read regularly; only bills of very small consumers were allowed to be estimated. Meter reading was observed to be very closely supervised, and it was noted that all estimated bills were based on estimates done personally the Council Engineer.

Bills were being issued for about 63% of water produced in Nyeri Town, and 83% in Kiganjo. Revenue collection was very commendable, and was over 99% of billing in the previous 3 financial years. Water bill debts (total value of unpaid water bills) had held steady at the equivalent of about 4 months billing. Great significance was being placed on revenue collection and billing, with direct attention to these aspects by senior Council officials. Most of the water unaccounted for was considered attributable to physical causes.

1.3.8 Tariffs and Costs

The Situation Assessment found that in 1992/93, the revenue from water and sanitation services just about covered O & M costs, but went in to serious deficit after the high inflation of 1993. Annual revenue between the 1991/92 and 1993/94 financial years ranged from Shs 11.3 mio to Shs 14.2 mio. In September 1994 the tariffs were doubled, and it was projected that in the 1995/96 financial year, O & M costs will be covered, together with part of existing loan obligations. The present tariff is from Shs 14/m^3 in the 6 - 20 m^3/mth range, to Shs. 22/m^3 for over 50 m^3/mth. This is roughly equivalent to the NWCPC tariff (such as in is applied in Aguthi) but is only half the NWCPC tariff in the above 100 m^3/month range. This was noted to have significant financial implications. A tariff revision was recommended to be implemented in mid 1996 to allow some time gap from the recent very large increase. The recommended magnitude of increase will be reported on in the Feasibility Report, in the next study stage.

1.3.9 Organisation and Staff

It was reported that the water and sanitation services fell under the Town Engineer's department, but that a separate department within the Municipal Council was being set up. There was a serious shortfall within senior positions for these services, with vacancies in both assistant engineer posts, no sewage works manager, and all 13 foremen posts vacant. The Engineer was being assisted in the Water Section by a superintendent and two technicians, and in the Sewerage Section by an assistant works manager and 3 technicians. The dedication of the present Engineer was seen as a significant factor in the continued running of the services.

1.3.10 Financing

The Situation Assessment report found that the Council did not have monies set aside in a replacement and renewals fund, due to financial constraints. Water and Sanitation loan debts stood at Shs. 250 million, 95% being for sewerage. No significant repayments had been made on the sewerage loan and arrears were accumulating.

Council revenue was found to be maintained in four separate accounts in different banks, one being for water and sewerage. The monies were being kept distinct, but some "borrowing" between accounts was practised when one was in surplus and another in deficit. In 1994 the Water account was a net borrower, but after the tariff increase had "repaid" most of the amounts obtained from other accounts.

There was no distinction being made between revenue/expenditure for water and that for sewerage.

1.3.11 Sanitation

The Nyeri town sewerage system was found to cover almost all densely built up areas. The Kiganjo sewers cover the main Kiganjo centre and most large institutions; the other densely

populated parts of the Kiganjo area were noted to need a new sewage pumping station if they were to be included in the coverage. The rest of the Municipality is served by on-plot systems. Based on physical inspections, septic tanks were in the large part of acceptable standards, but many pit latrine slabs were not. There were a few VIPs found, but the concept did not seem to be understood and they were not properly constructed.

The recently completed Nyeri town sewage works were reported to be based on double stage biofiltration and maturation ponds. Principal problems were extensive recirculation pumping due to the inadequate in-flows to the works (needed to turn the bio-filter arms) and failure of mechanical seals on submersible sewage pumps. For the first problem, a reduction in length of bio-filter distributor arms or other modifications were seen as practicable. The requirements for pumps with lesser maintenance difficulties was also seen as being in need of investigation.

The Nyeri town sewage works were designed for 6,000 m^3/day in-flow; measurements taken by the Consultant over 3 months put the present in-flows at about 2,100 m^3/day.

The Kiganjo sewers terminate at a sewage pump station with submersible pumps which are similar to those at the Nyeri works, and with similar problems. The sewage is then pumped 2 km to sewage ponds (anaerobic, facultative and maturation). The sludge drying beds for these works are in a swampy area so do not work; thus sludge draining from the anaerobic ponds was not being carried out.

1.3.12 Urgent Measures

Measures seen in the Situation Assessment as urgently required included (i) computerization of billing, (ii) a block mapping and consumer survey, (iii) a leak detection exercise, and (iv) an immediate works rehabilitation/augmentation programme.

The computerization of billing proceeded under an addendum to the Consultancy agreement.

Discussions with the project Financier in November 1995 resulted in it becoming apparent that donor funds for this study could not be a means through which the other proposals could be executed. It was considered that a blockmapping and consumer survey could be a precursor to an investment programme, under the financing for the construction project. If an immediate works programme were to be instituted, it would also need to come under the project rather than study financing, should it be deemed appropriate.

In those discussions, the Council was encouraged to institute physical water loss reduction measures with their own resources. To assist in financial water loss reductions the Financier offered to pay for the procurement of 500 No. consumer water meters. This procurement is in hand.

1.4 Availability of Existing Records

In the Situation Assessment Report, one of the constraints mentioned was lack of access to some critical existing records, these being:

(i) the mapping associated with the 1979 and 1989 cencii

(ii) drawings of the existing water supply facilities which had been retained by the Water Ministry after they handed over as water undertaker to the Municipal Council in 1982, and

(iii) drawings associated with the previous water supply study, carried out in the early 1980s.

The mapping associated with past cencii has not been, and is not expected to be availed.

Following discussions with the Water Ministry by the Client and the Financier in November 1995, the Water Ministry reviewed it's earlier position with regard to assistance with access to drawings.

In discussions of 21st November 1995, the Consultant was informed that the drawings available in Maji House could be obtained. After provision of materials for reproduction, the drawings were provided on 8th December 1995.

The Consultant was also provided with a letter dated 22nd November 1995, addressed to Sir Alexander Gibb and Partners, authorising the release of the drawings for the earlier study. These drawings were obtained on 22nd December 1995.

This report has taken into account the information available from those records. In addition, the final version of the drawings for the Situation Assessment Report, which are yet to be submitted, will take into account the information in the drawings obtained from the Water Ministry.

1.5 Illustrations in this Report

In light of the basic intents of this report, which are to outline the alternatives available for future development, and to compare and contrast them, the drawings presented mainly serve illustrative purposes. The mapping done at the Situation Assessment Report stage of this study has been used for the layout maps. For clarity, these maps are reproduced in Figures 1.1 and 1.2 overleaf, with principal place names given. These maps may be referred to during perusal of this report to obtain an indication of the places being referred to.

Figure 1.1
PLACE NAMES - OUTLYING AREAS

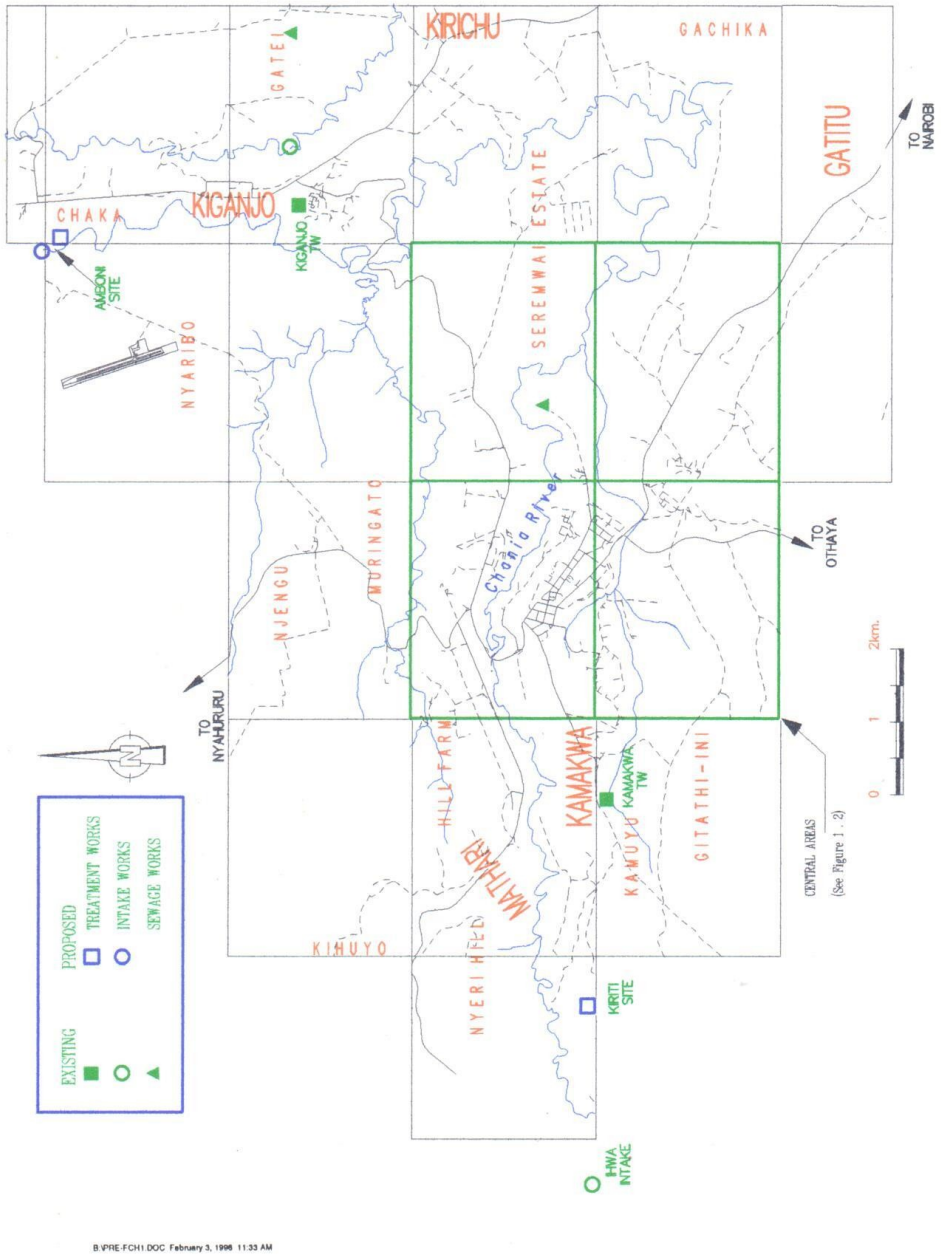
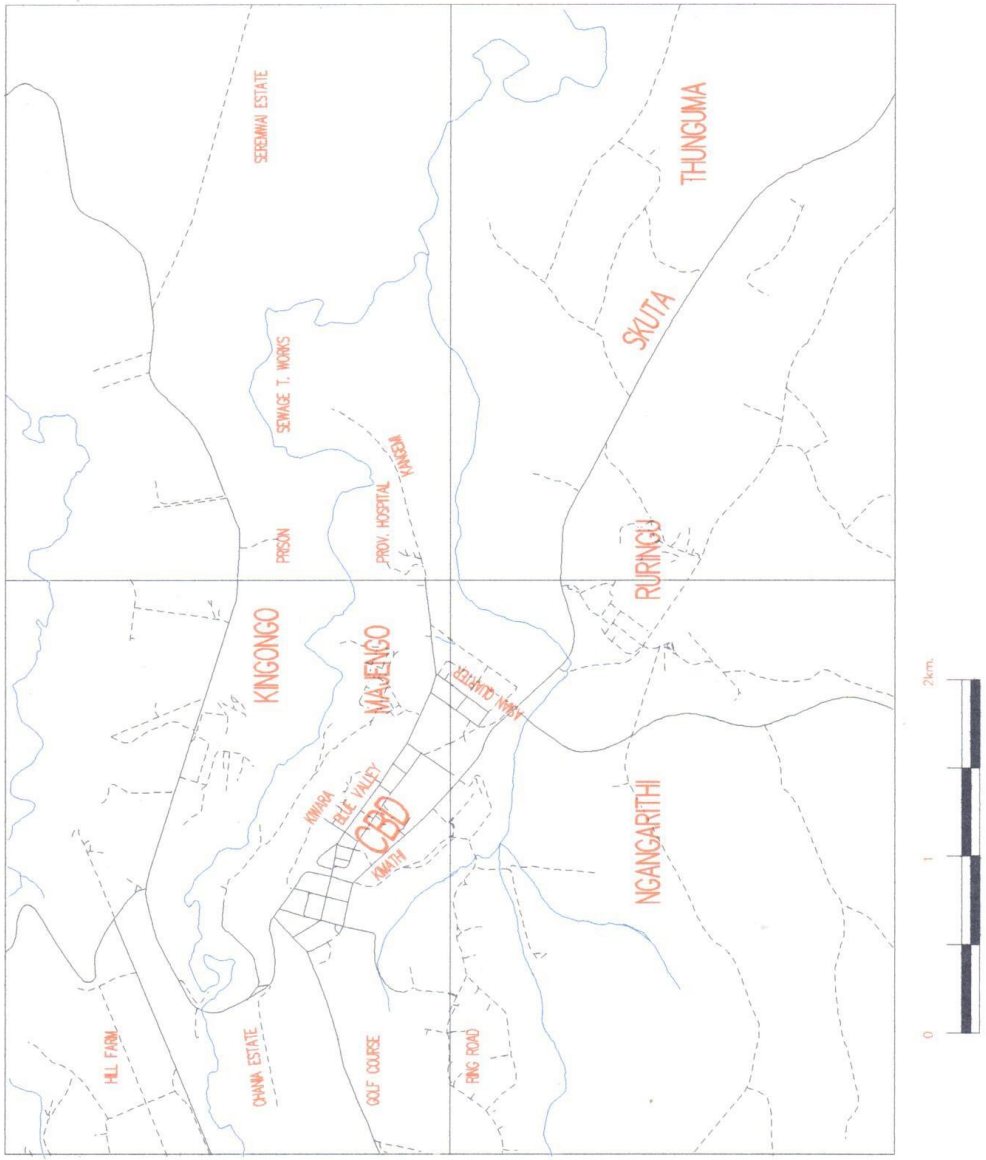


Figure 1.2
PLACE NAMES - CENTRAL AREAS



B:\PRE-FCH1.DOC January 26, 1996 12:08 PM

2. PRESENT LAND USE

2.1 General

The most striking aspects of the present land use is it's wide disparity, the changes in predominate development type over short distances, and the manner of mixing of different structures within one area.

There are three principal features which govern the distribution of land use categories: large holdings, rivers and the agricultural potential of the land.

River valleys in the project area are steep, and therefore seem to be the last choice for developers. Most roads also run along the tops of ridges, making access to valley bottoms difficult. It is therefore a common sight for valleys between two heavily built up areas to be under agricultural use.

To the north and west of the Nyeri town area are two large holdings - the Catholic Church owned Hill Farm, and the individually owned Seremwai Estate. Both of these act as a curb on urban development into those areas.

Lastly, there are the drier areas further north and to the northwest. Due to the manner in which urban development has been driven, as discussed below, the lack of agricultural potential has had a dampening factor on human settlement which has led to lack of urbanisation.

The key growth centres have been Nyeri "town" (or Mukaro), Ruringu, Mathari and Kiganjo. Both Mukaro and Ruringu have had administrative functions as the main development factor, Mukaro for central government functions (Provincial and District headquarters) and Ruringu as the seat of the local government district body (County Council). Mathari has grown from the Catholic Church institutions, and the later development of large educational institutions on church donated land. Kiganjo owes it's initial growth to the railway station, and later to the large educational institutions situated there.

2.2 Central Areas

The central areas are considered to be the Central Business District (CBD) and the adjacent Ring Road, Kimathi, Asian Quarter, Kangemi, Blue Valley, Majengo and King'ong'o areas.

Central Business District

The CBD has an elongated shape, generally following two main streets with adjacent side streets, and occupies roughly 2 km^2. At the northwest end are the principal government offices, and the lower (southeast) end has the Provincial General Hospital and Presbyterian Church institutions.

Virtually all of the business in this CBD are retail shops, distributors, and service outlets (cafes, butcheries, lodgings, etc.). There are also three bus parks, a small stadium, and a warehousing area.

Majengo/Blue Valley

The most densely populated housing in the Municipality is adjacent to the CBD on the northern side. The Blue Valley housing was a formal low cost housing development which originally housed public servants. This is adjacent to the original Majengo area which had self constructed housing, mostly for migrant labour from distant places. Growth has occurred around these two principal settlements, but is predominantly low cost housing, both temporary and permanent, mixed with commercial properties and informal industry premises *[see Picture 1 on Page 2 - 9]*

Kangemi

The Kangemi area is to the east of the CBD and Majengo, past the Provincial General Hospital on the way to the Sewage Treatment Works. Development in this area is fairly recent, but it has rapidly assumed a densely populated low cost permanent housing character. Most of the urban type housing is however still fairly close to the main road, with very small agricultural holdings and temporary low cost housing in the valleys on both sides of the main road. *[see Picture 6]*

Further down the road is a large property owned by Kenya Breweries, on which a malting plant was to be constructed. It is understood the lack of security of water supply has been a principal cause of postponement of construction of this industrial facility.

Asian Quarter

The name is derived from it's previous zoning in colonial times, and the area still has the Hindu and Sikh temples, as well as the educational facilities developed at that time for the Asian community.

The Asian Quarter is located on the right hand side as one approaches the CBD from Nairobi, and is bounded by the CBD to the northwest, Majengo to the north, and Kangemi to the east.

The housing style has been changing with time. Originally, there were a mixture of high cost and middle cost residences only. These older buildings are now mixed with housing for less affluent residents such as flats and blocks of middle income small houses. Community shopping rows have also come up.

Kimathi

This area is on the sides of the valley to the southwest of the CBD.

The principal residential area in Kimathi is a formal low cost permanent housing development. Around it has grown a mixture of high rise housing blocks, low cost permanent residences and some medium cost houses on small individual plots. Further away from the CBD, on the southern side, there is a gradual move towards low cost temporary housing developments, with the valley bottom in agricultural use *[see Picture 2]*. On the western side the area is bounded by the Green Hills Hotel and the adjacent Nyeri Technical Institute, both of which are on fairly large land parcels.

Ring Road

The principal high cost housing district has always been the Ring Road (now officially Mumbi Road) area. This lies to the south of the road from the CBD to Kamakwa. Land parcels are substantial for a residential area, most being of 0.2 ha ($^1/_2$ acre) and larger. There are a good number of very impressive houses in this area. The land adjacent to the road to Kamakwa is occupied by the Golf Course. In this area is also the Mt. Kenya Hospital.

Chania

On the northern side of the Golf Course, going down to the Chania river valley, with the Kamakwa area and CBD to the west and east respectively, is the Chania housing area.

The parts along the main road to Kamakwa are dominated by high income housing, starting from the Provincial Commissioner's official residence near the CBD, to the District Commissioner's residence near Kamakwa. In the middle is the Outspan Hotel. The housing spreads down towards the Chania river valley, and is mixed between medium and high cost residences. *[see Picture 9]*

2.3 Western Suburbs

The urban area on the south bank of the Chania River extends westwards up to Kamakwa, with the adjacent Kamuyu and Gitathi-ini areas.

Kamakwa is a fast growing suburb, with a mixed land usage. There are several public offices and facilities here, including the District Water Office, and the Municipal Council Water Works. The shopping centre itself has more than 40 premises, mostly cafes, retail shops and craftmen's stalls, as well as a busy market, three main churches and a recently constructed small hospital.

Housing around the shopping centre is fairly dense, and predominantly low cost permanent buildings, although some tend towards middle income housing.

Kamuyu is further up the road, going away from the CBD. This is actually a rural trading centre which has began to attract development of suburban housing.

To the south of Kamakwa, across a valley, is Gitathi-ini. This is a relatively densely populated area, but with a rural aspect to the present development. Apart from the shops at the trading centre, the majority of housing is of temporary materials, and on small holdings of about 0.1 ha ($^1/_4$ acre). Surrounding this village are small scale agricultural holdings, but with the beginnings of sub-urban high and medium cost housing development.

2.4 Chania River North Bank

From the CBD, there is only one bridge across the Chania river. After rising from the river valley, the road proceeds east through King'ong'o towards Kiganjo, and there are two branches, one going north towards Nyahururu, and the other to the west, to Mathari.

King'ong'o

King'ong'o is the principal industrial area for Nyeri town, including the Coca Cola and Pepsi bottling plants (Mount Kenya Bottlers and Highlands Mineral Co.), sawmills, and an industrial park. The industrial area extends into the area south of Mathari road *[see Picture 11]*, and north of the Kiganjo road.

There is also a fairly densely built up low to medium cost housing area *[see Picture 10]*

The area further along the road to Kiganjo has several large residential institutions, including the Nyeri Primary School, Baptist High School and the prison.

Mathari

The Mathari area is dominated by large institutions, these being:

1) Kamwenja College

   This is a primary teacher training college on the northern part of Mathari. It consists of about 4 ha. (10 acres) of built up area and (76 acres) of farmed land mixed with livestock keeping.

   The built up area mostly comprises building facilities for administration, dining, recreation, study, student dormitories and teachers quarters.

2) Nyeri High School

   This is a major high school in the municipality with about 1.5 ha. (4 acres) of built up area and 27 ha. (68 acres) of land mostly under forest but with a little farming and livestock keeping. The built up area mainly comprises administrative, dining, study, recreational, boarding and teachers quarters. *[see Picture 12]*

3) Saint Paul Seminary

This is a smaller high school compared to its neighbour Nyeri High School. It occupies about 1.5 ha. (4 acres) of built up land and 20 ha. (50 acres) of farming and livestock keeping land. The built up area comprises of administrative, dining, recreational, study, teacher quarters and priests quarters. *[see Picture 12]*

4) Mathari Mission

This is a large complex *[see Picture 12]* on which various types of church institutions are found including:

(a) Mathari Hospital

This is a hospital consisting of administration, wards, labs, examination, mortuary and residential buildings.

(b) St. Teresa's Primary School

It offers boarding for students and residence for staff members.

(c) Pastoral training centres with housing for the staff.

(d) 2 nursery schools

(e) Mary Immaculate Convent

(f) Procurement section and printing equipment.

5. St. Teresa commercial college

This college is next to the main road on the higher side of Mathari mission with boarding for students and residences for staff.

Between these large institutions is agricultural land for the Hill Farm. This farm is very extensive, and stretches between the Mathari Road and the Kihuyo rural area, to the road to Nyahururu. Most of it is under coffee.

Next to Mathari mission is the Mathari village. This is largely an area of very small holdings (down to less than 0.1 ha or $^1/_4$ acre) with a commercial centre of retail shops. On the slopes of the Nyeri Hill are larger, but still small holdings of between 0.1 ha and 0.4 ha ($^1/_4$ to 1 acre). The predominate housing is of low cost temporary materials, chiefly timber walling and corrugated iron sheet roofing. Occupants of the village mostly work in Hill Farm, but others are employed in the neighbouring institutions and Nyeri Town.

On top of Nyeri Hill there are facilities related to various institutions which require telecommunications repeater equipment. Staff manning these installations live up there.

2.5 Eastern Suburbs

The main commercial centre other than the CBD is Ruringu *[see Pictures 3 and 4]*. This area is located within the fork of the Nyeri-Nairobi and Nyeri-Othaya main roads. Adjacent areas where there is significant development of new housing are Ngangarithi (opposite Ruringu on the Othaya Road) and from Ruringu going towards Nairobi are Skuta, Thunguma and Gatitu.

Housing around the main Ruringu shopping centre is predominantly low cost to medium cost in fairly dense concentration, interspersed with small retail shops, bars and lodging premises. The main stadium for Nyeri is at Ruringu, which also serves as the grounds for annual provincial agricultural shows.

Ngangarithi, Skuta and Thunguma *[see Pictures 5, 7 and 8]* all have similar characteristics. These were all formally areas of purely small scale agricultural holdings, with the occasional local trading centre and maybe church and primary school. Relatively recently, the landowners have sold off small plots to more affluent people who wish to live in suburban areas, these "newcomers" putting up a very wide variety of structures, ranging from opulent mansions, to rows of single roomed temporary dwellings. Although the new very low cost housing tends to be nearer the main road, there is no pattern to this development. Each purchaser puts his land to his own use, with little concern for the environs. One example was seen of a very large clearly expensive house, bordered on one side by a farm of maybe 1.5 ha. (4 acres) with timber walled housing, on the other by a row of attractive middle income maisonettes, and across the narrow access road, a row of single roomed housing made of corrugated iron sheet walls and roofing.

Within the Thunguma area are two noteworthy institutions. To the north of the road to Nairobi is the private Thunguma Academy, and straddling this road is the Wambugu Farm, with the associated Farmers Training Institute.

2.6 Kiganjo

The area which will in this report be referred to as Kiganjo in fact consists of a strip of urban development along the Nairobi-Nanyuki road, on a ridge between the parallel Amboni (Honi) and Nairobi rivers. When approaching from Nairobi (from the south) one first encounters Kirichu trading centre and village, then several large institutions, followed by Kiganjo proper, then the fairly recent developments in the Chaka area.

The Kirichu trading centre *[see Picture 13]* is associated with an adjacent "village" of small plots mostly of 0.05 to 0.1 ha ($^1/_8$ to $^1/_4$ acre) in size. In the village some very intensive subsistence farming is practised, but the residents essentially survive on low income

employment. Most buildings in the village are temporary (mud and wattle or timber walling, with thatch or CGI roofing).

Further along are several institutions, namely Kirichu Primary School, Kagumo High School (one of the oldest and most reputable in the country), the Catholic church run primary school and Sacred Heart Secondary School, and largest of all, the Kiganjo Police College. Along this stretch is also a mortgage housing scheme which is of a standard somewhere between low and medium cost.

The Kiganjo main centre is all on the east side of the main highway. A loop road has the main commercial centre on either side of it *[see Picture 14]*, and the railway station and milk processing factory *[see Picture 15]* are enclosed between the loop road and the highway. The area to the south of the loop road has a mixture of rows of shops, masonry low cost housing, an open market, and also wooden structures which are in mixed residential and commercial usage.

Proceeding north, one passes the solitary wheat mill *[see Picture 16]*, before coming to Chaka *[see Picture 17]*. The development at Chaka is relatively new, and in fact there was almost no building there 5 years ago. The shops and houses are almostly exclusively temporary and in some cases rudimentary. The cause of settlement is the availability of employment in the quarries, match factory, wheat mill and saw mills nearby. A row of shops fronts the main road, with residences behind.

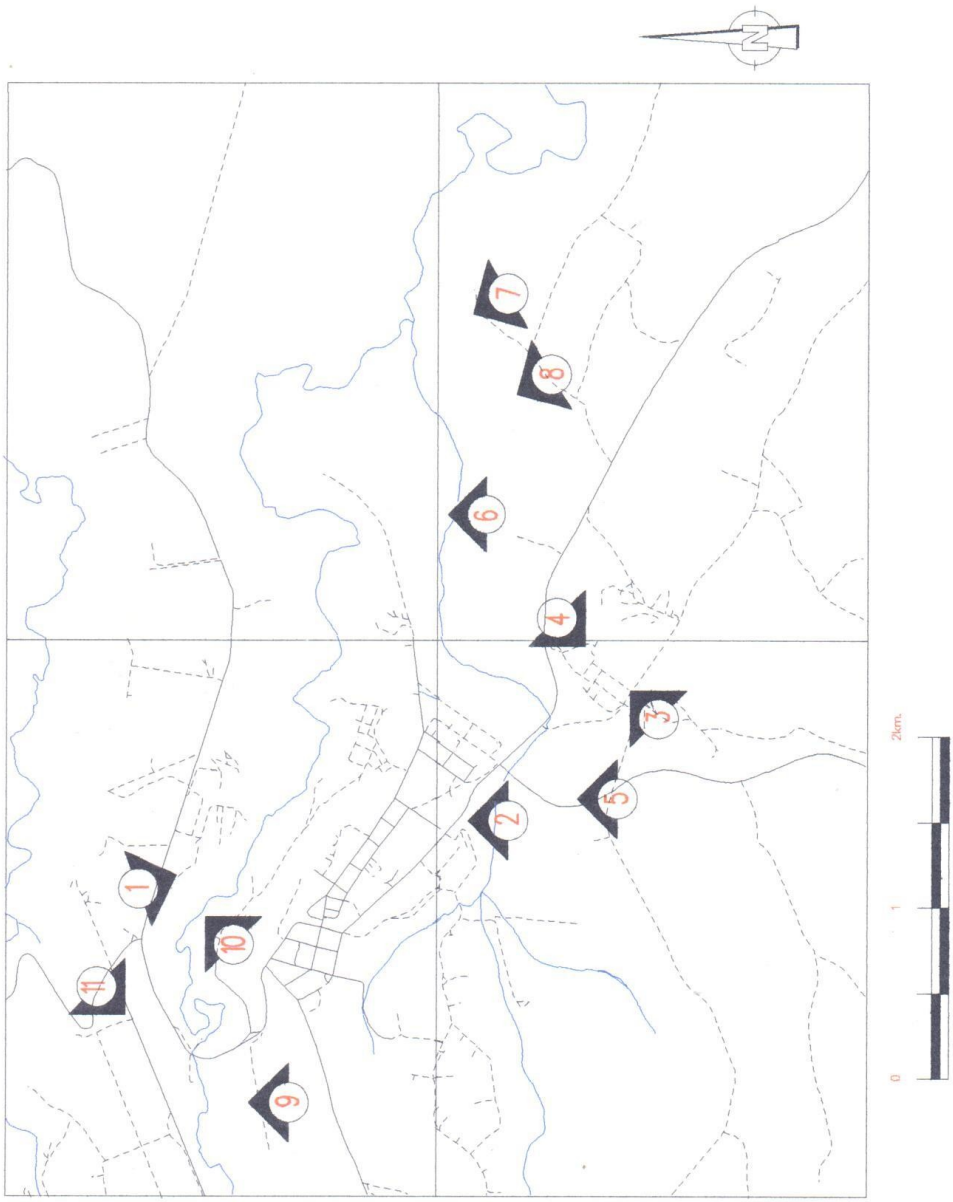
2.7 Other Areas

The rest of the Nyeri Municipality area is essentially rural or forested, with no immediate indication of urbanisation.

In very general terms, the north is dry *[see Picture 18]* , and therefore with little scope for intensive subsistence farming. Immediately about the Nyeri CBD are the Hill Farm, Seremwai and other large estates, which are primarily under coffee. Further north, there is forest on both sides of the road to Nyahururu, and dry grass lands to the east and west of Kiganjo.

The eastern, southern and western extremities are all fertile small scale agricultural properties, interspersed with small shopping centres. The farms are generally in sizes of about 1 to 4 ha. (say 2 to 10 acres) and housing normally low cost, of timber and CGI construction, but with a fair distribution of more substantial residences.

Figure 2.1
LOCATION OF PHOTOGRAPHS - CENTRAL NYERI



B:\PRE-FCH2.DOC February 3, 1996 11:48 AM

PICTURE 1

A view of Majengo, taken from across the Chania valley. The CBD is at the top of the hill, above Majengo. Parts of the King'ong'o housing area are at the left of the picture.

PICTURE 2

Parts of Kimathi low cost housing. More informal low cost housing is developing across the valley.

PICTURES 3 and 4

Parts of the Ruringu commercial area

PICTURE 5

Housing development on the Nyeri - Othaya road, near Ngangarithi.

PICTURE 6

Low cost housing developing on the road to the Sewage Works, at Kangemi. Note that at present, development is at the top of the ridge only. In the foreground are quarries for building stone.

PICTURES 7 and 8

Medium to high cost housing coming up in the farm lands around Skuta and Thunguma.

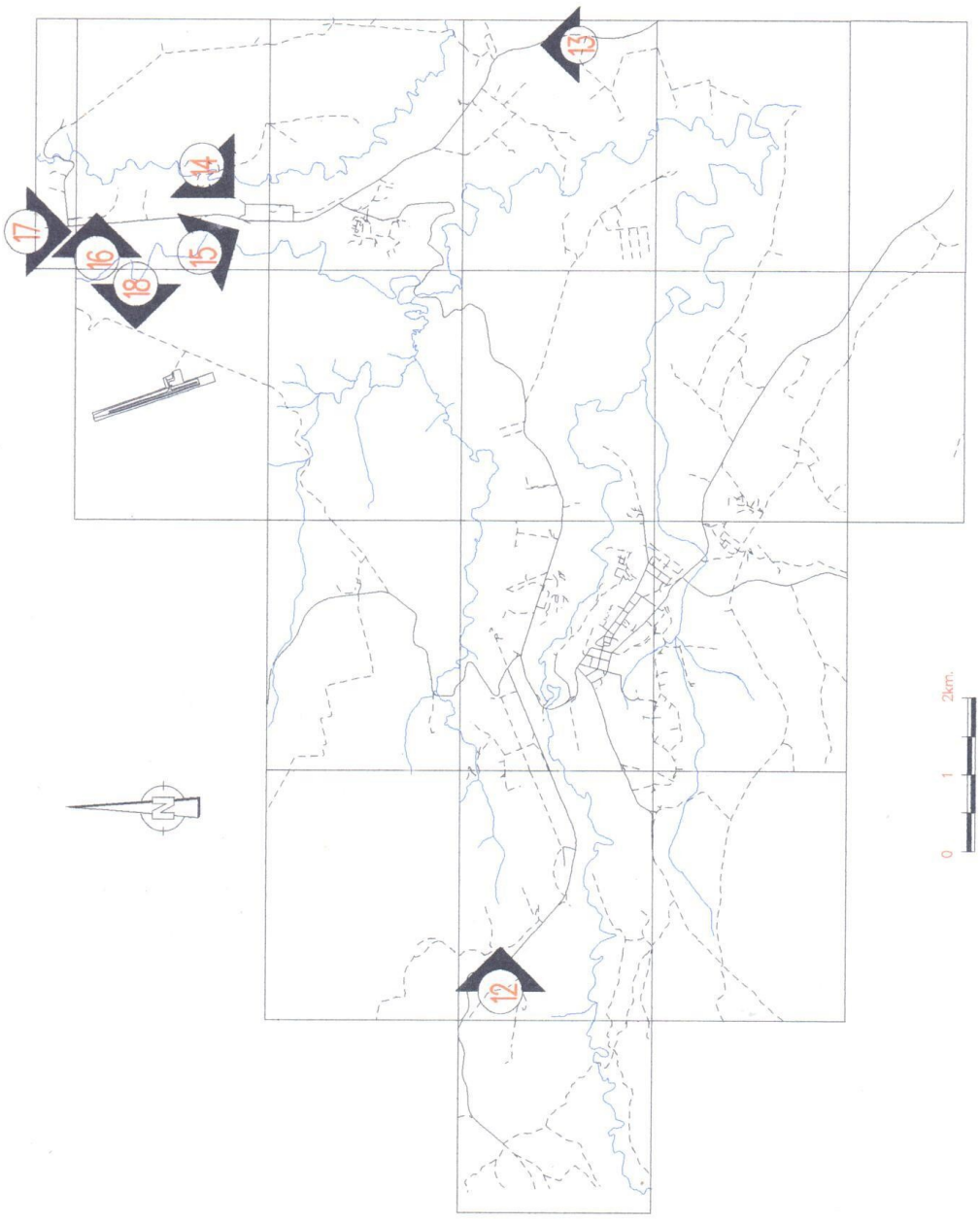
PICTURE 9

Medium cost housing in Chania Estate.

PICTURE 10

The middle left hand side of the picture shows the Ministry of Works Provincial Headquarters, on the south bank of the Chania river. Across the river (See the right hand side of the picture) is the King'ong'o housing area with medium to low cost properties.

Figure 2.2
LOCATION OF PHOTOGRAPHS - OUTLYING AREAS



B:\PRE-FCH2.DOC January 26, 1996 12:14 PM

PICTURE 12

A view of principal institutions - St. Paul's Seminary (left foreground), Nyeri High School (behind St. Paul's) and parts of Mathari Mission in the middle right hand side of the picture. Kamwenja College is out of the picture to the middle left hand side, and there is a commercial college just out of the picture, to the bottom right hand side. The light green expanse (coffee) and darker green in front of the coffee (forest) are within Hill Farm, as are the valleys between the institutions, and the land up to the road at the bottom of the picture.

PICTURE 13

A view of Kirichu centre. The commercial area is in the middle left hand side of the picture. To the right of the shopping centre and behind the church is a densely built up "village" of small plots.

PICTURE 14

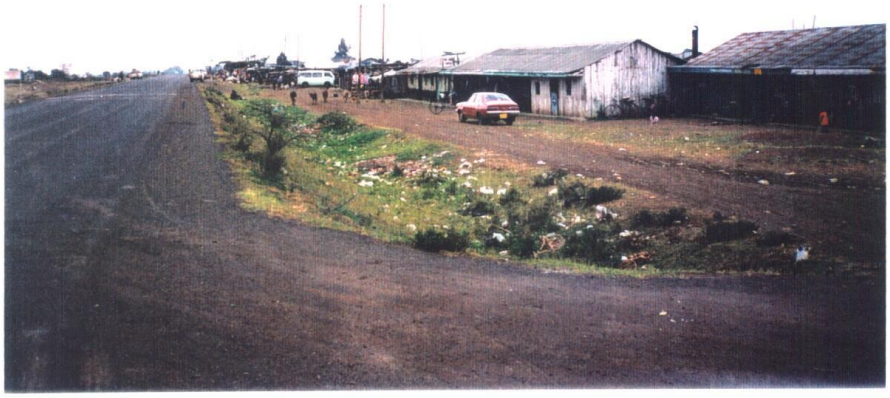
Part of the Kiganjo main commercial street.

PICTURES 15 and 16

Principal industries in Kiganjo. The top picture shows the KCC milk processing plant, and the lower picture the wheat mill.

PICTURE 17

A view of the row of shops at Chaka. Temporary housing is built up behind the shops.



PICTURE 18

The flat open plains in Nyaribo, across the Amboni river from Chaka.

3. PROJECTIONS OF LAND USE CHANGES

3.1 Physical Development Planning

In preparation for this report, particular effort was made to try and define the official expectations with regard to land use changes, and to obtain details of physical plans, land zoning, and other official policy guidelines which would have an effect on the physical growth of urban settlement. These efforts were as follows:

(i) Nyeri Municipal Council

Firstly, the Council does not have a planner, or any staff with physical planning related duties. Further, the Council has not developed a Local Authority Development Plan, which would be the policy document on physical development. It was gathered that where specific need arises, matters related to zoning and physical planning are dealt with by the Chief officers personally. Overall there was no official council document relating to physical development. Information gathering at the Council were therefore confined to obtaining the personal opinions of key people, on past and expected future growth trends.

(ii) Ministry of Agriculture

The District Agricultural Office was contacted in an effort to obtain information on the land use changes in the present farm lands surrounding the urban areas. In particular, some reports quoted in the District Development Plan as having been produced by this office, and whose titles indicated they might be of interest, were sought. No useful information was found. There had been recent changes in key personnel at this office, and the new persons were not able to locate the reports sought, neither did they have personal insight into reasonable expectations.

(iii) District Lands Office

Several discussions were held with a number of members of staff at the District Lands Office, who it had been expected would have had knowledge of land use patterns. No useful information whatsoever was available. This office appeared to confine itself to matters of land ownership registration, and determination of property boundaries.

(iv) District Planning Office

The only pertinent document at this office was the Nyeri District Development Plan, but this had already been obtained earlier. This document is however of very limited use for the present purposes. It is essentially a report on government development projects, and gives status reports on "development indicators" such as literacy, availability of health care facilities and access to utilities. The other pertinent information was related to figures for past cencii, again already available to the

Consultant. This office has a "District Planning Information Centre" which is essentially a library. A thorough search through it's shelves failed to produce any relevant physical planning reports. The only useful results of the visits to this office were in obtaining the personal opinions of the District Planning Officer.

(v) Provincial Physical Planning Office

At this office, the Long Term Development Plan maps at 1:5,000 scale were available for the whole municipal area, although this is not a development plan as such, but an overall map of land parcels, with principal large parcels which have been allocated but not occupied provided with the names of allottees. The limiting factor was however, that the overall maps were last updated in 1978.

Since that time, the Physical Planning Office only prepares what are called Part Development Plans. These are small drawings (about A6 size) showing the details of individual land sub-divisions or land allocations. Every such property boundary change is shown on a separate sheet, and these are maintained in voluminous files. Time was taken to abstract basic details on each such land boundary revision in the last few years, to be able to discern a pattern of parcel size trends.

Other than that, the only other result of the visits to the Provincial Physical Planning Office was being informed that they considered the Municipal Council to be the body which should concern itself with actual physical planning within the Municipal borders.

As can be discerned from the foregoing, there obviously is no specific planning for land use, and no zoning for particular types of properties. The only exceptions to this are areas in Kiganjo excised from forest land for the specific purposes of industrial development.

In view of this, the only practicable means of proceeding has been to take into account the present land use and the apparent trends, and to project what would be a reasonable expectation for the future.

3.2 Expected Land Use Changes

3.2.1 General Trends

The principal factors which are expected to influence physical development are considered to be communication, topography, present land use, and land values.

Communication in Nyeri is closely linked to topograhical features, particularly the deep river valleys and intervening ridges. The two valleys between the CBD and Ruringu to the south, and between the CBD and King'ong'o to the north, have had and are expected to have a continuing impact on the spread of urban development. The first reason for this is the paucity of river crossing points. Approaching Nyeri town from the south, there is only one

way in, although from there it is possible to travel through the CBD to Kamakwa along paved roads, or to go through a southern route, traversing Ngangarithi and Gitathi-ini, to also get to Kamakwa. This later route is presently a growth corridor for suburban housing, and is expected to continue to be so.

Again, communication to the north bank of the Chania river (to King'ong'o, Mathari, Kiganjo and other areas) is only across one bridge. This tends to increase travel times between physically proximate places. Thus the area past the prison towards Kiganjo is only a direct distance of 1 km from the lower parts of the CBD, but the road travel distance between them is more than 6 km.

The other topographical influence is through the lack of development access to valley bottoms, and thus their unattractiveness to developers. Without a public sector initiative to open up such areas, which it would be unsafe to assume will occur, development will be largely in areas where easy road access exists, or can be developed at low cost.

Topography will have an even bigger influence on physical development in Kiganjo. Most of that area is on a relatively narrow flat topped ridge between two deep valleys. The steep valley sides are difficult to open up, leaving a strip of between 500 m to 1 km width along which it is practicable for development to occur. This ridge does however spread out to the south into a much broader "plateau", by the time one reaches Kirichu.

One advantage for development in Kiganjo is the very flat and open nature of the area on top of the ridge.

Present land use is perhaps the most important factor which will have an influence on development, in some cases tied in with the related aspect of land value and attractiveness for the intended purpose.

It has been noted that the Nyeri town area is hemmed in to the north by large privately owned agricultural holdings. Development into the areas these farms occupy will depend on whether the present owners decide to market parts of their properties or not.

Present trends have been for subdivision of land along the Nyeri-Kiganjo road, and the Mathari mission also provided plots to some people on the slopes of Nyeri Hill in the early 1980's. There are prospects for further land sub-division in the former area, but it cannot be expected that Hill Farm will be a source of significant further land allocation.

Overall, it can be expected that these large holdings will maintain their present character in the horizons for this study.

To the southeast and west of the Nyeri CBD, however, are small agricultural properties, mostly inherited by the owners. Urban proximity increases the land values, making the sale of carved out parcels attractive to the original owners, especially those of limited means but substantial obligations for essentials such as education, health care and the like.

