# BASIC DESIGN STUDY REPORT
# ON
# THE WATER SUPPLY PROJECT
# FOR EBURRU REGION
# IN
# REPUBLIC OF KENYA

FEBRUARY 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

# BASIC DESIGN STUDY REPORT
# ON
# THE WATER SUPPLY PROJECT
# FOR EBURRU REGION
# IN
# REPUBLIC OF KENYA

FEBRUARY 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

## ABBREVIATIONS

| | | |
|---|---|---|
| BP | : | Booster Pump |
| CWP | : | Communal Water Point |
| GDP | : | Gross Domestic Product |
| ha | : | hectare |
| IBRD | : | International Bank for Reconstruction and Development |
| IC | : | Individual Connection |
| JICA | : | Japan International Cooperation Agency |
| JWWA | : | Japan Water Works Association |
| km | : | kilometre |
| $km^2$ | : | square kilometre |
| lpcd | : | litre per capita per day |
| $m^3$/day | : | cubic metre per day |
| $m^3$/sec | : | cubic metre per second |
| mm | : | millimetre |
| MERD | : | Ministry of Energy and Regional Development |
| MOWD | : | Ministry of Water Development |
| MW | : | Mega Watt |
| O&M | : | Operation and Maintenance |
| p.a. | : | per annum |
| % | : | per cent |
| RWS | : | Rural Water Supply |

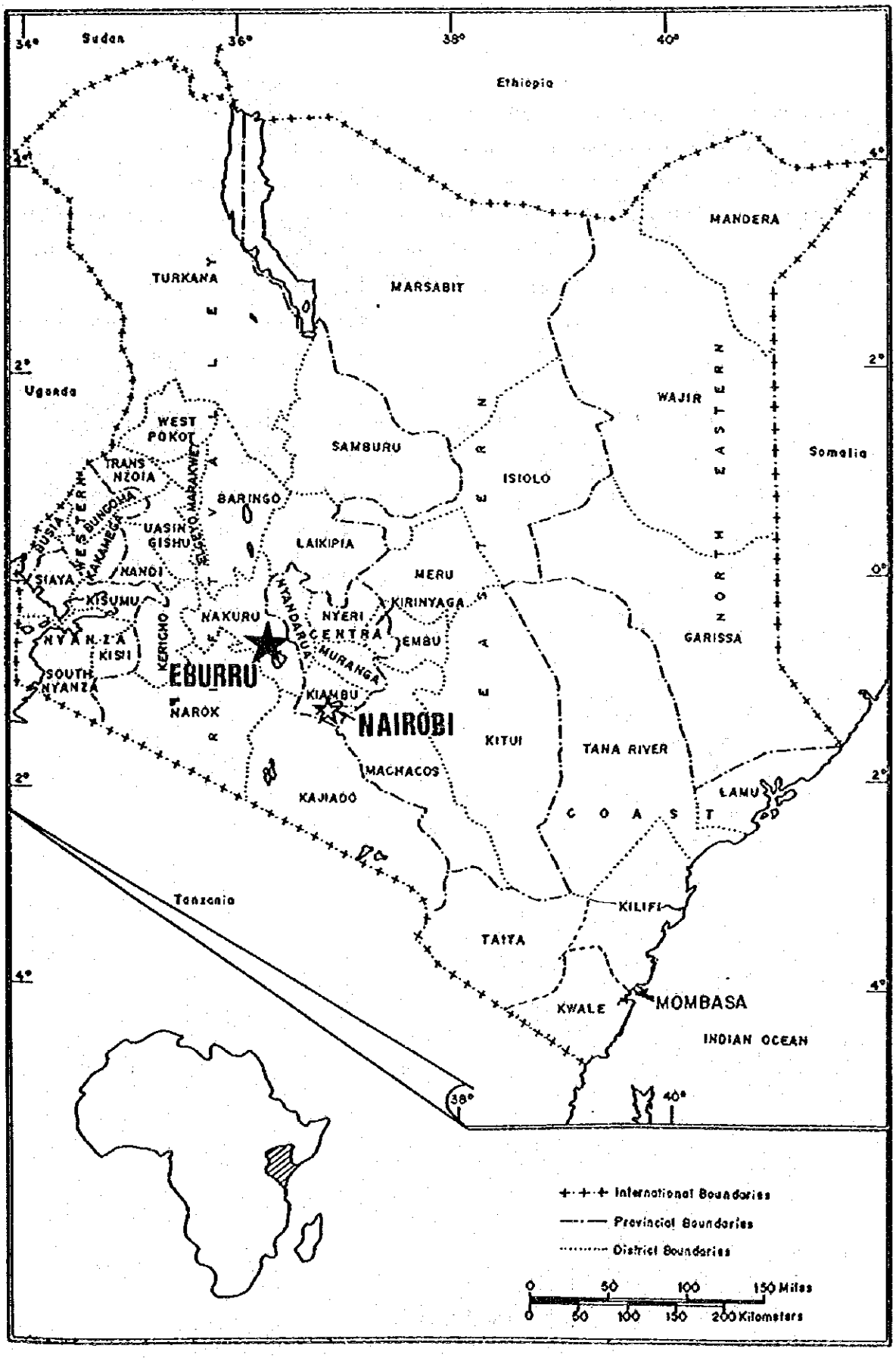
CURRENCY

US$ 1 = KSH 14.556

US$ 1 = ¥ 235

K£ 1 = KSH 20

# LOCATION MAP



## PREFACE

In response to the request of the Government of Republic of Kenya, the Government of Japan decided to conduct a basic design study on the Water Supply Project in the EBURRU Region and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Kenya a study team headed by Mr. Takeshi IMAZU, Deputy Head Basic Design Division, Grant Aid Department, JICA from July 15 to August 11, 1984.

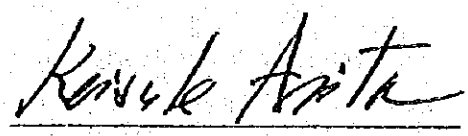
The team had discussions on the Project with the officials concerned of the Government of Kenya and conducted a field survey in EBURRU Region.

After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of Republic of Kenya for their close cooperation extended to the team.

February, 1985



Keisuke Arita
President
Japan International
Cooperation Agency

# SUMMARY

The Government of Kenya is intensely implementing a Rural Water Supply Programme. Out of this national programme, the Eburru Water Supply Project was selected with the first priority of implementation designated as the present basic design study.

Eburru Settlement, the center of the project area, was developed under the national settlement scheme in 1968. To date, about 200 families have settled in 150 plots in this area. However, water supply and irrigation facilities have never been provided under the national scheme. On this point it can be said that the national settlement programme for this area has not been completed yet.

The Eburru area has no economically available water sources. Traditionally the residents are obtaining small amounts of water by utilizing the consolidated natural steam spouting near their houses. The nearest available and reliable water source is Lake Naivasha which is about 10 km away from the Eburru hills, and located about 600 m lower in elevation. It will require a significant amount of investment to develop this lake source as the water supply for Eburru hills.

The present project area is described as having medium agricultural development potential. However, due to a lack of water supply in the area, regional physical development has been suspended.

Further, the Government (Ministry of Energy and Regional Development) is carrying out a geothermal power development programme in this project area. In the series of exploration work planned in the programme, test boring of exploration wells is scheduled, for which a certain amount of water is urgently needed. The MERD requested the Ministry of Water Development (MOWD) to provide water for the above purpose.

Based on the above background, MOWD requested the Government of Japan to implement the Eburru Water Supply Project under Japanese Grant Aid. In response to this request the Government of Japan decided to conduct a study and JICA dispatched a basic design study team to Kenya in July, 1984.

The objective of the present project is to construct water supply facilities utilizing the water source of Lake Naivasha to provide water for domestic and livestock use in Eburru hills and its vicinity an area of about 150 $km^2$, and to supply water for geothermal development uses which are also needed in the project area.

To comply with the above objective, a plan to construct water supply facilities with a capacity of 1,300 $m^3$/day on the basis of the estimated water demand in 2006 is covered in this study.

The proposed water supply system starts from the raw water intake located at the north lakeshore at Lordia. Water is pumped to the treatment plant constructed near the lake. After this, the treated water is boosted by pumping to the Eburru hills through a 9 km transmission pipeline. At the end of transmission pipeline, a storage reservoir will be provided to store water for distribution by gravity.

Major facilities investigated in this study include the following:

(1) Intake pipe and pumps

(2) Water Treatment Plant: Slow sand filters, chlorination equipment, and clear water reservoir

(3) Transmission Facilities: Transmission pumps, booster pumps at four stations, transmission pipeline with 150 mm in dia. and approx. length of 9 km.

(4) Distribution Facilities: Distribution reservoirs – 700 $m^3$ one unit and 100 $m^3$ one unit, distribution pipelines ranging from 40 mm to 150 mm in dia. and for a total length of about 30 km.

The project executing agency is the Ministry of Water Development which is in charge of planning and construction of all water development projects, including the largest water undertaking in the country. The present project is being implemented under the administration of MOWD Headquarters. After construction completion, operation and maintenance will be handled by full-time operators trained at MOWD's training centre and other technical institutes.

By implementing this project, it is possible to improve the sanitary environment of the people by supplying clear and sufficient amounts of water, and to develop the agricultural industry by providing enough water for livestock.

Also by supplying water for geothermal development, in the future when the geothermal power plant is built in this area, not only the regional physical development but also the national economic development will be enhanced by the abundance of geothermal power energy.

Considering the above advantages, it is recommended to implement the proposed water supply project under Japanese Grant Aid.

However, the O & M costs for the proposed facilities are estimated to be higher than the average rural water supply in the country. Therefore, MOWD is recommended to handle this with an appropriate management policy.

Further, MOWD is recommended to engage well trained operators for the new water supply system, since it will have multistage booster pump facilities which require selective and optimized pump operation.

To achieve successful project implementation, the Government of Kenya or MOWD is expected to carefully adopt appropriate solutions.

REPUBLIC OF KENYA
MINISTRY OF WATER DEVELOPMENT

REPORT ON
BASIC DESIGN STUDY FOR
THE WATER SUPPLY PROJECT
FOR EBURRU REGION

## TABLE OF CONTENTS

## LIST OF TABLE

## LIST OF FIGURE

# 1. INTRODUCTION

Over 87 per cent of the people live in the rural areas in Kenya. Providing water facilities to the rural communities therefore has been an important component of the Government's development strategy. The Rural Water Supply Programme, which started in 1970, is being intensely implemented and will be one of the most important activities of the Ministry of Water Development (MOWD) during the Fifth Development Plan period. Priority will be given to the implementation of over 200 schemes which are under different stages of design and construction. A total amount of K£ 62 million has been set aside for the implementation of the programme over the Plan period. A rehabilitation programme of over 40 Rural Water Supply projects has also been planned at an estimated cost of K£ 3.1 million.

In addition to the above, the Government will continue to give technical advice, material and financial support to self-help endeavours. The resources allocated for such self-help water supply programmes in the development budget will be K£ 18.1 million.

By the end of the Plan period, 30 per cent of the rural areas will have access to improved water supplies. In 1988, the served population would grow to 5.5 million by this programme.

The MOWD has responsibility for the country's water supply development and it is also the largest undertaker of water supply projects. The MOWD has given the highest priority to the water supply scheme of Eburru where no local sources of water supply are available.

Further, MOWD was requested by the MERD to supply water for geothermal power development in the Eburru area. Under these circumstances, MOWD made a request to extend the Japanese Grant Aid to the multipurpose development of the water supply to encompass domestic, livestock and geothermal development uses in the study area.

In response to this request, the Japan International Cooperation Agency (JICA) dispatched a basic design study team headed by Mr. T. Imazu, Basic Design Division, Grant Aid Department, JICA to conduct a field survey for the basic design survey from 15th July to 11th August, 1984. Based on this field survey and subsequent analyses made during home work in Japan, this study report was prepared.

The minutes of discussions for the survey were prepared based on both parties' consent to report to both governments, and the copy is attached as Appendix 1 of this report. The team member list and the schedule of the field survey are presented in Appendices 2 and 3 respectively.

## 2. BACKGROUND OF THE PROJECT

### 2.1 National Level

The Government of Kenya stated in the Fifth Development Plan the theme of "mobilizing domestic resources for equitable development".

The nation's external debt service burden is approaching its prudent limit. The critical issue the nation now faces is to make every conceivable effort to mobilize the nation's resources in a major domestic development scheme. The Government, therefore, is attempting to promote external trade as well as to increase private savings, and to lighten the burden of financial debts. The Government is also setting targets of more effective government administration, curtailment of non-essential investments and cost sharing with beneficiaries of public services.

Meanwhile, to supplement domestic funds, external funds are needed, and such activities as foreign investment and technology transfer are welcomed. Regarding development funds procurement, commercial loan applications are regulated. On the contrary, soft loans and grants from international lending agencies and friendly nations are much sought.

Key economic and social indicators for the period 1980 to 1983 are presented in Table 2-1. Details of the performance of the various sectors of the economy are presented in Table 2-2.

Among the sectoral patterns of development, projects and programmes for social infrastructure are focussed on herein.

Previous development plans have emphasized the importance of infrastructure facilities for all modes of transport and communications, the building and construction industry, and the energy sector. Concerted efforts to improve basic infrastructure in these areas have contributed to development in other sectors, particularly Agriculture, Industry and Commerce. The basic economic criteria applied in the planning of infrastructure development has been optimization of returns on investment of public funds. Also, in the planning and co-ordination of project implementation and management, emphasis has been placed on capacity utilization and facility maintenance. These will continue to be the guiding principles throughout the 1984-88 Plan period.

## Table 2-1
## Key Economic and Social Indicators, 1980-1983

| | | 1980 | 1981 | 1982 | 1983* | | |
|---|---|---|---|---|---|---|---|
| 1. Population | (million) | 16.67 | 17.34 | 18.04 | 18.78 | | |
| 2. Growth of G.D.P. at constant prices | (percent) | 3.3 | 5.3 | 3.4 | 3.9 | | |
| 3. G.D.P. at market prices | (K£mn) | 2,632 | 3,039 | 3,399 | 3,809 | | |
| 4. Net cost of petroleum products (K£mn) | (K£mn) | 116 | 200 | 179 | 214 | | |
| 5. Exports of merchandise | (K£mn) | 516 | 475 | 510 | 614 | | |
| 6. Imports of merchandise | (K£mn) | 960 | 972 | 940 | 949 | | |
| 7. Trade balance | (K£mn) | -443 | -395 | -332 | -276 | | |
| 8. Balance of payments | (K£mn) | -329 | -336 | -253 | -116 | | |
| 9. Coffee production | ('000 tonnes) | 91.3 | 90.7 | 88.4 | 95.3 | | |
| 10. Tea production | ('000 tonnes) | 89.9 | 90.9 | 95.6 | 119.3 | | |
| 11. Maize production | ('000 tonnes) | 1,584 | 1,967 | 2,349 | 2,178 | | |
| 12. Wheat production | ('000 tonnes) | 205 | 204 | 235 | 242 | | |
| 13. Sugar cane production | ('000 tonnes) | 3,972 | 3,822 | 3,108 | 3,286 | | |
| 14. Milk sold | (mn litres) | 187 | 222 | 236 | 315 | | |
| 15. Change in manufacturing output volume | (percent) | +5 | +4 | +2 | +5 | | |
| 16. Construction output | (K£mn) | 351 | 403 | 402 | 404 | | |
| 17. Change in construction output volume | (percent) | +6 | +8 | -12 | -14 | | |
| 18. Cement consumption | ('000 tonnes) | 730 | 712 | 581 | 404 | | |
| 19. Petroleum consumption | ('000 tonnes) | 1,671 | 1,585 | 1,489 | 1,373 | | |
| 20. Electricity consumption | (mn kwh) | 1,538 | 1,663 | 1,701 | 1,747 | | |
| 21. Tourism earnings | (K£mn) | 83 | 90 | 118 | 122 | | |
| 22. New registrations of vehicles | (Number) | 23,246 | 18,115 | 15,061 | 13,479 | | |
| 23. Rail freight | (mn ton/km) | 2,277 | 2,241 | 2,097 | 2,091 | | |
| 24. Air passengers handled | ('000) | 1,847 | 1,972 | 1,900 | 1,928 | | |
| 25. Consumer price increase | (percent) | 12.8 | 12.6 | 22.3 | 14.6 | | |
| 26. Wage employment | ('000) | 1,006 | 1,024 | 1,046 | 1,093 | | |
| 27. Education – primary enrolment | ('000) | 3,929 | 3,981 | 4,184 | 4,324 | | |
| 28. Education – secondary enrolment | ('000) | 399 | 411 | 438 | 494 | | |
| 29. Education – higher enrolment | ('000) | 20.9 | 23.3 | 21.7 | 24.0 | | |
| 30. Hospital beds and cots | (Number) | 27,691 | 28,108 | 29,044 | 29,294 | | |
| 31. Registered doctors and dentists | (Number) | 1,853 | 2,254 | 2,390 | 2,655 | | |
| Index Number; (1976 = 100) | | | | | | % Change 1982-1983 | Annual % rate of change 1976-1983 |
| 1. Export volumes | | 97 | 92 | 89 | 85 | -4.5 | -2.3 |
| 2. Import volumes | | 133 | 104 | 88 | 80 | -9.1 | -3.1 |
| 3. Terms of trade | | 89 | 77 | 73 | 78 | +6.8 | -3.5 |
| 4. Money supply | | 191 | 217 | 252 | 264 | +4.8 | +14.9 |
| 5. Total domestic credit | | 212 | 264 | 341 | 341 | – | +19.2 |
| 6. Consumer prices | | 155 | 175 | 214 | 245 | +14.6 | +13.6 |
| 7. Real wages | | 92 | 95 | 83 | 77 | -7.0 | -3.9 |
| 8. Recorded wage employment | | 116 | 118 | 120 | 125 | +4.5 | +3.2 |

* Provisional.

