REPUBLIC OF BOTSWANA

Ministry of Local Government & Lands
Central District

CENTRAL DISTRICT PLANNING STUDY

MAIN REPORT
VOLUME 1

FINAL REPORT

MAY 1992

Environmental Consultants
a division of Aqua Tech Groundwater Consultants (Pty) Ltd
P.O. Box 10072 Gaborone, Botswana

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LIST OF MAPS

ABBREVIATIONS

ALDEP	Arable Lands Development Programme
ARAP	Accelerated Rainfed Arable Programme
asl	Above Sea Level
AVHRR	Advanced Very High Resolution Radiometer
BC	Bush cleared
BCL	(Bamangwato Concessions Ltd)
BDC	Botswana Development Corporation
BDF	Botswana Defence Force
BMC	Botswana Meat Commission
BPC	Botswana Power Corporation
BRET	Botswana Renewable Technology Project
CDC	Central District Council
CDLUPU	Central District Land Use Planning Unit
CEC	Cationic Exchange Capacity
CFDA	Communal First Development Area
CHA	Controlled Hunting Area
CKGR	Central Kalahari Game Reserve
CLUP	Co-ordinator of Land Use Planning
CSO	Central Statistics Office
CV	Coefficient of Rainfall Variation
dbL	Diameter at Breast Height
DDC	District Development Committee
DDP IV	District Development Plan IV
DHV	DHV Consulting Engineers
DLUPU	District Land Use Planning Unit
DMS	Department of Meteorological Services
DOL	District Officer Lands
DOR	Department of Roads
DSL	Department of Surveys and Lands
DWA	Department of Water Affairs
DWNP	Department of Wildlife and National Parks
EIA	Environmental Impact Assessment
ERL	Energy Resources Limited
FAO	Food and Agriculture Organisation
FCC	False Colour Composite
FS	Flaked Stone
ft	Feet

SGAB	Swedish Geological International (AB)
SLEMSA	Soil Loss Estimation Model for Southern Africa
SLOCA	Services to Livestock Owners in Communal Areas
SMEC	Snowy Mountains Engineering Corporation
Struc.Rems.	Structural Remains
t	Tonnes
TGLP	Tribal Grazing Land Policy
UK	United Kingdom
UNDP	United Nations Development Programme
UTM	Universal Transverse Mercator
VDC	Village Development Committee
WMA	Wildlife Management Area
ZAB	Zaire Air Boundary

1. INTRODUCTION

This study has been carried out, in close consultation with the Reference Group, on behalf of the Ministry of Local Government, Lands and Housing from September 1990 to March 1992.

1.1 TERMS OF REFERENCE

The Terms of Reference are included in Appendix 1.1. The study deviated substantially from the Terms of Reference in a number of ways:

- The study has used GIS (PC ArcInfo) rather than traditional drafting methods. Consequently, the map scales specified in the Terms of Reference have not been adhered to as the GIS provides the facility to produce maps at any scale. The GIS files will be handed over to the Central District Administration. The scale of each hard copy of the maps has been agreed upon with the Reference Group and reflects the availability of data for each theme.

- The existing population data, from the 1981 census, was considered to be unreliable due to its age. It was therefore agreed that the final report be delayed until the results of the 1991 census were available and analysed in early 1992. However only preliminary populations figures were available and released to this study on the understanding that would not be published.

- The Terms of Reference did not require the preparation of an agro-climate thematic map. This has been included as it is a logical step after preparation of climatic, soils and ecological zones thematic maps and is an important element in agricultural and land use planning.

- The Terms of Reference required that all water points be mapped. However, the existing location maps are extremely poor and in view of the ongoing Water Points Surveys, it was decided to drop this theme.

- During the study, the Reference Group requested that the feasibility of creating a sixth Sub-district based on Tonota and Mmadinare be evaluated. This is discussed in Section 13.

- Also outside the Terms of Reference was the consultation conducted with the Central District Council. Sections 12 and 13 were presented to them and their comments included.

- Areas of influence
- Land use/tenure
- Population
- Size
- Ecological zoning

The overall rationale is that the more homogeneous and cohesive the planning area, the easier it will be to implement and manage development policies and extension services.

1.3.1 Physiographic Units

These were determined by analysing principally the surficial geology, topography and pre-Kalahari geology. The district was divided into three physiographic units; the Hardveld in the east, the Sandveld in the south west and north and the Makgadikgadi Basin in the west. Each has distinct geomorphological characteristics and has formed the basis for ecological zoning.

1.3.2 Ecological Zones

The ecological zones were determined to three orders or levels.

The physiographic zones described above formed the first order ecological zones. The second order zones were based on pre-Kalahari geology, surficial geology, soils and physiography. The third order zones were based primarily on soil and vegetation differences.

1.3.3 Agro-climate

This was aimed at dividing the district into areas of relatively uniform agricultural potential. This was done by analysing existing agro-climatic maps in relation to the soils map and soil moisture storage properties.

1.3.4 Settlements and Population

The analysis of settlement patterns and population has been derived from data supplied by CSO (1991 Census preliminary results). The usage of the population information has been restricted to settlements with a population of over 500. The location of all settlements/localities has been digitised from the Census maps.

1.3.5 Land Tenure and Land Use

The land tenure has been described from literature sources and published maps, whereas land use has also been mapped from satellite imagery.

Section 11 presents the 1991 Census Enumeration Areas and the GRAS boundaries.

Section 12 describes the methodology employed in delineating the District Planning Units and presents the building blocks and proposed DPUs.

Section 13 describes the methodology used in determining the feasibility of a sixth Sub-district and recommendations.

1.5 ACKNOWLEDGEMENTS

The consultants would like to acknowledge the members of the Reference Group without whose help this study could not have been completed.

We would also like to acknowledge the assistance given by many individuals throughout the study. A list of those consulted is presented in Appendix 1.3.

2. PHYSIOLOGY

2.1 PHYSICAL ENVIRONMENT

2.1.1 PRE KALAHARI GEOLOGY

Introduction

The pre-Kalahari geology consists of "bedrock" units ranging in age from in excess of 3000 million years old to 150 million years old. These units are extensively overlain by younger surficial deposits (0-130 million years old) comprising soils, sands and cretes. The pre-Kalahari rocks contain most of the potential aquifers and ore deposits in the district and play an important role in determining the nature of the overlying surficial geology.

The aeromagnetic maps used in this study are compiled from very accurate measurements of disturbances to the earth's magnetic field measured from a low flying aircraft. The disturbances are caused by small variations of magnetic mineral content in the various rock units. None occur in the surficial deposits. Consequently, this provides a means of mapping pre-Kalahari geology where these units are obscured, but the interpretations are by no means unique.

The term lithology means rock type.

Methodology

Mapping has been carried out by the Geological Survey at various scales in the district. The 1:125 000 series covers the eastern part of the district where there is most bedrock exposure. 1:250 000 scale mapping has been carried out in a narrow strip through and to the west of Orapa where there are relatively thin surficial deposits. The entire district is covered by a 1:1 000 000 map.

The above mentioned sources have been used to compile the pre-Kalahari geology map (for source diagram see Map Number 2.1).

Maps were prepared and digitised at 1:250 000 scale and modified where edge matching errors occurred using the 1:250 000 scale aeromagnetic maps (which cover the whole district) and borehole data.

The boundary between areas of thick surficial cover and areas where cover is thin or absent has been digitised from the National Geological Map and is shown by the Kalahari boundary on the geology map.

Karoo Supergroup

Rocks of the Karoo Supergroup are extensively developed in two areas or basins; the first being a large area covering the western half of the district (the western basin), and the other in the eastern corner of the district east of Bobonong (the eastern basin).

Basalt

This occurs in a large area occupying the central portion of the district, extending to its southern boundary, in the north of the district (both in the western basin) and east of Bobonong (the eastern basin). It is almost entirely covered by surficial deposits in the first two areas but where exposed they are flat lying and form flat outcrops of mafic lava. At outcrops they occasionally weather to dark clay rich soil often containing isolated, unweathered, round boulders. However, in the Bobonong area they do not weather as well and support shallow stony soils. The groundwater potential is moderate to good but good at its contact with the underlying fine grained sandstone.

Fine grained sandstone

This is a flat lying sedimentary unit which underlies the basalt. It occurs in a large area in the central westen part of the district between the central and northern basalt areas of the western basin. It also occurs as a rim around the edges of the two basins. It occasionally forms kopjes, particularly around the eastern basin, and weathers easily to a fine grained white sand. Its groundwater potential is moderate but good at its contact with the overlying basalt.

