

REPUBLIC OF KENYA



MINISTRY OF WATER DEVELOPMENT

WATER RESOURCES ASSESSMENT STUDY
IN
BARINGO DISTRICT

EXECUTIVE SUMMARY

MAY 1987

WATER RESOURCES ASSESSMENT DIVISION
NAIROBI, KENYA

TNO-DGV INSTITUTE OF APPLIED GEOSCIENCE
DELFT, THE NETHERLANDS

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EXECUTIVE SUMMARY

The Water Resources Assessment Project

The Water Resources Assessment Project (WRAP) carried out a water resources assessment study of Baringo District as part of the co-operation between the Ministry of Water Development, Nairobi and TNO-DGV Institute of Applied Geoscience, The Netherlands. This summary gives a brief account of the results of the investigations carried out between May 1984 and April 1987, with emphasis on the potential for water development. Full particulars are reported in: Ministry of Water Development, Water Resources Assessment Study in Baringo District, Main Report; Nairobi, 1987.

Project Area

The area of investigation is approximately bounded by the parallels 0°30'S and 1°40'N and the longitudes 35°35'E and 36°30'E. It includes the whole of Baringo District (11,000 km²) and, for the hydrological study, parts of Samburu, Laikipia and Nakuru Districts, also (Figure 1a).

Baringo District is divided administratively into seven divisions: Kabarnet, Kabartonjo, Tenges, Eldama Ravine, Mogotio, Marigat and Nginyang. The estimated population in 1987 is about 260,000.

The present topography of Baringo District is closely related to the formation of the East African Rift Valley System. The Kerio Valley in the west (lowlands below 1,000 m above m.s.l) is separated from the Lake Baringo Basin by the Tugen Hills and Tiati Hills (over 2,000 m high). The Laikipia Escarpment (over 2,000 m) borders the district to the east (Figure 1b).

The drainage system in Baringo consists of numerous seasonal streams that drain to the Kerio River, Lake Bogoria, Lake Baringo and the Suguta River. The Perkerra River and the upper parts of Molo and Kerio Rivers are the only larger streams that carry water throughout the year. The district has three lakes: Baringo, Bogoria and Kammarok.

Lavas and tuffs are the most important rocks in the district. These rocks are intensely fractured. In addition, some Basement rocks are found in the north. Thick sediments occur in the Kerio Valley and between Lake Bogoria and Lake Baringo.

The soils on the mountains and major scarps are generally well drained and comprise stony loam or clayey loam. In the flat lowlands, complex soils with various textures and drainage conditions have developed. A large part of the district has shallow, stony soils with rock outcrops and lava boulders.

The climate in Baringo is strongly affected by the variation in altitude. The highlands have low annual evaporation (less than 1,500 mm) and high rainfall (over 1,200 mm). The semi-arid lowlands have high annual evaporation (over 2,500 mm) and low rainfall (less than 700 mm). Generally, the rains occur between March and September, with peaks in May and August.