## Table 2-2
## Gross Domestic Product, 1980-1983

K£million

| | Current Prices | | | | Constant (1976) Prices | | | |
|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983* | 1980 | 1981 | 1982 | 1983* |
| A. Traditional economy | | | | | | | | |
| Forestry | 16.66 | 19.22 | 21.71 | 24.95 | 10.69 | 110.06 | 11.44 | 11.83 |
| Fishing | 0.55 | 0.82 | 1.03 | 1.21 | 0.37 | 0.43 | 0.55 | 0.59 |
| Building and construction | 41.57 | 46.20 | 48.96 | 52.38 | 25.74 | 25.73 | 26.46 | 27.17 |
| Water collection | 15.10 | 17.12 | 19.29 | 21.77 | 9.79 | 9.95 | 10.10 | 10.25 |
| Ownership of Dwellings | 57.79 | 67.41 | 73.59 | 91.95 | 34.54 | 35.95 | 37.42 | 38.89 |
| Total traditional economy | 131.67 | 150.77 | 164.58 | 192.26 | 81.13 | 83.12 | 85.97 | 88.73 |
| B. Monetary economy | | | | | | | | |
| 1. Enterprises and non-profit institutions | | | | | | | | |
| Agriculture** | 688.13 | 791.74 | 907.16 | 1,030.61 | 522.03 | 554.39 | 578.88 | 602.61 |
| Forestry | 13.96 | 16.98 | 21.14 | 24.94 | 7.70 | 8.13 | 8.48 | 8.90 |
| Fishing | 4.37 | 6.56 | 8.27 | 9.89 | 2.97 | 3.43 | 4.55 | 4.94 |
| Mining and quarrying | 5.73 | 5.16 | 5.78 | 6.20 | 4.05 | 3.32 | 3.32 | 3.32 |
| Manufacturing** | 295.14 | 342.44 | 384.44 | 408.26 | 212.95 | 220.74 | 225.64 | 235.88 |
| Electricity and Water | 32.48 | 41.00 | 46.98 | 54.98 | 21.21 | 22.94 | 23.98 | 25.02 |
| Building and construction | 105.17 | 121.00 | 120.58 | 127.81 | 63.21 | 68.37 | 60.39 | 57.86 |
| Trade, restaurants and hotels | 244.66 | 274.03 | 299.22 | 346.25 | 171.15 | 171.09 | 167.96 | 172.73 |
| Transport, storage and communications** | 127.81 | 143.39 | 164.10 | 195.25 | 93.46 | 94.86 | 99.22 | 106.51 |
| Finance, insurance, real estate and business services | 135.68 | 168.82 | 206.92 | 233.95 | 97.36 | 110.09 | 123.16 | 129.25 |
| Ownership of dwellings | 103.41 | 127.42 | 145.90 | 163.48 | 69.97 | 76.57 | 82.23 | 85.30 |
| Other services | 49.41 | 56.15 | 62.68 | 70.15 | 35.82 | 38.26 | 41.94 | 43.56 |
| Less: Imputed bank service charges | -62.86 | -71.21 | -84.19 | -96.82 | -45.11 | -46.39 | -50.11 | -53.49 |
| Total | 1,743.09 | 2,023.48 | 2,288.98 | 2,574.95 | 1,256.77 | 1,325.80 | 1,369.64 | 1,422.35 |
| 2. Private households (Domestic services) | 28.15 | 32.07 | 36.96 | 42.53 | 19.29 | 20.90 | 22.30 | 23.75 |
| 3. Producers of government services | | | | | | | | |
| Public administration | 71.30 | 87.22 | 90.87 | 95.59 | ... | ... | ... | ... |
| Defence | 14.90 | 14.35 | 17.75 | 24.92 | ... | ... | ... | ... |
| Education | 154.18 | 178.19 | 200.04 | 213.74 | ... | ... | ... | ... |
| Health | 36.16 | 41.64 | 48.22 | 51.36 | ... | ... | ... | ... |
| Agricultural services | 22.24 | 27.67 | 31.73 | 33.83 | ... | ... | ... | ... |
| Other services | 33.68 | 41.85 | 52.75 | 61.98 | ... | ... | ... | ... |
| Total | 332.46 | 390.91 | 441.35 | 481.41 | 233.47 | 245.84 | 255.18 | 265.89 |
| Total monetary economy | 2,103.70 | 2,446.46 | 2,767.29 | 3,098.89 | 1,509.53 | 1,592.54 | 1,647.12 | 1,712.03 |
| Total traditional and monetary economy | 2,235.37 | 2,597.23 | 2,931.87 | 3,291.15 | 1,590.66 | 1,675.66 | 1,733.09 | 1,800.76 |
| Gross domestic product per capita K£ | 133.42 | 149.34 | 162.41 | 175.64 | 94.94 | 96.35 | 96.01 | 96.10 |

* Provisional.

** Later data and observation indicate that these estimates need to be revised upwards. The revisions will however have a small impact on the annual growth rates.

Out of the total social infrastructure development plans, those for the water supply and electricity sectors are separated and briefly described as follows:

(1) Water Supplies

The main objectives for water development during the Fifth Plan period will remain essentially the same as those for the Fourth Development plan.

That is: (a) to provide potable water supplies, to all rural and urban population balancing those supplies between human needs, requirements for livestock development, and the needs of the industrial sector, (b) the management and development of water resources to achieve multi-purpose development goals, and (c) the adoption of water distributive practices and water pricing policies which will ensure that social objectives are not ignored.

Strategies and Policies for Rural Water Supplies

The strategies to be adopted for the rural areas will be:

(a) to provide water facilities within reasonable distances, i.e., 1 km in the high and medium potential land areas, and 5 km in the low potential areas. Those that will require connections to private homesteads will meet the cost of such connections.

(b) the provision, operation and maintenance of water supply facilities will be undertaken primarily through joint efforts between the Government and the beneficiaries.

(c) the current design standards for both urban and rural water supplies appear to be too high in relation to the needs and the costs. The Government will undertake a review of these standards aiming at cost-effectiveness and increased coverage with the available resources.

(d) cost recovery will be an essential element in the water supply programmes. Pricing policy for water is critical in this respect. In the rural areas generally, water rates should cover at least the direct operation and maintenance costs of the water supply.

Urban Water Supplies

The rapid growth of the major towns in the country has led to the need to expand water facilities in these centres. During past development plans, augmentations and expansions have taken place in Kisumu, Eldoret, Kitale, Embu, Mombasa, Nakuru, Thika, Nyahuru and other district head-quarters. During this Plan period, the MOWD will undertake to complete 24 minor Urban Water projects as compared to 15 completed during the 1979-83 period. Other projects to be commenced will include the Greater Nakuru Water Supply Project as well as further construction work for District and Divisional head-quarters. A total of K£ 32.2 million has been set aside for the urban water supply programme. It is expected that by 1990 the water coverage of the urban population will be about 4.5 million people compared to 2.8 million people in 1983.

(2) Electricity

The country's total potential for hydro-electric power generation is estimated at 30,150 million kwh per annum, however not all of it can be economically exploited. Much of the hydro potential is at the Tana River which is estimated at 15,350 million kwh per annum. Towards the end of the Plan period, the Kiambere hydro-electric power project will be commissioned. This will add 140 MW to the national grid system. The Turkwell gorge project with a capacity of 120 MW will be completed in the next Development Plan. The country has also good potential for geothermal energy which is conservatively estimated at 7,000 million kwh per annum. Already two units of 15 MW each capable of generating 200 million kwh per annum have been commissioned and the third of the same capacity is due for completion in the middle of 1985. Exploration for this form of energy will be intensified during the Plan period.

The Government intends to undertake electric power development over the Plan period with the following policy objectives:

(a) The role of Regional Development Authorities will be expanded in electrical facility planning, development and generation. The Kenya Power and Lighting Co. will have transmission and distribution responsibilities, while the Ministry of Energy and Regional Development will provide policy guidance.

(b) Geothermal explorations will be accelerated in order to determine the total commercially viable potential.

(c) In order to meet projected power demand growth, exploitation of proven commercially-viable geothermal wells will be accelerated.

(d) The country's hydro-electric power potential assessment study carried out in late 70's will be reviewed and updated.

(e) Electric tariffs will be maintained at levels sufficient to meet generation and transmission costs, while protecting low-income users from the full burden through graduated rates.

(f) The Rural Electrification Programme will be stepped up so as to provide a greater source of lighting energy to the rural population and to stimulate industrial and agricultural development in rural areas.

Electricity consumption for the year 1983 through 1988 is estimated as shown in the following table.

Projection of Electricity Consumption, 1983-88 (GWH)

| Year | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
|---|---|---|---|---|---|---|
| Units Generated | – | 2,176 | 2,307 | 2,446 | 2,592 | 2,748 |
| Units sold | 1,760 | 1,865 | 1,977 | 2,096 | 2,221 | 2,355 |

Source: Development Plan 1984 – 1988

The Government of Kenya subscribed to the goals of the "International Drinking Water Supply and Sanitation Decade, 1981-1990", and the declared targets to be achieved by 1990 are water supply coverage of 100% in urban areas and 75% in rural areas. At present, about 87 per cent of the total population live in the rural areas, and the implementation to achieve the above targets is to invest heavily in these rural areas. To this purpose about K£ 60 million of investment per year is estimated to be required.

This investment, for example, amounts to as much as about 17 per cent of the national development expenditure for one year. Thus, water supply development projects are very active. Projects ongoing and/or under planning or designing total almost 200 schemes at present. The major projects are presented in Table 2-3.

Table 2-3
Proposed Major Water Supply Projects

| Project Name | District | Aid Agency | Status | Project Cost (Million Ksh at 1981 prices) |
|---|---|---|---|---|
| 1. Garissa | Garissa | W. Germany | P.D. fin | 41 |
| 2. Greater Nakuru Phase I | Nakuru | France & others | P.D. | 552 |
| 3. Kajiado | Kajiado | IBRD | P.D. ongoing | 30 |
| 4. Oldirailmue | Nairobi | W. Germany | P.D. | 40 |
| 5. Kwale | Kwale | | P.D. | 30 |
| 6. Lamu Lake Kenyatta | Lamu | W. Germany | P.D. | 80 |
| 7. Macalder | South Nyanza | | P.D. | 30 |
| 8. Maguga Village | Kiambu | | P.D. | 30 |
| 9. Nyeri | Nyeri | W. Germany | P.D. fin | 100 |
| 10. Ruiru | Kiambu | W. Germany | F.D. | 58 |
| 11. Laikipia West | Lakipia | | F.D. | 73 |
| 12. Sotik | Kericho | | F.D. | 73 |
| 13. Eburru | Nakura | | Under planning | 50 |
| 14. Gembe Ph. 2 | South Niyanza | | P.D. | 70 |
| 15. Mwimbi Ph. 2 | Meru | U. Kingdom | P.D. fin | 24 |
| 16. Chepalung Ph. 3 | Kericho | | P.D. | 100 |
| 17. Embu Rural III | Embu | U. Kingdom | F.D. | 70 |
| 18. Kapatir | Turkana | SIDA | Under planning | 12 |
| 19. Mosizo | Narok | SIDA | P.D. | 11 |
| 20. Sigor-Longisa | Kericho | | F.D. | 150 |

Note: P.D. = Preliminary Design
F.D. = Final Design
SIDA = Swedish International Development Agency

The Ministry of Water Development has responsibility for all water supplies in the nation, and its 1984 development budget allocation is about 10 per cent of the total national development budget, which represents the fourth biggest allocation following that of the ministries of Transportation and Communication, Agriculture, and Energy. This demonstrates that priority is also given to this sector.

Table 2-4 indicates the development expenditure on water supplies and related services incurred by the Government and other public authorities during the period 1979/80 to 1983/84.

Foreign Aid for Water Development

Various aid agencies have supported the sector's important projects with large size loans and grants, Table 2-5 indicates the foreign financing in the period 1970 to 1980.

表 2 — 4

**Development Expenditure on Water Supplies and Related Services, 1979/80 – 1983/84**

K£'000

| | 1979/80 | 1980/81 | 1981/82 | 1982/83 | 1983/84* |
|---|---|---|---|---|---|
| Water Development | 5,828 | 12,338 | 970 | 558 | 845 |
| Training of Water Development Staff | 10 | 307 | 360 | 56 | – |
| Rural Water Supplies | 3,723 | 4,151 | 9,511 | 5,252 | 11,272 |
| Self-Help Water Supplies | 1,431 | 3,110 | 5,199 | 2,900 | 4,541 |
| Country Council and Urban Water Supplies | 3,431 | 3,110 | 11,600 | 5,591 | 4,734 |
| Miscellaneous and Special Water Programmes | 806 | 939 | 4,828 | 2,698 | 745 |
| Total | 15,229 | 23,955 | 32,468 | 17,055 | 22,137 |

* Provisional.

Note: Source, Economic Survey 1984

Table 2-5
Foreign Financing, 1970 – 1980

| Financing Agency | Project | Year Implemented | Remarks |
|---|---|---|---|
| United Kingdom | Naivasha-Suswa Water Supply | 1970 | Loans |
| Sweden | National Water Master Plan | 1974 | Grants |
| | Rural Water Supply I, II and III | 1970 – 74 | Grants |
| Norway | Minor Urban Water Supply | 1974 | Grants |
| West Germany | Nakuru, Kisumu, Eldoreto, Malindi Water Supplies | 1973 – 75 | Loans |
| IBRD | Mombasa & Coastal Water Supply | 1975 – 79 | Loans |
| Japan | Ithanga Water Supply | 1977 | Grants |
| | Mombasa Water Augmentation Program | 1980 | Technical Assistance |

Source: WHO, IBRD Reports
Ministry of Finance 1978

## 2.2 Local Level

The project area is located in the administrative district of Nakuru in the Rift Valley Province, and in the Naivasha Division in which it overlies in two Locations of Naivasha and Gilgil, as shown on Fig. 2-1.

The present water supplies in Nakuru District, including the present project area, are composed of three urban water supplies, and more than ten rural water supplies, ranch water developments, and self-help water schemes. However, their details on the systems are not clear. In Naivasha Division, under the control of the Naivasha District Water Office, there are only two urban water supplies for Naivasha and Gilgil, and one rural water supply for Suswa and its neighboring area.

About the future water development plan, in and around the present project area, two comprehensive programmes have been under preparation in this Nakuru District; they are, (1) the Greater Nakuru Water Supply programme to supply water for Nakuru, six neighboring towns and their surrounding rural areas, and (2) the Eburru Water Supply programme, which is to cover a part of Naivasha and Gilgil towns and rural areas with about 720 km$^2$ of total supply area.

Both programmes have reached the stage of preliminary design studies completed in 1982, and are waiting their implementation. Details of the programmes are presented in Chapter 3 of this report.

Nakuru District has been growing in manufacturing industries, having a high industrial potential since it is located near Nairobi, along the highway connecting Uganda-Kenya. Rapid future development in agriculture industries is also expected.

According to the report "Rift Valley Province Regional Physical Development Plan, 1971", the agricultural development potential for this project area is defined based on the soil condition and climate of this area described as: medium quality soils, rainfall 700 – 1,000 mm. This category is principally found in Nakuru and Narok District where, the soil is excessively light and porous, and it tends to be too dry to support arable farming but does provide good grazing land. On areas of better soil, wheat or sisal may be grown and where irrigation is available as at Naivasha, horticulture is practiced.

According to reports prepared so far on geothermal energy resources, geothermal power development is expected in this project area at Eburru. As previously mentioned, the present project area is located in the Kenyan Rift Valley which is well known as part of the East African Great Rift Valley, which has volcanic activities and a geothermal field.

The Government of Kenya is intensely implementing studies on utilization and development of alternative energy sources, such as alcohol, solar energy, and geothermal power the petroleum-based energy of the future. Among others, geothermal power development is going to be the backbone of the Government's energy policy.

The Government first started geothermal exploration surveys in the 1950's in the Olkaria area. In the period 1970 to 1974, associated with UNDP the Government carried out extensive geological, geophysical, hydrogeological, and geochemical surveys in the southern part of the Rift Valley. In this period, the major geothermal fields were evaluated and the three fields of Olkaria, Eburru and Lake Bogoria were selected as the most suitable areas for geothermal power development.

In Olkaria, which had a priority for development, drilling commenced in 1973 with the assistance of UNDP, and IDA assisted in constructing the geothermal plant. Phase I of the Olkaria geothermal power station was completed in 1981 and the first 15 megawatts (MW) of geothermal turbo-generation in Africa was commissioned and placed into continuous operation. The second phase of the project was completed and another 15 MW turbine commissioned in November 1982. The third phase development is now underway with a development capacity of 15 MW by the year of 1985.

Meanwhile, the Eburru and Lake Bogoria fields have been left in the exploration stage without any intensive investment for power plant construction due to the lack of financing and the availability of technical staff. Thus development is still waiting for foreign assistance.

Based on the study results of the UNDP survey, the total Rift Valley fields are estimated to have about 500 MW of geothermal power potential, and the Government is planning to develop geothermal power production of about 200 MW in this field in the next 15-20 years.

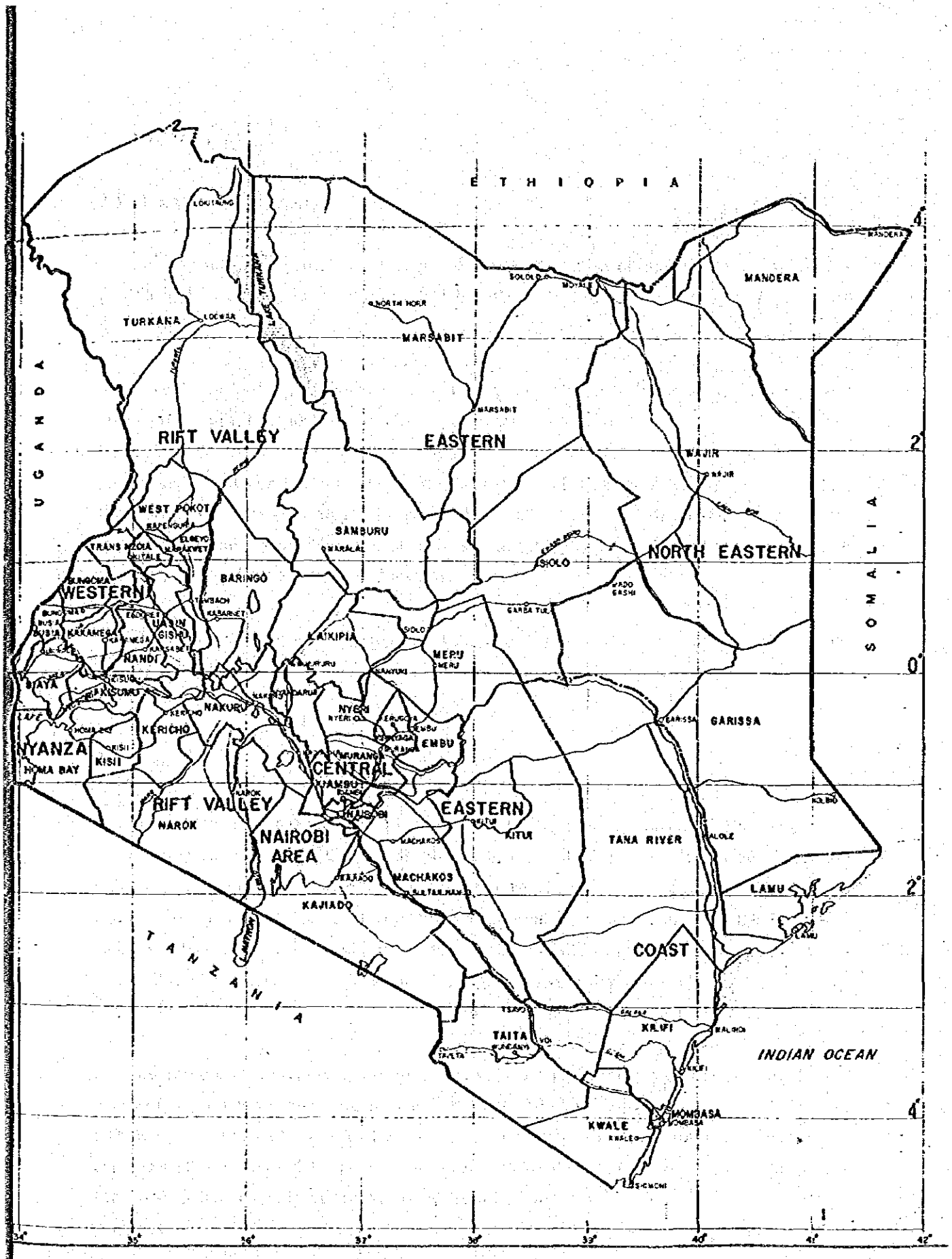



Fig. 2-1 Kenya Administrative Boundaries

# 3. PROJECT AREA

## 3.1 Location and Communication

The centre of the project area is situated in the Great Rift Valley of Kenya at latitude 0°39'S and longitude 35°17'E, and stretches about 10 km east to west and 18 km north to sourth.

Lake Naivasha forms the southern boundary, and about 20 km away from the project area to the south, the Olkaria geothermal power station is located.

Meanwhile, Lake Elementeita, Gilgil township and Nakuru township are located to the north of the project area. The national highway A104 runs from Nairobi to Nakuru via Naivasha and Gilgil. The project area is connected by a rough road for a distance of about 20 km to the highway near Naivasha.

The distance between Naivasha and the project area is about 150 km, which is about a two hour car drive.

## 3.2 Climate

The Project area has an annual mean maximum temperature varying from about 26°C on the eastern side to 18°C towards Eburru forest and Kiambogo Estate. Similarly, the annual mean minimum temperature varies from 14°C to 6°C. The evaporation loss in the project area is approximately 1,700 mm per annum. It is humid on the high lands like Eburru with a relative humidity upto 90% during the morning and 80% during the afternoon. But in the low lying areas, the atmosphere is very dry and is characterized by dry winds.

The rainfall is generally distributed in two seasons, like most of the area in Kenya. The wet seasons have long rains in March to May and short rains in October to December, although some parts like Eburru hills do receive extensive short rains during August. However, the seasons have their peak in April and November with more precipitation during the April season. There is a drought period from December to March.