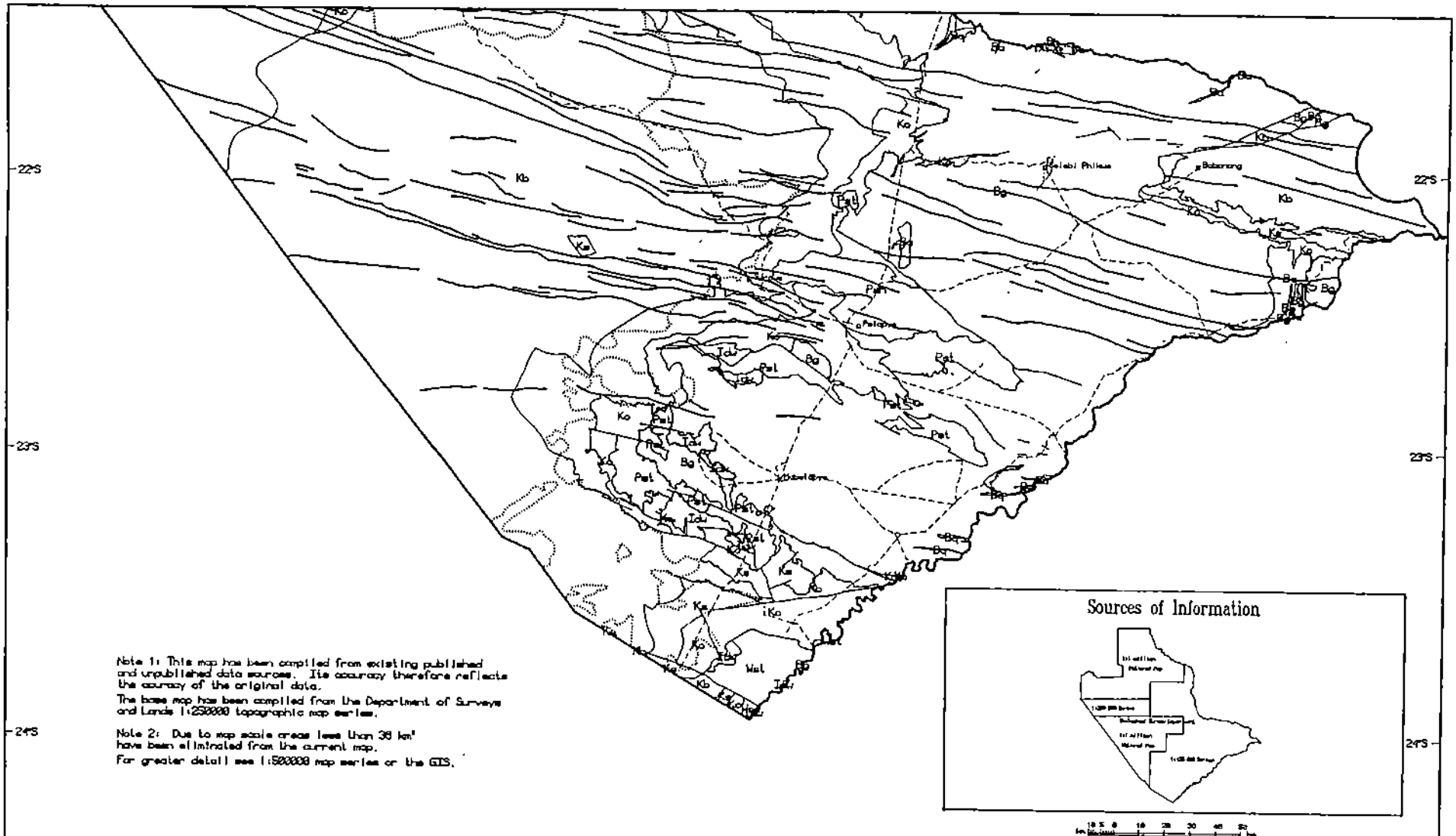
Sandstone, shale, mudstone and coal

This is a flat lying sequence of sedimentary rocks which underlies the fine grained sandstone and also occurs as a rim around the edges of the two basins. This rim is more extensive in the Palapye and Mmamabula areas. The sandstones weather easily to a coarse to fine grained sand with a variable clay content dependent on the amount of shale and mudstone present. Its groundwater potential is moderate to good.

Ghanzi Supergroup

Sandstone, shale, quartzite and limestone

This unit occurs in a small area in the extreme west of the district. It is covered by thick surficial deposits and its presence has been inferred from aerial magnetic data and boreholes. The dominant lithology is a



Note 1: This map has been compiled from existing published and unpublished data sources. Its accuracy therefore reflects the accuracy of the original data.

The base map has been compiled from the Department of Surveys and Lands 1:250000 topographic map series.

Note 2: Due to map scale areas less than 36 km² have been eliminated from the current map.

For greater detail see 1:500000 map series or the GIS.

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Granite/gneiss

This is by far the most abundant lithology in the Basement Complex and consists of quartz and feldspar rich granitic rocks. It has variable weathering characteristics, forming relatively sparse, flat lying outcrops and isolated kopjes, and it supports sandy soils.

Amphibolite

This is the second most abundant rock type in the Basement Complex, occurring generally in thin stringers that are usually too narrow to map at 1:250 000 scale. It is a mafic unit with a high percentage of hornblende. It is generally poorly exposed and weathers more readily than the granite/gneiss to a more clay rich soil.

Quartzite

This also occurs as thin stringers in the Basement Complex which are difficult to map, except in the area around Matsitama. It mostly comprises quartz rich lithologies which form kopjes and ridges due to their poor weathering characteristics.

Calcitic rocks and marble

This unit has been mapped in the Selebi Phikwe area but also occurs as stringers in the area between Mahalapye and Machaneng. It is poorly exposed, weathers to form calcareous soils and often gives rise to calcrete in overlying surficial deposits.

Limestone and graphitic schist

This unit is restricted to two small outcrops in the Matsitama area and comprises calcitic and graphitic lithologies. It is poorly exposed and gives rise to calcareous soils.

Banded Ironstone

This generally occurs as thin stringers in the Basement Complex in the area south east of Bobonong; the only area which can be mapped at 1:250 000 scale occurs near Maitengwe in the north east of the district. It is an iron and silica rich unit which usually forms ridges and kopjes. It does not weather easily, but where it does, it forms ferruginous soils.

Mineral Occurences

Mining Leases

Ten mining leases have been issued in the district. These are listed below (Table 2.2).

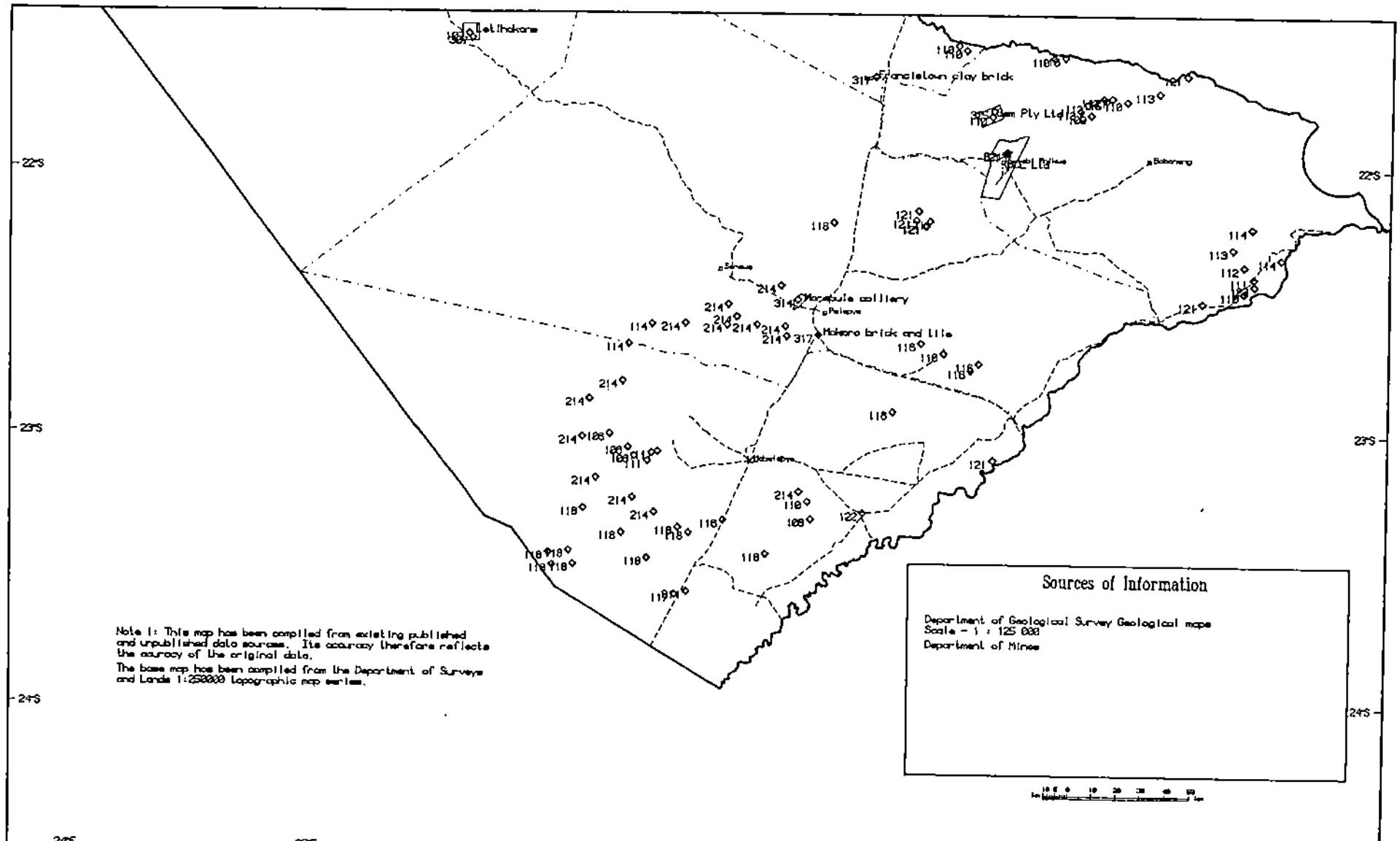
Diamonds are mined at Orapa and Letlhakane and this is likely to continue for the next 30 to 50 years. Copper and nickel are mined at Selebi Phikwe where there are reserves sufficient for at least another 10 years. Coal is mined at Morupule where there are very large reserves in the adjoining area. Salt and soda ash are mined near Nata where there are reserves sufficient for at least the next 50 years.

The remainder of the mining leases are for small scale mining. Salt is being mined in the north of Ntwetwe Pan. Marble has been mined north of Selebi Phikwe (for use in the Selebi Phikwe smelter) but operations have apparently been recently suspended. Mining leases have been issued for brick earth (for brick and tile manufacture) west of Foley and south of Palapye.

Small scale extraction of construction materials, particularly sand in the major rivers, is being carried out without Mining Leases but under the traditional provisions of the Mines Act.

TABLE 2.2 AREAS HELD UNDER MINING LEASE

Lease Number	Location	Mineral	Held By	Expires
10/71	Orapa	Precious Stones	De Beers Botswana Mining Co. (Pty) Ltd.	30/6/1992
8/75	Letlhakane	Precious Stones	De Beers Botswana Mining Co. (Pty) Ltd.	28/7/1992
4/76	Morupule	Coal	Morupule Colliery Pty	30/6/1992
4/72	Selebi Phikwe	Copper & Nickel Ore	Bamangwato Concession Ltd.	30/6/2001
3/88	Sowa Pan	Sodium carbonate & sodium chloride	Soda Ash Botswana Pty Ltd.	28/11/2013
87/2R	Makoro	Clay (restricted)	Makoro Brick & Tile (Pty) Ltd.	21/12/1997
88/2R	Foley	Brick Clay (restricted)	Francistown Clay Bricks & Products (Pty) Ltd.	18/09/1998
83/2R	Mmadinare	Marble (restricted)	Gem (Pty) Ltd.	28/09/1993
86/1	Ntwetwe Pan	Salt	Touch of Class	02/02/2002
90/1	Thakadu	Copper & Nickel	Falconbridge	21/08/2015



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MAP TITLE: MINERAL OCCURRENCES

MAP NO: 2.2

The usefulness of the pre-Kalahari geology in planning is primarily related to the types of soils that are derived from the different lithologies. This will affect the type of natural vegetation and agricultural potential of the area and hence land use. At the level of the present study, the information is considered adequate particularly if used in conjunction with the soil map. It is of fundamental importance to hydrogeology and the map is sufficiently reliable for estimating the potential groundwater resources of the district. However, it is too generalised for water borehole siting and detailed work in localised areas will be required for this purpose.

TABLE 2.3 SURFICIAL GEOLOGY

SYMBOL	LITHOLOGY	ASSOCIATION
1	Kalahari Sand, and residual superficial sands obscuring bedrock east of the Kalahari Group boundary. Some dune forms, minor calcrete and silcrete.	Sandveld, Serorome corridor.
2	Major calcrete and silcrete outcrops not associated with pans or dry valleys.	Sandveld, Kalahari periphery.
3	Lacustrine sediments, including pan sediments, calcrete and silcrete. Some aeolian dune forms.	Makgadikgadi Basin, major and minor pans.
4	Alluvial sands, gravels and clays with calcrete and silcrete, deltaic deposits and floodplains, extensive colluvium.	Dry valley deposits, Boteti and Makgadikgadi, hardveld.
5	Beach ridges and shorelines	Makgadikgadi and Nata basins.
6	Pre-Kalahari rock exposures, with or without soil cover.	Hardveld.