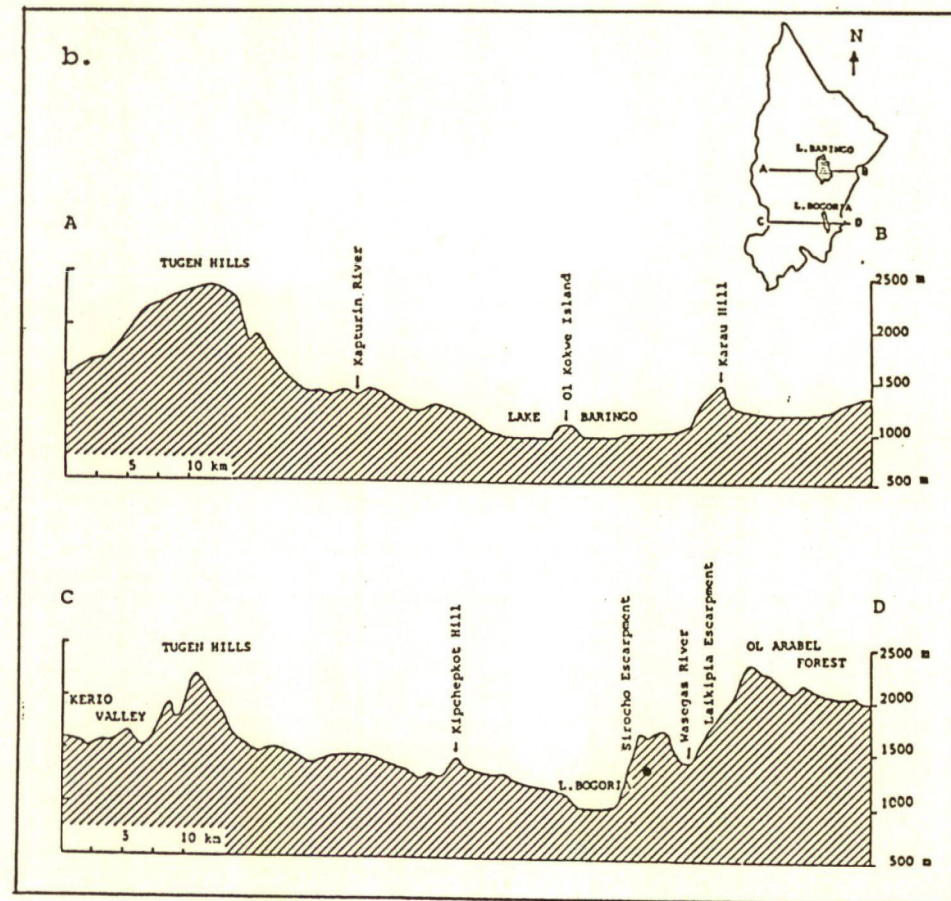
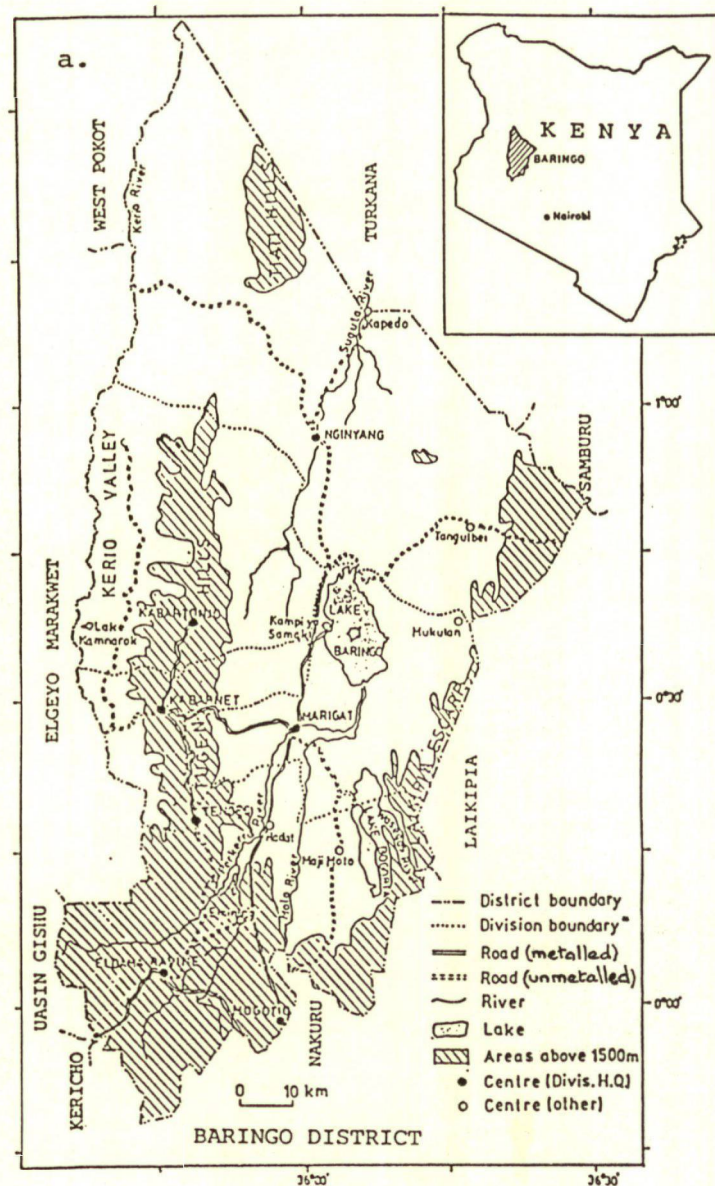


Figure 1 Location Map of Baringo District (a) and Relief Sections (b).

