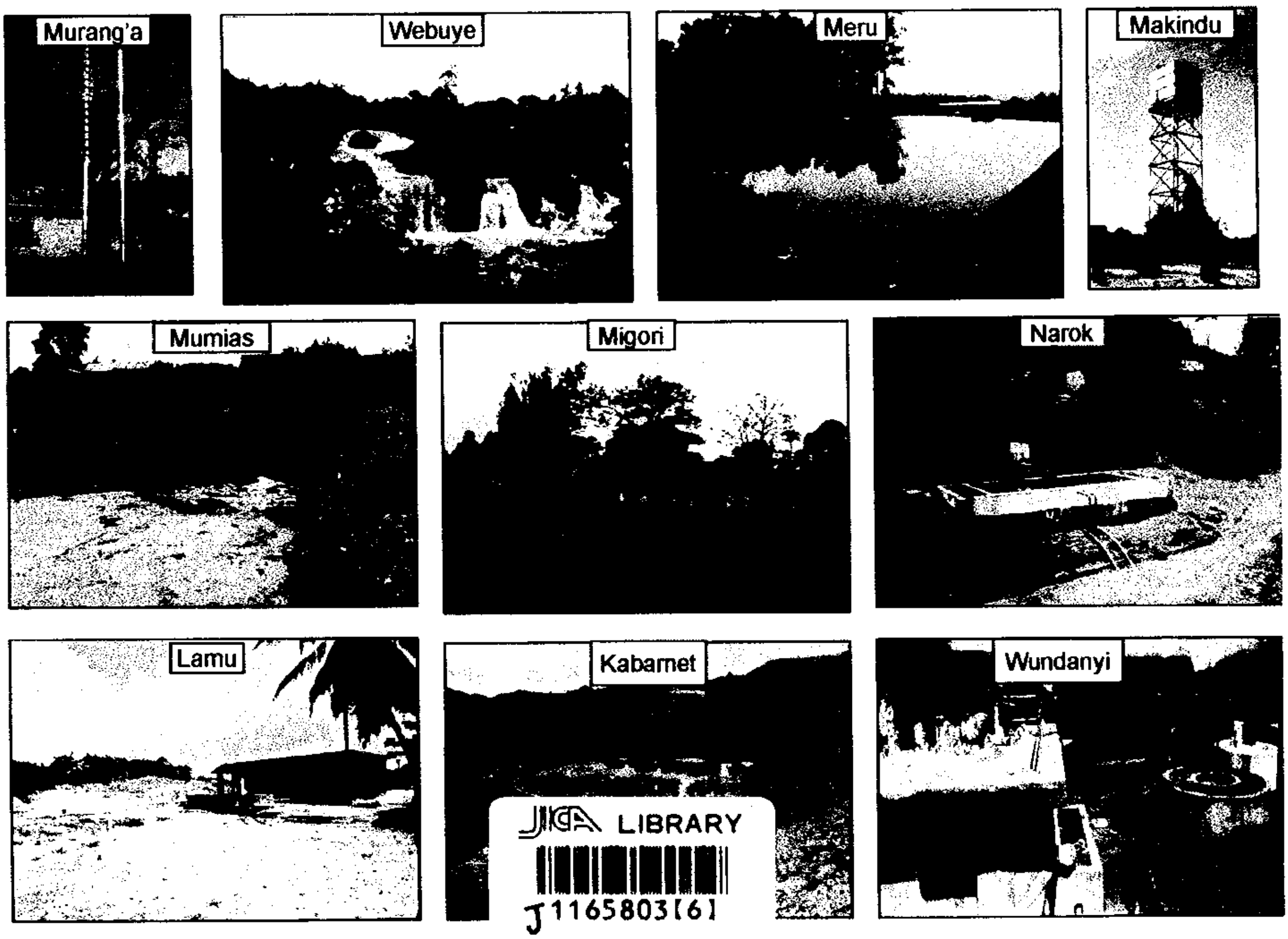
JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF KENYA

MINISTRY OF ENVIRONMENT AND NATURAL RESOURCES

THE STUDY ON INSTITUTIONAL IMPROVEMENT AND REHABILITATION OF WATER SUPPLY SYSTEMS FOR 10 LOCAL TOWNS IN THE REPUBLIC OF KENYA

No.1



FINAL REPORT

Volume 2A : Main Report (including Appendices) - Narok Town

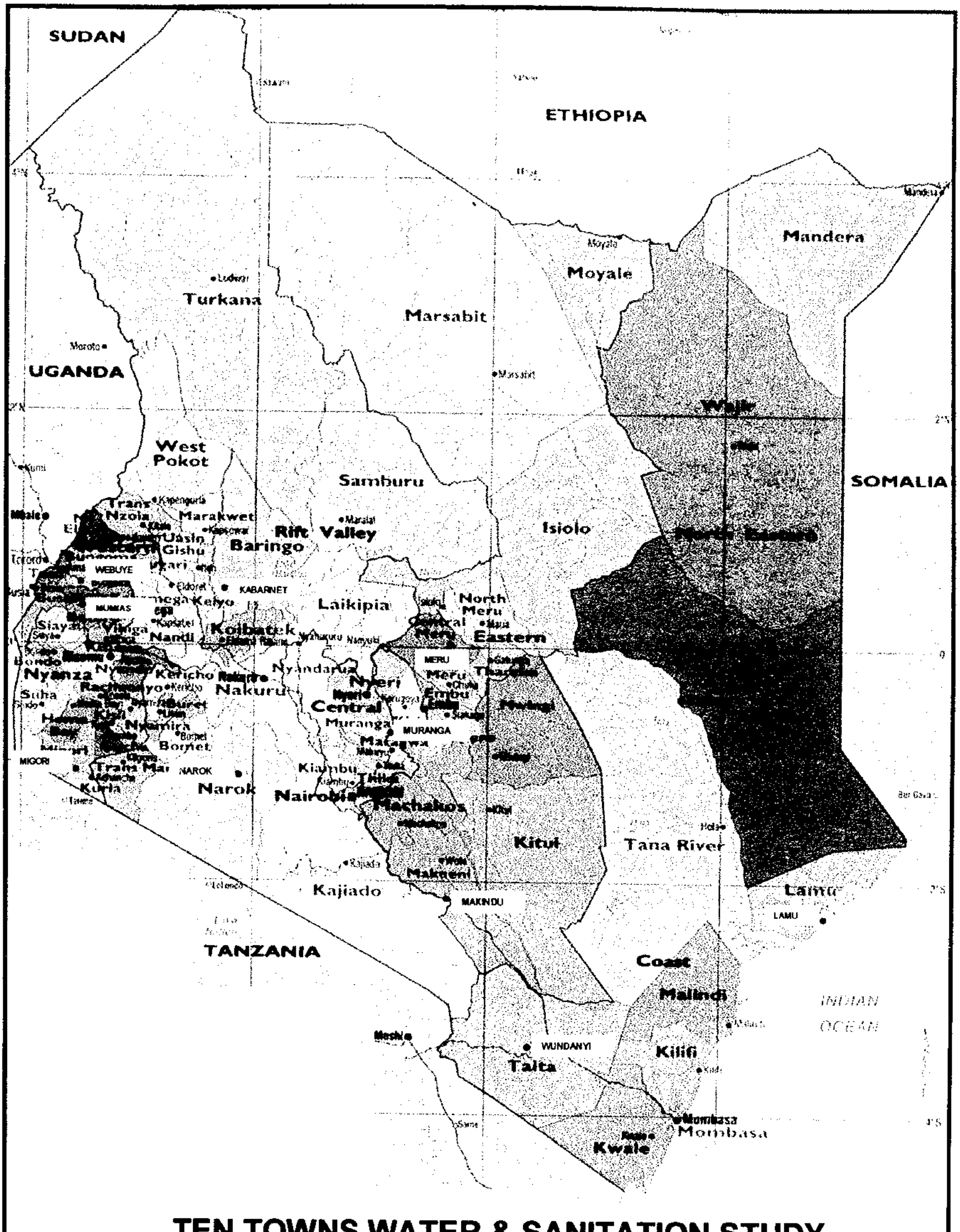
FEBRUARY 2001

Development Impact Consulting

Engineering and Utility Management Ltd.

Gibb Eastern Africa Ltd.

GIBB Eastern Africa
LAWGIBB Group Member



TEN TOWNS WATER & SANITATION STUDY

TOWNS LOCATION MAP

DIC Development Impact Consulting

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NAROK WATER SUPPLY

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LIST OF ABBREVIATIONS

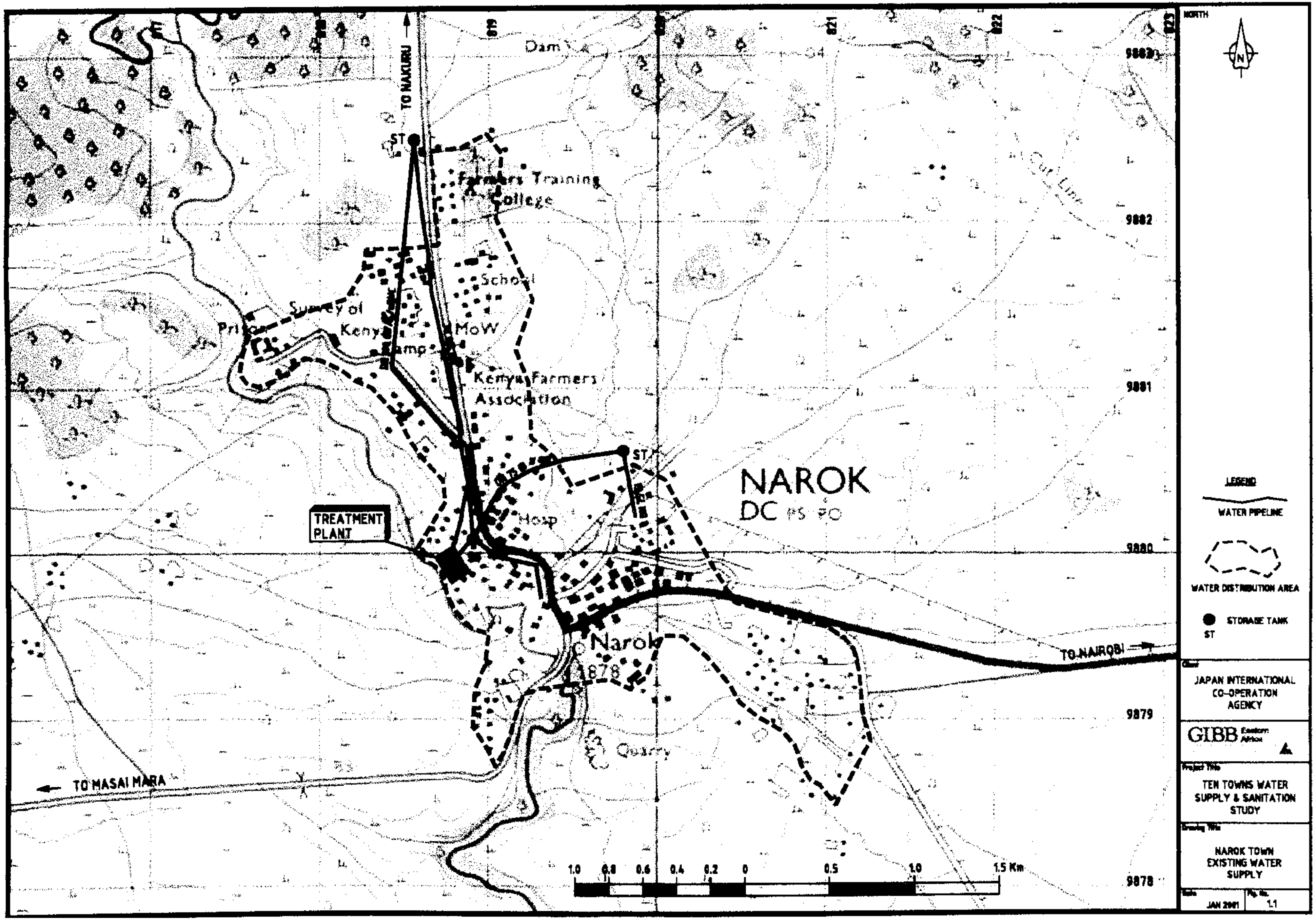
AC	Asbestos Cement (Pipe)
AFW	Accounted for water
AG	Attorney General
AIDS	Acquired Immune Deficiency Syndrome
AIE	Authority to Incur Expenditure
AMREF	African Medical Research Foundation
ASK	Agricultural Society of Kenya
ATP	Ability to Pay
bgl	Below ground level
BH	Borehole
BOT	Board of Trustees
BPT	Break Pressure Tank
CBD	Central Business District
CBR	Cost Benefit Ratio
CIM	Centre for International Migration
CMT	Core Management Team
CTB	Central Tender Board
CV	Contingent Valuation
CWS	Community Water Supplies
DAF	Daily Average Flow
DCO	District Commissioner's Office
DDC	District Development Committee

DWD	Department of Water Development
Dia	Diameter
DTO	District Treasury Office
DWE	District Water Engineer
DWF	Dry Weather Flow
DWO	District Water Office(r)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
ENEP	El-Nino Emergency Project
FIRR	Financial Internal Rate of Return
FY	Financial Year
GAA	German Agro Action
GI	Galvanized Iron
GoK	Government of Kenya
Gph	Gallons per hour
GPS	Global Positioning System
GTZ	German Technical Assistance
H	Head
Ha	Hectares
HO	Head Office
HQ	Headquarters
IEE	Initial Environmental Examination
ITCZ	Inter-tropical Convergence Zone

JICA	Japan International Cooperation Agency
KEFINCO	Kenya-Finland Co-operation
KEWI	Kenya Water Institute
Km	Kilometer
Km^2	Square Kilometers
KP&LC	Kenya Power and Lighting Company
KR	Kenya Railways
Kshs	Kenya Shillings
L	litre
LA's	Local Authorities
L/c/d	Litres per capita per day
LPO	Local Purchasing Order
L/sec	Litres per second
M^3/day	Cubic meters per day
M^3/hr	Cubic meters per hour
MENR	Ministry of Environment and Natural Resources
MoLG	Ministry of Local Government
MTB	Ministerial Tender Board
MW	Mega-watts
NAWARD	National Water Resources Database
NEAP	National Environment Action Plan
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organisation

NPV	Net Present Value
NTU	Nephelometric Turbidity Units
NWC&PC	National Water Conservation and Pipeline Corporation
NWMP	National Water Master Plan
ODA	Official Development Assistance
O&M	Operation and Maintenance
PE	Polyethylene Pipe
PSP	Private Sector Participation
PVC	Polyvinyl Chloride
PWO	Provincial Water Office(r)
Q	Discharge
RDF	Rural Development Fund
RER	Revenue Expenditure Ratio
RGS	River Gauging Station
RHS	Random Households Survey
SIDA	Swedish International Development Agency
SS	Subordinate Staff
STD	Subscriber Trunk Dialing
STW	Sewage Treatment Works
TDS	Total Dissolved Solids
ToT	Training of Trainers
T-Works	Treatment Works
UFW	Unaccounted for water

UNICEF	United Nations Children's Fund
WHO	World Health Organization
WMS	Welfare Monitoring Survey
WRAP	Water Resources Assessment Project
WS	Water System
WSS	Water Supply System
WTP	Water Treatment Plant



TO NAKURU
Dam
Farmers Training College
School
Survey of Kenya Camp
MoW
Kenya Farmers Association
TREATMENT PLANT
Hosp
NAROK
DC PS PO
Narok
1878
Quarry
TO MASAI MARA
TO NAIROBI
Cut Line
ST
9882
9881
9880
9879
9878
1.0 0.8 0.6 0.4 0.2 0 0.5 1.0 1.5 Km
NORTH
N
LEGEND
WATER PIPELINE
WATER DISTRIBUTION AREA
STORAGE TANK
ST
JAPAN INTERNATIONAL CO-OPERATION AGENCY
GIBB Eastern Africa
TEN TOWNS WATER SUPPLY & SANITATION STUDY
NAROK TOWN EXISTING WATER SUPPLY
JAN 2001
1.1

1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Kenya's water and sanitation sector is in critically poor condition. Like in many developing countries, the sector is plagued by a series of problems. These problems have arisen because of lack of technically sound operation and maintenance practices resulting in a backlog in rehabilitation, and above all, poor utility management. The existing institutional framework and organizational procedures result in bottlenecks and failure to create required authority and responsibility capacity at the most beneficial levels. Lack of autonomy for the managers of water utilities at all levels is one of the key causes for sustained inferior performance.