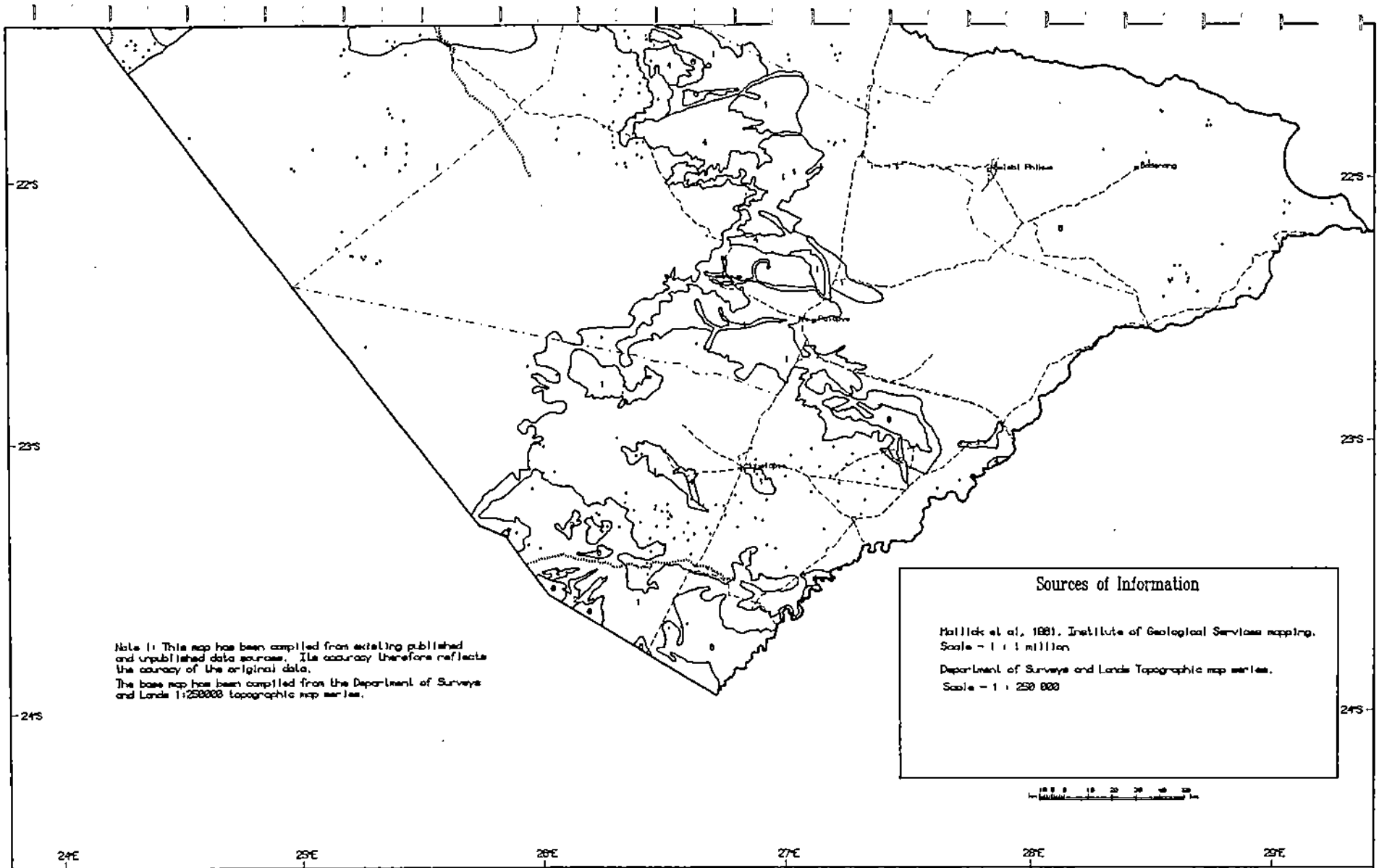
Reference can also be made to active rivers (hydrology section), hardrock lithology (geology section) and soil development (soil section).

Description

Surficial geology refers to unconsolidated and consolidated sediments of the Kalahari Group in the sandveld, and to surface sands and weathering residues in the hardveld.

The Kalahari Group contains sequences of sands, silts, clays, gravels, conglomerates, marls and duricrusts (calcretes, silcretes and ferricretes) whose origins and distributions are not fully understood. Sand and calcrete are the dominant members present in the district, although silcretes are common around pans and dry valleys. The depth of Kalahari Group sediments vary from 0 m at rock outcrops and the sandveld periphery to 200 m in parts of the Makgadikgadi Basin.

The Makgadikgadi Basin below 950 m asl forms a distinct unit within the Kalahari Group as the sediments are related to the form and function of a massive palaeo-lake. They include beach ridges, calcrete, silcrete, lacustrine, alluvial and deltaic sediments, and saline playa sediments related to present groundwater-surface water interactions. The Boteti lies within this lacustrine basin, whilst the landforms of the Nata catchment have also been influenced by the activity of this lake.



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: SURFICIAL GEOLOGY

MAP NO: 23

2.1.3 TOPOGRAPHY

Introduction

This section describes the topography of Central District.

Methodology

Contours are indicated on a variety of map scales, but tend to lack consistency. Thus 1:50 000 maps covering the eastern part of the district may have contours at 20 m or 50 ft intervals depending on the age of the map edition, whilst the Makgadikgadi area is not contoured at all. 1:250 000 maps are available for the whole district, but only the first edition, of limited coverage, are contoured at 50 and 100 m intervals. The 1:500 000 hydrogeology sheets are contoured at a 50 m interval in the sandveld and 30 m in the hardveld.

Generalised contours at 100 m intervals have been taken from the Geological Survey National Gravity data base for consistency. Hill massifs and escarpments have been mapped from the soils data base and checked using 1:250 000, 1:500 000 sources and Landsat Imagery. The 1:50 000 topographic maps have been used to check the altitudes of hill massifs in the hardveld.

Presentation

The topography of the District has been digitised into 2 GIS coverages:

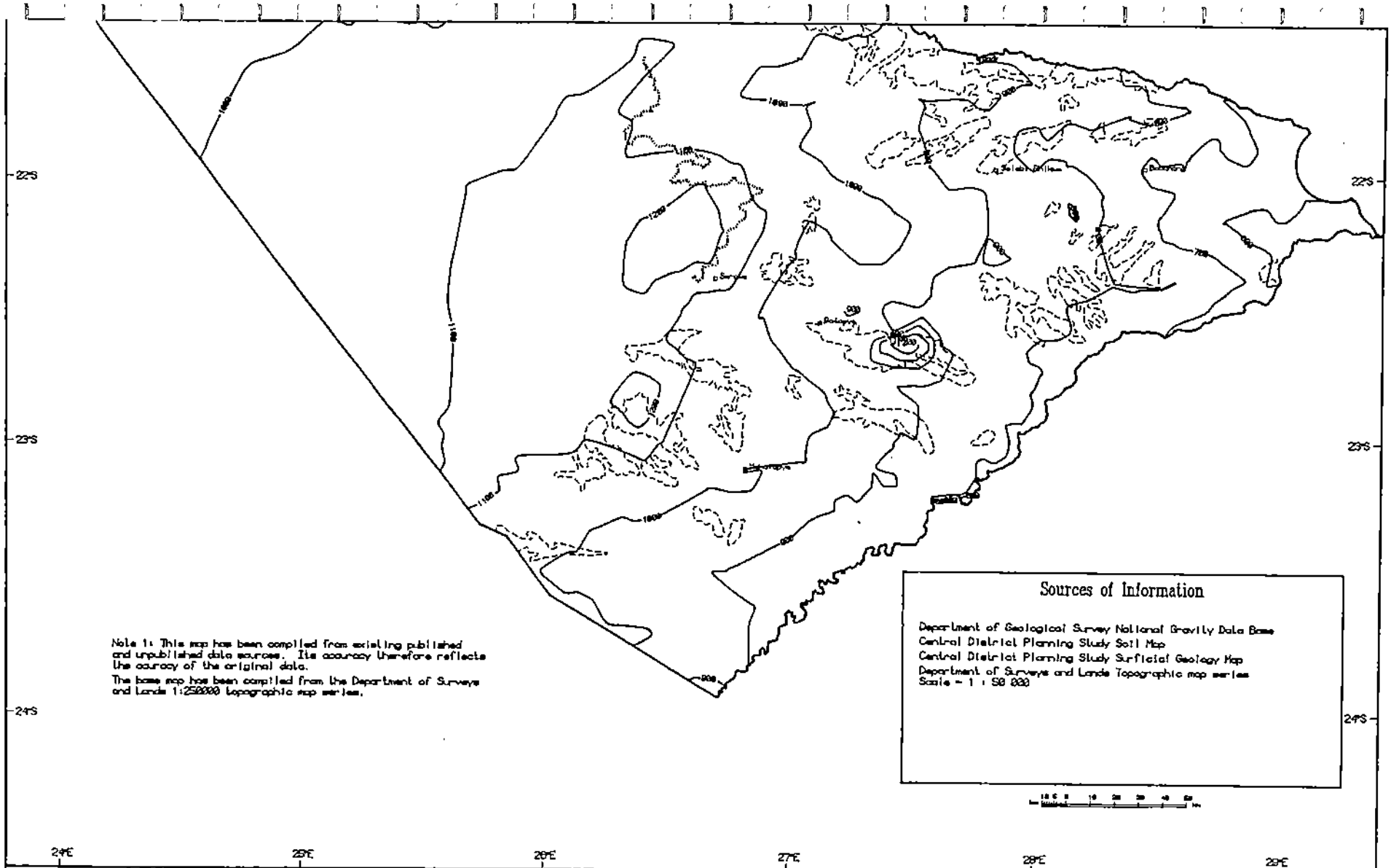
- 100 m generalised contours
- hill massifs and escarpments

The Topography map is presented on Map Number 2.4.

Description

Topography

The highest parts of Central District lie along the Limpopo-Kalahari watershed at 1200 m asl to the west of Serowe. To the east the hardveld (the area with insignificant surficial cover) drains towards the Limpopo, with a lowest point of < 600 m at the Limpopo-Shashe confluence. Within this area significant hill massifs rise to 1100-1300 m, and include the major ranges of the Mokgware, Shoshong, Tswapong and Tsweneng Hills.



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2.1.4 CLIMATE

Introduction

This section describes the four climate parameters of rainfall, temperature, evapotranspiration and wind, together with their sources of data. Patterns and variations in the climate parameters are also discussed.

Methodology

The primary source of information for Central District is the rainfall, temperature and evapotranspiration data collected and published by the Department of Metereological Services, Gaborone. Wind data has been derived from Larsson (1986). The data sets are available on small scale (1:2 000 000) national maps.