Investigations

The data used in the water resources assessment were collected through an inventory of previous studies and through field investigations. The hydrological field work included installing evaporation pans, stream gauging, measuring discharge and collecting of water samples for chemical analysis. The exploration for groundwater included geological methods (remote sensing techniques and ground survey) and geophysical methods (resistivity and electromagnetic surveys). Five test boreholes were drilled and test pumped. Groundwater samples were collected for chemical analysis.

Water Supplies

An inventory of water supplies in Baringo District was carried out by WRAP in July 1986, through an inquiry in the divisional water offices. Data on 40 supplies were collected (Plate 1). Most supplies (12) are found in Mogotio Division. Eldama Ravine and Kabartonjo Divisions have 7 supplies each, Kabarnet Division has 6 supplies, Nginyang and Tenges Divisions have three supplies each and Marigat Division has only two supplies. Of the 40 supplies, 21 use groundwater from boreholes and springs and 19 are based on surface water use. According to the available figures, about 110,000 people are supposed to benefit from the above supplies however, only 17 supplies serving about 51,000 people are reported to be in good working order. Some of the supplies contain water that has a high total dissolved solid content or a high fluoride concentration. Pans and earth dams are an important source of water both for people and cattle in Baringo. The project collected data on 81 pans and earth dams (Plate 1). The storage capacity of these water sources varies between 3,000 and 27,000 m³. The hazard of organic pollution of the water in the pans is high.

Irrigation is carried out on a small scale. The estimated total irrigated area in Baringo is only 800 ha.

Water Demand

Table 1 Forecast Total Water Demand for Baringo District, 1987 and 2000.

Water Use	1987			2000		
	Population	Demand m ³ /d	Demand m ³ /y	Population	Demand m ³ /d	Demand m ³ /y
Human	259,000	8,200	2.99M	410,000	15,000	5.47M
Livestock*	90,500	6,600	2.48M	102,500	7,700	2.81M
Total		15,000	5.47M		22,700	8.28M

*=LSU

The water demand was calculated for 1987 and 2000, using the 1979 census figures for the population projections and the 1980 figures for the livestock projections. The total human demand for water amounts to 8,200 m³/day and 15,000 m³/day for 1987 and 2000 respectively. The livestock (cattle, sheep, goats, camels) water demand shows only a slight increase from 6,800 m³/day in 1987 to 7,700 m³/day in the year 2000. This means that the total demand for water in Baringo District will increase from 5.47 Mm³ in 1987 to 8.28 Mm³ in the year 2000 (Table 1). The increase reflects a rapid population growth of close to 4%.

Surface Water Resources

Lake Baringo is the largest source of water in the district. It stores about 700 Mm³. Various estimates from previous studies suggest that between 16 and 26 Mm³ of water can be abstracted annually from the lake, but its use is limited because of its poor quality.

Lake Bogoria contains brine which is not suitable for any normal water use.

The annual discharges of the four major rivers amount to 300-500 Mm³ for the Kerio River, 160 Mm³ for the Perkerra, 110 Mm³ for the Molo and 30 Mm³ for the Subukia respectively. The combined annual discharge of small streams is estimated at about 50 Mm³. This means that on average between 650 and 850 Mm³ of water is discharged annually in the streams of Baringo.

On a daily basis, the actual amount of water available is considerably lower (Plate 2). The river discharges are subject to seasonal variations and the major part of the total flow is discharged during a few months only. Without storage, most peak flows remain unused. Low flow figures give a better indication for the assessment of available surface water than total annual flows. The 95% flow (the flow exceeded for 95% of the time) is generally used for the design of water supplies. The figures calculated for Perkerra, Molo and Subukia amount to 8, 6.5 and 1 Mm³ respectively.

Access to the surface water is another factor that must be considered. Without a distribution system the river water is only available to people living along the river courses.