The tremendous pressure occasioned by population increase, rural-urban migration and unplanned settlements have strained the water and sewerage schemes beyond the original design capacities.

Periodic technical and financial reviews of water services in Kenya and the Aftercare Study on Kenya's National Water Master Plan have revealed that there is need for serious re-evaluation of management of water and sanitation utilities to meet the targets of effective service delivery in support of the integrated development plans. Decentralization of decision making and management to the local levels and transferring to the private sector activities that can be carried out without compromising social, health or vital economic requirements of the population are of cardinal importance.

Against this background, the Government of Kenya recently approved the National Water Policy paving the way for legislative changes in the Laws of Kenya that touch on water activities. The changes aim at rationalizing management, decentralizing operations to the local level, creating the necessary regulatory framework and activating private sector participation in the sector, in order to obtain a more responsive management system that ensures efficient service delivery and project sustainability at the most economical cost.

JICA, one of Kenya's leading development partners, would like to help create a sustainable environment for water and sanitation service delivery systems, by supporting formulation and development of workable management arrangements in the water sector.

The Study on Institutional Improvement and Rehabilitation of Water Supply Systems for Ten Local Towns is being undertaken in order to provide Kenya with feasible, viable and implementable options that are sensitive to local conditions, especially social, environmental, economic and political.

The findings, recommendations and work plans derived from this study may then be used to develop a more comprehensive framework for rehabilitation and extension of water services to meet development objectives as enshrined in the National Poverty Eradication Plan for the rest of the nation.

The use of local initiatives such as Kitale and Nakuru to investigate the potential and/or constraints for commercialization of water services within local authority setting will be a useful barometer for the future of the National Water Policy, which envisions decentralization of water activities to local authorities in urban areas. Malindi, which is under a partnership between the National Water Conservation and Pipeline Corporation and Gauff Utility Services, will provide another alternative for comparison of performance and benchmarking.

1.2 OBJECTIVES OF THE STUDY

The objectives of the study are:

(1) To obtain the baseline information regarding the water supply systems for the ten local towns;

(2) To recommend the institutional arrangement for effective water service delivery and rehabilitation plan of the relevant facilities in the project areas;

(3) To give advice on the application of the recommendation to the other areas in the Republic of Kenya.

1.3 SCOPE OF THE STUDY

The fundamental philosophy of this study hinges on the fact that without appropriate intervention in the water supply and sanitation sector, no major improvements in service delivery will be realized. This study focuses on ten (10) towns in the Republic of Kenya namely: Meru, Lamu, Kabarnet, Webuye, Mumias, Migori, Narok, Muranga, Makindu, and Wundanyi as a pilot programme of implementing the desirable interventions which will serve as a show case for replication in the rest of the country.

The interventions entail three main components, which must go hand in hand:

(1) To restore the water supply and sanitation facility to its original technical and functional capacity by undertaking the necessary physical rehabilitation.

(2) To put in place an appropriate institution to run the water supply and sanitation facility. This institution should be more responsive to the needs of, and directly answerable to the consumers. The institution should have the legal backing and formed in line with the current National Water Policy, which advocates active private sector participation in the water sector for more efficient service delivery.

(3) To put in place an appropriate technical team of operators, with the necessary skills and equipment and tools to take over the day to day operation and maintenance of the rehabilitated facility. It is envisaged that a team starting with an efficiently functioning facility free of major repairs and replacements, and with a good management backing,

stands a better chance of achieving a self-sustaining facility within a reasonable time span.

In order to achieve the foregoing intervention goals and the overall project objectives, the study entails a two-phase strategy for collecting the relevant data and information: a Preliminary and a Pre-feasibility phase.

The preliminary study covers review of relevant data and information, diagnostic survey of existing water supply and sanitation facilities, water demand projection, revision of water supply facility plan, cost estimation and evaluation, identification of the laws and regulations of environmental impact assessment, legal and regulatory framework on facility performance. It entails basic data collection, field reconnaissance and field inspection of the utilities to assess the current condition and situation of the water supply and sanitation schemes.

The pre-feasibility study phase covers establishing the socio-economic characteristics of the study area, assessment of surface water and groundwater potential, identification of institutional and legal constrains that affect improvement in operations of water facilities and determination of viable financial and commercial plans that ensure long-term sustainability of the facilities.

The pre-feasibility phase includes review of existing data, evaluation of the technical, socio-economic, institutional and financial aspects, formulation of water supply and sanitation facility rehabilitation plans, and formulation of preliminary technical and institutional development plans on which recommendations will be based.

In addition to the ten towns that constitute the pilot programme, operational experiences have been obtained from the towns which have been undergoing the commercialization approach, promoted by GTZ, i.e. Malindi, Kitale and Nakuru, for comparison purposes. The year 2010 has been chosen as a planning horizon.

1.4 COMPOSITION OF THE FINAL REPORT

The final report comprises of a total of two volumes as follows:

Volume 1: Executive Summary
Volume 2: Main Report

As indicated by their titles, Volume 1 is a summary of the study while Volume 2 is a presentation of the full town report including supporting and back-up data.

2 EXISTING PHYSICAL AND SOCIO-ECONOMIC CONDITIONS

2.1 GEOGRAPHY OF THE STUDY AREA

2.1.1 Location

Narok township is located in the Mau Division of Narok District in the Rift Valley Province, approximately 110 km west of Nairobi.

The township is a designated rural centre shortly to be designated a municipality and is the headquarters of Narok District.

The designated town boundary contains an area of 310 km^2 of which only approximately 10 km^2 are considered urban.

There is potential for growth of the town as an institutional, commercial and industrial centre due to the recent improvement of major connecting roads and the proximity of the Masai Mara Game Reserve.

2.1.2 Climate and vegetation

Narok lies in a medium potential rainfall area. Records for rainfall station no. 91.35/01 located in the township shows a mean annual rainfall of 741mm over 65 years. The driest months are between June and October, with April being the wettest month.

Narok is situated at an altitude of approximately 1,890m above mean sea level. The mean maximum and minimum temperatures are 24^0 Celsius and 9^0 Celsius respectively.

The dominant vegetation is leleshwa scrub with extensive grasslands. Acacia trees are common in river valleys.

2.1.3 Topography and geology

The township is bounded on the west by the Loita Plains where game is plentiful. The land rises northwards towards the southern edge of the densely forested Mau Highlands.

The township falls within a strip of broad north-south ridges carved in volcanic ash and separated by deep winding river valleys of the Engare Narok and Seyabei river systems.

The geology of the area is volcanic ash underlain by tuffs and phonolites.

2.1.4 Natural resources

There are no minerals of economic importance in the immediate area of Narok.

Crushed rock for road and building construction is obtainable from tuff and lavas, and from particularly hard phonolites which outcrop in several places. There are a number of of murram and stone quarries in the area. Good free stone, light and easy to handle and used extensively for building purposes, is derived from a vesicular variety of tuffs.

Salt lick is common along the margins of the Engare Narok river. The salt lick comprises yellowish and structureless alluvium formed from altered volcanic ash.

There is little agricultural activity around the township the land having a limited marginal potential for crop production. However, agricultural potential increases on higher elevations towards the Mau highlands. The areas near Mau Narok and Melili are very favourable for wheat production and form one of the major wheat belts of the country.

2.2 PHYSICAL INFRASTRUCTURE

2.2.1 Communications

(a) Road links

Narok is connected to Nairobi by a tarmac trunk road (B3) which branches off the Nairobi-Nakuru trunk road (A104) at the bottom of the escarpment near Kijabe. The C57 connects Narok with Nakuru. A recently re-constructed tarmac road connects Narok to Sotik and a planned road running westwards from Narok will connect western Kenya with north - east Tanzania.

Matatu services connect Narok to Nairobi and to all surrounding towns.

(b) Air transport

The township has a serviceable airstrip located 10 km to the south-west.

(c) Tourism

Narok is the gateway to the Masai Mara game reserve and experiences a continuous flow of tourist traffic with consequent commercial advantages.

(d) Telecommunications

Subscriber trunk dialling (STD) telephone services and fax facilities are available in the town, as are Internet service bureaux.

(e) **Power supply**

Narok is connected to the national grid.

(f) **Water supply and sanitation infrastructure**

Water and sanitation are the subjects of the present study and a detailed evaluation of the appropriate infrastructures is included in the chapters that follow.

2.3 SOCIO-ECONOMIC CONDITIONS

2.3.1 Administration

Narok is a cosmopolitan town situated in Narok district, Rift Valley province of Kenya approximately 150 kms south west of Nairobi. It is the administrative headquarters of Narok district under an urban council status. The urban Council in conjunction with Central Government is responsible for providing basic infrastructure under three main policy areas such as community services, social development and economic development on the basis of the towns' physical development plan. The Central Business District (CBD) houses offices of the district commissioner, other district departmental heads, urban council, county council as well as offices of a few non-governmental organizations. The town is a major business convergence zone for the hinterland economy particularly on market days when urban visitation is at its peak as the local people meet to sell their wares, which includes livestock. The town covers 213.1km^2 out of which only 9 km^2 is urban. Despite its positioning within an arid and semi arid area, the potential for growth of the town as an institutional, commercial and industrial center is enormous due its proximity to the world famous Maasai Mara game reserve.

2.3.2 Population structure and distribution

According to the 1999 housing and population census, the population of Narok town as at 1999 was 41,162[1] people. This contrasts with the 1979 and 1989 censuses where the total population was placed at 5,690 and 17,385 respectively representing an inter censal growth rate of 9.0% for 1989-1999 period compared to 7.15 for 1979-1989. This does not include special considerations such as population peaks on market days when mainly livestock traders and buyers (normally non-resident population) converge to trade. The number of households increased from 4,645 in 1989 to 10,386 units in 1999 with a mean household size of 5.6. The urban population density (considering the CBD) varied from 1,297 persons per km^2 in 1989 to 1488 in 1999. The distribution of the population and number of households on the basis of sub locations and water service area is shown in table 2.1 below. See appendix C 1-1 for an in depth exposition of the population structure.

[1] This excludes non-residential population but includes the special population. Special population in this regard based on the 1999 census enumeration procedures considered to include though not restricted to people in hotels/lodgings, bus stops, police cells, on-transit, idlers and street urchins found within the town as at mid-night of the census enumeration day.

Table 2.1 **Population structure and distribution (1999)**

Location	(a) Sub-Location	Number of Households	Population in urban council	Population in Service area
Lower Melili	Narok Town	6,408	22,315	[illegible]
	Olopito	663	2,866	[illegible]
	Naisoya	981	4,751	[illegible]
Nkareta	Nkareta	842	4,180	[illegible]
	Oleleshwa	582	2,758	[illegible]
	Nkoben	302	1,436	[illegible]
	Ereteti	608	2,856	[illegible]
Total		**10,386**	**41,162**	**20,773**

Source: District Statistical Office, Narok and Central Bureau of statistics, 2001

2.3.3 Population projection

The 1989-1999 inter censal growth rate for the town was 9.0% compared to 7.15 % in 1979-1989 periods. A critical analysis of national trends in population growth in urban areas shows a declining trend. This is linked to reduced fertility rates and a fall back in job opportunities in urban areas. However, given the strategic positioning of Narok town along the entry route to the world famous Maasai Mara game reserve, it is expected that the population growth and investment climate will remain relatively stable over the next ten years. The 1989-1999 inter censal growth rate was therefore adjusted in lieu of this changes to 4.5% ands used to project the population of the town to 2010. Table 2.2 below gives a comparative trend of the population growth for the next ten years based on the water service area and population in the urban council.

Table 2.2 **Population projection[2] to the year 2010.**

1.1.2 Year	Area under Urban Council	Existing Water Service Area
2000	43000	[illegible]
2001	44900	[illegible]
2002	47000	[illegible]
2003	49100	[illegible]
2004	51300	[illegible]
2005	53600	[illegible]
2006	56000	[illegible]
2007	58500	[illegible]
2008	61200	[illegible]
2009	63900	[illegible]
2010	66800	[illegible]

2.3.4 Economic and commercial activities

Narok town is a fast growing town especially with the opening up of the Mai Mahiu-Narok-Sotik road. It is a major town that serves the hinterland as well

[2] Projections based on the following formula [$P_{projected} = P_{actual} (1+r)^t$] where r=rate of pop growth and t=year and the base year is the 1999 estimated population rounded off to the nearest 100.

as the world famous Maasai mara game reserve that is home to several tourist lodges. The economic orientation of the peri urban and rural population is pastoralism, which is the engine of growth of the town. Most people in the hinterland draw piped water for their livestock especially during dry seasons. The economic and Industrial /Commercial scenario is as shown in the Table 2.3 below:

Table 2.3 Business and commercial activities

Type of activity	Number
NCPB Depot	1.
Slaughter house	1
Bakery	1
Retail Shops	31
Jua Kali Sheds	28
Posho mills	8
Hotels and Restaurants	22
Milk bars	15
Open air market	1
Total	**108**

Source: District Trade office, Narok

2.3.5 Social infrastructure

2.3.5.1 Communication

Narok town is connected to Nairobi by a tarmac trunk road (B3) that branches off the Nairobi-Nakuru trunk road (A104) at the bottom of the escarpment near Kijabe. The C57 connects Narok with Nakuru. A newly constructed tarmac road connects Narok to Sotik and most commuters to Kisii use this route quite often. The township has a serviceable airstrip located 10 kilometres to the southwest. Narok is the gateway to the Maasai Mara game reserve and experiences a continuous flow of tourist traffic. There is an existing water supply network, electricity and telephone (including fax) services. However there is no sewerage system. Table 2.4 below summarizes the distribution of institutions in Narok town.