Annual rainfall and seasonal rainfall variability were digitised from SMEC/WLPU/SGAB maps (Botswana National Water Master Plan 1991). Wind velocity was digitised from Larsson's Wind map of Botswana (1986). The location of rainfall stations, as listed in Table 2.5, is shown on Map Number 2.5d. Temperature and evapotranspiration patterns cannot be mapped adequately from the available data, and are described below.

Presentation

Data has been assembled in four GIS coverages:

- Annual rainfall
- Seasonal rainfall variability
- Wind velocity
- Location of rainfall stations

This data is presented on Map Numbers 2.5a - 2.5d.

The above factors, together with temperature, evapotranspiration and climatic controls, are described in the next section.

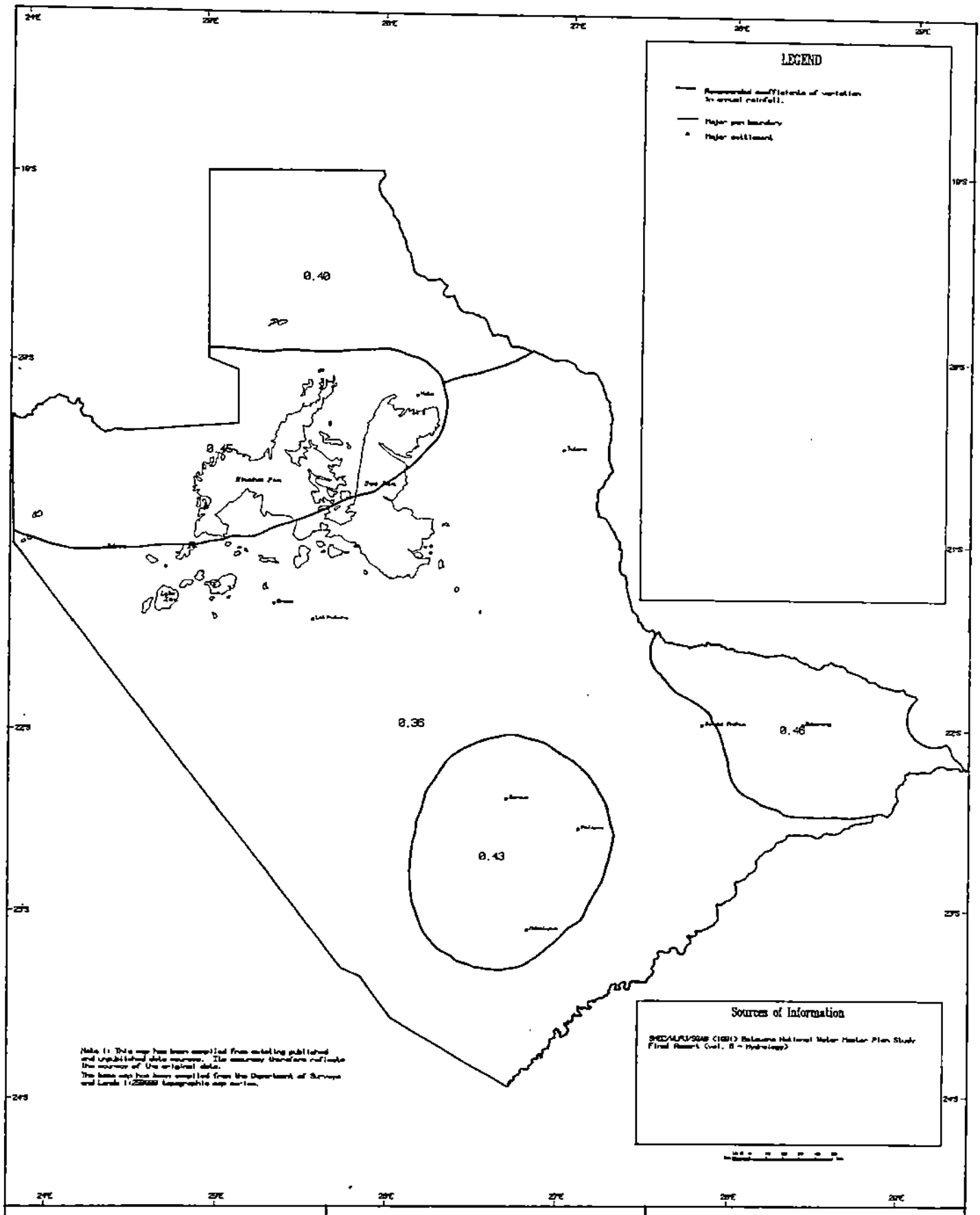
on average 1 year in 7, whilst crop failure is frequently associated with dry spells. Spatial variation of rainfall between stations is also marked.

TABLE 2.4 AVERAGE MEAN AND MAXIMUM RAINFALL IN MM PER MONTH AND PER ANNUM FOR SELECTED LOCATIONS

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
Tutume (1959-87)													
MEAN	21.8	68.4	98.8	118.4	82.4	66.1	31.8	4.7	1.1	0.6	0.6	7.1	348.2
MAX	88.0	161.0	263.3	404.5	234.0	230.9	124.0	42.0	11.0	17.0	13.5	70.0	763.9
Mahalapye (1911 - 88)													
MEAN	30.2	67.2	79.0	88.6	82.2	66.6	25.2	9.4	3.4	2.3	2.6	7.8	468.4
MAX	105.4	171.5	255.0	287.7	447.0	257.2	125.0	100.5	49.8	63.6	48.1	61.0	891.3
Serowe (1921 - 88)													
MEAN	29.1	58.7	84.2	90.2	86.5	66.9	25.0	7.6	1.5	1.4	1.0	6.0	456.8
MAX	138.0	171.4	280.5	338.2	427.5	211.9	112.5	86.9	37.1	17.3	22.9	72.1	1090.7
Bobonong (1959 - 88)													
MEAN	23.5	47.0	60.6	68.0	82.5	32.6	30.1	4.0	2.9	0.1	0.0	4.3	346.6
MAX	83.0	199.0	172.5	241.5	233.0	149.6	137.5	26.5	44.5	2.5	1.0	31.0	786.3
Selebi Phikwe (1972 - 88)													
MEAN	27.8	63.0	82.9	91.9	74.0	48.1	27.6	3.7	0.6	1.7	1.3	15.8	422.7
MAX	92.3	170.7	250.4	236.8	265.2	142.3	127.8	32.1	5.0	24.1	16.1	90.2	732.6
Francistown (1922 - 88)													
MEAN	27.3	58.7	90.7	100.8	85.0	60.2	25.0	6.6	2.7	0.4	1.0	6.4	467.0
MAX	125.8	165.0	292.8	364.4	348.3	246.8	93.5	75.9	36.0	11.4	14.3	69.4	969.1
Nata (1958 - 88)													
MEAN	27.4	55.8	95.5	107.1	96.7	59.3	24.8	3.0	1.4	1.0	0.0	4.7	410.2
MAX	91.0	116.5	297.0	323.0	224.0	204.0	103.5	22.0	24.0	18.0	0.0	37.0	708.4
Orapa (1968 - 88)													
MEAN	25.9	42.9	69.1	91.3	70.2	57.1	20.2	9.0	0.6	0.1	0.4	7.6	373.4
MAX	127.3	140.0	157.8	280.7	183.0	144.1	74.9	99.9	5.5	2.0	4.0	40.6	685.2
Martins Drift (1961 - 88)													
MEAN	31.5	65.8	53.4	97.3	50.4	42.2	30.0	4.7	0.8	0.7	0.6	7.8	394.8
MAX	89.0	197.7	145.0	280.7	205.5	219.0	112.5	52.5	13.0	6.0	5.5	60.5	611.9
Rakops (1959 - 88)													
MEAN	17.6	42.9	61.0	87.5	61.5	50.9	27.2	4.1	2.3	0.2	1.1	3.8	355.5
MAX	107.5	113.5	198.0	263.6	228.0	231.0	134.5	56.0	57.0	5.8	20.5	24.5	724.0
Shoshong (1971 - 87)													
MEAN	27.3	62.1	95.7	94.9	66.2	65.8	31.4	5.1	0.0	0.5	1.0	12.9	447.4
MAX	67.6	186.0	303.0	295.1	218.0	273.0	103.0	34.0	0.0	6.7	12.0	60.0	862.7
Palapye (1922 -88)													
MEAN	25.9	53.0	67.9	84.4	71.2	60.0	26.0	6.7	2.5	0.8	1.2	7.0	410.0
MAX	103.0	158.1	254.1	240.3	405.3	205.5	114.9	84.7	36.3	17.7	37.6	98.3	1016.5

Source: Botswana National Water Master Plan Study, Final Report Volume 6 - Hydrology (1991).

Mean annual rainfall figures range from around 350 mm (Tutume, Bobonong, Rakops) to slightly over 450 mm in the southern part of the District. The cv of seasonal rainfall (in %, Oct-Apr) increases from 30-35% in the northeastern and southern parts of the District to over 45% in the central and west central portion of the District (Bhalotra 1985: 37).



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MAP TITLE: COEFFICIENTS OF VARIATION IN ANNUAL RAINFALL

MAP NO: 25b

Evapotranspiration

Potential evapotranspiration, measured from Class 'A' Pans at selected stations, exceeds the mean annual rainfall by a factor of 3-4. Mean daily evapotranspiration rates are lowest in June (c. 2.5 mm) and increase to a maximum (c. 5.5-6.5 mm) in the summer months, dependent on temperature and cloud cover (Bhalotra 1987: 94/97). The coefficient of variation of annual values is very low at less than 0.05. Only during periods of prolonged or heavy rainfall is evapotranspiration exceeded by precipitation.

Reliability and Gaps in Data

Reliability is a function of distribution and length of operation of gauging stations, the accuracy of data collection and interpretation.