## 3.3 Topography and Geology

The general topography of the area is as shown on Fig. 4-1. The Eburru area is bounded by the 2,600 m contour on high land falling steeply to Lake Naivasha at approximately 1,900 m on the sourthern side. According to the JICA report on "Geothermal Development Survey-Second Year, 1980", and the report titled "Geology of the Naivasha Area", in the project area, distinguish Lake Naivasha, the Eburru mountains and numerous volcanic craters and steam jets, into the following two groups:

(1) Lavas and pyroclastics and (2) Lacustrine deposits

The lavas range from undersaturated basic rocks to acid rocks with numerous gradations in between. The rift floor is largely covered with sediments that have accumulated in lakes during the Gamblian stage of the Pleistocene period. They contain a large portion of volcanic ejecta and a few diatomaceous beds are known to occur.

## 3.4 Population in the Project Area

The present population in the project area, as of August 1984, was obtained by field survey, which is shown with sub area breakdowns as follows:

| Sub area | Population |
|---|---|
| Eburru Settlement area | 4,000 |
| Lake Naivasha & Malewa area | 2,400 |
| Total | 6,400 |

In the other relating report on Eburru water supply, the population for areas in the Eburru settlement and lake side were estimated at 4,010 and 2,005 respectively for 1985.

The average population growth rate, for the 10-year period from 1969 to 1979, for Nakuru District including the present project area was recorded at about 6% per annum. The urban and rural areas in Naivasha Division were recorded at 5.2% and 6.3% respectively. The population growth rate for the whole nation at the same period was 3.4%. Therefore the growth rates of the project area are considerably higher than the nations average, see Table 3-1.

**Table 3-1**
**Population and Growth Rate by Census**

| Area | 1969 Census | 1979 Census | Population Growth Rate (% per annum) |
|---|---|---|---|
| Whole Nation | 10,943,000 | 15,327,000 | 3.43 |
| Rift Valley Province | 2,224,085 | 3,240,402 | 3.84 |
| Nakuru District | 290,853 | 552,709 | 6.04 |
| Naivasha Rural | 21,035 | 38,858 | 6.33 |
| Gilgil Rural | 13,035 | 26,234 | 7.24 |
| Eburru Forest | 23 | | Ave. 6.79 |
| Gilgil Rural | 2,626 | | |
| Elmentaita | 3,278 | | |
| Eburru | 3,698 | | |

### 3.5 Infrastructure and Public Facilities

The public road system in the project area is not well developed. It is observed that this area is generally ranch farming area, and houses are scattered. Electricity and telephone services are available only along the main roads in the area.

As discussed in Chapter 4, the existing schools in the project area consist of two primary schools and one secondary school, which are generally of Harambee type organized by the farm people and the parents of the children working on the farms donate money and build these schools.

There are two health dispensaries in the project area, one at Eburru and the other at Lordia with a few alotted staff who fluctuate in numbers due to various reasons. However, shortage of drugs and other essential supplies due to financial constraints and inefficient distribution has caused difficulties in running the dispensary. The project area is also served by mobile health units. However, residents usually go to hospitals in Naivasha for medical treatment.

### 3.6 Land Use and Industries

Although the project area generally consists of grazing land suited for both dairy and ranching livestock development, there are pockets of arable land like Eburru Settlement where subsistence crops of maize, beans and potatoes are normally gorwn. In Eburru Settlement, cash crops such as pyrethrum, castor oil, barley and wheat are also grown.

The cash crops are growing in land areas of about 140 ha, 700 ha and 300 ha for pyrethrum, wheat and barley, respectively.

There are many small farmers who own between 0.4 and 1.2 ha of land. These farmers usually grow crops and do not keep cattle because they can not afford to. They would normally plant the whole of the plot with maize interplanted with beans and even potatoes as subsistence crops. Usually they eat what they grow and sell a little for other necessities. Pyrethrum is sold through the Pyrethrum Board of Kenya and wheat through the Kenya Farmers Association.

The number of livestock in the project area is not comfirmed exactly. The study team estimated the following number of livestock while conducting the field survey.

| | |
|---|---|
| Dairy cattle | 855 |
| Beef and native cattle | 2,630 |
| Sheep and goats | 1,370 |
| Total | 4,855 |

The above figures are converted into livestock units, and the equivalent total becomes 1,800, which is about 0.28 head/person for the present population in the area. The number of livestock units in the Naivasha division, was 35,000 in 1983 and on the basis of area population, the livestock units per population was estimated at about 0.3 head/person.

### 3.7 Present Water Supply in Project Area

At present, there are no piped water supply systems in the project area except those privately owned or operated by a farm company. In the Eburru hill area, especially, only facilities for steam vents exist.

In the lake area, farms are supplied water from the lake by pumping for irrigation and livestock use. Deepwells (bore holes) are developed in the area for the resident's drinking water.

There are two major steam vents C 2870 and C 2887 plus many small steam vents, used as sources for drinking water. The depths of these holes are 105 m and 97 m respectively. These two steam vents, after condensing steam to water, are inter-connected. The condensate from these vents is distributed to four ground storage tanks (3 at 45 $m^3$ and 1 at 90 $m^3$) by 50 mm dia G.I. pipe. There are totally four communal water points. The water is used without any treatment.

Average water usage in Eburru is estimated at approximately 80 l/family/day according to information obtained at the Eburru Cooperative Office. From this amount, the average per capita use was estimated at 10 – 15 lpcd. People who live away from the lake, and further have no water sources so have to bring water for a considerable distance on their back and/or by way of using matatu. Water transporting is generally the task for women and children, which is common not only in the area but throughout the rural area in this country.

### 3.8 Water Sources in the Project Area

Water sources for the present project area are: (1) Lake Naivasha, (2) Boreholes in the lake area, (3) Gilgil river, and (4) Malewa river. Gilgil river has a low flow of about 860 $m^3$/day, and flows from Bahati forests through fairly gradual sloping ground in the south-easterly direction to join the lake.

The Malewa is a major perennial river fed by several tributaries flowing the Aberdare mountains. This river flows in a southerly direction in the vicinity of the project area. The stream data on this river show the minimum flow at about 1.33 $m^3$/sec or 14,910 $m^3$/day.

There are 11 boreholes at present in the lake area, and their average yield is estimated at about 18 $m^3$/hr (440 $m^3$/day). Water quality of the well water in this area can generally be described as rich in minerals containing karium, natorium and calcium. Also well water has the characteristic of high alkalinity, and with slightly high fluoride concentrations.

The most promising water source for the project area is Lake Naivasha. According to the report titled "Geology of Naivasha Area (1963, Geology of Kenya)", in the period 1910 to 1930, the lake elevation was approximately 6,200 – 6,210 feet (1,891 – 1,984 m), and at the beginning of 1956 the water surface was approximately at the 6,184 foot con-

tour, and thereafter in 1960's not exceeding 6,195 feet. Water depth in this lake was measured in the 1920's. The deepest part had about 34 feet with more than half of the lake area exceeding a depth of 27 feet. The Lake area, in 1956, was estimated at about 95 km², when the lake surface was 6,184 feet above sea-level.

Presently, the lake surface is relatively stable with its elevation at about 1,889 m, see Table 3-2. The annual surface variation currently is about 90 – 100 cm according to a farm owner living on the lake. The water depth at the proposed water intake site for this project was about 1.7 – 1.8 m, when the water elevation was lower than average.

Water quality of the lake water varies however, the results of water quality analyses on the water sample, taken from the proposed intake site, demonstrated that the lake water is amenable to normal treatment methods for drinking water. The water quality analyses for two samples are presented in Appendix 5.

### 3.9 Other Related Water Supply Schemes

Two preliminary design studies were made by MOWD on water supply schemes in and around the present project area. A French aid project to include a part of the Greater Nakuru Water Supply Project (Phase 1) has been implemented in 1984.

The above two schemes are briefly described as follows.

#### (1) Greater Nakuru Water Supply Project (May 1982)

This program covers the supply of water to Nakuru, neighboring six towns, and their surrounding rural areas, and for about 950 thousand people with about 150,000 m³/day of water in 2005. Major components of the programme are:

- Project Area: Approx. 6,000 km²
- Served Population: in 1985 427,000
  in 2005 547,000
- Water Demand: in 1985 50,480 m³/day
  in 2005 148,400 m³/day
- Proposed Water Source: Londiani River
  Malewa River
  Eldama River

(2) Eburru Water Supply Project (March 1982)

This project includes supply of water to part of Gilgil and Naivasha towns with an area of about 720 km²; a population of about 56,000 with about 7,100 m³/day of water in 2005.

The present project area is included in this project.

Major items of the programme in the project are:

- Proposed Served Population: in 1985 22,000
  in 2005 56,000
- Water Demand: in 1985 2,710 m³/day
  in 2005 7,110 m³/day
- Proposed Water Source: Turasha River

As described before, MOWD selected the present project, with the first priority of implementation, out of the above concurrent water supply programmes. The main reasons for its selection are (1) Eburru hill area, the core of the present project area, has no available water source except steam vents, and is suffering serious difficulty in obtaining water for people and livestock compared to neighboring areas, and (2) the present project area is close to Lake Naivasha which has enough fresh water to be utilized effectively with optimum size of the water supply system not only for the domestic and livestock uses but also for the geothermal development use in the project area.

Table 3-2
Lake Naivasha Water Levels

| Year | Max. Stage (m) | Min. Stage (m) |
|---|---|---|
| 1970 | 1,890.19 | 1,889.59 |
| 1971 | 1,890.30 | 1,889.52 |
| 1972 | 1,890.06 | 1,889.44 |
| 1973 | 1,888.67 | 1,888.57 |
| 1974 | 1,888.84 | 1,888.16 |
| 1975 | 1,888.93 | 1,888.14* |
| 1976 | 1,888.70 | 1,888.13* |
| 1977* | – | – |
| 1978 | 1,890.49 | 1,889.33 |
| 1979 | 1,890.82 | 1,890.34 |

*: Only a few data taken.

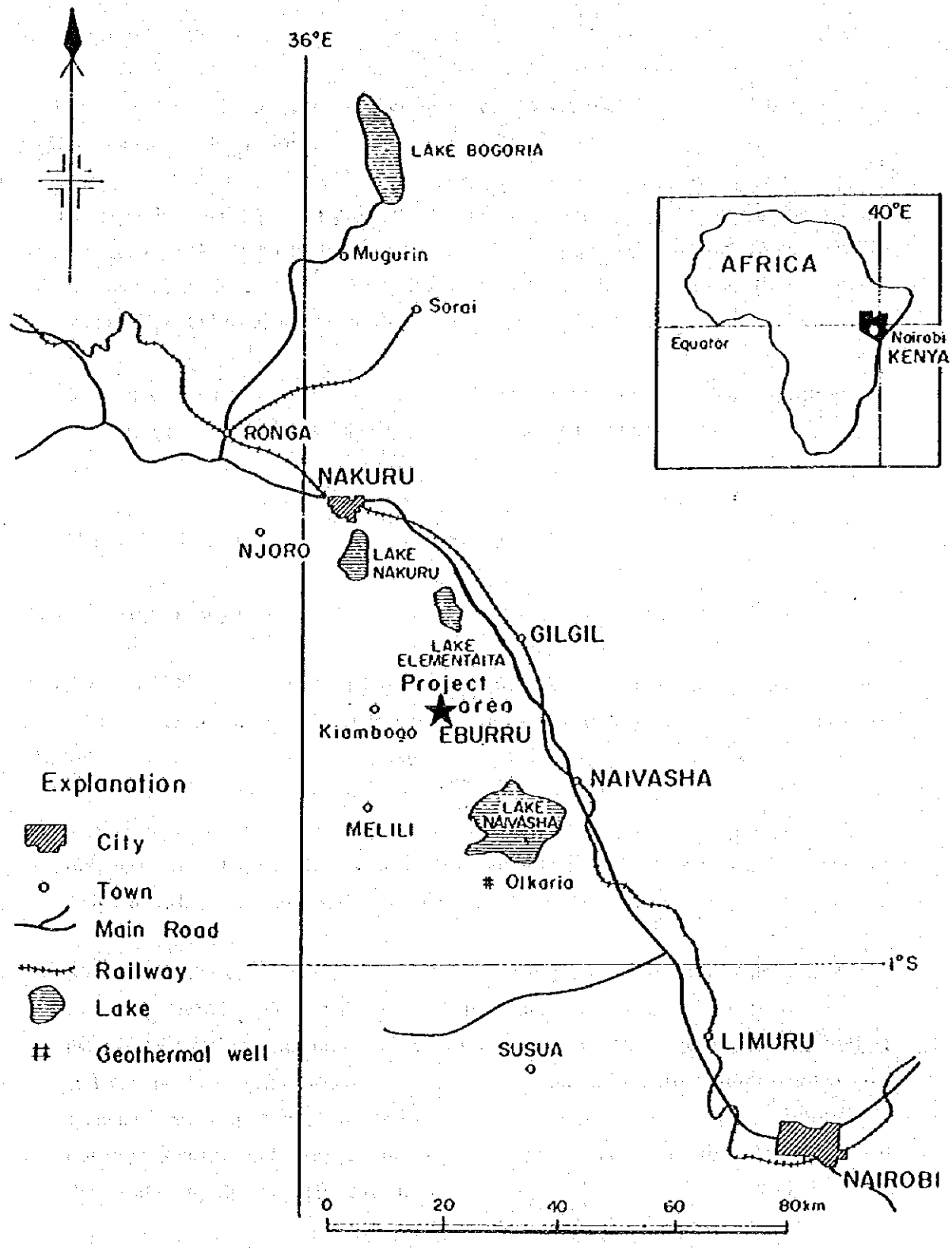



Fig. 3-1 Location of Project Area

# 4. OUTLINE OF PROJECT

## 4.1 Objective of Project

Based on the request of the Government of Kenya, the objective and the scope of project are identified as follows.

The objective of the present project is to construct water supply facilities utilizing the water source of Lake Naivasha to provide water for domestic and livestock uses in Eburru hills and its vicinity an area of about 150 km², and to supply water for geothermal development use expected to be needed in the project area as well.

The project area is shown in Fig. 4-1, and the detailed discussions on the proposed population to be served and water demand are made in the following section.

## 4.2 Master Plan for Project

### 4.2.1 Priority of Project

Priority of the present project has been confirmed through the analysis of data and information obtained during the field survey. The supporting material to justify priority is as follows:

(1) The present means to obtain drinking water for the population in the project area only achieves 10 lpcd. It can be interpreted that the residents in the area are not satisfied with this minimal satisfaction of basic human needs.

(2) Studies on the water supply project covering the present project area have been prepared by MOWD, and based on these, two schemes have been put on the waiting list for project implementation. Due to the chronic insufficiency of the local budget and having no specific proposal for foreign aid and support from international loan agencies, the project implementation timing is uncertain. If the present project is not implemented, water supply for the present project area may not be realized until these water supply schemes are realized.

(3) The sanitary or environment conditions in the Eburru area are not satisfactory due to lack of water, therefore, people cannot enjoy a comfortable daily life. Although the Eburru settlement scheme was one of the national settlement schemes, so far any water supply facilities have not been provided. Lack of water supply has resulted in very little development in this settlement scheme.

### 4.2.2 Design Year

The Design Manual of MOWD is prescribes the design years of a water supply programme as follows:

(1) Initial Year: The year when the supply is expected to be placed into operation

(2) Future: 10 years from the initial year

(3) Ultimate: 20 years from the initial year

The proposed completion of present project construction is the middle of 1986, therefore, the above design years can be set at (1) 1986, (2) 1996 and (3) 2006, respectively. Based on this, water demand in the project area is forecast for the above design years.

The design capacity of the facilities for the present project is defined as sufficient to supply water for the ultimate design year, or 1,300 $m^3$/day in 2006.

The service area to be covered by the present project was prepared by MOWD as the requested project scope, and the study team confirmed the area as valid, which is shown in Fig. 4-1.

### 4.2.3 Population Projection and Consumers Estimate

The future population in the project area has been estimated utilizing the population projection standards of MOWD taking into account the related development planning in Kenya.

Basic population in sub-locations of the project area was not obtainable from the 1979 population census, therefore, in this study the estimated present population of 6,400 (1984) was used as the base for future population projections.

Population Growth Rate

As discussed in Chapter 3, the average annual population growth rate in the 10 year period from 1969 to 1979 was rather high at 6 – 7% in the project area. This can be explained by a high emigration rate to this area during this period.

The Eburru settlement scheme has almost been completed, therefore, a high population increase is not estimated for the future. Using the most prevailing annual growth rate of 4%, the future population in the project area is projected as shown in Appendix 6.

In addition to the above projection, and for comparison purposes the growth rates of 3.0%, 3.5% and 4.5% were applied for population projection and are also shown in Appendix 6.

According to the National Master Water Plan, MOWD, (Chapter 10 Population Projection), the annual average growth rate for the period in 1978-2000 for Nakuru District was set at 4.17%. The present project area is considered to have a medium level of agricultural development potential, but is expected to become a high potential area in the future when water supply is provided, especially the area in Malewa, which could have a population increase by emigrants when water supply is provided. Taking into account the above expected population increase, future population in the project area is forecast as shown below. The overall population growth rate in the period 1996-2006 is estimated at 4.6%.

**Table 4-1**
**Future Population and Population Density**

| Sub area | Area ($km^2$) | 1984 | | 1986 | | 1996 | | 2006 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Population | Pop. Density (per $km^2$) | Population | Pop. Density (per $km^2$) | Population | Pop. Density (per $km^2$) | Population | Pop. Density (per $km^2$) |
| Eburru | 56 | 4,000 | 71 | 4,330 | 77 | 6,400 | 114 | 9,480 | 169 |
| Lake area | 54 | 2,300 | 43 | 2,490 | 46 | 3,680 | 68 | 5,450 | 101 |
| Malewa | 47 | 100 | 2 | 110 | 2 | 1,110 | 24 | 2,110 | 45 |
| Total | 157 | 6,400 | 30 | 6,930 | 45 | 11,190 | 71 | 17,040 | 109 |

## Educational Facilities

### (1) Present Educational Facilities

The present educational facilities provided within the project area are of poor quality. The number of schools and the strength of school children and teacher in each school were surveyed during the field visit as presented in Table 4-2.

### (2) Future School Population

According to the Preliminary Design Report on Eburru Water Supply Project, the school population increase is estimated at a rate of 5% p.a. Following the above design report, the future number of school children and teachers for the existing schools are estimated using the increase rate of 5% p.a. as shown in Table 4-2. In this study, taking into account the expected future population increase in Malewa area, one primary school is expected to be established in the future.

## Health Facilities

There are two health dispensaries in the project area, and the present use of mobile health units are the dominant health service in the project area.

There are no definite proposals to improve the health facilities in the project area, except that the frequency of mobile clinic visits are being increased. In this study it is estimated to install a dispensary in the Malewa area as population in this area increases.

## Administrative Offices

At present, there is only one cooperative office with two members of staff, and no definite plans for improving or expanding the administrative centre in the project area. In this study, however, it is estimated that the administrative structure within the project

Table 4-2
School Population Projection

| School | School Population | | | |
|---|---|---|---|---|
| | 1984 | 1986 | 1996 | 2006 |
| Eburru Primary | 471[1)] | 519 | 846 | 1,378 |
| Eburru Secondary | 21[2)] | 23 | 38 | 62 |
| Lordia Primary | 314[3)] | 346 | 564 | 918 |
| Malewa Primary | – | – | 147 | 307 |
| Total | 806 | 888 | 1,597 | 2,665 |

Note: 1) 11 teachers included
2) 2 teachers included
3) 9 teachers included

area will be improved to provide the people in this area with the much needed services of the government. It is estimated that the administrative offices will be installed in the Lake area and Malewa area, and personnel required will be as shown below.

| | 1984 | 1986 | 1986 | 2006 |
|---|---|---|---|---|
| Eburru area | 2 | 2 | 3 | 5 |
| Lake area | 0 | 0 | 2 | 3 |
| Malewa area | 0 | 0 | 2 | 3 |

Livestock

The present livestock population and distribution in the project area are presented in Table 4-3.