2.3.5.2 Social institutions

Narok town is a growing institutional centre with a number of varied institutional establishments as shown in the table 2.4 and 2.5 overleaf. This institutions form the basis of population variations, especially urban visitation for social services.

Table 2.4 Educational institutions

Type of institution	Number
Pre-Primary Schools	38
Primary Schools	15
Secondary Schools	4
Teacher Training College	1
Technical institutions	2
Total	**60**

Table 2.5 Social institutions

Type of institution	Number
Mission Hospital	2
GoK Hospital	1
Slaughter house	1
GK. Prison	1
Children home	1
Churches	18
Total	24

Source: District Development Office, Narok

2.3.6 Income levels

The distribution of income in the town is quite uneven as it reveals major disparities in household resource endowment. Urban households earn more income (through wages, salaries and profits) than their peri urban counterparts. According to the findings of the Welfare Monitoring Survey (WMS) II focusing on households in Narok, the mean monthly household income is considered to be Kshs. 18,162 against an annual per capita income of Kshs. 27,556 as shown in table 2.6 below. 74% of the urban households mean monthly income is drawn from wages, salaries and profits.

Considering populations from low-income areas based on income and expenditure levels, it expected that most of the urban population of Narok have a surplus income and consequently able to pay for water. A random sample survey of 80 households carried out by the study team focusing on domestic consumers revealed that more than half of the households interviewed earn an average income of over Kshs 5,000 per month, which is above the national crude poverty line for urban areas of kshs. 1490. According to the DWO the problem at the moment is not the level of the tariff but the level of service. In fact, currently most of the households pay as high as Kshs 10 to 25 for a 20L jerricane to source water drawn from vendors and other sour

Table 2.6 Mean monthly household incomes (Kshs).

Income Source	Mean
Wages/salaries/profits	9969.5
Other Non-agriculture income	1269.7
Agriculture income	5692.3
Crop income	1232.7
Total household income	**18164.2**

Source: Welfare Monitoring Survey II, 1994

2.3.7 Willingness and ability to pay for water services

2.3.7.1 Ability to pay

Ability to pay is a function of level of household incomes, the acceptable share of water/sewerage services in total expenditures, tariffs and the target consumption levels. The main consideration in the ability to pay in this study is the household level of income. On average, it is considered that the budget share of income an average household can spent on water/sewerage services is normally taken to be 5%. This figure nonetheless varies from one income group to another. Generally, households in the lower income bracket spent a higher budget share of their income in real terms on water than households in the middle to high income group who spent approximately 2.2% and 1.4 % of their incomes respectively.

Considering that about 45% of the town's population live in the low income bracket under very poor sanitary conditions and normally draw water from non treated water sources in times of acute water shortage, a re-evaluation of their income levels, W/ATP and W/ATA is integral and forms an important component of the perceived water and sanitation improvement plan. This is also in line with the national poverty reduction strategy paper.

2.3.7.2 Willingness to pay

To get information on willingness to pay[3] the study team carried out a random survey on a sample of 80 households mainly within the service area. Through questionnaire based interviews, each household head was asked questions on how much they would be willing to pay for a cubic meter of water assuming improved service delivery. The general conclusion of the survey was that most households were willing to pay more for improved service delivery commensurate with the level of tariff increase and subject to an individual's perception of the water problem in a particular area. This means that it is important to note that satisfaction of the expectations of consumers form an important component of their decision making process.

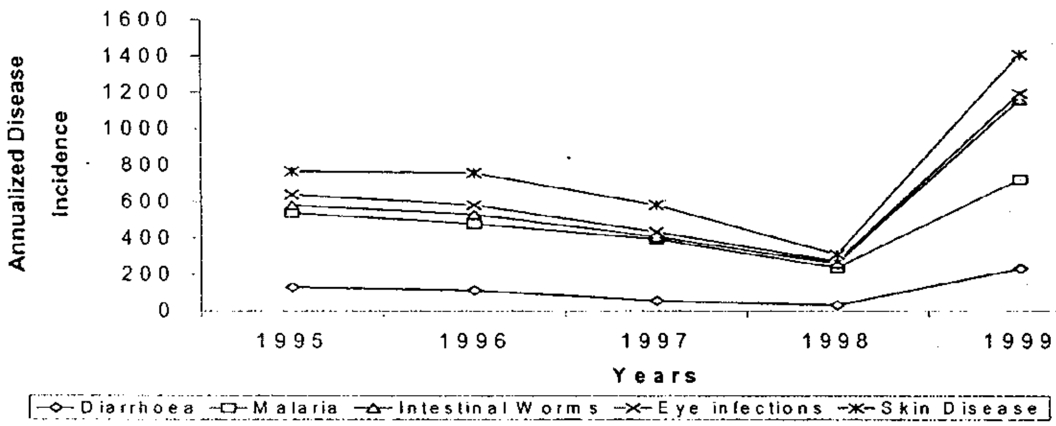
[3] The appropriate methodology in estimating willingness and ability to pay (W/ATP)/ willingness and ability to accept (W/ATA) is to use the contingent valuation (CV) approach. This approach is validated through asking water consumers at the household level hypothetical questions (which are a true reflection of actual water consumption levels) how much they are paying for water as compared to how much they would be WTP if existing water supply externalities are internalized.

The preliminary analysis of information collected indicated that over 80% of the households interviewed were willing to pay up to Kshs. 500 for actual water consumption compared to an average monthly bill of Kshs. 300. This average bill is implied based on existing tariff structure, water availability, billing inadequacies and general decline in commitment of interest of the household to pay for water to an inefficient undertaker. A similar survey in the areas not currently serviced established that majority of the households would be willing to pay for water at the current general water tariff of Kshs. 30/m^3 especially considering that the hinterland population travel over 30 kilometres to get drinking water for themselves as well as their animals. Simulations to establish the threshold tariff beyond which people would not be willing to pay revealed that even with increment of up to 30% in the tariff, people would still be willing to pay.

2.3.8 Health and sanitation situation

The health and sanitation situation was sufficiently analyzed and measures to address the sanitation deficiencies through general community mobilization and sensitization noted. However, though 46.8 % of the population sampled in a random household survey use pit latrines, promotion of septic tank-based systems has remained a long-term objective. Narok town hosts the district hospital, which is the main health facility in the district acting as a referral hospital for the smaller health centres and where the district public health officer is based. However on the general sanitation conditions and incidence of water borne diseases, chart 1 below gives a graphical presentation.

Chart 1: Incidence of Water related Diseases in Narok Town



Source: Ministry of Health, Health Information Systems 2001

2.3.9 Types of settlement

The formal settlement of the town is estimated to be 60% of the total settlement while the informal settlement is 30%. Residential houses (permanent structures) are mainly government owned. An enumeration of settlement patterns and levels of income is shown in table 2.7, and 2.8 below.

Table 2.7 Summary of household socio economic characteristics

Type of Activity	Low Density Household	Medium Density Household	High Density Household
Main occupation of the family head	Professionals/Businessmen/Senior Government Officers	Teachers / Nurse	Hawker / Casual labourer
Estimated family income	Kshs.40, 000	Kshs.8, 000	Kshs.2, 000
Source of Water	Piped	Piped	Piped (C.W.P's)
Distance of water source	Nil	Nil	0.5 Km-1Km from existing C.W.P's (kiosks)
Means of collection	Direct from mains	Direct from mains	Donkeys, handcarts, Tankers, individual, Wheelbarrows et.
Frequency of water collection in a Day	Constant	3 days in a week (rationing)	1 day in a week (rationing)
Types of water storage facility	Roof tanks	Roof tanks	Inadequate
Level of satisfaction with service	Fairly adequate	Inadequate	Inadequate
Willingness to pay	Willing	Willing	Willing
Land size	1 acre plots	¼ acre plots	1/8 acre plots
Crops grown	Flower / Veg. Gardens	N/A	N/A
Livestock reared	N/A	N/A	N/A
Refuse disposal	Pits / burning	Pits/burning	Communal disposal
Type of sanitation facilities	Septic / pit latrines	Septic / pit latrines	Pit latrines / Bush
Incidence of water related diseases	Rare	Frequent	Very frequent
Adequacy of water everyday	Fairly adequate	Inadequate	Very inadequate

Source: District development Office, Narok

Table 2.8 Distribution of the population based on settlement patterns broad income categories

Income category	Number	Percentage
High income	4,651	17
Middle income	16,682	38
Low income	19,829	45
Total	**41,162**	**100.0**

2.3.10 Situation of women in society

Women make up a disproportionately large share of the poor and very poor in urban areas as they are particularly vulnerable to many factors that create and perpetuate poverty. Most families whether poor or not may not be able to survive without the help of female family members. However, for the urban population, water collection remains a preserve of women and only forms one of their major social roles among many other economic activities within the household. Therefore, women in Narok like other parts of Kenya are traditionally responsible for collecting water for domestic use in the household. This when weighed against other domestic chores such cooking and tendering calves makes them a major vulnerable group in society. It is considered that inadequate access to water in a household can therefore have negative repercussions on the length and hardship of an average day of a poor woman's working day. This therefore means that the rehabilitation exercise planned for the towns must meet societal expectations. Such that the impact of the planned programmes on an average woman's workload will remain as a key indicator since it affects their priorities in family care. Other than situations where donkeys are used, the burden for carrying water requires women to have a substantial amount of energy irrespective of whether one's focus is on urban or peri-urban focus. This condition is energy sapping and causes considerable stress especially to pregnant women leading to multiple complications at childbirth. Other causes of stress include headaches, backaches, sometimes and deformation of the spine. Accidents do occur and these include slipped discs, paralysis, injury to children carried on the back to extreme cases such as strangulation by the head strap. Improved water supply conditions would change all these and ease the burden on women, releasing time and energy for other development activities necessary in nation building.

2.4 EXISTING WATER RESOURCES, MANAGEMENT AND UTILISATION

2.4.1 Hydrogeology (groundwater resources)

(a) Geology

The geology of Narok comprises Tertiary volcanic rocks, mainly ashes, pyroclastics, tuffs and phonolites. There is generally a thick overburden due to the easy weathering nature of volcanic ashes, forming clay. Thick clay layers of 6 m or more can therefore be found in the superficial material. The loose nature of ashes also makes them susceptible to underground piping leading to formation of vugs and cavities. Heavy seasonal rainfall therefore sometimes may lead to soil creep (washaways).

(b) Hydrogeology

The hydrogeological units of Narok are the weathered zones of the tuff and phonolite. The ashes are too tight to be of hydrogeological significance. The transmissivity of these rocks in general is often very low, between 10^{-4} to 10^{1}. This transmissivity range can however sustain yields of more than 10 m^3/hr.

The hydrogeological conditions in the Narok area can be summarised as follows:

- Depth range to the main aquifer: 40 – 100 m.
- Depth range of water rest level: 50 – 60 m.
- Discharge range: 3 – 10 m^3/hr.
- Water quality: Although little information is available, the groundwater here is expected to be fresh to brackish. The ionic concentrations of iron, manganese and silica may be high due to the acidic volcanic rocks.

Aquifers are mainly confined, occurring in weathered and fractured zones. Recharge to the aquifers occurs by lateral underflow from recharge catchments. Local infiltration also contributes to recharge.

(c) Status of existing groundwater supply facilities

The Water Department in Narok Town does not operate any boreholes. However, a few private boreholes have been drilled in outlying areas. These boreholes were not inspected because they do not constitute sources operated and maintained by the local Water Department.

Table 2.9 presents data for some of the existing boreholes in the general area.

Table 2.9 **Completion data for private boreholes**

SERIAL No.	Total depth M	Water strike Levels M	Rest level M	Tested yield m^3/hr	Distance From town
C-12872	110	39-45 54-68	60	7.2	6 km north-west
C-5278	215	52 72	56	3.3.0	Unknown

Data source: NAWARD, MENR

(d) Potential for groundwater development

There is a potential for groundwater development for individual use. However, as yields will not normally exceed 10 m^3/hr, the groundwater resource is probably not sufficient for development for municipal water supply. Such boreholes could augment the municipal water system by supplying dedicated residential estates.

2.4.2 Hydrology (surface water resources)

The town is situated to the east of the Loita plains and to the south of the Mau highlands. The town lies within a strip of broad north - south ridges separated by the deep winding river valleys of the Engare Narok and Siyapei rivers. The geology of the area comprises volcanic ashes underlain by tuffs and phonolites.

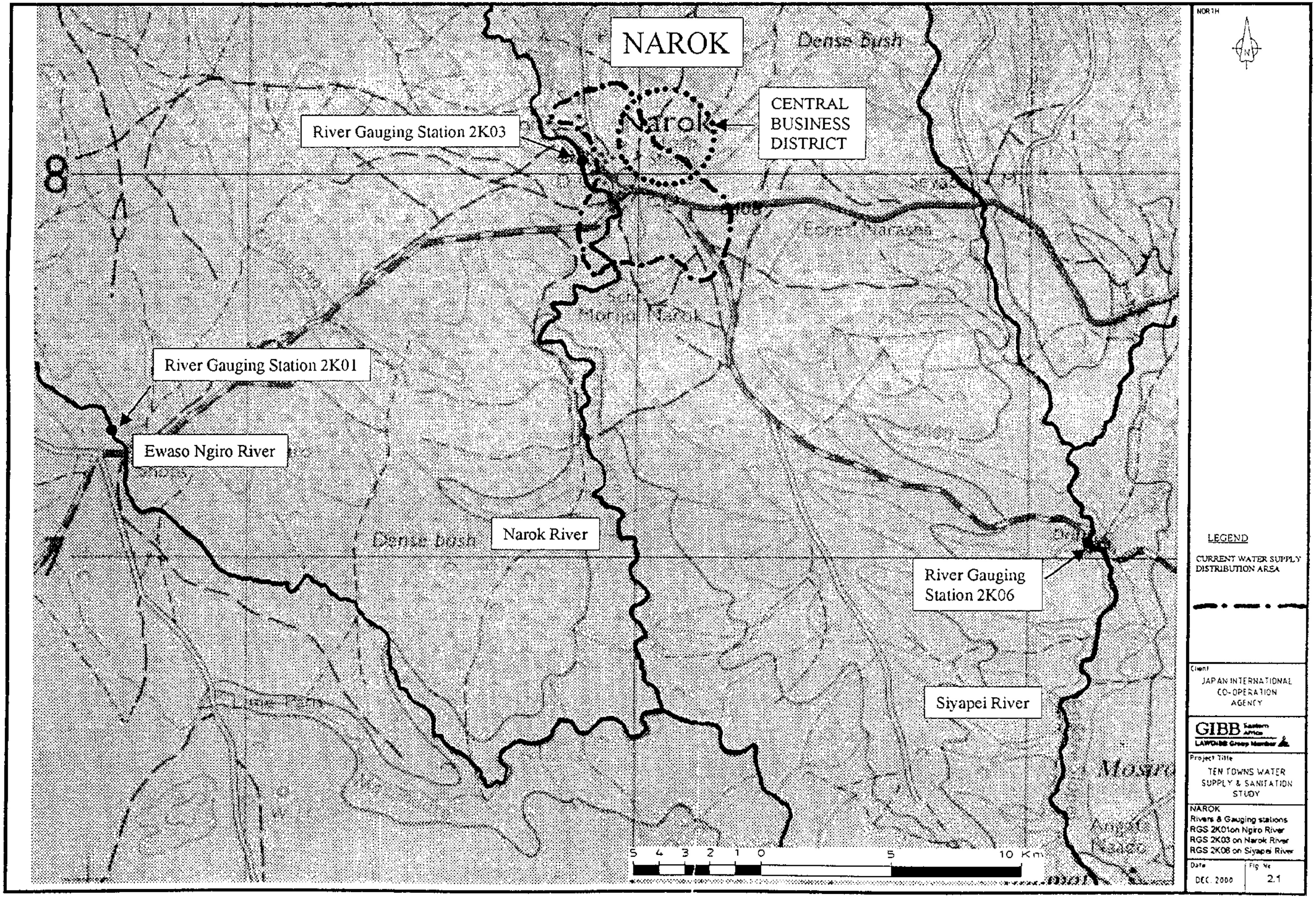
Rainfall in Narok averages 780 mm per year. Annual rainfall increases in the upper parts of the catchment to over 1,000mm, which supports thick forest vegetation.