In the 1960s and 1970s, trends were for the original owners to sell whole land parcels outright to more affluent town dwellers, who sought a rural "home" for occasional weekend visits, and eventual retirement. The seller would obtain land of far greater agricultural potential (maybe less fertile, but much larger in size) for the same money, in new settlement areas in Kieni, Nyandarua or the Rift Valley. By the 1980s, the scope for such movement became limited. The trend therefore became for those with financial difficulties to carve out small parcels for sale, and to continue to try and make a living on the remaining land. The purchasers would then construct residences from which they would commute to work in Nyeri town.

These suburban residents look for good road access, and availability of utilities, particularly electricity and water. They can therefore be expected to have preference for areas along major roads.

3.2.2 Commercial Land Use

Areas where essentially commercial land use is expected to grow are the present CBD, Ruringu, Kamakwa and Kiganjo.

Growth of the CBD is expected to be constrained by the Chania river on the northern side, and the affluent Ring Road area to the west. The expectation is that most growth will be

(i) into the area along the road to King'ong'o,

(ii) by displacement of the present informal low cost housing in Kiawara and Majengo,

(iii) into Kangemi, but mostly along the road corridor,

(iv) through gradual change in the character of Asian Quarter, and

(v) by changes in the nature and density of properties in the valley on the southern slope away from the CBD, between Kimathi Estate and the area below Green Hills Hotel.

In particular, the informal housing in Kiawara and Majengo presently occupies prime land, and it is expected that the pressure of urban growth will force these people further down, into the less accessible parts of the valley. The people to be affected first will be those with doubtful claim to the land they occupy.

Ruringu was once the cross roads for traffic between Nyeri, Othaya and Nairobi. Road improvements took the main roads away from the built up area, but as is common in Kenya, developers have been moving towards these main paved roads. Development is expected to be towards, and along, the Nyeri-Nairobi and Nyeri-Othaya roads.

Kamakwa again can be expected to grow along the main road.

Kiganjo's commercial centre on the other hand is expected to grow southwards, due to constraints in available land for commercial development in other directions. To the east and west, as mentioned, are steep valleys, and to the north the land is zoned for industry.

3.2.3 Residential Areas

Residential areas are expected to grow in two distinct patterns.

Housing for low income earners will be near the facilities with employment opportunities: commercial centres, industries and institutions. This trend can be expected to be encouraged by the present complete lack of short haul public transport, requiring those without vehicles to walk to their destinations. The only exceptions to this lack of commuter transport is in Kamakwa, and the availability of passage on long haul vehicles on the routes from Nyeri to Nairobi, Othaya, Ihururu (past Mathari) and Kiganjo.

Medium to high cost housing on the other hand, will develop in areas where access to paved roads is proximate, and other services are available.

Overall, it is expected that low cost housing will front the main roads nearer town, and other housing will be behind the main road frontage, and along the main roads but more distant from town.

3.2.4 Institutional and Industrial Siting

The growth of large consumers in the areas presently under small scale agriculture is not expected, due to the inherent difficulties in those areas in acquiring a sizeable property. Growth of institutions and industries is therefore expected to be in two areas.

The first in King'ong'o, where there are large holdings within reasonable proximity to town, and with access to the Nyeri-Kiganjo road, and thus to rail transport.

Industry however, is mostly expected to grow on the northern side of Kiganjo, but only if there is security of water supply. At Kiganjo there is land zoned for industrial development, carved out from forest land. A potential developer can obtain the allocation of land from the government and Council, without the rigors and high cost of purchase from private individuals. Communications by road and rail are also very much better there. Further, the land is flat and open, rendering development less costly.

3.3 Overall Expectations

The overall patterns of changes in land use, derived from the foregoing parameters, are illustrated in Figures 3.1, 3.2 and 3.3 on pages 3 - 7 to 3 - 9. It must be emphasised that these are illustrations only, to give a general impression of the expectations.

What is clear is the expectation for new growth areas to be to the west (Kamakwa and Mathari) and to the southeast (Ngangarithi, Skuta, Thunguma) of the CBD. In Kiganjo, it is expected that growth will be in the narrow corridor along the main road, and almost exclusively on the east side of the road.

Figure 3.1
PREDOMINATE LAND USE 1995

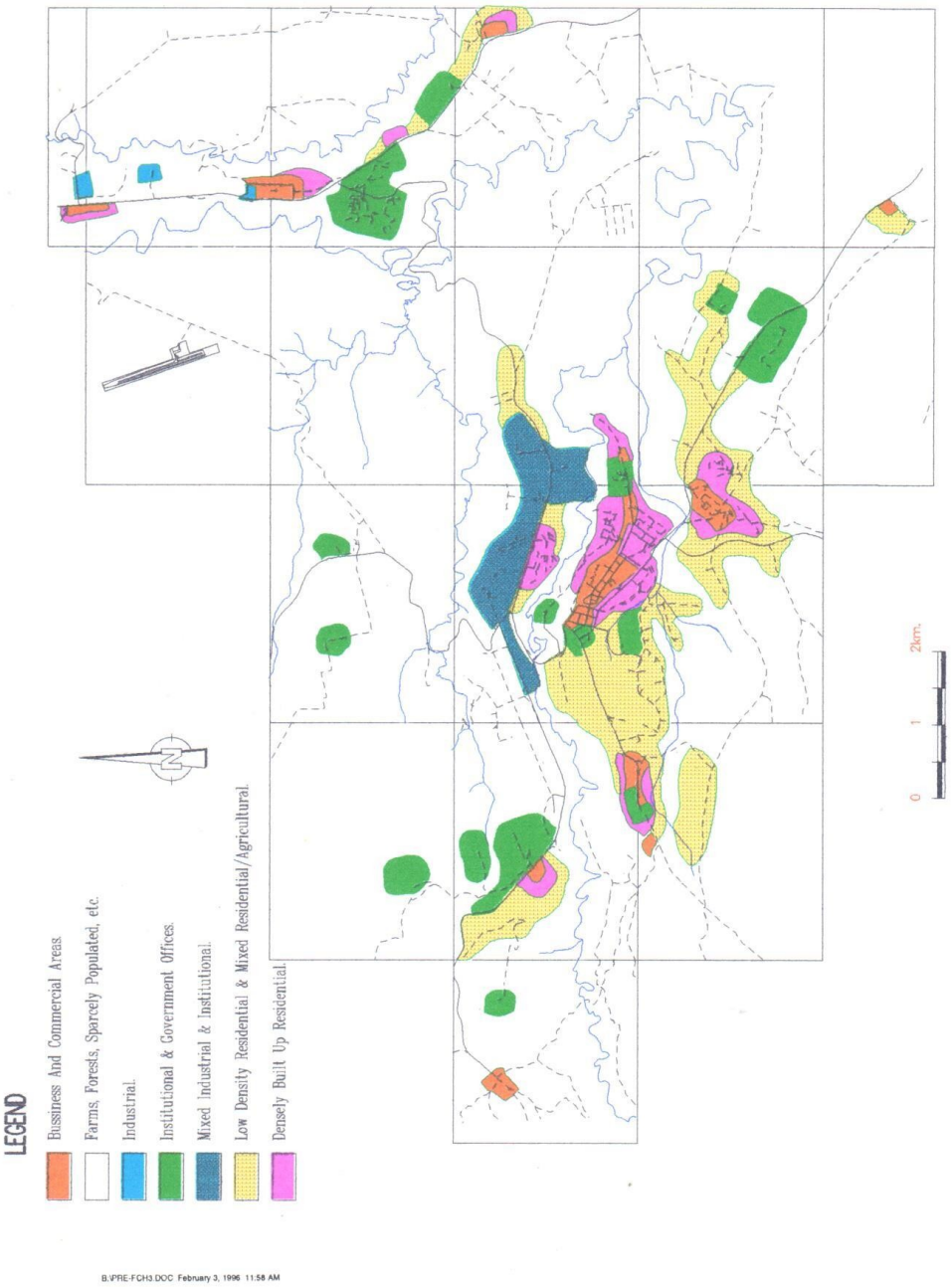


Figure 3.2
PREDOMINATE LAND USE 2010

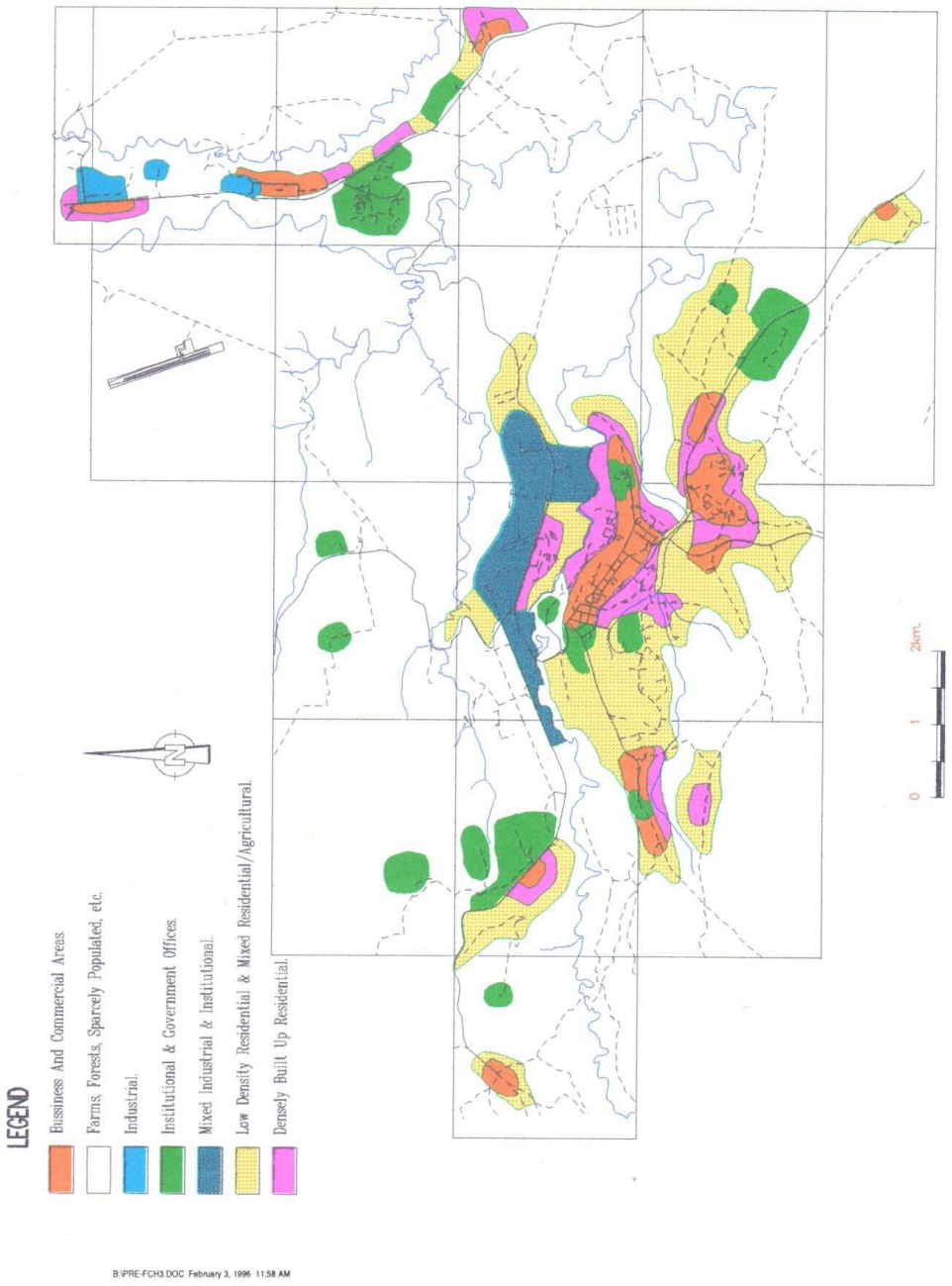
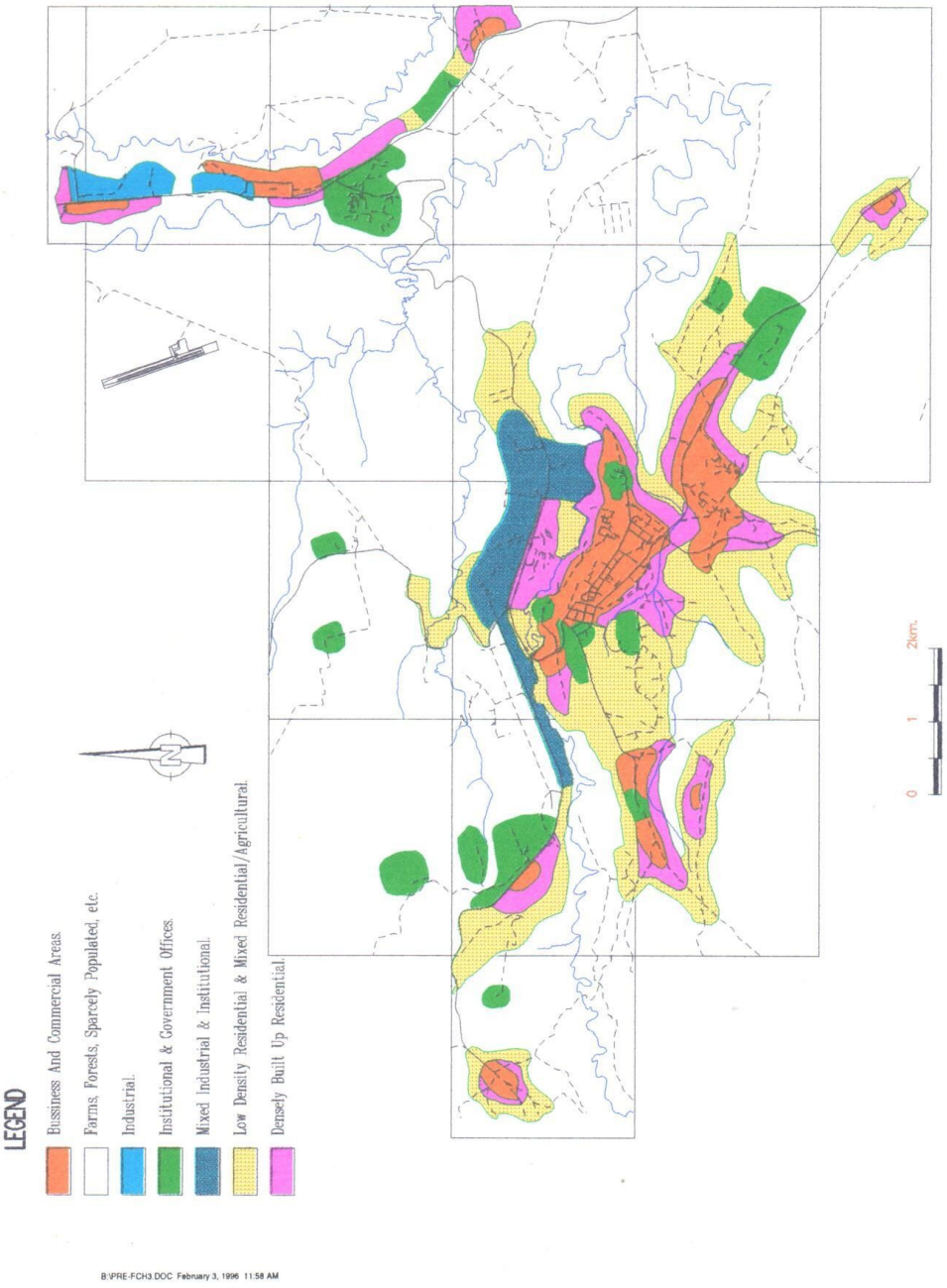


Figure 3.3
PREDOMINATE LAND USE 2020



4. PROPOSED SERVICE AREA AND LEVEL

4.1 Service Area

4.1.1 Mukaro (Nyeri town)

The central part of Nyeri Municipality is covered by the water supply reticulation as shown in Figure 4.1. This reticulation encompasses most of the areas in which urban development has occurred or is expected to occur within the design horizons (see Figures 3.1 to 3.3), except the following:

(i) parts of Mathari
(ii) Gitathi-ini, and
(iii) some southeastern areas along the Nyeri-Othaya and Nyeri-Nairobi roads.

These areas are recommended for incorporation into the reticulation system, together with wider incorporation of areas around Kangemi which are developing an urban character.

It should be emphasised here that these new areas are defined on the basis of where it is anticipated new trunk mains will be required. In some other areas, principally the Chania valley, eastern King'ong'o and the valley between Skuta and Kangemi, it is expected that expansion of consumer connections and small diameter pipework will in itself cover the new development which is proximate to the existing supply areas.

The areas outside these proposed limits of supply are the southern farmlands and the northern drylands and estates. The former are essentially within the Tetu-Thegenge and Aguthi rural water supply systems and basically of rural nature with little potential for urban growth. It is not recommended that the Council takes upon itself the burden of rural networks due to the inherent high cost of servicing and maintaining pipework between which there are few consumers. Firstly it is expensive (on a unit quantity supplied basis) to maintain such rural networks. Then, revenue collection is more difficult, time consuming and costly, when distances between consumers are relatively great. Lastly, the Council need not assume the responsibility, since this is already in the hands of the undertakers for those projects, whether the schemes are fulfilling their level of intended service or not at present.

The large estates can and should cater for themselves, as their domestic water needs are only a very small proportion of overall requirements.

This then leaves the Nyaribo area. It is a fairly dry part of the municipal area, with few natural water courses. Some parts of Nyaribo do have modestly sized farms with the resultant higher population density than surrounding parts, but there is no part of Nyaribo with a dense rural, let alone peri-urban population density. The other aspect of Nyaribo is it's distance from the main urban concentrations at Nyeri town and Kiganjo. The physical separation with Kiganjo is the deep Honi river valley, and the separation from Nyeri is the large estates. Overall, the combination of low population and distance from other service

areas makes the Nyaribo area unattractive for incorporation into the Municipal water supply system.

4.1.2 Kiganjo

Figure 4.1 also shows the proposed supply area for Kiganjo.

In the large part, there is no necessity for enlargement of the supply area, in fact the opposite is the case.

From Kirichu and to the north is the "urban" and peri-urban land use area, which is all proximate to the main Nairobi-Nanyuki road. All of this is an area which for readily apparent reasons the Kiganjo system should serve. There are then two other supply sub-areas. Both are of essentially rural nature, namely Kanuna (to the west of the main road, between Kirichu and Kiganjo) and the southern "tail" of the supply system, towards Gachika.

The southern parts are not presently receiving a supply of water, and have not done so for a considerable period. This is an area which is effectively a past service area rather than a present one. The question therefore is that of re-incorporation of those areas into the scheme as opposed to one of their continuity in the scheme.

The recommendation is that this southern tail should be physically severed from the system, if a new scheme is being implemented. Firstly, the arguments above regarding low returns against high operation inputs will apply to this particular rural area. To compound the arguments against resumed supply to that part of the system is the fact of disused pipework and old connections. It is to be expected that these pipes will have deteriorated with lack of usage, and unless an expensive relaying of the network is carried out, to a similar scale to that needed in a new supply area, then this area would be a source of unacceptably high water losses. The physical losses would be compounded by administrative losses arising from the difficulties of re-registering all of the old consumers, whose connection pipework remains in place.

It is not considered to be in the Council's interests that this area remains within the intended supply area.

Kanuna on the other hand is presently being served, and is a relatively small area. It is not seen as practicable for the Council to disengage itself from providing services to those who are already receiving them. The fact of their present status by itself would make the consideration of whether they should actually be in or out of the service area a moot point.

One last area is the Ngonde plains to the northeast, which were incorporated into the Municipality in 1992. The reasons for this boundary change are not apparent, and certainly Ngonde is not within any definition of a peri-urban area. The population is sparse and this is not likely to change in the foreseeable future. This area is not considered a possible part of the Municipal water supply area.

4.2 Potential for Communal Water Points

4.2.1 Basic Factors

The factors which are expected to influence the selection by particular consumers of whether to obtain an individual connection are:

(i) their ability to finance the installation, and

(ii) their status with regard to the security of tenure on the property occupied.

Starting with the latter, it is quite clear that a person who is occupying land illegally, or in doubtful circumstances, will not go to the expense of obtaining permanent installations, since he will not have any security in enjoying the investment. This applies to many slum areas, where the residents have simply occupied unused land, without any regard for it's ownership.

The ability to finance the installations will be measured from the available resources (and in some cases willingness) of the property owner, as opposed to those of the physical occupant. Where the occupant is the owner, he will make an independent assessment of his resources and needs, in relation to the costs. For rental premises, the question will be that of potential financial gain from an investment in a connection, in view of the resultant attractiveness of the property to potential tenants.

For those who do not then have access to an individual connection, the only options which will be available will be to obtain water from:

(i) natural resources

(ii) roof catchment and storage

(iii) formal communal water points (CWPs) or kiosks

(iv) mobile water vendors,

(v) arrangements with neighbours with water connections, with or without the exchange of money, or

(vi) a combination of any of the foregoing.

Principal factors in selection of the source of water will be the availability of options, cost versus available resources, convenience, and to varying extents, public health awareness.

In many cases, where there are several available options, the source of potable water may be different from the source of water for other uses.

4.2.2 Other Experiences

It is relevant at this point to review experiences in two other KfW financed projects in Kenya.

In Malindi (eastern Kenya), there were eight existing kiosks, and 72 more were constructed during project implementation. All of these kiosks have been useful, most are very busy, and in fact

(i) it is known that perhaps more should have been built, and

(ii) at least two "self built" kiosks have been put up by individuals since project implementation.

In Kericho (western Kenya), the project omitted kiosks, however towards the end of implementation, 7 No. were constructed, in order to assess their potential and decide whether more should be built. Of these, two were successful, these being within shopping centres outside the main town. The others, in residential and in rural locations, were closed within a short time, due to the lack of business. There was a need for kiosks, but this was in only a few areas with particular characteristics, unlike the general success of kiosks in Malindi.

These two cases illustrate the diverse nature of circumstances relating to the potential success of kiosks. The critical aspects are the range of alternatives available to residents, and factors relating to their inclination to particular options.

In comparison with Malindi, Kericho is far wetter, with more natural sources of water, greater potential for roof catchment systems and most important, the residents are better educated and more affluent. With the lumpsums available from cash crop payment, most peri-urban and rural residents can easily finance a connection. Those who cannot (perhaps being fairly distant from a mainline) can erect roof catchment facilities for potable water, and use the available natural sources for other needs. The Malindi area has few natural sources, and the natural fibre roofing used there cannot support roof catchment systems. In addition, income levels are relatively low, and there is very little by way of commercial farming.

As noted, in areas with a variety of options available to those without individual connections, smaller peripheral commercial/residential areas have a greater potential for kiosk usage. In such centres, there is little room for storage of catchment water, the residents are generally of lower income than surrounding areas, and tenants predominate over resident property owners.

4.2.3 Existing Situation in Nyeri

In the Situation Assessment, a review was made of the situation with regard to kiosks in Nyeri. This was reported on in Chapter 7 pages 18 and 19 of the Report for that stage of this study. In general, it was found that there were only two water kiosks in the supply area,

and one was closed due to non-payment of water bills at the time of the field investigations for that report.

The kiosk at Mathari was open, but it was found that it's continued operation was due to it's low location and thus ability to tap occasional low pressure flows. Almost all properties in the area had individual connections, but did not obtain a supply. With adequate water supply pressure in the area, it is quite certain this kiosk would close down.

Overall, it is considered that the potential for water kiosks is likely to prove lower in Nyeri than even Kericho. The two areas have similar climate and topography, but Nyeri has more rivers in the denser populated areas, and a population with higher incomes.

4.3 Service Levels

It is to be expected that the following types of consumers will be served by individual connections:

(i) medium and high cost residential properties

(ii) permanent urban low cost housing

(iii) formal industry

(iv) institutions, and

(v) formal commercial properties

The essential categories that remain are "rural" and temporary urban low cost housing, and "informal" small scale commercial and industrial (crafts) properties.

These types of premises will be in three categories namely:

(i) "rural" type properties, essentially on ancestral land, where the occupants will have access to an income from cash crops, dairy farming or other income where lumpsum payments are to be expected,

(ii) those properties built for lease, where the capital expenditure is met by the land owner with commercial motivation, but the convenience lies with the tenant, and

(iii) urban area low cost development of essentially slum nature, where the occupants are the "developer" and are there due to dire financial circumstances.

The first group are expected to have individual connections. This is due to the length of occupancy, allowing greater time to assemble the resources to finance the installation, and

also due to their access to lumpsum payments which can be applied to purposes other than routine subsistence expenditure.

Again, the last group, in slums, will clearly be expected not to have individual connections. These are the people living in the lower parts of Kiawara and Majengo at present, which is the only significant informal housing area of Nyeri. These people do however have access to the Chania river, at most 500 m away. It was observed that there is significant use of the river for laundry and for water for general domestic usage, at present. It can be expected that at present, were there to be kiosks available in the area, there would be business for them in satisfying needs for potable water. In fact, it was found that in absence of formal arrangements, some residents have set up water sales to neighbors.

The difficulty here is to differentiate between the needs for water that would be met by kiosks, and those that would continue to be met by the natural source. The assessment is that free water, close to hand, will continue to play the major role. It would be optimistic to presume that kiosks would do much more than to satisfy the need for drinking and cooking water, which is a small proportion of overall needs, estimated at between 5 and 7 l/capita/day.

Further, it is difficult to see slum development occurring outside the Chania valley in Nyeri, due to pressure of land. The open space available to the north is in large estates, with owners who are near to hand, and would not therefore permit unauthorised settlement. In other directions are small holdings where again, informal settlement would meet strong resistance. The Chania valley has land which was and in some cases still is in public possession, leading to greater ease of occupation without formal authorisation. What is however expected is that the slums will be pushed further down the valley by development nearer the CBD, and will spread across the valley to the north bank. This will bring the residents to even closer proximity to the river as a source of water.

In Kiganjo however, the situation in the northern part is different. There are large tracts of land with absentee land owners, who purchased the property more with a speculative (or proprietary instinct) motivation, than for needs of immediate usage. Other unoccupied land is zoned for eventual allocation to industrial developers, and thus is still in public ownership. In such cases, informal settlement can take root with little resistance, as has been the case at Chaka.

The last category of potential residential users of kiosks are tenants of commercial low cost housing developments. Those nearer the CBD will house low income employees, who are expected to demand at least a common tap on the premises, whose bills will be met by the landowner. Others nearer to the peripheral trading centres on the other hand, will house workers who do not have fixed employment, mostly working on casual and piecework basis in surrounding agricultural holdings. It is this latter category who are expected to have lesser means, and thus be less demanding.

Low cost commercial properties are expected to follow a similar trend to low cost residential properties, especially since, in this case, one is considering small premises such as retail

kiosks, tea houses, craftsmen workshops, and the like. Those nearer the CBD are likely to have higher volumes of business and so better access to resources for a connection. The types of such premises likely to be without connections are those with informal tenancy on the land, and those in peri-urban shopping centres.

Thus public taps should be situated where they are expected to be of use, that is

(i) in the Kiawara and Majengo areas, and
(ii) in peri-urban trading centres.

Due to the expected shifts in land use in Majengo however, it is to be expected that the target population will be on the move, and thus the appropriate actual location for individual public taps will, with time, need re-assessment. Thus will be the case particularly if there is a significant period between project design and implementation.

At the expected levels of usage, it is unlikely that convectional water kiosks will be financially self sustaining. There would therefore seem to be two options namely:

- manned subsidised water kiosks, the shortfall being made up by the water undertaker as a 'service' to the community, and/or

- the use of unmanned 'token' operated slot meter water dispensers common in South America. These are now being introduced in southern Africa and are shortly to be given a trial on the Sabaki water pipeline to Mombasa currently under refurbishment.

With the use of a token operated water dispenser, a householder purchases a month's supply of tokens (say) from the council. The charge for such tokens can be a 'real' charge no higher per unit volume than the base charge in a stepped tariff structure for individual connections. Each token allows the dispensing of 20 litres of water which is probably sufficient for the potable water needs of family of about 3 to 4 persons.

5. DEMAND FORECASTS

5.1 Horizons

The Terms of Reference (TOR) had stipulated that the water consumption and demand forecasts should be determined for the expectations in the years 2010 and 2015. The technical proposals by this Consultant had however indicated the need to re-assess these time frames in light of the objectives to be achieved in selection of design horizons.

The horizons which had been put forward are fifteen and twenty years from the present. In this report the first horizon will be called the "future", and the later one, the "ultimate" horizon.

It is possible to argue that the future horizon is fairly close to the present. It may be considered that after this study there will at best be a one to two year period for securing financing, followed by final design and tender documentation, prequalification, tendering, and then actual construction. An optimistic projection would be for the first stage works to be completed by the year 2002. This would allow only an eight year period during which there would be the early utilisation of the new works, and then also the implementation of the second stage works, for them to be ready by the year 2010.

This future horizon is therefore devoid of an appreciable project implementation "rest" period, even under an optimistic scenario. It is not however unfeasible since it is possible for the stage II implementation to closely follow stage I commissioning. The TOR future horizon has therefore been retained.

The ultimate horizon on the other hand, is considered to warrant reconsideration. After completion of the stage II works which result from this study, the Client will need to commence another major project cycle, inclusive of preliminary design. It is not practicable for such a major project implementation cycle, inclusive of construction, to start in the year 2010 and be completed in less than five years, so as to be ready by the year 2015.

On the other hand, planning for very distant horizons would tend to increase the costs of unitary components which of necessity are constructed for the ultimate requirements. An ultimate horizon of 25 years would not however be very distant. Taking the above into consideration, the demands, and therefore project design, have been based on a future horizon of the year 2010, and ultimate horizon of the year 2020.

5.2 Present Demand from Existing Consumers

The existing situation with respect to water consumption and demand was analysed in Chapter 8 and 9 of the Situation Assessment Report for this study. For clarity, some of the principal aspects will be recapitulated here.

Although the Council estimate was that there were a total of 4,027 consumers whose accounts were running in both the Nyeri Town and Kiganjo Water Supplies, the Consultant enumerated a total of 3884 accounts in the meter reading books, which is a difference of 4%. The latter figure was used in the Situation Assessment Report, and will be used here.

In addition to these consumers with running accounts ("active" consumers), there were said to be 550 "inactive" consumers, these being consumers with permanently closed connections, and without an open account. The reasons for such a status occurring can be varied, but in this water supply the pedominate cause was long-term lack of water, leading to the connection becoming obsolete. In most of such instances however, the pipework remains in place, thus the dormant consumer would readily re-activate his account should the water availability situation improve.

In the Situation Assessment, demand was analysed on the basis of active consumers only. Consumers were grouped into "Major" and "Other" consumers, the former being those with more than 100 m^3/month average billed consumption. The water demand of major consumers was analysed on an individual basis, and this accounted for 38% of overall estimated existing demand. The demand from other consumers was assessed on the basis of the estimated demand per consumer of various types, and the estimated distribution of the numbers of consumers into such categories.

An exercise of consumer sampling, covering about 10% of consumers, was undertaken during the Situation Assessment, with a view of obtaining real data on per capita consumption for the project area. Regrettably, it was found that there were few areas of reliable water supply, such that there was little data on unsuppressed demand which could be applied directly. In that report, the following per capita residential demand figures were put forward:

	Recommended Figures l/cap/day	Maji Design Manual l/cap/day
• Residential High Cost	210	250
• Residential Medium Cost	125	150
• Residential Low Cost		
- Permanent Construction	65	75
- Temporary Construction	55	75

These figures were recommended on the basis of some consumer samples which seemed to be within the unsuppressed demand state, together with common expectations from available literature.

Although the recommended per capita demand figures are lower than the Water Ministry's guidelines, it is believed they are an essentially accurate assessment of actual expectations. These recommended figures are the basis of the projections in this study stage.

The overall existing average daily demand in the Nyeri town system was estimated in the Situation Assessment Report at 6,798 m^3/day. That for Kiganjo was put at 1,466 m^3/day.

For the purposes of this study phase, it has been found appropriate to distribute these demands directly into consumer categories, without the distinction between major and other consumers. These figures are presented in Table 5.1.

5.3 Present Demand in Proposed Supply

The foregoing demand analysis was based on the water needs of existing "active" consumers. In order to determine future demands in the proposed project however, the base reference needs to be the demand for the consumer base that is expected to grow into the future. There is therefore need to adjust the "existing" demand when considering the base 1995 "present" demand, by adding:

(i) the potential demand by "inactive" consumers who are already connected to the existing system, but who are not presently served, largely because they are in areas where there is no flow,

(ii) the demand by existing potential consumers in those same areas, who will not have obtained a connection in view of the prevailing situation, but would do so if there were at least reasonable flow,

(iii) the demand of consumers within the existing supply area who have had to make their own water supply arrangements to ensure the security of their supply, and

(iv) the present potential demand within the areas within which the water supply reticulation is proposed to be extended.

The potential demand from "inactive" consumers is best analysed by the Council estimate of their numbers. They are put at a total of 550, which is 14% of the number of "active" consumers. The distribution of these consumers to Nyeri/Kiganjo is difficult, but it is clear the proportionate distribution would be higher in Kiganjo. On the other hand, many of the Kiganjo inactive consumers would be in areas where it is recommended the Council should separate from the Kiganjo System (see Chapter 4).

The information on the potential consumer base is sparse, and is one area which it had been proposed a consumer survey would address in a complete manner. In absence of actual data and information, however, it is necessary to proceed on the basis of the best possible estimation.

Table 5.1
DISTRIBUTION OF DEMAND OF EXISTING CONSUMERS

Zone	Residential *[by Cost Categories]*			Comm./	Large	Educational	Major	Other	Industrial	Total
	High	Medium	Low	Residential	Hotels		Institutions	Comm./Instit.		
NYERI										
1	32	47	37	4			10	21	35	**186**
2			106	13			10	118		**247**
3				95	22		22	129		**268**
4		22		70	111		35	66		**304**
5	62	27	2		70		35	30		**226**
6	129	91	29			75	25	21		**370**
7	5	19	144	29				53		**250**
9				307	73		140	365		**885**
10	15	61	60	15		22		50		**223**
11		22	173	22			4	11		**232**
12		40	94	16	6	9	16	54		**235**
14	16	29	240	51		4	37	50		**427**
15		13	83	77				54		**227**
16	5	19	123					5		**152**
17		5	277	44			469	24		**819**
18	26	37	131	18	6	179	463	41	223	**1,124**
19		46	204	26		105		22		**403**
20	7	12	186					16		**221**
Subtotal	**297**	**490**	**1,889**	**787**	**288**	**394**	**1,266**	**1,130**	**258**	**6,799**
KIGANJO										
K1		4	24	33		507		69	470	**1,107**
K2		11	138			110		13		**272**
K3		3	51	7				26		**87**
Subtotal	**-**	**18**	**213**	**40**	**-**	**617**	**-**	**108**	**470**	**1,466**
TOTAL	**297**	**508**	**2,102**	**827**	**288**	**1,011**	**1,266**	**1,238**	**728**	**8,265**

Note: All figures are average daily demands in m^3/day

NYRPROJ1.XLS exist 05/02/96 15:27

For purposes of this evaluation, it is postulated that Kiganjo has some 316 active and 120 inactive consumers, a ratio of 2.6 : 1. Of these inactive consumers, say 40% are within the intended supply area, and are proportionally distributed between the zones. The balance of 330 inactive consumers would be in Nyeri Town, concentrated in the most critical water shortage areas of Thunguma, Skuta, Ngangarithi and Mathari Village (zones 14, 16, 18 and 20). Overall, it is considered these "inactive" consumers would be predominantly low cost housing, with small numbers of commercial/residential, and commercial properties.

An allowance also needs to be made for potential consumers in those same areas, who have never attempted to obtain a connection, in view of the known lack of water. These will represent more recent development, principally as a result of land subdivision, and thus will be in lesser numbers than those who do have at least a dead connection. A margin of 60% over the demand of "inactive" consumers has been applied to cater for this category of properties.

The adjustments to the average daily demand for these two categories of existing potential consumers, are in total 642 m^3/day for Nyeri Town and 227 m^3/day for Kiganjo, which represent 9% and 15% of the estimated total demand at present for "active" consumers.

The next adjustment is for those consumers who have had to resort to their own supplies, even though they are within the existing reticulation, due to their need for security of supply, or because they do not receive any water at all from the public supply. These are, for practical reasons, only a few, and quite large consumers. They are as follows, with the estimate of their present demand.

(i)	Wambugu Farmers' Training Institute	:	150 m^3/day
(ii)	Thunguma High School and Institute	:	80 m^3/day
(iii)	Mt. Kenya Bottlers (Coca Cola)	:	600 m^3/day

The last category of adjustments, is that for the demand within areas which are not presently served. This is of two types: demand from large institutions principally in the Mathari area, and general demand in areas which are assuming a sub-urban residential nature.

In this first group are the following institutions:

(i)	Kamwenja Teachers' College	:	120 m^3/day
(ii)	Nyeri High School	:	130 m^3/day
(iii)	St. Paul's Seminary	:	35 m^3/day
(iv)	Mathari Mission and Hospital	:	400 m^3/day

The Situation Assessment Report had detailed the diverse nature of the facilities at the Mathari mission, including a large hospital, boarding primary school, two nursery schools, Convent, Pastoral Training Institute, and the like. Both Kamwenja and Nyeri High were also described, and have large resident student populations, together with almost all the staff being housed within the institutions.

The other category within the new supply areas is the general demand. The Mathari area does not have any significant non-institutional land use, the surrounding land being in the large part the Catholic Church owned Hill Farm. There are however some areas with small plots within the Mathari Village which are outside the present reticulation, and proposed to be served. Other areas which are to be incorporated into the reticulation do not have significant large consumers. These areas are as described in Table 5.2 below.

Table 5.2
POPULATION WITHIN NEW SUPPLY AREAS
(excluding large institutions)

ZONE	DESCRIPTION OF LOCATION	AREA (km^2)	1989 POPULATION DENSITY (per km^2)	1995 ESTIMATED POPULATION
7	Gitathi-ini and Upper Kamakwa	1.7	815	1723
20	Ngangarithi	1.1	750	1026
18	Mathari Village	0.5	1200	746
14 and 16	Eastern Thunguma and Gatitu (excluding Wambugu Farm)	5.7	530	3757
K1	Northern Kiganjo and Chaka	0.6	675	504
	TOTAL	9.6		7756

The population data available from past cencii and the analysis of population growth rates, were in the Situation Assessment Report Chapter 6. It was found that boundary and name changes between the 1979 and 1989 cencii areas had been significant, and further, the consultant was refused access to the relevant mapping for these census areas. This made the analysis of growth trends difficult, particularly in assessing this within the varied land use areas.

In addition, detailed population information of small areas was not available, making the assessment of population densities in specific parts of an urban area much less accurate than would be desirable.

Overall, however, a population growth rate of 3.70% per annum for urban areas was arrived at, and this rate has been applied to the 1989 population densities above, to arrive at the 1995 population densities. These 1989 densities are however estimates for specific areas, based on general densities for larger areas.

To arrive at the demand from this population, it has been assumed that the following split of consumer types pertains:

(i) Residential properties (percentage of population)

- High cost 5%
- Medium cost 35%
- Low cost 60%

(ii) Non Residential Properties : One per every 100 persons

The demands applied are those analysed in Chapter 9 of the Situation Assessment Report, these being:

(a) Residential

- High cost 210 lit/capita/day
- Medium cost 125 lit/capita/day
- Low cost 60 lit/capita/day

(b) Non Residential 1.6 m^3/property/day

All of the foregoing adjustments have been computed, giving the additional demands presented in Table 5.3.

After taking this into account, the daily average water demands in the proposed project area at present are as shown in Table 5.4. It is found that the proposed Nyeri Town reticulation area has a total present daily average demand of 9,726 m^3/day, and Kiganjo 1,746 m^3/day.

5.4 Demand Growth Factors

The principal factors in water demand increase are population growth and physical development.

Population growth rates will determine not only residential demand, but also small scale service related development, such as commercial properties. Educational facilities may not follow the population growth when fiscal limitations reduce the monies available for new construction. On the other hand unless the proportion of the school age population that enrolls in schools declines, this will be countered by crowding of existing facilities, as is already evident in recent years. The end result is higher student populations per school, and growth of the water demand at the same pace as population growth. This of course assumes an unchanged proportion of the populace which attains an education.

Other physical developments will be at a rate which is not related to the local population growth.

Table 5.3
EXISTING DEMAND OF UNSERVED CONSUMERS IN PROPOSED PROJECT AREA

	Zone	Residential [by Cost Categories]			Comm./	Large	Educational	Major	Other	Industrial	Total
		High	Medium	Low	Residential	Hotels		Institutions	Comm./Instit.		
NYERI											
	1										-
	2										-
	3										-
	4										-
	5										-
	6										-
	7	18	75	62					28		**183**
	9										-
	10										-
	11										-
	12										-
	14	20	82	236	35			150	61		**584**
	15										-
	16	20	82	145	18		80		45		**390**
	17										-
	18	8	33	129	23		285	400	32	600	**1,510**
	19										-
	20	11	45	145	23				36		**260**
	Subtotal	**77**	**317**	**717**	**99**	**-**	**365**	**550**	**202**	**600**	**2,927**
KIGANJO											
	K1	5	22	67	9				16		**119**
	K2			73	18				15		**106**
	K3			38	9				8		**55**
	Subtotal	**5**	**22**	**178**	**36**	**-**	**-**	**-**	**39**	**-**	**280**
	TOTAL	**82**	**339**	**895**	**135**	**-**	**365**	**550**	**241**	**600**	**3,207**

Note: All figures are average daily demands in m^3/day

NYRPROJ1.XLS add 05/02/96 15:31

Table 5.4
PRESENT DEMAND IN PROPOSED PROJECT AREA

	Zone	Residential *[by Cost Categories]*			Comm./	Large	Educational	Major	Other	Industrial	Total
		High	Medium	Low	Residential	Hotels		Institutions	Comm./Instit.		
NYERI											
	1	32	47	37	4	-	-	10	21	35	**186**
	2	-	-	106	13	-	-	10	118	-	**247**
	3	-	-	-	95	22	-	22	129	-	**268**
	4	-	22	-	70	111	-	35	66	-	**304**
	5	62	27	2	-	70	-	35	30	-	**226**
	6	129	91	29	-	-	75	25	21	-	**370**
	7	23	94	206	29	-	-	-	81	-	**433**
	9	-	-	-	307	73	-	140	365	-	**885**
	10	15	61	60	15	-	22	-	50	-	**223**
	11	-	22	173	22	-	-	4	11	-	**232**
	12	-	40	94	16	6	9	16	54	-	**235**
	14	36	111	476	86	-	4	187	111	-	**1,011**
	15	-	13	83	77	-	-	-	54	-	**227**
	16	25	101	268	18	-	80	-	50	-	**542**
	17	-	5	277	44	-	-	469	24	-	**819**
	18	34	70	260	41	6	464	863	73	823	**2,634**
	19	-	46	204	26	-	105	-	22	-	**403**
	20	18	57	331	23	-	-	-	52	-	**481**
	Subtotal	**374**	**807**	**2,606**	**886**	**288**	**759**	**1,816**	**1,332**	**858**	**9,726**
KIGANJO											
	K1	5	26	91	42	-	507	-	85	470	**1,226**
	K2	-	11	211	18	-	110	-	28	-	**378**
	K3	-	3	89	16	-	-	-	34	-	**142**
	Subtotal	**5**	**40**	**391**	**76**	**-**	**617**	**-**	**147**	**470**	**1,746**
TOTAL		**379**	**847**	**2,997**	**962**	**288**	**1,376**	**1,816**	**1,479**	**1,328**	**11,472**

Note: All figures are average daily demands in m^3/day

NYRPROJ1.XLS pres 05/02/98 15:30

The major institutions are in the large part government, religious and health institutions. Growth of government offices and facilities is dependant of the administrative role that the town plays, and manpower planning for the civil service as a whole. Nyeri can be expected to remain a provincial and district headquarter. It's administrative role cannot be increased, since the next step on the ladder is only the national capital. As for civil service staffing, the present trend is in reduction of personnel due to the perceived over establishment in relation to the work in hand. This must however be a short term situation. When either the reductions result in the desired personnel levels, or the will to reduce staff is satisfied, whichever comes first, then it can be expected that a positive growth trend will resume. There are however exceptions to this, especially the penal institutions. With population increases, and deteriorating economic circumstances, it is to be expected that there will be higher growths of prison and remand home residents than general population growth rates.