In general, the surface water quality of major streams in Baringo district is good. Increased fluoride concentrations are found only in the streams that are fed by hot springs.

Potential for Developing Surface Water

The major problem in surface water development is the water distribution in time and space. Many of the streams in Baringo are seasonal, and storage facilities are required to bridge dry spells.

In previous studies carried out by consultants, the large-scale development of surface water resources, based on the construction of dams and distribution systems, has been proposed. However, this would require substantial investment. A cost-benefit analysis and social impact study was beyond the scope of this WRAP study. There is ample potential for developing surface water for domestic use and livestock watering on a small scale. On the

perennial rivers in the southwestern parts of the district, development by means of river runoff intakes can be considered, although a careful cost analysis must be made to assess the economic feasibility of such schemes. Small streams can be dammed with weirs.

In the semi-arid areas of Baringo, subsurface dams and sand-filled dams, built in the beds of seasonal rivers, may provide the required storage capacity. The cost of a masonry wall was KShs 1,400/- per m³ in 1984.

Pans and earth dams are another method of water development in the semi-arid areas. The present total storage capacity (over 770,000 m³) and the spatial distribution of the pans over the district seem to be sufficient to meet the livestock water demand, providing the pans are in good order. Rehabilitation of existing pans should therefore be considered first, before plans are made to construct new ones. The storage costs per m³ of water range from KShs 3/- to 5/-. Using water directly from the pans and earth dams for human consumption is not recommended, because of high pollution hazards. The construction of a dug well and a filter trench may guarantee safe water.

Medium-scale irrigation without regulation can be considered only for the Perkerra, Molo and Subukia rivers. The amount of water that can be diverted from the lower reaches of these streams during dry seasons varies between 130 and 450 l/s for Perkerra, 85 and 200 l/s for Molo and 15 and 70 l/s for Subukia (Table 2).

Table 2 Mean Monthly Dry Season Flows in l/s
(available in 9 years out of 10)

River	Dec.	Jan.	Feb.	Mar.
Perkerra at 2EE7	450	320	130	225
Molo at 2EGL	200	115	90	85
Subukia at 2EB3	70	20	15	25

These flows, however, available nine years out of ten, are already used. Therefore, all new irrigation schemes will require storage. The storage capacity of the Chemeron dam (4.5 Mm³) considerably increased the irrigation potential in the Marigat area.

Despite its poor quality, water from Lake Baringo can be used for irrigation, if special attention is paid to crop selection, drainage and leaching.

Groundwater Resources

In Baringo, groundwater occurs in weathered or fractured volcanic and Basement rocks, in sediments interbedded between volcanic rocks and in sediments deposited by rivers and lakes upon the volcanic rocks.

The total amount of groundwater that can theoretically be replenished by rainfall every year, has been estimated at about 80 Mm³. The actual amount of water that can be recovered is probably considerably lower. A part of the infiltrating rain may penetrate to great depths or, on the other hand re-emerge as springs at a short distance from the source area. As the present and future water demands in Baringo are less than 10 Mm³/year they can easily be met by groundwater, even if the actual amount available is much less than the estimated 80 Mm³.

Groundwater availability in Baringo (Plate 3) depends on the spatial distribution of water-bearing zones and the water quality.

The high potential areas, with wells having yields of over 5 m³/h of good quality water from a depth not exceeding 100 m below the surface, are found in the elevated parts of southern and western Baringo and in the south-eastern part of the district. In the latter area, very high yielding boreholes (over 100 ? m³/h) may, however, produce water with a high fluoride concentration. High yielding boreholes are also expected in the foothills of the eastern Tugen Hills, but the fluoride concentration is high there too.

Below most of the Rift Valley floor (semi-arid Baringo), groundwater is much less available than on the valley flanks. This is presumably because of lower recharge, intense faulting, presence of clayey deposits and geo-thermal activity. These factors are responsible for the lower yields of boreholes, deep groundwater levels and poor water quality (especially with regard to fluoride). Boreholes with sufficient yields (more than 2 m³/h) and acceptable fluoride concentrations (less than 3 mg/l) are expected only in the southernmost part of the valley floor and along the major streams.