The rivers in the area are indicated on Figure 2.1. The principal river is the River Engare Narok which flows through the town. The river rises in the Mau forest about 70 km north of the town. It falls steeply in the upper reaches before flattening out. The catchment lies within Sub-Drainage Area 2K of the Ewaso Ngiro South basin.

There are two other major rivers nearby, namely the Siyapei and the little Ewso Ngiro, both of which are tributaries of the Ewaso Ngiro River, and both are gauged.
Details of the gauging stations are presented in Table 2.10.

The River Engare Narok is the main source of water supply to Narok. The intake is located at the site of river gauging station RGS 2 K03.

Non-dimensional flow duration curves for the Ewaso Ngiro, Narok and Siyapei Rivers are presented in Figure 2.2. These curves have been abstracted from the *"Aftercare Study on the National Master Plan conducted by Japan*



NAROK
Dense bush
CENTRAL
BUSINESS
DISTRICT
River Gauging Station 2K03
Narok
River Gauging Station 2K01
Ewaso Ngiro River
Dense bush
Narok River
River Gauging
Station 2K06
Siyapei River
5 4 3 2 1 0 5 10 Km
NORTH
LEGEND
CURRENT WATER SUPPLY DISTRIBUTION AREA
Client
JAPAN INTERNATIONAL
CO-OPERATION
AGENCY
GIBB Eastern Africa
LAWGIBB Group Member
Project Title
TEN TOWNS WATER
SUPPLY & SANITATION
STUDY
NAROK
Rivers & Gauging stations
RGS 2K01on Ngiro River
RGS 2K03 on Narok River
RGS 2K06 on Siyapei River
Date
DEC. 2000
Fig No
2.1

International Cooperation Agency (JICA), 1998". As very little additional data has been collected since the time of the JICA study, the curves are applicable today.

The flow duration curve shows the relationship between any given discharge and the percentage of time that the discharge is exceeded. The flow duration curve is derived from daily flow data by assigning daily discharges to class interval and counting the number of days within each interval. The proportion of the number of days above the lower limit of any given class interval is then calculated and plotted against the lower limit of the interval.

The 50% exceedence flow in Figure 2.2 is the daily discharge that was exceeded 50% of the time. The 100% exceedence flow is the flow that was exceeded 100% of the time during the flow sequence. Thus, the 100% exceedence value represents the lowest daily discharge on record.

The JICA *"Aftercare Study"* defined the yield of an unregulated river source as follows:

- *"The reliable flow at a given site of a given river is defined to be a 90% dependable flow deducted by river maintenance flow ...",* and
- *"The 90% dependable flow is obtainable from the flow duration curve of the nearest gauging station ...".*
- The maintenance flow is defined as *"... the recorded daily minimum runoff of the river concerned".*

Thus, the difference between the 90% and 100% exceedence flows corresponds to the available water resource. For consistency of approach, the same definition of reliable flow is adopted for this project.

The runoff characteristics derived from Figure 2.2 are presented in Table 2.11.

The comparison of source of yields and demand is presented in Table 2.12.

Table 2.10 Details of gauging stations

RGS	River	Latitude	Longitude	Station opened	Station closed	Rated	Catchment area km²	Mean Annual Runoff m³/s
2K01	Ewaso Ngiro	00⁰ 10'98"	35⁰45'28"	1959	1996	Yes	688	3.7
2K03	Narok	00⁰15' 50"	35⁰ 51'40"	1959	1996	Yes	869	4.4
2K06	Siyapei	00⁰14' 75"	35⁰ 57'07"	1962	1996	Yes	581	2.4

Source; The Aftercare Study on the National Water Master Plan, Data Book, 1998

Table 2.11 Flow characteristics

Station reference number	2K01	2K03	2K06
Mean annual runoff (m³/s) Q_{ave}	3.70	4.40	2.40
50% exceedence flow ratio Q_{50}/Q_{ave}	0.55	0.40	0.50
90% exceedence flow ratio Q_{90}/Q_{ave}	0.23	0.15	0.18
100% exceedence flow ratio Q_{95}/Q_{ave}	0.18	0.18	0.15

Table 2.12 Comparison of source yields and water demand

	Demand & abstraction rates	2K01	2K03	2K06
	M³/day	M³/day (l/sec)	M³/day (l/sec)	M³/day (l/sec)
Present abstraction capacity	2,500		-	
2000 demand	5,723		-	
2010 demand	8,725		-	
90 % exceedence flow	-	73,500 (850)	57,000 (660)	37,000 (430)
100 % exceedence flow	-	57,500 (670)	38,000 (44-0)	31,000 (360)
Available water resource	-	16,000	19,000	6,000

From Table 2.12, it would seem that the present source can sustain the existing and future demand. These results are at variance with previous studies.

In 1980, a preliminary design study was undertaken (Ref: *Narok Water Supply Project, Preliminary Design Report, Kigoni & Partners, July 1980*). The hydrological analysis was based on the following records:

- RGS 2K03 1959 to 1979.
- RGS 2K06 1963 to 1973.

The lowest discharges were reported as follows:

- RGS 2K03 (area 832 km²) 8.2 l/sec
  37.7 l/sec
  37.7 l/sec
  40.0 l/sec

41.9 l/sec
60.0 l/sec

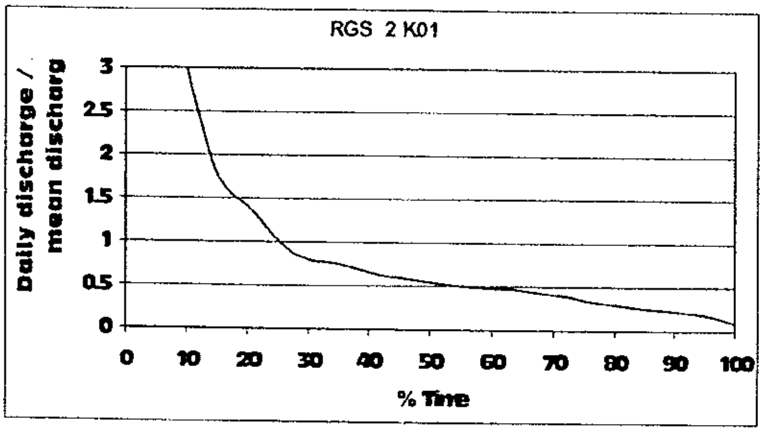
- RGS 2 K06 (area 581 km^2) 56.0 l/sec

59.0 l/sec
68.0 l/sec
78.0 l/sec

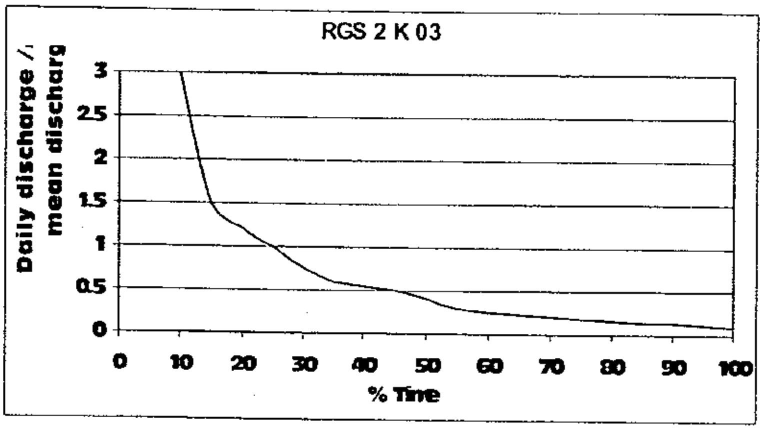
The above data is not consistent with the JICA *Aftercare Study* results in Table 2.12. The figures in Table 2.12 are an order of magnitude larger. This difference is crucial.

Figure 2.2 Flow Duration Curves.

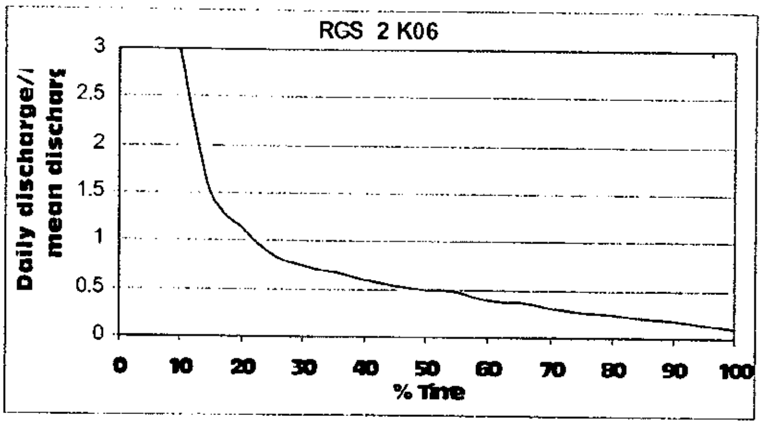
Flow duration curve for Ewaso Ngiro.



Flow duration curve for Engare Narok.



Flow duration curve for Siyapei.



2.4.3 Raw water quality

The existing water source supplying Narok is the Engare Narok River. Four water quality analyses are given in the original Kigoni and Partners design report for the scheme (1983). These are presented in the following sections.

(a) Sample from January 1980 reported in Appendix B1

This sample had a reported pH of 7.5 and an alkalinity of 152 mg/l expressed as calcium carbonate. The calculated ionic balance is shown in Table 2.5.

Table 2.13 Ionic balance sample dated January 1980 in App. B1

Cations	Mg/l	Meq/l	Anions	Mg/l	meq/l
NH_4^+	0	0.000	Cl^-	10	0.290
Na^+	52	2.262	NO_2^-	0.01	0.000
K^+	20.8	0.532	NO_3^-	0	0.000
Ca^{2+}	13.6	0.679	F^-	2.8	0.147
Mg^{2+}	2.4	0.197	HCO_3^-	185.5	3.040
$Fe^{2+,3+}$	0.3	0.013	CO_3^{2-}	0	0.000
Mn^{2+}	0	0.000	SO_4^{2-}	0	0.000
			PO_4^{3-}	0	0.000
Sum		3.683	Sum		3.478

The calculated hardness is 45 mg/l.

(b) Sample from January 1980 reported in Appendix B2

This sample had a reported pH of 7.8 and an alkalinity of 178 mg/l expressed as calcium carbonate. The calculated ionic balance is shown in Table 2.6.

Table 2.14 Ionic balance sample dated January 1980 in App. B1

Cations	mg/l	Meq/l	Anions	Mg/l	Meq/l
NH_4^+	0.2	0.011	Cl^-	10	0.290
Na^+	58.5	2.545	NO_2^-	0	0.000
K^+	50	1.279	NO_3^-	0	0.000
Ca^{2+}	12.8	0.639	F^-	2.3	0.121
Mg^{2+}	3.3	0.272	HCO_3^-	217.2	3.560
$Fe^{2+,3+}$	0.3	0.013	CO_3^{2-}	0	0.000
Mn^{2+}	0.2	0.007	SO_4^{2-}	3.5	0.073
			PO_4^{3-}	0	0.000
Sum		4.766			4.044

The calculated hardness is 47 mg/l.

(c) Sample from March 1975 reported in Appendix B3

This sample had a reported pH of 8.5 and an alkalinity of 206 mg/l expressed as calcium carbonate. The calculated ionic balance is shown in Table 2.7.

Table 2.15 Ionic balance sample dated March 1975 in App. B3

Cations	mg/l	Meq/l	Anions	Mg/l	Meq/l
NH_4^+	0	0.000	Cl^-	15	0.435
Na^+	74	3.219	NO_2^-	0	0.000
K^+	23	0.588	NO_3^-	0	0.000
Ca^{2+}	10	0.499	F^-	3.6	0.189
Mg^{2+}	8	0.658	HCO_3^-	227	3.720
$Fe^{2+,3+}$	0.2	0.009	CO_3^{2-}	24	0.400
Mn^{2+}	0	0.000	SO_4^{2-}	12	0.250
			PO_4^{3-}	0	0.000
Sum		4.973			5.395

The calculated hardness is 58 mg/l.

(d) Sample from January 1980 reported in Appendix B4

This sample had a reported pH of 7 and an alkalinity of 130 mg/l expressed as calcium carbonate. The calculated ionic balance is shown in Table 2.8.

Table 2.16 Ionic balance sample dated January 1980 in App. B4

Cations	mg/l	Meq/l	Anions	Mg/l	Meq/l
NH_4^+	0	0	Cl^-	11	0.319
Na^+	64	2.784	NO_2^-	0	0.000
K^+	17.3	0.442	NO_3^-	0	0.000
Ca^{2+}	12	0.599	F^-	1.6	0.084
Mg^{2+}	2.4	0.197	HCO_3^-	158.7	2.601
$Fe^{2+,3+}$	0	0.000	CO_3^{2-}	0	0.000
Mn^{2+}	0	0.000	SO_4^{2-}	30	0.625
			PO_4^{3-}	0	0.000
Sum		4.023			3.629

The calculated hardness is 40 mg/l.

(e) Discussion

The four analyses show that the water is a soft, sodium bicarbonate type. Fluoride concentrations range from 1.6 mg/l to 3.6 mg/l, but these will be reduced during coagulation.

3 EXISTING WATER SUPPLY CONDITIONS

Chapter 3 presents a detailed assessment and diagnostic evaluation of the existing water supply system.

Chapter 4 recommends a rehabilitation plan in accordance with the terms of reference of the study.

The main features of Narok water supply are shown schematically in Figures 3.1 and 3.2.

The original water supply facilities were constructed in the early 1950s with expansions in 1970s and 1980s.

Water is currently distributed over an area of approximately 5 km^2.

3.1 SOURCES AND INTAKES

3.1.1 Intake from Engare Narok river

The concrete intake chamber is situated within the treatment works site some 1,100m upstream from the road bridge. The chamber is 1.23m square and is open on the river side. There is provision at entry for a coarse screen.