Criteria applied for this study for livestock projection are as follows:

(1) Utilizing the GDP target growth rate 4.9% p.a. for the fifth five year development plan, the average annual growth rate for livestock in the project area is set at 5% for 1984 – 1986, 6% for 1987 – 1996 and 7.0% for 1977 – 2006.

(2) The Lake area is presently developed for stock farms and expected to continue at the average growth rate as described above. Eburru hills and Malewa area are expected to be rapidly developed after water supply is started in these areas. Therefore, the following higher rates of growth are applied.

| Rates | Period |
|---|---|
| 5% | 1874 – 1986 |
| 8% | 1987 – 1991 |
| 10% | 1992 – 1996 |
| 12% | 1997 – 2001 |
| 14% | 2002 – 2006 |

Table 4-3
Present Livestocks Number

(Unit: Head)

| Livestocks | Area | | | |
|---|---|---|---|---|
| | Eburru | Lake area | Malewa | Total |
| Graded Cattle | 55 | 800 | – | 855 |
| Beef & Native Cattle | 530 | 1,100 | 1,000 | 2,630 |
| Sheep & Goats | 1,120 | 250 | – | 1,370 |

(3) Livestock units are estimated based on the MOWD's design manual as shown below:

| | |
|---|---|
| 1 Grade cattle | – 1 Livestock Unit |
| 3 Indigenous cattles | – 1 Livestock Unit |
| 15 Sheep or Goats | – 1 Livestock Unit |

(4) According to the MOWD's design criteria, the following land carrying capacities of livestock are applied for water demand projection to arrive at the saturation population of livestock units.

| Area with Annaul Mean Rainfall | Livestock Carrying Capacity |
|---|---|
| 600 – 800 mm | 1.2 ha/livestock unit |
| 800 – 1,000 mm | 1.0 ha/livestock unit |

Based on the above criteria, the future livestock units projection is made as shown in Table 4-4.

### 4.2.5 Water Demand Projection

(1) Design Criteria for Unit Water Demand

The area to be served is mainly rural with a medium demand potential. Based on the rates of demand criteria recommended by the MOWD and WHO, the following unit water demands have been applied for this study.

| | |
|---|---|
| People with IC | 50 lpcd |
| People with CWP | 15 lpcd |
| Day schools with WC | 25 lpcd |
| Day schools without WC | 5 lpcd |
| Dispensary and Health Center | 5,000 l/per day |
| Administrative Offices | 25 lpcd |
| Livestock Unit | 50 l per unit |
| Grade Cattle | 75 l per unit |

Note: IC – Individual connections, WC – Water Closet,
CWP – Communal water points

Table 4-4
Future Livestock Population Projection

| Sub area | Area (ha) | 1984 | | 1986 | | 1996 | | 2006 | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. Livestock (unit) | Unit Area (ha/unit) | No. Livestock (unit) | Unit Area (ha/unit) | No. Livestock (unit) | Unit Area (ha/unit) | No. Livestock (unit) | Unit Area (ha/unit) |
| 1. Eburru | 5,600 | 306 | 18.3 | 337 | 16.6 | 797 | 7.0 | 2,705 | 2.1 |
| 2. Lake area | 5,400 | 1,183 | 4.6 | 1,304 | 4.1 | 2,335 | 2.3 | 4,593 | 1.2 |
| 3. Malewa | 4,700 | 333 | 14.1 | 367 | 12.8 | 868 | 5.4 | 2,946 | 1.6 |
| Total | 15,700 | 1,822 | 8.6 | 2,008 | 7.8 | 4,000 | 3.9 | 10,244 | 1.5 |

Note: Number of livestock is presented by livestock units.

(2) Water Demand

Domestic Water Demands

Based on the present situation in the project area, the distribution of IC and CWP is projected as shown below.

The IC rate in the future is basically according to MOWD's design manual with consideration that the project area will become a high development area in the future.

| | 1986 | 1996 | 2006 |
|---|---|---|---|
| Individual Connections | 0% | 25% | 50% |
| Communal Water Points | 95% | 75% | 50% |
| Existing Sources | 5% | 0% | 0% |

Using the above distribution rates of consumer service connections, the population served and domestic use water demands were calculated as shown in Tables 4-5 and 4-6.

Table 4-5
Population Served

| Demand Area | 1986 | | | 1996 | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|---|
| | IC (0%) | CWP (95%) | Ext. (5%) | IC (25%) | CWP (75%) | Ext. (0%) | IC (50%) | CWP (50%) | Ext. (0%) |
| Eburru hills | 0 | 4,110 | 220 | 1,600 | 4,800 | 0 | 4,740 | 4,740 | 0 |
| Lake area | 0 | 2,370 | 120 | 920 | 2,760 | 0 | 2,730 | 2,720 | 0 |
| Malewa | 0 | 110[1)] | 0 | 280 | 830 | 0 | 1,060 | 1,050 | 0 |
| Total | 0 | 6,590 | 340 | 2,800 | 8,390 | 0 | 8,530 | 8,510 | 0 |

Note: 1) Malewa has no existing water source, and estimated 100% for CWP from the beginning.

Table 4-6
Domestic Water Demands

(Unit: $m^3$/day)

| Demand Area | 1986 | | | 1996 | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|---|
| | IC (0%) | CWP (95%) | Ext. (5%) | IC (25%) | CWP (75%) | Ext. (0%) | IC (50%) | CWP (50%) | Ext. (0%) |
| Eburru hills | 0 | 62 | 3 | 80 | 72 | 0 | 237 | 71 | 0 |
| Lake area | 0 | 36 | 2 | 46 | 41 | 0 | 137 | 41 | 0 |
| Malewa | 0 | 2 | 0 | 14 | 12 | 0 | 53 | 16 | 0 |
| Total | 0 | 100 | 5 | 140 | 125 | 0 | 427 | 128 | 0 |

## Water Demands for School, Health Facility and Public Office

Based on the Design Manual of MOWD and the unit demands, the water demands for schools, dispensaries and offices are projected as shown below.

Table 4-7
Water Demand for Public Use ($m^3$/day)

| | 1986 | 1996 | 2006 |
|---|---|---|---|
| 1. Schools | 22 | 40 | 67 |
| 2. Dispensaries | 10 | 15 | 15 |
| 3. Offices | 1 | 1 | 1 |
| Total | 33 | 56 | 83 |

## Livestock Water Demands

Based on the present situation in the demand areas, it is estimated that (1) the Eburru area will continue to use existing unimproved sources by 10% of total in the initial design period, and thereafter convert to improved sources, (2) the Malewa area will use improved sources from the initial design period, and (3) Lake area will continue to use existing sources at 20%, 15%, and 10% in the initial, future, and final design periods respectively.

Using the above projection and future livestock units, distribution of existing sources and improved sources is as shown in Table 4-8.

Water demands for livestock units are calculated as shown in Table 4-9.

Table 4-8
Distribution of Livestock Units to Existing and Improved Sources

(Unit: Livestock units)

| Demand Area | 1986 | | | 1996 | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Exist. | Improved | | Exist. | Improved | | Exist. | Improved | |
| | | M.C. | Others | | M.C. | Others | | M.C. | Others |
| Eburru | 34 | 31 | 272 | – | 239 | 558 | – | 1,623 | 1,082 |
| Lake area | 261 | 365 | 678 | 350 | 992 | 993 | 460 | 2,893 | 1,240 |
| Malewa | – | – | 367 | – | 174 | 694 | – | 1,767 | 1,179 |
| Total | 295 | 396 | 1,317 | 350 | 1,406 | 2,245 | 460 | 6,283 | 3,501 |

Note: M.C. = Milk cow

Table 4-9
Water Demand for Livestock

(Unit: $m^3$/day)

| Demand Area | 1986 | | | 1996 | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Exist. M.C. | Improved | | Exist. M.C. | Improved | | Exist. M.C. | Improved | |
| | | Others | Total | | Others | Total | | Others | Total |
| Eburru | 3 | 14 | 17 | 18 | 28 | 46 | 122 | 54 | 176 |
| Lake area | 27 | 34 | 61 | 74 | 50 | 124 | 217 | 62 | 279 |
| Malewa | 0 | 18 | 18 | 13 | 35 | 48 | 133 | 59 | 192 |
| Total | 30 | 66 | 96 | 105 | 113 | 218 | 472 | 175 | 647 |

Note: M.C. = Milk cow

Geothermal Development Use

There are five test boring locations in the present project area. Geothermal development water use is generally broken down into the following categories of usage:

(1) Normal bore drilling

(2) Extra water utilized for filling the faults and cracks met while bore drilling

(3) Emergency use for cooling the excess geothermal heat

(4) Borehole cleaning for registivity testing of layer

With the exception of item (1) above, other water uses are considered as the emergency use, therefore, they can be supplied from the storage tank wherever they are needed.

It is not necessary to supply the full amount of water needed for normal bore drilling, since the water for this usage can be recirculated. Therefore, the supply is only needed partially.

Additional supply amounts will varying due to conditions of the boring layers and dependent on drilling machines and associated equipment.

Generally, the supplement amounts are set at 10% – 50% of the total requirement. In this study, through checking of other experiences and reports, a maximum of 200 $m^3$/ day is estimated for the proposed test boring supplement amount.

Overall Water Demands

The estimated daily water demands for the project area are summarized as shown in Table 4-10.

Table 4-10
Water Demand ($m^3$/day)

| Consumer | Initial 1986 | Future 1996 | Utilimate 2006 |
|---|---|---|---|
| Domestic | 100 | 265 | 555 |
| Schools | 22 | 40 | 67 |
| Dispensaries | 10 | 15 | 15 |
| Offices | 1 | 1 | 1 |
| Livestocks | 96 | 218 | 647 |
| Geothermal Development | 200 | — | — |
| Total | 429 | 539 | 1,285 |
| Say | 450 | 550 | 1,300 |

### 4.2.5 Project Size and Design Capacity

As discussed in section 4.2.2 Design Years, the facilities provided in the present project are recommended to cover the water demands in 2006. And assuming that the present project will be implemented as a grant aid project under the Japanese Government, the project components and their size shall be as described as follows: Approximate locations of the proposed facilities are shown in Fig. 4-1.

(1) Project components will be that the lake water is pumped at Lardia located to the north of Lake Naivasha, treated near the lake shore, booster pumped through about 10 km of transmission pipeline to the centre of the project area, and stored in reservoirs for distribution. Water is supplied from the reservoirs, and when necessary, from the pump wells at booster pump stations by gravity to the consumer.

(2) Project components covered by the said grant aid will be the major items above, namely: the intake pump facilities, treatment plant, transmission pump, booster pump, transmission pipeline, storage reservoirs and main distribution pipelines. (See details in Section 5.4, Chapter 5 of this report.)

There are no difficulties anticipated for construction of the above facilities. One peculiar point to be mentioned is that the proposed water supply system requires multi-stage booster pump facilities to convey water from the source of Lake Naivasha to the demand center of Eburru hills, a total pump lift of about 800 meters.

### 4.2.6 Design Criteria

Design criteria applied for the design of facilities and equipment necessary for the project are presented in this section.

Principal considerations taken into account are:

(a) Easy operation and maintenance

(b) Low operation cost

(c) Sufficient durability and safety

(d) Easy repair of breakdowns or failure of facilities and equipment

(e) Locally available materials shall be utilized where applicable

(f) Facilities shall be located at places where access for O & M is available

(g) Minimum construction difficulties

#### (1) Selection of Water Source

The water source of the present project, Lake Naivasha was selected for the following reasons:

(a) Lake source development costs are estimated as less than river water source development in this project.

(b) Treatment of lake water is easier and more consistent than river water.

(c) Groundwater development in the project area was disregarded, due to the well water yield in the project area being estimated as too small (approximately 400 $m^3$/day per well). In addition the well water is reported to have excessive fluoride concentrations.

(d) The lake water source is sufficient in quantity and is of acceptable quality.

(e) The lake water system can be designed with the shortest length of transmission pipeline among the alternative sources.

Design water levels of the lake are set at the following elevations, based on the survey results of MOWD:

| | |
|---|---|
| Highest Water Level: | El + 1,891.0 m |
| Low Water Level: | El + 1,888.0 m |
| Lake Bottom Elevation: | El + 1,886.5 m |

(2) Lake Water Quality

Characteristics of the lake water quality are summarized based on the quality analysis made during the periods in 1979 to 1984 as shown below:

| | | |
|---|---|---|
| (a) | pH range: | Max. 8.6 and average 8.1 |
| (b) | Turbidity: | Max. 11 (JTU) and average 5.3 (JTU) |
| (c) | Alkalinity: | Rather high in Max. 186 ppm and average 139 mm |
| (d) | Coliform groups: | Examined during the field investigation. Results were 100 – 300 (100 ml MPN), which are within acceptable range |
| (e) | Fe, Mn and Fu: | Acceptable |

Overall evaluation of the water quality is that it is suitable for drinking water with common treatment, which is amenable to slow sand filtration and disinfection only.

(3) Selection of Treatment Method

As found in the above raw water quality analysis, slow sand filtration and disinfection by chlorination will be the treatment process applicable for the lake water. Chemicals for chlorination will be locally available tropical chloride of lime (TCL).

(4) Water Supply System

Single water supply system is provided for supplying treated water to the population and livestock in the project area.

(5) Location of Major Facilities

Proposed location of the major facilities are shown in Fig. 4-1.

(a) Intake Facility

For selection of the location for the intake facility, following points are examined.

- Water plants grow not much
- Affect of water polution is minimum
- Water depth is sufficient
- Space for intake facility is enough

(b) Water Treatment Plant

For locating water treatment plant, availability of enough area and electric power supply, and access from the main roads are taken into consideration.

(c) Transmission Pipeline Route and Booster Pump Station

The transmission pipeline route proposed by MOWD was investigated by the study Team and confirmed as the design route for this project. As for locations for booster pump stations on the transmission route, locations which are hydraulically best suited were selected.

(d) Distribution Reservoir

To facilitate gravity flow distribution, topographical site location is checked for the selection of storage reservoirs. Two storage reservoir sites were found for the above reason, as shown in Fig. 4-1.

(6) Selection of Power Source

Two kinds of power supply means were considered, and commercial electricity service supply was selected for the present system based on the following reasons:

(a) Unit cost is cheaper than oil.

(b) Maintenance is easier than diesel generator system.

(c) Diesel generator system is less efficient, since the present site for equipment installation is considerably high in elevation (EL + 1,900 m).

(7) Number of Pump Units

With provision of one standby unit for each pump station, two units of pumps are designed for installation at each pump station of intake, transmission and booster pump station.

(8) Type of Pumps

(a) Intake Pump

Pump units and accessories are designed to be installed on the ground elevation so that operation and maintenance are easy. To meet this requirement, volute type pump is selected.

(b) Transmission and Booster Pumps

Multi-stage volute type pump is recommended as most suitable type for this nature of transmission and boosting system. Operation and maintenance is easy for providing same type of pumps with same capacity.

(9) Pump Operation Method

Manual operation system is recommended based on the reasons that (i) system is simple, (ii) MOWD has experience, and (iii) operation and maintenance is not difficult.

(10) Selection of Pipe Materials

(a) Transmission Pipe

The proposed transmission system is subject to a static pressure of 23 kg/cm² (= 23 Pa), and the dynamic pressure will become 30 kg/cm² ( = 30 Pa) inclusive of water hammer. Generally, pipe materials to meet the above design requirement are considered to be steel or ductile iron pipes only.

In this study steel pipe is recommended for the transmission pipeline due to the superiority of pipe installation above the ground along the steep slope which is dominant part enroute of the transmission route.

Proposed pipe materials: Carbon Steel Pressure Pipe, STPG 38, Schedule 40 (JIS G 3454)

(b) Distribution Pipes

For distribution pipes, PVC pipe is recommended, since this is locally available for a pressure range 6 – 15 kg/cm².

(11) Measure for Water Hammer in Transmission System

Based on economy and easy O & M, a flywheel installation is recommended for protection against water hammer.

## 4.3 Basic Design

### 4.3.1 Intake Facility (See Fig. 4-2 and 4-3.)

| | | |
|---|---|---|
| (1) | Intake pipe: | D 300 mm S.P. L = 30 m |
| (2) | Intake pump: | Single suction volute pump<br>D 100 mm x 0.95 m³/min x 17 m x 5.5 kW, two units |
| (3) | Pump house: | 4.5 m x 5.0 m (22.5 m²), one unit |
| (4) | Raw water pipe (Intake pump house to treatment plant): | D 150 mm S.P. L = 250 m |

### 4.3.2 Treatment Facility (See Fig. 4-4 and 4-5.)

(1) Slow Sand Filter

| | |
|---|---|
| Dimension: | 11.5 m x 24.0 m, 2 units |
| Filter area: | 276 m²/unit |
| Filtration rate: | 5 m³/m²/day |
| Filter media: | sand 100 cm thick |
| Gravel layer: | 60 cm thick |
| Under drain system: | concrete |
| Water depth above sand layer: | 120 cm |

(2) Clear water reservoir (See Fig. 4-6.)

Dimension: 3.1 m x 6.2 m x 1.2 m (WD), 2 units
Detention time: 1 hr (Volume 57.7 $m^3$)

### 4.3.3 Transmission Facilities

(1) Transmission pipeline (See Fig. 4-7 and 4-8.)

D 150 mm S.P.,
T.P. – No. 1 BP/s: 4,400 m
No. 1 BP/s – No. 2 BP/s: 2,356 m
No. 2 BP/s – No. 3 BP/s: 560 m
No. 3 BP/s – Reservoir: 1,680 m

(2) Transmission pump
Multistage volute pump
D 100 mm x D 80 mm x 0.903 $m^3$/min. x 172 m x 55 kW, 2 units

(3) No. 1 booster pump
Multistage volute pump
D 100 mm x D 80 mm x 0.903 $m^3$/min. x 230 m x 75 kW, 2 units

(4) No. 2 booster pump
Multistage volute pump
D 100 mm x D 80 mm x 0.903 $m^3$/min. x 137 m x 45 kW, 2 units

(5) No. 3 booster pump
Multistage volute pump
D 100 mm x D 80 mm x 0.903 $m^3$/min. x 174 m x 55 kW, 2 units

(6) No. 1 pump chamber (See Fig. 4-9 and 4-10.)
Use as storage reservoir.
Dimension: 6.0 m x 6.0 m x 3.0 m (WD), 1 unit
Capacity: 108 $m^3$

(7) No. 2 and No. 3 pump chambers (See Fig. 4-11 and 4-12.)
Dimension: D 4.88 m x 2.95 m (WD), 1 unit
Capacity: 50 $m^3$

(8) Transmission pump house (See Fig. 4-13.)
6.7 m x 5.5 m, RC made ( = 37 $m^2$ )

(9) Booster pump houses (See Fig. 4-14.)
– No. 1 BP house: 6.3 x 5.5 m, RC made ( = 35 $m^2$ )
– No. 2 and No. 3 BP houses: 5.5 m x 5.5 m, RC made (= 30 $m^2$ ), each one unit

### 4.3.4 Distribution Facility (See Fig. 4-15 and 4-16.)

(1) No. 1 storage reservoir
Dimension: 7.8 m x 15.0 m x 3.0 m (WD), 2 units
Capacity: 700 $m^3$

(2) No. 2 storage reservoir
Dimension: D 7.5 m x 2.25 m (WD), 1 unit
Capacity: 100 $m^3$

(3) Distribution pump
Multistage volute pump
D 40 mm x 0.107 $m^3$/min. x 170 m x 11 kW, 2 units

(4) Distribution pump house
5.5 m x 5.5 m, RC made ( = 30 $m^2$ )

(5) Distribution pipelines
See Table 4-11 following, and the proposed distribution pipeline routes as shown in Fig. 4-1.