Potential for Developing Groundwater

In total, 52 boreholes were drilled in Baringo between 1930 and 1987. More than half of these boreholes were drilled in the southern part of Baringo in an area that covers only about 7% of the district.

Only 12 boreholes are currently in use. The equipping or rehabilitation of boreholes that have sufficient yields and good water quality should be considered as a first phase of groundwater development.

The exploitation of the areas of high potential should start with a borehole spacing not less than 2.5 km. The accessibility of promising sites in these predominantly mountainous areas may be a constraining factor. The current construction costs of a borehole 100 m deep, equipped with a submersible pump are estimated at KShs 200,000/-.

Although the yields of boreholes drilled in the Rift Valley floor may be sufficient for handpumps, the prospects for groundwater development in these regions are poor, because of the high fluoride concentrations. The concentration in excess of 3-6 mg/l can cause skeletal fluorosis, with the danger of crippling at concentrations higher than 10 mg/l.

Since groundwater is the only permanent source of water in many parts of Baringo, the choice is therefore between no water at all or water with a high fluoride concentration. The removal of fluoride would be the best solution. So far, however, there is no simple method that can be applied. The only solution is to look for sites where the lowest concentrations can

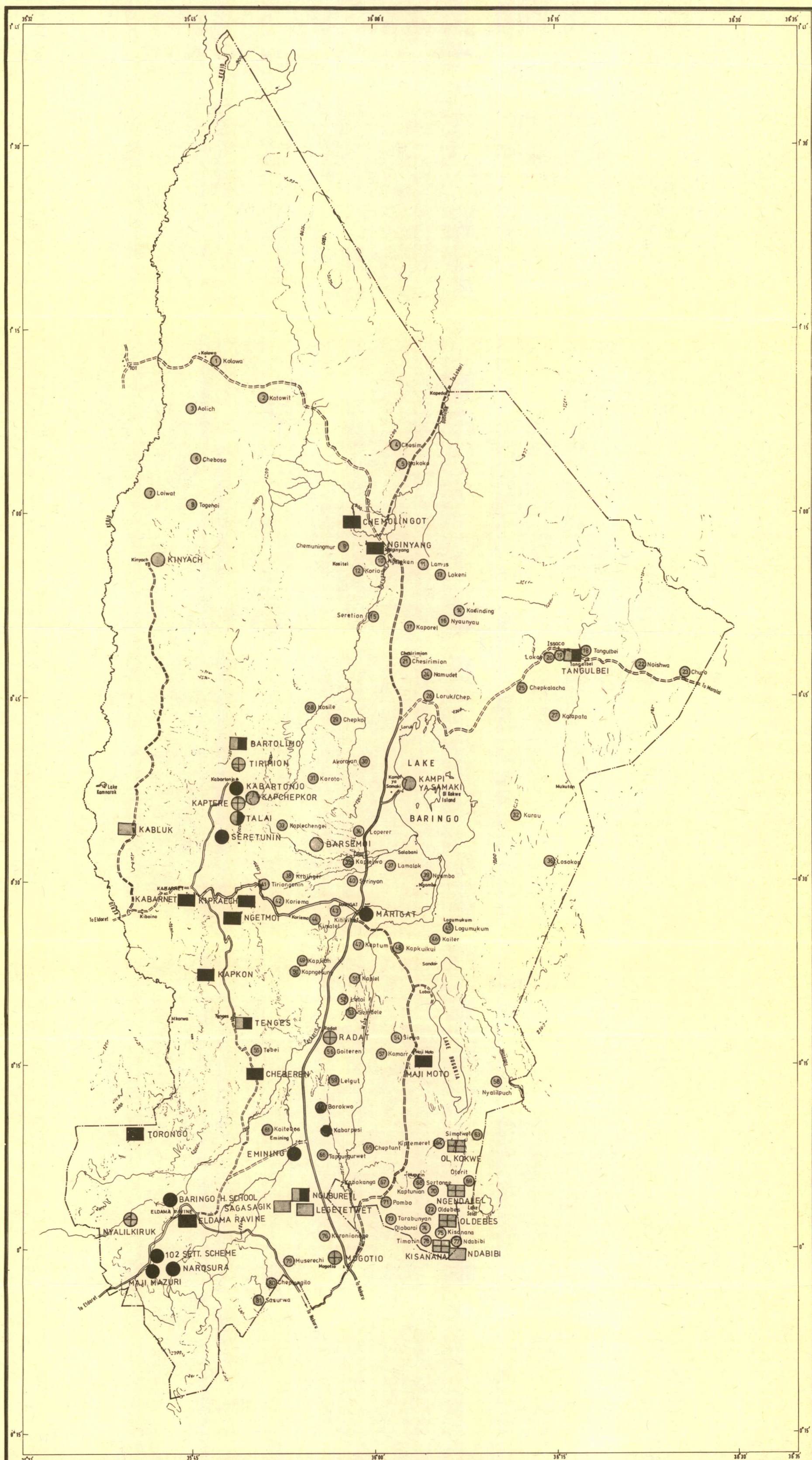
be expected. Sites along large faults should be avoided, because these faults may conduct juvenile gas from magma. The exploration should concentrate on the shallow aquifers, fed by fluoride-poor river water. Use of surface water during the rainy season may reduce the total intake of fluoride.