Growth of religious institutions will follow different trends. The very large Catholic Church presence was built up as a base for activities in surrounding areas, but as churches and other facilities continue to develop at village level, the central facilities will play a diminished role. Significant expansion would not be expected. Islamic and Presbyterian facilities are more modest but still significant. The central mosque in Nyeri is being expanded at present, and a new one in under construction at Kiganjo. There are clear signs of growth. The Presbyterian and other Protestant church facilities are not under present expansion in central areas.

There are three principal hospitals, the Provincial General Hospital (the largest), Mathari Mission, and the smaller Mt. Kenya Hospital. It is indisputable that these health facilities are inadequate even for the present populace, but the question is whether there will be the means to make up the present deficit, let alone provide for the future population.

This is primarily dependant on available government expenditure and private investment. There is doubt as to whether the government can mobilise sufficient monies for the extent of expansion that is necessary. On the other hand, private institutions have began to be developed, for instance a small new hospital at Kamakwa.

The remaining category is industry, inclusive of large hotels for the tourism industry. At present, the only large production plants in Nyeri are in the food and beverage field, namely soft drinks, milk processing and wheat milling. There are also saw mills, and an industrial park. The main obstacle to industrial growth has been water shortages, and thus until the situation is rectified, growth can be expected to be below the level of an unrestrained situation. Thereafter, investors may consider Nyeri Municipality a suitable site for locating consumer goods production facilities, to service regional demand. Such developments would be expected to be concentrated in Kiganjo. The hotel industry continues to develop. There has been no recent augmentation of bed space for foreign tourists, and within the supply area only the Outspan Hotel is in that category. Other hotels which have a basically local clientele have however been growing. The Green Hills Hotel has expanded considerably, a new Grand Batian Hotel opened in recent times, and others have been developed over time. There are clear signs of significant growth in this sector.

From the foregoing, the estimated demand growth rates in Table 5.5 have been derived.

Table 5.5
DEMAND GROWTH RATES

Consumer Category	Estimated Growth Rate Per Annum		
	Minimum	Average or Expected	Maximum
Residential	3.08%	3.7%	4.0%
Commercial/Residential	3.08%	3.7%	4.0%
Commercial	3.08%	3.7%	4.0%
Institutional	2.5%	3.0%	3.5%
Educational	3.0%	3.7%	4.0%
Industrial	2.0%	4.0%	6.0%
Hotels	3.0%	3.7%	4.5%

The extent of estimation involved in arriving at the above figures needs to be born in mind. This is however an unavoidable consequence of the refusal of the relevant authorities to release the mapping associated with past cencii, and the absence of recent official physical planning and development trend projections.

Overall however, the population growth rates arrived at in the Situation Assessment have been the guide, applying the overall Municipal area population growth rate between 1979 and 1989 as the minimum rate, that for "urban" parts of the Municipal area as the expected rate, and a marginally higher figure as the maximum expectation. For demand sectors which are not expected to closely follow population growth trends, higher or lower rates are estimated by the somewhat subjective evaluation of their extent of deviation from population growth trends.

5.5 Future and Ultimate Demands

From the foregoing analysis, the future (2010) and ultimate (2020) demands have been computed to be as in Table 5.6 below.

Table 5.6
DEMAND PROJECTIONS

		Nyeri	Kiganjo	Total
Present (1995)		**9,726**	**1,746**	**11,472**
Future (2010)	Minimum	14,722	2,621	17,392
	Expected	**16,536**	**3,047**	**19,583**
	Maximum	17,799	3,424	21,223
Ultimate) (2020)	Minimum	19,540	3,443	22,982
	Expected	**23,579**	**4,418**	**27,997**
	Maximum	26,774	5,419	32,192

Note: All figures are average daily demands without consideration of physical water losses, in m^3/day

For further development of the project alternatives, the above "expected" figures will be used.

It is considered appropriate at this stage, to comment on earlier demand projections for the Nyeri Water Supply. There have been only two studies in the not too distant past of relevance, these being in the late 1970's early 1980's. These are the design of the Nyeri Sewerage Scheme by Mangat, I.B. Patel and Partners, and the water supply design by Sir Alexander Gibb and Partners.

Mangat considered only estimates of sewage outflows from the expected consumer base in their 1978 preliminary design report, and the sewered area is only a small proportion of the water supply reticulated area. The only figures of some relevance to this study are the historic production figures for Kamakwa Water Works between 1971 and 1976. Indications are that in that period, the treatment works capacity could satisfy demand.

Gibb on the other hand carried out water supply demand projections, but only for the Nyeri town system. The figures they arrived at are as follows:

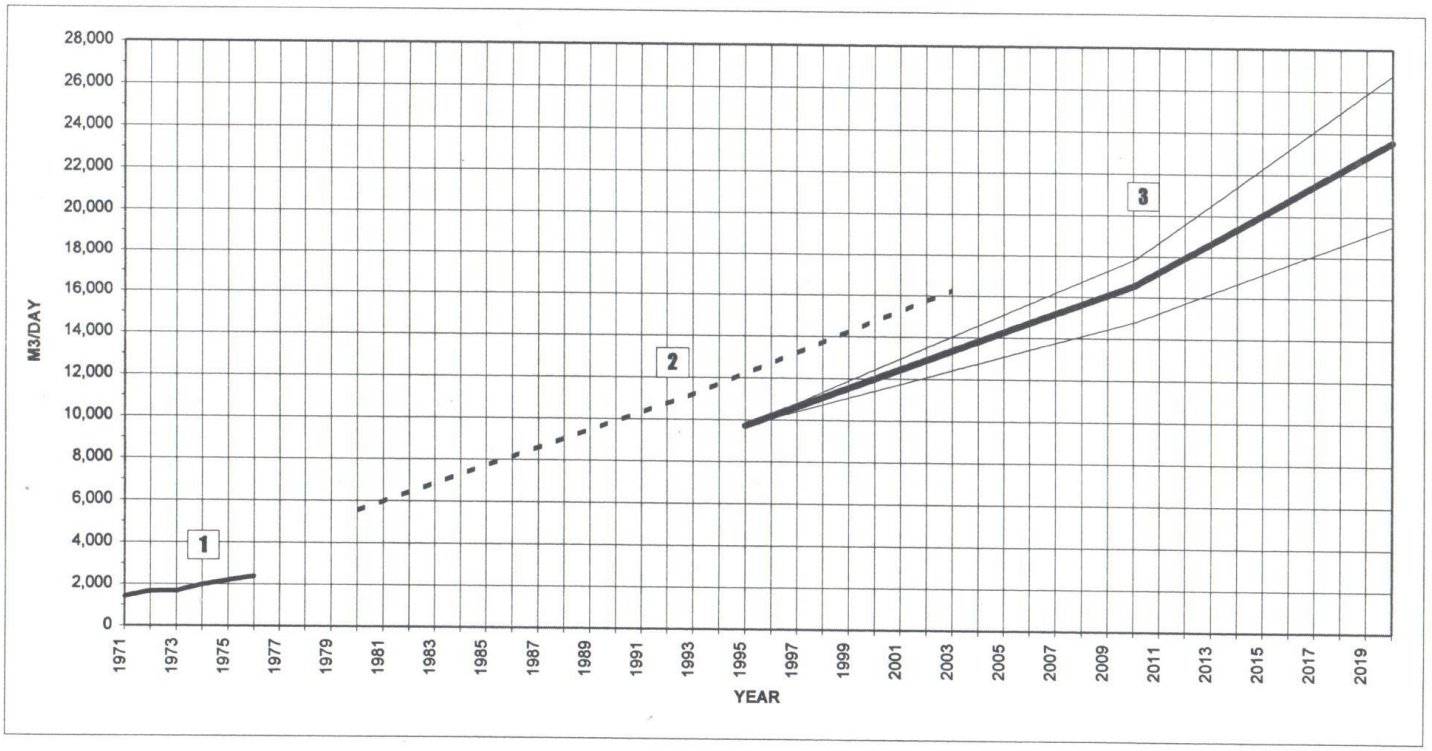
1980 demand : 5,555 m^3/day
1993 demand : 11,193 m^3/day
2003 demand : 16,262 m^3/day

These figures are compared with the projections made for this study, in Figure 5.1.

It must be emphasised that there are aspects which render the Gibb figures not directly comparable with the projections in this study.

The most critical of these is that Gibb used demand figures which were said to incorporate allowance for physical water losses in the distribution. As they did not quantify the

Figure 5.1
AVERAGE DAILY WATER DEMAND - NYERI TOWN ONLY



1 Historic production figures from the Kamakwa Water Works. Obtained from "Nyeri Sewerage Project Master Plan and Preliminary Design Report" of 1978 by Mangat, Patel and Partners.

2 Water demand projections obtained from "Nyeri Water Supply Preliminary Design Report" of 1980 by Sir Alexander Gibb and Partners. Note that the supply area considered in that report was different in some respects from that being considered in this study, and the Gibb demand figures were **including leakage losses**.

3 Demand projections for this study, with minimum, expected and maximum growth factors.

NYRPROJ2.XLS 05/02/98 15:34

magnitude of the allowance made, it has not been possible to remove the leakage quantities from their figures, in order to allow for direct comparison.

The only quantitative statement that they made in respect of leakage losses is that "Present production and sales figures indicate that less than 2% of the water metered into supply is lost; in Kitale the accepted corresponding figure is 18%". That figure for Nyeri is doubted, the one for Kitale would be indicative of a good situation. If however these are the bounds of leakage losses that they had in mind, then the allowance made for physical losses cannot have been very substantial.

In addition, the project area considered by Gibb was based on the whole of the 1971 Municipality borders, but

(i) excluding the Kiganjo area, and

(ii) including some areas which were within Mathira division at that time, and only incorporated into the Municipality in 1982.

Overall, the assessment is that much of the area by which the Gibb project proposals differed from these proposals would have had very low demand figures. These are the large farms (Hill Farm, Seremwai Estate etc.) sparsely populated areas (e.g. Nyaribo) and forest land. The exception is their inclusion of the Kihuyo small scale farming area to the northwest of Mathari.

Whereas the foregoing factors render direct comparison between the projections inappropriate, they do explain the fact that the Gibb figures were about 25% higher than those obtained in this study.

5.6 Adjustments to Average Demands

5.6.1 Adjustments Required

The basic adjustments to the average daily demand figures which are necessary to obtain the design supply and production quantities of water are:

(i) Water losses in the abstraction and treatment of water, including treatment works usage,

(ii) physical water losses in the distribution system,

(iii) seasonal fluctuations in the amount of water consumed in a day, and

(iv) fluctuations in the amount of water used at various times of the day.

The losses and usage upto the end of the treatment process will be considered in Chapter 6 below, and here the review is confined to the output from the treatment works, which is distributed in the reticulation.

5.6.2 Physical Water Losses

In the Situation Assessment Report, it was concluded that administrative water losses in Nyeri are not significant at present, due to the substantial effort that council officers put into the billing process. Overall losses as measured between production and billing quantities were 37%. At present therefore, an estimate of 35% for physical losses could be quite accurate.

The leakage allowances quoted in literature are very varied.

The Ministry of Water Development Design Manual has little in this regard which can be useful in this analysis.

A text which gives some useful figures, albeit widely disparate ones, is Twort *et al* **<1>**. This gives a general statement that "In practise total losses may vary from 5% to 55% of the total production". They also give more definite statements however. It is suggested that in an urban area of more than 10,000 inhabitants, losses of 16 to 17% are a low figure, to be expected only immediately after a leak detection and repair exercise. With routine waste reduction efforts, they quote a figure of 22 to 25% of total quantities produced in such urban areas, and state that higher figures indicate a need for more attention to losses. In smaller systems they suggest losses "should not be above 20% of the total supply".

Another text **<2>** indicates that water losses in Japan are 10% to 20% of the total supply amount. Taking into consideration the technological, administrative and fiscal differences with the situation in towns such as Nyeri, then higher figures would definitely be expected.

Future loss rates will also be dependant on whether there is a leakage detection and repair programme, as has been recommended. The present situation can definitely be improved upon both in the short and long term, by identifying presently problematic areas, repairing existing leaks, and replacing pipework which is in a poor state. In the long term leakages would still increase, but at a slower rate.

In absence of such a programme, it can only be expected that there will be a more significant rate of deterioration in the present situation, as a consequence of continued aging of presently defective pipework.

Assuming that any leak detection and repair programme which will result from the present recommendations will be completed by the end of 1997, then the physical loss assessment

---

<1> Water Supply Third Edition; A.C. Twort, F.M. Law, F.W. Crowley; 1985 - Pg 20 to 23
<2> Water Supply Engineering Vol. II; Japan International Cooperation Agency, 1981 - Pg 21

is as presented in Table 4.6 below. The assumption is that with a leakage detection/repair programme, long term increases in leaks will be at a rate of about 1.5% per annum thereafter, and without it, loss rates will increase at 2% per annum from the present.

Table 5.7
PHYSICAL WATER LOSS RATES

	Year			
	1995	1997	2010	2020
With a leak detection/repair programme	35%	18%	22%	25%
Without such a programme	35%	36%	47%	57%

The difference in the two scenarios is substantial and there are no present indications as to whether the leak detection/repair programme will proceed or not.

This programme clearly is needed, and it is trusted that it will proceed. It is therefore presumed that the lower loss rates are to apply and these are used in subsequent computations.

If however, it transpires that there will not be such a programme, than there will be need to re-adjust the design parameters. It is expected that the possibilities with regard to such a programme will be executed, and how successful it can be expected to be, will be clearer by the time of the Feasibility Report of this study, at which time, if indicated necessary, the adjustments would be made.

The figures for physical losses which are adopted for this report are therefore 22% for the year 2010, and 25% for the year 2020.

5.6.3 Seasonal Demand Fluctuations

Seasonal fluctuations in demand occur due to changes in water needs which are related to climatic conditions.

In temperate climates, such as Europe, summer time is associated with increased water usage for watering lawns, bathing and in air conditioning. A smaller peaking occurs in mid winter, where water is wasted to prevent freezing.

Analysis of the situation for tropical climates would be different of course, however peak dry seasons will be associated with increased demand for washing, and in some areas, watering

of lawns and domestic garden patches. In peak rain seasons, towns such as Nyeri would expect the muddy conditions to generate an increase in water demand as well.
Twort *et al* quote some seasonal demand peaking factors as follows:

(i)	UK residential towns in rural areas	22 - 25%
(ii)	UK industrial towns	17 - 22%
(iii)	Singapore and Hong Kong	22 - 23%
(iv)	Damascus and Toulon	15%
(v)	Barcelona and Marseilles	9 - 11%

None of these are equivalent to Nyeri. What can be considered however is that in smaller towns, fluctuations will be greater due to the lack of diversity of activity, and especially where the industrial demand is not high. This is due to the essentially constant nature of commercial/industrial water usage.

The Ministry of Water Development Design Manual again does not assist; they only indicate use of actual figures from the project area or similar towns.

After consideration of the available information, it is concluded that a seasonal peak factor of 25% would be reasonable for a town of Nyeri's circumstances.

5.6.4 Daily Demand Peaking

Raw water abstraction facilities, treatment works, and clear water trunk mains design quantities do not need to take into account daily demand fluctuations, as these are smoothened out by storage reservoirs, where these are adequate for the purpose. Pipework from the tanks to the consumers do however need to take this into consideration.

Water use patterns vary with the type of consumer base. Domestic consumption peaks at 6 to 7 o'clock, remaining high in the early morning (laundry and house keeping) and has a smaller peak in late afternoon and early evening. The lowest consumption is between 1 and 4 o'clock in the night; it will not fall to zero however, due to leaks within consumers' premises. Fluctuations for one individual consumer will range from a minimum hourly consumption rate of roughly 10% of the average for the day, to a maximum of about 280% of this average. For many premises together, differing peak use times will reduce the overall peak usage rates. In addition, in many cases, this fluctuation will be evened out by roof tanks and other on-plot storage, where these exist. In most Kenyan towns, roof tanks are fairly common in medium to high cost properties. With low cost residences however, roof storage is quite uncommon.

Industrial, non-residential institutional, and commercial consumers will in most cases also have marked peak usage during their operating hours. The incidence of on-plot storage on their part would normally be lower than in residential properties. In areas such as Nyeri where water shortages have persisted, however, it is reasonable to assume that the existing consumers will in the large part have installed some storage, but that this will not necessarily

be adequate for providing all of their peak use needs. Further, such large storage is unlikely to be the case with new developments when the supply situation has improved.

Daily peak usage adjustment factors quoted by Twort *et al* based on UK studies are as follows:

(i) Mainly residential, population 5,000 persons : peak factor of 2.5

(ii) Mainly residential, population 50,000 persons : peak factor of 2.2

(iii) Residential, industrial and rural, population 500,000 persons : peak factor of 1.8

The projections in the Situation Assessment Report were that Nyeri had an "urban" population of 51,415 persons in 1989, and this would grow by 3.7% per annum. The year 2010 and 2020 "urban" populations would then be 110,266 and 158,574 respectively, indicating a peak factor of about 2.0 on the foregoing basis.

With the present indications of the incidence of on-put storage facilities in some types of premises, a reduction from that figure is warranted, and a figure of 1.6 is proposed.

5.6.5 Overall Adjustments

From the foregoing, the adjustments in Table 5.7 below are arrived at.

Table 5.7
ADJUSTMENTS TO AVERAGE DEMANDS

	Year	
	2010	**2020**
1. Physical reticulation losses	22%	25%
2. Seasonal demand fluctuations	25%	25%
Aggregate 1	53%	56%
3. Additional allowance for daily demand peaking	60%	60%
Aggregate 2.....	144%	150%

These adjustments are inclusive of an assumption that a leak detection and repair programme will be carried out.

6. PROJECT OPTIONS

6.1 General

The scope and purpose of this Pre-Feasibility Report is in general the identification and comparison of development options, followed by the selection of one option, for further detailing in the Feasibility Report. To serve the intended purposes, it has only been necessary to size and detail the essential elements of the possible options, so as to provide the basis of costing and technical comparison.

In the Feasibility Report, the basic computations and sizing of components for the selected option will be reviewed and refined, and the elements of the works detailed to a greater extent.

6.2 Earlier Studies

The only study of the Nyeri Water Supply carried out in recent times was by Sir Alexander Gibb and Partners, in 1982. Drawings of the design carried out were finally obtained in late December 1995.

The Gibb proposals were based on abstraction and treatment at the existing Ihwa and Kamakwa sites. Distribution was then based on several service zones namely:

(i) Western - Kamuyu, Kamakwa and Gitathi-ini,

(ii) Mathari - Kihuyo, Mathari village and the large institutions,

(iii) Upper Central - Hill Farm area, Kingongo upto the prison, Chania Estate, Ring Road the northern part of the CBD upto Town Hall, MOW area, Kimathi Estate and Ngangarithi,

(iv) Lower Central - the rest of the CBD, Kiawara, Majengo, Blue Valley, Asian Quarter, and Kangemi,

(v) Ruringu - Skuta, Thunguma and Ruringu; and

(vi) Future (stage II) service areas, these being the Eastern zone (Seremwai and Kingongo past the prison) and the Northern Zone (Muringato, Njengu and Nyaribo).

The Mathari zone was divided into an immediate supply area, this being only Mathari village and Mathari Mission, and the rest was to be incorporated into the supply area in the stage II project.

Both the Mathari and Western zones were for supply by pumping. For the Western Zone, a pump station at the treatment works was to supply a tank near the Kamakwa-Tetu road

junction with the road to Gitathi-ini. Two trunk mains from there would then gravitate to Kamuyu/Kamakwa, and to Gitathi-ini.

The Mathari zone system was planned to be an expansion and augmentation of what exists at present. A gravity main from the Kamakwa Works would have crossed the Chania river near the existing pumping intake, and take water to a Lower Reservoir at the Mathari shops. From there, water would be pumped to an Upper Reservoir, near the Commercial College, above the Mission.

Other areas were to be supplied by gravity, the Upper Central Zone directly from storage at the treatment works, the Lower Central zone from a tank on Ring Road, and the Ruringu zone from a tank in Ngangarithi. The relative top water levels for the various zonal reservoirs were to be as follows:

Reservoir/Station	Top Water Level Level	Difference with Kamakwa TWL
Western	1945 m	64 m
Upper Mathari	1920 m	39 m
Lower Mathari	1865 m	-16 m
Kamakwa (new tanks) (also supplying Upper Central Zone)	1881 m	
Lower Central	1825 m	- 56 m
Ruringu	1812 m	- 69 m

Overall, the Gibb proposals are very similar in many respects to one of the options developed for this report in advance of obtaining details of the Gibb design. The principal deviation is in the zoning by Gibb of the main supply area into three parts.

Gibb had two zones (Lower Central and Ruringu) which were to be supplied by tanks about 60 m below the elevation at Kamakwa. Their Preliminary Design Report [pg 7/8] stated that the rationale for dividing the supply area into the selected zones was to "minimise static pressures, sizes of mains and to provide the service storage as close as possible to the area of consumption". This would obviously have been aimed at reducing the PVC pipe pressure classes for new mains, and reducing the diameter of mains, but only those upto the tanks. This may have it's advantages, however it could alternatively be considered that:

(i) the distances between the Kamakwa works and the two zonal tanks were to be only 1 to 2 km, which are relatively short distances;

(ii) with lower heads, the pipework after the tanks, over distances upto 4 km, would have had to be sized larger: for example, the Ruringu Reservoir had an incoming trunk main of largely 200 mm dia., and an outgoing supply trunk main of 300 mm dia.; and,

(iii) the existing pipework which was to form the bulk of distribution pipework is already capable of sustaining the head from Kamakwa.

In addition, it is not clear why there was the need to have two adjacent pressure zones, supplied by tanks only one kilometre apart, with top water levels which differed by only 13 m.

With regard to treatment, the Gibb proposals were based on upward flow clarification. The advantages and disadvantages of such systems are addressed further below.

6.3 Supply Zones

Figures 6.1 to 6.3, which show the schematic layouts of the proposed project options, also give the elevations of various supply areas. Ihwa Intake is at 1923 masl, and the top water level for the existing storage at the Kamakwa Water Works is at 1884 masl.

The western parts of the supply area are higher than the Kamakwa Treatment Works Site. This includes Kamuyu, Gitathi-ini, and most parts of Kamakwa and Mathari.

Within Mathari, the principal supply areas are within elevations of 1850 to 1900 masl and further, this is an area which is physically distinct from other service areas. There are also consumers or potential consumers at even higher elevations. The institutions at the top of Nyeri Hill (1970 masl) have their own existing pumping station near the Mathari Hospital. For design purposes their relative elevation has been taken to be that of their existing pumping station, since it would be uneconomic to consider project alternatives which would incorporate them into the general supply. Others with high elevation are the very small farm holdings on the slopes of the Nyeri Hill. These potential consumers would be difficult to supply without a high head pumping station serving relatively few potential consumers who would pay for water at the low rates for small consumers.

The other high areas are Kamakwa, and areas to the west of Kamakwa like Kamuyu and Gitathi-ini. Elevations in that supply area are from a maximum of 1920 masl.

The rest of the proposed supply area in Nyeri town is the same as the existing supply area or peripheral to it, and has elevations which are readily served from Kamakwa. Noteworthy characteristics of this area, are the deep river valleys. Although these are uninhabited in the large part, they can serve to increase static pressures in sections of trunk mains. Generally, the main part of the supply area slopes to the east away from Kamakwa, and has ridge top elevations of between 1860 and 1730 masl.

Kiganjo is essentially a supply area along one ridge, which is highest at it's northern and southern extremities. The main supply area is in the centre. The supply area is between 1758 and 1680 masl.

The foregoing gives four distinct supply areas namely:

(i) Kiganjo - due to it's physical separation,

(ii) Mathari - also physically separate, but with high elevation

(iii) Western (Kamakwa, Kamuyu, Gitathi-ini) near the existing treatment works, but too high for gravity supply from them, and

(iv) Central, including Nyeri town and all other peripheral areas, which are readily served by gravity by the Kamakwa Treatment Works.

There is however one variation to the foregoing. Where supply to Mathari is by gravity, it is shorter and more convenient to route a bulk supply to Kingongo and Kiganjo through the Mathari road, resulting in the Kingongo/Njengu/Kimathi Institute supply to be in the Mathari rather than the Central Zone.

6.4 Treatment Works Location

The present water works are at Kamakwa, and the 1982 Gibb proposals were for future augmentation of treatment facilities to be in an adjacent parcel of land. The Nyeri Municipal Council has already acted in light of these recommendations, and acquired the land which had been identified. Further, the Terms of Reference require that use of existing facilities be maximised, which means continued use of the existing treatment works. There would be some advantage therefore, if all treatment facilities were at one location.

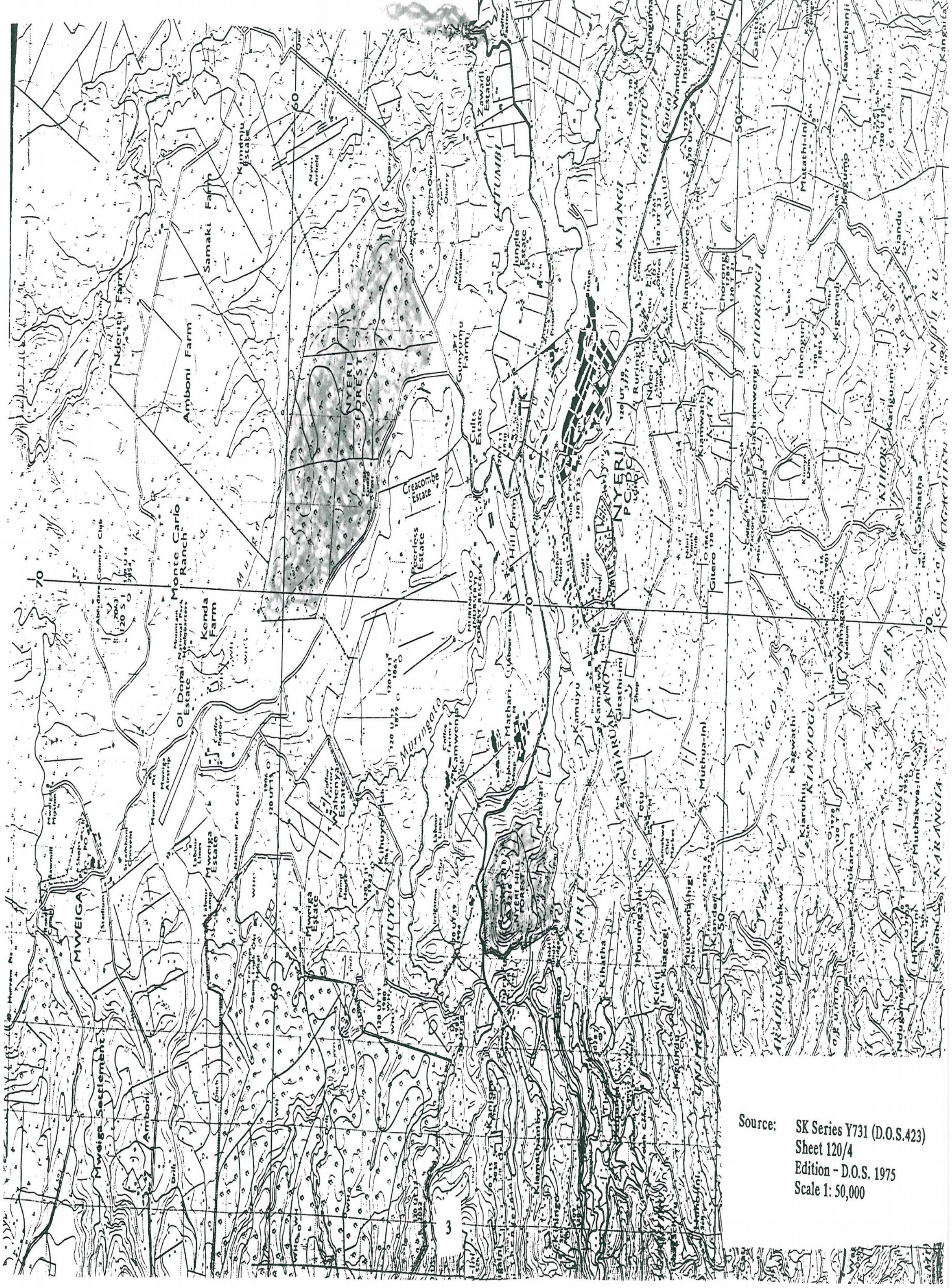
From the foregoing, locating the new treatment works at Kamakwa is one obvious alternative.

This site does have two disadvantages. One is it's overall limited size and its relatively steep slope. The second is it's elevation relative to some supply areas. The existing intake is at an elevation of 1932 masl, and the same source is proposed, as analysed in the Situation Assessment Report. The Kamakwa site is at roughly 1886 masl.

The elevation is below all of the proposed Western zone, and most of the principal supply area for the Mathari zone. Supply to those areas would have to be all by pumping if the new treatment works were at Kamakwa.

The intake elevation is just 10 m above the highest parts of the Western zone, thus, if most of the head were conserved, it would be possible to supply most of that zone by gravity, (Kamakwa, Kamuyu) and have low head pumping for limited areas (Gitathi-ini). All of the Mathari Zone could be fed by gravity.

Fig. 1: Nyeri Town and its Environs



Source: SK Series Y731 (D.O.S.423)
Sheet 120/4
Edition – D.O.S. 1975
Scale 1: 50,000

Locating the treatment works at the intake without pumping would however be impracticable. To meet with the heads available, significant amounts of excavation would be involved, and rock is close to the surface in that valley.

Analysis of the raw water main profile has led to the identification of a suitable site about 2.2 km from the intake. At this location, the hydraulic profile is close to ground levels, thus there would be little loss of head through the open structures of the treatment works. The land there is open, gently sloping, with deep soils, and not heavily developed (See Picture 19).

This proposed site will be referred to as the **KIRITI** Treatment Works Site, with an elevation of 1923 masl. It should be noted that even with the new works at Kiriti, it will still be necessary to run the Kamakwa Works at the present capacity if there is to be conformity with the requirement in the TOR for maximisation of the use of existing facilities.

Supply to Kiganjo can be effected from the Nyeri Water Supply. The relative elevations are about 165 m from the Kiriti Site, and 128 m from the Kamakwa Site. The Kiganjo supply area is only separated from the Nyeri supply area by the Amboni river valley, and therefore they are within fairly close proximity. The present straight distance between the extremities of the Nyeri town and Kiganjo reticulation systems is about 3 km.

An alternative to that would be to retain the Kiganjo system as a separate entity. The Situation Assessment found two principal difficulties which would affect the present system in the long run, these being:

(i) the source river (Nairobi) is subject to excessive upstream abstraction, leading to near zero flows in the dry season, and

(ii) the present treatment works facilities have significant structural defects and are nearing the end of their useful life.

The source would need to be changed, and the present treatment works cannot be part of plans for the future.

The alternative raw water source for Kiganjo which was identified in the Situation Assessment was the Amboni river, on the east side of the ridge on which Kiganjo is located. Regrettably, an analysis of the topography clearly indicates that a gravity supply should not be practicable, thus it would be necessary to have pumping.

In those circumstances, the appropriate approach if the Amboni river is to be the source, is to locate the intake and treatment works in the valley, with the treatment works adjacent to the most suitable treated water header tank location. The selected site is in the valley below Chaka, and will be referred to as the **AMBONI** site.

6.5 Basic Project Options

The basic project options derive directly from the treatment works location alternatives which have been outlined above. These options are as follows:

Option	New Treatment Works for Nyeri	Treatment Works for Kiganjo
A1	Kamakwa	Kamakwa
A2	Kamakwa	Amboni
B1	Kiriti	Kiriti
B2	Kiriti	Amboni

For the "B" options, the existing Kamakwa Works would continue in operation.

The basic outlines for these project options are illustrated schematically in Figures 6.1 to 6.3. It should be noted that the outlines of options A2 and B2 for Nyeri alone are the same as A1 and B1 respectively, save for elimination of the trunk main supply from Nyeri town to Kiganjo.

The basic outline of the supply parameters are as follows:

(i) NYERI OPTION "A"

The treatment works at Kamakwa would be augmented, inclusive of a new raw water main from Ihwa. Treated water tanks for the proposed works would be interconnected with the existing tank.

A pumping station at the treatment works would pump all the water for both Western and Mathari zones to a new tank on the Kamakwa-Tetu road (Kamuyu tank) which would then feed the Western zone directly by gravity, and a separate Mathari tank also by gravity. The Mathari tank would serve the Mathari area.

The rest of the distribution system would be fed by gravity from the water works.

One principal new northern trunk main would cross the Chania river below the Outspan Hotel, and augment supplies to Kingongo and Njengu. Under Option A1, the same trunk main would feed a Kingongo tank, which would be the source of water for Kiganjo.

Picture 19
PROPOSED KIRITI TREATMENT WORKS SITE

This view is taken looking away from the Intake. The treatment facilities would be on the right, and staff housing on the left of the road. The existing raw water mains cross the road from left to right just below this picture

Figure 6.1
SCHEMATIC LAYOUT - OPTION A1

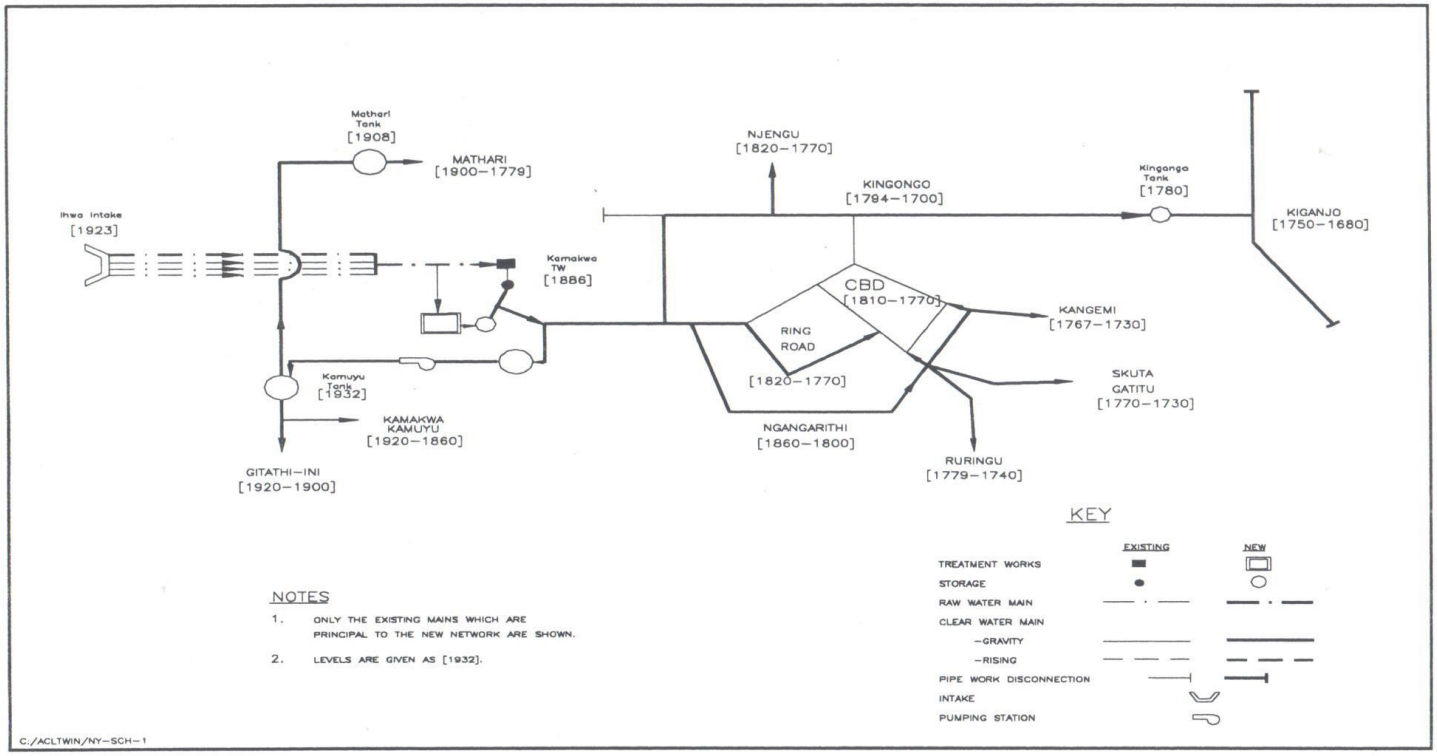


Figure 6.2
SCHEMATIC LAYOUT-OPTION B1

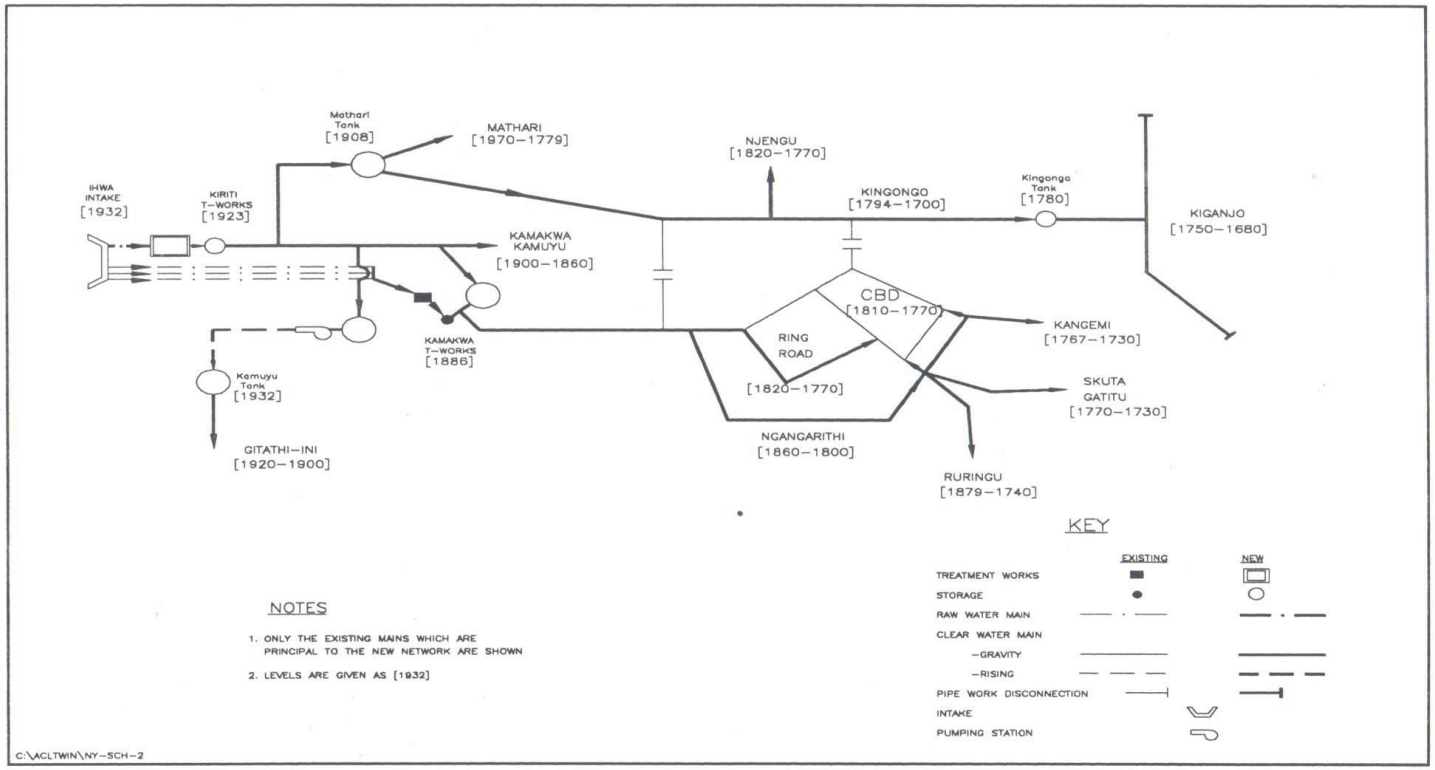
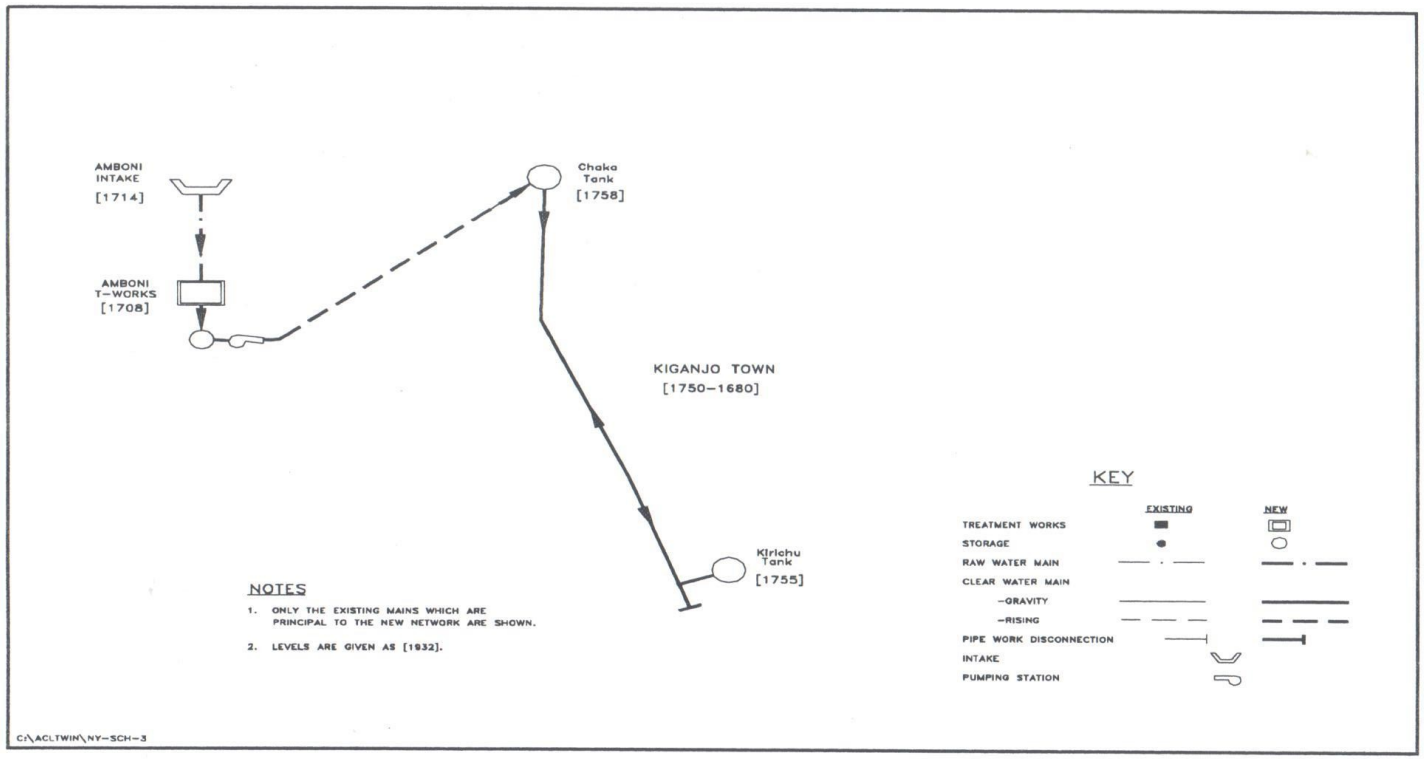


Figure 6.3
SCHEMATIC LAYOUT - OPTION A2 & B2
KIGANJO WATER SUPPLY ONLY



Two ring trunk mains would augment supplies to central parts of Nyeri town, Ruringu, Skuta and adjacent areas. One would traverse through Ring Road and join into the existing system near Kimathi Estate, and a more southern ring main would pass through Ngangarithi to Temple Road, from where it would feed the southern parts of the Central Business District, and have branches into Ruringu, Skuta/Gatitu, and Kangemi.