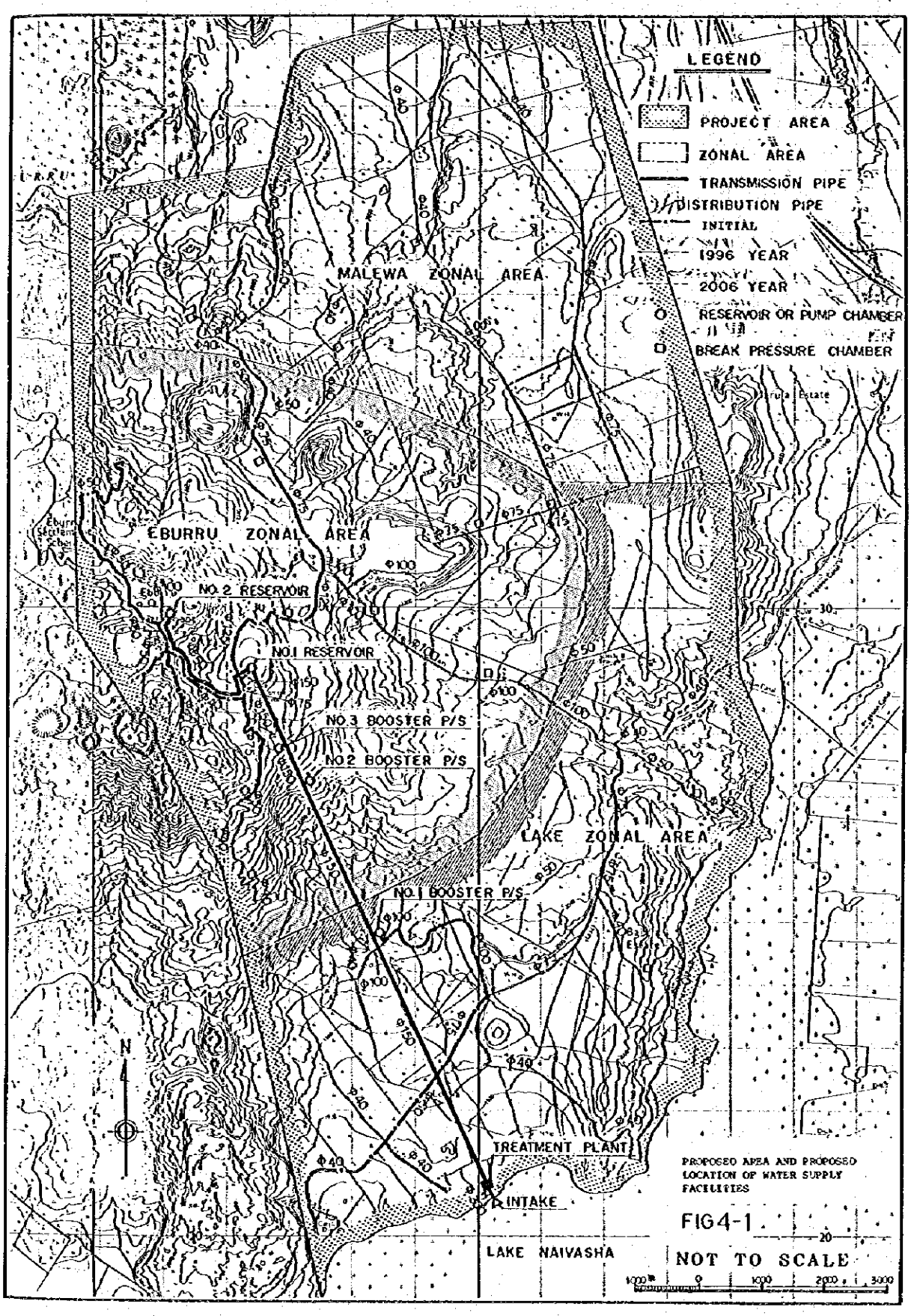
(6) Break pressure tank

(7) Communal water point

(8) Individual connection

Table 4-11
Distribution Pipe

| Distribution | Pipe Class | Dia. (mm) | Pipe Length (m) | | | |
|---|---|---|---|---|---|---|
| | | | Initial | 1996 | 2006 | Total |
| No. 1 Reservoir | PVC, Class B | ϕ 150 | 200 | – | – | 200 |
| | | ϕ 125 | 1,300 | – | – | 1,300 |
| | | ϕ 100 | – | 500 | 2,700 | 3,200 |
| | | ϕ 75 | 950 | – | 3,600 | 4,550 |
| | | ϕ 50 | 720 | 930 | – | 1,650 |
| | PVC, Class C | ϕ 100 | 550 | 4,350 | – | 4,900 |
| | | ϕ 75 | 2,000 | 5,500 | 2,400 | 9,900 |
| | | ϕ 40 | – | 1,400 | 9,350 | 10,750 |
| | PVC, Class D | ϕ 75 | – | 2,100 | – | 2,100 |
| | | ϕ 50 | – | 5,050 | – | 5,050 |
| | | ϕ 40 | – | 1,700 | 1,500 | 3,200 |
| | PVC, Class E | ϕ 125 | 1,550 | – | – | 1,550 |
| | | ϕ 100 | – | 2,900 | – | 2,900 |
| | | ϕ 75 | 2,300 | 500 | – | 2,800 |
| | | ϕ 40 | – | 6,400 | 7,300 | 13,700 |
| No. 2 Reservoir | PVC, Class B | ϕ 100 | 300 | – | – | 300 |
| | | ϕ 50 | 1,700 | – | – | 1,700 |
| | PVC, Class C | ϕ 40 | 1,900 | – | – | 1,900 |
| | PVC, Class D | ϕ 40 | 1,300 | – | – | 1,300 |
| | PVC, Class E | ϕ 50 | 4,000 | – | – | 4,000 |
| No. 1 Pump | PVC, Class B | ϕ 100 | 3,100 | – | – | 3,100 |
| | | ϕ 75 | – | 2,000 | – | 2,000 |
| | PVC, Class C | ϕ 75 | 1,500 | – | – | 1,500 |
| | | ϕ 40 | – | 5,450 | – | 5,450 |
| | PVC, Class D | ϕ 50 | 1,400 | – | – | 1,400 |
| | | ϕ 40 | 1,200 | – | – | 1,200 |
| | PVC, Class E | ϕ 40 | 2,420 | 3,280 | – | 5,700 |
| Total | | | 28,390 | 42,060 | 26,850 | 97,300 |


LEGEND
PROJECT AREA
ZONAL AREA
TRANSMISSION PIPE
DISTRIBUTION PIPE
INITIAL
1996 YEAR
2006 YEAR
RESERVOIR OR PUMP CHAMBER
BREAK PRESSURE CHAMBER
MALEWA ZONAL AREA
EBURRU ZONAL AREA
LAKE ZONAL AREA
NO.2 RESERVOIR
NO.1 RESERVOIR
NO.3 BOOSTER P/S
NO.2 BOOSTER P/S
NO.1 BOOSTER P/S
TREATMENT PLANT
INTAKE
LAKE NAIVASHA
N
PROPOSED AREA AND PROPOSED LOCATION OF WATER SUPPLY FACILITIES
FIG4-1
NOT TO SCALE

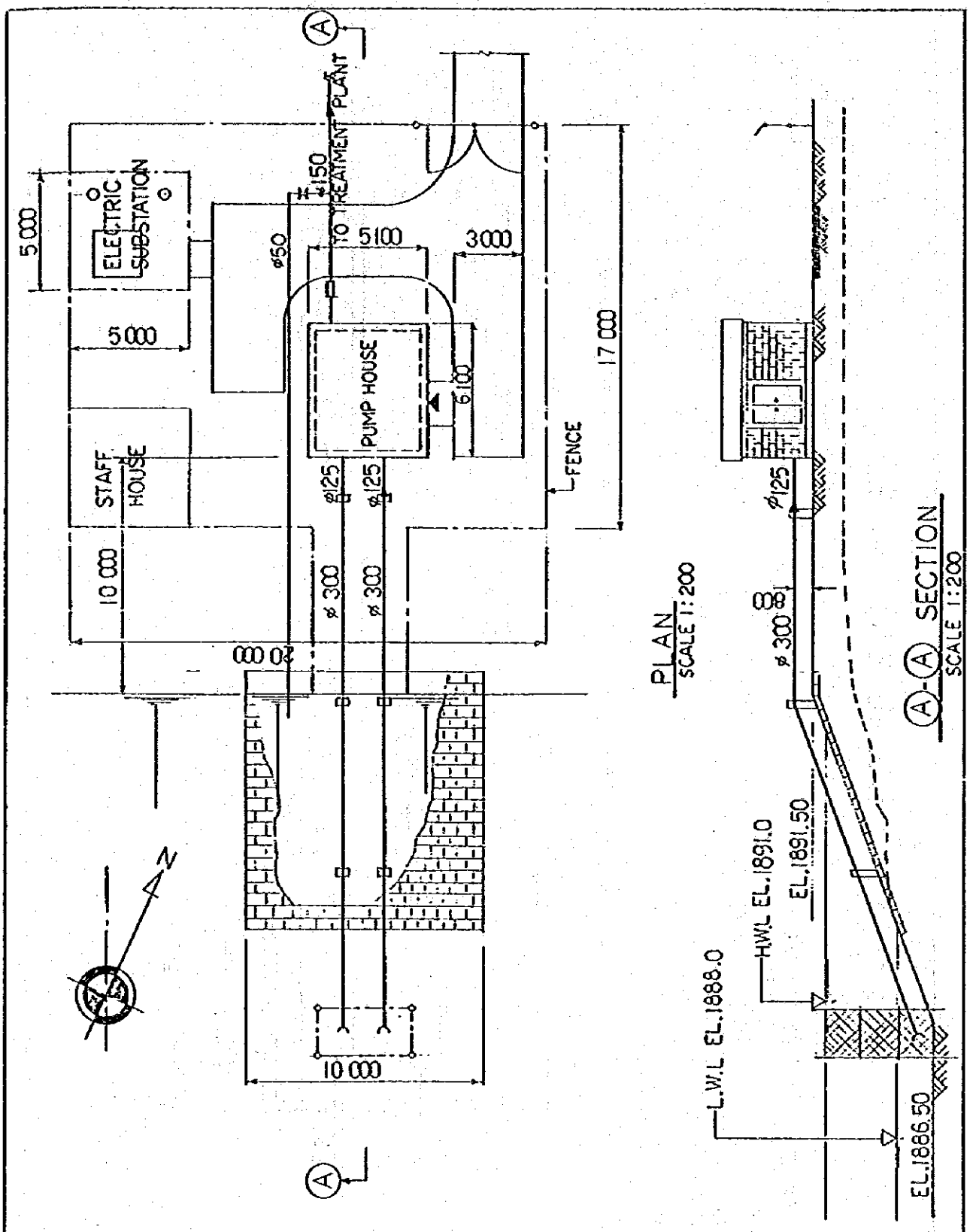
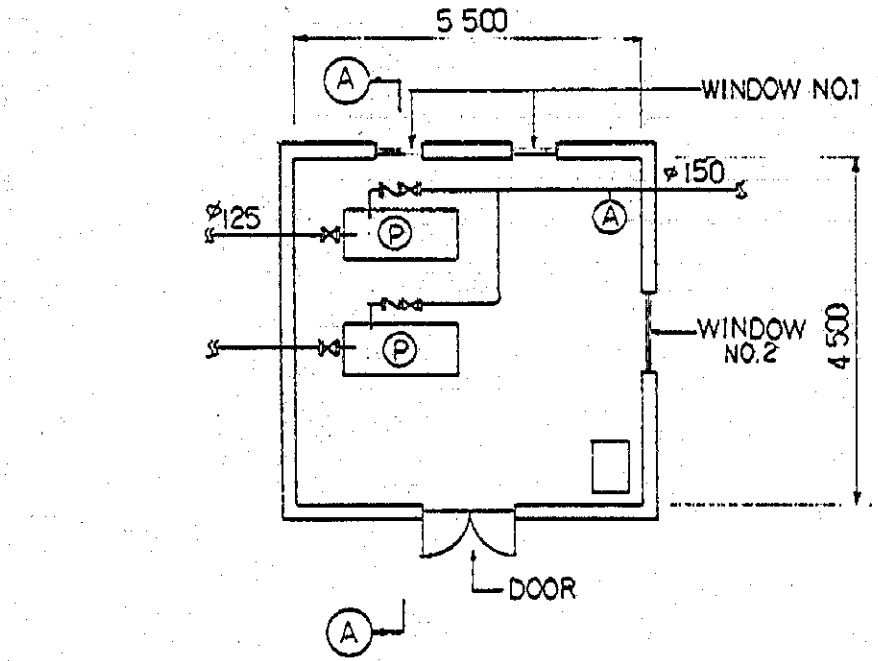