Cold springs in the elevated parts of the district are suitable for supplying small communities, provided the springs are protected against pollution. The same holds true for those hot springs that are not saline and in which the fluoride concentration is acceptably low.

With only a few exceptions, the average yields of boreholes are below 10 m³/h. Large-scale irrigation is therefore not feasible. Small-scale irrigation can be considered in the surroundings of a borehole yielding a minimum of 5 m³/h. In that case about 1 ha can be irrigated if the borehole is pumped for 8 hours per day. Areas suitable for small-scale irrigation in terms of groundwater quantity and quality are generally confined to the elevated parts of the district. These areas receive sufficient rainfall for rainfed farming and have enough surface water potential. In the semi-arid parts of Baringo, the use of groundwater for irrigation is limited either because of low yields or a high mineralization of the water.

Conclusion

The study area has sufficient potential to meet current and future (year 2000) water demand for domestic use and cattle watering. A combined use of surface water and groundwater is necessary, to overcome the limited extent of the former and poor quality of the latter. Improvement of the existing surface water supplies should increase their availability. Groundwater development should proceed in stages. Although the projected demand upto 2000 would not adversely affect the storage, any development of water at a larger scale than predicted should be studied carefully.



LEGEND

District boundary

All weather road (bound surface)

All weather road (loose surface)

Perennial stream

Contour (m above m.s.l.)