(ii) NYERI OPTION "B"

The main Kiriti Treatment Works would be supplied by a new raw water main, whilst the existing raw water mains would continue to serve the existing Kamakwa Works.

On the route from the Kiriti Works to Kamakwa, a branch off the new clear water trunk main would serve the Mathari tank, which would in turn serve the Mathari area, Njengu, and Kingongo (and the Kingongo tank for Kiganjo supply in Option B1). This new northern trunk would give a different static head for all the supply areas north of the Chania River, leading to the necessity of cutting off the two present links across the valley.

The clear water trunk main from the Kiriti Works would continue to the existing treatment works, feeding Kamuyu, Kamakwa and upper parts of Ring Road (Western zone) on route. A small pumping station would however need to be located at Kamuyu trading centre to feed the Kamuyu tank, for supply to Gitathi-ini.

After supply to the Mathari zone, Kingongo area and the Western zone (and Kiganjo in Option B1) directly from Kiriti, the remaining clear water would empty into new balancing tanks at the Kamakwa Works, which would be linked to the existing tank. The existing treatment works would continue to supply the existing tank. Distribution from there into Ring Road, the CBD, Kangemi, Ngangarithi, Ruringu and Skuta would be augmented by two principal southern trunk mains, as in Option A.

(iii) KIGANJO SEPARATE SYSTEM

In Options A2 and B2, the Kiganjo system is to be separate from the Nyeri town system, and has it's source on the Amboni River.

A new concrete weir on the Amboni river would be needed, providing a gravity raw water supply to new treatment facilities in the valley.

Storage facilities would of necessity be at the extremities of the distribution system, due to topography, thus the southern Kirichu tank would act as a floating head tank, with interconnected inlet and outlet.

There would be a contact tank/pump sump at the treatment works, and a rising main to the main Chaka tank.

Augmentation of the distribution system would largely consist of one trunk main across the supply area, from Chaka to Kirichu.

The parameters for the preliminary sizing of these facilities are described below.

6.6 Treatment Works Process Selection

The basic and standard treatment process which apply to a raw water quality such as that under consideration are coagulation, flocculation, clarification/sedimentation, followed by rapid sand filtration and disinfection.

In general, the principal considerations in selection of the individual processes are reliability and cost. Reliability in the circumstances will largely be defined by the levels of personnel and resources that can reasonably be expected to be available for operation and maintenance, even with the best of intentions.

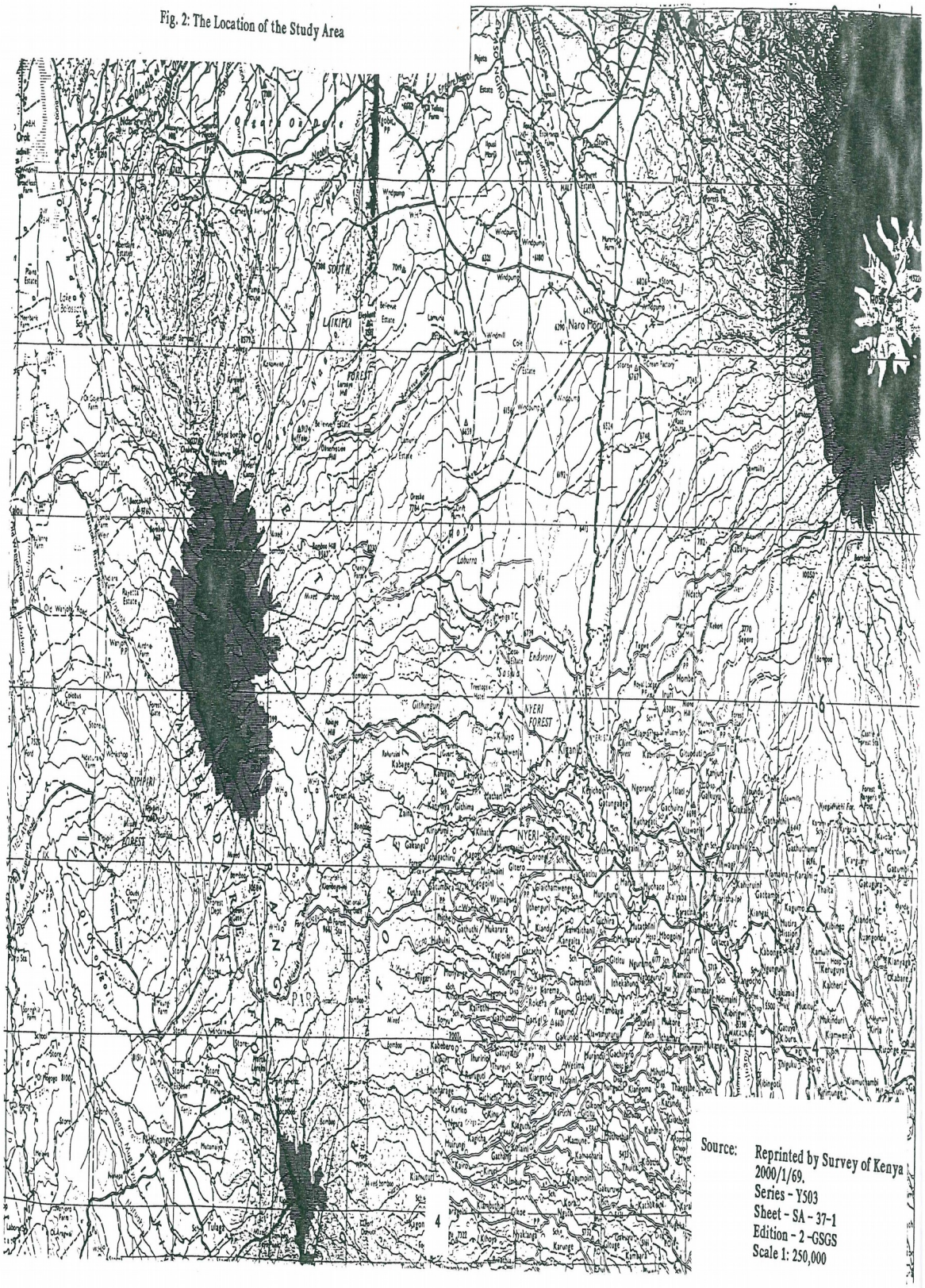
It is a fact that in Kenya and other similar countries, personnel for operation and maintenance are generally not to be expected to have very high standards of education. The City of Nairobi is known to deploy graduate engineers, and sometimes even qualified engineers, to directly supervise the operation of water works facilities, but no other local authority in Kenya is in a similar position. This basic circumstance is not expected to change, unless there are far reaching changes to the national water sector management scenario.

The situation with regard to maintenance staff is similar, and mechanical plant is normally kept running by artisans of limited educational qualification.

It is however possible that there will be basic changes to the setup for managing local authority water supplies. It is to be expected that if there were a commercial perspective to the operation and maintenance of these schemes, such as in a case where private sector participation were introduced, it would be possible to deploy qualified manpower and institute sound repair and preventive maintenance measures. Considerations of that nature are to be addressed in the next study stage, and may or may not result in an appropriate management structure being implemented.

Whereas one may hope that there will actually be marked sustainable improvements, for the better, the only reasonable means of proceeding at this point in time is in light of the known existing conditions. This requires that mechanical equipment be minimised, and that the treatment processes be as simple to operate as possible. Should it be considered that the improvements which it is expected should be practicable with private sector participation will actually be implemented, then this can be taken into account in a reassessment of these criteria.

Fig. 2: The Location of the Study Area



The foregoing criteria lead to the selection of the following as elements of the treatment processes:

(i) use of aluminium sulphate as the coagulant, and soda ash for pH correction,

(ii) chemical dosing by gravity dosers and solution preparation by manual stirring,

(iii) flash mixing over a V-notch

(iv) sinuous flow flocculation through channels

(v) horizontal flow sedimentation

(vi) disinfection by sodium hypochlorite solution.

This Consultant's experiences in Kenya and neighbouring countries over many years lead to the recommendation against metering pumps, electrical stirrers, mechanical flocculators, and upward flow clarifiers.

Mechanical/electrical equipment is usually a source of significant problems in maintenance, especially with small and medium sized plants. It is usually uneconomic for every small fault to be analysed by service agents called in from Nairobi, and the water authority's staff are usually not in the best position to carry out the maintenance. Where there are simple mechanisms available as an alternative, these have been adopted.

Upward flow clarification has one principal advantage - it is more economical on space than horizontal flow sedimentation. Depending on the land values and the availability of land for acquisition, this can be a critical factor. In this particular case, it is not considered to be an overriding consideration. The land which would be needed at Kamakwa has already been acquired, and the proposed Kiriti site is on agricultural land.

The main disadvantage of upward flow clarification in a case such as Nyeri is in the level of expertise required for proper operation. A good sludge blanket takes time to develop, and is easily destroyed. The operators need to continuously adjust the dosing of coagulant and alkali to obtain optimum conditions, depending on raw water quality and ambient conditions. This Consultant has found that it is often the case that this is not wholly within the capabilities of the calibre of operators commonly to be found in Kenya. [eg Kisumu Water Supply]. Without proper operation of the clarifiers, there are adverse effects on the quality of clear water and on the operation of rapid sand filters.

In contrast, horizontal flow sedimentation basins have the ability to give a reasonable product within a broader range of operational capabilities and sub-optimal dosing. They also are less susceptible to changes in influent flows, intermittent usage, and to any overloading.

The treatment chemicals chosen are soda ash, alum, and sodium hypochlorite. All of these are readily available in granular or lump form from local manufacturers. In particular, and for

the flows involved, chlorine solution dosing is preferred over gaseous chlorination. Gaseous chlorine is imported, and not in common usage, thus procurement delays can be experienced. More importantly, the complementary equipment is relatively complicated, which leads to higher possibilities of breakdowns, the system pipework easily clogs in a manner difficult to rectify, if air ingress is allowed or occurs, and gas leaks, where they occur, can be dangerous, if not lethal. Experiences with gaseous chlorination systems at the Baricho Water Works (serving Malindi, Kilifi and Mombasa) and the Kisumu Water Supply are that in the course of time, it becomes necessary to change to or have the means of chlorine solution dosing, due to operation and maintenance problems.

6.7 Sizing of Treatment Works Components

In general, the sizing of treatment works units has been carried out in accordance with the guidelines of the Ministry of Water Development Design Manual, unless otherwise stated.

The demands for which the treatment works need to cater should be inclusive of reticulation losses and seasonal demand fluctuations. The rates for those adjustment are given in Table 5.7. In addition, allowance needs to be made for water usage within the water works, including:-

(i) filter backwashing

(ii) cleaning of tanks, channels, sedimentation basins,

(iii) water losses in deslugding sedimentation basins, and

(iv) treatment works uses in solution preparation and other activities.

The recommendations of the Ministry of Water Development manual are that "it should be assumed that 5% of the water production is used in backwashing of rapid sand filters, ... other internal uses (in the treatment works) may be neglected...". It is not stated, but it can be assumed that these are the levels of water usage recommended when air scour is in use. Twort *et al* on the other hand recommended that total washwater usage should not normally exceed 2% of treated water output, and should be less when air scour is in use. Other water uses would increase that figure but not by a large proportion. For this study the more conservative Ministry of Water Development figure of 5% has been used.

The new works need to produce the water requirements which are above the present treatment capacity. For the present purposes, the existing Kamakwa works are assessed at their design capacity of 5,580 m^3/day. It should be noted however that they are reported to produce slightly more than 6,000 m^3/day with adequate raw water supply, although this is unconfirmed, and there are proposals, which may or may not be implemented, to uprate the existing works to a maximum of 9,000 m^3/day. It may be indicated that such an uprating will be carried out directly by the Council, or as a precursor to the construction of the main project, under donor financing. Prior to such positive indications, it has been considered

unsafe to allow for the uprated capacity of the existing works, in the design of the new works. The capacity of the existing Kiganjo works is not taken into account, as it is recommended these be phased out. Taking the foregoing into consideration, the treatment works design capacities are as given in Table 6.1. After rounding off, the various design capacities for the new treatment works are as follows:

		Year 2010	Year 2020
(i)	Separate Nyeri TW	20,600 m^3/day (238 l/s)	32,800 m^3/day (380 l/s)
(ii)	Separate Kiganjo TW	4,900 m^3/day (57 l/s)	7,200 m^3/day (83 l/s)
(ii)	Combined Supply	25,500 m^3/day (295 l/s)	40,000 m^3/day (463 l/s)

The basic phasing of the treatment works is designed such that the initially constructed works can satisfy the year 2010 requirements, and simple augmentation at a later date will give the year 2020 production capacity.

If the uprating of the existing works is considered a likely possibility, the above figures for Nyeri alone and for a combined supply would be reduced by 3,500 m^3/day each.

The principal criteria used in sizing of facilities is as follows:

(i) alum solution dosing : 40 mg/l

(ii) alkalinity adjustment (soda ash) : 15 mg/l

(iii) flocculation channels:

- first section: $G = 60\ s^{-1}$; Gt = 18,000; Channel velocity = 0.3 m/s; Slot velocity = 0.6 m/s
- second section: $G = 60\ s^{-1}$; Gt = 21,000; Channel velocity = 0.2 m/s; Slot velocity = 0.45 m/s
- third section: $G = 60\ s^{-1}$; Gt = 32,400; Channel velocity = 0.1 m/s; Slot velocity = 0.3 m/s
- overall retention time = 20 minutes

Table 6.1
TREATMENT WORKS DESIGN CAPACITY

	Year 2010			Year 2020		
	Nyeri	Kiganjo	Total	Nyeri	Kiganjo	Total
Average Daily Demand	16,536	3,047	19,583	23,579	4,418	27,997
Adjustments for:						
- Water Losses	22%	22%	22%	25%	25%	25%
- Seasonal Demand Fluctuations	25%	25%	25%	25%	25%	25%
Output Requirements	25,217	4,647	29,864	36,842	6,903	43,745
Less existing treatment capacity	5,580	-	5,580	5,580	-	5,580
Required output from new TW	19,637	4,647	24,284	31,262	6,903	38,165
Adjustment for TW Water Use	5%	5%	5%	5%	5%	5%
REQUIRED NEW TW PRODUCTION CAPACITY	20,618	4,879	25,497	32,825	7,248	40,073

Note: All production figures in m^3/day

(iv) sedimentation basins : surface overflow rate of 1$m^3/m^2/hr$, retention time of 2 hrs, and a 25% allowance for sludge accumulation.

(v) filters : filtration rate of 6.0 m/hr, allowance for 40% bed expansion, and backwashing rate of 50 $m^3/m^2/hr$.

(vi) disinfection : sodium hypochlorite dosing at 10 mg/l with 5% strength solution.

Using the above criteria, preliminary sizing of components has been carried out, together with identification of principle works components. The essential details are given in Figures 6.4 to 6.13 at the end of this Chapter.

Full computations for sizing of the selected project option will be presented in the Feasibility Report.

6.8 Storage

Storage locations have been determined in the selection of project options, these being as follows, for the alternative treatment sites:

(i) For Kamakwa Treatment Works alternatives (Option A1 and A2), storage to be at:

- Kamakwa Treatment Works (existing and new storage)
- Mathari
- Kamuyu, and
- Kingongo (Option A1 only, to supply Kiganjo)

(ii) For Kiriti Treatment Works alternatives (Option B1 and B2) storage to be at:

- Kiriti Treatment Works
- Kamakwa Treatment Works (existing and new storage)
- Mathari
- Kamuyu, and
- Kingongo (Option B1 only, to supply Kiganjo)

(iii) For Amboni Treatment Works alternative (separate Kiganjo Supply), storage to be at:

- Amboni Treatment Works,
- Chaka, and
- Kirichu

For the storage at the treatment works, consideration of contact time (30 minutes) for chlorine is required. Other considerations for overall storage are:

(a) Balancing of the variation in demand within a day, against a constant output from source, and

(b) Emergency storage to ensure an acceptable continuity of supply during breakdowns at source or on trunk mains to the storage, or for heavy limited time usage in fire fighting.

An accurate determination of balancing storage requires data on the fluctuations in demand over a daily period; that level of information is not available here. Where this is the case, the MOWD recommendations are for a capacity of 50% of the average daily demand downstream of the tank. This seems, intuitively to be rather high, especially for a gravity supply system, whilst on the other hand, the recommendation by Twort *et al* for 25% storage in an "average sized" distribution system seems on the lower bound, for Nyeri's circumstances. It had been mentioned in Chapter 5 that without significant diversity of user categories, peaking of demand is higher.

Overall, it has been decided to apply a balancing storage rate of 30% of average daily demand, which is equivalent to about 7 hours storage.

The recommendations by MOWD regarding emergency storage are that

(i) large facilities, (industries, schools, hotels etc) should cater for themselves through on-plot storage, and

(ii) for other consumers 12 hours storage (50% of average daily demand) should be provided.

Following those recommendations, and adding the 30% balancing storage, the storage requirements have been computed as follows:

		Storage Requirements [@80% of average daily demand]	
		2010	2020
(i)	Nyeri	16,200 m^3	24,200 m^3
(ii)	Kiganjo	2,800 m^3	4,300 m^3

As described above, storage for Nyeri will be at the treatment works location(s) and at Kamuyu and Mathari. Storage for Kiganjo would be at Kingongo, where there is a clear water supply from Nyeri, and otherwise at Chaka and Kirichu.

6.9 Reticulation

The required sizes of reticulation pipework have been computed using the Consultant's REHM network analysis software. The basic criterion in sizing has been to maintain a minimum peak use pressure lead of 10 m in all parts of the reticulation. This basic parameter has however been relaxed to 5 m in peripheral parts of the Kiganjo System, as this was found to have a significant effect on pipe sizes, in this relatively flat service area, and high rise buildings are not expected to develop in those areas.

Initial sizing was carried out using the year 2020 demands, for each option.

Analysis was thereafter carried out based on the year 2010 demands and the pipe sizes already computed, to determine where there were pipelines which could be postponed to the second stage of the project. Overall, it was found that such pipework, which could be omitted in the first stage, was peripheral to the system, and of about 6% to 8% of the cost of the overall estimated year 2020 reticulation for the various project alternatives. Such reductions are at present considered too small to warrant their being postponed to a later phase.

Another approach would of course be to size the reticulation for year 2010 demands, and then determine the augmentation needed in the stage two works to meet the year 2020 demands. Such an approach can be expected to result in extensive duplication of pipework, with high stage two capital costs, and high future maintenance costs and water loss rates. That approach has therefore not been pursued. It can however be reconsidered if financial restraints suggest it to be necessary.

In view of the foregoing, the reticulation pipework in all project alternatives has been sized for single stage implementation. The second stage works would therefore consist of treatment capacity and storage augmentation.

The sizing and location of the reticulation augmentation measures are illustrated in Figures 6.14 to 6.17

Figure 6.4
LAYOUT OF TREATMENT WORKS - OPTION A1

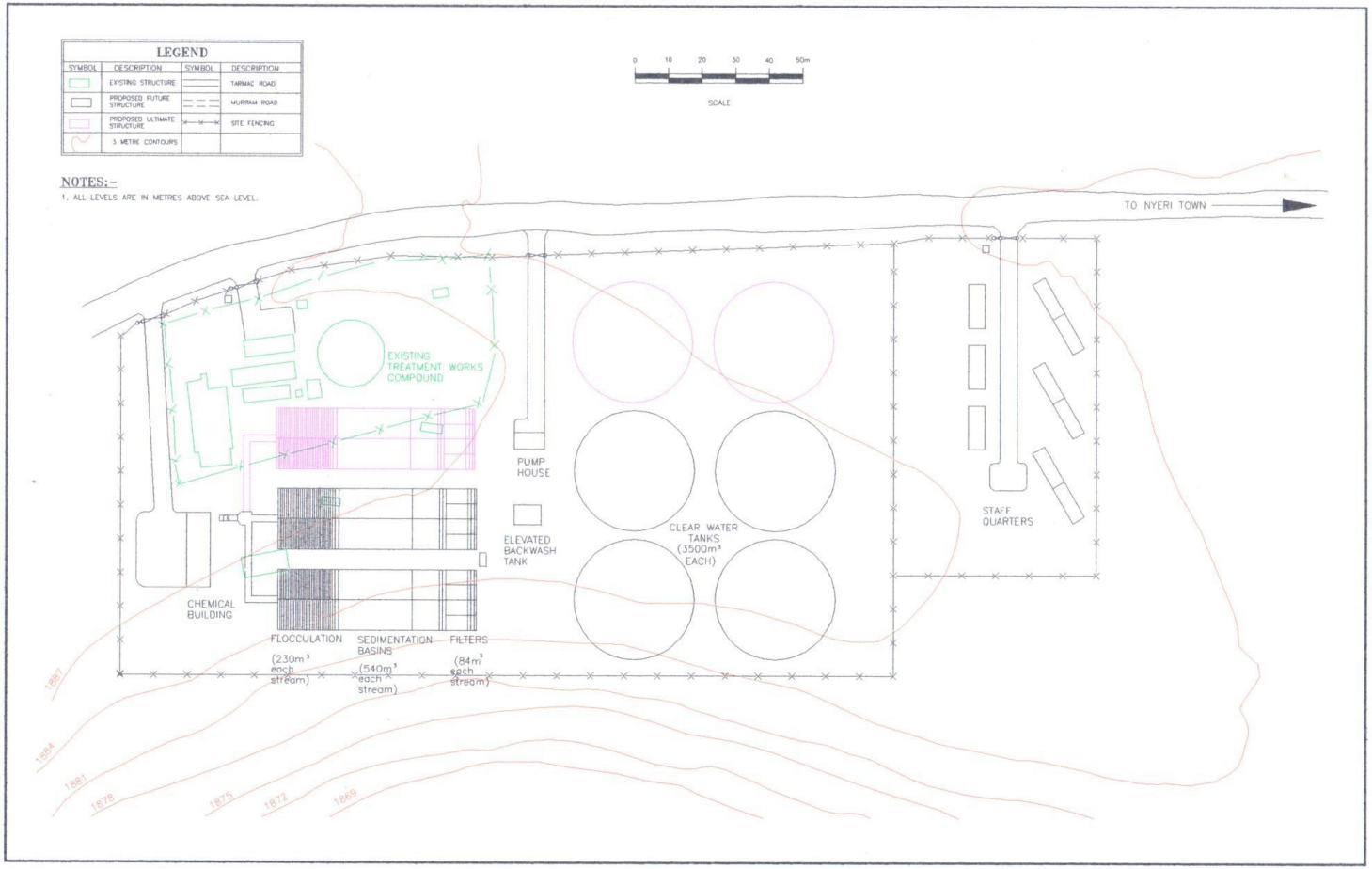
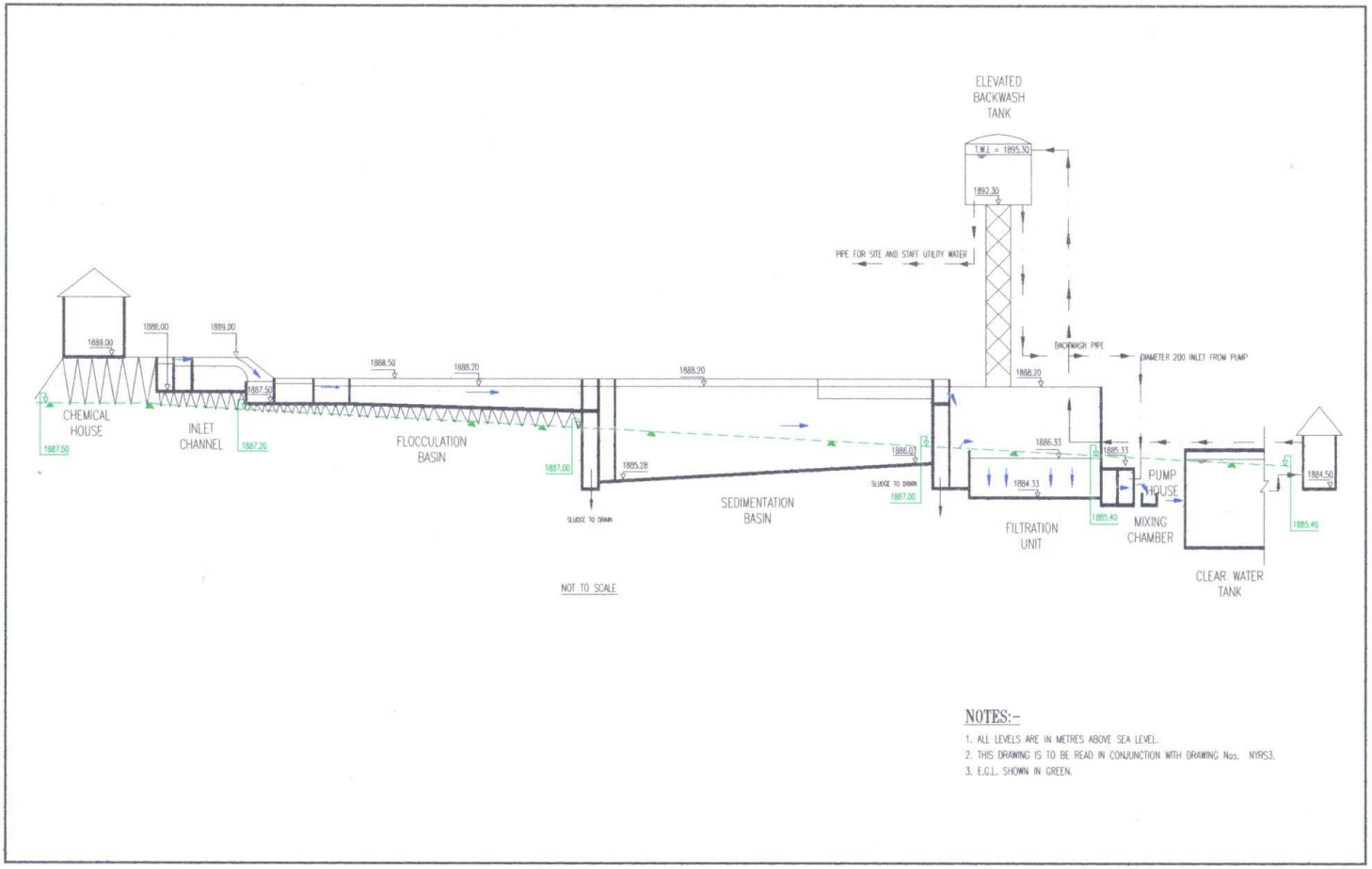


Figure 6.5

SECTION THROUGH TREATMENT WORKS - OPTION A1



NOTES:-

1. ALL LEVELS ARE IN METRES ABOVE SEA LEVEL.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH DRAWING Nos. NYRS3.
3. E.G.L. SHOWN IN GREEN.