The concrete is in good condition but the screen is missing. A new screen will be provided under the rehabilitation works proposed in this report.

3.1.2 Raw water pumping

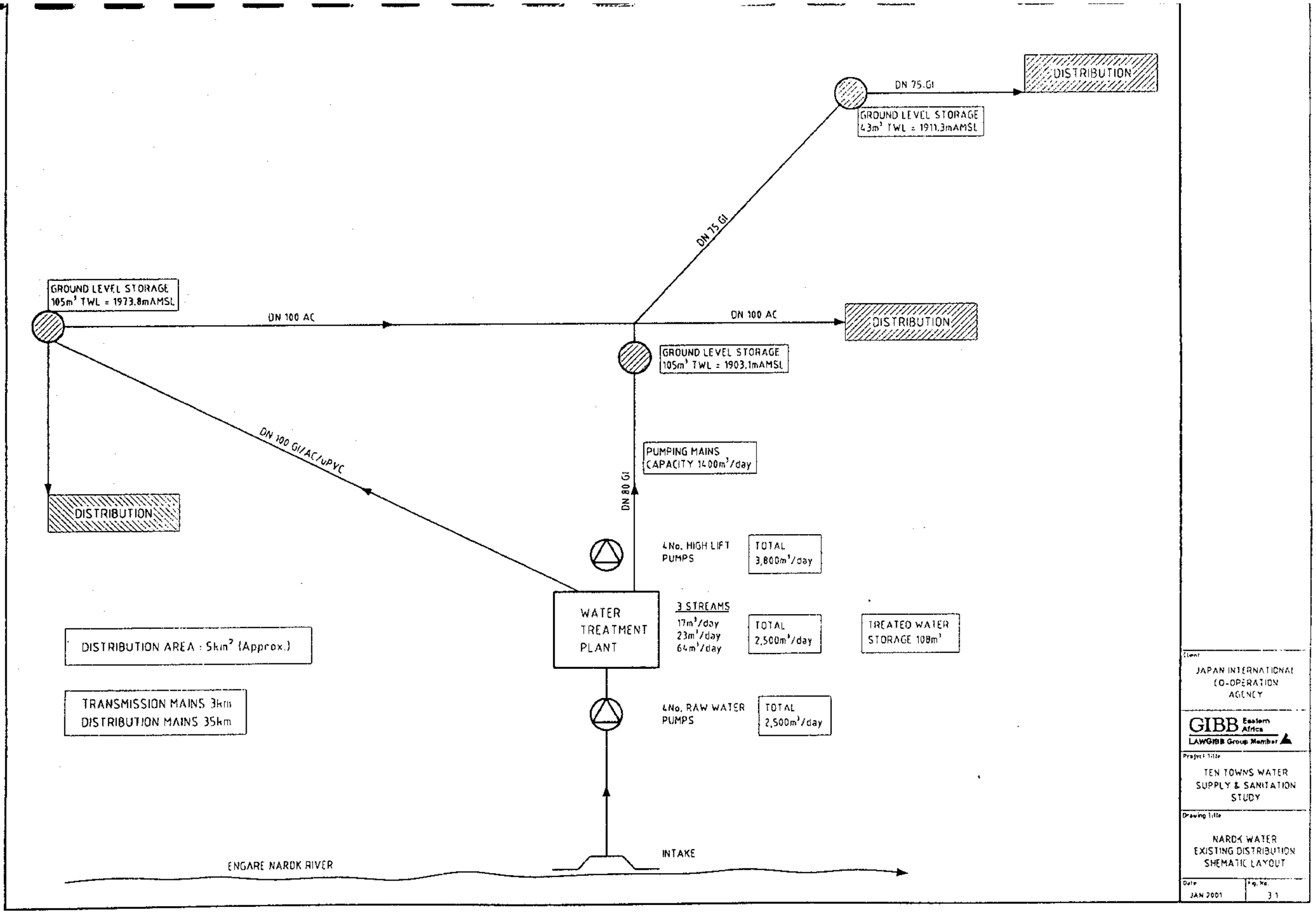
5 no. low lift pumps draw raw water through 3 no. DN 80 GI suction mains and distribute to the 3 no. treatment units.

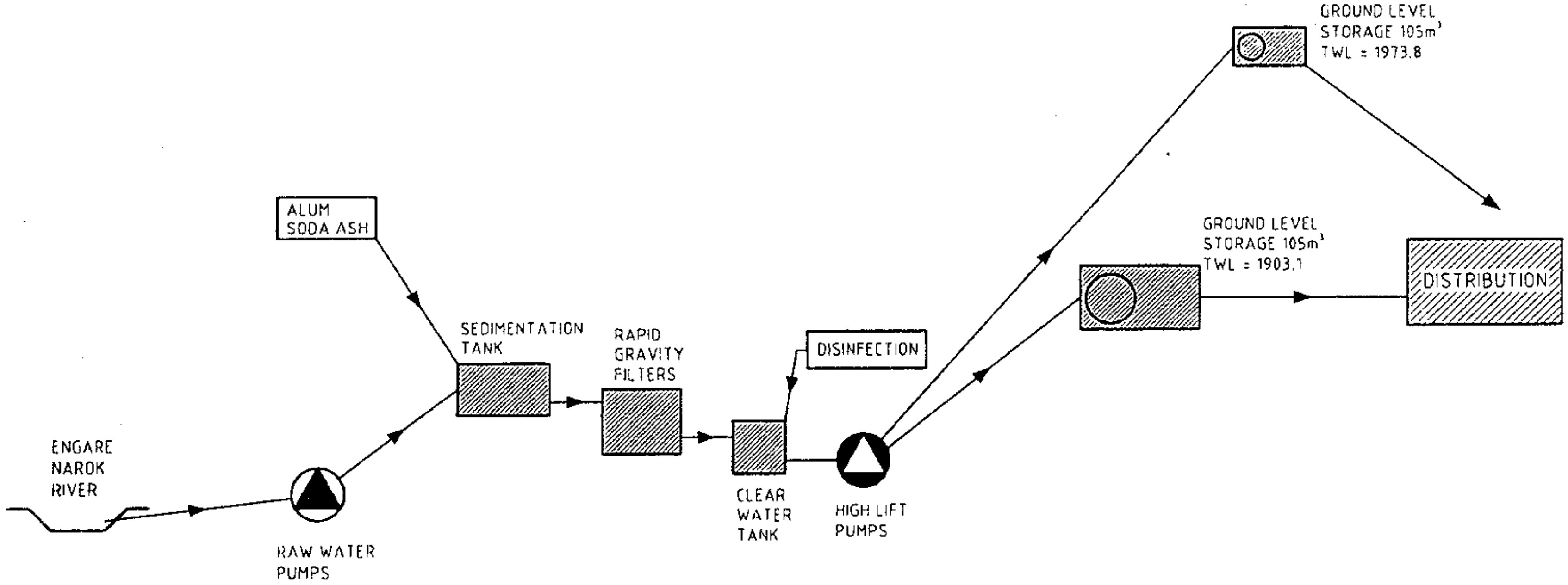
4 no. low lift raw water pumps are operational, giving a maximum output of 100m^3/hour (2,400m^3/day).

Table 3.1 Details of raw water pumps

Make	Type	Number	Q m^3/hr	H m	Motor Kw
Southern Cross	Horizontal centrifugal	3**	25	100	7.5
Stock	Horizontal centrifugal	1	25	100	7.5
Lowara	Horizontal centrifugal	1	21	50	4

** *1 no. Southern Cross pump is not working.*


DISTRIBUTION
DN 75 GI
GROUND LEVEL STORAGE
43m³ TWL = 1911.3mAMSL
DN 75 GI
GROUND LEVEL STORAGE
105m³ TWL = 1973.8mAMSL
DN 100 AC
DN 100 AC
DISTRIBUTION
GROUND LEVEL STORAGE
105m³ TWL = 1903.1mAMSL
DN 100 GI/AC/uPVC
PUMPING MAINS
CAPACITY 1400m³/day
DN 80 GI
DISTRIBUTION
4No. HIGH LIFT PUMPS
TOTAL 3,800m³/day
WATER TREATMENT PLANT
3 STREAMS
17m³/day
23m³/day
64m³/day
TOTAL 2,500m³/day
TREATED WATER STORAGE 108m³
DISTRIBUTION AREA : 5km² (Approx.)
TRANSMISSION MAINS 3km
DISTRIBUTION MAINS 35km
4No. RAW WATER PUMPS
TOTAL 2,500m³/day
INTAKE
ENGARE NAROK RIVER
Client
JAPAN INTERNATIONAL CO-OPERATION AGENCY
GIBB Eastern Africa
LAWGIBB Group Member
Project Title
TEN TOWNS WATER SUPPLY & SANITATION STUDY
Drawing Title
NAROK WATER EXISTING DISTRIBUTION SHEMATIC LAYOUT
Date
JAN 2001
Fig. No.
3 1



TRANSMISSION MAINS 3km
DISTRIBUTION MAINS 35km

Client	JAPAN INTERNATIONAL CO-OPERATION AGENCY
	GIBB Eastern Africa, LAWGIBB Group Member
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Drawing Title	NAROK WATER EXISTING POSITION SHEMATIC
Date: JAN 2001	Fig. No. 3.2

The pumps are leaking copiously from seals and packing, and power cables are strewn on the floor of the building. Control equipment and cables are untidy and should be re-fixed to walls.

The low lift pumping station building is in need of basic rehabilitation i.e. replacement of windows and doors, making good holes where pipes pass through walls, internal and external painting.

3.2 TREATMENT

The existing treatment works layout is shown in Figure 3.3.

3.2.1 Clarification and filtration

There are 3 no. distinct treatment streams :

- $17m^3$/hour horizontal flow sedimentation tanks and filters, discharging into an $8m^3$ clear water tank.

  Sedimentation : 2 no. units each 3.35 x 2.7m
  Filtration : 2 no. units each 2.65 x 1.25m

- $23m^3$/hour upward flow sedimentation tank and $43m^3$/hour filter, discharging into $8m^3$ clear water tank (as above).

  Sedimentation : 1 no. unit 4.47 x 4.32m
  Filtration : 1 no. unit 4.32 x 2.3m

- 2 no. $32m^3$/hour horizontal flow sedimentation tanks and filters, discharging into a $100m^3$ clear water tank.

  Sedimentation : 2 no. units each 8.66 x 4.4m
  Filtration : 2 no. units each 4.4 x 4.4m

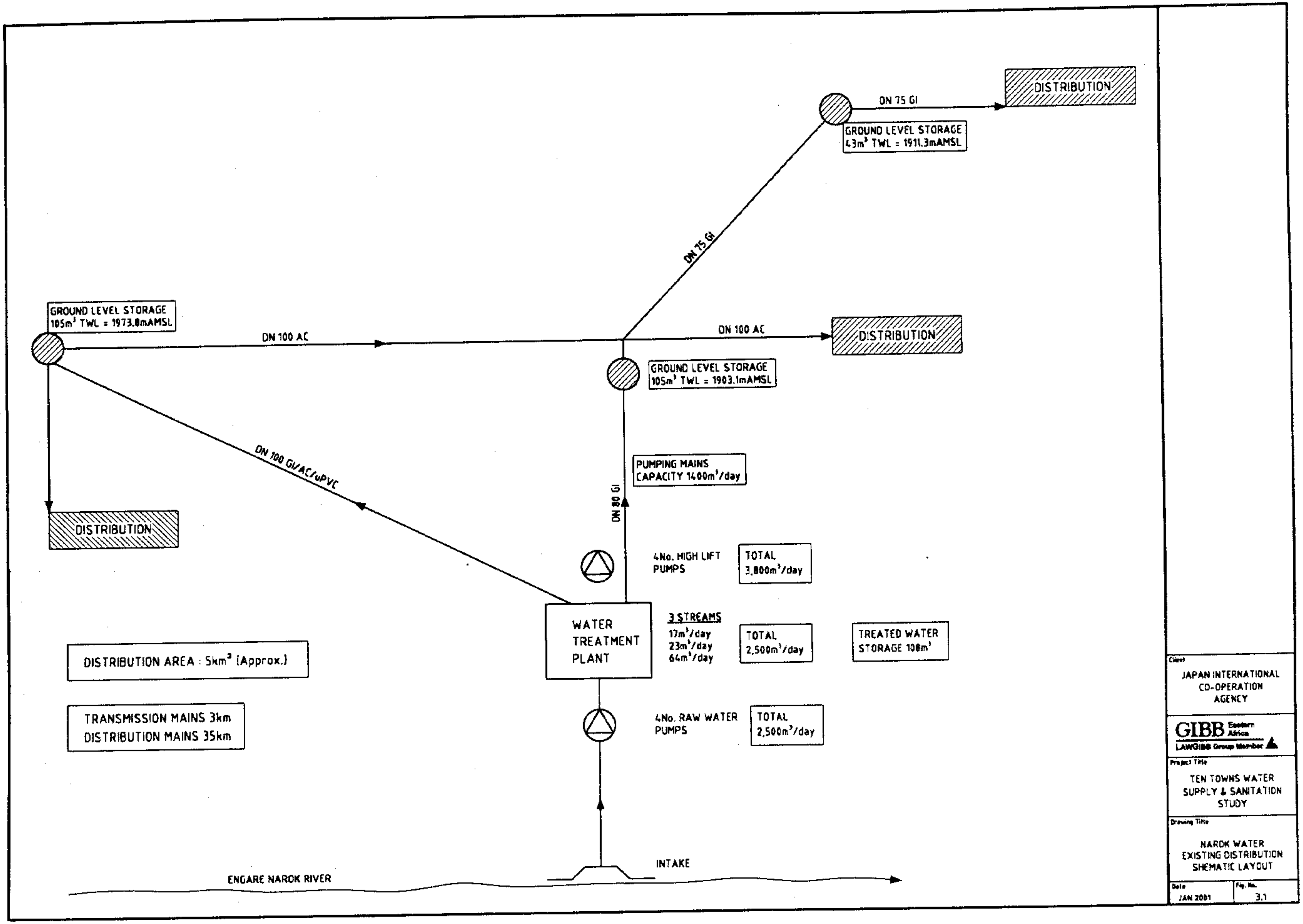
The treatment capacity of the existing works is $104m^3$/hour or $2,496m^3$/day, say 2,500 m^3/day.