Centre

Pan/earth dam

GROUNDWATER SUPPLY

Good working condition

Poor working condition

Not operating

Under construction

SURFACE WATER SUPPLY

Good working condition

Poor working condition

Not operating

Under construction

scale: 0 5 10 km

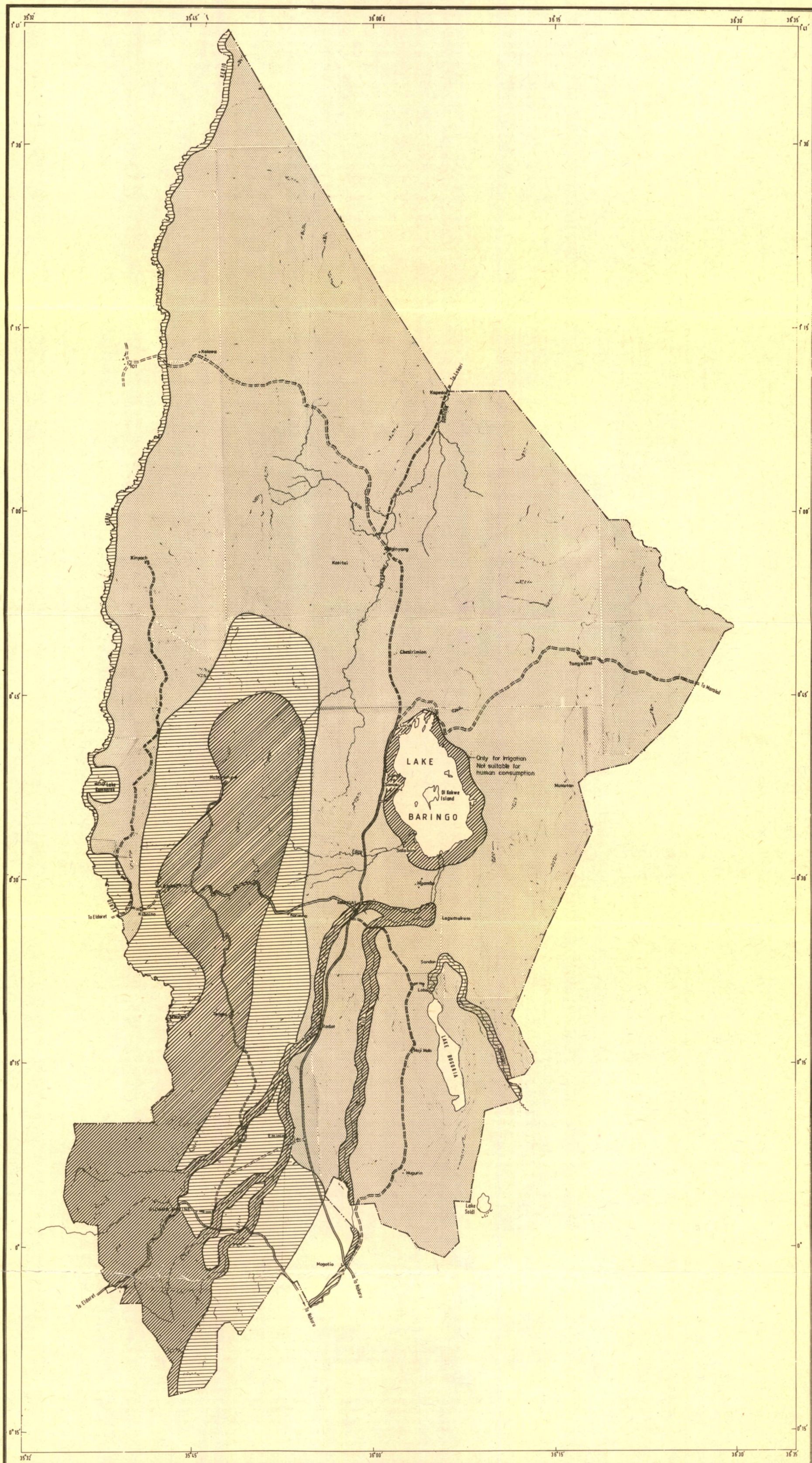
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Plate 1 WATER SUPPLIES



LEGEND

- | | | | |
|----------------------------------|-------|--------------------|--|
| District boundary | ----- | HIGH POTENTIAL | High rainfall areas (over 1200mm/year) |
| All weather road (bound surface) | ===== | MODERATE POTENTIAL | Major streams with minimum flow >100 l/s |
| All weather road (loose surface) | ----- | | Intermediate rainfall areas (1000-1200mm/year) |
| Perennial stream | ~~~~~ | | Major streams with minimum flow 10-100 l/s |
| Contour (m above m.s.l.) | ----- | | Stream flowing at least 9 months/year |
| Centre | • | LOW POTENTIAL | Low rainfall areas (less than 1000mm/year) |
| | | | Stream flowing less than 9 months/year |