Figure 6.6
LAYOUT OF NYERI TREATMENT WORKS - OPTION A2

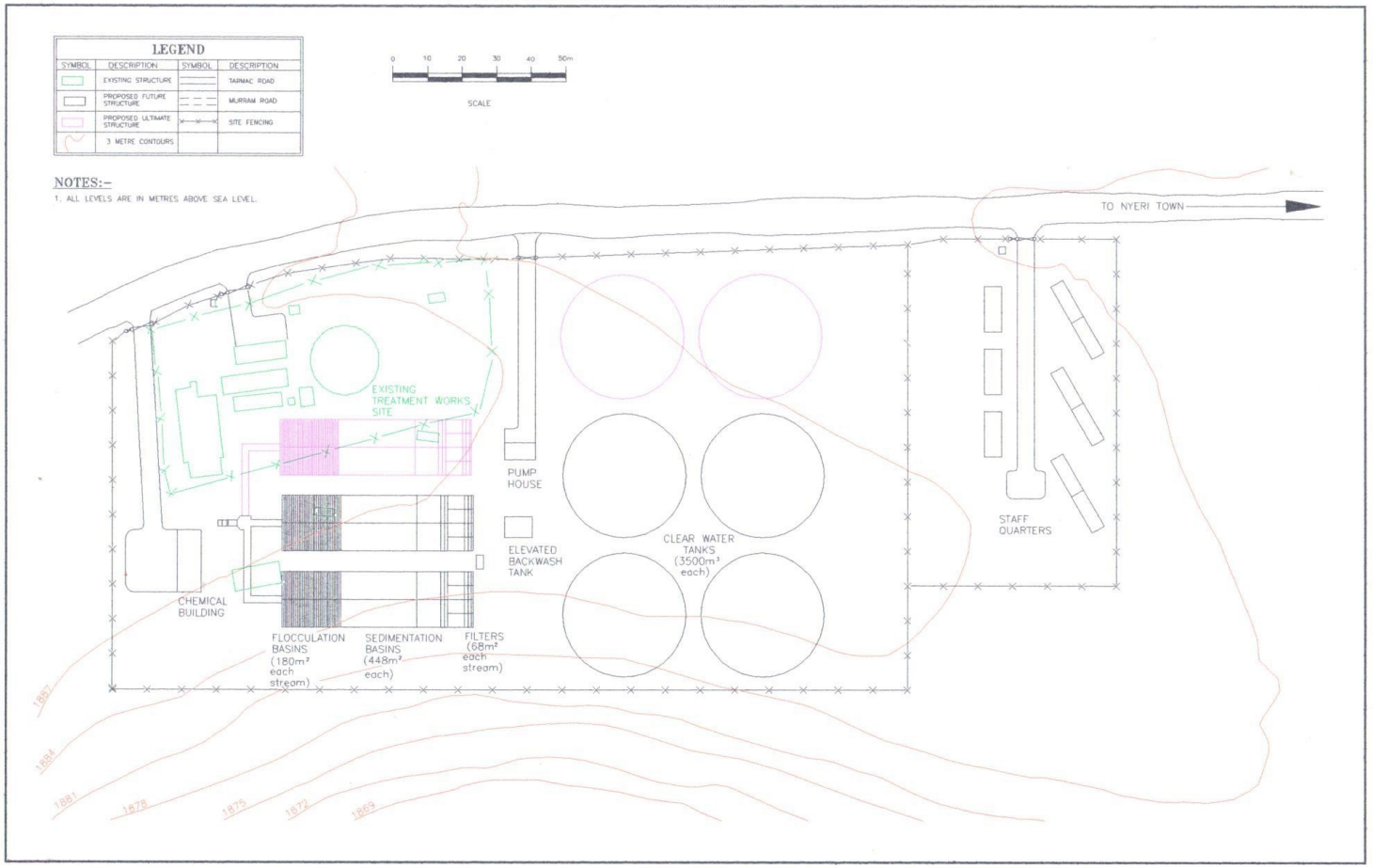


Figure 6.7
SECTION THROUGH NYERI TREATMENT WORKS - OPTION A2

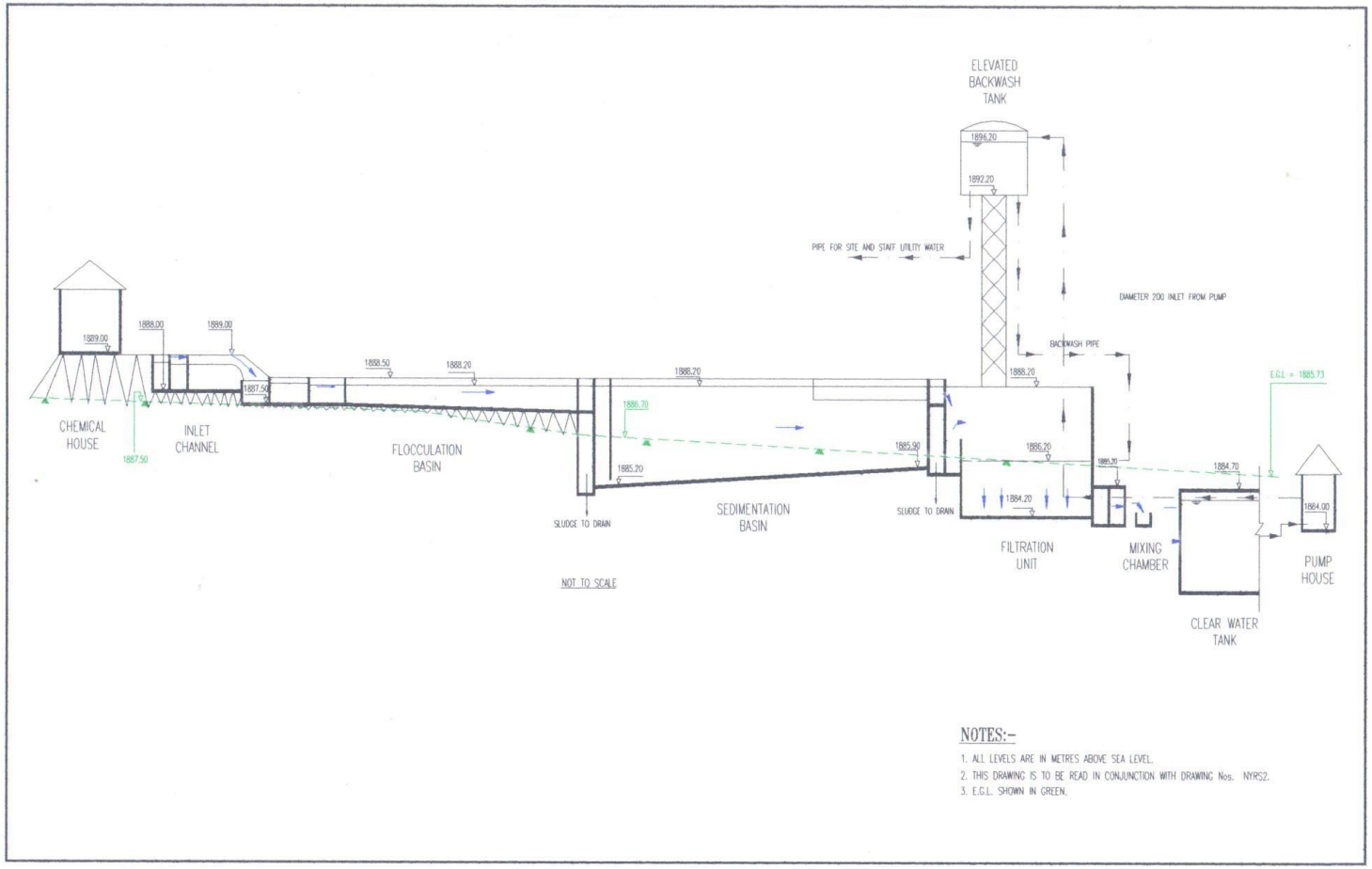


Figure 6.8

LAYOUT OF NYERI TREATMENT WORKS - OPTION B1

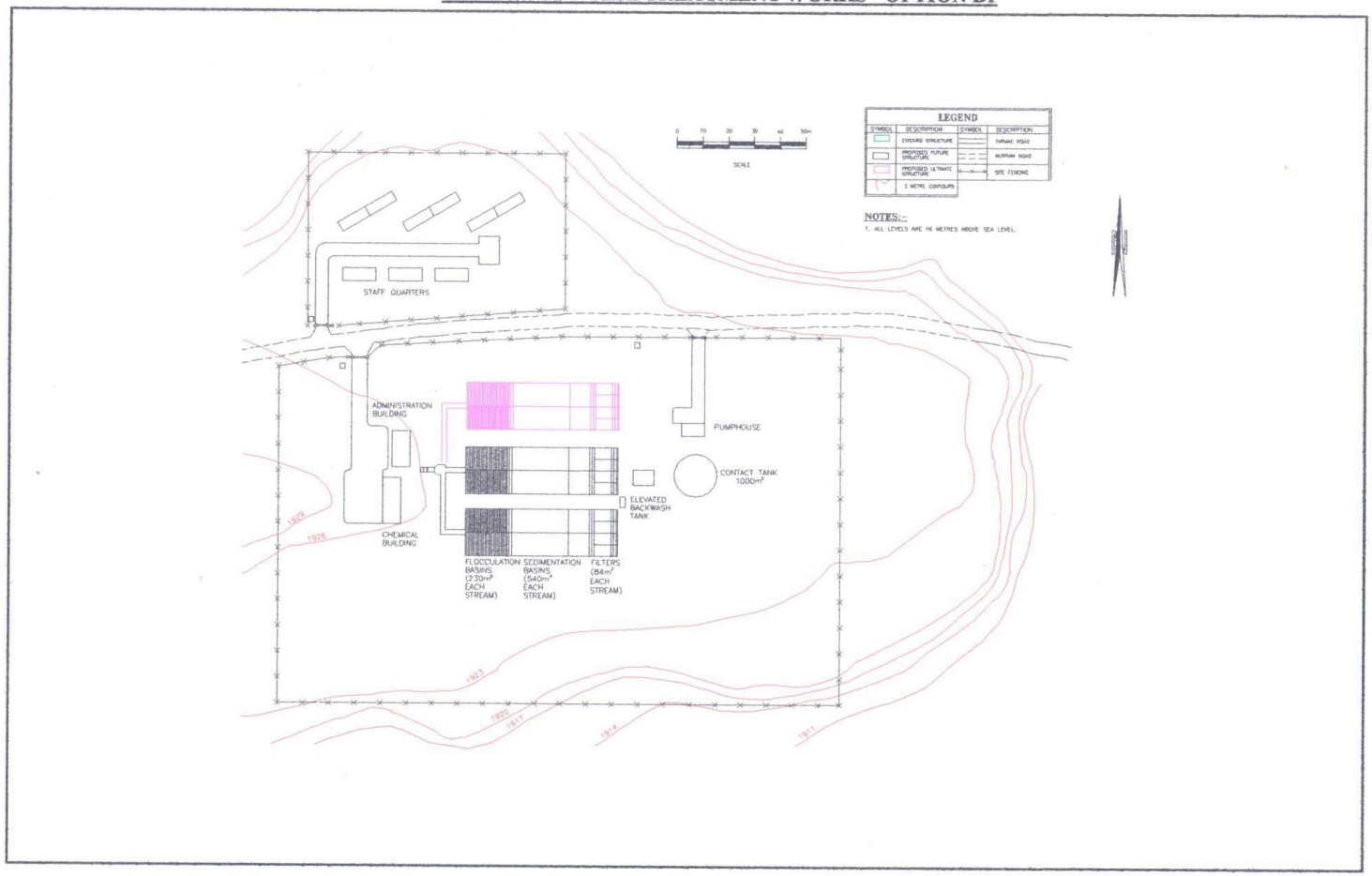


Figure 6.9

SECTION THROUGH NYERI TREATMENT WORKS - OPTION B1

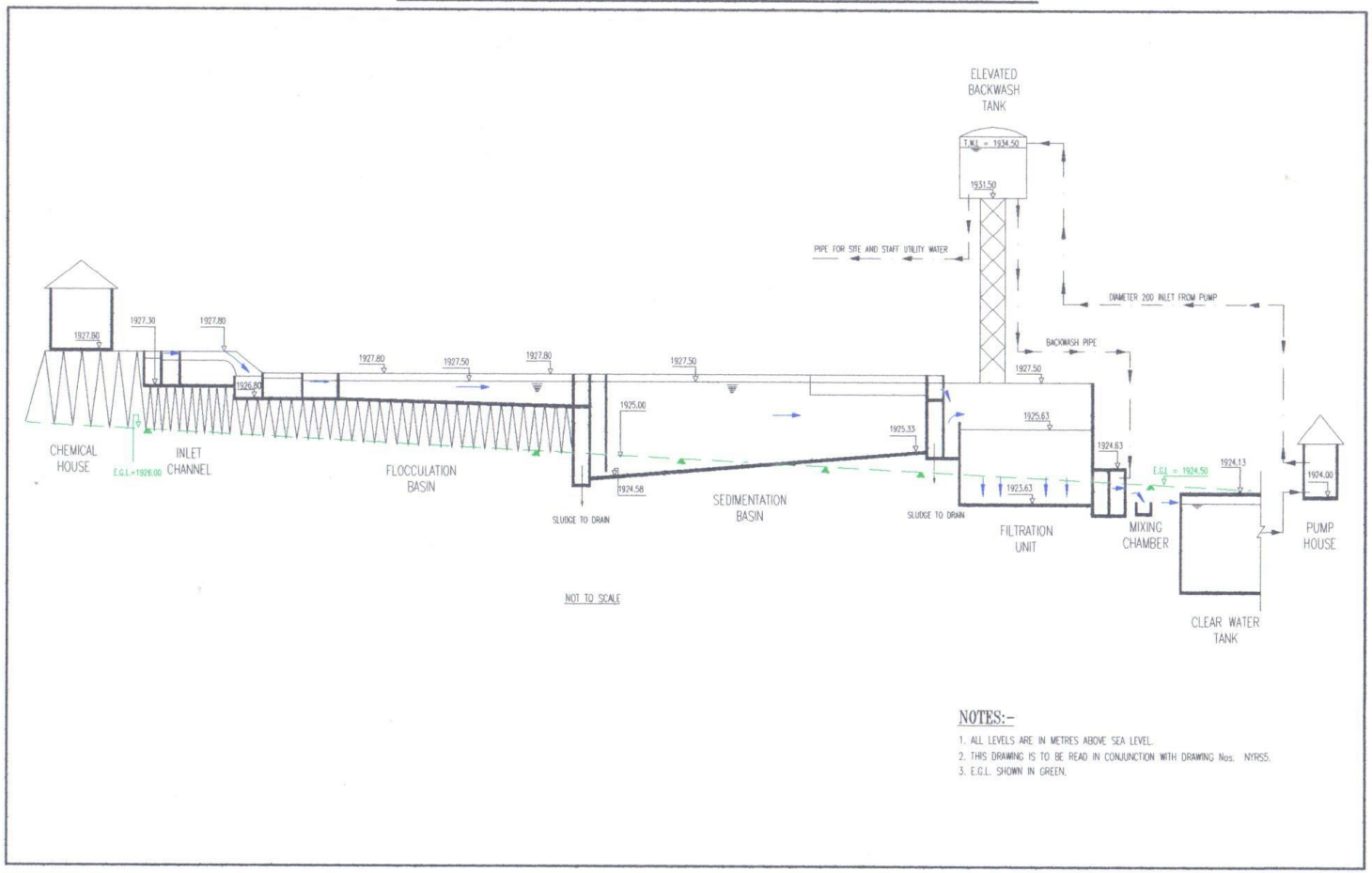


Figure 6.10

LAYOUT OF NYERI TREATMENT WORKS - OPTION B2

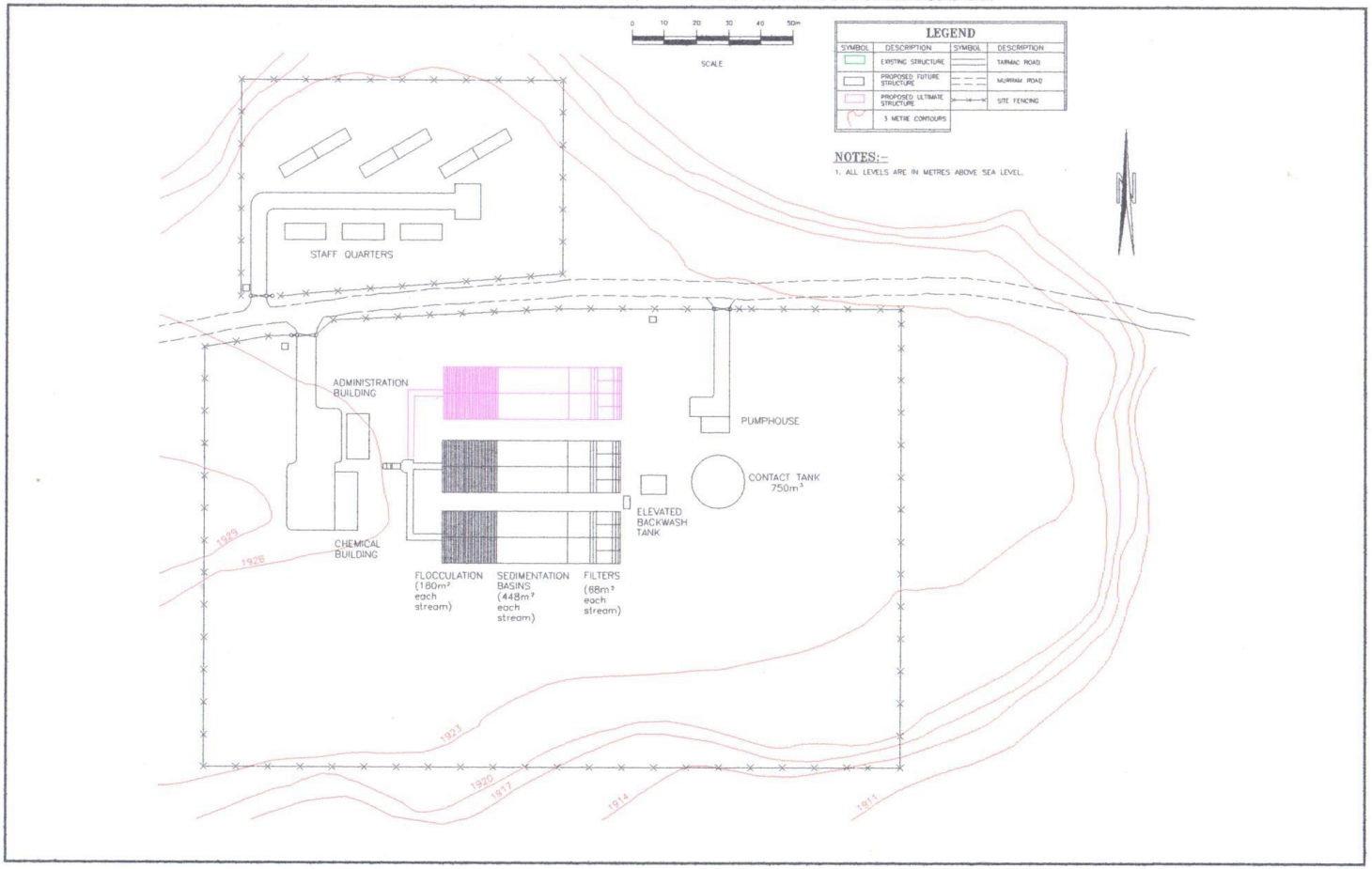


Figure 6.11

SECTION THROUGH NYERI TREATMENT WORKS - OPTION B2

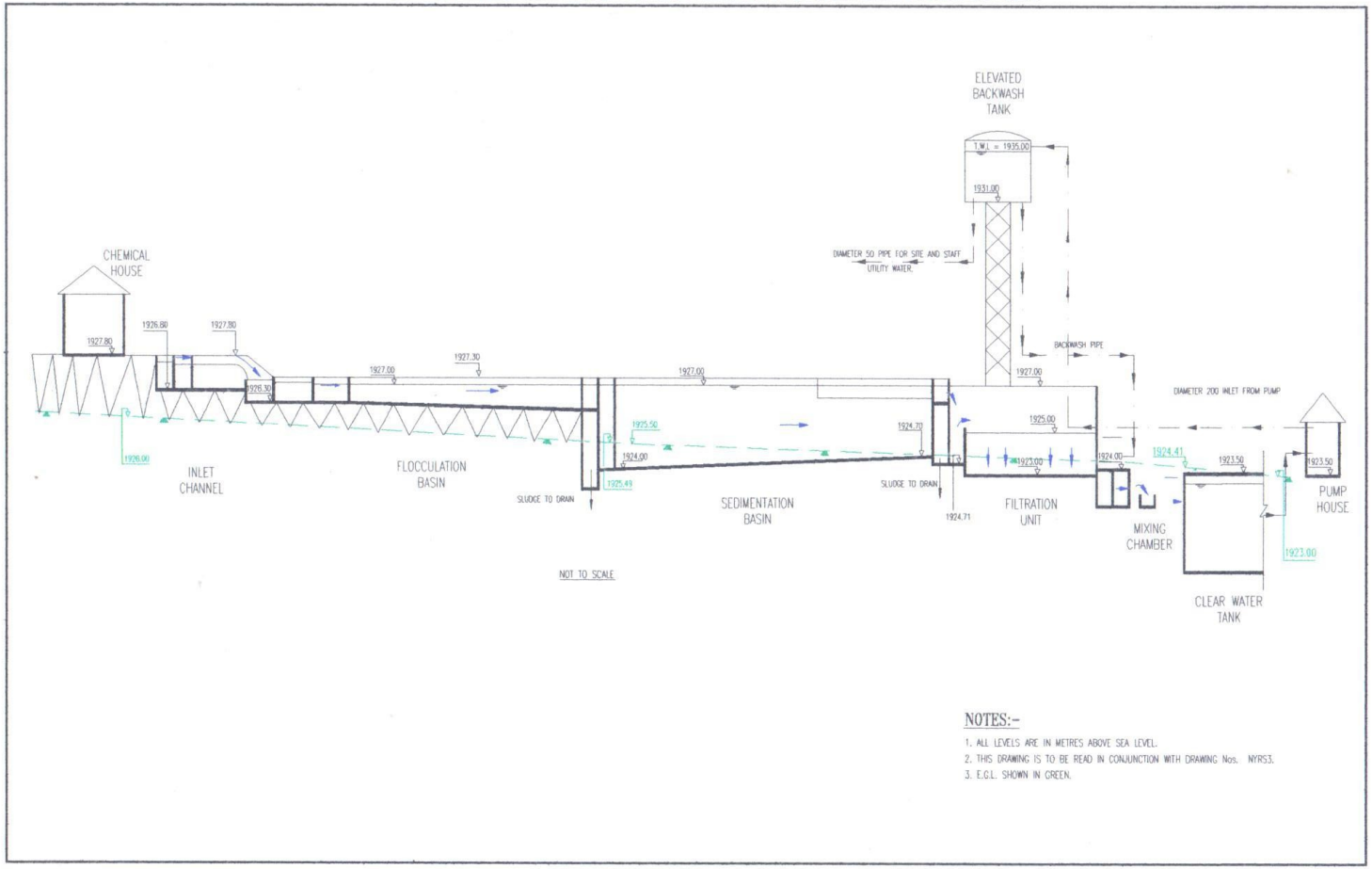


Figure 6.12
LAYOUT OF SEPERATE KIGANJO TREATMENT WORKS

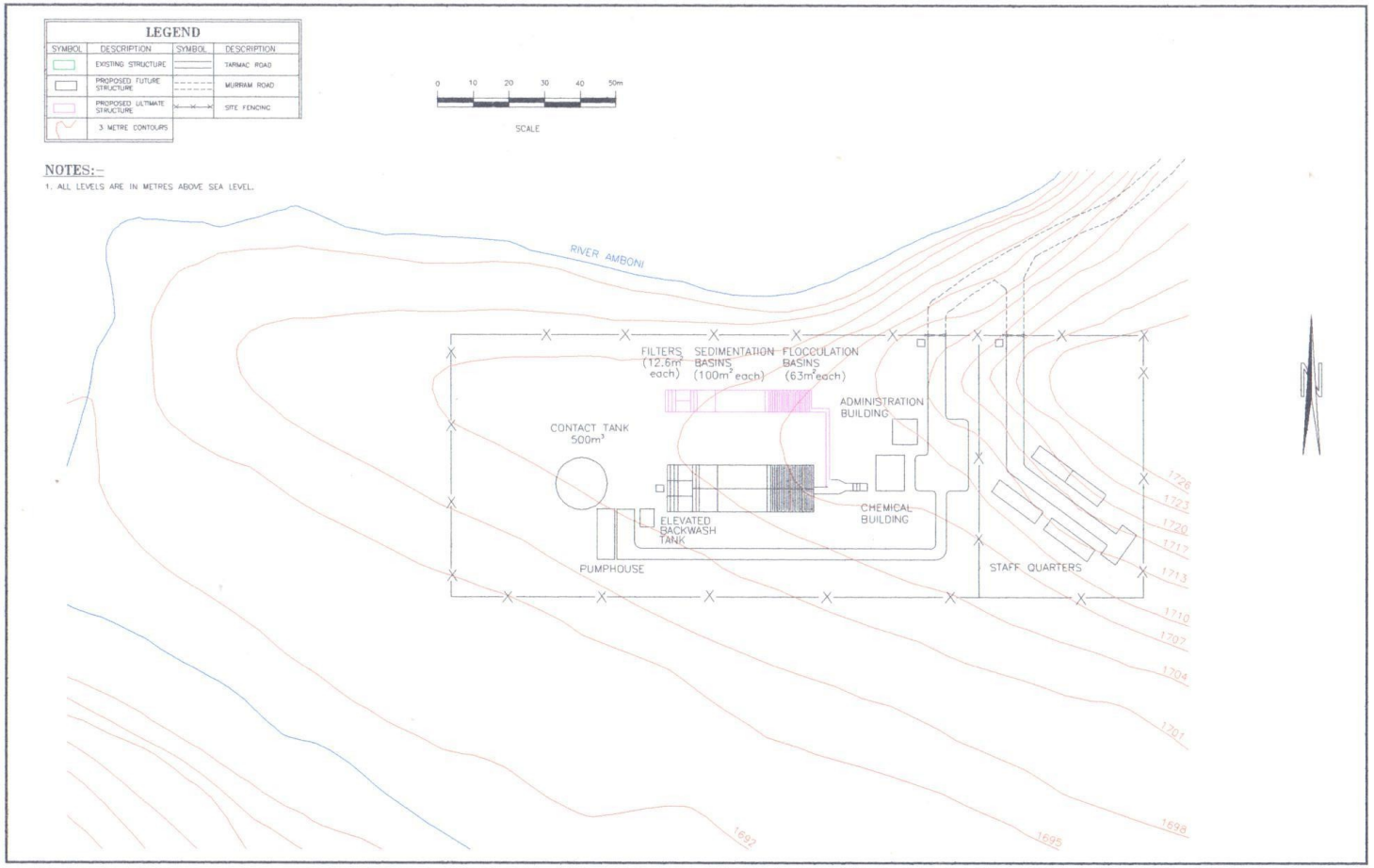


Figure 6.13

SECTION THROUGH SEPERATE KIGANJO TREATMENT WORKS

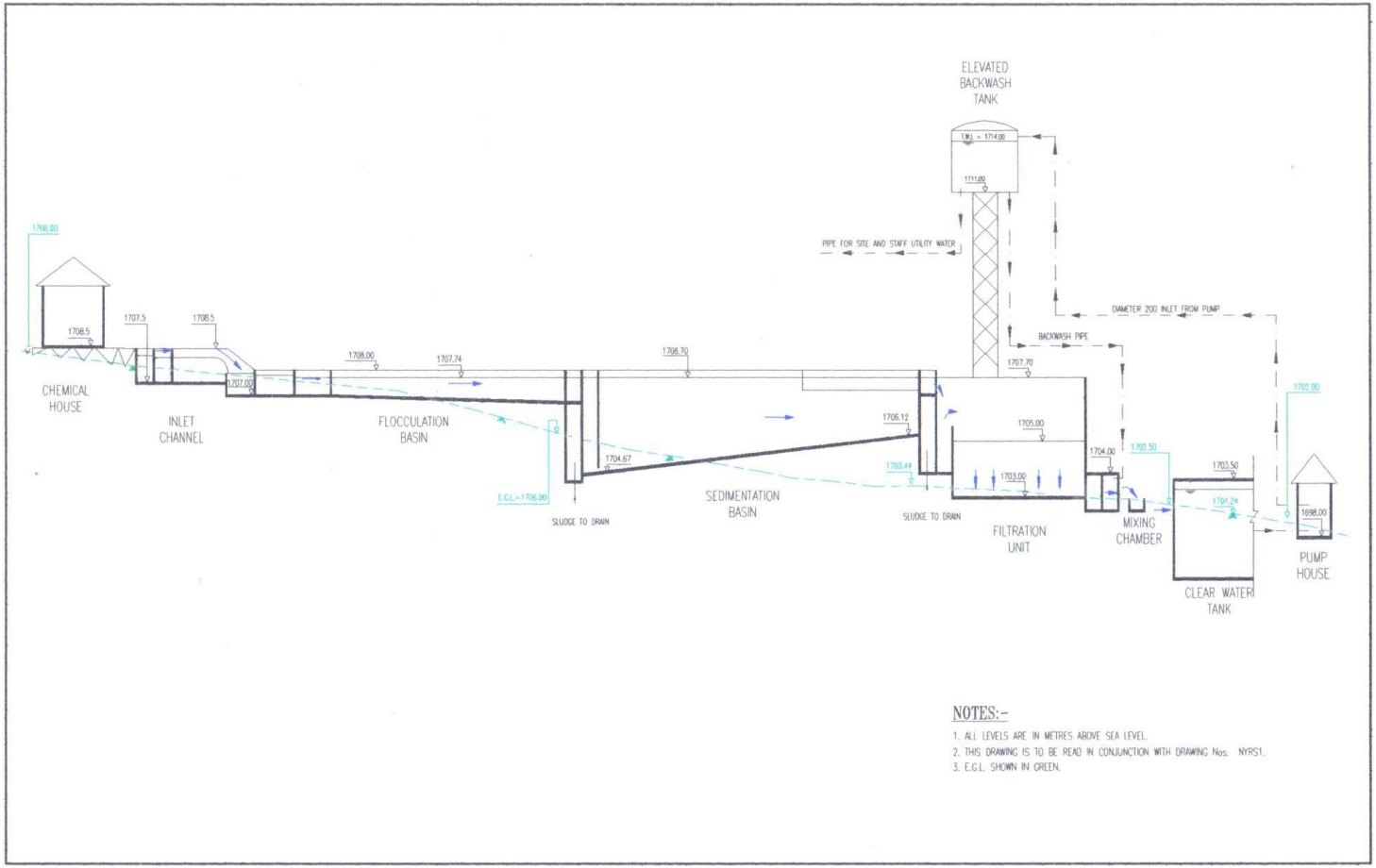


Figure 6.14
RETICULATION LAYOUT - OPTION A1

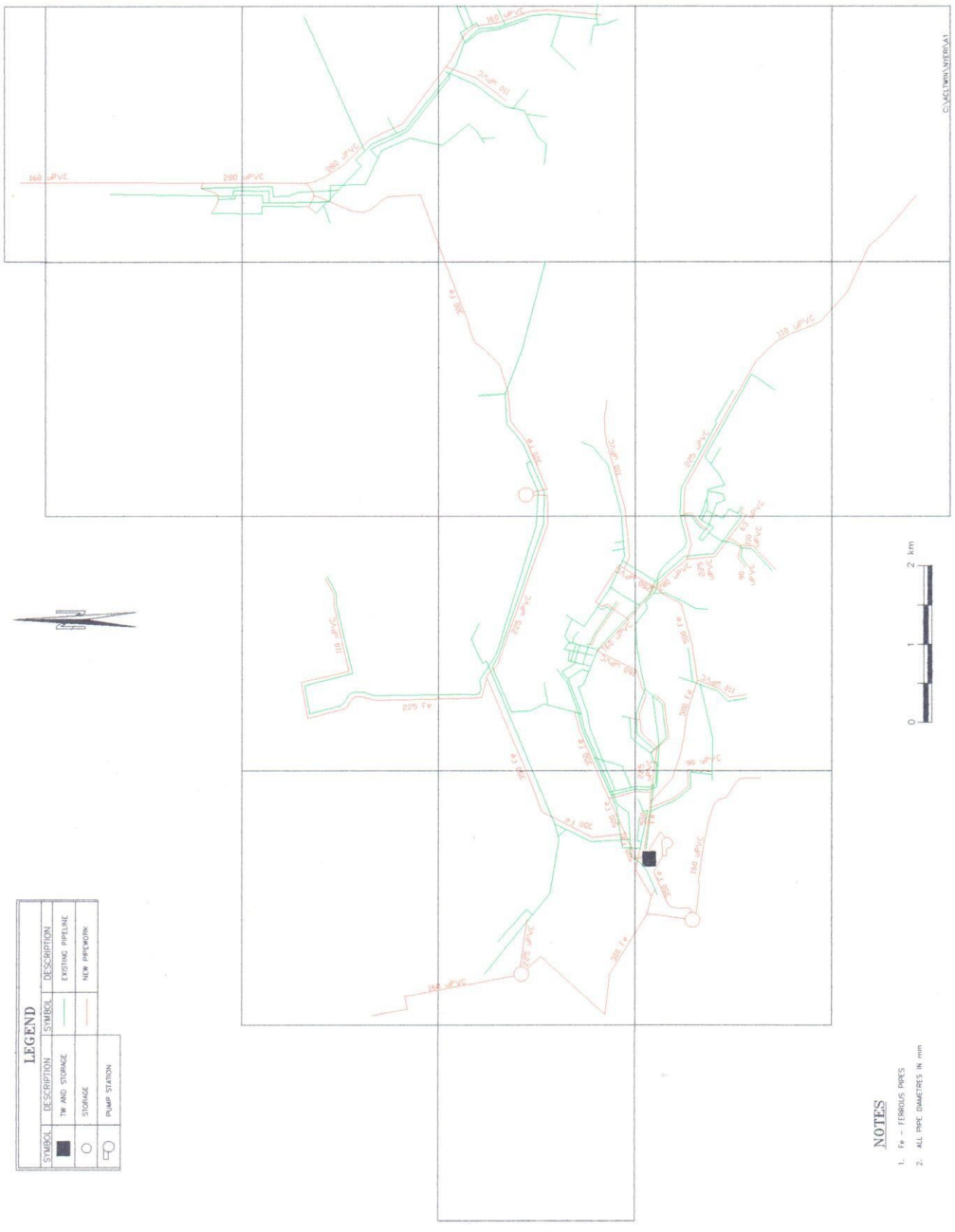


Figure 6.15
RETICULATION LAYOUT - OPTION A2

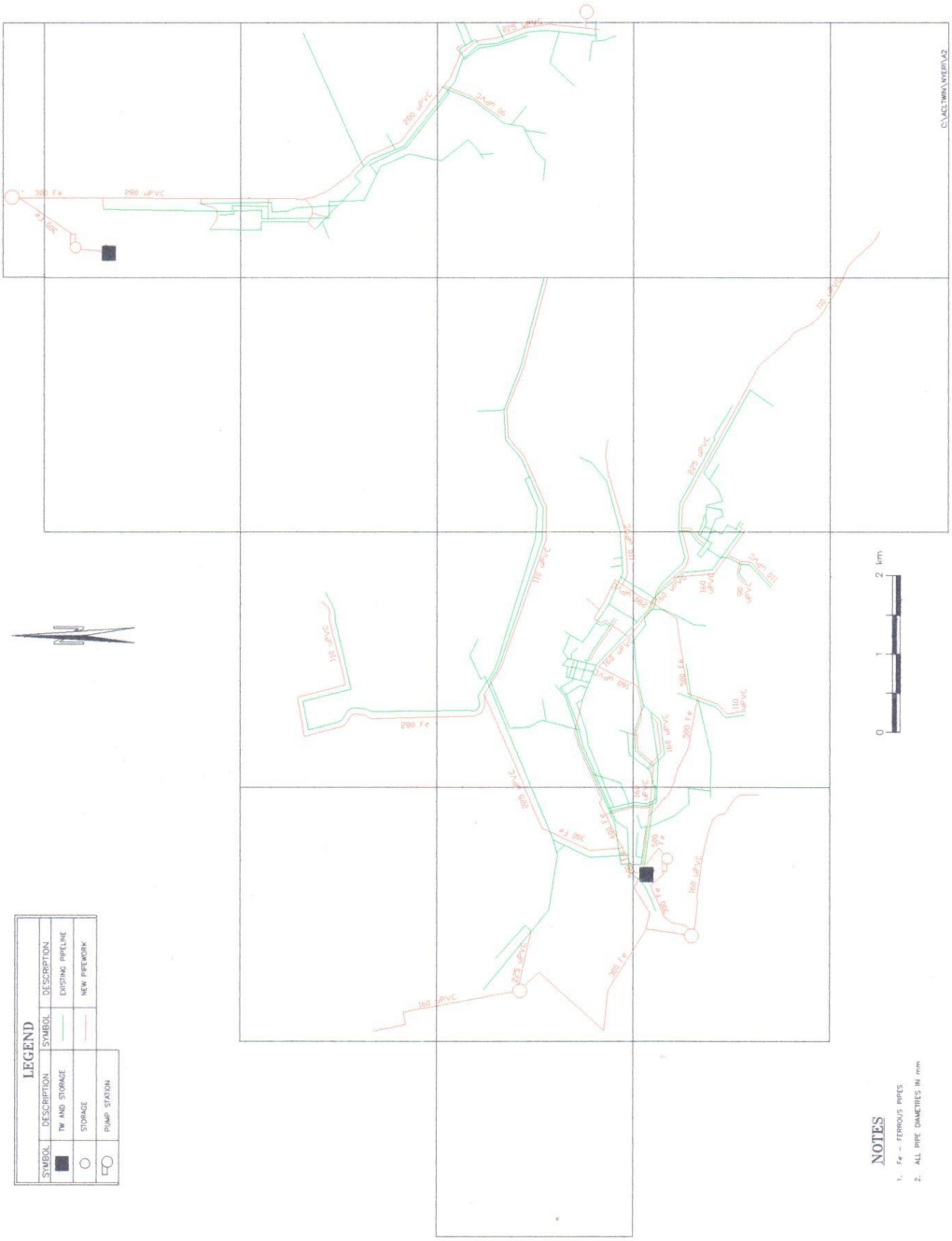


Figure 6.16
RETICULATION LAYOUT - OPTION B1

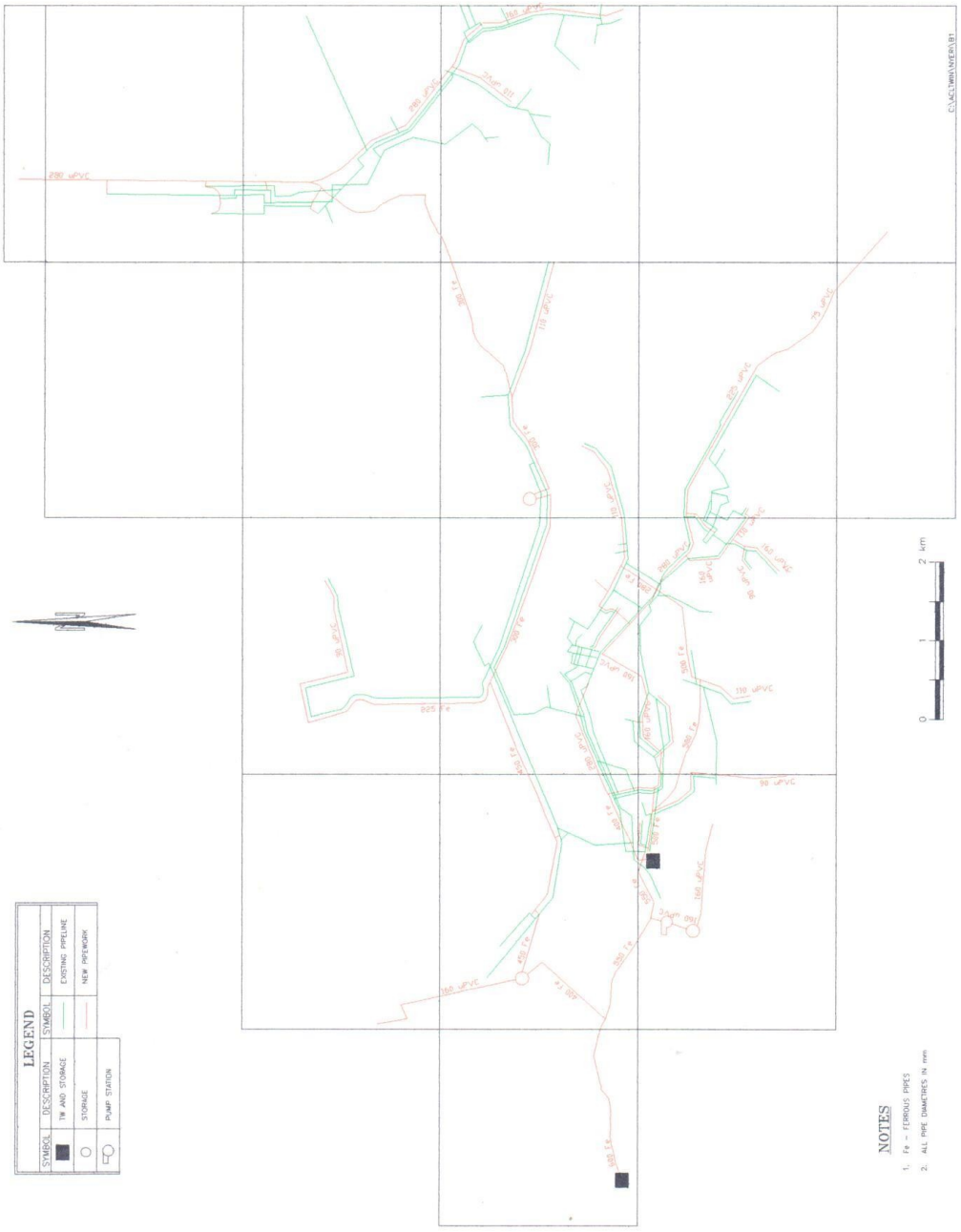
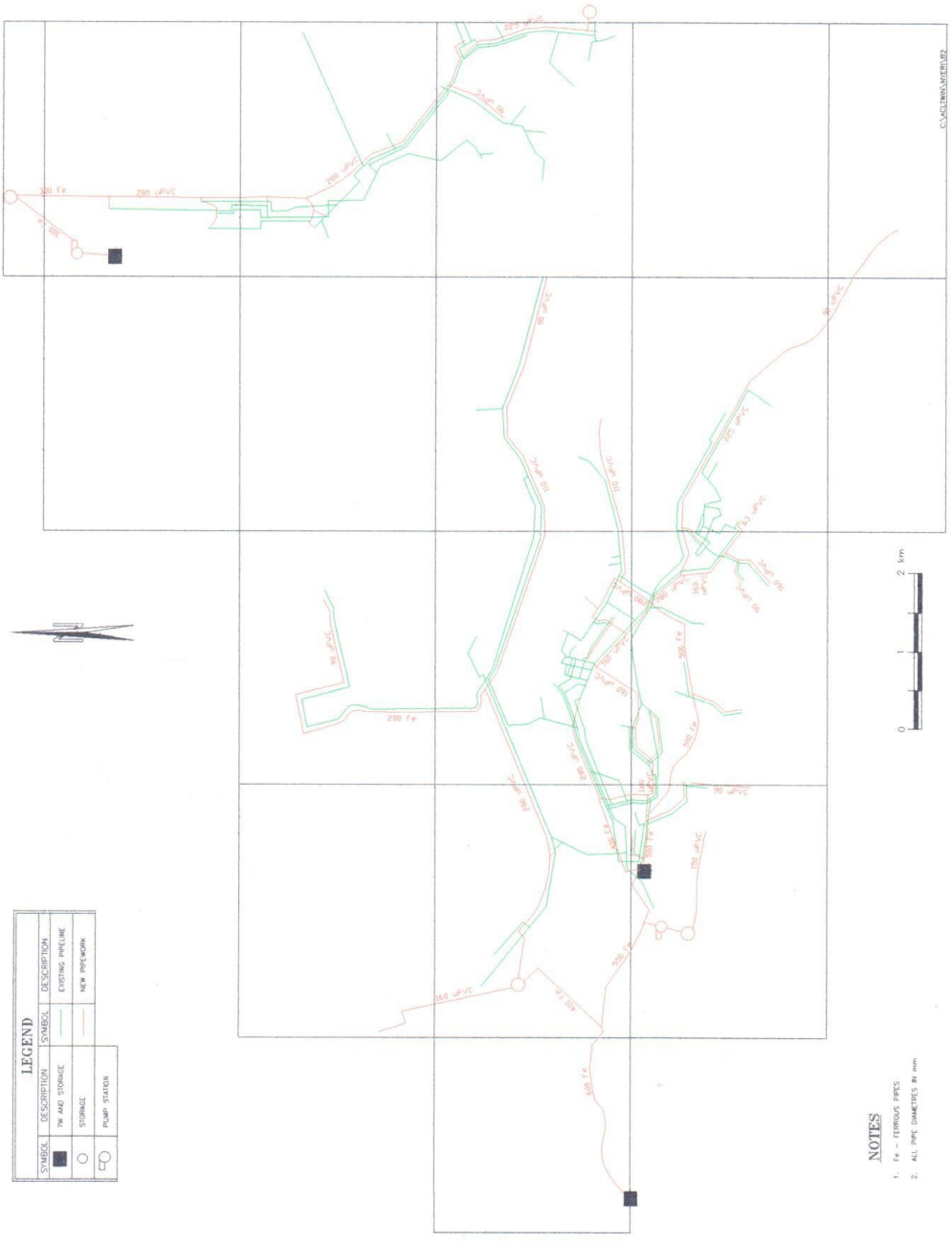


Figure 6.17
RETICULATION LAYOUT - OPTION B2



7. COMPARISON OF OPTIONS

7.1 Technical Comparison

As outlined in Chapter 6 above, the basic options being examined for Nyeri Town are essentially derived from the possible sites for locating the new treatment works, these being:

A : Kamakwa (site of existing treatment works)
B : Kiriti (between Kamakwa and the existing intake)

Variations on these basic options are in the aspect of whether or not Kiganjo is fed with clear water from Nyeri, thus giving rise to the following options:

A1 and B1 : Kiganjo fed with clear water from Nyeri

A2 and B2 : Kiganjo System remains separate

In all these options, the existing water works at Kamakwa would remain in operation, either at present capacity (the basis of this report) or at an augmented capacity, after an Immediate Works Programme.

Illustrations of the principal components of these project options are at the end of Chapter 6, and Table 7.1 gives a comparison of the basic technical aspects of these options.

Three main issues are considered critical to the technical comparison of these options, these being:

(i) number of facilities that will require to be operated,
(ii) extent of pumping required, and
(iii) security of the raw water source in future.

The intakes vary from one to two, but these are in all cases gravity run-of-river abstraction facilities with little operation and maintenance requirements, save for occasional cleaning of screens. The tank sites vary from three to four locations outside treatment works, and again such sites will pose little difficulty in attendance.

The "B" options have one pumping station which will be located outside a treatment works site, this being off the clear water trunk main from Kiriti to Kamakwa, serving the Kamuyu tank. In the "B" options however, only a small part of Gitathi-ini will require this pumped supply, and at a low head. It is envisaged that an on-line booster station would be constructed, employing shrouded submersible pumps(s) coupled directly on the pipework. The station is intended to be just less than 1 km from the Kamakwa treatment works, thus in close enough proximity for a rapid response to any failure. Controls for routine operation would be automatic, and activated by suction and delivery pressure sensors. This then is not a pumping station that would present marked difficulties or input into operation.

Table 7.1
TECHNICAL COMPARISON OF ALTERNATIVES

ASPECT		PROJECT OPTION			
		A1	A2	B1	B2
		Nyeri New Treatment Works at Kamakwa		Nyeri New Treatment Works at Kiriti	
		Kiganjo Supplied from Nyeri	Kiganjo Separate	Kiganjo Supplied from Nyeri	Kiganjo Separate
Number of Facilities	Intakes	1	2	1	2
	Treatment Works	1	2	2	3
	Separate Pump Stations	-	-	1	1
	Separate Tank Sites	3	4	3	4
Pumping into Distribution (For year 2010)		2,590 m^3/day @ 55 m	2,590 m^3/day @ 55 m; and 4,665 m^3/day @ 74 m	200 m^3/day @ 13 m	2,590 m^3/day @ 55 m; and 4,665 m^3/day @ 74 m
Personnel Requirements		Lowest			Highest
Risks of Future Raw Water Problems			Amboni River may soon suffer excessive upstream, abstraction, threatening supply to Kiganjo.		Amboni River may soon suffer excessive upstream, abstraction, threatening supply to Kiganjo.

NYRCHAP7.XLS Sheet1 13/02/96 11:05

The area of distinct difference in ease of operation and maintenance, with regard to the number of water supply facilities, is the number of treatment works. Presently, there are two water treatment works, one at Kamakwa, for Nyeri town, and the other at Kiganjo.

In the options being compared, the least number of water works would be in Option A1, where all water for Nyeri and Kiganjo would be treated at Kamakwa. The greatest number would be in Option B2, where there would be two treatment works for Nyeri town (the main works at the new Kiriti site, and the existing works at Kamakwa) and also a separate water treatment works for Kiganjo.

Centralised operation has it's obvious advantages. Supervision and monitoring is far easier thus more likely to result in more efficient operation. Other inputs into operation such as transport and communication are in lesser demand. Moreover, water works maintenance needs are concentrated into fewer locations, resulting in more rapid response to problems. Cost factors arise in the personnel involved, superintendence costs, number of laboratories required, and the like.

The extent to which pumping is required has both cost and technical implications. Backwash water pumping into elevated storage will be required at all treatment works as a fixed proportion of total output, thus this is not a factor for comparison of alternatives. Where the difference lies is in the extent of pumping clear water into the reticulation system.

Table 7.1 gives the various pumping duties required for such pumping needs, for the various project options. It can be noted that in the "B" options, pumping into a limited area south west of Kamakwa is required at the low rate of 200 m^3/day against 13 m head. This is a fairly minor pumping installation, thus essentially the system will be a gravity one.

Under the "A" options however, the low elevation of the Kamakwa works site in relation to western parts of the supply area will give rise to pumping into that area of 2,590 m3/day against 55 m head at the year 2010 demand, this quantity of pumping being just over 10% of the requirements for the Nyeri town area. In that case, the distribution would be mainly by gravity, but pumping would be a significant aspect of the system.

Where supply to Kiganjo is concerned, it is a simple case of either gravity clear water supply from Nyeri (Options A1 and B1) or all of the clear water for that area being pumped from locally situated treatment works. Where pumping is required the rate would be 4,665 m^3/day against 74 m head for the 2010 demands.

In summary, the proportions of the clear water supply that would need to be pumped into the distribution system for the various project options are as follows:

Proportion of Water Pumped into Distribution

	Nyeri	Kiganjo	Overall
Option A1	10%	-	9%
Option A2	10%	100%	24%
Option B1	1%	-	1%
Option B2	1%	100%	16%

It is clear that Option A2 (Nyeri treatment all at Kamakwa and separate Kiganjo treatment works) has a clear disadvantage in that nearly a quarter of all water supplied will have to be pumped. In this regard Option B1 is also clearly advantageous in that only an insignificant proportion of 0.7% of the distributed water will have to be pumped.

It may be noted that the above comparisons exclude consideration of the relatively minor supply to the telecommunications installations at the top of Nyeri Hill, which is pumped at present from using a dedicated pump station and rising main. This setup is expected to continue regardless of the development option pursued.

The last aspect of technical comparison mentioned above is security of raw water availability.

It has been mentioned in Chapter 9 that the Nanyuki river which serves the present Kiganjo Water Works has essentially no flow during dry seasons, due to excessive upstream abstraction. This is not the case at present with the Amboni river, which is the proposed source for a development scenario which includes separate water works for Kiganjo. What was also noted however, was that land use in the Amboni catchment is changing. With increased land sub-division, ranches and other low water use lands are being transformed into small scale farms with higher populations and with high water use for intensive subsistence and cash crop farming.

Without a base line previous study to refer to, it is difficult to establish the rate of change in land use in the Amboni catchment, and thus estimate the probable rate of increase in upstream abstraction. The difficulty of the situation is compounded by the varied nature of new land owners, who have different levels of means to invest in irrigation, and most importantly, the fact that a significant proportion of this abstraction would be likely to be without statutory authority, and thus not on record.

The only precise statement that can be made is that abstraction upstream of the proposed intake location on the Amboni river will increase, leading to lower dry weather flows in future. The rate at which this deterioration in the reliability of the source will occur cannot be quantified.

In summary however, the present source for Kiganjo (Nairobi river) is inadequate, and the alternative source, if the Kiganjo system is to remain separate, is risky. The alternative which can be seen as clearly reliable is to supply Kiganjo with clear water from Nyeri.

7.2 Construction Costs

The estimated construction costs for the various options are summarised in Tables 7.2 and 7.3 for the year 2010 and 2020 scope of works respectively. Details of these estimates are in Annex 4.

Essentially, it is found that the lowest capital cost option for developing both the Nyeri and Kiganjo supplies in Option A1, which involves all treatment being carried out at Kamakwa. The cost of this option for the Phase I works is found to be KShs. 504 million [DM 12.6 million at todays exchange rates of 1 DM = KShs. 40]. The option of treating water at the new Kiriti site in addition to the existing Kamakwa works, [Option B1] is estimated to cost KShs. 573.5 million, equivalent to DM 14.3 million.

In the "A" option, construction of separate Nyeri and Kiganjo water schemes would be more expensive, but in the "B" option, the converse is found to apply.

On the other hand, construction of a scheme for Nyeri only, and leaving out Kiganjo, would reduce the construction costs by 18% in the "A" option, and by 22% in the "B" option.

7.3 Financial Comparison

The inputs into the financial comparison of project options have been the operation, maintenance, personnel, administration and investment costs, compared with projected water production, and at varying discount rates. All computations are based on 1995 prices.

Operation costs which have been computed directly are energy costs (general treatment works electricity use, and pumping) together with chemical usage. Maintenance costs are estimated on the basis of the capital cost of facilities, the annual rates applied being 1% for structures, 2% for treatment facilities and pipelines, and 5% for electrical/mechanical plant. General administrative costs are also estimated on the basis of the investment cost, in this case a figure of 1% of the capital cost per annum being applied.

The costs of personnel are based on estimated manpower levels and current remuneration. The estimates of manpower levels have been carried out to the degree of accuracy necessary to attach a personnel cost element to the comparison of options, and thus these manpower figures should not be taken as the recommended establishment. That aspect will be addressed in detail in the next study stage.

The personnel cost estimates are in Annex 4. The costs of staff who would be engaged in both water and sewerage related duties are apportioned on a 60:40 basis to water and sewerage respectively.

Table 7.4 gives a summary of the average incremental financial costs per unit output for the various options, and the detailed figures are in Annex 4. The discount rates applied range from 5% to 12% per annum.

The overall financial cost per unit output in KShs/m^3 of water, at a discount rate of 10%, and at the year 2010 are as follows:

A1	:	all treatment at Kamakwa, Kiganjo supplied from Nyeri	18.14 Shs/m^3
A2	:	Nyeri treatment all at Kamakwa, Kiganjo scheme separate	24.79 Shs/m^3
B1	:	new treatment works at Kiriti, and Kiganjo supplied from Nyeri	17.72 Shs/m^3
B2	:	new treatment works for Nyeri at Kiriti, and Kiganjo scheme separate	22.82 Shs/m^3

The other discount rates give a similar result order, and so does the year 2020 comparison.

The option of constructing new treatment works at the proposed Kiriti site, and supplying Kiganjo with clear water from Nyeri, has the lowest incremental cost. The principal cost element which gives rise to this financial advantage is the cost of pumping. For the various options, the annual energy costs are found to be as follows in the year 2010:

Option	Annual Energy Cost in 2010	Proportion of Phase I Investment Cost
A1	Shs. 39.1 mio	7.8%
A2	Shs. 88.9 mio	16.7%
B1	Shs. 20.9 mio	3.6%
B2	Shs. 70.7 mio	12.5%

The difference in the extent of pumping required for various options has been analysed earlier in this chapter, and here the financial effects of these differences are obvious. In Option A2, nearly a quarter of all clear water supplied would need to be pumped, giving rise to a major financial impact.

Overall, the financial comparison gives the result that Option B1 (new treatment works at Kiriti, and Kiganjo supplied from Nyeri) is the most attractive.

7.4 Conclusions

From the foregoing, the various options have the following comparative advantages and disadvantages:

	NYERI TREATMENT AT KAMAKWA		NEW NYERI WORKS AT KIRITI	
	Kiganjo supplied from Nyeri [A1]	Nyeri/Kiganjo separate [A2]	Kiganjo supplied from Nyeri [B1]	Nyeri/Kiganjo separate [B2]
No. of treatment works	★	☆	☆	
Extent of pumping	☆		★	
Personnel requirements	★		☆	
Investment cost	★	☆		
Incremental financial cost	☆		★	

★ Best option
☆ Second best option

In this comparison, it is clear that combining the presently separate supplies is advantageous from almost all perspectives. The only exception to this is in the aspect of capital costs in the options where the new Nyeri treatment works are at Kiriti. In that case having the Kiganjo works separate would give a 2% reduction in investment costs for the year 2010 works. That margin is however small and greatly outweighed by other factors.

It is thus easy to conclude that an investment programme for both Nyeri and Kiganjo should be based on a combined scheme, with treatment being in the Nyeri area, and clear water being gravitated to Kiganjo.

The comparison between the options of augmenting treatment at the existing Kamakwa site (and an adjacent plot of land), or developing new works closer to the intake whilst maintaining the present works in service, is not as clear cut.