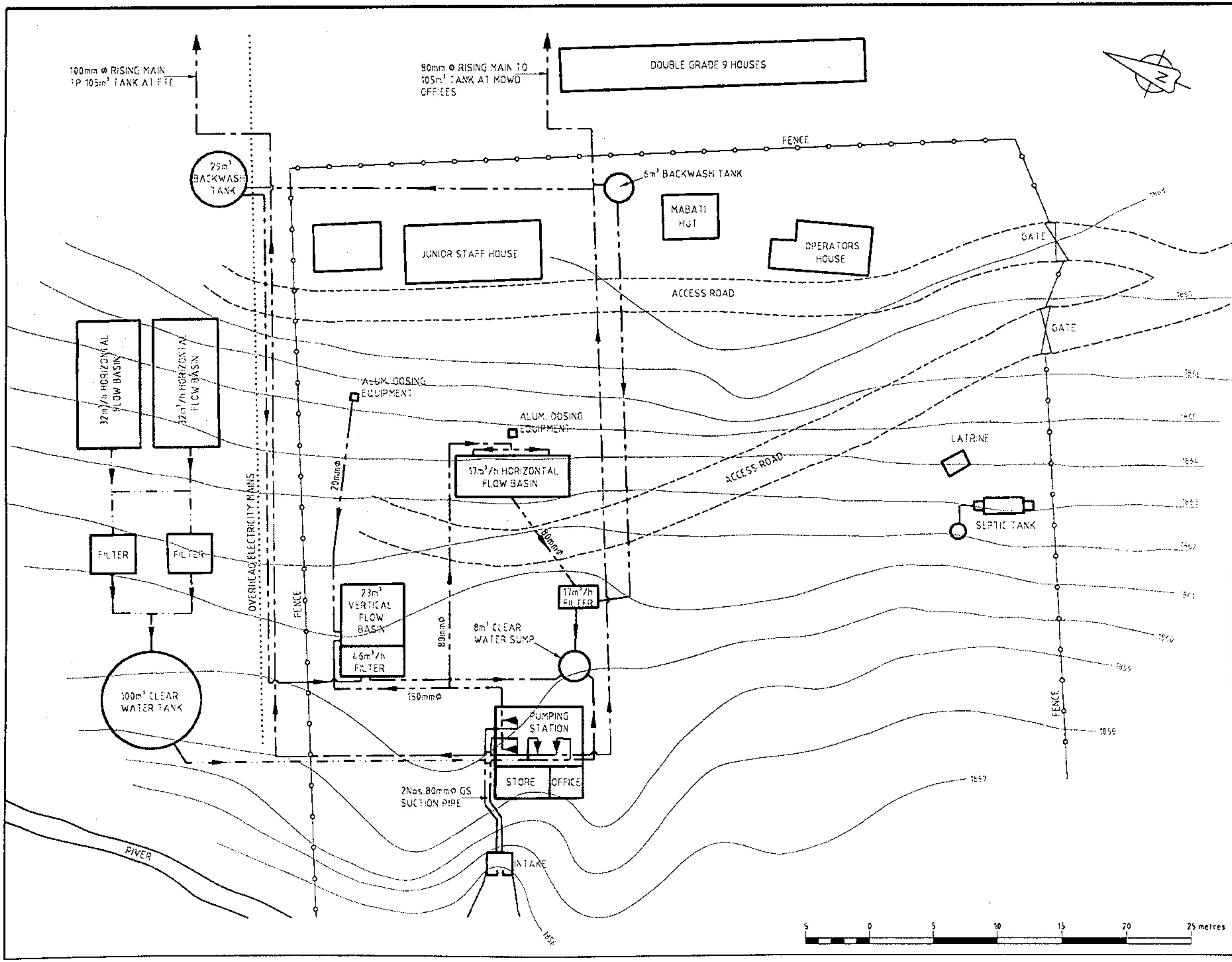
Filter backwashing is carried out under gravity using 2 no. backwash tanks having a total capacity of $35m^3$.

The concrete and masonry structures are in an acceptable state of repair with no structural cracks. Flow control valves are leaking or have ceased to function.

3.2.2 Chemical dosing

Soda ash (sodium carbonate) is added at the inlets of all treatment streams for pH correction. Alum (aluminium sulphate) is also added at the inlets as a coagulant. Water is disinfected by adding chlorine in the form of calcium hypochlorite or tropical chloride of lime to the filtered water in the clear water


DISTRIBUTION
DN 75 GI
GROUND LEVEL STORAGE
43m³ TWL = 1911.3mAMSL
DN 75 GI
GROUND LEVEL STORAGE
105m³ TWL = 1973.8mAMSL
DN 100 AC
DN 100 AC
DISTRIBUTION
GROUND LEVEL STORAGE
105m³ TWL = 1903.1mAMSL
DN 100 GI/AC/uPVC
PUMPING MAINS
CAPACITY 1400m³/day
DN 80 GI
DISTRIBUTION
4No. HIGH LIFT
PUMPS
TOTAL
3,800m³/day
WATER
TREATMENT
PLANT
3 STREAMS
17m³/day
23m³/day
64m³/day
TOTAL
2,500m³/day
TREATED WATER
STORAGE 108m³
DISTRIBUTION AREA : 5km² (Approx.)
TRANSMISSION MAINS 3km
DISTRIBUTION MAINS 35km
4No. RAW WATER
PUMPS
TOTAL
2,500m³/day
INTAKE
ENGARE NAROK RIVER
Client
JAPAN INTERNATIONAL
CO-OPERATION
AGENCY
GIBB Eastern Africa
LAWGIBB Group Member
Project Title
TEN TOWNS WATER
SUPPLY & SANITATION
STUDY
Drawing Title
NAROK WATER
EXISTING DISTRIBUTION
SHEMATIC LAYOUT
Date
JAN 2001
Fig. No.
3.1



Client

JAPAN INTERNATIONAL CO-OPERATION AGENCY

GIBB Eastern Africa

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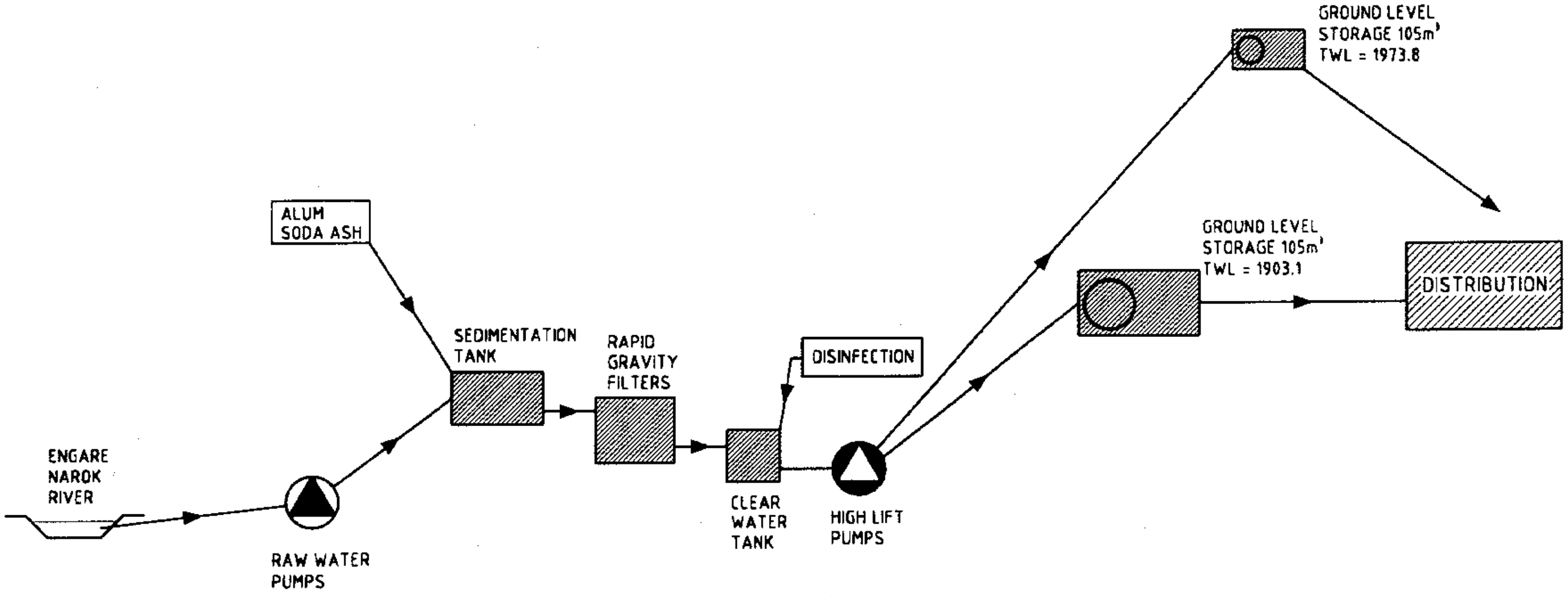
Project Title

TEN TOWNS WATER SUPPLY & SANITATION STUDY

Drawing Title

NAROK TOWN WATER SUPPLY TREATMENT WORKS LAYOUT

Date	Fig. No.
JAN 2001	3.3



TRANSMISSION MAINS 3km
DISTRIBUTION MAINS 35km

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GIBB Eastern Africa
LAWGIBB Group Member

Project Title: TEN TOWNS WATER SUPPLY & SANITATION STUDY

Drawing Title: NAROK WATER EXISTING POSITION SHEMATIC

Date: JAN 2001 | Fig. No. 3.2

tanks. Soda ash is also added at the clear water tanks for pH correction of the final water.

The original dosing equipment has broken down, and dosing is by means of simple manually controlled gravity systems.

Quantities of chemicals used :

Aluminium sulphate (alum)	100 – 150 kg/day
Soda ash	8 - 10 kg/day
Calcium hypochlorite	150 kg/month

3.2.3 Treated water pumping

There are 5 no. high lift pumps, 4 no. of which are working.

Table 3.2 Details of treated water pumps

Make	Type	Number	Q m^3/hr	H m	Motor kw
Grundfos	Vertical centrifugal	3**	30	171	22
Stock	Vertical centrifugal	1	25	150	18.5
Stock	Horizontal multistage	1	45	171	37

** *1 no. Grundfos pump is not working.*

The potential daily maximum pump quantity is 3,840m^3.

Only 3 no. pumps maximum can operate simultaneously as a greater number results in excessive pressures in the existing DN100 and DN80 rising mains with consequent bursts. The existing pumping mains are under-sized.

Production is limited to between1,300 and 1,500m^3/day.

3.2.4 Transmission (rising mains)

There are 2 no. transmission mains :

- DN100 GI, AC, PVC length 2,600m discharging to a 105m^3 ground level masonry tank; and
- DN80 GI length 400m discharging to a 105m^3 ground level masonry tank.

Flows in the pumping mains are metered.

As mentioned in Section 3.2.3 above, the pumping mains are under-sized and because of their age they are in poor condition. Immediate replacement will result in the maximum output from the high lift pumps being obtained.

3.3 DISTRIBUTION

The existing distribution network is shown in Figure 3.4.

3.3.1 Reticulation pipework

The reticulation system consists of approximately 35 km of small diameter AC and GI pipework constructed in 1950s with small extensions being constructed since then. Pipes have corroded and have become encrusted with consequent increase in friction losses.

The pipework system is now grossly undersized in relation to current and projected demands. A complete network analysis of the reticulated area is necessary. The results of the analysis will indicate the positions of undersized pipes which should be replaced or augmented.

Not all the town is served, the distribution system being concentrated in the central business area.

Pipelines should be laid to distribute water to the whole of the service area.

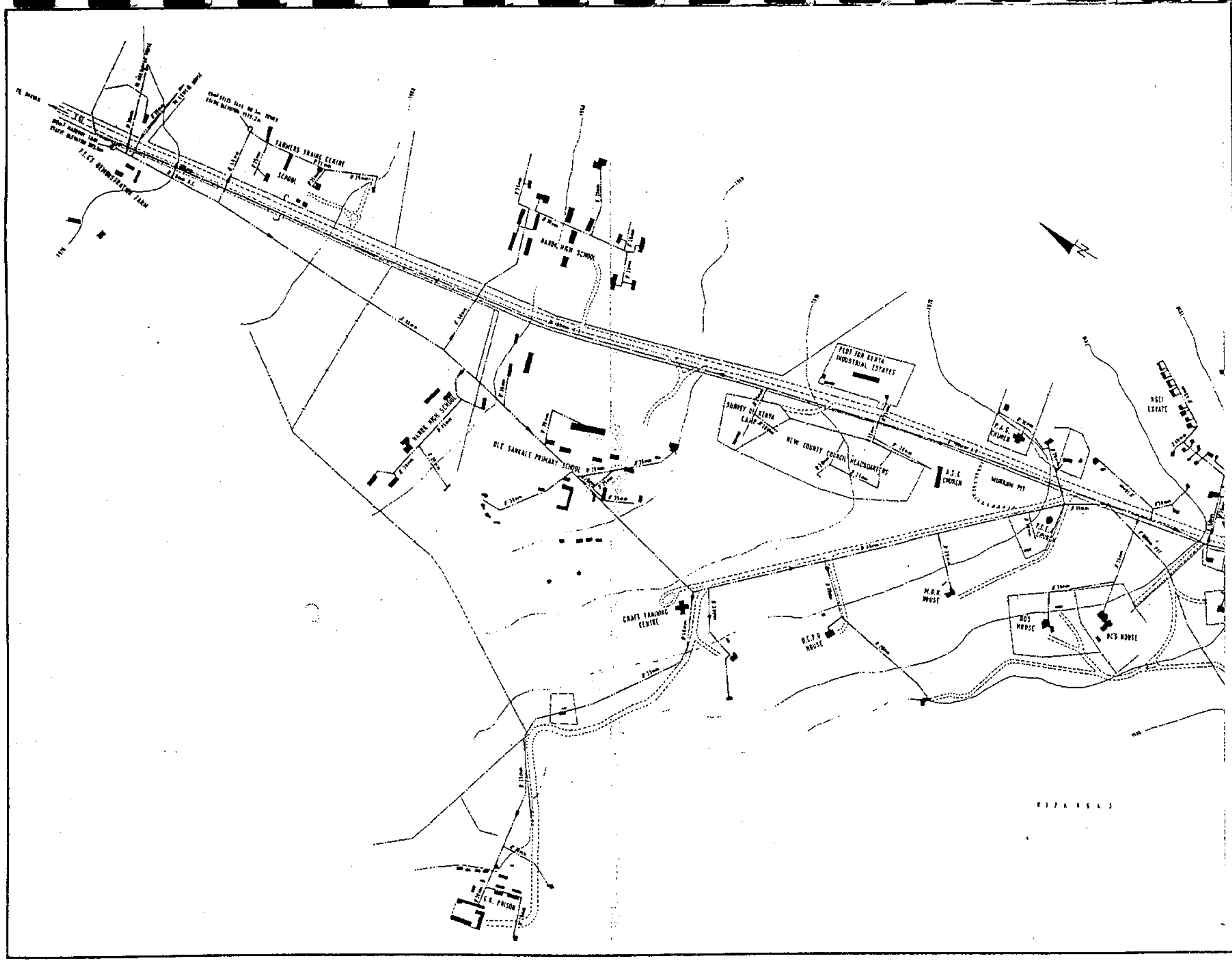
Details of the current reticulation mains are summarised in the table below :

Table 3.3 Details of reticulation mains

Diam Mm	Material	Length m
100	UPVC	1,600
100	AC	2,700
75	UPVC	3,100
75	AC	2,500
75	GS	2,100
50	GS	2,200
40	GS	4,600
25	GS	5,500
<25	GS	10,500

3.3.2 Consumer connections

There are 1,333 connections in Narok of which 999 are metered, of which 425 are working. The degree of accuracy of the meters is not known as there are no facilities for calibration.