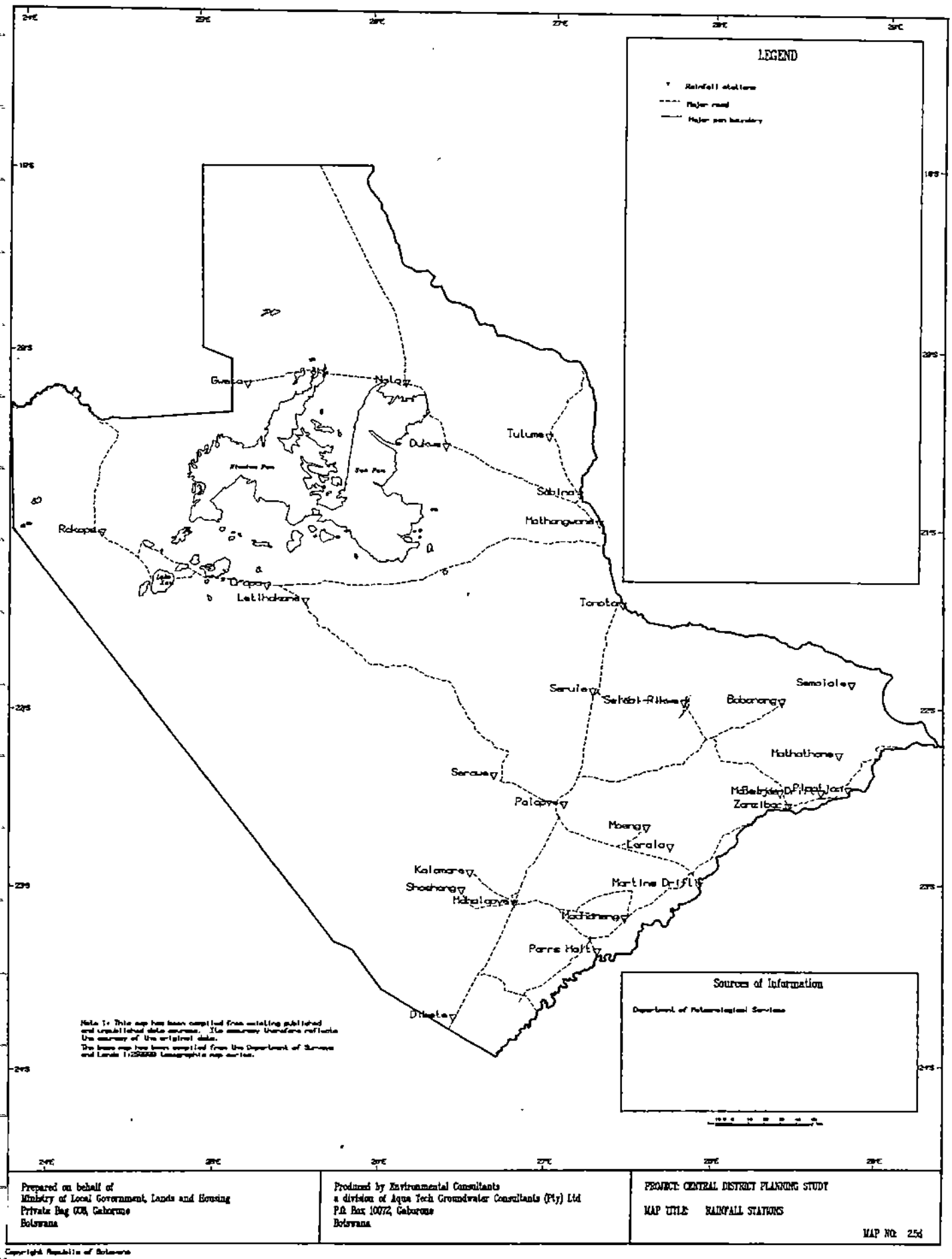
In the Central District there are 30 rainfall gauges operative at present (Table 2.6). Of these, 4 have records extending c.70 years (Kalamare, Mahalapye, Palapye and Serowe), whilst a further 17 were installed in the period 1959-61. Reliability of rainfall data is dependent on the site of the gauge and the motivation of the operator. This varies significantly between villages and a number of records have considerable gaps. Data collection has improved greatly over recent years with training by the Department of Meteorological Services.

Density of rainfall gauges is low at 1:4450/km². The present distribution of rainfall gauges is not consistent, with the western and northern parts of the district being poorly served. Given the erratic distribution of rainfall events the present gauge network is not sufficient to accurately record rainfall distribution. No data is being collected on temporal variations in rainfall (e.g. intensity).

TABLE 2.6 LOCATION OF RAINFALL STATIONS WITH DATES OF INITIAL RECORDS

Station	Date of Initial Record	Station	Date of Initial Record
Baines Drift	1/9/60	Nata	1/5/59
Bobonong	1/10/59	Orapa	1/11/68
Dibete	1/4/58	Palapye*	1/2/22
Dukwe*	1/5/59	Parrs Halt*	1/11/59
Gweta	1/4/59	Plaatjan	1/12/80
Kalamare	1/11/23	Rakops	1/1/59
Lerala	1/2/81	Letlhakane	1/10/59
Machaneng	1/5/58	Sebina	1/5/58
Mahalapye	1/3/11	Shoshong*	1/10/71
Martins Drift*	1/11/61	Selibi Phikwe	1/4/72
Mathengwane	1/10/59	Semolale	1/2/82
Mathathane	1/12/80	Serowe	1/9/21
Moeng*	1/10/59	Serule	1/4/59
Tonota	1/4/59	Tutume	1/10/59
Moletji	1/2/82	Zanzibar	1/12/80

* indicates incomplete records
No records are available for the gauges at Palla Road and Talana Farm.



2.1.5 HYDROLOGY

Introduction

This section describes the hydrology and hydrogeology of Central District. It describes the characteristics of the surface drainage of the District, the hydrological monitoring network maintained by the Department of Water Affairs, and existing and planned dam sites. A number of potential dam sites have also been identified for future use. These are listed in the consultant's reports in the references.

It also describes the groundwater potential, groundwater quality, recharge, piezometric surface and summarises borehole statistics. (The piezometric surface is the height of the water table above mean sea level. Consequently the depth to the water table can be obtained by subtracting the piezometric surface from the altitude.)

Since preparing the Draft Final Report, the National Water Master Plan (NWMP) has become available. We have reviewed it and found a number of discrepancies between the text and data bases such that we have concluded that only the piezometric surface and recharge data can be used for this study.

Methodology

The primary sources of data are the 1:250 000 topographic sheets and the 1:500 000 hydrogeological reconnaissance maps of Botswana. Data for dam sites and the hydrological monitoring network has been taken from DWA records and consultant's reports.

Data reported by Gibb (1976), MacDonald (1987) and the NWMP (1991) has been used to calculate run off in most of the catchments.

The groundwater potential coverage was prepared by analysing the borehole statistics (Jennings, 1974) and modifying the results according to our own experience. The values derived for groundwater potential for each rock unit was then attached to the geology coverage. The piezometric surface and recharge data has been obtained from the NWMP.

Presentation

The level of information shown on the source maps has proved to be too detailed for the current exercise and has therefore been simplified.

The major ephemeral rivers in the Limpopo Basin are:

- Limpopo River
- Shashe River
- Motloutse River
- Lotsane River
- Mhalatswe River

The Serorome Valley, in the south of the District, is a fossil tributary of the Limpopo. However, it does flow occasionally below its confluence with the Bonwapitse due to run off in the Bonwapitse catchment.

Most of the rivers have seasonal flow characteristics and have rock, clay and "sand river" channels. They respond to prolonged or high rainfall events within their catchments by flows lasting from a few hours to several days. Most of the rivers experience one or more flows throughout the wet season, although completely dry years are known. They are also prone to flash flooding, with risk to infrastructure and disruption of communications.

The river catchments are entirely within Botswana with the following exceptions:

- Boteti River (Angolan Highlands)
- Nata River (Zimbabwe)
- Shashe River (Zimbabwe)
- Limpopo River (South Africa)

The flow characteristics of the Boteti River are modified by the Okavango Swamps, and most of the flow in the Nata River is generated in the Zimbabwe portion of the catchment.

Dams

The following major dams have been constructed:

- Shashe Dam (Shashe River)
- Mopipi Dam (Boteti River)

The following dams have been proposed as part of ongoing projects and are at the feasibility or design stage:

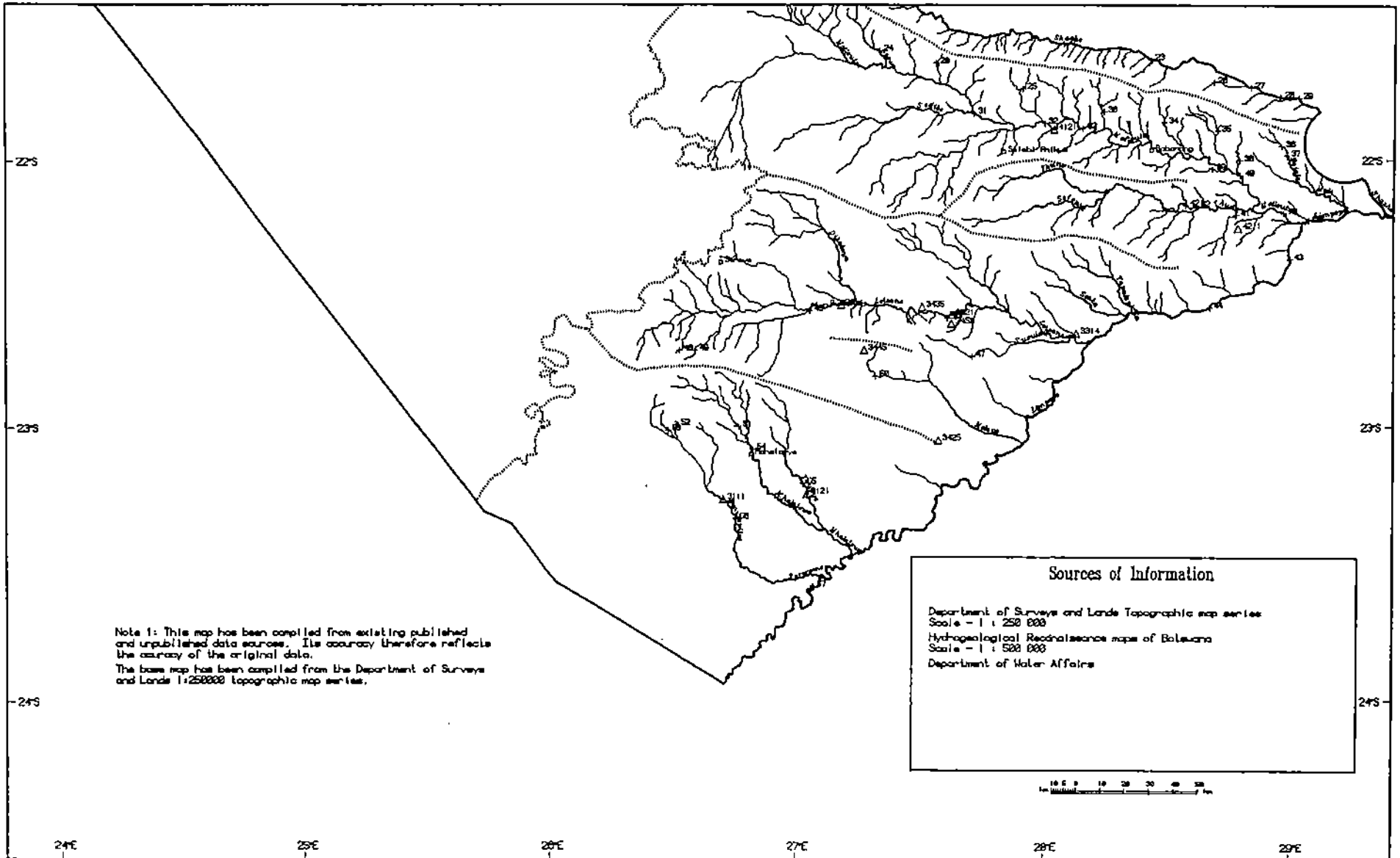


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TABLE 2.9 CATCHMENT RUN OFF

Catchment	Run Off (mm)
Notwane	4.4
Serorome	2.0
Mhalatswe upstream of Madiba Gauge	9.8
Mhalatswe downstream of Madiba Gauge	6.1
Lotsane upstream of Palapye Gauge	3.6
Lotsane downstream of Palaype Gauge	1.6
Motloutse upstream of Tobane Gauge	8.1
Motloutse downstream of Tobane Gauge	4.4
Shashe upstream of Shashe Dam	13.7
Shashe between Shashe Dam and Lower Shashe Gauge	28.7
Shashe below Lower Shashe Gauge	7.2
Nata upstream of Nata Old Bridge Gauge[a]	0.9
Motsetse upstream of Mosetse Old Bridge Gauge	6.0
Mosope upstream of Matsitama Gauge	6.0

Note: [a] Only for catchment area within Botswana

The run off data for the Botetl catchment is meaningless as its catchment is ultimately in the Angolan highlands. The run off for the sandveld area is effectively nil, although dry valleys such as the Serorome, Nunga and Letlhakane occasionally carry water for short distances under extreme circumstances (e.g. Letlhakane - 1968, Nunga - 1988). Pans form important surface water reservoirs in many areas.