Augmenting the Kamakwa works has two singular advantages, in that treatment would be centralised at one place, and the investment cost would be 12% lower than having the new works at Kiriti. The physical disadvantages of the Kamakwa site are however in its rugged nature, steep slopes, and the limitations in the amount of land that can become available.

The other principal aspects in which the "Kiriti option" is more attractive than having the new works at Kamakwa, are in the extent of clear water pumping, and factors which arise from that aspect. Locating the new treatment works at the Kiriti site would reduce the amount of clear water pumping required to insignificant levels, rendering the scheme an essentially gravity one. Attendant advantages arising from this are in the ease of maintenance and thus security of supply, and in greatly reduced recurrent financial requirements for maintenance, and most of all, energy.

It is recommended that Option B1 (with the new works being at Kiriti) should be selected, based upon the primary aspect of incremental financial costs. The other advantages of this option, as described above, strengthen this recommendation.

Under that recommendation, the development project would consist of:

(i) the Kamakwa works continuing to operate as at present (or uprated under an Immediate Works Programme), using the same intakes and raw water mains,

(ii) new treatment works at the proposed Kiriti site, with their separate raw water main from the existing Ihwa intake,

(iii) clear water supply from the Kiriti works to
- most western suburbs (Mathari, Kamuyu, Kamakwa) by gravity,
- to higher parts of Gitathi-ini by limited on-line boosting,
- to Kingongo and Kiganjo by gravity from Mathari

and the balance of clear water gravitating to the Kamakwa site for onward distribution,

(iv) supply from Kamakwa of water treated at that site, as well as water supplied to there from the Kiriti Works, to the CBD, Ruringu, and adjacent areas.

The initial investment would be sufficient for the year 2010 demands, but with provision for a Phase II augmentation sufficient for upto the year 2020.

If this investment package is accepted by the Client and Financier upon perusal and consideration of this Report, then the proposed works will be detailed and costed to a higher degree in the Feasibility Report.

Table 7.2
CONSTRUCTION COST ESTIMATES
YEAR 2010 WORKS

Item	Description	Estimated Cost [KShs]					
		Option A1	Option A2		Option B1	Option B2	
			Nyeri	Kiganjo		Nyeri	Kiganjo
1	Intake	1,000,000	1,000,000	3,000,000	1,000,000	1,000,000	3,000,000
2	Raw Water Main	50,050,500	47,158,000	8,450,000	30,682,000	28,301,500	8,450,000
3	Treatment Works	70,899,300	59,203,800	36,035,500	79,046,600	67,166,500	36,035,500
4	Storage and Contact Tanks	74,500,000	62,700,000	17,400,000	83,600,000	70,800,000	17,400,000
5	Reticulation	176,988,000	136,053,160	23,109,000	230,495,000	162,673,000	23,108,800
	Subtotal	**373,437,800**	**306,114,960**	**87,994,500**	**424,823,600**	**329,941,000**	**87,994,300**
Add	!5% for Preliminary and General	56,015,670	45,917,244	13,199,175	63,723,540	49,491,150	13,199,145
Add	20% Contingencies	74,687,560	61,222,992	17,598,900	84,964,720	65,988,200	17,598,860
	TOTAL	**504,141,030**	**413,255,196**	**118,792,575**	**573,511,860**	**445,420,350**	**118,792,305**
				532,047,771			**564,212,655**

A1 : Combined Scheme, treatment at Kamakwa
A2 : Separate Nyeri/Kiganjo Schemes, Nyeri Treatment at Kamakwa
B1 : Combined Scheme, Nyeri Treatment at new site
B2 : Separate Nyeri/Kiganjo Schemes, Nyeri Treatment at new site

NYROPT1.XLS Sheet1 15/02/96 13:07

Table 7.3
CONSTRUCTION COST ESTIMATES
YEAR 2020 WORKS

Item	Description	Estimated Cost [KShs]					
		Option A1	Option A2		Option B1	Option B2	
			Nyeri	Kiganjo		Nyeri	Kiganjo
1	Intake	1,000,000	1,000,000	3,000,000	1,000,000	1,000,000	3,000,000
2	Raw Water Main	50,050,500	47,158,000	8,450,000	30,682,000	28,301,500	8,450,000
3	Treatment Works	96,297,000	78,541,000	41,961,800	104,207,000	86,471,400	41,961,800
4	Storage and Contact Tanks	102,900,000	88,300,000	20,200,000	112,000,000	96,400,000	20,200,000
5	Reticulation	183,151,000	146,545,000	23,323,000	235,025,000	167,885,310	23,323,000
	Subtotal	433,398,500	361,544,000	96,934,800	482,914,000	380,058,210	96,934,800
Add	!5% for Preliminary and General	65,009,775	54,231,600	14,540,220	72,437,100	57,008,732	14,540,220
Add	20% Contingencies	86,679,700	72,308,800	19,386,960	96,582,800	76,011,642	19,386,960
	TOTAL	**585,087,975**	**488,084,400**	**130,861,980**	**651,933,900**	**513,078,584**	**130,861,980**
				618,946,380			**643,940,564**

A1 : Combined Scheme, treatment at Kamakwa
A2 : Separate Nyeri/Kiganjo Schemes, Nyeri Treatment at Kamakwa
B1 : Combined Scheme, Nyeri Treatment at new site
B2 : Separate Nyeri/Kiganjo Schemes, Nyeri Treatment at new site

NYROPT2.XLS Sheet1 15/02/96 15:11

Table 7.4
AVERAGE ANNUAL INCREMENTAL COSTS PER UNIT PRODUCTION

DISCOUNT RATE	OPTION A1		OPTION A2		OPTION B1		OPTION B2	
	Treatment Works for both Nyeri and Kiganjo at the existing Kamakwa site.		*Treatment Works for Nyeri at the existing Kamakwa site, and separate works for Kiganjo.*		*New Treatment Works for both Nyeri and Kiganjo at the new Kiriti site, and continued use of the existing Kamakwa Works.*		*New Treatment Works for Nyeri at the Kiriti site, continued use of the existing Kamakwa Works, and separate works for Kiganjo.*	
	YEAR 2010	YEAR 2020	YEAR 2010	YEAR 2020	YEAR 2010	YEAR 2020	YEAR 2010	YEAR 2020
5%	15.79	*13.60*	20.66	*17.77*	14.68	*11.88*	19.67	*16.75*
8%	16.70	*14.61*	22.24	*19.03*	15.85	*13.17*	20.88	*18.10*
10%	18.14	*16.26*	24.79	*21.10*	17.72	*15.31*	22.82	*20.31*
12%	19.14	*17.43*	26.61	*22.58*	19.01	*16.82*	24.16	*21.88*

All the above costs are in KShs./m3 of water produced.

NYRAIC1.XLS Sheet1 13/02/96 11:45

8. SOCIO-ECONOMIC REVIEW

8.1 Introduction

A socio-economic review of Nyeri Municipality and its position within Nyeri District and Central Province were undertaken so as to provide a people oriented perspective for the proposed water supply. The socio-economic review report is presented in Annexe 2 to this Pre-Feasibility Study report.

The non-release of detailed data and mapping from the 1989 census as discussed in the previously released Situation Assessment Report, somewhat limited the sociological study and required significantly more fieldwork than had been anticipated. As a result and where it proved not possible to obtain quantitative data, some qualitative statements have proven necessary.

8.2 Historical Perspective

Nyeri town owes its origins to the colonial subjugation of the Kikuyu at the beginning of this century, a fort being established in 1902. From this origin Nyeri became the administrative and trade centre for the local area. Administrators and settlers were European. Traders were Asian and by 1905 a small but flourishing community had been established.

Catholic missionaries arrived around 1903. They settled just outside the town at Mathari near the base of Nyeri Hill.

The missionaries are primarily responsible for the high literacy rate in the area.

By 1910, Nyeri town occupied land between the Amboni and Chania Rivers. To the north the colonial government wished to provide land for white settlers and as a result the Kikuyu in that area were forced to return to the south and east of town onto 'native' reserves whilst the Laikipia Maasai were relocated to Narok from what today are the administrative divisions of Kieni East and Kieni West.

The topography of the area determined the settlement patterns or the town with the central ridge being occupied by both administrative and commercial buildings. A bridge was built across the Chania river to serve the settlers to the north whilst the official white residential area developed on another ridge to the west. This included the Outspan Hotel and golf course area.

The Asian quarters were located to the south of the administrative ridge whilst African servants were initially housed where the Ministry of Works is now located before being moved further away to Majengo in 1913. Africans were not allowed to buy land in the town until 1958. As a result of the discrimination, African townships developed beyond the town boundary of that time, at Ruringu and later at Kamakwa. By 1912 Nyeri was the

administrative capital of Nyeri District, then became the administrative capital of the Province of Kenya and by 1933 the Provincial capital.

Between 1918 and 1950 it was one of the main settler towns, an urban district council being formed in 1954 and became an urban town in 1961 with an area of 8 sq. km. In 1971 Nyeri was declared a Municipality covering 72 sq km, being expanded further in 1983 to 176 sq km.

In the ten years after independence, most European settlers left, as did a significant number of Asian traders. Newcomers were primarily African, both administrators and locals seeking economic opportunity.

During this significant period there was considerable national and local investment to cater for the expanding bureaucracy. The local co-operative movement was also organised and invested heavily in the town.

National organisations such as the Kenya Farmers Association expanded as did Kenya Co-operative Creameries. Nearby, coffee farming expanded, tea was introduced and dairy farming expanded as did the banking sector. Notwithstanding significant and rapid expansion, the historic segregation into ethnic areas caused problems. White highland areas near Nyeri town were sold, rather than being allocated to the poor as had been expected, and hence involved a transfer from rich European to rich African. The latter subsequently sold the less productive land to their poorer kinsmen at a profit. Land buying companies participated in this and it was not until 1980 that their land was sub-divided to provide areas for the poor.

For Nyeri town, the presidential proclamation for this subdivision had the impact of settling a lot of people in the northern Kieni areas. This settlement and its subsequent evolution is one of the major socio-economic variables impacting on the evolution of Nyeri town. Its effects are felt particularly in the area of owner occupier housing construction and on the long term use of water from both the Nyandarua and Mount Kenya catchments.

Africanisation of Nyeri town effectively began in 1967 with the passing of the 1967 Trade Act which unintentionally generated considerable insecurity amongst the Asian traders so that many left Nyeri.

Institutions such as the Industrial and Commercial Development Corporation helped Africans enter trade and this accelerated business activity in Nyeri at all levels through the 1970's and l980's. The first half of the present decade has been dramatically different with GDP stagnating and inflationary pressure making towns such as Nyeri unattractive places, especially for the poor, many of whom have began to leave the municipal area.

The future development of the town will therefore reflect its past and present situation.

8.3 Demography and Demographic Indication

In comparing Nyeri District and town with the national scene, Nyeri scores well on almost every count.

Its population growth rate is lower and at the District level was 2.24% per year between 1979 and 1989 compared with 3.34% overall. This reflects the District's good environment, education and the adoption of family planning. The town's estimated growth rate at 3.0% per year is also modest compared with many others. Both town and District have a highly homogeneous population with over 96% at district level being Kikuyu.

In the town, the sex ratio is approximately unity compared with the national urban average of 1.18; whilst about 54% of the urban population is in the dependant age ranges. This is expected to alter dramatically as fertility rates are dropping rapidly. The result will be an increasing non-dependant producing population who will put demands on services such as water.

Out migration of all but the rural poor is uncommon for urban Kenya and the majority of the present population can be expected to remain in the town.

When compared to the rest of Kenya, Nyeri District and town have a highly literate population, and such a population is more likely to be in a position to demand more and better services.

Even by 1983, Nyeri town stood out in terms of owner occupied housing and income whilst at the same time having a lower than average median construction cost. It is likely to increase as more and more people with ties to this area are retiring into the town.

Businesses have expanded threefold over the last twenty-five years but are primarily of the service rather industrial type. Total employment in Nyeri town has been difficult to determine but has been estimated to currently be about 56,400 or 51% of the total population.

Whilst traditional farming has suffered in recent years and the outlook for tourism remains uncertain, horticulture and floriculture is beginning to boom in East and West Kieni and is likely to be constrained only by availability of water for irrigation. This will place ever increasing demand on the Nairobi and Amboni rivers making them increasingly less desirable as sources of water for urban water supply.

Prospects overall especially into the next century are regarded as good with growth in employment keeping pace with growth in population at approximately 3% per year.

In the absence of information on labour productivity, incomes and income disposal patterns, a two day meeting of key district officials was instituted and resulted in the estimate of net per capita incomes in the town as given in Table 8.1.

Table 8.1
INCOME LEVELS

Occupation	Monthly Net Income (KShs)
Wholesaler	100,000
Large-scale Farmer	75,000
Retailer	10,000
Industry Non-Labour	6,600
Smallholder Farmer	5,700
Civil Servant	5,000
Informal Sector Artisan	4,500
Small Scale Trader	4,000
Industrial Worker	2,000
Labourers	1,800
Domestic Workers	1,500

Conclusions were that all but the lowest three categories had incomes that allow them to pay for their own water services. On the other hand, industrial workers, labourers and domestic workers generally live in housing where there is a connection for several rooms or small houses occupied by several tenants. This single connection is invariably paid for by the landlord.

Income disposal was then estimated as shown in Table 8.2 below.

Table 8.2
INCOME DISPOSAL

CATEGORY	PERCENTAGE
Education	50
Housing	25
Food	20
General	3
Utilities	2

Notable in this table is the absence of savings.

8.4 Property Values and Development Pattern

The original 8 sq. km of Urban Nyeri were valued at KShs. 8,128,148 in 1971 and at KShs. 232,895,000 in 1995, nearly a 29 fold increase.

This is the only area of the Municipality where rates can be charged and as 48% of this area is occupied by government related institutions that are not always prompt in paying, the weakness of the municipal financial base is apparent and made worse by the fact that the area of service provision is nearly 200 sq. km.

Land transaction values were also established for much of the municipality, varying from KShs. 25,000 for 0.1 ha ($^1/_4$ acre) in Kiganjo to KShs. 290,000 in Skuta and Ruringu and KShs. 325,000 along Ring Road.

In comparison, in Kieni without water, the average land price per 0.1 ha is KShs. 4,000 rising to KShs.12,500 with water.

Compared with 1991 for which limited data was available, prices have in general increased, doubling in Thunguma and Kamakwa. Only in Ruringu has little change been observed.

Conclusion reached are:

- market forces will result in the purchases and upgrading of Majengo and subsequently Kiawara;
- in these areas, sewers are in place but underutilised, water reticulation is in place but the supply grossly inadequate especially in the lower business sections of the town;
- attempts to bring Ruringu and Kamakwa onto the valuation roll will improve revenue for the Council and make these areas ripe for formal development requiring improvements in water and sewerage infrastructure;
- in Skuta and Thunguma, the transformation of land from rural peasant farming to high cost owner occupier housing will continue and needs to be catered for by water service infrastructure, however plot sizes make on-plot sanitation practicable;
- the Nyeri town area itself is unsuited to industry, plot sizes are generally small, topography is rugged, land prices are high and access is generally limited; in Kiganjo on the other hand, plots are large, topography is gentle, land prices are low and access both by road and rail is good;
- overall the provision of adequate water will enhance the value of all urban land and thereby improve the revenue base of the Municipality.

8.5 Living Standards and the Poor

Nyeri district is not one of the districts designated as having extensive poor people. In 1991 such persons were said to be from amongst:

i) about 30% of Kenya households which are female headed of whom 53% were found to be poor;

ii) the rural poor are mainly subsistence farmers, landless and pastaralists whose incidence of poverty in 1992 was 52%, 50% and 43% respectively;

iii) fifty-seven percent of household heads who had no education lived below the absolute poverty line; and

iv) the poor spent 61% of their total expenditure on food as compared to 46% by the non-poor.

Besides the above characteristics of the poor, other recent studies have shown the poor as:

i) having difficulty in access to reasonably priced credit;
ii) being slow in adopting new seed varieties;
iii) having high fertility and low contraceptive prevalent rates;
iv) having high incidence of child malnutrition;
v) having high morbidity
vi) not having easy access to clean water and sanitation facilities; and,
vii) having difficult access to markets because of geographic isolation, poor infrastructure and high cost of transportation.

Almost none of these conditions apply to Nyeri.

In Nyeri District, less than half of one percent of the 10-14 age group were without schooling in 1989.

In the district as a whole only 12% had never attended school, half the national average; whilst less than 13% were illiterate compared with 27% nationally. In Nyeri town teacher/pupil ratios were 1:14 at secondary school level, 1:22 at primary school level and 1:25 at pre-primary level. Infant mortality in 1979 was 62 per thousand compared to 100 per thousand nationally.

Two thirds of all households are headed by people in the most active economic age group (20 to 44 years old).

Ninety six percent of all urban dwellings had durable roofing materials. Seventy five percent of all households had access to a piped water supply.

This and other data shows clearly that there are few really disadvantaged people in the town. There are however pockets of poor people of about one-quarter of the population presently without access to any form of piped water supply.

Based largely on Nairobi experience, it has been argued that in Kenya, self help activity is often a good indicator of poverty.

In Nyeri municipality there are 120 self help women's groups with 4,460 active members. Analysis of their activities does not suggest that such groups are instruments of the poor with over $^{2}/_{3}$rds being for credit activities.

Even in the poorer parts of Kamakwa, Ngangarithi, Ruringu, Kangemi and Thunguma, occupancy rates were 3.6 persons/unit compared to a national average of 5.

Even when allocating market stalls to the poor, the Municipal Council had noted that many such persons had bank accounts of between KShs. 60,000 and KShs. 100,000.

Analysis of records for different communities show that the poor spend up to 33% of their net income on rent, averaging at 26%. In contrast high and medium income earners spend less than 20% of their net income on rent.

Clearly Nyeri poor are somewhat different from their Nairobi counterparts.

9. ENVIRONMENTAL IMPACT ASSESSMENT

9.1 General

The demand for treated water within the Nyeri Municipality greatly exceeds current supply. A project to expand the water supply system to meet the demands up to year 2010 is the subject of this planning study.

The project will augment the levels of treated water distributed within the urban and peri-urban parts of the Municipality, and should lead to improved sanitation and result in the reduction of water borne diseases.

The execution of such a project will be impacted upon by the environment upstream and surrounding it. At the same time, the project will impact upon that environment and particularly on those within the area of supply, and on areas and people located downstream of the project.

A base line environmental study of the area had not been previously undertaken, although individual aspects that together form much of a study of this sort had been investigated and reported on. These have been drawn together, although in some aspects the quantitative data available is somewhat dated.

The environmental baseline study report, the likely positive and negative impacts of the anticipated project, and the mitigations considered necessary to deal with or lessen the negative impacts are presented in detail in Annexe 3 Volume II of this report.

The project area is essentially the 208 sq. km. of the Nyeri Municipality of Kenya. The environmental impact study area on the other hand is of necessity considerably larger than the area of the project. The study area has been taken as extending from the catchment watersheds on the Aberdare mountains to the West, down across the Nyeri saddle to the slopes of Mount Kenya to the East, and downstream on the Chania and Sagana rivers as far as the Sagana hydro-power station.

9.2 Topography and Geology

The principal geographical features of the study area are Mt. Kenya (5,199 masl) to the east of Nyeri town, and the Nyandarua (Aberdare) range of mountains (3,999 masl) to the west. Mt. Kenya is the source of the Burguret, Naromoru, Nairobi, Sagana and Ragati rivers, and the Nyandarua range the source of the Ewaso Nyiro, Chania, Amboni, Gura, Muringato and other rivers. In general, the rivers flow initially in a east/west direction to the valley between the mountains, forming into the Ewaso Nyiro which heads north, and the Sagana which flows south to southeast. The rivers have cut deep valleys which form a predominate characteristic of the area around Nyeri Municipality.

The present landscape has been created by repeated faulting and volcanic activity dating back to the mid Tertiary age (25 million years). In the mid Tertiary age (2 - 25 million years ago), the volcanic Mount Kenya was formed, as were the faulting features of the Rift Valley and the Nyandarua Range.

The major rock formations in Nyeri District are volcanic basalts including the old Simbara series which are exposed in major river valleys, overlying Sattima Series, overlaid again by the Nyeri Tuff and then the Laikipia Series. Other rock formations are the Mt. Kenya series, and Pleistocene and recent superficial deposits.

Soils are in three major groups, according to altitude.

The lower areas (2,700 masl or less), which constitute the inhabitated parts, have mostly dark red to reddish brown nitisols known locally as Kikuyu Red Loam. These soils are deep, friable and porous, and have favorable moisture storage and aeration properties. They show a marked structural stability.

The upper mountain slopes (2,700 - 3,300 masl) have soils which range from silty to sandy loams, whilst in the high mountain belt, above 3,300 masl, stony dark loams predominate.

9.3 Climate

The climate of Nyeri District is governed by the proximity to the equator, and the high altitude of Mt. Kenya and the Nyandarua range. The general climatic regimes which prevail are:

(i) the moist windward areas to the south west of Mt. Kenya,

(ii) the drier north west slopes of Mt. Kenya bordering the semi-arid Laikipia Plateau, and

(iii) the moist windward areas to the east of the Nyandarua range,

There are great variations in precipitation in these areas, ranging from a high of 2,300 mm per annum, to about 700 mm per annum in the Laikipia Plateau. The maximum rainfall is from March to May (long rains) and the short rains are from October to December. Intervening periods are relatively dry. During rainy seasons, most precipitation occurs between 3:00 pm and 6:00 pm.

Seasonal fluctuations in temperature are very small, with a decrease in temperature of about 0.56°C for every 100 m rise in altitude. In altitudes similar to Nyeri town, monthly mean daily minimum and maximum temperatures are in the extremes of 8.2 to 24.6°C in January, to 10.2 to 20.2°C in July. Absolute minimum temperatures can however fall to as low as 1.5°C at night. At moderately higher altitudes than Nyeri town, night frost is not unusual.

9.4 Flora

Interaction of varying relief, rainfall, temperatures, geology, soils and human activity have given rise to a wide range of plant species in Nyeri District. There are six broad natural vegetation categories however, these being

(i) afro-alpine vegetation in the highest reaches of Mt. Kenya and the Nyandarua range, above 3,350 masl, with a high occurrence of endemic species, dominated by moorland vegetation and scrubby plants;

(ii) a mountain bamboo zone at slightly lower altitudes (2,400 to 3,300 masl) dominated by bamboo thicket and also scattered trees (*Podocarpus latifolius* and *Nixia congesta*) in some areas;

(iii) moist montaine forest in high rainfall areas to the southwest of Mt. Kenya and to the east of the Nyandarua Range, between 1,700 to 2,400 masl, dominated by *Cassipourea malosana* and *Podocarpus latifolius* amongst others, except where heavy logging has occurred and *Olea capensis* and *Teclea nobilis* predominate;

(iv) intermediate forests in areas of 1,300 to 2,000 masl with moderate precipitation in the saddle between Mt. Kenya and the Nyandarua Range (such as Nyeri town) with semi-decidous trees and dense shrub undergrowth;

(v) montane Sclephyll forests to the north of this mountain saddle with lower precipitation, such as Kiganjo, dominated by the pencil cedar (*Juniperus procera*); and lastly

(vi) upland bushland, dominated by grasses and shrubs, in areas even further north, bordering on the semi-arid Laikipia Plateau.

The bulk of this natural vegetation only remains within the area of the protected National Parks and Forest Reserves of Mt. Kenya and the Nyandarua Range. Human activity has replaced the natural vegetation in other parts with cultivated coffee, tea, maize, bananas, beans, and other crops. In these cultivated areas, the indigenous trees have been replaced by exotic species such as *Eucalyptus saligna*, *Pinus patula* and *Cupressus lusitanica*. Small remnants of natural vegetation are on Nyeri Hill, Kabiru-ini Forest and Kiganjo Forest, as well as narrow bands of natural riverine vegetation along the Chania, Amboni, and Nairobi rivers.

9.5 Fauna

Indigenous animals in Nyeri District are essentially confined to the protected Forest Reserve and National Parks in Mt. Kenya and the Nyandarua Range. These areas are however unfenced except for parts of the Aberdare (Nyandarua) National Park, allowing movement of animals into cultivated areas, with resultant conflict with humans.

The large herbivores include elephant, buffalo and rhino, with various antelopes in areas from forests to high moorlands.

Natural predators include leopard, golden cat, civet, genet, mongoose and hyena. Lions were previously common in the northern grasslands, and now have been introduced to the forested protected areas.

Avian animals such as river ducks, francolins, mountain buzzards, crowned and hawk eagles, plovers, and others are common. Reptilian life is minimal.

Common fish are the rainbow and brown trout introduced into mountain streams for sporting purposes.

Of these species, the elephant is a key agent of vegetation change, causing significant deafforestation in places, especially near artificial water holes. Elephants venturing out of the park cause considerable damage to crops.

Mt. Kenya and the Nyandarua Range are the only strongholds of the Bongo in the world, this antelope only being known to exist in low numbers in a few other areas such as the Cherangani Hills, and Mau Summit in Western Kenya.

9.6 Land Use and Tenure

The main categories of land ownership in Nyeri District are:

(i) Government land, including National Parks and Forest Reserves;

(ii) Trust land of which the Game Reserves are the principal components; formally the "Native Reserves" were in this category but virtually all these have been adjudicated into individually owned land parcels;

(iii) Leasehold land within the old urban area borders, which is individually held but on fixed term leases; and

(iv) Freehold land covering most of the district, in which individual proprietors have absolute title.

Actual land use is determined by climate and altitude.

High altitude areas are set aside for forests and national parks. Within Nyeri District there are 10.4 km^2 of gazetted forest, as well as 0.4 km^2 of privately owned and County Council forest. There is also 7.6 km^2 in the Aberdare National Park and 7.2 km^2 within the Mount Kenya National Park.

There are three agro-ecological zones. The Upper Highland zone is near the mountain forests, and supports crops such as tea, pyrethrum, potatoes, cabbage, carrots, and peas, sheep and dairy farming, and plum, pear, and apple orchards.

The most intense agricultural activity is in the Upper Midland Zone, in the southern part of the Nyeri District. Crops include tea and coffee, maize, beans, kale, cabbages, bananas, and fruit such as pawpaw, avocado, loquats, and citrus fruits. Horticultural crops and dairy farming are also common.

The Lower Highland zone in northern parts of the district is drier, and has mostly been occupied by ranching, and limited wheat and barley production in the past. In recent times irrigation and sub-division of land parcels has given rise to maize, beans, cabbage, carrot and kale production.

9.7 Human Health

Records of morbidity (illness) and mortality (death) through disease from the 1980's onwards have not been found to be being collated into accessible records, and there was severe reluctance on the part of individual health institutions in providing statistics of their own experiences.

In the 1970's however, the diseases with the highest incidence in Nyeri District were respiratory ailments, upper respiratory tract infections and pneumonia. Other diseases with high incidence were Salmonellosis, and infectious hepatitis. In addition, commonly reported ailments were gonorrhea, gastroenteritis, malaria, measles (which was however showing a remarkable decline as a result of the success of immunization programme), mumps, tetanus and trachoma.

During the fieldwork for this report, the only factual data which could be obtained, albeit with difficulty, were the morbidity figures for one health centre in Nyeri town, between July and October 1995. These figures show respiratory diseases as the most common ailment, followed by diseases of the skin, including ulcers. Other common diseases were diarrhoel, instestinal worms, and diseases of the circulatory system.

The available records show water borne diseases such as Gastroenteritis and Typhoid Fever to have been important but not the predominate causes of illness in the 1970s. In the records of the Nyeri Town Health Centre, however these diseases are not featured as present causes of morbidity. Intestinal worms, as mentioned, do have a significant incidence, but these, especially Ascariasis, are more commonly transmitted from eggs in the soil, to hand, to mouth. What is most important is the lack of incidence of diseases such as Cholera and Poliomyelitis.

Overall, a 1995 survey found that Nyeri District has a relatively low rate of morbidity, with only 13.7% of the population reporting being sick per annum. This was attributed to the

accessibility of health care, with only 6% of the population being more than 8 km from a health facility.

Infant mortality in Nyeri District was only 3.5% in 1989, compared with a national average of 6.2%. This low mortality rate is attributed to relatively high incomes, extensive coverage by immunization programmes, and relative accessibility of health care facilities. This district wide child mortality rate does not however give the complete picture. In the northern parts of the district (Kieni), infant mortality is about the same level as the national average, meaning that other areas have even lower child mortality rates than the district average would suggest.

The population of Nyeri District also has relatively high levels of nutrition, except for the dry Kieni East and West divisions, and some pockets within the high productivity areas of Tetu, Mukurwe-ini and Othaya divisions, where some farmers have placed too much emphasis on cash crops, leading to low production of essential subsistence crops.

9.8 Poverty

These are two groups of poor people - rural and urban.

The rural poor are those whose land parcels will not give assurance of reasonable subsistence. There is the incidence of rural poor people within Nyeri District in dry and unproductive areas, such as pockets of Kieni East and Kieni West, Gorano Location in Mathira Division and Rutune in Mukurwe-ini Division. The other types of rural poor are those in productive areas, but whose land parcels are so small that the areas have assumed a semi-urban characteristic, and subsistence farming cannot provide a full livelihood. Examples of such areas are essentially all in Nyeri Municipality, these being Mathari and Gitathi-ini to the western part of the Municipality, some of the people in areas along the Nyeri-Nairobi road, and Kirichu village south of Kiganjo.

Incidences of rural poor have in the past been rare, as the sub-division of rural farms into uneconomic units is a fairly recent phenomenum. The origins of this situation are in increased availability of health care and thus reduced mortality, coupled with late introduction of complementary reductions in child bearing. On the other hand, there were until the late 1980s adequate alternatives to the excess population remaining on the same land, due to opportunities for migration into Nyandarua District, the Rift Valley, northern parts of Nyeri District, and urban areas such as Nairobi.

Today, the opportunities for this are less, and although birth rates are reducing, there is still a significant increase in population. It can be expected that there will be a noteworthy trend in the increase of rural poor in and around Nyeri Municipality.

The urban poor can be found in the informal housing (slums) of Kiawara and Majengo, in the Chania river valley next to the Central Business District. These are the historic areas in

which the urban poor have lived. Although no actual data is available, the residents of these areas are obviously on the increase.

A new area of informal housing is Chaka, just north of Kiganjo. In roughly 5 years, this has developed from a fairly deserted place, into a crowded strip of temporary houses and shops, about 500 m long.

9.9 Gender Issues

The three main areas of concern regarding the status of women are job opportunities, school drop outs and adolescent motherhood.

Employment opportunities for all population sectors in the rural areas have continued to decline, forcing young women, amongst others, to move to towns in search of jobs. Many young women have been employed as low income house servants. On the other hand there is the encouraging phenomenon of women's groups, which are steadily growing. These sprang from home improvement activities, and then gradually transformed into entrepreneurial enterprises, engaged in agriculture, intensive animal husbandry, craft production, cottage industry and the like. Whereas women's groups will not reverse the creation of poverty amongst women, they do reduce the rate at which this occurs by the pooling of resources and ideas, and by enabling the harnessing of capital.

One aspect of significant impact in the improvement of the lot of women is the increasing use of contraception, reductions in birth rates, and attendance at antenatal clinics and family planning sessions. Reductions in fertility are occurring, reducing dependency and improving women's welfare.

9.10 Surface Water Sources

The natural surface waters are of excellent chemical quality, being slightly acidic to neutral, with low to moderate alkalinity. Fluoride and nitrate levels are low, as are those of substances detrimental to human health. However, all surface waters tested are contaminated with faecal coliform although in some instances, as found high up to the Chania River, these can be of animal rather than human origin. The surface waters are therefore unsatisfactory for human consumption unless treated.

Three rivers have been or are being considered for future water supply, the Nairobi, Chania and Amboni Rivers. The Nairobi River is currently the source for Kiganjo. During the dry season, flow is negligible and already insufficient without regulation. This is as a result of upstream abstraction, largely for irrigation.

The Amboni River is as yet untapped for urban water supply, and currently offers a realistic alternative for the supply to Kiganjo. However, qualitatively it is more polluted than the

Chania River which supplies Nyeri town. Quantitatively is likely to go the same way as the Nairobi River due to increasing abstraction upstream for irrigation.

In the longer term, only the Chania River is seen as the appropriate water source for both Nyeri town and Kiganjo. Within the design horizons of this present project (2010), regulation is unlikely to be necessary. Limited regulation may be possible at the present site at Ihwa. In the longer term however, upstream regulation will become necessary, whilst increasing use of agro-chemicals is already making the present intake location less than desirable as a long term location.

9.11 Existing Environmental Problems

Most environmental problems in the project area stem from human activities, including agricultural practises, industrial activity, and the matching of provision of essential services to the growth of urban areas.

Soil erosion is not presently a serious problem in Nyeri District due to early introduction of soil conservation practises, prior to the development of population pressure on the land. Today however, the increasing population is encroaching on steep slopes and marginal lands, without corresponding improvements in land use techniques. Soil erosion could therefore develop into a significant problem. The Agriculture Act forbids cultivation of slopes greater than 38%, but this needs enforcing. Between slopes of 13% and 38%, terracing is required, but again the Act is not being enforced in this regard.

Industrial pollution is also not a significant issue in the project area at present, due to the limited industrial development. Wastes from coffee processing factories are however a source of intermittent problems due to the inefficiencies of waste water treatment facilities. Saw mill employees have poor working conditions, with unacceptable levels of exposure to dust and noise, without protective equipment. Where saw mills are too close to habitation (eg Kiawara) the sawdust blocks drains and is a general hazard.

Mining is not important in Nyeri District, but building stone quarrying and more recently sand removal is carried out along most important river valleys. These quarries increase erosion along river banks and siltation in rivers, and many are dangerous to the workers.

Within the main built up areas of Nyeri town, the principal environmental issues at present are:

(i) Health hazards : poor refuse collection, poor sanitation in a few areas, open and blocked drainage, inadequate supplies of potable water, lack of public toilets;

(ii) Environmental degradation : burning of tyres, exhaust fumes, quarrying, poor vegetation cover, and pollution of the Chania river.

Pollutants into the Chania as it passes below the CBD are introduced from the open drains in the Blue Valley/Majengo/Kiawara area, effluents from the slaughter house, leachates from the old, and potentially from the new solid waste disposal sites, and effluent from the Municipal Sewage Works. The environmental quality of the river deteriorates from the informal housing and quarries along it, and cultivation of the riparian reserve. At present the general quality of the river water is not unacceptable, but there is the potential for a future significant problem. The bacteriological quality does however deteriorate significantly as the river passes through the urban area, with E. Coli counts of 80 cells/100 ml at the Ihwa Intake, increasing to 1,800 cells/100 ml at the Chania pumped intake, and 1,600 cells/100 ml after the Nyeri Sewage Works.

Municipal sewage and industrial effluents are strong with high levels of biological and chemical oxygen demand (BOD_5, and COD) and permanganate value. The Kenya Co-operative Creameries effluent is particularly so and should receive pre-treatment before it enters the municipal sewerage system.

The most acute of these is the disposal of solid waste. Although the Blue Valley dumping site was officially closed in February 1995, the site is still being occasionally used for dumping. This should cease immediately. The new site is an old disused quarry at Kangemi near the Nyeri sewage treatment works. Unfortunately this site like the Blue Valley site is situated close to the Chania river and is on a steep gradient. Leachate from the dump is therefore likely to pollute the river as presently occurs from the older site, especially during the rainy season. It is also sited in proximity to Municipal staff houses. The new dump therefore poses a health hazard to the neighborhood from flies, vermin, dust, smoke, and smell.

It is recommended that the Kangemi site be closed and instead an alternative site, a disused quarry in the Nyeri (Kabiru-ini) forest be adopted as soon as practicable. The Kabiru-ini quarries are located in an undulating landscape far from the Kamweiga stream and far from any human habitation. Health risks associated with this site are considered negligible.

At present however, the quarries are overgrown with vegetation and in places filled with quarry waste, rock and debris. They will therefore need clearing and partial re-excavation so as to provide a sanitary landfill site; thus both preparation costs and the transportation cost associated with the greater travel distance would have to be covered by an increase in solid waste removal charges.

9.12 Project Impacts

9.12.1 General

The project is expected to consist of increased abstraction from the existing Ihwa Intake, construction of new pipelines along the existing route from Ihwa to Kamakwa (either all raw water, or raw water followed by clear water), and construction of new treatment works and

water distribution pipework construction, including tanks. The project impacts will arise during construction and during operation and usage of the completed works.

The overall impacts are summarised in Table 9.1.

9.12.2 Construction Phase

The works are to be constructed in both rural and urban natured areas, but it is important to note that protected natural habitat is outside the areas of expected activity.

Treatment works construction will take place at either the new "Kiriti" site, or at Kamakwa. At the new site, heavy traffic of construction machinery and vehicles can be expected to give rise to increased dust and noise pollution, especially over the unpaved rural roads. Little other impact is expected. At Kamakwa, the existing fairly urban environment is not expected to be noticeably affected.

Construction of pipelines along steep slopes is an area in which increased soil erosion and vegetative cover destruction can be of significant impact. This can be mitigated against by proper reinstatement and re-planting in urban areas. The impact of construction work will be in noise, dust, exhaust fumes, and interruption of services including drainage. These impacts will however be of very short duration in any one location, as the pipelaying crews and equipment move along.

9.12.3 Operational Phase

The major positive impact to be expected in the operational phase of the project is in the availability of an adequate supply of potable water and the resultant beneficial effects on public health and the quality of life. Water availability will also have significant positive impacts on employment opportunities through increased commercial and industrial activity.

Negative impacts may arise through treatment works operations, erosion along pipeline routes and increased waste water outputs.

The treatment works are expected to generate wastes through chemical sludges, and through disposal of wash water from cleaning of the facilities. The chemical sludges are expected to be the principal concern.

The sanitation impacts are addressed separately below.

9.13 Mitigation Against Negative Impacts

The following measures are proposed to mitigate against the expected negative project impacts:

(i) Included within the proposed Stage I Project

- Following completion of site construction activities, and in order to help restore the degraded habitats, curb erosion and siltation, landscaping activities including where necessary terracing and planting of sediment binding grasses such as *Cynodon dactylon* should be carried out.

- Disposal of sludge generated at the water treatment works should be by use of a sanitary landfill facility.

- An increase in the efficiency of the Nyeri sewage treatment works, possibly by the conversion of the tertiary treatment waste stabilisation ponds into constructed wetlands, should be pursued.

(ii) Prior to or as a part of a Stage II Project

- Construct a balancing reservoir upstream of the intake to be able to maintain necessary minimum downstream flows.

- Relocate the intake upstream above the agricultural areas so as to avoid the abstraction of water containing agro-chemical residues.

Table 9.1
ENVIRONMENTAL IMPACT MATRIX

Parameter	Pre-Construction	Construction	Operation
Sanitation	0	0	3
Human Health	0	0	3
Natural Protected Environment	0	0	0
Soil Erosion	0	-1	-1
Biodersity	-1	-2	0
Noise and Air Pollution	0	-2	0
Siltation of Rivers	0	-1	0
Pollution of Natural Water Resources	0	0	-1
Downstream Water Usage	0	0	-1
Quality Human Life	0	2	3

Key
3 Positive Impact : High
2 Positive Impact : Moderate
1 Positive Impact : Light/Negligible

0 No Impact

-1 Negative Impact : Light/Negligible
-2 Negative Impact : Moderate
-3 Negative Impact : High

10. SANITATION IMPACTS

10.1 General

A study of-sanitation in all urban and peri-urban parts of the municipality had been carried out for the Situation Assessment Report. Study of the sanitation situation continued in order to determine which areas, if any, would benefit from extensions to the sewerage system and where on-plot sanitation would continue to suffice. Particular attention was given to areas where building development has taken place, is taking place now, or appears likely in the future. As previously, many pit latrines were examined, and several householders with septic tanks discussed their satisfaction or problems.

Twelve institutions and two industrial concerns were also visited, and senior staff were helpful in describing their present sanitation methods and discussing the advantages of sewerage connections, if they could be conveniently provided.

In addition, an analysis was made of the capacity of the existing sewerage system, and the expected sewage output from sewered areas in the water supply design horizons, to determine whether the sewers will be adequate.

10.2 Field Investigations

The specific field investigations were targeted at areas of potential growth, to determine the extent to which existing sanitation methods are expected to continue to be adequate. The findings were as follows:

(i) Nyeri

- **Area near Game Rock Inn, Kenya Wildlife Service and Mount Kenya Academy:** [virtually undeveloped area to the east of the town, on the road leading to Kiganjo]

The area is suitable for good quality housing; a board on a coffee farm now offers half-acre plots for sale. Sewerage in the long term (2020) may be justified if development goes ahead. This will however depend on whether the large scale farms are sub-divided to provide land for high cost housing.

- **Central Business District:** [central]

While the district is generally well covered by sewerage, a small part comprising the Central Hotel and buildings near Muhoya Road, has been missed. A new short length of sewer should be added and the area should be surveyed to ensure that all large business premises, hotels, restaurants etc. are connected.

- **Chania Estate:** [Mortgage housing, west of town centre, towards Chania River valley, behind Outspan Hotel]

The estate mainly consists of good but fairly small properties. They are sewered into communal septic tanks, for which occupants pay sewerage charges. The Council maintains the sewers and tanks. The system appears to be quite satisfactory for the present, but with the evident encroachment of higher density medium cost housing, it is likely that connection to the main sewer system will be advisable in the long term (2020).

- **Kamuyu:** [West of town centre, along Baden Powell Road, beyond Kamakwa]

At present most of the buildings are low cost, and on moderately large land parcels. It seems unlikely that expansion will justify sewerage by 2020.

- **Kamakwa:** [West of town centre, along Baden Powell Road, near Water Works]

At present mainly low-cost buildings. On-site sanitation is certain to suffice in the medium term, although there is the prospect that in the long term the area will begin to be in need of sewers.

- **Kangemi:** [peri-urban area to east of town centre, towards Nyeri Sewage Treatment Works]

It appears to be ripe for development as a number of boards offer plots for sale and numerous low cost houses have come up. The area is close to the Nyeri Sewage Works, with adequate fall for gravity flow and with trunk sewers in the two valleys on either side. Sewerage is likely to be justified in the medium term.

- **Kunneville:** [to east of Chania Estate]

Mixed quality houses, some very good, with own septic tanks, about which there were no complaints. It probably does not justify sewerage, although it is close to the existing sewerage area.

- **Kiawara and Blue Valley** [Old African township centre, to the north of Kimathi Way]

It seems likely that the present very bad properties will gradually be replaced by business and light industry and that by 2020 most buildings will be good and substantial, resulting in greater utilisation of existing (or improved) sewers.

- **Mathari** [West of town centre, opposite Mathari Mission]

This has fairly dense habitation, with concrete block dwellings gradually replacing low-cost structures. The area is said to be rapidly expanding and might justify sewerage in the medium term. It is however quite distant from the existing sewer network.

- **Mathari road:** [North-west of town centre]

The area to the north of this road, although now used for coffee, would appear to be a prime site for good-quality housing if the Catholic Mission agreed to sell the land. It might justify investment in sewerage as part of a site-and-services package, but this is only in the case that the Catholic Church disposes of the land.