FIG 4-2 GENERAL PLAN AND SECTION OF INTAKE



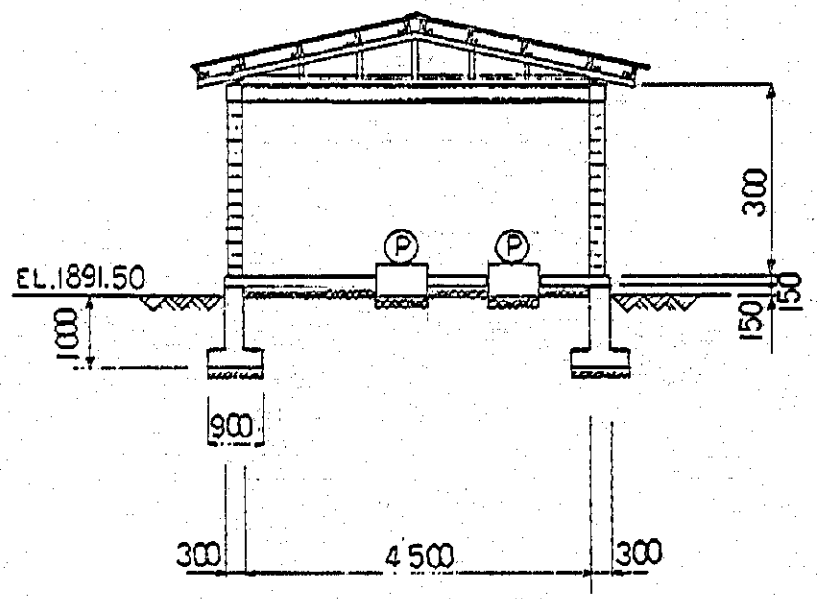

LEGEND

Ⓟ : PUMP

Ⓐ : AIR VALVE

PLAN

SCALE 1: NONE




Ⓐ-Ⓐ SECTION

SCALE 1:NONE

FIG 4-3 INTAKE PUMP HOUSE

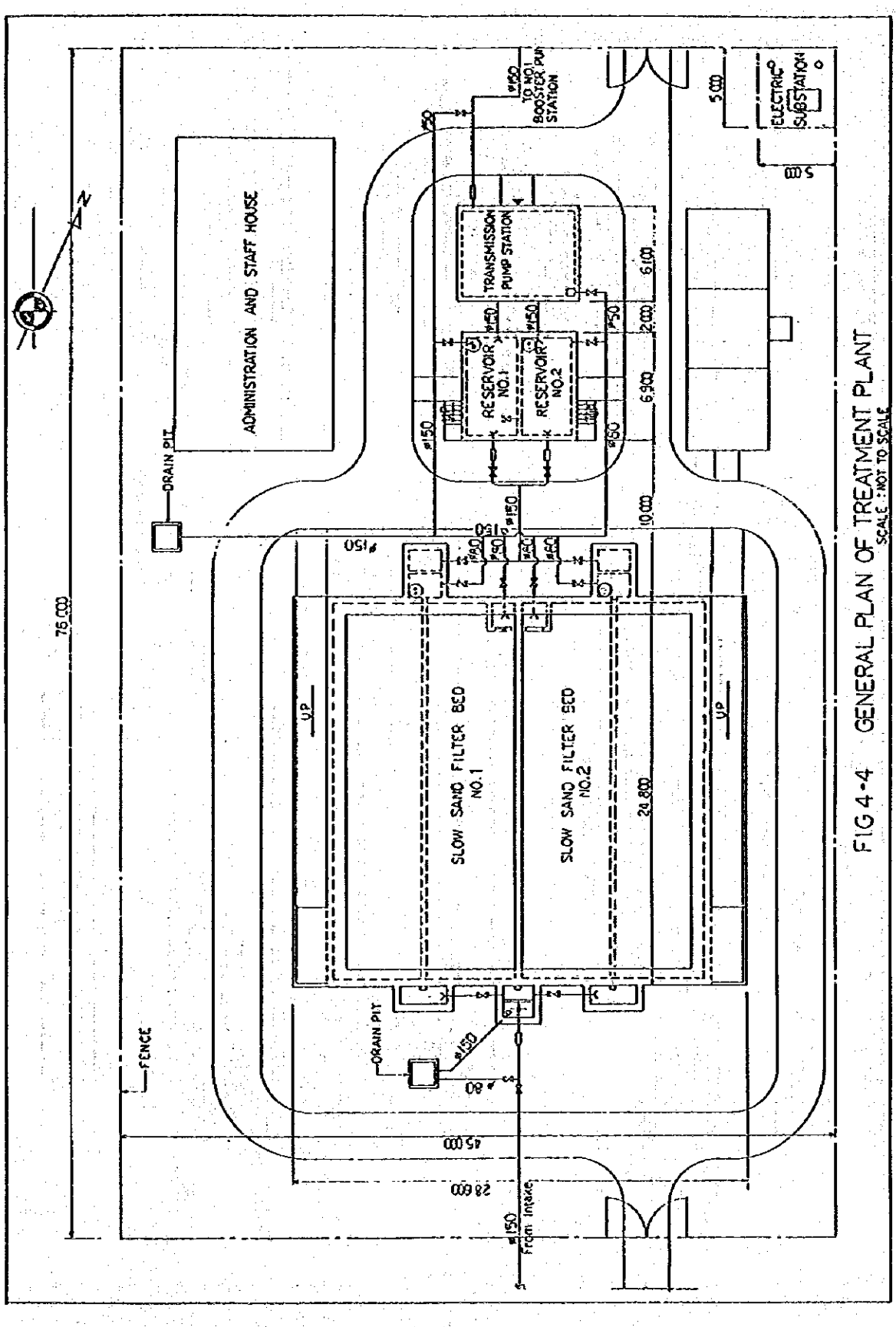



FIG 4-4 GENERAL PLAN OF TREATMENT PLANT
SCALE : NOT TO SCALE

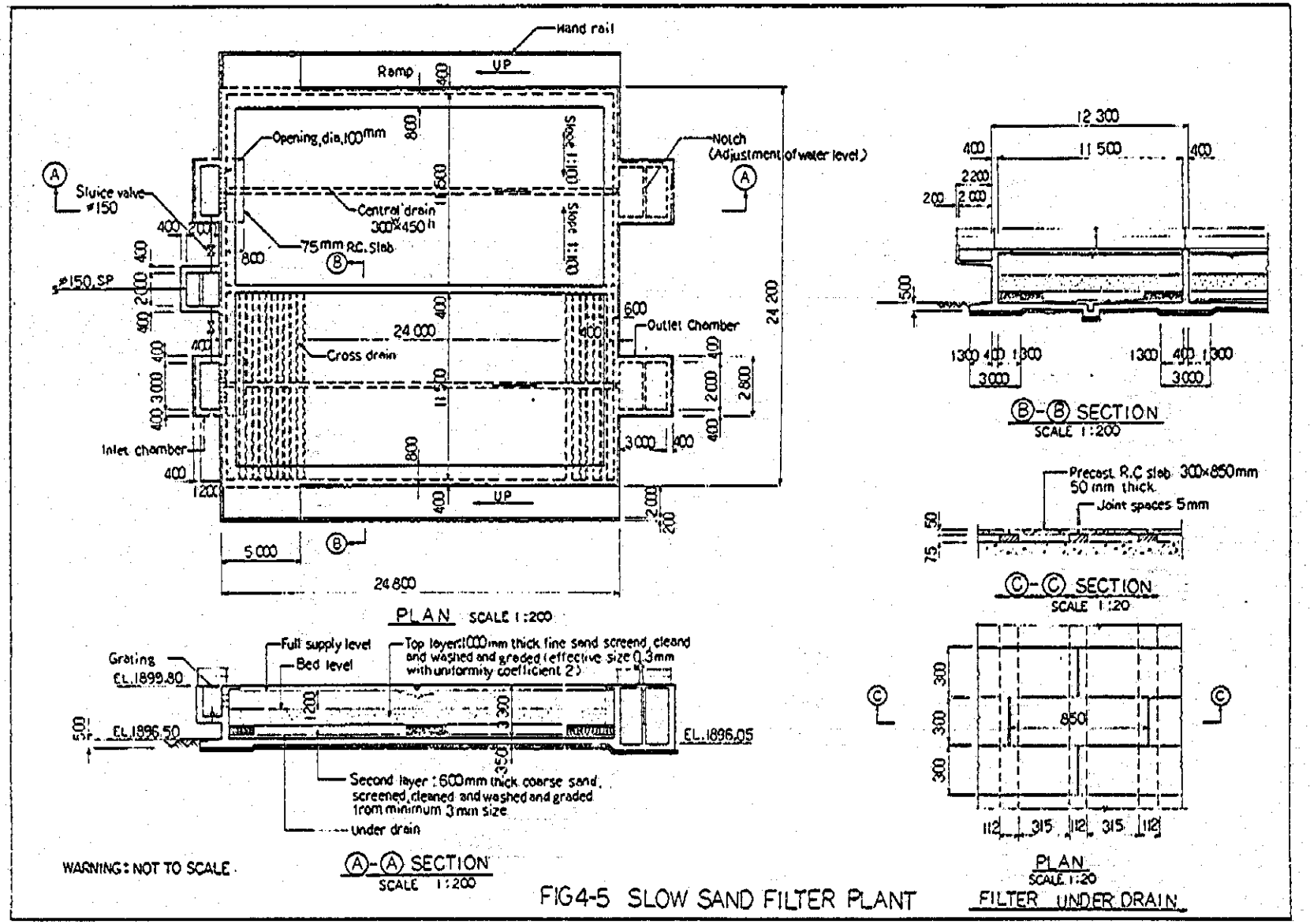



FIG4-5 SLOW SAND FILTER PLANT

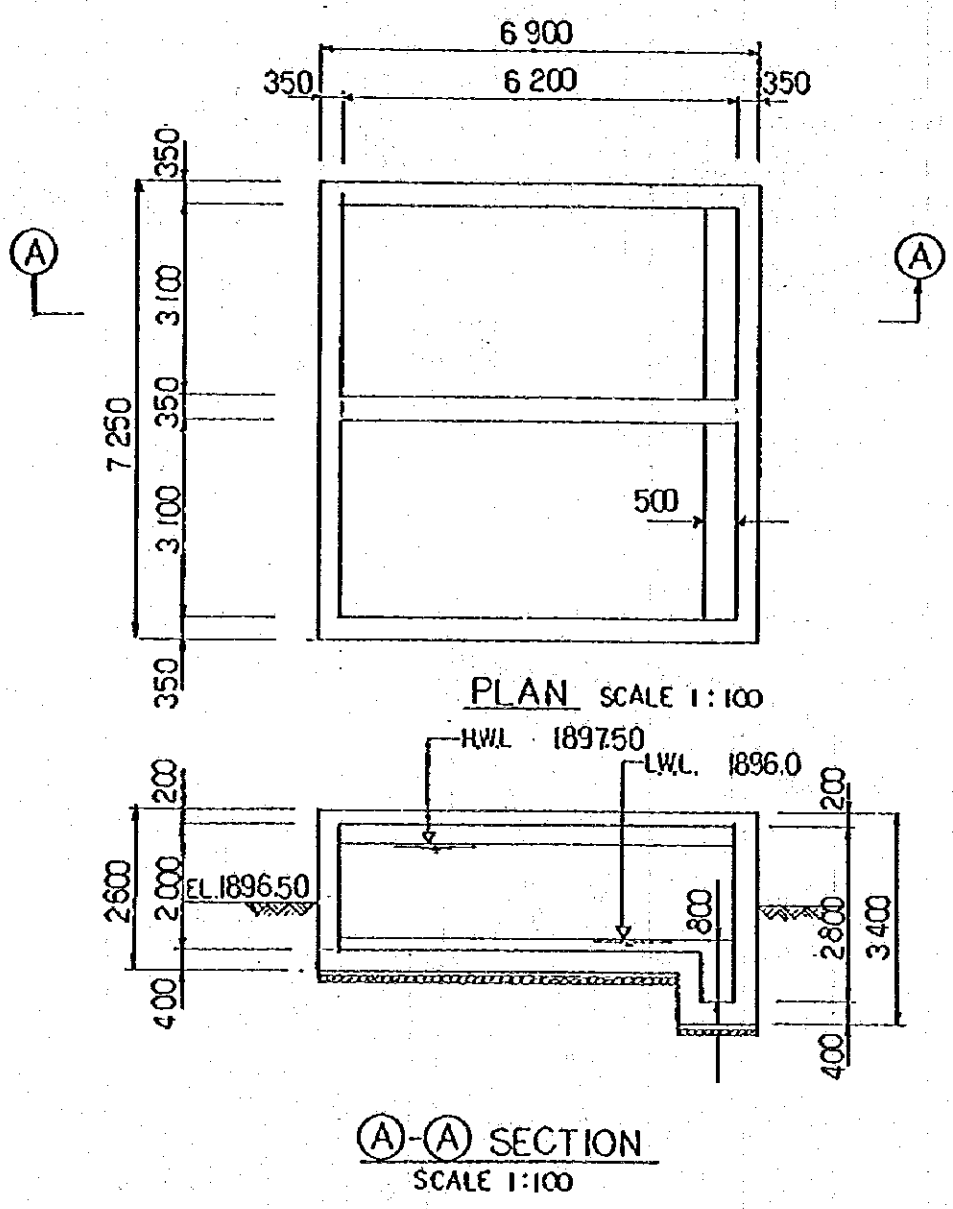



FIG 4-6 RESERVOIR

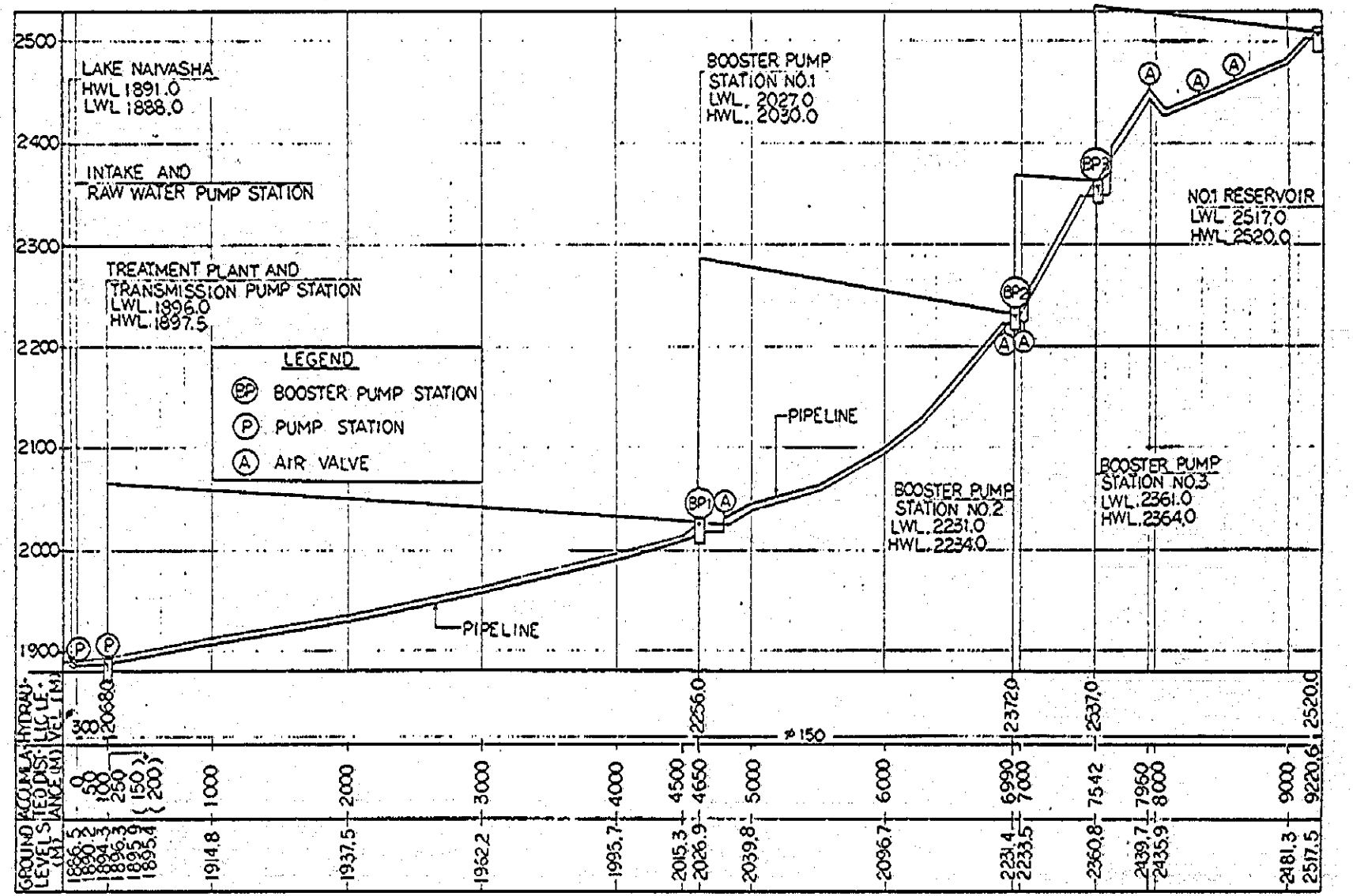



FIG 4-7 TRANSMISSION PIPELINE PROFILE SCALE: NOT TO SCALE

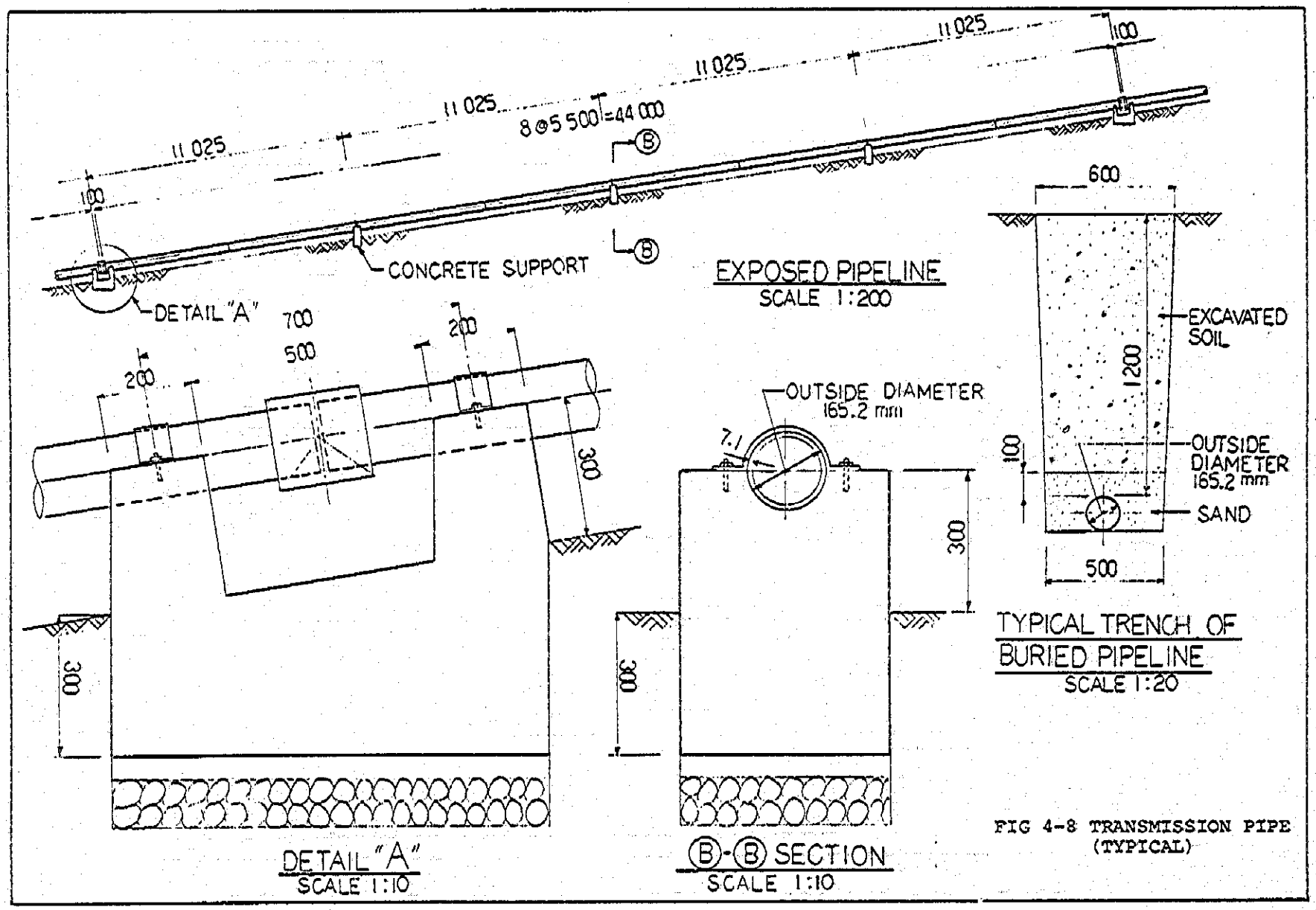



FIG 4-8 TRANSMISSION PIPE (TYPICAL)

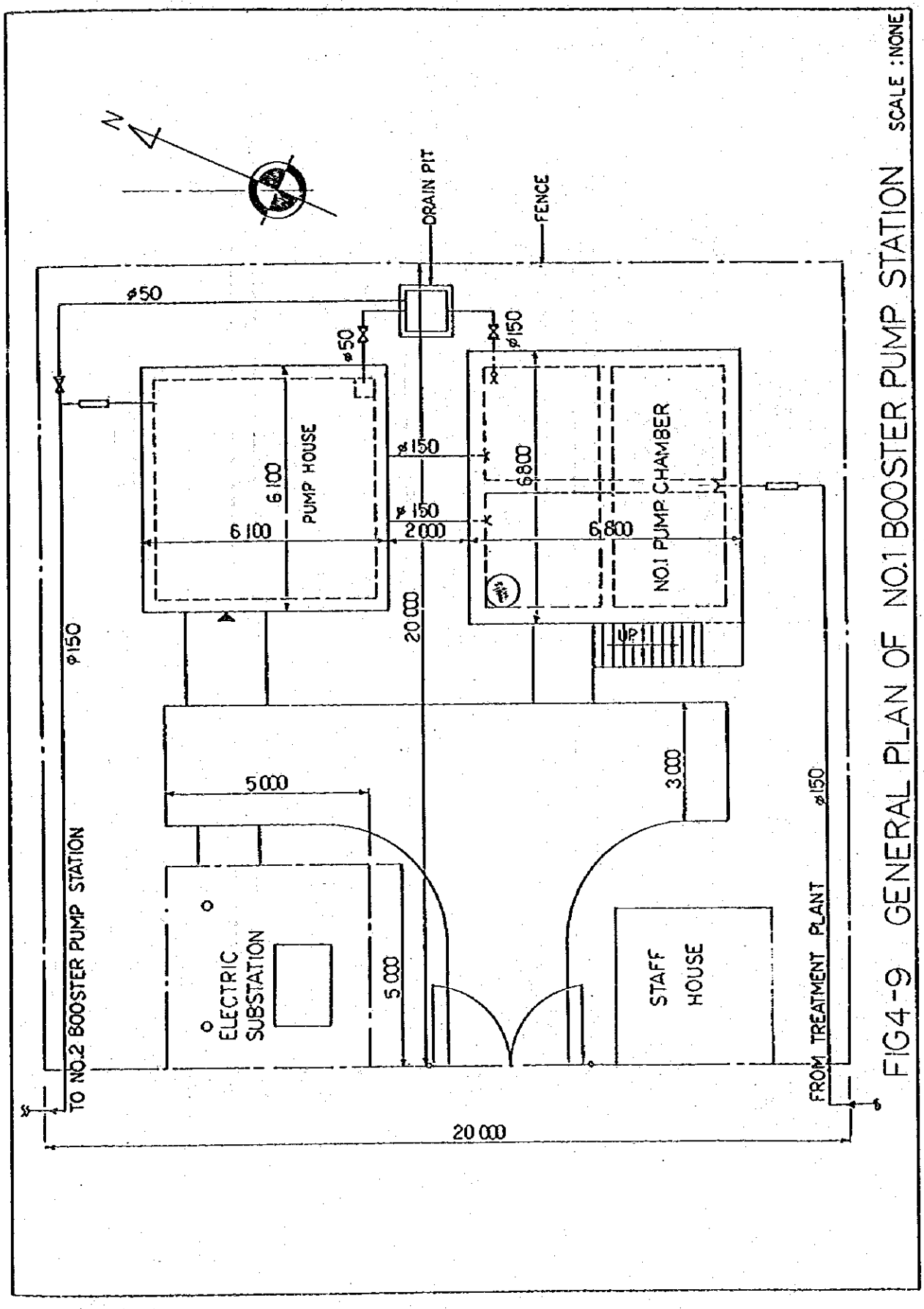
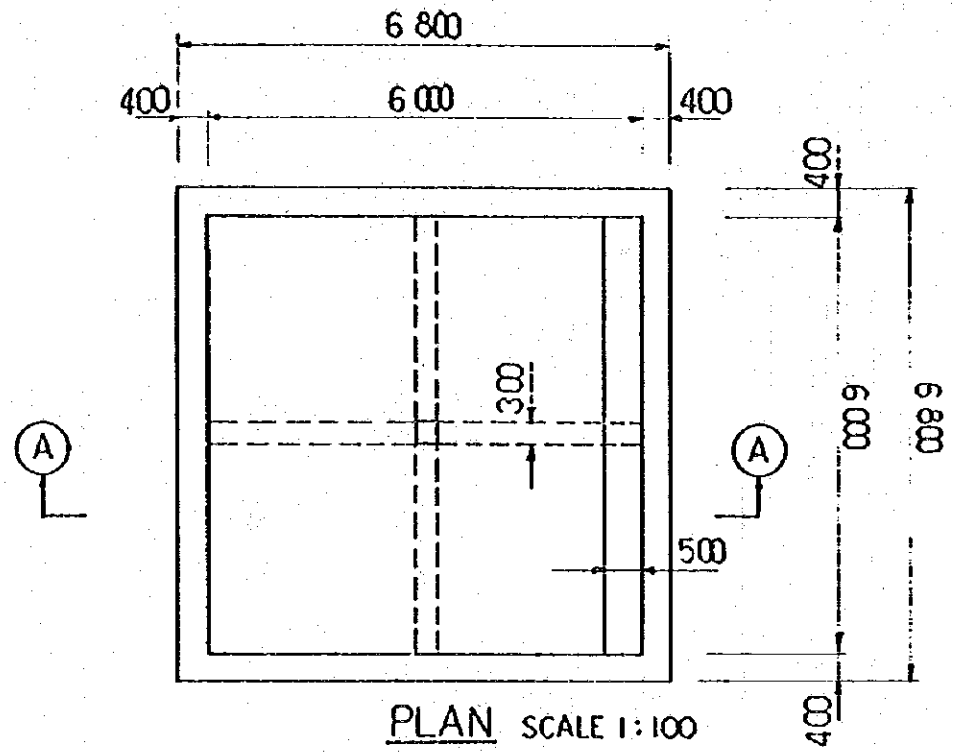