Surface Water Quality

There is little data available. However, the water quality of major rivers is generally good with total dissolved solids values below 200mg/l, except where there are point sources of pollution (NWMP 1991).

Surface Water Pipelines

These connect Shashe Dam to Francistown, Shashe Dam to Selebi-Phikwe and Mopipi Dam to Orapa. Pipeline maps were not received in time for inclusion in this study. However, most of the Shashe Dam to Francistown pipeline is within the Gaborone - Francistown road reserve and the Shashe Dam to Selebi-Phikwe pipeline apparently follows the power transmission line. The Mopipi Dam to Orapa pipeline apparently follows the Mopipi - Orapa road.

It would therefore appear that soil type is the major control on rainfall recharge.

About 35% of recharge can be extracted from fractured aquifers in the hardveld area (approximately 0.5 to 4mm).

Water quality has a general relationship to recharge. Where there is relatively high recharge, water quality should be better than areas with low recharge. Ground water quality data is sporadic. The area surrounding and including the Makgadikgadi Pans has poor water quality due to the brines in the area. It is suspected that poor water quality may be encountered in the Kalahari beds throughout most of the District, except along the Boteti River where the river water should recharge the aquifer.

Table 2.10 summarises available reliable borehole statistics for some of the different rock units.

TABLE 2.10 BOREHOLE STATISTICS ON VARIOUS GEOLOGICAL FORMATIONS IN BOTSWANA

	(B)	(W)	(Kb)	(Ks)	(Ko)	(D)	(CK)
Number of Boreholes drilled	472	209	128	76	250	99	169
Number of successful ("wet") boreholes	220	157	93	49	118	42	123
Number of blank ("dry") boreholes	202	52	35	27	132	57	66
Number of saline boreholes (including blank total above)	3	3	3	2	22		18
Average yield m^3/hr	4.3	4.6	6.0	4.7	6.2	3.9	6.0
Average depth successful boreholes (m)	56.58	86.27	72.21	111.66	137.72	65.85	36.26
Average depth of all boreholes (m)	57.99	86.60	76.74	105.05	115.82	60.83	41.45
Average depth water struck (m)	34.32	40.35	38.65	67.72	97.05	30.79	23.05
Average depth to static water level (m)	23.20	27.57	26.63	54.66	65.25	19.20	18.09
Success rate % (i.e. % of "wet" boreholes)	57.2	75.11	72.65	64.77	42.20	42.42	65.07

Description:

(B) Basement Complex
(W) Waterberg and Palapye Supergroups
(Kb) Karoo Supergroup
(Ks) Karoo Supergroup
(Ko) Karoo Supergroup
(D) Dolerite dykes
(CK) Surficial deposits

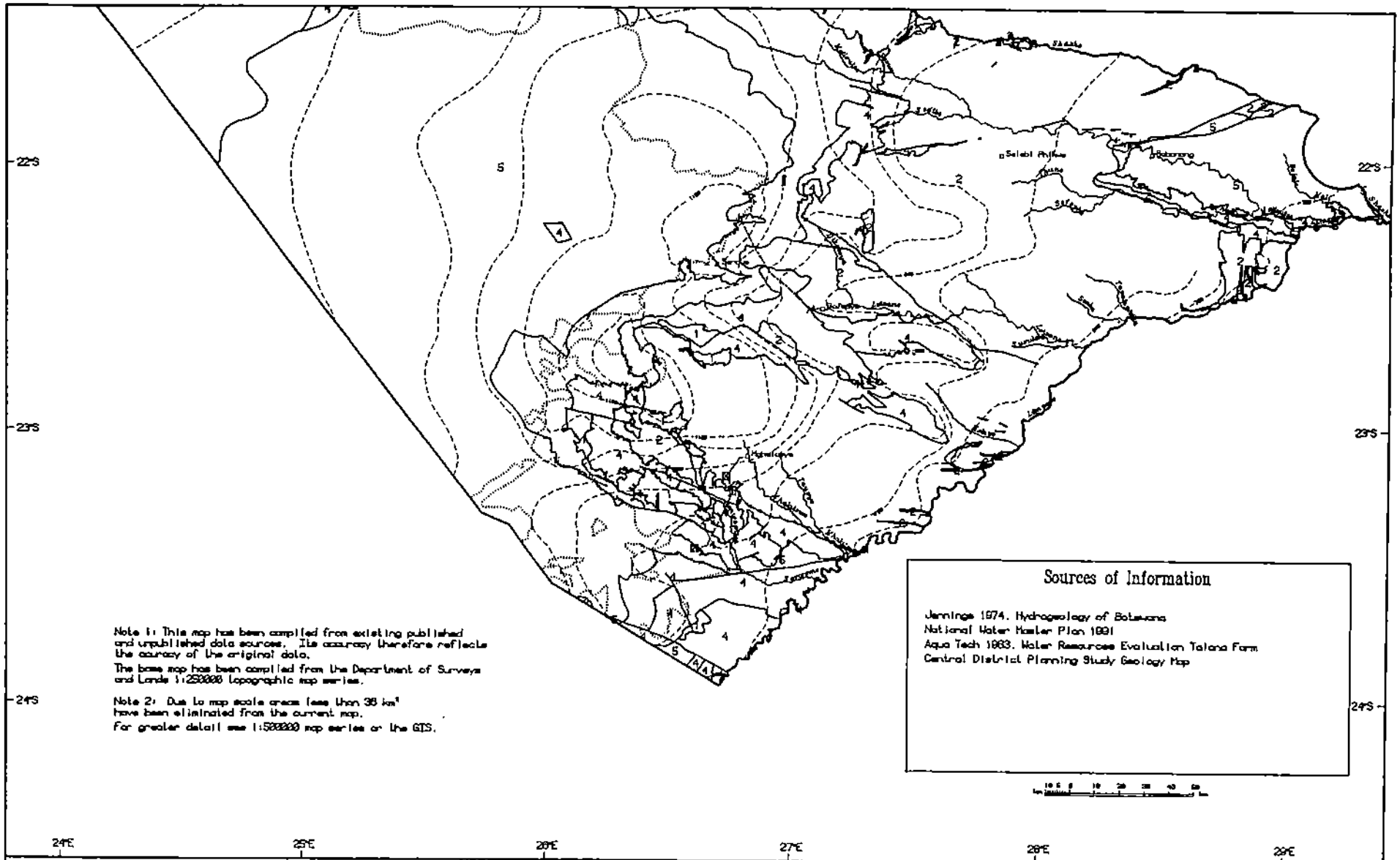
Note: no meaningful data available for the Ghanzi Supergroup.

Source: Jennings, 1974, "Hydrogeology of Botswana"

The following describes the groundwater potential for each rock unit:

Alluvium (Ca)

The largest and thickest developments of alluvium occur at Talana Farm on the confluence of the Motloutse and Limpopo Rivers, and at Dikatlhong at the confluence of the Mhalatswe and Limpopo Rivers. Further



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: GROUNDWATER POTENTIAL

MAP NO: 2.7

Ghanzi Supergroup (Gh)

Nothing is known of the groundwater potential of this unit within Central District. However, it is known that in Ghanzi District it is a good aquifer at outcrop but that borehole yields and water quality deteriorates rapidly as surficial cover thickens. Consequently, it's groundwater potential in Central District is considered to be poor and the water quality should similarly be poor.

Palapye Supergroup shale (Psh)

The ground water potential is poor to moderate. Groundwater only occurs in faults in fractures. Water quality is generally poor except where there is local recharge along rivers.

Palapye Supergroup sandstone with minor shale & limestone (Pst)

The ground water potential is moderate to good. Groundwater only occurs in faults and fractures. However, nothing is known of the limestone unit and it is possible that this may have good groundwater potential. The water quality is generally good.

Waterberg Supergroup sandstone with minor shale (Wst)

The ground water potential is moderate to good. Groundwater only occurs in faults and fractures. The water quality is generally good but may deteriorate where there are thick surficial deposits.

Basement Complex (Ba, Bc, Bg, Bs and Bi)

The ground water potential of the Basement Complex is poor to moderate overall. However, little is known about the rock types other than the gneiss and granite (Bg) and the amphibolite (Ba). The ground water potential of the amphibolite is slightly better than the granite and gneiss due to better weathering characteristics. Ground water occurs in faults and fractures and local areas of deep weathering. Water quality is generally good but can be locally poor.

Intrusives (Idk, Idw and Ids)

Little is known of these units other than the late - post Karoo dolerite dykes (Idk). The groundwater potential is considered to be generally poor. However, boreholes sited next to the late - post Karoo dolerite dykes can have moderate yields and hence the groundwater potential of this unit is considered to be poor to moderate. Groundwater occurs predominantly in faults and fractures but also in local zones of deep

Reliability and Gaps in Data

The run off data described above can only be used for broad planning purposes as it will be modified continually as more river flow measurements become available. The data for the Mosope and Motsetse Rivers are considered to be unreliable as they are based on short periods of river flow records. The data for the other rivers has been taken from an analysis of the Limpopo catchment as a whole in which river run offs were modelled for an extended period of 60 years, based on shorter periods of actual flow measurements. Consequently, the run offs reported in the Limpopo Basin rivers are comparable to each other, but may not be comparable to the rivers in the Makgadikgadi Basin.

The borehole statistics are also based on an old data set. The NWMP hydrogeological data base is currently being updated and should be used provided the discrepancies with the report can be resolved. It should also be modified at regular intervals as further drilling and water quality data becomes available. The hydrogeological potential map and data can also only be used for broad planning purposes.

DWA river flow records suffer from a number of reliability problems. These include:

1. The brief span of records does not cover the full range of possible hydrological conditions. The first gauge recorders were installed in 1969-70, although most records have been extended synthetically to about 1920.

2. Gauging covers mostly the major rivers, usually at road bridges or at potential dam sites. Most of the coordinates provided were incorrect and were not improved on checking by DWA. They were moved to the best estimated position on the accompanying map but still require checking by DWA.