- **Ngangarithi:** [Peri-urban area due south of town centre near Nyeri-Othaya Road]

The area is developing with quite a number of new buildings, some of which are high-cost on large plots. Septic tanks are suitable for large modern buildings; pit latrines are adequate for low-cost buildings.

- **Ring Road:** [To south-west of town centre, south of Baden Powell Road]

Almost all properties are good buildings on large plots, for which septic tanks are proving quite satisfactory.

- **Ruringu:** [Peri-urban area to south-east of town centre]

Ruringu is designated as an urban centre (Director of Physical Planning, 1978). Part appears to warrant extension of sewerage in the medium term, as housing density is quite high and there are a number of medium-cost dwellings. In the area to the south of Misha Road there appears to be less justification for sewerage as the area lies further from existing sewers.

- **Skuta:** [Peri-urban area to the east/south-east of town centre]

Plots are generally large and appear to be more suitable for septic tanks than sewerage.

- **Thunguma:** [Peri-urban area to the east of Skuta]

There is a fair sprinkling of good quality houses and bungalows, all on large plots, but also more not-so-good buildings - some timber, some blockwork. Sewerage is not justified.

(ii) Kiganjo

- **Chaka:** [North of Kiganjo]

Quite a large settlement said to be growing because of nearby quarries. Most existing buildings are low-cost timber construction, although there is some evidence of better buildings going up. Gravity flow to the sewage pumping works may be possible, but even if water reticulation is extended to this area there is little likelihood of permanent building development proceeding to justify construction of sewerage.

- **Kagumo High:** [Area to south-east of Kiganjo restricted by sides of the ridge]

Sewage from the school and nearby high-class properties may be able to gravitate to the Kiganjo Sewage Pumping Station if the water supply situation improves.

- **Kirichu Town, Gachika, Kahiga, Kanuna and Ndurutu:** [Areas to south of Kiganjo]

An area of very scattered development with only Kirichu having a significant population density, and only part of which continues to receive piped water. Some water is supplied to Kirichu and Kanuna at night, but other pipes are dry, and no water fees are charged. There are a few good quality houses, but no justification for sewerage, even if the water supply improves greatly. To connect these areas to the sewerage system, a new pump station would be required.

(iii) Institutional and selected industrial concerns

- **Kamwenja Teachers College**

The principal Michael G. Kanore, would like water connection and sewerage if the costs were reasonable. Present sewage treatment consists of three large ponds. The first was said to be 5.5 m deep, the second and third 6 m deep. The ponds are in reasonable condition, but there is some scum in a 'dead' corner. Effluent from the ponds goes to soakpits - four sets of seven used in turn - each soakpit said to be 9 m deep and 1.2 m diameter, filled with rock.

- **Kihuyo Secondary**

Connected to rural water supply. Six pit latrines for 98 pupils.

- **Nyeri High School**

Deputy Headmaster, John G. Maina was very co-operative and friendly on two visits. There are four septic tanks for boys' use. They have been emptied about twice a year by contractors using buckets. All staff quarters have WCs and septic tanks.

- **St Paul's Seminary**

Fr. Mwongi said they have 250 pupils, who prefer pit latrines to WCs.

- **St Teresa's Commercial College**

Now 130 students, but plan to have 250, in which case they would need more water. At present students use pit latrines as there is not enough water for flushing WCs, which would discharge to septic tanks if they were used. They would like more water so that WCs could be used.

- **Mount Kenya Academy**

The headmistress, Charity W. Mwangi, said 110 pupils and 40 staff live on site. The headmistress would like more and better water and connection to sewer. Cost is no difficulty as it would be covered by parents paying more fees. A trunk sewer main into that area (along the Nyeri-Kiganjo road), would however have few consumers.

- **Baptist High School**

Mr. Gifford, American missionary who appears to be responsible for 'estates', was very helpful and showed three septic tanks, two for latrine waste, one for grey water - they are satisfactory. There are insufficient toilets for 350 pupils. Mr. Gifford is in favour of sewer connection if not too costly, but the same applied as for Mt. Kenya Academy.

- **Kagumo High School** [between Kiganjo and Kirichu]

The Headmaster, Mr. Wahome said that on site there are 760 boys and about 100 staff with their families. He would welcome sewerage. There appears to be sufficient fall for a sewer to run from the school to the municipal pumping station.

- **Nyeri Primary School** [Kingongo]

The school has 400 boarders and 1100 day scholars. Existing septic tanks are satisfactory. The headmaster was concerned about the possible cost of connecting to sewers as water charges are already a major worry.

- **Mathari Mission Hospital and other Mission properties**

The procurator, Fr. Vincent Wambugu, said there are over a hundred septic tanks; many septic tanks and soakaways were overflowing because of increase of resident population. As an example, seventeen septic tanks had to be emptied recently.

- **Nyeri Technical College**

The Bursar reported that there had been no trouble since the College was connected to the municipal sewer about four years ago.

(iv) Industrial water users

- **Coffee Processing Plant**

Water is abstracted from a river, stored in a large tank; used twice for processing coffee, with recirculation tank. After second use effluent passed to large open pits.

- **Mount Kenya Bottlers Ltd (Coca Cola)**

Water is abstracted from a river. All wastewater goes into a very large holding/settling tank from which effluent goes to Municipal Sewage Works.

10.3 On-Plot Sanitation

The examination of on-site sanitation in Nyeri confirmed the earlier assessment in the Situation Assessment Report. The vast majority of pit latrines are deep, clean, without offensive smell and with no fly or mosquito nuisance. Providing vent pipes seems to make no difference to either smell or flies, which is hardly surprising as most pits without vents are free from these troubles. Also, as found earlier, many vent pipes were either wrongly fitted or had no flyproof netting. The investigation included some VIP latrines recently built with UNICEF funds and with commendable community management. None of the vent pipes was correctly installed.

Pit latrines are entirely appropriate for the large number of low cost and medium cost dwellings that continue to be built throughout the peri-urban areas. Recommendations for improvements are that good quality concrete floor slabs should replace timber floors, and that when sanitation is provided for multiple-occupancy dwellings, more than one pit should be dug.

Similarly, for high cost houses, septic tanks are appropriate outside the central business area, which in any case is already sewered. In all directions, but especially to the south of Nyeri town, there is evidence of prosperous citizens building large houses of excellent quality. All plots on which these luxury dwellings are built are large enough for septic tanks, especially with the excellent permeability of Nyeri soils. The one and only difficulty with septic tanks is insufficiency of water for WC flushing. To overcome deficiencies in piped supplies many owners of septic tanks have resorted to rainwater catchment tanks.

In and near the centre of the town there are areas that have characteristics that differ from the low density development for which pit latrines and septic tanks are so suitable. One is a corner of the Central Business District which is unsewered. This is possibly because of its earlier intended use as a bus station, but it is now fully built up, with some multi-storey buildings. Sewers should be provided.

Nearby in Kiawara and Blue Valley there are sewers with only a few connections among the crowded low-cost squatter shacks and nearby the insanitary latrines in the Municipal housing area. It seems likely that by the year 2020 this district will have developed with properties making proper use of the sewerage system, and the "informal" housing will have moved further down the valley.

It is possible that some peri-urban areas may develop is such a way that sewerage is appropriate by 2020. The only areas which have present indications of having such a potential are the Kamakwa and Mathari settlements. The difficulty with these areas are their

distance from the existing sewer system, with no potential consumer base in between. It is considered that a localised sewer system, such as exists in Chania Estate, would be more appropriate in the horizons for this study, particularly if designed for eventual integration into the central system.

10.4 Capacity of Existing Sewerage System

An analysis was made of the existing sewer capacities and expected sewage in-flows, in the water supply design horizons. This was not a fully detailed study, and was confined to the degree of detail needed to arrive at qualitative statements.

The sewer system and coverage area can be considered in three components, namely:

(i) the old sewers, which became linked into the new system,

(i) the existing "new" sewers, commissioned in the early 1980's, and

(iii) proposed sewers, whose coverage area was incorporated into the design capacity for the existing "new" sewers.

The sewers and sewage works were designed with an ultimate capacity for the year 2000. On the other hand however, some areas such as parts of Kingongo and Ruringu, and the housing in the Chania river valley off Baden Powell road (such as Chania Estate) were designed to be in the sewer coverage by the year 2000, so their expected sewage output was incorporated into the trunk main design.

Overall, the assessment is that without the planned sewer extensions, the present sewer system is basically adequate for the area it serves, upto the year 2010. Any near term sewer coverage expansions would however need to involve some trunk main augmentation, if the design criteria assumes an adequate water supply.

For the ultimate horizon of this study however, the two trunk mains to the Sewage Works, starting from Ruringu and from the old Sewage Works, would definitely need augmentation.

In-flows to the sewage works, if there are no sewer extensions, are estimated at 8,500 m^3/day in 2010, and 16,400 m^3/day by 2020. The existing works were designed for 6,000 m^3/day, but with a Phase II extension, were expected to handle 15,000 m^3/day in the year 2000, serving an area inclusive of sewer extensions. It would therefore seem probable that there will be the need for sewerage works augmentation even if there are no sewer extensions.

11. NEED FOR A PROJECT

11.1 Present Situation and it's Effects

The Situation Assessment Report concluded that the Nyeri town system was designed at a total production of 5,580 m^3/day, but the 1995 production requirements were an average of 10,8000 m^3/day, and during peak use seasons, 14,040 m^3/day. Thus the treatment works can only meet 40% to 50% of the present requirements.

The distribution system was also found to be wholly inadequate. With adequate water production, only a few areas around Kamakwa and on Ring Road would be assured of a "fair" supply or better, whereby their demands during average use seasons, inclusive of reticulation losses, would be met. Large areas of the reticulation would receive occasional or no supply of water, including the densely populated areas of the lower part of the CBD, Ruringu, Kangemi, Skuta, Thunguma and Mathari.

Clearly the present water supply facilities are far from adequate, resulting in widespread and critical water shortages.

This lack of an adequate water supply could have an impact on the following:

(i) incidence of water borne diseases

(ii) sanitation

(iii) commercial activity

(iv) industrial growth and activity

(v) provision of public services

(vi) labour productivity

(vii) quality of life, and

(viii) environmental quality

Most of the above criteria are interlinked and thus not independent variables. The present status and beneficial effects of a project on those aspects are examined below.

11.2 Water Borne Diseases

In Chapter 9 above, it was pointed out that there is a paucity of readily available recent data on water borne diseases in Nyeri District. Records from the 1970's do however show that water borne diseases such as Gastroenteritis and Typhoid were important, even if not the

predominate causes of morbidity. In the only health centre (centrally located in Nyeri town) for which 1995 records were obtained however, diseases which were clearly water borne did not feature. It is not clear whether this is the situation throughout the project area, but that is very much doubted.

What is clear however, is that water borne diseases are not very widespread or in critical dimensions in the project area, or in the environmental impact assessment area (Nyeri District as a whole).

The reasons for this are seen as being principally twofold, namely educational levels and availability of health care facilities.

Educational attainment will be accompanied by exposure to a variety of information sources, and where there is high literacy, there can be expected to be high public health awareness. This will lead to avoidance of consumption of clearly contaminated water. The population will then, in general, either consume treated water (for those with a connection), construct facilities for roof catchment of acceptable quality drinking water, or otherwise boil water from other sources.

Availability of health care will result in rapid containment of any outbreak of water borne diseases, cutting off the disease spread cycle, and resulting in lower risks for those who do drink untreated or otherwise unsafe water.

The scenario for the future envisages a continued or greater public health awareness situation, but unfortunately, it is to be expected that availability of "real" health care will decline.

Health care in the large part is a public sector activity, and greatly dependant on availability of central government fiscal resources. Within the presently declining level of availability of public resources, it is a reasonable expectation that construction of new health care facilities will not keep pace with population growth, and recurrent expenditure for equipment, staff, drugs and consumables will become more and more scarce. With a deterioration in health care, the risks of spread of water borne diseases will rise.

With a situation where the quantities of potable water supply are inadequate, and, in fact become more inadequate with time as production remains constant and demand rises, it can be expected that the probability for spread of water borne diseases will rise. A greater proportion of people will be forced to resort to unsafe water sources, increasing the numbers of those who would not take adequate precautions before consuming such water.

Rectification of the water supply situation is therefore essential if it is to be expected that the public health situation will not deteriorate.

11.3 Sanitation

Proper sanitation is a pre-requisite for prevention and control of water borne diseases. All acceptable sanitation methods require some element of water use, even though of varying quantity.

The quality of water used in sanitation systems is not very critical, except of course if the water is so polluted as to be a hazard by mere contact. On the other hand, such water would normally be drawn from the same source as that for other uses.

Water borne systems obviously require significant quantities of water if they are to operate in a satisfactory manner. This applies to both sewered and to on-plot facilities such as septic tanks.

Other systems such as pit latrines on the other hand, have much lower water requirements, but the need to keep the slabs clean cannot be satisfied without some water usage.

Without adequate quantities of water supply, the sanitation systems will suffer from being maintained in an unsanitary condition, water borne systems will not work, and sewers may easily become blocked.

An adequate water supply is therefore essential for a satisfactory sanitation situation and therefore to maintaining an acceptable public health situation.

11.4 Commerce and Industry

Virtually all commercial and industrial activity requires some input of water, in the least case for use by personnel and in cleaning, and in the greatest case, as a primary input for wet industries.

In a situation where an adequate water supply cannot be assured, developers will obviously be discouraged. Clear cases of such occurrences are the shelving of the plans to construct a factory for Kenya Breweries in Nyeri, and the lack of interest in the industrial land available for allocation in Kiganjo.

The direct impact of lack of commercial and industrial development is on employment opportunities. The greater impacts are however indirect, but closely associated.

Within the small scale agricultural sector, lack of outlets (such as food processing industries) will reduce the marketability of produce and thus depress incomes.

Lack of entrepreneural or employment opportunities in commerce and industry will also depress the level of available resources in the community, leading to unemployment and low incomes. The results of this are loss of quality of life, lower levels of nutrition, lack of

resources for education and health care, increases in crime and vagrancy, and other negative socio-economic effects.

Whereas an adequate water supply will not in itself provide an acceptable socio-economic environment, it is an elementary input into the developments which can lead to such a situation.

11.5 Public Services

Two essential public services which are quick to suffer from inadequate water supply are health care and fire fighting.

The latter is clearly not possible without a reasonable assurance of well distributed water supply. The lack of availability of such services poses a risk to life and property, and to socio-economic activity.

Health care facilities also cannot render the services for which they are intended without adequate supplies of potable water. The situation can even arise where they are a health hazard, if people with health problems are concentrated together, without the means of maintaining hygienic conditions. At present, operations at all health care facilities in the project area (except to some extent the Mt. Kenya Hospital very near the Kamakwa treatment works) are severely hampered by inadequate water supply. At the Provincial General Hospital (one of the largest in Kenya) the water supply is in basic minimal quantities, and effected through special arrangements. These include periodic diversion of water to the pipeline to the hospital, to enable them to fill their tanks, and supply by the Council fire engines. The lack of adequate water limits the number of operations that can be carried out, directly resulting in unnecessary death and suffering. The difficulties in maintaining adequately hygienic conditions are also expected to contribute to less than fully effective alleviation of the health problems brought to the hospital.

11.6 Labour Productivity

Harnessing of the potential productivity of the human resources is hampered in a situation of poor water supply due to mortality and morbidity, reduced employment opportunity creation, and expenditure of time on obtaining water for daily needs.

High incidence of illness in the labour force will result in a situation where spread of water borne diseases is rife through lack of potable water or poor sanitation, and where health care facilities cannot function effectively. This increases the costs of production and commercial activity, leading to less competitive operation, and diverting income which could have been deployed in increased production or activity.

The socio-economic effects of reduced employment creation have been noted above.

The time spent on obtaining water can be important, and will in many cases have a direct impact on the well being of women, who are in general to be expected to shoulder that responsibility. This will reduce the time available to them for other activities and in this situation, the capacity for Nyeri women to organise themselves to better their circumstances has been pointed out in Chapter 8. Without the time for these activities, the levels of success of their endeavors is expected to be significantly affected. Young children are also expected to participate in water drawing, and this can reduce the time available to them for study, affecting their academic achievement and thus their future.

11.7 Quality of Life

Whereas quality of life may not be a physical achievement such as good health or generation of income, it is perhaps the primary motivation for all other aspects of human activity. There are however some physical impacts resulting from improved quality of life, stemming largely from the state of motivation and psychological outlook of the populace.

The basic inputs to the quality of human are shelter, food, water, clothing, education and health care. Other criteria have an impact on improvements above basic needs, such as the quality of the foregoing, and availability of goods and services for convenience and leisure.

Availability of adequate water (both in quantity and quality) will have an impact on many of these needs and thus affect the quality of life.

The greatest impact will be on the creation of resources through commercial and industrial activity, providing the means for purchasing these goods and services. Other impacts will be in providing a basic input for service provision facilities to operate effectively, and for activity such as building construction for housing improvements to take place.

The quality of life will also improve through reduced difficulty and the convenience of obtaining water not only for basic needs, but also for maintaining the desired standard of life, and in more time for economically productive activity, or leisure.

11.8 Environmental Quality

One of the principal impacts on the environment by water supply is in the efficiency of sewage disposal and treatment. As mentioned above, adequate water supply is necessary for proper sanitation, and this leads to an impact on the quality of the general environment.

A related impact is on the quality of waste water discharges, including those from industrial facilities. With limited water availability, such discharges tend to be more concentrated, and thus more difficult to bring to an acceptable standard before discharge into the environment.

An improvement in the socio-economic circumstances of the populace in general will also have impact on the environment. Availability of resources will be a prime influence on the

ability and motivation of people to maintain habits and investment in developments which are beneficial to the environment.

11.9 Summary

The basic factors which indicate the need for a project are given in Table 11.1 - Logical Framework Matrix. That table also indicates the activities in the project which will lead to an elimination of the problems or achievements of the purposes, to which the project is to be geared.

Table 11.1
LOGICAL FRAMEWORK MATRIX

	Intervention Logic	Objectively Verifiable Indicators	Sources of Verification	Assumptions
Overall Objectives	Provision of safe, and adequate water supply, stimulate commercial and industrial development, improve quality of life and the lot of women, provide basic input to provision of public services including health care, education, fire fighting, etc.	Reduced or continually low incidence of water related diseases, increase in commercial and industrial activity, reductions in unemployment.	Records of health centres and hospitals, central government statistics, surveys of income levels and living standards.	Consumer awareness of value of safe water, motivation for entrepreneural initiatives, provision of health care facilities in adequate proportions.
Project Purpose	Provide adequate water supply for the expected demands for the year 2010, with capacity to augment the facilities for expected demands in 2020.	All consumers receiving an unrestrained supply of acceptable quality water.	Operations records of production quantities and treated water quality, consumer reaction.	Proper operation of facilities, provision of adequate resources for operation and maintenance, availability of qualified management and personnel.
Results	Projected demands met in two stage development.	Project constructed and commissioned, and subsequently operated as intended, personnel and fiscal resources made available for O & M.	Construction records and post-construction evaluation.	Financing obtained, project proceeds as planned, operational and maintenance provisions and structure adequate, and revenue adequate for operational needs.

Table 11.1 [cont'd]

	Intervention Logic	Objectively Verifiable Indicators	Sources of Verification	Assumptions
Activities	Completion of design, securing of financing, construction, commissioning, operation, maintenance, revenue collection, staff training and recruitment, and implementation of phase 2 works.	Overall objectives attained, proper organisational structure set up, cost covering tariff implemented, loan obligations met.	Design reports, construction progress reports, Client's financial and technical records.	Adequate technical support in design and implementation, adequate will from the Client to implement organisational and financial improvements.

Table 4.1
FINANCIAL PROJECTIONS - OPTION A1

Year	OUTPUT	Energy and Costs							Pipelines		Pumps			Structures		Treatment					Personnel Costs	Admin-istration Costs	Annual Invest-ment Cost	Total Annual Operat'n Cost	Total Annual Maint'ce. Cost
	increase at 3.84 % /year	Pump-ing hrs.	Power Req'd at 3.90/kWh		Demand 0.80 pf	250/= /KVA	Monthly Charge 480/=	Total Energy Cost	Capital Cost	Maint. at 2% p.a.	Capacity increase Cost	Replac-ment Cost	Maint. at 5% p.a.	Capital Cost	Maint. at 1% p.a.	Capital Cost	Maint. at 2% p.a.	Alum 40 mg/l @ 35.0/=/kg	Soda Ash 15 mg/l @ 15.0/=/kg	TCL 5 mg/l @ 215.0/=/kg					
	m3/day	hrs/day	kW	K.shs	KVA	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs
1995	17,876	13.6	780.1	26,652,905	975	2,925,547	5,760	29,584,213	307,325,475	6,146,510	901,125	-	45,056	101,115,000	1,011,150	94,812,930	1,896,259	9,134,656	1,468,067	7,014,096	14,036,000	5,041,545	504,154,550	66,278,556	9,098,974
1996	18,562	14.2	792.8	27,086,023	991	2,973,088	5,760	30,064,871		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	9,485,406	1,524,440	7,283,437	14,036,000	5,041,545		48,358,154	9,098,974
1997	19,275	14.7	806.0	27,535,772	1007	3,022,455	5,760	30,563,987		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	9,849,646	1,582,979	7,563,121	14,036,000	5,041,545		49,559,732	9,098,974
1998	20,015	15.3	819.7	28,002,792	1025	3,073,717	5,760	31,082,269		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	10,227,872	1,643,765	7,853,545	14,036,000	5,041,545		50,807,451	9,098,974
1999	20,784	15.9	833.9	28,487,745	1042	3,126,948	5,760	31,620,453		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	10,620,622	1,706,886	8,155,121	14,036,000	5,041,545		52,103,082	9,098,974
2000	21,582	16.5	848.6	28,991,321	1061	3,182,223	5,760	32,179,304		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	11,028,454	1,772,430	8,468,277	14,036,000	5,041,545		53,448,465	9,098,974
2001	22,411	17.1	863.9	29,514,234	1080	3,239,620	5,760	32,759,614		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	11,451,947	1,840,491	8,795,459	14,036,000	5,041,545		54,845,511	9,098,974
2002	23,271	17.8	879.8	30,057,226	1100	3,299,221	5,760	33,362,208		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	11,891,702	1,911,166	9,131,128	14,036,000	5,041,545		56,296,204	9,098,974
2003	24,165	18.4	896.3	30,621,070	1120	3,361,111	5,760	33,987,941		6,146,510	-	667,500	45,056	-	1,011,150	-	1,896,259	12,348,343	1,984,555	9,481,763	14,036,000	5,041,545	667,500	57,802,603	9,098,974
2004	25,093	19.1	913.4	31,206,565	1142	3,425,378	5,760	34,637,703		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	12,822,519	2,060,762	9,845,863	14,036,000	5,041,545		59,366,848	9,098,974
2005	26,057	19.9	931.2	31,814,543	1164	3,492,113	5,760	35,312,416		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	13,314,904	2,139,895	10,223,944	14,036,000	5,041,545		60,991,159	9,098,974
2006	27,057	20.6	949.7	32,445,868	1187	3,561,410	5,760	36,013,038		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	13,826,196	2,222,067	10,616,544	14,036,000	5,041,545		62,677,845	9,098,974
2007	28,096	21.4	968.9	33,101,435	1211	3,633,368	5,760	36,740,563		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	14,357,122	2,307,395	11,024,219	14,036,000	5,041,545		64,429,299	9,098,974
2008	29,175	22.3	988.8	33,782,176	1236	3,708,089	5,760	37,496,026		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	14,908,436	2,395,999	11,447,549	14,036,000	5,041,545		66,248,009	9,098,974
2009	30,295	23.1	1009.5	34,489,058	1262	3,785,680	5,760	38,280,498		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	15,480,920	2,488,005	11,887,135	14,036,000	5,041,545		68,136,557	9,098,974
2010	31,459	24.0	1031.0	35,223,084	1289	3,866,250	5,760	39,095,094		6,146,510	-	-	45,056	-	1,011,150	-	1,896,259	16,075,387	2,583,544	12,343,601	14,036,000	5,041,545		70,097,626	9,098,974
2011	32,667	17.1	1192.7	40,747,696	1491	4,472,657	5,760	45,226,113	8,320,050	6,312,911	1,219,050	-	60,953	38,340,000	1,394,550	33,067,845	2,557,616	16,692,682	2,682,752	12,817,595	20,126,000	5,851,015	80,946,945	77,419,142	10,326,029
2012	33,921	17.8	1215.5	41,525,269	1519	4,558,007	5,760	46,089,036		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	17,333,681	2,785,770	13,309,791	20,126,000	5,851,015		79,518,278	10,326,029
2013	35,224	18.4	1239.1	42,332,701	1549	4,646,635	5,760	46,985,095		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	17,999,294	2,892,744	13,820,887	20,126,000	5,851,015		81,698,020	10,326,029
2014	36,576	19.1	1263.6	43,171,138	1580	4,738,665	5,760	47,915,563		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	18,690,467	3,003,825	14,351,609	20,126,000	5,851,015		83,961,464	10,326,029
2015	37,981	19.9	1289.1	44,041,771	1611	4,834,230	5,760	48,881,761		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	19,408,181	3,119,172	14,902,710	20,126,000	5,851,015		86,311,824	10,326,029
2016	39,439	20.6	1315.6	44,945,836	1644	4,933,465	5,760	49,885,061		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	20,153,455	3,238,948	15,474,975	20,126,000	5,851,015		88,752,439	10,326,029
2017	40,954	21.4	1343.1	45,884,618	1679	5,036,510	5,760	50,926,887		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	20,927,348	3,363,324	16,069,214	20,126,000	5,851,015		91,286,773	10,326,029
2018	42,526	22.3	1371.6	46,859,449	1715	5,143,512	5,760	52,008,720		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	21,730,958	3,492,475	16,686,271	20,126,000	5,851,015		93,918,425	10,326,029
2019	44,159	23.1	1401.2	47,871,713	1752	5,254,622	5,760	53,132,095		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	22,565,427	3,626,586	17,327,004	20,126,000	5,851,015		96,651,133	10,326,029
2020	45,855	24.0	1432.0	48,922,848	1790	5,370,000	5,760	54,298,608		6,312,911	-	-	60,953	-	1,394,550	-	2,557,616	23,451,939	3,765,847	17,992,382	20,126,000	5,851,015		99,488,777	10,326,029
Totals																									
2020	774,477			935,314,856	34,222	102,664,521	149,760	1,038,129,137	315,645,525	161,473,257	2,120,175	667,500	1,330,425	139,455,000	30,123,900	127,880,775	55,916,295	395,757,544	63,603,891	303,885,257	425,836,000	139,174,872	585,768,975	1,820,453,376	248,843,875
2010	385,174			489,011,819	17,892	53,676,218	92,160	542,780,198	307,325,475	98,344,152	901,125	667,500	720,900	101,115,000	16,178,400	94,812,930	30,340,138	196,824,112	31,632,447	151,132,800	224,576,000	80,664,725	504,822,050	941,447,102	145,583,590

NYRPFSIL3.LS OPT. A1 16/2/96 13:30

Table 4.1 [contd]

NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - AVERAGE INCREMENTAL FINANCIAL COSTS

Year	INVESTMENT COSTS			Incremental	REINVESTMENT COSTS		RECURRENT COSTS					TOTAL COSTS	OUTPUT at 3.84 % per year	A.I.F.C.
	Existing Assets	New Project	Interest during Const.	Working Capital	Existing Assets	New Project	Personnel	Maintenance and Repairs	Energy	Treatment	Administration			
	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	m3/day	K.shs/m3
1	2	3	4	5	5	6	7	8	9	10	11	12	13	14
1995	47,600,000	504,154,530	-		7,500,000	-	14,036,000	9,098,974	29,584,213	17,616,798	5,041,545	634,632,060	17,876	97.3
1996		-	-			-	14,036,000	9,098,974	30,064,871	18,293,283	5,041,545	76,534,674	18,502	108.6
1997		-	-			-	14,036,000	9,098,974	30,563,987	18,995,745	5,041,545	77,736,252	19,275	119.6
1998		-	-			-	14,036,000	9,098,974	31,082,269	19,725,182	5,041,545	78,983,971	20,015	130.4
1999		-	-			-	14,036,000	9,098,974	31,620,453	20,482,629	5,041,545	80,279,602	20,784	141.0
2000		-	-			-	14,036,000	9,098,974	32,179,304	21,269,162	5,041,545	81,624,985	21,582	151.4
2001		-	-			-	14,036,000	9,098,974	32,759,614	22,085,897	5,041,545	83,022,031	22,411	161.5
2002		-	-			-	14,036,000	9,098,974	33,362,208	22,933,996	5,041,545	84,472,723	23,271	171.5
2003		-	-		500,000	-	14,036,000	9,098,974	33,987,941	23,814,661	5,041,545	86,479,122	24,165	181.3
2004		-	-			-	14,036,000	9,098,974	34,637,703	24,729,144	5,041,545	87,543,367	25,093	190.8
2005		-	-			-	14,036,000	9,098,974	35,312,416	25,678,743	5,041,545	89,167,679	26,057	200.2
2006		-	-			-	14,036,000	9,098,974	36,013,038	26,664,807	5,041,545	90,854,365	27,057	209.4
2007		-	-			-	14,036,000	9,098,974	36,740,563	27,688,736	5,041,545	92,605,819	28,096	218.4
2008		-	-			-	14,036,000	9,098,974	37,496,026	28,751,983	5,041,545	94,424,529	29,175	227.3
2009		-	-			-	14,036,000	9,098,974	38,280,498	29,856,059	5,041,545	96,313,077	30,295	236.0
2010		-	-			-	14,036,000	9,098,974	39,095,094	31,002,532	5,041,545	98,274,146	31,459	244.6
2011		80,946,945	-		2,000,000	2,000,000	20,126,000	10,326,029	45,226,113	32,193,029	5,851,015	198,669,131	32,667	261.2
2012		-	-			-	20,126,000	10,326,029	46,089,036	33,429,242	5,851,015	115,821,321	33,921	270.6
2013		-	-			-	20,126,000	10,326,029	46,985,095	34,712,925	5,851,015	118,001,063	35,224	279.8
2014		-	-			-	20,126,000	10,326,029	47,915,563	36,045,901	5,851,015	120,264,507	36,576	288.8
2015		-	-			-	20,126,000	10,326,029	48,881,761	37,430,063	5,851,015	122,614,868	37,981	297.6
2016		-	-			-	20,126,000	10,326,029	49,885,061	38,867,378	5,851,015	125,055,482	39,439	306.3
2017		-	-			-	20,126,000	10,326,029	50,926,887	40,359,885	5,851,015	127,589,816	40,954	314.8
2018		-	-			-	20,126,000	10,326,029	52,008,720	41,909,705	5,851,015	130,221,468	42,526	323.2
2019		-	-			-	20,126,000	10,326,029	53,132,095	43,519,037	5,851,015	132,954,176	44,159	331.5
2020		-	-			-	20,126,000	10,326,029	54,298,608	45,190,169	5,851,015	135,791,820	45,855	339.6
TOTALS	47,600,000	585,101,475	-		10,000,000	2,000,000	425,836,000	248,843,875	1,038,129,137	763,246,693	139,174,872	3,299,932,052	774,477	5,802.6

Discount Rate	Discounted Costs	Discounted Output	Cost/ Output
5	1,518,631,181	96,176,256	15.79
7	1,405,614,821	84,174,150	16.70
10	1,272,960,842	70,176,302	18.14
12	1,203,160,449	62,859,784	19.14

YEAR 2010 WORKS

Discount Rate	Discounted Costs	Discounted Output	Cost/ Output
5	2,015,238,310	148,161,438	13.60
7	1,747,131,447	119,596,747	14.61
10	1,471,372,221	90,472,851	16.26
12	1,342,931,058	77,026,609	17.43

YEAR 2020 WORKS

Table 4.1 [contd]

NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - DISCOUNT RATES AND DISCOUNTED COSTS

Year	No	Required Discount Rates				Discounted Costs (KShs)				Discounted Output (m^3/day)			
		5 %	7 %	10 %	12 %	5 %	7 %	10 %	12 %	5 %	7 %	10 %	12 %
							NPV				NPV		
1	15	16	17	18	19	20	21	22	23	24	25	26	27
1995	0	1.000	1.000	1.000	1.000	634,632,060	634,632,060	634,632,060	634,632,060	17,876	17,876	17,876	17,876
1996	1	0.952	0.935	0.909	0.893	72,890,166	71,527,733	69,576,976	68,334,530	17,679	17,348	16,875	16,574
1997	2	0.907	0.873	0.826	0.797	70,509,072	67,897,853	64,244,836	61,970,864	17,483	16,836	15,930	15,366
1998	3	0.864	0.816	0.751	0.712	68,229,323	64,474,447	59,341,826	56,219,230	17,290	16,339	15,038	14,247
1999	4	0.823	0.763	0.683	0.636	66,046,227	61,244,924	54,832,048	51,019,138	17,099	15,856	14,196	13,209
2000	5	0.784	0.713	0.621	0.567	63,955,311	58,197,486	50,682,694	46,316,208	16,910	15,388	13,401	12,246
2001	6	0.746	0.666	0.564	0.507	61,952,318	55,321,085	46,863,772	42,061,545	16,723	14,933	12,650	11,354
2002	7	0.711	0.623	0.513	0.452	60,033,187	52,605,367	43,347,864	38,211,170	16,539	14,492	11,942	10,527
2003	8	0.677	0.582	0.467	0.404	58,532,474	50,331,637	40,343,149	34,927,467	16,356	14,064	11,273	9,760
2004	9	0.645	0.544	0.424	0.361	56,431,235	47,617,791	37,126,934	31,569,016	16,175	13,649	10,642	9,049
2005	10	0.614	0.508	0.386	0.322	54,741,220	45,328,327	34,378,000	28,709,606	15,996	13,246	10,046	8,390
2006	11	0.585	0.475	0.350	0.287	53,120,665	43,164,254	31,843,901	26,118,459	15,820	12,855	9,483	7,778
2007	12	0.557	0.444	0.319	0.257	51,566,385	41,118,091	29,507,068	23,769,607	15,645	12,475	8,952	7,212
2008	13	0.530	0.415	0.290	0.229	50,075,344	39,182,822	27,351,423	21,639,665	15,472	12,107	8,451	6,686
2009	14	0.505	0.388	0.263	0.205	48,644,649	37,351,872	25,362,243	19,707,564	15,301	11,749	7,978	6,199
2010	15	0.481	0.362	0.239	0.183	47,271,544	35,619,073	23,526,049	17,954,319	15,132	11,402	7,531	5,747
2011	16	0.458	0.339	0.218	0.163	91,012,618	67,296,108	43,236,191	32,407,239	14,965	11,065	7,109	5,329
2012	17	0.436	0.317	0.198	0.146	50,532,459	36,666,064	22,914,631	16,868,720	14,800	10,739	6,711	4,940
2013	18	0.416	0.296	0.180	0.130	49,031,879	34,912,257	21,223,528	15,344,810	14,636	10,421	6,335	4,580
2014	19	0.396	0.277	0.164	0.116	47,592,749	33,254,138	19,664,208	13,963,524	14,474	10,114	5,981	4,247
2015	20	0.377	0.258	0.149	0.104	46,212,254	31,686,012	18,225,919	12,711,087	14,315	9,815	5,646	3,937
2016	21	0.359	0.242	0.135	0.093	44,887,710	30,202,535	16,898,819	11,575,087	14,156	9,525	5,329	3,650
2017	22	0.342	0.226	0.123	0.083	43,616,562	28,798,701	15,673,895	10,544,343	14,000	9,244	5,031	3,385
2018	23	0.326	0.211	0.112	0.074	42,396,373	27,469,813	14,542,894	9,608,776	13,845	8,971	4,749	3,138
2019	24	0.310	0.197	0.102	0.066	41,224,824	26,211,466	13,498,252	8,759,301	13,692	8,706	4,483	2,909
2020	25	0.295	0.184	0.092	0.059	40,099,701	25,019,531	12,533,042	7,987,724	13,541	8,449	4,232	2,697
TOTALS		15	13	10	9	2,015,238,310	1,747,131,447	1,471,372,221	1,342,931,058	405,922	327,662	247,871	211,032

Table 4.2
FINANCIAL PROJECTIONS - OPTION A2

Year	OUTPUT increase at 3.84 % /year	Energy and Costs							Pipelines		Pumps			Structures		Treatment					Personnel Costs	Admin-istration Costs	Annual Invest-ment Cost	Total Annual Operat'n Cost	Total Annual Maint'ce. Cost
		Pump-ing hrs.	Power Req'd at 3.90/kWh		0.80 pf Demand	250/= /KVA	Monthly Charge 480/=	Total Energy Cost	Capital Cost	Maint. at 2% p.a.	Capacity increase Cost	Replac-ment Cost	Maint. at 5% p.a.	Capital Cost	Maint. at 1% p.a.	Capital Cost	Maint. at 2% p.a.	Alum 40 mg/l @ 35.0/=/kg	Soda Ash 15 mg/l @ 15.0/=/kg	TCL 5 mg/l @ 215.0/=/kg					
	m3/day	hrs/day	kW	K.shs	KVA	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs
1995	17,876	13.6	1591.0	54,555,129	1989	5,966,273	5,760	60,527,162	290,745,666	5,814,913	2,356,425	-	117,821	112,725,000	1,127,250	126,216,630	2,524,333	9,154,636	1,468,067	7,014,096	17,056,000	5,320,437	532,043,721	100,320,397	9,584,317
1996	18,562	14.2	1628.1	55,655,228	2036	6,108,977	5,760	61,769,965		5,814,913	-	-	117,821		1,127,250	-	2,524,333	9,482,406	1,524,440	7,283,437	17,056,000	5,320,437		80,083,248	9,584,317
1997	19,275	14.7	1668.6	57,055,230	2086	6,257,182	5,760	63,318,172		5,814,913	-	-	117,821		1,127,250	-	2,524,333	9,849,646	1,582,979	7,563,121	17,056,000	5,320,437		82,263,917	9,584,317
1998	20,015	15.3	1709.6	58,407,113	2137	6,411,057	5,760	64,823,930		5,814,913	-		117,821		1,127,250	-	2,524,333	10,227,872	1,643,765	7,853,565	17,056,000	5,320,437		84,548,092	9,584,317
1999	20,784	15.9	1752.2	59,862,808	2190	6,570,821	5,760	66,439,389		5,814,913		-	117,821	-	1,127,250	-	2,524,333	10,620,622	1,706,886	8,155,121	17,056,000	5,320,437		86,922,017	9,584,317
2000	21,582	16.5	1796.5	61,374,401	2246	6,736,741	5,760	68,116,901		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	11,028,454	1,772,430	8,468,277	17,056,000	5,320,437		89,386,063	9,584,317
2001	22,411	17.1	1842.4	62,944,039	2303	6,909,031	5,760	69,858,831		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	11,451,947	1,840,491	8,795,459	17,056,000	5,320,437		91,944,728	9,584,317
2002	23,271	17.8	1890.1	64,573,952	2363	7,087,938	5,760	71,667,650		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	11,891,702	1,911,166	9,131,128	17,056,000	5,320,437		94,601,646	9,584,317
2003	24,165	18.4	1939.7	66,266,453	2425	7,273,715	5,760	73,545,928		5,814,913	-	1,745,500	117,821	-	1,127,250	-	2,524,333	12,348,343	1,984,555	9,481,763	17,056,000	5,320,437	1,745,500	97,360,589	9,584,317
2004	25,093	19.1	1991.1	68,023,946	2489	7,466,626	5,760	75,496,332		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	12,822,519	2,060,702	9,845,863	17,056,000	5,320,437		100,225,476	9,584,317
2005	26,057	19.9	2044.5	69,848,927	2556	7,666,944	5,760	77,521,631		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	13,314,904	2,139,895	10,223,964	17,056,000	5,320,437		103,200,375	9,584,317
2006	27,057	20.6	2100.0	71,743,987	2625	7,874,955	5,760	79,624,702		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	13,828,196	2,222,067	10,616,544	17,056,000	5,320,437		106,289,539	9,584,317
2007	28,096	21.4	2157.6	73,711,818	2697	8,090,953	5,760	81,808,531		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	14,357,122	2,307,395	11,024,219	17,056,000	5,320,437		109,497,267	9,584,317
2008	29,175	22.3	2217.4	75,755,213	2772	8,315,246	5,760	84,076,219		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	14,908,436	2,395,999	11,447,549	17,056,000	5,320,437		112,828,202	9,584,317
2009	30,295	23.1	2279.5	77,877,075	2849	8,548,151	5,760	86,430,986		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	15,480,920	2,488,005	11,887,135	17,056,000	5,320,437		116,287,045	9,584,317
2010	31,459	24.0	2344.0	80,080,416	2930	8,790,000	5,760	88,876,176		5,814,913	-	-	117,821	-	1,127,250	-	2,524,333	16,075,387	2,583,544	12,343,601	17,056,000	5,320,437		119,878,708	9,584,317
2011	32,667	17.1	2627.9	89,778,221	3285	9,854,476	5,760	99,638,457	14,453,359	6,103,985	4,032,315	-	201,616	38,340,000	1,510,650	30,073,410	3,125,801	16,692,682	2,682,752	12,817,595	23,983,000	6,189,430	86,899,284	131,831,486	10,942,051
2012	33,921	17.8	2700.0	92,241,781	3375	10,124,888	5,760	102,372,429		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	17,333,681	2,785,770	13,309,791	23,983,000	6,189,430		135,801,671	10,942,051
2013	35,224	18.4	2774.8	94,799,942	3469	10,405,684	5,760	105,211,386		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	17,999,294	2,892,744	13,820,887	23,983,000	6,189,430		139,924,311	10,942,051
2014	36,576	19.1	2852.6	97,436,337	3566	10,697,262	5,760	108,139,359		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	18,690,467	3,003,825	14,351,609	23,983,000	6,189,430		144,205,260	10,942,051
2015	37,981	19.9	2933.3	100,214,737	3667	11,000,057	5,760	111,220,554		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	19,408,181	3,119,172	14,902,710	23,983,000	6,189,430		148,650,598	10,942,051
2016	39,439	20.6	3017.2	103,079,060	3771	11,314,438	5,760	114,399,258		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	20,153,455	3,238,948	15,474,975	23,983,000	6,189,430		153,266,636	10,942,051
2017	40,954	21.4	3104.2	106,055,373	3880	11,640,913	5,760	117,700,045		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	20,927,348	3,363,324	16,069,214	23,983,000	6,189,430		158,059,931	10,942,051
2018	42,526	22.3	3194.6	109,141,899	3993	11,979,924	5,760	121,127,583		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	21,730,958	3,492,475	16,686,271	23,983,000	6,189,430		163,057,288	10,942,051
2019	44,159	23.1	3288.5	112,349,025	4111	12,331,953	5,760	124,686,738		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	22,565,427	3,626,586	17,327,024	23,983,000	6,189,430		168,205,775	10,942,051
2020	45,855	24.0	3386.0	115,679,304	4233	12,697,500	5,760	128,382,564		6,103,985	-	-	201,616	-	1,510,650	-	3,125,801	23,431,939	3,765,847	17,992,382	23,983,000	6,189,430		173,572,733	10,942,051
Totals																									
2020	774,477			2,078,279,435	76,041	228,121,645	149,760	2,306,550,840	305,199,225	154,078,458	6,388,740	1,745,500	3,901,298	151,065,000	33,142,500	156,290,040	71,647,330	395,757,544	63,603,891	303,885,227	512,726,000	147,021,296	620,688,505	3,092,173,970	262,769,585
2010	385,174			1,057,485,756	38,692	116,074,569	92,160	1,173,652,485	290,745,666	93,038,613	2,356,425	1,745,500	1,885,140	112,725,000	18,096,000	126,216,630	40,389,322	196,824,112	31,632,447	151,132,800	272,898,000	85,126,995	533,790,221	1,575,618,281	153,349,075