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JAPAN INTERNATIONAL CO-OPERATION AGENCY

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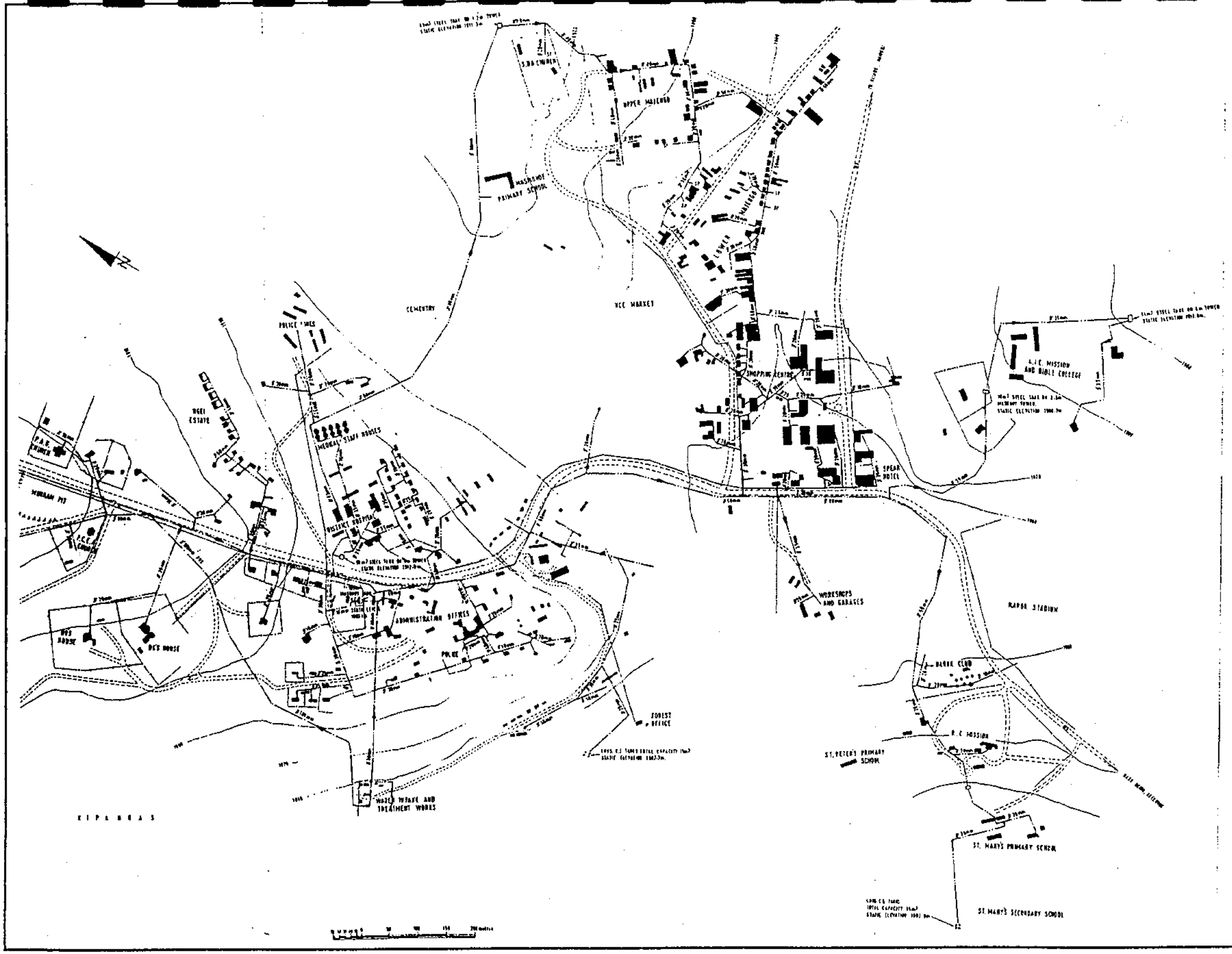
LAWGIBB Group Member

Project Title
TEN TOWNS WATER SUPPLY & SANITATION STUDY

Drawing Title
NAROK TOWN EXISTING WATER RETICULATION SYSTEM

SHEET 1 OF 2

Date	Fig. No.
JAN 2001	3.4



Client
JAPAN INTERNATIONAL CO-OPERATION AGENCY

GIBB Eastern Africa
LAWGIBB Group Member

Project Title
TEN TOWNS WATER SUPPLY & SANITATION STUDY

Drawing Title
NAROK TOWN EXISTING WATER RETICULATION SYSTEM

SHEET 2 OF 2

Date	Fig. No.
JAN 2001	3.4

3.4 STORAGE

3.4.1 Ground level tanks

There are 2 no. 105m^3 masonry tanks with reinforced concrete roofs in good condition. The tank adjacent to the District Water Office is too low which restricts its use as effective storage.

3.4.2 Elevated tanks

The following tanks exist:

- 1 no. 43 m^3 steel tank (not in use because of excessive leaking).

- 1 no. 90 m^3 steel tank (property of Narok District Hospital – in good condition).

There are other privately owned elevated tanks in Narok, e.g. at the Teachers' Training College and Farmers' Training College.

3.5 EXISTING O&M

The Narok water supply has a technical staff of 6 as follows:

- The District Water Officer (hydrologist).
- 3 no. waterworks superintendents.
- A pollution control superintendent.
- An electrical inspector.

There are also semi-skilled plant/pump attendants.

Treated water is pumped 24 hours/day.

There are few if any spares - pipes, valves, electrical components.

A high percentage of water meters are out of order and there are no spares.

Typical production problems are the quality of filter sand, failure of electrical pump control equipment and of electric pump motors.

There are no funds available locally and all purchases are made or authorised through the Ministry in Nairobi.

3.6 ON-GOING OR PLANNED EL NINO WORKS

There are no El Nino Rehabilitation Project works planned for Narok.

3.7 OTHER WORKS AND PROJECTS

A comprehensive gravity water supply system design was completed in 1983, designed by Kigoni and Partners, Consulting Engineers, Nairobi, using the year 2000 as the design horizon. The design population for 2000 was estimated to be 48,000; the actual population for 2000 is approximately 40,000.

The design capacity of the proposed treatment plant is 5,600m^3/day.

The design includes additional sedimentation tanks and filters constructed on the existing site, with an impoundment, capacity 140,000 m^3, constructed some 160 m upstream from the existing intake works.

The scheme has not yet been implemented.

3.8 LEVELS OF SERVICE

3.8.1 Population served

According to the District Water Officer there are currently 1,333 connections in Narok of which 828 are active.

The 1999 population of Narok is given as 41,162 (41,200), in 10,386 households, an average household size of 3.96.

The population of Narok living inside the water supply service area is estimated to be 20,773 (20,800) or 50% of the population.

The number of people with active connections is 828 x 3.96 = 3,280 or 16% of the people within the serviced area.

3.8.2 Per capita supplies

The total daily water production is 1,250 m^3, or 37,500 m^3/month. Water consumption is estimated to be 15,000 m^3/month, indicating massive quantities of unaccounted for water.

The per capita consumption for the estimated 'connected' population is equivalent to 152 lcd , or an average of 24 lcd for the population living within the serviced area.

4 PROPOSED STRATEGY FOR WATER SUPPLY REHABILITATION

4.1 DEMAND/CONSUMPTION PROJECTIONS TO 2010

4.1.1 Population projections to 2010

The population of Narok and surrounding peri-urban areas according to the 1999 census is 41,162 in 10,386 households. Annual growth rate is 4.5%.

Yearly population projections to 2010 (rounded to the nearest '00) are shown in Table 4.1.

Table 4.1 Population projections to 2010

Year	Population
1999	41,200
2000	43,000
2001	44,900
2002	47,000
2003	49,100
2004	51,300
2005	53,600
2006	56,000
2007	58,500
2008	61,200
2009	63,900
2010	66,800

4.1.2 Water demand projection

Demand rates are taken from the Ministry of Water Development Design Manual (1986) and are included in Appendix A2

Table 4.2 shows estimated daily demand from 2000 to 2010 compared with the current capacities of the various system components.

Demand has been calculated using the following percentages for different level income brackets of consumers, ascertained from data collected in the field. Reference is made to Table 2.8 of this report which shows the categorisation of the population by income.

Category	Proportion	Population (1999)	Rate (lcd)	Demand (m^3/day)
High income	17	6,998	250	1,749
Middle income	38	15,642	150	2,346
Low income	45	18,523	75	1,389
Total domestic water demand				**5,484**

Table 4.2
Narok Water Supply Projected Water Demands and Current System Capacities

Year	Population	Income brackets		Population	Demand rate lcd	Demand m^3/day	Institutional demand m^3/d	Total demand m^3/day	Production capacity m^3/day	Transmission capacity m^3/d	Storage capacity m^3
		Status	%								
1999	41,200	High	17	7,004	250	1,751					
		Middle	38	15,656	150	2,348	300	**5,790**	2,500	1,500	360
		Low	45	18,540	75	1,391					
2000	43,000	High	17	7,310	250	1,828					
		Middle	38	16,340	150	2,451	300	**6,030**	2,500	1,500	360
		Low	45	19,350	75	1,451					
2001	44,900	High	17	7,633	250	1,908					
		Middle	38	17,062	150	2,559	300	**6,283**	2,500	1,500	360
		Low	45	20,205	75	1,515					
2002	47,000	High	17	7,990	250	1,998					
		Middle	38	17,860	150	2,679	300	**6,563**	2,500	1,500	360
		Low	45	21,150	75	1,586					
2003	49,100	High	17	8,347	250	2,087					
		Middle	38	18,658	150	2,799	300	**6,843**	2,500	1,500	360
		Low	45	22,095	75	1,657					
2004	51,300	High	17	8,721	250	2,180					
		Middle	38	19,494	150	2,924	300	**7,136**	2,500	1,500	360
		Low	45	23,085	75	1,731					
2005	53,600	High	17	9,112	250	2,278					
		Middle	38	20,368	150	3,055	300	**7,442**	2,500	1,500	360
		Low	45	24,120	75	1,809					
2006	56,000	High	17	9,520	250	2,380					
		Middle	38	21,280	150	3,192	300	**7,762**	2,500	1,500	360
		Low	45	25,200	75	1,890					
2007	58,500	High	17	9,945	250	2,486					
		Middle	38	22,230	150	3,335	300	**8,095**	2,500	1,500	360
		Low	45	26,325	75	1,974					
2008	61,200	High	17	10,404	250	2,601					
		Middle	38	23,256	150	3,488	300	**8,455**	2,500	1,500	360
		Low	45	27,540	75	2,066					
2009	63,900	High	17	10,863	250	2,716					
		Middle	38	24,282	150	3,642	300	**8,815**	2,500	1,500	360
		Low	45	28,755	75	2,157					
2010	66,800	High	17	11,356	250	2,839					
		Middle	38	25,384	150	3,808	300	**9,201**	2,500	1,500	360
		Low	45	30,060	75	2,255					

The following institutional demands have been included in addition :

Hospital (200) beds	500l/200 beds	100 m^3/day
Prison	50l/300	15 m^3/day
Boarding schools	50l/3000	150 m^3/day
Teachers' college	50l/200	10 m^3/day
Craft training centre	50l/100	5 m^3/day
Farmers' training centre	50l/100	5 m^3/day
Total institutional demand		**285 m^3/day** **say 300 m^3/day**

Commercial activity is of a level such that domestic water usage rates can be applied. There are no major industries in Narok.

The existing abattoir operates under very primitive and unhygienic conditions, water usage is minimal.

4.2 PRELIMINARY DESIGN OF RECOMMENDED REHABILITATION OPTIONS

Principal design criteria for water engineering design is presented in Appendix A2.

The following comments summarise the main focus of the proposed rehabilitation plan for Narok water supply.

Table 4.3 shows the summary schedule of the proposed rehabilitation works.

4.2.1 High priority rehabilitation works

The recommended works comprise :

- Replacement of the coarse screen at the inlet works.
- Rehabilitation of pumping station (low and high lift).
- Refurbishment of low lift pump sets.
- Provision of gravity chemical dosing equipment.
- Replacement of filter media and de-sludging valves.
- Refurbishment of high lift pump sets.
- Refurbishment of buildings at the treatment works site and at the District office.
- Provision of laboratory equipment and reagents.
- General rehabilitation of structures at the treatment works site (leaking and non-functioning valves, leaking pipes, broken stairs, painting, etc.).
- Provision of bulk and domestic water meters.
- Replacement of elevated steel tank.
- Replacement of existing rising mains.
- Laying approximately 5km of new distribution pipes.
- Provision of vehicles, office equipment and furniture.

Table 4.3

NAROK WATER SUPPLY
SUMMARY SCHEDULE OF PROPOSED REHABILITATION WORKS

Item	Unit	Ref	Component	Condition	Proposed action	Comments	Implementation
1.	Inlet works	1.1	Trash rack and screens	Missing	Replace	Essential to prevent foreign materials from being drawn into the low lift pumps	Rehabilitation
2.	Pumphouse low & high lift	2.1	Structure				
			Doors		Rehabilitate, repair or replace as necessary	Structure has been neglected. Rehabilitation is cosmetic	Rehabilitation - all
			Windows				
			Roof		Paint externally and internally		
			Floor (drainage & cable ducts)				
			Walls	Pipe entries	Repair holes		
		2.2	Low lift pumps				
			Pump motors	Suspect	Replace as necessary	Pump layout is untidy and shows lack of cleaning or preventive maintenance	Rehabilitation - all
			Pumps	Leaking	Replace packing & seals		
			Plinths	Broken	Repair		
			Controls & cabling	Untidy	Rehabilitate		
3.	Treatment streams	3.1	$17m^3$/hour horizontal flow sedimentation tank				
			Alum dosing equipment	Manual dosing	Replace	Gravity dosers are preferred	Rehabilitation
			De-sludging valves	Unknown	Replace as necessary	Affects performance of tank	Rehabilitation
		3.2	$17m^3$/hour rapid gravity filter				
			Filter media		Replace	Affects performance of filter	Rehabilitation
			Underdrains		Inspect & replace as necessary		Rehabilitation
		3.3	$23m^3$/hour vertical flow sedimentation tank				
			Alum dosing equipment	Manual dosing	Replace	Gravity dosers are preferred	Rehabilitation
			De-sludging valves	Unknown	Replace as necessary	Affects performance of tank	Rehabilitation
		3.4	$46m^3$/hour rapid gravity filter				
			Filter media		Replace	Affects performance of filter	Rehabilitation
			Underdrains		Inspect & replace as necessary		Rehabilitation
		3.5	2 no. $32m^3$/hour horizontal flow sedimentation tanks				
			Alum dosing equipment	Manual dosing	Replace	Gravity dosers are preferred	Rehabilitation
			De-sludging valves	Unknown	Replace as necessary	Affects performance of tank	Rehabilitation
		3.6	2 no. $32m^3$/hour rapid gravity filters				
			Filter media		Replace	Affects performance of filter	Rehabilitation
			Underdrains		Inspect & replace as necessary		Rehabilitation
4.	Clear water tanks	4.1	$100m^3$ clear water tank				
			Structure	Good	None		
			Chlorine dosing equipment	Manual dosing	Replace	Gravity dosers are preferred	Rehabilitation
			Soda ash dosing	Manual dosing	Replace	Gravity dosers are preferred	Rehabilitation
		4.2	$8m^3$ clear water tank				
			Structure	Good	None		
			Chlorine dosing equipment	Manual dosing	Replace	Gravity dosers are preferred	Rehabilitation
			Soda ash dosing	Manual dosing	Replace	Gravity dosers are preferred	Rehabilitation
5.	High lift pumps	5.1	Pump motors	Suspect	Replace as necessary	Pump layout is untidy and shows lack of cleaning or preventive maintenance	Rehabilitation - all
			Pumps	Leaking	Replace packing & seals		
			Plinths	Broken	Repair		
			Controls & cabling	Untidy	Rehabilitate		
6.	Buildings	6.1	Chemical store	Unused	Complete rehabilitation		Rehabilitation - all
			Laboratory	Unused	Complete rehabilitation	Equip with chemicals and apparatus for carrying out daily tests. Train technicians	Immediate
7.	Meters	7.1	Bulk meters on rising mains (2 no)		Replace		Rehabilitation
		7.2	Zonal bulk meters		New		Rehabilitation
		7.3	Domestic meters		Replace		Rehabilitation
8.	Rising mains	8.1	Existing DN100 & DN80 pipes	In use	Replace using DN200	Existing mains are too small and cannot convey the amount of treated water to storage.	Rehabilitation
9.	Storage	12.2	Existing $45m^3$ sectional steel tank	Unused	Replace		Replace
10.	Distribution	10.1	Existing pipes = and > DN100	In use	Rehabilitate, replace		Rehabilitation

4.2.2 Rising mains

The existing DN80 and DN100 pipes will be replaced by uPVC DN200 pipes. These will be dedicated pipelines and no tappings will be permitted.