3. DWA have experienced many problems with equipment malfunction and operator error in both data collection and interpretation.

Dam site investigations have led to a reasonable comprehension of the regimes of the Shashe, Motloutse, Mhalatswe, Lotsane and Botetl Rivers. There is little reliable data on the smaller rivers.

Further data on the hydrology of the ephemeral rivers is required, although the collection of such data is expensive and time consuming. Information is also necessary on sedimentation in seasonal streams, the hydrology of small catchments and rates of groundwater recharge. Some data is being collected on these in current research projects.

2.1.6 SOILS, ERODIBILITY AND EROSION POTENTIAL

Introduction

This section covers soils classification, erodibility and erosion in Central District.

Methodology

Sources of information on soils are the maps produced by the FAO/Ministry of Agriculture soils unit, as follows:

1:1 000 000 soil map of Botswana, using the FAO Soil Map of the World revised legend (1988). In the district there are 14 soil groups and 33 subgroups mapped, with a further 325 soil associations indicated and referred to appendices.

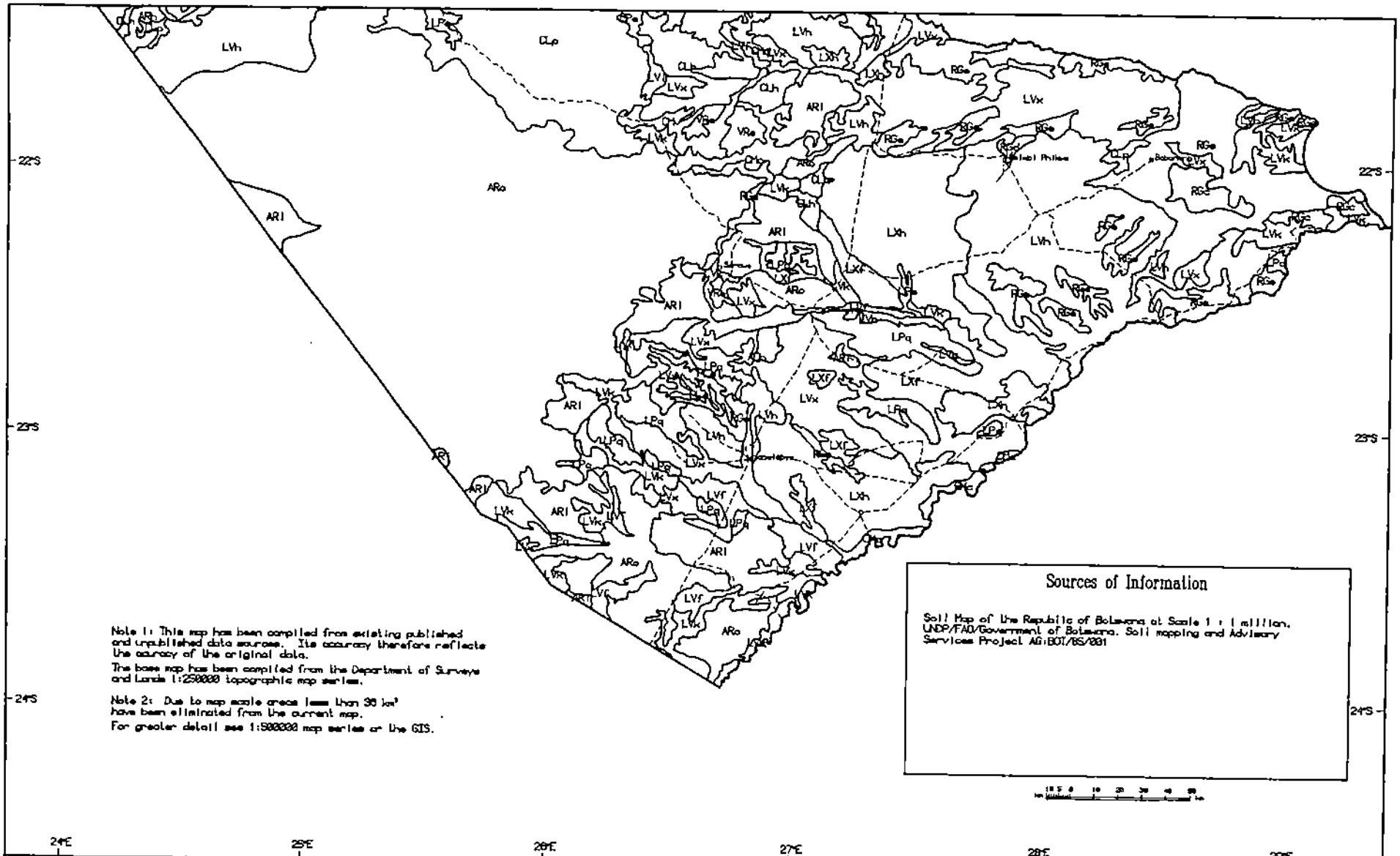
1:250 000 soils maps covering all of the district apart from some areas in the western sandveld. The maps are based on the FAO Soil Classification for Botswana (Remmelzwaal, 1988), and are mapped as soil associations, with up to three soils per map unit, annotated in order of importance. The number of combinations runs into hundreds.

Although both soil map sets are based on the FAO soil classification they use different sets of symbols, and a different classification emphasis - in the case of the 1:250 000 sheets initial classification is based on parent material rather than soil characteristics. A key to the two classifications is available.

Land suitability maps for rain-fed sorgum are available only for the southeast Central District (Remmelzwaal, 1989 a and b) and parts of the northeast (Venema, 1980). A 1:1 000 000 land suitability map for the entire country is due for publication at the end of 1991, to correlate with the soil map of the same scale. No data is available for soil limitations at present.

For the purposes of this study the 1:250 000 series is too complex, so the 1:1 000 000 map has been used at a scale of 1:250 000, utilising only the first two levels of data, namely soil groups (indicated by the first two (upper case) letters) and soil subgroups (indicated by the third (lower case) letter). For the third level of data, soil associations, reference may be made to the original 1:1 000 000 map and its appendices. Likewise, studies at the local scale may use the 1:250 000 published data. The Soils Map is presented on Map Number 2.8

There is soil erosion by both wind and water in the District, but little soil erosion data is available. It is also apparent that current models of soil erosion used in the region have little applicability. (The Stocking model



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: SOILS

MAP NO: 28

Presentation

The soil classification data is stored in a single coverage: soils.

Abbreviated defining characteristics of the soil groups and subgroups are shown in Table 2.11. Comments on the distribution of the soil groups, and their likely limitations, are given in Table 2.12. Descriptions of the terminology used in these tables can be found in the memoir accompanying the 1:1 000 000 soil map published by MoA.

TABLE 2.11 SOIL UNITS

SYMBOL	SOIL GROUP	SUBGROUP	DESCRIPTION
LP	LEPTOSOL		Soils limited in depth by rock or a calcareous layer.
LPe		Eutric	Ochric A horizon and base saturation >50%.
LPq		Lithic	Rock or cemented layer within 10 cm of surface.
LPk		Rendzic	Mollic A horizon with calcareous layer.
VR	VERTISOL		Contain 30% or more clay in top 50 cm. Subject to cracking.
VRe		Eutric	Base saturation of 50% or more. No calcic horizon.
FL	FLUVISOL		Soils derived from fluvial deposits.
FLc		Calcaric	Calcareous between 20 and 50 cm depth.
FLe		Eutric	High base saturation.
SC	SOLONCHAK		Soils with salic properties.
SCh		Haplic	Ochric A horizon, no gleyic properties.
SCg		Gleyic	Gleyic properties within 100 cm of surface.
GL	GLEYSOL		Formed from unconsolidatd materials, subject to saturation and chemical reduction (gleying).
GLc		Calcic	Calcic horizon within 120 cm of surface.
PL	PLANOSOL		An E horizon showing properties of water stagnation, overlying an impermeable (or slowly permeable) horizon.
	PLe	Eutric	Ochric A horizon and base saturation >50% in the impermeable layer.
AR	ARENOSOL		Soils coarser than sandy loam in top 100 cm. No diagnostic horizons.
ARh		Haplic	Lack diagnostic horizons. Lack ferralic, gleyic or calcic properties.
ARo		Ferralic	Contain iron accumulation. No clay increase. Lack albic, calcic or gleyic properties.
ARl		Luvic	Show clay increase within 125 cm of surface. Lack albic, calcic or gleyic properties.
ARc		Calcaric	Calcareous between 20 and 50 cm of surface.
RG	REGOSOL		Soils derived from unconsolidated materials. No diagnostic horizons.
RGe		Eutric	Base saturation of 50% or more. No calcic horizon.
RGc		Calcaric	Calcareous between 20 and 50 cm of surface.
RGd		Dystric	Base saturation of <50% between 20-50 cm of surface.

Description

Soil Classification

A great variety of soil types are encountered in the Central District, resulting from the variety in geology and geomorphology. Approximately 50% of the world's soil groups and 30% of the subgroups are represented.

Soils of the sandveld are invariably arenosols derived from the Kalahari Sand, with some calcisols and luvisols encountered in and around pans, depressions and in dry valleys. Soil fertility and water retention are low in arenosols, whilst the finer-grained pan and valley soils are limited by the presence of calcrete horizons.

In the Makgadikgadi Basin soils are strongly controlled by the influx of saline groundwater and past lacustrine events. The lowest parts of Sowa and Ntwetwe Pans have solonchaks, whilst calcisols and calcaric fluvisols, arenosols and regosols occupy higher ground. Thus all of the soils are limited by their drainage properties and the presence of excessive calcium carbonate or sodium salts.