FIG4-9 GENERAL PLAN OF NO.1 BOOSTER PUMP STATION SCALE : NONE



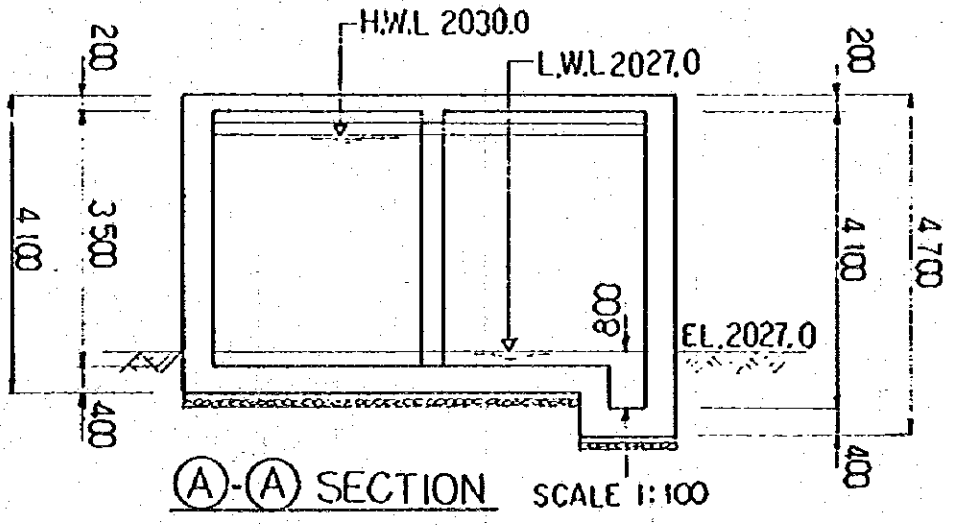




FIG4-10 NO.1 PUMP CHAMBER

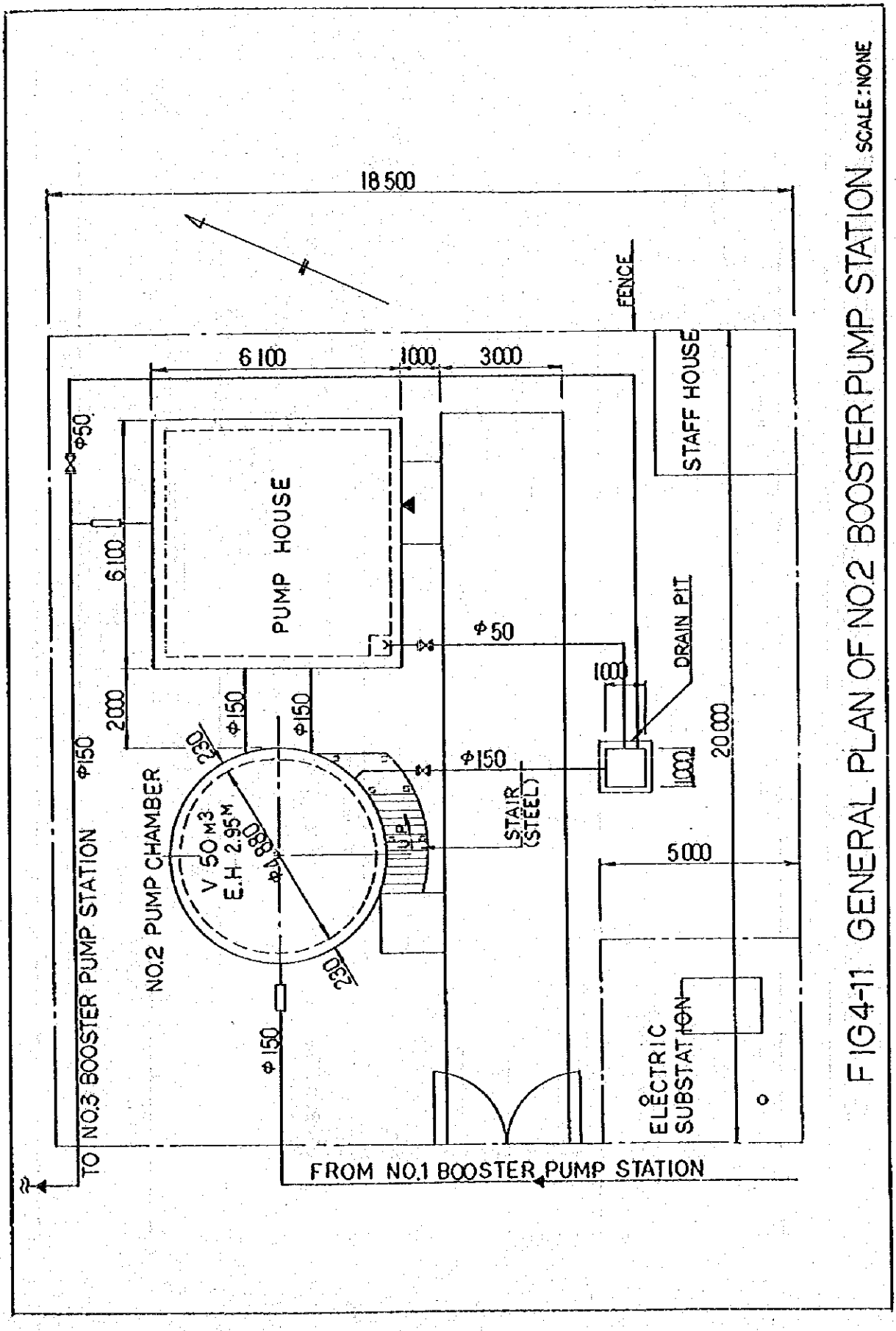



FIG 4-11 GENERAL PLAN OF NO.2 BOOSTER PUMP STATION SCALE: NONE

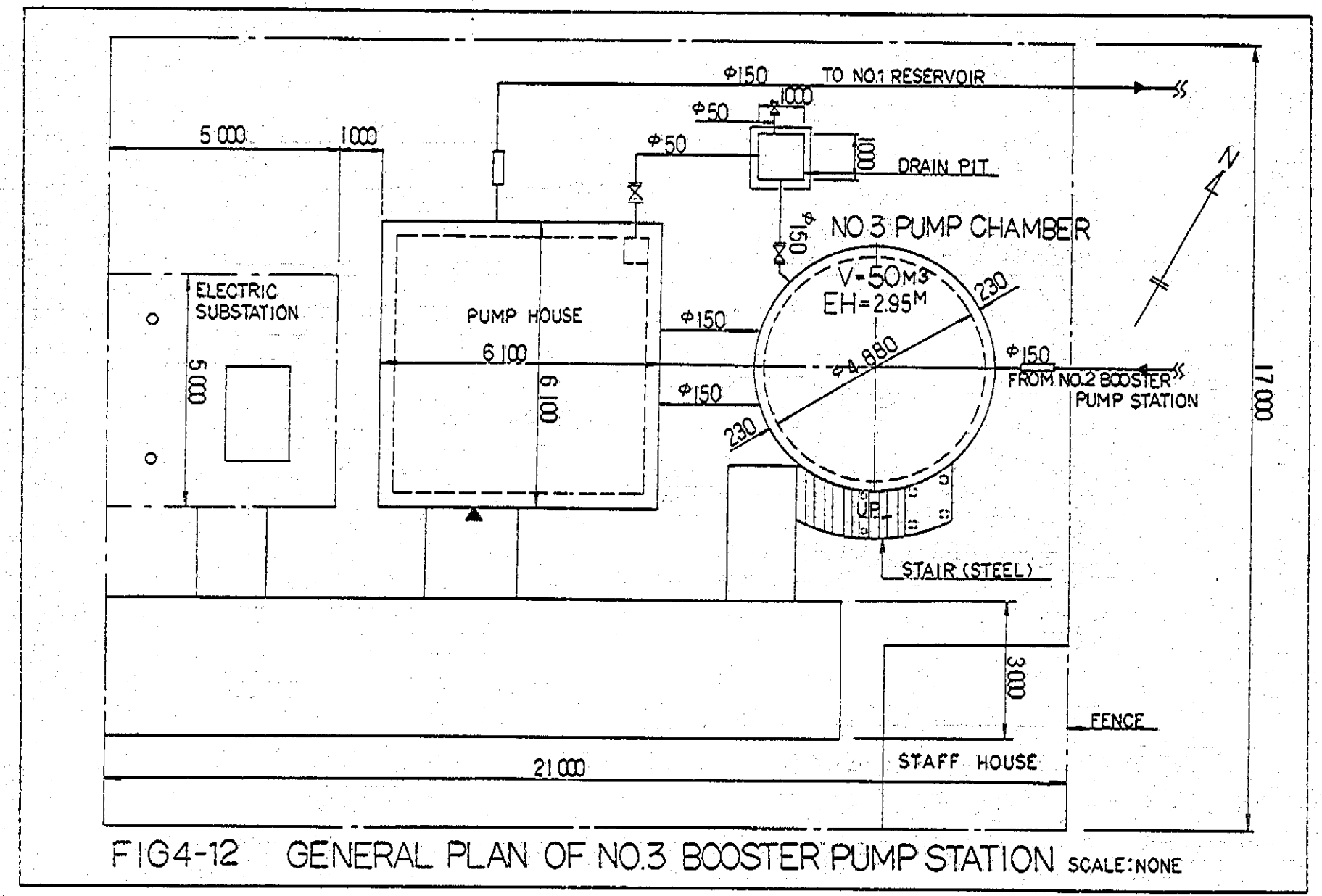
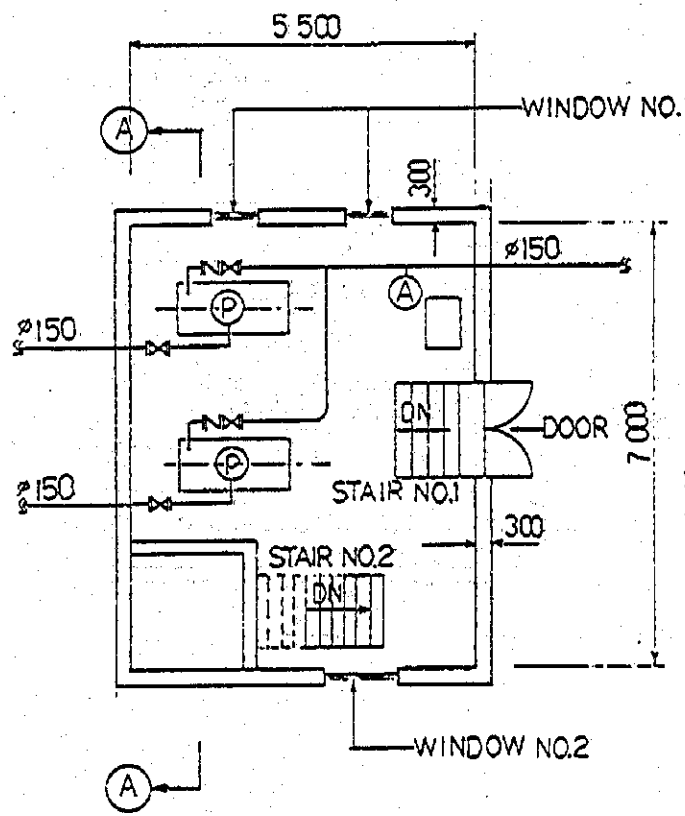
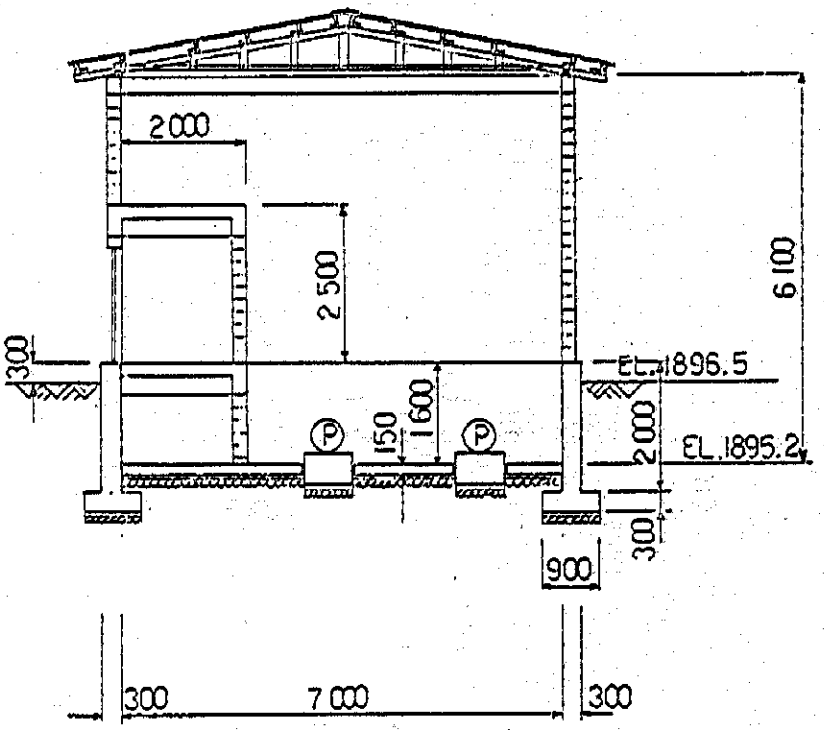



FIG4-12 GENERAL PLAN OF NO.3 BOOSTER PUMP STATION SCALE:NONE




PLAN
SCALE 1:100




A-A SECTION
SCALE 1:100

LEGEND
Ⓟ : PUMP
Ⓐ : AIR VALVE

FIG4-13 TRANSMISSION PUMP HOUSE

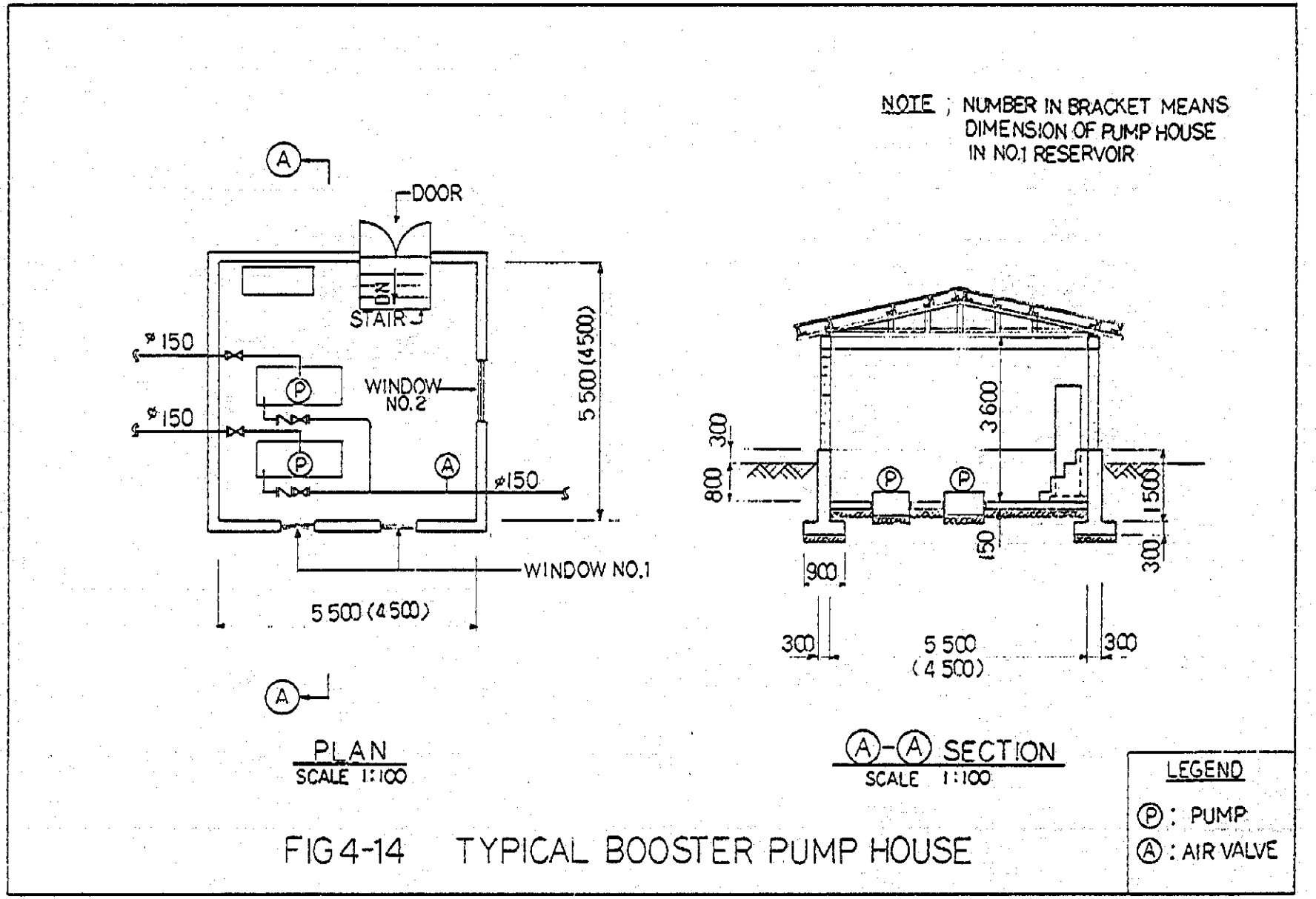
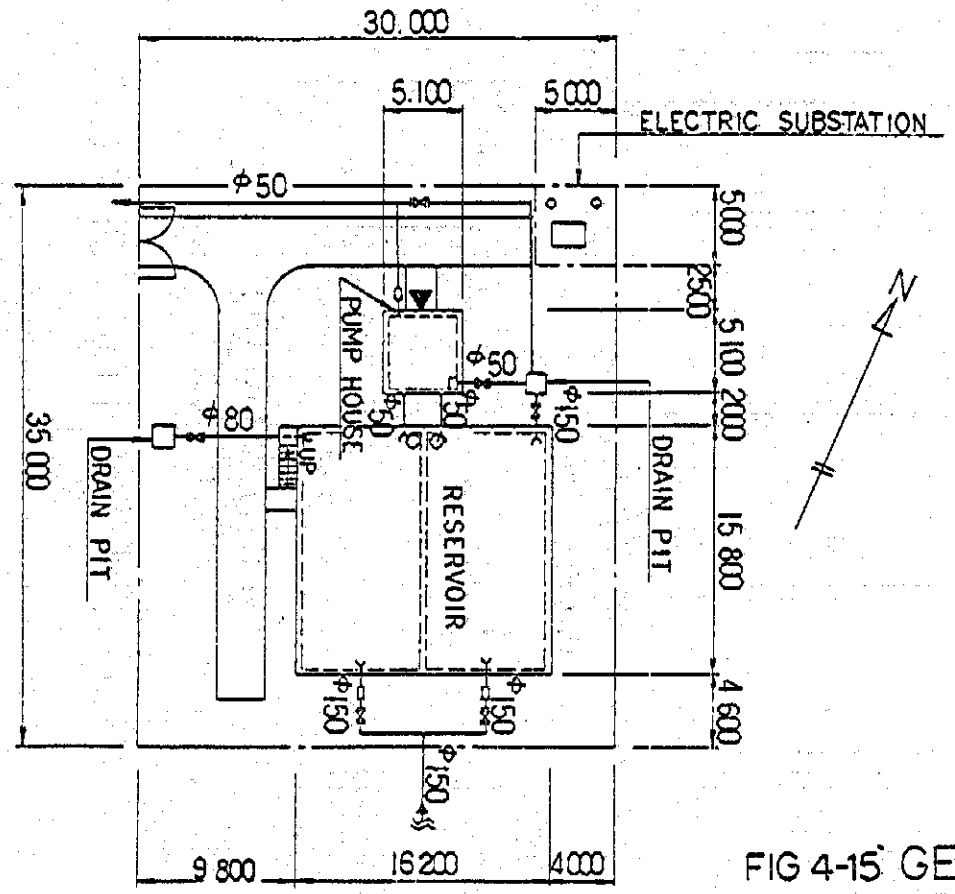