0 5 10 km

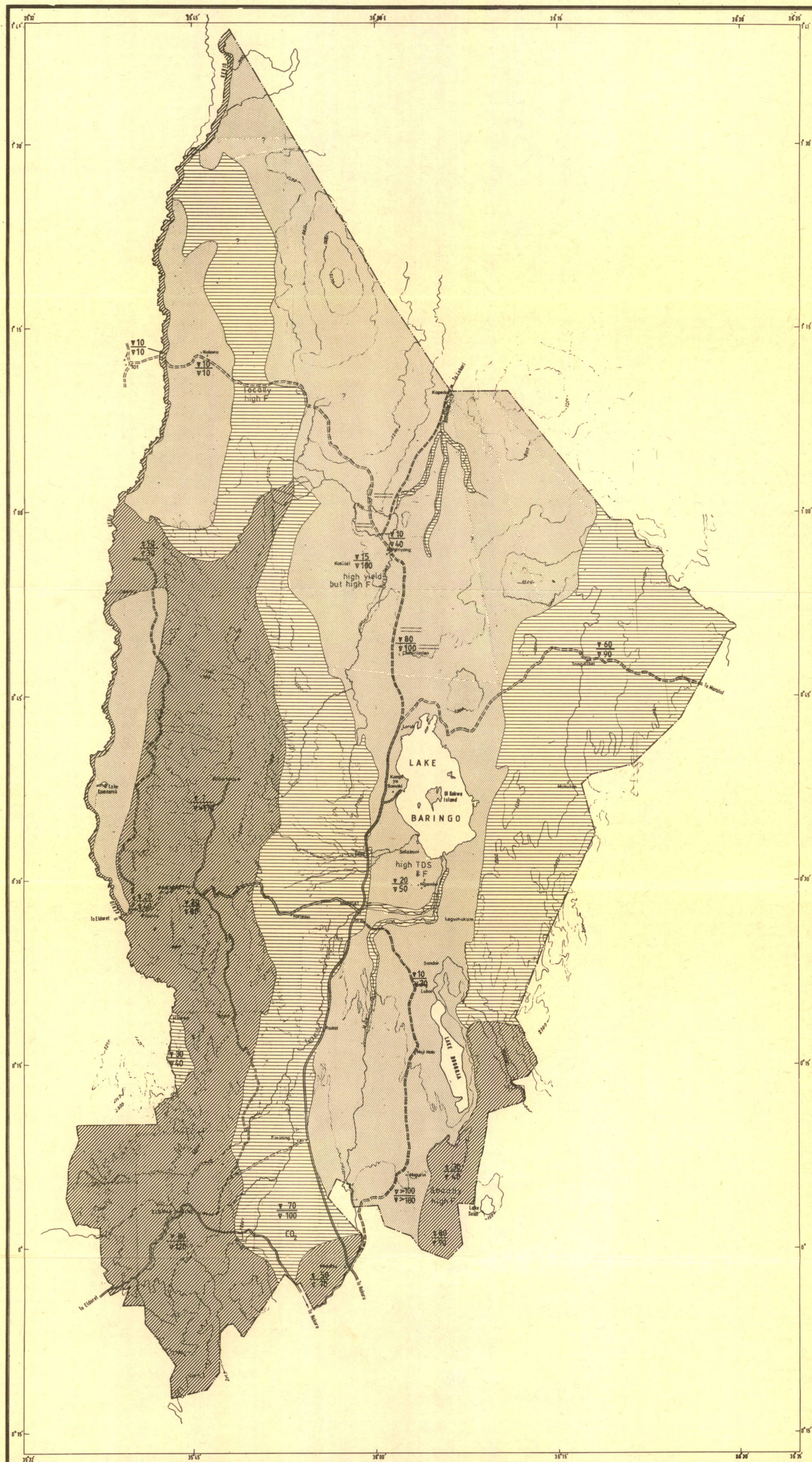
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Plate 2 SURFACE WATER AVAILABILITY MAP



LEGEND

District boundary ————

All weather road (bound surface) ————

All weather road (loose surface) ————

Perennial stream ————

Contour (m above m.s.l.) ————

Centre ————

HIGH POTENTIAL ———— Yield $> 5 \text{ m}^3/\text{h}$ at 10m. drawdown
TDS $< 100 \text{ mg/l}$, F. cont. $< 1.5 \text{ mg/l}$

MODERATE POTENTIAL ———— Yield $1-5 \text{ m}^3/\text{h}$ at 10m. drawdown
TDS $< 1500 \text{ mg/l}$, F. cont. $< 3.0 \text{ mg/l}$

LOW POTENTIAL ———— Yield $< 1 \text{ m}^3/\text{h}$ at 10m. drawdown
TDS $> 1500 \text{ mg/l}$, F. cont. $> 3.0 \text{ mg/l}$

$\nabla 50$ Average water rest level (m. below surface)

$\nabla 120$ Average water struck level (m. below surface)

scale: 0 5 10 km

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Plate 3 GROUNDWATER AVAILABILITY MAP