4.2.3 Dosing equipment

Gravity dosers will be provided for the dosing of aluminium sulphate (alum), soda ash and calcium hypochlorite (tropical chloride of lime).

4.2.4 Chemical dosing for coagulation and pH correction

(a) Current dosing regime

The best ionic balance for the samples taken in 1980 is that reported in Appendix B1 to the Kigoni and Partners design report. This analysis shows a pH of 7.5 and an alkalinity of 152 mg/l. The calculated coagulation pH and dissolved carbon dioxide (in mg/l as CO_2) for the current dosing regime of 85 mg/l of aluminium sulphate and 6.2 mg/l of soda ash are shown below.

Temperature (°C)	10	15	20	25
Coagulation pH	6.79	6.76	6.73	6.71
Dissolved CO_2 (mg/l)	47.2	46.0	45.1	44.3

The coagulation pH remains above 6.5: the Ministry's lower limit of acceptability. Although the water complies with the Ministry's guidelines for pH, the hardness is only 45 mg/l and the dissolved carbon dioxide is some 45 m/l. According to the charts given in the Ministry's design manual, the water will be very aggressive towards concrete and iron products.

Another measure of the passivity of water is the degree of saturation with respect to calcite. The sample had a calcium content of 3.39×10^{-4} mol/l and the final carbonate concentration is 5.51×10^{-7} mol/l for water at 25°C. The ion activity product is 1.87×10^{-10}, but the dissociation constant for calcium at this temperature is 4.9×10^{-9}. The product water is strongly under-saturated (3.8%) with respect to calcite, and will attack concrete products.

(b) Required soda ash dose for passive water

The pH and alkalinity can be raised by increasing the soda ash dose. Adding soda ash (sodium carbonate) increases both the alkalinity and the total inorganic carbon. This will lower the dissolved carbon dioxide, but will not affect the hardness. The Ministry's design manual shows that water with a hardness of 45 mg/l and dissolved carbon dioxide of 5 mg/l will be only slightly aggressive to concrete and steel. The calculated soda ash doses to achieve this value are shown below, together with the final pH.

Temperature (°C)	10	15	20	25
Alum dose (mg/l)	85	85	85	85
Soda ash dose (mg/l)	109.5	106.5	104.2	102.6
PH	8.03	7.98	7.94	7.91
CO_2 (mg/l)	5.0	5.0	5.0	5.0

At 25°C, the finished water is slightly over-saturated with respect to calcite (107.1%).

The calculated soda ash doses to produce water that is saturated with respect to calcite are summarised below.

Temperature (°C)	10	15	20	25
Alum dose (mg/l)	85	85	85	85
Soda ash dose (mg/l)	105.5	103.9	102.6	101.8
PH	7.92	7.90	7.89	7.88
CO_2 (mg/l)	6.5	6.0	5.6	5.3

The current chemical dosing regime produces aggressive water. To stabilise the water, the soda ash dose must be increased substantially (or the aluminium sulphate dose reduced). This highlights the importance of regular jar tests to determine the optimal dosage rates.

(c) Stabilisation using lime instead of soda ash

In many countries, lime is preferred to soda ash for stabilising water. Dosing lime increases both the alkalinity and the hardness, so the required rise in pH is not as great to produce stable water.

The calculated lime doses to produce water that is saturated with respect to calcite are summarised below.

Temperature (°C)	10	15	20	25
Alum dose (mg/l)	85	85	85	85
Lime dose (mg/l)	34.8	34.3	34.0	33.8
PH	7.66	7.65	7.64	7.64
CO_2 (mg/l)	8.7	8.0	7.5	7.0

Using lime for pH correction and stabilisation, the required dosage rates are much lower than for soda ash.

(d) Chemical dosing for disinfection

The World Health Organisation recommends that water intended for potable use should be disinfected with 0.5 mg/l of free available chlorine for at least thirty minutes at a pH less than 8. This recognises that germicidal efficiency is dependent on both the free chlorine concentration and the time of contact.

To achieve a free chlorine residual, sufficient chlorine must be dosed to react with any dissolved ammonia, iron, manganese, etc. The required doses are:

Temperature (°C)	10	15	20	25
Alum dose (mg/l)	85	85	85	85
Soda ash dose (mg/l)	109.5	106.5	104.2	102.6
PH	8.03	7.98	7.94	7.91
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To achieve a free chlorine residual, sufficient chlorine must be dosed to react with any dissolved ammonia, iron, manganese, etc. The required doses are:

Pump motors which have been re-wound will be replaced with motors of a similar speed and kw rating.

Control equipment will be tested and all faulty components replaced.

Control cables will be routed either in floor level cable ducts or clipped neatly in cable trays affixed to walls.

4.3 COSTING OF RECOMMENDED REHABILITATION PLAN

An indicative budget for rehabilitating the existing Narok water supply system is Kshs 165 million as shown in Table 4.4.

Cost of works (from Table 4.4)	Kshs	84,600,000
Add 20% preliminary and general items		16,920,000
Add 15% contingencies		15,228,000
Add 20% consultancy fees		23,349,600
TOTAL		**140,097,600**
	say Kshs	**140 million**

Table 4.4 : Cost estimates of rehabilitation works for Narok water supply

Ref	Description	Unit	Quantity	Rate (Kshs)	Amount (Kshs)
1.	**Raw water intake**				
1.1	Trash rack, coarse and fine screens	sum		400,000	400,000
2.	**Pumphouse & raw water pumps**				
2.1	Rehabilitate structure (doors, windows, etc)	sum		1,000,000	1,000,000
2.2	Low lift pumps (motors, seals, impellers, etc.)	sum		1,000,000	1,000,000
3.	**Treatment works**				
3.1	**17m³/hr horizontal flow sedimentation tank**				
3.1.1	Gravity chemical dosers	no.	2	600,000	1,200,000
3.1.2	De-sludging valves	no.	4	25,000	100,000
	Filters				
3.1.3	Filter media	m³	30	5,000	150,000
3.1.4	Underdrain system	sum		500,000	500,000
3.2	**23m³/hr upward flow sedimmtation tank**				
3.2.1	Gravity chemical dosers	no.	2	600,000	1,200,000
3.2.2	De-sludging valves	no.	4	25,000	100,000
	Filters				
3.2.3	Filter media	m³	30	5,000	150,000
3.2.4	Underdrain system	sum		500,000	500,000
3.3	**32m³/hr horizontal flow sedimentation tank**				
3.3.1	Gravity chemical dosers	no.	4	600,000	2,400,000
3.3.2	De-sludging valves	no.	8	25,000	200,000
	Filters				
3.3.3	Filter media	m³	50	5,000	250,000
3.3.4	Underdrain system	sum		1,000,000	1,000,000
4.	**Clear water tanks (100m³ & 8m³)**				
4.1	Gravity chemical dosers	no.	4	600,000	2,400,000
5.	**High lift pumps**				
5.1	Low lift pumps (motors, seals, impellers, etc.)	sum		1,000,000	1,000,000
6.	**Buildings**				
6.1	Rehabilitate offices, chemical store and laboratory	sum		3,000,000	3,000,000
6.2	Laboratory equipment	sum		3,000,000	3,000,000
6.3	Reagents	sum		1,000,000	1,000,000
7.	**Water meters**				
7.1	Bulk meters (various diameters)	no.	8	250,000	2,000,000
7.2	Domestic meters	no.	2,000	6,000	12,000,000
8.	**Storage**				
8.1	50m³ steel tank on existing supports	sum		7,000,000	7,000,000
9.	**Pipes**				
9.1	Pumping mains uPVC DN200	m	3,000	6,000	18,000,000
9.2	Distribution uPVC DN 50 - 100	km	5	2,000	10,000,000
10.	**Logistical facilities and equipment**				
10.1	Rehabilitate existing office buildings	sum		5,000,000	5,000,000
10.2	4WD twin-cab pick-ups	no.	2	2,500,000	5,000,000
10.3	Saloon cars	no.	1	1,500,000	1,500,000
10.4	Motorcycles	no.	5	250,000	1,250,000
10.5	Computers	no.	3	200,000	600,000
10.6	Printers	no.	2	100,000	200,000
10.7	Computer software	sum		500,000	500,000
10.8	Office equipment & furniture	sum		1,000,000	1,000,000
		Total of works			**84,600,000**
Add	20% preliminaries and general items				16,920,000
		Sub-total			101,520,000
	15% contingencies				15,228,000
		Sub-total			116,748,000
	20% consultancy fee				23,349,600
		GRAND TOTAL			**140,097,600**
				say	**140 million**

4.4 EXPANSION OF WATER SUPPLY FACILITIES

The design horizon for expansion works is the year 2010.

4.4.1 General

There are three matters of concern regarding the expansion of water treatment facilities in Narok - the adequacy of the existing source (the Engare Narok river), recurrent pumping costs and distributing water to high level areas in the service area.

(a) Adequacy of source

Section 2.3.2 of this report refers to flows in the Engare Narok river.

Two sets of data have been collected, one showing that the river cannot sustain the abstraction rates needed for future demand flows without construction of an impoundment, and the other indicating that there is a plentiful supply of raw water.

The data differ by an order of magnitude. Further investigations are being carried out to resolve the anomaly.

(b) Recurrent pumping costs

The supply of water for distribution in Narok is double pumped i.e. raw water is pumped to the treatment units and treated water is pumped to town storage.

Recurrent electricity charges are high which has a direct bearing on tariffs charged.

Pumping charges can be eliminated by constructing a new intake and treatment works at a higher elevation and supplying the town by gravity.

With a new treatment works constructed at a higher elevation the whole of the urban area will be able to be served without recourse to booster pumping.

The tentative proposed expansion plan includes identification of a new upland surface water source, new 10,000 m^3/day treatment works (cost analysis may indicate that a larger works would be more economically viable), gravity transmission mains and increased storage.

4.4.2 Water treatment works

An expansion of the existing works will lead to increased electricity charges for pumping and a knock - on tariff increase effect.

It is recommended that a new works be constructed at higher elevation, ref. 4.4.1 above.

4.4.3 Transmission

A DN500 pipe, assumed velocity 1 m/sec can carry peak flows of 18,400 m^3/day (peak factor 2).

The preferred pipe material for engineering and economic reasons is steel.

4.4.4 Storage

Minimum storage for a gravity water supply scheme is 12 hours average daily demand.

The average daily demand in 2010 is 9,200 m^3/day and minimum storage is therefore 4,600m^3.

Existing storage in Narok is less than 400m^3.

Provision of the required new storage can be phased by constructing 3no. tanks each 1,400m^3 capacity.

4.4.5 Distribution

A network analysis of the entire service area will be carries out using topographical survey information and population density and settlement data.

The results of the analysis will identify optimum locations for storage tanks and sizes of primary, secondary and tertiary distribution pipelines.

The service area will in the first instance be concentrated in the designated urban area.

4.4.6 Costs of expansion works

Cost details are presented in Table 4.5.

4.5 O&M COSTS AFTER REHABILITATION

Cost details are presented in Table 4.6.

Table 4.5 : Cost estimates of expansion works for Narok water supply

Ref	Description	Unit	Quantity	Rate (Kshs)	Amount (Kshs)
1.	Raw water intake and raw water main	sum			15,000,000
2.	10,000 m^3/day water treatment works	sum			100,000,000
3.	DN500 transmission main	km	10	20,000	200,000,000
4.	4,200m^3 storage	sum			20,000,000
5.	Break pressure tanks	nr	10	500,000	5,000,000
6.	Distribution pipework	km	75	3,000	225,000,000
7.	Bulk meters	nr	10	250,000	2,500,000
.8.	Domestic meters	nr	8,000	5,000	40,000,000
	Total for works				**607,500,000**
	20% preliminary and general items				121,500,000
	15% contingencies				109,350,000
	20% consultancy fee				167,670,000
	GRAND TOTAL				**1,006,020,000**
				say	**1,006 million**

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Table 4.6 : Cost estimates of O&M activities for Narok water supply

Ref	Description	Unit	Amount (Kshs)
1.	**Capital costs**		
1.1	Management consultancy (2 years)	sum	25,000,000
1.2	Vehicles, office equipment, etc.	sum	10,000,000
	Sub-total		**35,000,000**
2.	**Recurrent costs (monthly)**		-
2.1	Salaries and allowances	sum	1,500,000
2.2	Electricity charges	sum	500,000
2.3	Chemical charges	sum	250,000
2.4	Vehicle running costs & maintenance	sum	150,000
2.5	Office running costs	sum	100,000
2.6	Housing maintenance	sum	100,000
	Sub-total		**2,600,000**
3.	**Spare parts (for 1 year)**		
3.1	Pipes	sum	1,000,000
3.2	Fittings	sum	200,000
3.3	Valves	sum	250,000
3.4	Meters		
3.4.1	bulk	sum	500,000
3.4.2	domestic	sum	2,000,000
3.5	Pumps		
3.5.1	impellers	sum	1,000,000
3.5.2	seals	sum	100,000
3.5.3	packing	sum	100,000
3.6	Electric motors, re-winding	sum	250,000
3.7	Pump controls, relays, MCBs, etc.	sum	250,000
3.8	Dosing equipment, spares	sum	200,000
	Sub-total		**5,850,000**