Table 4.2 [contd]

NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - AVERAGE INCREMENTAL FINANCIAL COSTS

Year	INVESTMENT COSTS			REINVESTMENT COSTS		RECURRENT COSTS					TOTAL COSTS	OUTPUT at 3.84 % per year	A.I.F.C.
	Existing Assets	New Project	Interest during Const.	Existing Assets	New Project	Personnel	Maintenance and Repairs	Energy	Treatment	Administration			
	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	m3/day	K.shs/m3
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1995	47,600,000	532,043,721	-	7,500,000	-	17,056,000	7,059,985	60,327,162	133,230,726	5,320,437	810,138,030	17,876	124.2
1996		-	-		-	17,056,000	7,059,985	61,769,965	7,283,437	5,320,437	98,489,824	18,562	138.7
1997		-	-		-	17,056,000	7,059,985	63,268,172	7,563,121	5,320,437	100,267,715	19,275	153.0
1998		-	-		-	17,056,000	7,059,985	64,823,910	7,853,545	5,320,437	102,113,877	20,015	166.9
1999		-	-		-	17,056,000	7,059,985	66,439,389	8,155,121	5,320,437	104,030,931	20,784	180.6
2000		-	-		-	17,056,000	7,059,985	68,116,901	8,468,277	5,320,437	106,021,600	21,582	194.1
2001		-	-		-	17,056,000	7,059,985	69,858,831	8,793,459	5,320,437	108,088,712	22,411	207.3
2002		-	-		-	17,056,000	7,059,985	71,667,650	9,131,128	5,320,437	110,235,200	23,271	220.3
2003		-	-	500,000	-	17,056,000	7,059,985	73,545,928	9,481,763	5,320,437	112,964,113	24,165	233.1
2004		-	-		-	17,056,000	7,059,985	75,496,332	9,845,863	5,320,437	114,778,617	25,093	245.6
2005		-	-		-	17,056,000	7,059,985	77,521,631	10,223,944	5,320,437	117,181,997	26,057	258.0
2006		-	-		-	17,056,000	7,059,985	79,624,702	10,616,544	5,320,437	119,677,668	27,057	270.1
2007		-	-		-	17,056,000	7,059,985	81,808,531	11,024,219	5,320,437	122,269,172	28,096	282.0
2008		-	-		-	17,056,000	7,059,985	84,076,219	11,447,549	5,320,437	124,960,190	29,175	293.7
2009		-	-		-	17,056,000	7,059,985	86,430,986	11,887,135	5,320,437	127,754,542	30,295	305.3
2010		-	-		-	17,056,000	7,059,985	88,876,176	12,343,601	5,320,437	130,656,199	31,459	316.7
2011		86,899,284	-	2,000,000	2,000,000	23,983,000	7,816,250	99,638,457	42,891,005	6,189,430	271,417,426	32,667	339.4
2012		-	-		-	23,983,000	7,816,250	102,372,429	13,369,791	6,189,430	153,670,900	33,921	351.8
2013		-	-		-	23,983,000	7,816,250	105,211,386	13,820,887	6,189,430	157,020,953	35,224	364.1
2014		-	-		-	23,983,000	7,816,250	108,159,359	14,351,609	6,189,430	160,499,648	36,576	376.1
2015		-	-		-	23,983,000	7,816,250	111,220,534	14,902,710	6,189,430	164,111,925	37,981	387.9
2016		-	-		-	23,983,000	7,816,250	114,399,258	15,474,975	6,189,430	167,862,913	39,439	399.6
2017		-	-		-	23,983,000	7,816,250	117,700,045	16,069,214	6,189,430	171,757,939	40,954	411.1
2018		-	-		-	23,983,000	7,816,250	121,127,583	16,686,271	6,189,430	175,802,535	42,526	422.4
2019		-	-		-	23,983,000	7,816,250	124,686,738	17,327,024	6,189,430	180,002,442	44,159	433.6
2020		-	-		-	23,983,000	7,816,250	128,382,564	17,992,382	6,189,430	184,363,626	45,855	444.6
TOTALS	47,600,000	618,943,005	-	10,000,000	2,000,000	512,726,000	191,122,256	2,306,550,840	460,175,297	147,021,296	4,296,138,693	774,477	7,520

Discount Rate	Discounted Costs	Discounted Output	Cost/ Output
5	1,964,834,413	95,113,737	20.66
7	1,816,397,022	81,688,259	22.24
10	1,642,302,742	66,246,429	24.79
12	1,530,770,951	58,280,000	26.61

YEAR 2010 WORKS

Discount Rate	Discounted Costs	Discounted Output	Cost/ Output
5	2,633,293,509	148,161,438	17.77
7	2,276,079,565	119,596,747	19.03
10	1,909,360,182	90,472,851	21.10
12	1,738,901,060	77,026,609	22.58

YEAR 2020 WORKS

NYRPHASE.XLS OPT. A2 16/02/96 13:31

Table 4.2 [contd]

NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - DISCOUNT RATES AND DISCOUNTED COSTS

Year	No	Required Discount Rates				Discounted Costs (KShs.)				Discounted Output (m3/day)			
		5 %	7 %	10 %	12 %	5 %	7 %	10 %	12 %	5 %	7 %	10 %	12 %
		(fill in above values)				NPV				NPV			
1	15	16	17	18	19	20	21	22	23	24	25	26	27
1995	0	1.000	1.000	1.000	1.000	810,138,030	810,138,030	810,138,030	810,138,030	17,876	17,876	17,876	17,876
1996	1	0.952	0.935	0.909	0.893	93,799,832	92,046,564	89,536,203	87,937,343	17,679	17,348	16,875	16,574
1997	2	0.907	0.873	0.826	0.797	90,945,773	87,577,705	82,865,880	79,932,808	17,483	16,836	15,930	15,366
1998	3	0.864	0.816	0.751	0.712	88,209,806	83,355,341	76,719,667	72,682,640	17,290	16,339	15,038	14,247
1999	4	0.823	0.763	0.683	0.636	85,586,504	79,364,699	71,054,526	66,113,537	17,099	15,856	14,196	13,209
2000	5	0.784	0.713	0.621	0.567	83,070,698	75,591,936	65,831,072	60,159,503	16,910	15,388	13,401	12,246
2001	6	0.746	0.666	0.564	0.507	80,657,461	72,024,072	61,013,260	54,761,105	16,723	14,933	12,650	11,354
2002	7	0.711	0.623	0.513	0.452	78,342,098	68,648,942	56,568,088	49,864,806	16,539	14,492	11,942	10,527
2003	8	0.677	0.582	0.467	0.404	76,458,558	65,746,142	52,698,592	45,624,311	16,356	14,064	11,273	9,760
2004	9	0.645	0.544	0.424	0.361	73,987,320	62,431,963	48,677,338	41,390,320	16,175	13,649	10,642	9,049
2005	10	0.614	0.508	0.386	0.322	71,939,581	59,569,385	45,178,733	37,729,467	15,996	13,246	10,046	8,390
2006	11	0.585	0.475	0.350	0.287	69,973,054	56,857,998	41,946,292	34,404,470	15,820	12,855	9,483	7,778
2007	12	0.557	0.444	0.319	0.257	68,084,050	54,288,974	38,958,726	31,383,451	15,645	12,475	8,952	7,212
2008	13	0.530	0.415	0.290	0.229	66,269,056	51,854,036	36,196,516	28,637,650	15,472	12,107	8,451	6,686
2009	14	0.505	0.388	0.263	0.205	64,524,725	49,545,414	33,641,764	26,141,111	15,301	11,749	7,978	6,199
2010	15	0.481	0.362	0.239	0.183	62,847,865	47,355,819	31,278,055	23,870,399	15,132	11,402	7,531	5,747
2011	16	0.458	0.339	0.218	0.163	124,339,450	91,938,473	59,068,340	44,274,062	14,965	11,065	7,109	5,329
2012	17	0.436	0.317	0.198	0.146	67,046,105	48,648,272	30,402,968	22,381,297	14,800	10,739	6,711	4,940
2013	18	0.416	0.296	0.180	0.130	65,245,449	46,456,834	28,241,599	20,418,940	14,636	10,421	6,335	4,580
2014	19	0.396	0.277	0.164	0.116	63,515,161	44,379,490	26,242,975	18,635,097	14,474	10,114	5,981	4,247
2015	20	0.377	0.258	0.149	0.104	61,852,059	42,409,640	24,394,192	17,012,952	14,315	9,815	5,646	3,937
2016	21	0.359	0.242	0.135	0.093	60,253,111	40,541,090	22,683,411	15,537,326	14,156	9,525	5,329	3,650
2017	22	0.342	0.226	0.123	0.083	58,715,429	38,768,028	21,099,771	14,194,507	14,000	9,244	5,031	3,385
2018	23	0.326	0.211	0.112	0.074	57,236,261	37,084,997	19,633,303	12,972,110	13,845	8,971	4,749	3,138
2019	24	0.310	0.197	0.102	0.066	55,812,981	35,486,873	18,274,856	11,858,939	13,692	8,706	4,483	2,909
2020	25	0.295	0.184	0.092	0.059	54,443,090	33,968,846	17,016,025	10,844,878	13,541	8,449	4,232	2,697
		15	13	10	9	2,633,293,509	2,276,079,565	1,909,360,182	1,738,901,060	405,922	327,662	247,871	211,032

Table 4.3

OPTION B1 - NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - OUTPUT, INVESTMENT AND EXPENDITURE

Year	OUTPUT	Energy and Costs							Pipelines		Pumps			Structures		Treatment					Personnel	Admin-	Annual	Total	Total
	increase at 3.84 % /year	Pump-ing hrs.	Power Req'd at 3.90/kWh		0.80 pf Demand 250/= /KVA		Monthly Charge 480/=	Total Energy Cost	Capital Cost	Maint. at 2% p.a.	Capacity increase Cost	Replac-ment Cost	Maint. at 5% p.a.	Capital Cost	Maint. at 1% p.a.	Capital Cost	Maint. at 2% p.a.	Alum 40 mg/l @ 35.0/=/kg	Soda Ash 15 mg/l @ 15.0/=/kg	TCL 5 mg/l @ 215.0/=/kg	Costs	istration Costs	Invest-ment Cost	Annual Operat'n Cost	Annual Maint'ce. Cost
	m3/day	hrs/day	kW	K.shs	KVA	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs
1995	17,876	13.6	506.2	17,361,718	635	1,905,703	5,760	19,273,181	353,398,950	7,067,979	901,125	-	45,056	113,400,000	1,134,000	105,811,785	2,116,236	9,134,656	1,466,067	7,014,096	16,525,000	5,735,119	573,511,060	59,130,096	10,363,271
1996	18,562	14.2	510.4	17,458,054	638	1,914,082	5,760	19,357,896		7,067,979	-	-	45,056		1,134,000	-	2,116,236	9,485,406	1,524,440	7,283,457	16,525,000	5,735,119		37,651,179	10,363,271
1997	19,275	14.7	512.7	17,537,321	641	1,922,783	5,760	19,445,864		7,067,979	-	-	45,056		1,134,000	-	2,116,236	9,849,666	1,582,979	7,563,121	16,525,000	5,735,119		38,441,609	10,363,271
1998	20,015	15.3	515.2	17,599,633	644	1,931,818	5,760	19,537,210		7,067,979	-	-	45,056		1,134,000	-	2,116,236	10,227,872	1,643,765	7,853,545	16,525,000	5,735,119		39,262,392	10,363,271
1999	20,784	15.9	517.7	17,685,105	647	1,941,200	5,760	19,632,064		7,067,979		-	45,056	-	1,134,000	-	2,116,236	10,620,022	1,706,886	8,155,121	16,525,000	5,735,119		40,114,693	10,363,271
2000	21,582	16.5	520.3	17,772,859	650	1,950,942	5,760	19,730,560	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	11,028,454	1,772,430	8,468,277	16,525,000	5,735,119		40,999,722	10,363,271
2001	22,411	17.1	522.9	17,866,021	654	1,961,058	5,760	19,832,839	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	11,451,947	1,840,491	8,795,459	16,525,000	5,735,119		41,918,736	10,363,271
2002	23,271	17.8	525.7	17,961,722	657	1,971,562	5,760	19,939,045	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	11,891,702	1,911,166	9,131,128	16,525,000	5,735,119		42,873,041	10,363,271
2003	24,165	18.4	528.7	18,061,099	661	1,982,470	5,760	20,049,329	-	7,067,979	-	667,500	45,056	-	1,134,000	-	2,116,236	12,348,343	1,984,555	9,481,763	16,525,000	5,735,119	667,500	43,863,990	10,363,271
2004	25,093	19.1	531.7	18,164,291	665	1,993,797	5,760	20,163,848	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	12,822,519	2,060,762	9,845,863	16,525,000	5,735,119		44,892,992	10,363,271
2005	26,057	19.9	534.8	18,271,446	669	2,005,559	5,760	20,282,765	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	13,314,904	2,139,995	10,223,944	16,525,000	5,735,119		45,961,508	10,363,271
2006	27,057	20.6	538.1	18,382,715	673	2,017,773	5,760	20,406,248	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	13,826,196	2,222,067	10,616,564	16,525,000	5,735,119		47,071,055	10,363,271
2007	28,096	21.4	541.5	18,498,258	677	2,030,455	5,760	20,534,473	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	14,357,122	2,307,395	11,024,219	16,525,000	5,735,119		48,223,208	10,363,271
2008	29,175	22.3	545.0	18,618,227	681	2,043,625	5,760	20,667,621	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	14,908,436	2,395,999	11,447,549	16,525,000	5,735,119		49,419,605	10,363,271
2009	30,295	23.1	548.6	18,742,823	686	2,057,300	5,760	20,805,883	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	15,480,920	2,488,005	11,887,135	16,525,000	5,735,119		50,661,942	10,363,271
2010	31,459	24.0	552.4	18,872,194	691	2,071,500	5,760	20,949,454	-	7,067,979	-	-	45,056	-	1,134,000	-	2,116,236	16,075,387	2,583,564	12,343,691	16,525,000	5,735,119		51,951,906	10,363,271
2011	32,667	17.1	681.4	23,280,244	822	2,555,348	5,760	25,841,353	2,899,125	7,125,902	1,219,050	-	60,953	44,550,000	1,579,500	32,747,490	2,771,186	16,692,682	2,682,752	12,817,595	22,300,000	6,549,275	81,415,665	58,034,382	11,537,600
2012	33,921	17.8	684.6	23,387,067	826	2,567,074	5,760	25,959,901		7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	17,333,681	2,785,770	13,309,791	22,300,000	6,549,275		59,389,142	11,537,600
2013	35,224	18.4	687.8	23,497,992	830	2,579,249	5,760	26,083,001		7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	17,999,294	2,892,744	13,820,887	22,300,000	6,549,275		60,795,926	11,537,600
2014	36,576	19.1	691.2	23,613,176	864	2,591,891	5,760	26,210,829	-	7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	18,690,467	3,003,853	14,351,609	22,300,000	6,549,275		62,256,730	11,537,600
2015	37,981	19.9	694.7	23,732,784	868	2,605,021	5,760	26,343,565	-	7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	19,408,181	3,119,172	14,902,710	22,300,000	6,549,275		63,773,628	11,537,600
2016	39,439	20.6	698.3	23,856,984	873	2,618,454	5,760	26,481,398	-	7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	20,133,455	3,238,948	15,474,975	22,300,000	6,549,275		65,348,776	11,537,600
2017	40,954	21.4	702.1	23,985,954	878	2,632,810	5,760	26,624,524	-	7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	20,927,348	3,363,324	16,069,214	22,300,000	6,549,275		66,984,409	11,537,600
2018	42,526	22.3	706.0	24,119,876	883	2,647,510	5,760	26,773,146	-	7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	21,720,958	3,492,475	16,686,271	22,300,000	6,549,275		68,682,851	11,537,600
2019	44,159	23.1	710.1	24,258,940	888	2,662,774	5,760	26,927,475	-	7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	22,565,457	3,626,586	17,327,024	22,300,000	6,549,275		70,446,512	11,537,600
2020	45,855	24.0	714.3	24,403,345	893	2,678,625	5,760	27,087,730	-	7,125,902	-	-	60,953	-	1,579,500	-	2,771,186	23,431,979	3,765,847	17,992,382	22,300,000	6,549,275		72,277,899	11,537,600
Totals 2020	774,477			526,930,837	19,240	57,840,384	149,760	584,941,201	356,298,075	184,367,279	2,120,175	667,500	1,330,425	157,950,000	33,939,000	138,559,275	61,571,626	395,737,564	63,603,891	303,885,257	487,400,000	157,254,650	655,595,025	1,370,448,013	281,188,330
2010	385,174			288,814,694	10,547	31,701,626	92,160	320,608,280	353,398,950	113,087,664	901,125	667,500	720,900	113,400,000	18,144,000	105,811,785	33,859,771	196,824,112	31,632,447	151,132,800	266,400,000	91,761,898	574,179,360	722,437,758	165,812,335

Table 4.3 [contd]

NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - AVERAGE INCREMENTAL FINANCIAL COSTS

Year	INVESTMENT COSTS			REINVESTMENT COSTS		RECURRENT COSTS					TOTAL COSTS	OUTPUT at 3.84 % per year	A.I.F.C.
	Existing Assets	New Project	Interest during Const.	Existing Assets	New Project	Personnel	Maintenance and Repairs	Energy	Treatment	Administration			
	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	m3/day	K.shs/m3
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1995	47,600,000	573,511,860	-	7,500,000	-	16,525,000	8,247,035	19,273,181	112,825,881	5,735,119	791,218,076	17,876	121.3
1996		-	-		-	16,525,000	8,247,035	19,357,896	7,283,457	5,735,119	57,148,487	18,562	129.7
1997		-	-		-	16,525,000	8,247,035	19,445,864	7,563,121	5,735,119	57,516,139	19,275	137.9
1998		-	-		-	16,525,000	8,247,035	19,537,210	7,853,545	5,735,119	57,897,909	20,015	145.8
1999		-	-		-	16,525,000	8,247,035	19,632,064	8,155,121	5,735,119	58,294,339	20,784	153.5
2000		-	-		-	16,525,000	8,247,035	19,730,560	8,468,277	5,735,119	58,705,992	21,582	160.9
2001		-	-		-	16,525,000	8,247,035	19,832,839	8,793,459	5,735,119	59,133,452	22,411	168.2
2002		-	-		-	16,525,000	8,247,035	19,959,045	9,131,128	5,735,119	59,577,327	23,271	175.2
2003		-	-	500,000	-	16,525,000	8,247,035	20,049,329	9,481,763	5,735,119	60,538,246	24,165	182.0
2004		-	-		-	16,525,000	8,247,035	20,163,848	9,845,863	5,735,119	60,516,865	25,093	188.7
2005		-	-		-	16,525,000	8,247,035	20,282,765	10,223,944	5,735,119	61,013,863	26,057	195.1
2006		-	-		-	16,525,000	8,247,035	20,406,248	10,616,544	5,735,119	61,529,945	27,057	201.3
2007		-	-		-	16,525,000	8,247,035	20,534,473	11,024,219	5,735,119	62,065,845	28,096	207.3
2008		-	-		-	16,525,000	8,247,035	20,667,621	11,447,549	5,735,119	62,622,324	29,175	213.2
2009		-	-		-	16,525,000	8,247,035	20,805,883	11,887,135	5,735,119	63,200,171	30,295	218.9
2010		-	-		-	16,525,000	8,247,035	20,949,454	12,343,601	5,735,119	63,800,208	31,459	224.5
2011		81,415,665	-	2,000,000	2,000,000	22,300,000	8,766,414	25,841,353	45,565,085	6,549,275	194,437,792	32,667	240.8
2012		-	-		-	22,300,000	8,766,414	25,959,901	13,309,791	6,549,275	76,885,381	33,921	247.0
2013		-	-		-	22,300,000	8,766,414	26,083,001	13,820,887	6,549,275	77,519,577	35,224	253.0
2014		-	-		-	22,300,000	8,766,414	26,210,829	14,351,609	6,549,275	78,178,127	36,576	258.9
2015		-	-		-	22,300,000	8,766,414	26,343,565	14,902,710	6,549,275	78,861,965	37,981	264.6
2016		-	-		-	22,300,000	8,766,414	26,481,398	15,474,975	6,549,275	79,572,062	39,439	270.1
2017		-	-		-	22,300,000	8,766,414	26,624,524	16,069,214	6,549,275	80,309,427	40,954	275.5
2018		-	-		-	22,300,000	8,766,414	26,773,146	16,686,271	6,549,275	81,075,106	42,526	280.7
2019		-	-		-	22,300,000	8,766,414	26,927,475	17,327,024	6,549,275	81,870,188	44,159	285.8
2020		-	-		-	22,300,000	8,766,414	27,087,730	17,992,382	6,549,275	82,695,801	45,855	290.7
TOTALS	47,600,000	654,927,525	-	10,000,000	2,000,000	487,400,000	219,616,704	584,941,201	442,444,532	157,254,650	2,606,184,613	774,477	5,490.7

Discount Rate	Discounted Costs	Discounted Output	Cost/ Output
5	1,412,048,588	96,176,256	14.68
7	1,334,538,579	84,174,150	15.85
10	1,243,251,644	70,176,302	17.72
12	1,195,049,512	62,859,784	19.01

YEAR 2010 WORKS

Discount Rate	Discounted Costs	Discounted Output	Cost/ Output
5	1,759,755,485	148,161,438	11.88
7	1,575,497,103	119,596,747	13.17
10	1,384,843,028	90,472,851	15.31
12	1,295,540,157	77,026,609	16.82

YEAR 2020 WORKS

NYWFPSOL.XLS OPT. B1 14/02/96 13:35

Table 4.3 [contd]

NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - DISCOUNT RATES AND DISCOUNTED COSTS

Year	No	Required Discount Rates				Discounted Costs (KShs)				Discounted Output (m^3/day)			
		5 %	7 %	10 %	12 %	5 %	7 %	10 %	12 %	5 %	8 %	10 %	12 %
		(fill in above values)				NPV				NPV			
1	15	16	17	18	19	20	21	22	23	24	25	26	27
1995	0	1.000	1.000	1.000	1.000	791,218,076	791,218,076	791,218,076	791,218,076	17876	17876	17876	17876
1996	1	0.952	0.935	0.909	0.893	54,427,130	53,409,801	51,953,170	51,025,435	17679	17348	16875	16574
1997	2	0.907	0.873	0.826	0.797	52,168,834	50,236,823	47,533,999	45,851,514	17483	16836	15930	15366
1998	3	0.864	0.816	0.751	0.712	50,014,391	47,261,940	43,499,556	41,210,588	17290	16339	15038	14247
1999	4	0.823	0.763	0.683	0.636	47,958,897	44,472,472	39,815,818	37,047,106	17099	15856	14196	13209
2000	5	0.784	0.713	0.621	0.567	45,997,681	41,856,561	36,451,802	33,311,356	16910	15388	13401	12246
2001	6	0.746	0.666	0.564	0.507	44,126,292	39,403,116	33,379,292	29,958,847	16723	14933	12650	11354
2002	7	0.711	0.623	0.513	0.452	42,340,494	37,101,765	30,572,589	26,949,757	16539	14492	11942	10527
2003	8	0.677	0.582	0.467	0.404	40,974,668	35,233,810	28,241,539	24,450,382	16356	14064	11273	9760
2004	9	0.645	0.544	0.424	0.361	39,009,711	32,917,165	25,665,058	21,822,988	16175	13649	10642	9049
2005	10	0.614	0.508	0.386	0.322	37,457,219	31,016,354	23,523,485	19,644,831	15996	13246	10046	8390
2006	11	0.585	0.475	0.350	0.287	35,975,285	29,232,434	21,565,870	17,688,389	15820	12855	9483	7778
2007	12	0.557	0.444	0.319	0.257	34,560,585	27,557,978	19,776,091	15,930,757	15645	12475	8952	7212
2008	13	0.530	0.415	0.290	0.229	33,209,955	25,986,038	18,139,457	14,351,420	15472	12107	8451	6686
2009	14	0.505	0.388	0.263	0.205	31,920,381	24,510,116	16,642,580	12,932,007	15301	11749	7978	6199
2010	15	0.481	0.362	0.239	0.183	30,688,991	23,124,132	15,273,263	11,656,060	15132	11402	7531	5747
2011	16	0.458	0.339	0.218	0.163	89,074,193	65,862,807	42,315,329	31,717,016	14965	11065	7109	5329
2012	17	0.436	0.317	0.198	0.146	33,544,837	24,339,943	15,211,363	11,197,921	14800	10739	6711	4940
2013	18	0.416	0.296	0.180	0.130	32,210,985	22,935,246	13,942,577	10,080,614	14636	10421	6335	4580
2014	19	0.396	0.277	0.164	0.116	30,937,739	21,616,903	12,782,748	9,077,010	14474	10114	5981	4247
2015	20	0.377	0.258	0.149	0.104	29,722,245	20,379,450	11,722,329	8,175,365	14315	9815	5646	3937
2016	21	0.359	0.242	0.135	0.093	28,561,784	19,217,694	10,752,618	7,365,159	14156	9525	5329	3650
2017	22	0.342	0.226	0.123	0.083	27,453,767	18,126,895	9,865,690	6,636,973	14000	9244	5031	3385
2018	23	0.326	0.211	0.112	0.074	26,395,728	17,102,541	9,054,319	5,982,366	13845	8971	4749	3138
2019	24	0.310	0.197	0.102	0.066	25,385,318	16,140,431	8,311,920	5,393,780	13692	8706	4483	2909
2020	25	0.295	0.184	0.092	0.059	24,420,299	15,236,633	7,632,492	4,864,440	13541	8449	4232	2697
TOTALS		15	13	10	9	1,759,755,485	1,575,497,103	1,384,843,028	1,295,540,157	405,922	327,662	247,871	211,032

NYERPROJ.XLS OPT. B1 16/02/96 13:32

Table 4.4

OPTION B2 - NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - OUTPUT, INVESTMENT AND EXPENDITURE

Year	OUTPUT	Energy and Costs							Pipelines		Pumps			Structures		Treatment					Personnel Costs	Admin-istration Costs	Annual Invest-ment Cost	Total Annual Operat'n Cost	Total Annual Maint'ce. Cost
	increase at 3.84 % /year	Pump-ing hrs.	Power Req'd at 3.90/kWh		0.80 pf Demand	250/= /KVA	Monthly Charge 480/=	Total Energy Cost	Capital Cost	Maint. at 2% p.a.	Capacity increase Cost	Replac-ment Cost	Maint. at 5 % p.a.	Capital Cost	Maint. at 1 % p.a.	Capital Cost	Maint. at 2% p.a.	Alum 40 mg/l @ 35.0/=/kg	Soda Ash 15 mg/l @ 15.0/=/kg	TCL 5 mg/l @ 215.0/=/kg					
	m3/day	hrs/day	kW	K.shs	KVA	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs
1995	17,876	13.6	1319.1	45,065,883	1649	4,946,642	5,760	50,018,285	201,226,830	6,024,537	2,356,425	-	117,821	123,660,000	1,236,600	136,966,275	2,739,326	9,134,686	1,468,007	7,014,096	19,545,000	5,642,096	564,299,550	92,822,178	10,118,284
1996	18,542	14.2	1366.7	46,709,275	1683	5,050,193	5,760	51,065,227		6,024,537	-	-	117,821		1,236,600	-	2,739,326	9,485,456	1,524,440	7,283,437	19,545,000	5,642,096		69,358,510	10,118,284
1997	19,275	14.7	1373.4	46,988,892	1719	5,157,720	5,760	52,152,372		6,024,537	-	-	117,821		1,236,600	-	2,739,326	9,849,666	1,582,979	7,563,121	19,545,000	5,642,096		71,148,117	10,118,284
1998	20,015	15.3	1405.2	48,006,127	1756	5,269,376	5,760	53,281,264		6,024,537	-		117,821		1,236,600	-	2,739,326	10,227,872	1,643,765	7,853,545	19,545,000	5,642,096		73,006,445	10,118,284
1999	20,784	15.9	1436.1	49,062,424	1795	5,385,221	5,760	54,453,504		6,024,537		-	117,821	-	1,236,600	-	2,739,326	10,620,022	1,706,886	8,155,121	19,545,000	5,642,096		74,906,133	10,118,284
2000	21,582	16.5	1468.2	50,159,202	1835	5,503,717	5,760	55,670,759		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	11,028,454	1,772,430	8,468,277	19,545,000	5,642,096		76,939,921	10,118,284
2001	22,411	17.1	1501.5	51,298,260	1877	5,630,736	5,760	56,934,757		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	11,451,947	1,840,491	8,793,459	19,545,000	5,642,096		79,030,654	10,118,284
2002	23,271	17.8	1536.1	52,480,975	1920	5,760,557	5,760	58,247,292		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	11,891,702	1,911,166	9,131,128	19,545,000	5,642,096		81,181,288	10,118,284
2003	24,165	18.4	1572.1	53,709,106	1965	5,895,362	5,760	59,610,228		6,024,537	-	1,765,500	117,821	-	1,236,600	-	2,739,326	12,348,343	1,984,555	9,481,763	19,545,000	5,642,096	1,765,500	83,439,889	10,118,284
2004	25,093	19.1	1609.4	54,984,397	2012	6,035,364	5,760	61,025,501		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	12,822,519	2,060,762	9,845,863	19,545,000	5,642,096		85,754,645	10,118,284
2005	26,057	19.9	1648.2	56,308,659	2060	6,180,701	5,760	62,495,120		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	13,314,904	2,139,895	10,223,944	19,545,000	5,642,096		88,173,864	10,118,284
2006	27,057	20.6	1688.4	57,683,773	2111	6,331,640	5,760	64,021,173		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	13,826,196	2,222,067	10,616,544	19,545,000	5,642,096		90,685,900	10,118,284
2007	28,096	21.4	1730.2	59,111,692	2163	6,488,375	5,760	65,605,827		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	14,357,122	2,307,395	11,024,219	19,545,000	5,642,096		93,294,562	10,118,284
2008	29,175	22.3	1772.6	60,594,442	2217	6,651,129	5,760	67,251,331		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	14,908,436	2,395,999	11,447,549	19,545,000	5,642,096		96,003,314	10,118,284
2009	30,295	23.1	1818.7	62,134,130	2273	6,820,132	5,760	68,960,022		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	15,480,930	2,488,005	11,887,135	19,545,000	5,642,096		98,816,081	10,118,284
2010	31,459	24.0	1865.5	63,732,942	2332	6,995,625	5,760	70,734,327		6,024,537	-	-	117,821	-	1,236,600	-	2,739,326	16,075,387	2,583,564	12,343,601	19,545,000	5,642,096		101,736,839	10,118,284
2011	32,667	17.1	2116.0	72,291,299	2645	7,935,000	5,760	80,232,059	7,356,194	6,171,061	4,032,315	-	201,616	38,340,000	1,620,000	30,029,805	3,339,922	16,692,682	2,682,752	12,817,595	26,157,000	6,439,379	79,728,314	112,425,118	11,332,598
2012	33,921	17.8	2168.5	74,083,362	2711	8,131,755	5,760	82,220,857		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	17,333,681	2,785,770	13,309,791	26,157,000	6,439,379		115,650,099	11,332,598
2013	35,226	18.4	2222.9	75,964,239	2779	8,335,994	5,760	84,285,993		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	17,999,294	2,892,744	13,820,887	26,157,000	6,439,379		118,998,918	11,332,598
2014	36,576	19.1	2279.5	77,876,575	2849	8,543,096	5,760	86,430,431		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	18,690,467	3,003,825	14,351,699	26,157,000	6,439,379		122,479,332	11,332,598
2015	37,981	19.9	2338.2	79,885,112	2923	8,768,343	5,760	88,657,215		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	19,408,181	3,119,172	14,902,710	26,157,000	6,439,379		126,087,279	11,332,598
2016	39,439	20.6	2399.2	81,966,701	2999	8,997,047	5,760	90,969,508		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	20,153,455	3,238,948	15,474,975	26,157,000	6,439,379		129,836,886	11,332,598
2017	40,954	21.4	2462.5	84,130,299	3078	9,234,534	5,760	93,370,593		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	20,927,348	3,363,324	16,069,214	26,157,000	6,439,379		133,730,478	11,332,598
2018	42,526	22.3	2528.3	86,376,979	3160	9,481,140	5,760	95,863,879		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	21,730,958	3,492,475	16,686,271	26,157,000	6,439,379		137,773,584	11,332,598
2019	44,159	23.1	2596.6	88,709,932	3246	9,737,216	5,760	98,452,908		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	22,565,427	3,626,586	17,327,014	26,157,000	6,439,379		141,971,945	11,332,598
2020	45,855	24.0	2667.5	91,132,470	3334	10,003,125	5,760	101,141,355		6,171,061	-	-	201,616	-	1,620,000	-	3,339,922	23,431,939	3,765,847	17,992,382	26,157,000	6,439,379		146,351,524	11,332,598
Totals																									
2020	774,477			1,669,725,228	61,092	183,276,830	149,760	1,853,151,817	308,553,044	158,103,201	6,388,740	1,765,500	3,901,298	162,000,000	35,985,600	166,996,080	77,228,424	395,737,544	63,023,891	303,845,257	574,290,000	156,667,314	645,683,364	2,641,583,606	275,216,522
2010	385,174			857,330,260	31,368	94,104,568	92,160	951,526,989	301,226,850	96,392,592	2,356,425	1,765,500	1,885,140	123,660,000	19,785,600	136,966,275	43,829,208	196,824,112	31,602,447	151,121,800	312,720,000	90,273,528	565,955,050	1,356,303,443	161,892,540

Table 4.4 [contd]

NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - AVERAGE INCREMENTAL FINANCIAL COSTS

Year	INVESTMENT COSTS			REINVESTMENT COSTS		RECURRENT COSTS					TOTAL COSTS	OUTPUT at 3.84 % per year	A.I.F.C.
	Existing Assets	New Project	Interest during Const.	Existing Assets	New Project	Personnel	Maintenance and Repairs	Energy	Treatment	Administration			
	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	K.shs	m3/day	K.shs/m3
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1995	47,600,000	564,209,550	-	7,500,000	-	19,545,000	7,378,958	50,018,285	143,980,371	5,642,096	845,874,259	17,876	129.6
1996		-	-		-	19,545,000	7,378,958	51,065,227	7,283,437	5,642,096	90,914,718	18,562	143.1
1997		-	-		-	19,545,000	7,378,958	52,152,372	7,563,121	5,642,096	92,281,547	19,275	156.2
1998		-	-		-	19,545,000	7,378,958	53,281,264	7,853,545	5,642,096	93,700,862	20,015	169.0
1999		-	-		-	19,545,000	7,378,958	54,453,504	8,155,121	5,642,096	95,174,679	20,784	181.5
2000		-	-		-	19,545,000	7,378,958	55,670,759	8,468,277	5,642,096	96,705,090	21,582	193.8
2001		-	-		-	19,545,000	7,378,958	56,934,757	8,793,459	5,642,096	98,294,270	22,411	205.8
2002		-	-		-	19,545,000	7,378,958	58,247,292	9,131,128	5,642,096	99,944,473	23,271	217.6
2003		-	-	500,000	-	19,545,000	7,378,958	59,610,228	9,481,763	5,642,096	102,158,045	24,165	229.2
2004		-	-		-	19,545,000	7,378,958	61,025,501	9,845,863	5,642,096	103,457,418	25,095	240.5
2005		-	-		-	19,545,000	7,378,958	62,495,120	10,223,944	5,642,096	105,285,118	26,057	251.6
2006		-	-		-	19,545,000	7,378,958	64,021,173	10,616,544	5,642,096	107,203,771	27,057	262.4
2007		-	-		-	19,545,000	7,378,958	65,605,827	11,024,219	5,642,096	109,196,099	28,096	273.1
2008		-	-		-	19,545,000	7,378,958	67,251,331	11,447,549	5,642,096	111,264,933	29,175	283.5
2009		-	-		-	19,545,000	7,378,958	68,960,022	11,887,135	5,642,096	113,413,210	30,295	293.8
2010		-	-		-	19,545,000	7,378,958	70,734,227	12,343,601	5,642,096	115,643,982	31,459	303.8
2011		79,728,314	-	2,000,000	2,000,000	26,157,000	7,992,677	80,232,089	42,847,400	6,439,379	247,396,858	32,667	324.6
2012		-	-		-	26,157,000	7,992,677	82,220,857	13,309,791	6,439,379	136,119,703	33,921	335.6
2013		-	-		-	26,157,000	7,992,677	84,285,993	13,820,887	6,439,379	138,695,935	35,224	346.4
2014		-	-		-	26,157,000	7,992,677	86,430,431	14,351,609	6,439,379	141,371,095	36,576	357.0
2015		-	-		-	26,157,000	7,992,677	88,657,215	14,902,710	6,439,379	144,148,981	37,981	367.4
2016		-	-		-	26,157,000	7,992,677	90,969,508	15,474,975	6,439,379	147,035,538	39,439	377.6
2017		-	-		-	26,157,000	7,992,677	93,370,593	16,069,214	6,439,379	150,028,862	40,954	387.6
2018		-	-		-	26,157,000	7,992,677	95,863,879	16,686,271	6,439,379	153,139,206	42,526	397.5
2019		-	-		-	26,157,000	7,992,677	98,452,908	17,327,024	6,439,379	156,368,987	44,159	407.2
2020		-	-		-	26,157,000	7,992,677	101,141,355	17,992,382	6,439,379	159,722,792	45,855	416.7
TOTALS	47,600,000	643,937,864	-	10,000,000	2,000,000	574,290,000	197,990,098	1,853,151,817	470,881,337	154,667,314	3,954,518,431	774,477	7,251.8

Discount Rate	Discounted Costs	Discounted Output	Cost/ Output
5	1,891,408,673	96,176,256	19.67
7	1,757,954,127	84,174,150	20.88
10	1,601,275,804	70,176,302	22.82
12	1,518,815,142	62,859,784	24.16

YEAR 2010 WORKS

Discount Rate	Discounted Costs	Discounted Output	Cost/ Output
5	2,481,610,435	148,161,438	16.75
7	2,164,158,920	119,596,747	18.10
10	1,837,553,641	90,472,851	20.31
12	1,685,394,855	77,026,609	21.88

YEAR 2020 WORKS

Table 4.4 [contd]

NYERI WATER SUPPLY - FINANCIAL PROJECTIONS - DISCOUNT RATES AND DISCOUNTED COSTS

Year	No	Required Discount Rates				Discounted Costs (KShs.)				Discounted Output (m3/day)			
		5 %	7 %	10 %	12 %	5 %	7 %	10 %	12 %	5 %	7 %	10 %	12 %
		(fill in above values)				NPV				NPV			
1	15	16	17	18	19	20	21	22	23	24	25	26	27
1995	0	1.000	1.000	1.000	1.000	845,874,259	845,874,259	845,874,259	845,874,259	17,876	17,876	17,876	17,876
1996	1	0.952	0.935	0.909	0.893	86,585,446	84,967,026	82,649,744	81,173,855	17,679	17,348	16,875	16,574
1997	2	0.907	0.873	0.826	0.797	83,702,083	80,602,277	76,265,741	73,566,284	17,483	16,836	15,930	15,366
1998	3	0.864	0.816	0.751	0.712	80,942,328	76,487,815	70,398,844	66,694,423	17,290	16,339	15,038	14,247
1999	4	0.823	0.763	0.683	0.636	78,300,444	72,608,307	65,005,586	60,485,229	17,099	15,856	14,196	13,209
2000	5	0.784	0.713	0.621	0.567	75,770,969	68,949,393	60,046,253	54,873,065	16,910	15,388	13,401	12,246
2001	6	0.746	0.666	0.564	0.507	73,348,697	65,497,622	55,484,553	49,798,936	16,723	14,933	12,650	11,354
2002	7	0.711	0.623	0.513	0.452	71,028,671	62,240,395	51,287,318	45,209,804	16,539	14,492	11,942	10,527
2003	8	0.677	0.582	0.467	0.404	69,144,586	59,456,912	47,657,482	41,259,921	16,356	14,064	11,273	9,760
2004	9	0.645	0.544	0.424	0.361	66,676,682	56,263,102	43,867,562	37,300,570	16,175	13,649	10,642	9,049
2005	10	0.614	0.508	0.386	0.322	64,635,930	53,521,615	40,591,971	33,898,990	15,996	13,246	10,046	8,390
2006	11	0.585	0.475	0.350	0.287	62,679,824	50,931,739	37,574,268	30,818,522	15,820	12,855	9,483	7,778
2007	12	0.557	0.444	0.319	0.257	60,804,474	48,484,374	34,793,242	28,027,919	15,645	12,475	8,952	7,212
2008	13	0.530	0.415	0.290	0.229	59,006,170	46,170,992	32,229,488	25,499,051	15,472	12,107	8,451	6,686
2009	14	0.505	0.388	0.263	0.205	57,281,378	43,983,598	29,865,243	23,206,590	15,301	11,749	7,978	6,199
2010	15	0.481	0.362	0.239	0.183	55,626,732	41,914,701	27,684,250	21,127,723	15,132	11,402	7,531	5,747
2011	16	0.458	0.339	0.218	0.163	113,335,351	83,801,875	53,840,764	40,355,787	14,965	11,065	7,109	5,329
2012	17	0.436	0.317	0.198	0.146	59,388,575	43,092,012	26,930,558	19,825,064	14,800	10,739	6,711	4,940
2013	18	0.416	0.296	0.180	0.130	57,631,026	41,035,123	24,945,683	18,035,963	14,636	10,421	6,335	4,580
2014	19	0.396	0.277	0.164	0.116	55,945,343	39,050,286	23,115,304	16,414,142	14,474	10,114	5,981	4,247
2015	20	0.377	0.258	0.149	0.104	54,328,235	37,250,836	21,426,828	14,943,459	14,315	9,815	5,646	3,937
2016	21	0.359	0.242	0.135	0.093	52,776,566	35,510,524	19,868,726	13,609,367	14,156	9,525	5,329	3,650
2017	22	0.342	0.226	0.123	0.083	51,287,347	33,863,489	18,430,442	12,398,762	14,000	9,244	5,031	3,385
2018	23	0.326	0.211	0.112	0.074	49,857,731	32,304,238	17,102,304	11,299,829	13,845	8,971	4,749	3,138
2019	24	0.310	0.197	0.102	0.066	48,485,005	30,827,617	15,875,455	10,301,918	13,692	8,706	4,483	2,909
2020	25	0.295	0.184	0.092	0.059	47,166,583	29,428,793	14,741,775	9,395,423	13,541	8,449	4,232	2,697
TOTALS		15	13	10	9	2,481,610,435	2,164,158,920	1,837,553,641	1,685,394,855	405,922	327,662	247,871	211,032