FIG 4-14 TYPICAL BOOSTER PUMP HOUSE



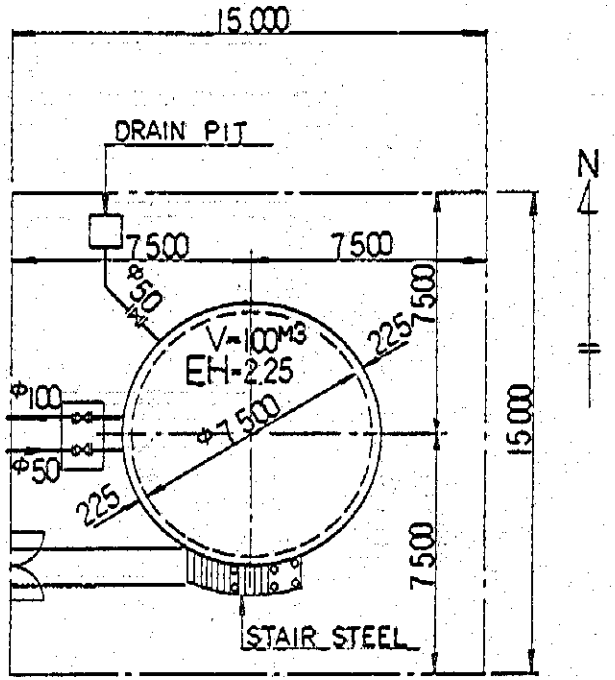




FIG 4-15 GENERAL PLAN OF NO.2 RESERVOIR
SCALE 1:200

FIG 4-15 GENERAL PLAN OF NO.1 RESERVOIR
SCALE 1:400

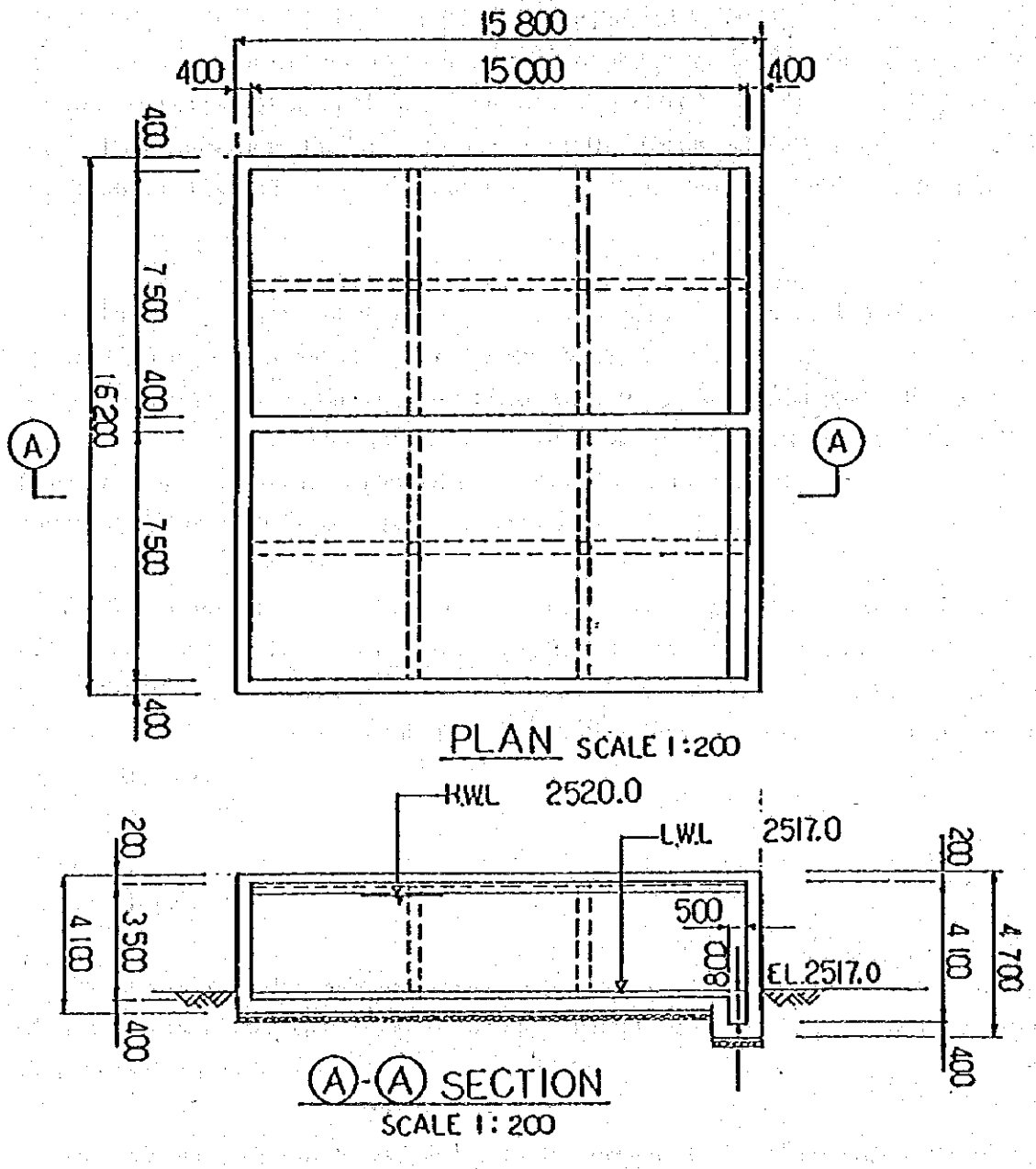



FIG 4-16 NO.1 RESERVOIR

# 5. PROJECT EXECUTION STRUCTURE

## 5.1 Project Executing Agency

As already described in Chapter 2, the present mainstay of water supply in Kenya is the Ministry of Water Development (MOWD), established in 1974, which is in charge of planning, design, construction and management of the water development projects in the country. The organization of MOWD is shown in Appendix 7. MOWD as Executing Agency has in its organization, the Water Development Department which is responsible for all the functions of planning, development, operation and maintenance of public water supplies throughout Kenya.

Under the Operation and Maintenance Branch in MOWD, provincial level water offices are established in each province. For the Rift Valley Province, a water office in Nakuru is functioning as the provincial water office with three divisions, namely, Engineering, Water Resources, and Administration. As one of the district water offices in the Rift Valley Province, Naivasha District Water Office is provided with a district water officer, two senior inspectors, several operators, and office staff.

For operation and administration, the Eburru water supply will be covered by this district water office. The present project implementation will be carried out by the staff of MOWD HQs up to the stage of construction completion, thereafter the completed system will be handed over to the control of the Rift Valley Province Water Office for operation and maintenance.

## 5.2 Staffing Schedule

The necessary staffing schedule for the implementation of the present project will be divided into two categories: (1) staff for project implementation, and (2) staff for water supply system operation.

The existing staff can be assigned with the personnel of MOWD HQs without any difficulty of recruiting.

Regarding operation staff, it will be necessary to recruit inspectors and operators to be engaged in the new water system operation. MOWD has their own educational and training system, through the Staff Training School, for all categories of technical and professional man power. Further, selected MOWD engineers are attending six-months to three-year engineering course for higher diplomas in water engineering at polytechnical institutes and universities. Inspectors and operators trained in the said schools and institutes will be engaged as the permanent staff for operation and maintenance of the proposed water supply system.

## 5.3 Construction Schedule

Construction of the proposed facilities shall be made by a Japanese contractor selected by formaly opening tenders from qualified companies. The contract for the project is recommended to be made as one package including both construction and procurement of equipment.

Administration of construction works will be made under the Implementation Branch of MOWD, and Japanese consultants will be engaged to assist in the construction supervision. The necessary construction period will be about 12 months including equipment and materials manufacturing and shipping. An additional 0.5 months will be needed for test running and operation training. The anticipated implementation schedule is shown in Table 5-1.

Since its establishment in 1974, MOWD has gained much experience in construction of urban water supply facilities by contract, and numerous construction works on rural water supplies by direct labour forces.

## 5.4 Scope of Construction Work

Scope of construction work to be covered by the Japanese Grant Aid is recommended as follows:

(1) Intake Facilities

Intake pipe, intake pumps and pump house

(2) Treatment Facilities

Balancing chamber, slow sand filters, chlorination equipment, clear water reservoir, operation room, store house and work shop, and chemical storage room

(3) Transmission Pump Facilities

Transmission pumps and pump house

(4) Electrical Facilities and Equipment for Intake, Transmission Pumps and Treatment Plant

Power receiving and transmitting facilities, pump operation switches, interior lighting

(5) Four Booster Pump Facilities

Booster pumps and pump houses in four stations, three pump chambers, power receiving and transforming equipment, and interior lighting in four booster pump stations

(6) Transmission Pipeline

D 150 mm – 8,980 m

(7) Storage Reservoir

No. 1: 700 $m^3$, and No. 2: 100 $m^3$

(8) Distribution Pipelines

D 150 mm – 200 m
D 125 mm – 2,800 m
D 100 mm – 4,300 m
D 75 mm – 6,800 m
D 50 mm – 8,500 m
D 40 mm – 7,300 m

(9) Communal Water Point

28 locations

Construction work items to be covered by the Government of Kenya will be for the following works:

(1) Construction of access roads to the sites of construction facilities

(2) Site clearing, filling and levelling before commencement of construction work

(3) Construction of staff houses

(4) Electric power supply to the treatment plant site

(5) All administrative works necessary for the construction works

## 5.5 Implementation Schedule

A tentative implementation schedule is prepared and presented in Table 5-1. In the case the Japanese Government Grant Aid is extended, the project cycle will be as follows:

(1) Detailed Design

The Japanese Consultants will be engaged by the Government of Kenya to conduct detailed design of the proposed project and construction supervision.

(2) Contract Tender

MOWD is required to select Japanese contractor(s) through formal tendering by qualified companies.

Tendering procedures shall follow the process presented below:

(a) Prequalification of tenders

(b) Tendering

(c) Tender evaluation

(d) Negotiation with the best evaluated tenderer

(e) Award of contract

(3) Construction

Construction works will be achieved with the following process:

(a) Approval of shop drawings

(b) Equipment manufacturing

(c) Equipment transporting

(d) Construction of intake, treatment plant, pump station, transmission pipeline and reservoir facilities

(e) Installation of pumps and equipment

(f) Test running

(g) Commissioning

(4) Construction Supervision

The selected Japanese Consultants will work on:

(a) Assistance to prepare tender documents, tendering, and tender evaluation

(b) Construction supervision work which will include:
Checking of shop drawings for manufacturing and shipping of equipment, control of construction schedule, inspection of completed facilities, observation of test running of the system and operation guidance.

## 5.6 O & M Schedule

Operation and maintenance of the system shall be carried out by the full-time staff. The necessary personnel to be assigned to the proposed system and their required capability is summarized as follows.

Staff grades and job groups of the proposed personnel were selected following the design manual of MOWD.

| | Staff Grade | Job Group | No. of Staff | Work to be covered |
|---|---|---|---|---|
| (1) | Intake & Treatment Plant | | | |
| | Operator IIA | E | 1 | Chief operator, to supervise all the system |
| | Operator IIB | D | 1 | In charge of all pump facilities |
| | Pump attendant | B | 1 | Assistant to pump operator |
| | Pipe technical I | C | 1 | In charge of all pipe facilities |
| | Pipe technician II | B | 1 | Assistant to pipe technician I |
| | Labourer | B | 4 | Miscellaneous works |
| | Mechanical & Elec. technician | C | 1 | In charge of all mech. & elec. equipment |
| (2) | Booster P/S Pump attendant | B | 4 | One each at a booster P/S to be stationed to operate pumps |
| | Total | | 14 | |

## Operation and Maintenance Cost

O & M costs are estimated as shown below.

| Item | Design Years 1986 (Kshs) | 1996 (Kshs) | 2006 (Kshs) |
|---|---|---|---|
| 1. Manpower | 149,040 | 149,040 | 149,040 |
| 2. Maintenance | 495,000 | 495,000 | 495,000 |
| 3. Chemicals | 2,192 | 2,672 | 6,328 |
| 4. Power Costs | 376,461 | 450,045 | 1,004,115 |
| Total | 1,022,693 | 1,096,757 | 1,654,483 |

Note: Above costs present 1984 prices.

## 5.7 Procurement

According to the survey on capacities of construction industries in Kenya made by JETRO, general construction materials are obtainable in this country. Materials necessary for the present project and locally obtainable are: cement, gravels, timber, steel bar, steel plate products, concrete pipe, UPVC pipe, paint, and bitumen.

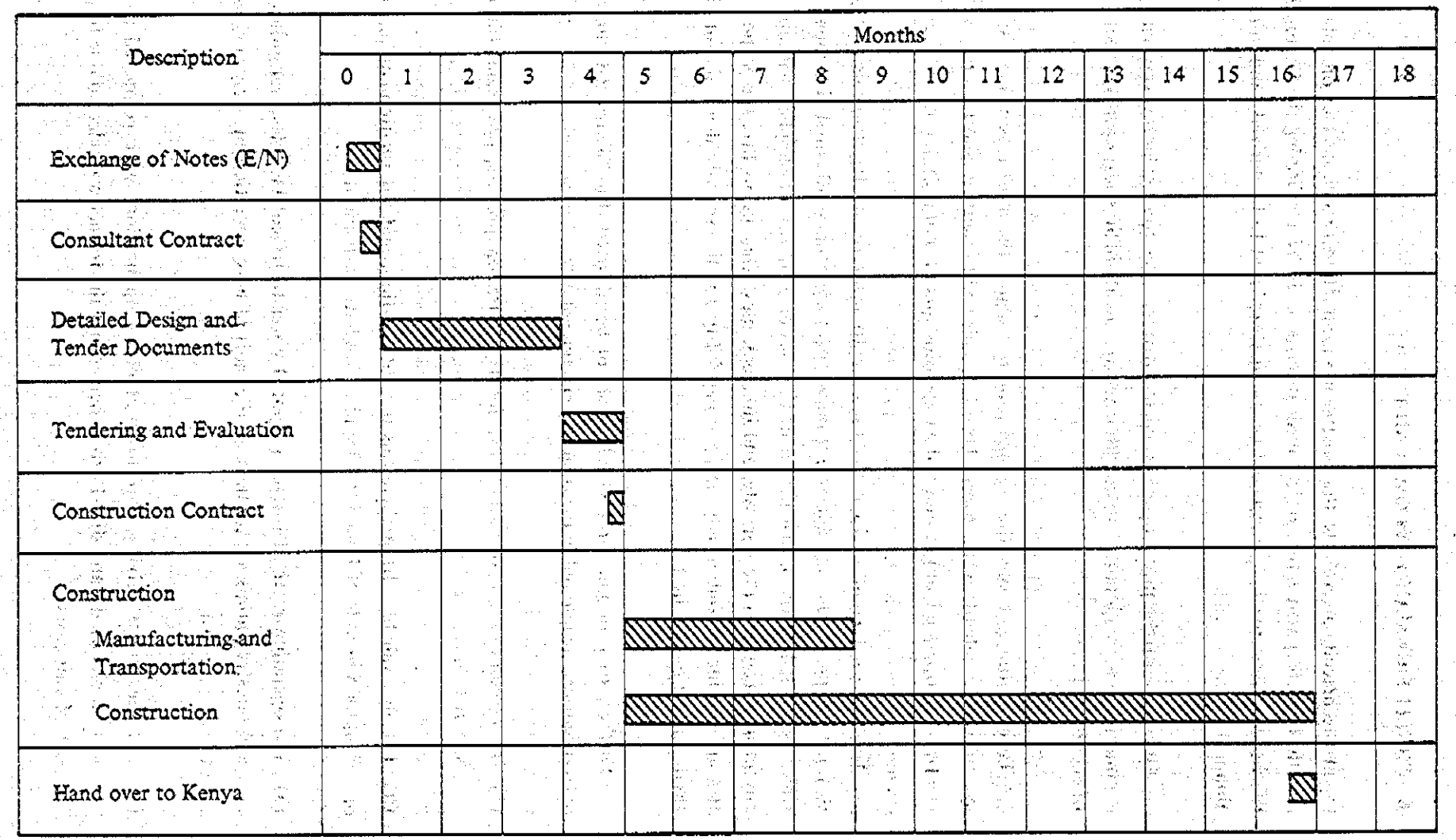
Necessary equipment for the project such as pumps, electric motors, pump operating switch boards, transformers, heavy duty electric cables, instrumentation equipment, and steel pressure pipe and valves are expected to be imported from Japan.

Imported goods will be unloaded at Mombasa port, and transported to the project site by land. The distance from Mombasa to the project site is about 650 km by road, which takes about 9 – 10 hours when driving by car.

Locally made products are generally obtained in and around Nairobi and transported by rail and road to their destination.

表 5 － 1

**Eburru Water Supply Implementation Schedule**



## 6. PROJECT EVALUATION

It is difficult to evaluate the benefits accruing from this project in monetary value, therefore, in this study the project evaluation is made by confirming the appropriateness of the objectives of the project and advantages expected to be derived from implementation.

Objectives of the present project are to provide water for residents, livestock and geothermal power development uses in the project area which are presently in serious lack of economical water sources.

To meet this purpose, the planned project provides the most reasonable water supply system with a reliable water source both in quality and quantity, and facilities which will can be easily operated and maintained with a minimum of training.

The proposed facilities have the capacity to meet the water demands to 2006. By this measurement, the considerable amount of water for geothermal development use, which is needed in the initial period of the master plan, can be supplied without making any inconvenience to the domestic and livestock uses. This means that the proposed facilities are designed economically to have capability for the specific demands for the geothermal development use.

Further, to economize the O & M costs to be incurred, the following technical considerations were employed in the basic design concept.

(1) To economize the operating cost for the filtration process, slow sand filters were selected.

(2) Locally available cheap chemicals for chlorination, and chlorination equipment with Tropital Chloride of Lime (TCL) application have been adopted.

(3) The operation method for the proposed water treatment facilities, transmission lines and booster pumps are planned on the basis of easy operation by average class operators.

(4) For the pumps driving, two different power applications were compared i.e., commercial electricity and diesel drive engines and the former was selected due to cheaper O & M unit costs.

Advantages which are intangible but will be derived from the project are as follows:

(1) By implementing this project, it is possible to improve the sanitary environment of the people and to contribute for development of agriculture by providing enough water for livestocks. This contribution will help complete the settlement scheme in this area.

(2) By supplying water for geothermal development use, in the future when the geothermal power plant is realized in this area, considerable advantages from water supply not only for the local society but also for the national economy will result.

# 7. CONCLUSIONS AND RECOMMENDATIONS

In the preceding chapters, the most economical and optimal planning of water supply facilities was prepared based on detailed analyses as request made by the Government of Kenya, on alternative water supply schemes, derived from reviewing data and information obtained during the field survey.

By implementing this project, the planned water supply facilities can be applied for the multipurpose usages of domestic, livestock and geothermal power development.

No piped water supply system was so far constructed in the project area, due to the difficulty in the economical water sources development.

The Government of Kenya is intensely implementing the Rural Water Supply Programme, and as a general rule, water supply projects in this country must seek solutions for developing economical water sources. In this project also, the investment for water source development is rather high but is the only practical and most suitable solution.

Japanese Grant Aid is particularly beneficial to this project where there is a high priority of implementation and also high investment for water resources development because otherwise the project could not proceed with the liminations of Kenya financing.

Also, by supplying water for geothermal power development use, in the future when the geothermal power plant is realized, it is expected that regional physical development will occur as well as the national economic development.

Multistage high lift booster pumps are recommended to be applied in the proposed transmission system, which will require knowledgeable and optimized pump operation. MOWD is recommended to engage well trained operators to take care of the above system operation.

The proposed facilities are designed on the basis of easy operation and maintenance, service lives and safety; however this design concept can be achieved only when the facilities are properly operated.

In the initial period, following commissioning of the water supply facilities, the revenues from water sales are estimated to be less than the necessary O & M costs, therefore MOWD is recommended to provide financing measures to augment this review.

Also it is recommended to establish a strategic plan of revenue increasing, by encouraging more individual connections and applying higher rates for the larger consumers, etc.

# APPENDICES