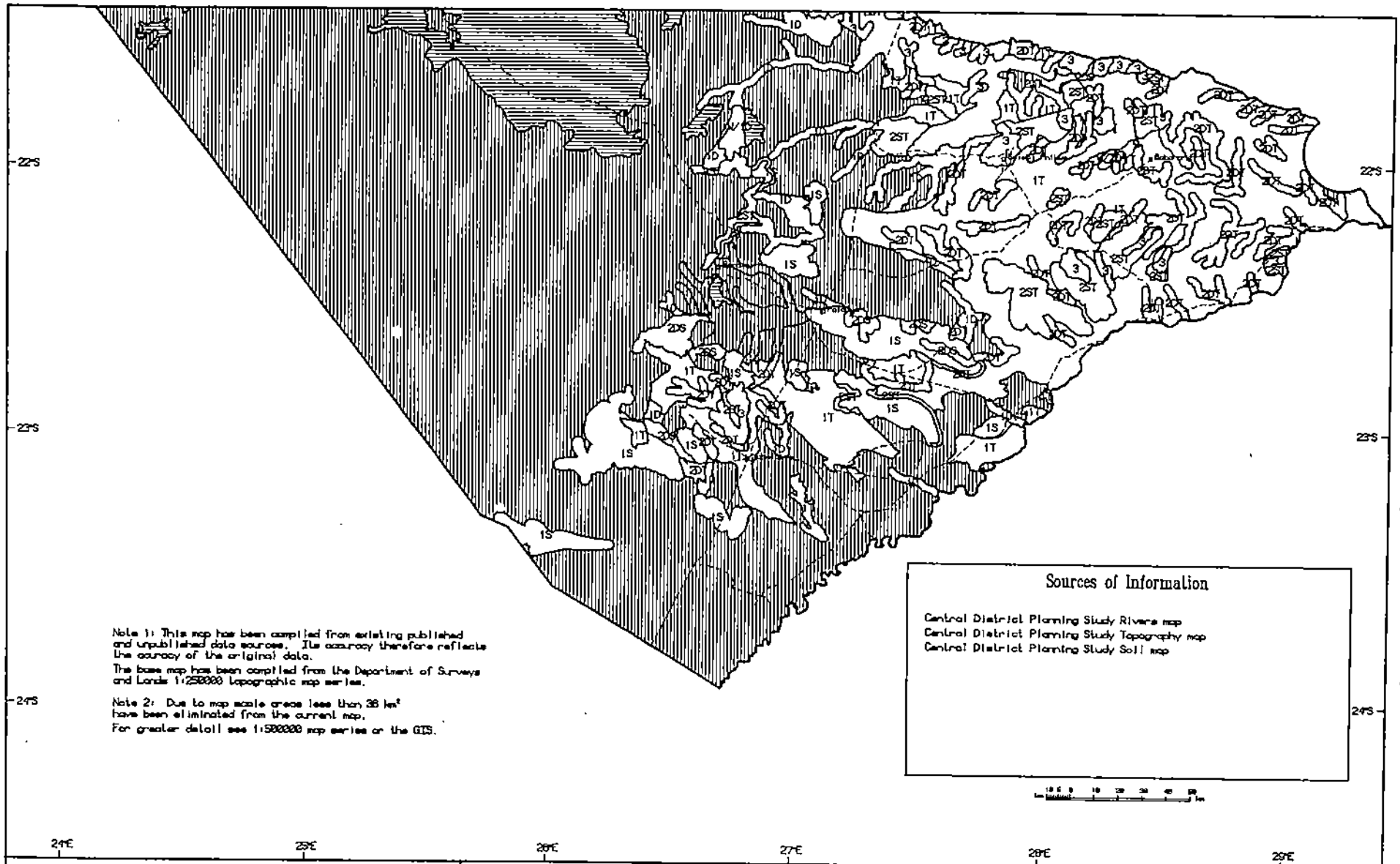
The soils of the hardveld show a greater variety, dependent on parent material and topographic position. Petric luvisols, leptosols and regosols are encountered on hills and rock exposures, which are mainly limited by both soil depth and slope. Vertisols are encountered locally throughout the hardveld on flood plains and in dambos (vleis), particularly in the upper Nata region, where they may prove to be intractable to cultivation and liable to flooding. On intermediate slopes, cambisols, luvisols and lixisols occur. Soil fertility varies from moderate (luvisols) to low (lixisols), and petric, lithic and petroferric phases are locally widespread.

Soil erodibility

Soil erodibility is dependent on a variety of factors within the categories of soil properties, topography, climate and human usage. An increase in relief leads to increased soil erosion potential in all soil types. All of the hardveld soils, with the exception of arenosols, are liable to water erosion. Those undergoing erosion by water at the present time include leptosols, regosols, and the petric and lithic phases of the luvisol-lixisol spectrum.

Fine textured soils are liable to wind erosion if low soil moisture conditions pertain. These soil types, which occur mostly in the Makgadikgadi area, are indicated in Table 2.12.

Soil erodibility is shown by soil groups in this chapter, by area in the ecological zones chapter, and on the separate soil erodibility map, which has been based on soil type, relief and drainage. In the absence of studies on soil erosion and erodibility in Botswana, this information should be used as a guideline only.



Note 1: This map has been compiled from existing published and unpublished data sources. Its accuracy therefore reflects the accuracy of the original data.

The base map has been compiled from the Department of Surveys and Lands 1:250000 topographic map series.

Note 2: Due to map scale areas less than 36 km² have been eliminated from the current map.

For greater detail see 1:500000 map series or the GIS.

Sources of Information

Central District Planning Study Rivers map
Central District Planning Study Topography map
Central District Planning Study Soil map

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Reliability and Gaps in Data

The soil classification maps are of good to high standard, and are of good quality for planning purposes. However, they are not always suitable for use by non-soil scientists. Soil suitability mapping could be extended, and maps of soil limitations would be of value.

There is no reliable data on rates of aeolian or fluvial soil erosion. Application of the SLEMSA soil erosion model (Stocking 1987) used by SARCCUS, which is based on regional parameters such as mean rainfall, slope length and gradient, tends to give unrealistically low figures, as much erosion in the hardveld takes place on roads and animal tracks at low gradients. Information on soil erosion is urgently required, particularly in the vicinity of settlements.

In the absence of realistic erosion studies the soil erosion map should be used as a guideline, and must be checked in the field before use as the basis of planning studies.

Discussion

The hardveld is subject primarily to weathering of bedrock, erosion by drainage networks on all scales, and slope degradation, particularly in areas of high gradient. The major landforms are hills and escarpments, strongly influenced by rock type and rock structure, together with fluvial networks and their associated characteristics.

The sandveld forms part of the larger Kalahari depositional basin, now being eroded at its periphery. Dominant processes appear to be weathering and chemical alteration of existing sediments by groundwater, together with limited aeolian activity.

Major landforms of the sandveld include pans and dry valleys, both associated with extensive calcrete formations. Small pans are unevenly distributed throughout the sandveld, with concentrations to the south of the Makgadikgadi, and around the Kalahari periphery. Pans also occur on interfluves in the hardveld.

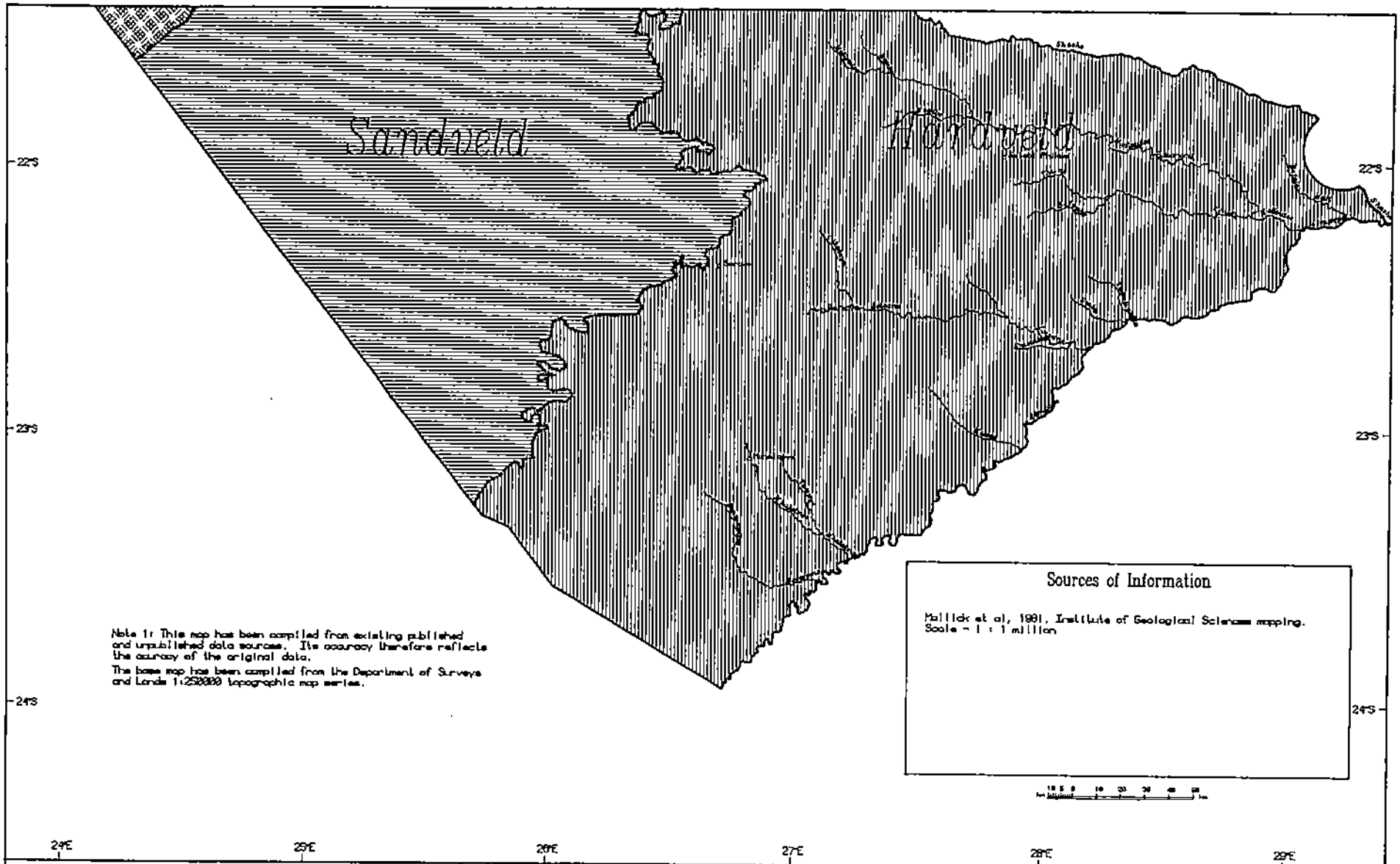
Kalahari pans have been classified, into sand, clay, rock and calc pans (Wellington, 1955), and into clay and grassed pans (Boocock and Van Straten, 1962). In practice there is a spectrum of pan forms, sediment textures, sediment salinity, vegetation cover and groundwater potential, which are difficult to evaluate from satellite imagery.

Networks of dry valleys, notably the Letlhakane system, drain the Kalahari rim towards the Makgadikgadi. The exception is the Serorome valley which leads to the Limpopo via a rift fault. All of the valleys originate on hardveld, or areas where the sand cover is limited, and act as conduits for the transfer of groundwater. Despite their impressive relief, usually developed in calcretised or silcretised sediments, they rarely carry surface flow. They have good groundwater potential, some of which is being exploited.

The Makgadikgadi Basin, as already noted, comprises a suite of landforms related to past lacustrine processes, including aeolian redistribution of sediments during low lake levels. Contemporary processes include fluvial activity in the Boteti and the Sowa pan, saline groundwater activity in lower lying pans (notably Sowa Pan) and the generation of wind-blown dust from bare pan surfaces.

Reliability and Gaps in Data

This reflects the reliability of both the topographic and geology maps and overall is considered to be moderate to good for the purposes of this study.



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MAP TITLE: PHYSIOGRAPHIC UNITS

MAP NO: 210

3. BIOLOGY/ECOLOGY

3.1 BIOLOGICAL ENVIRONMENT

3.1.1 VEGETATION

Introduction

This section describes the approach to deriving the vegetation ecology map of Central District, the distribution of vegetation types and their determinants. Limitations to the map and its use, and requirements for future work are also covered.

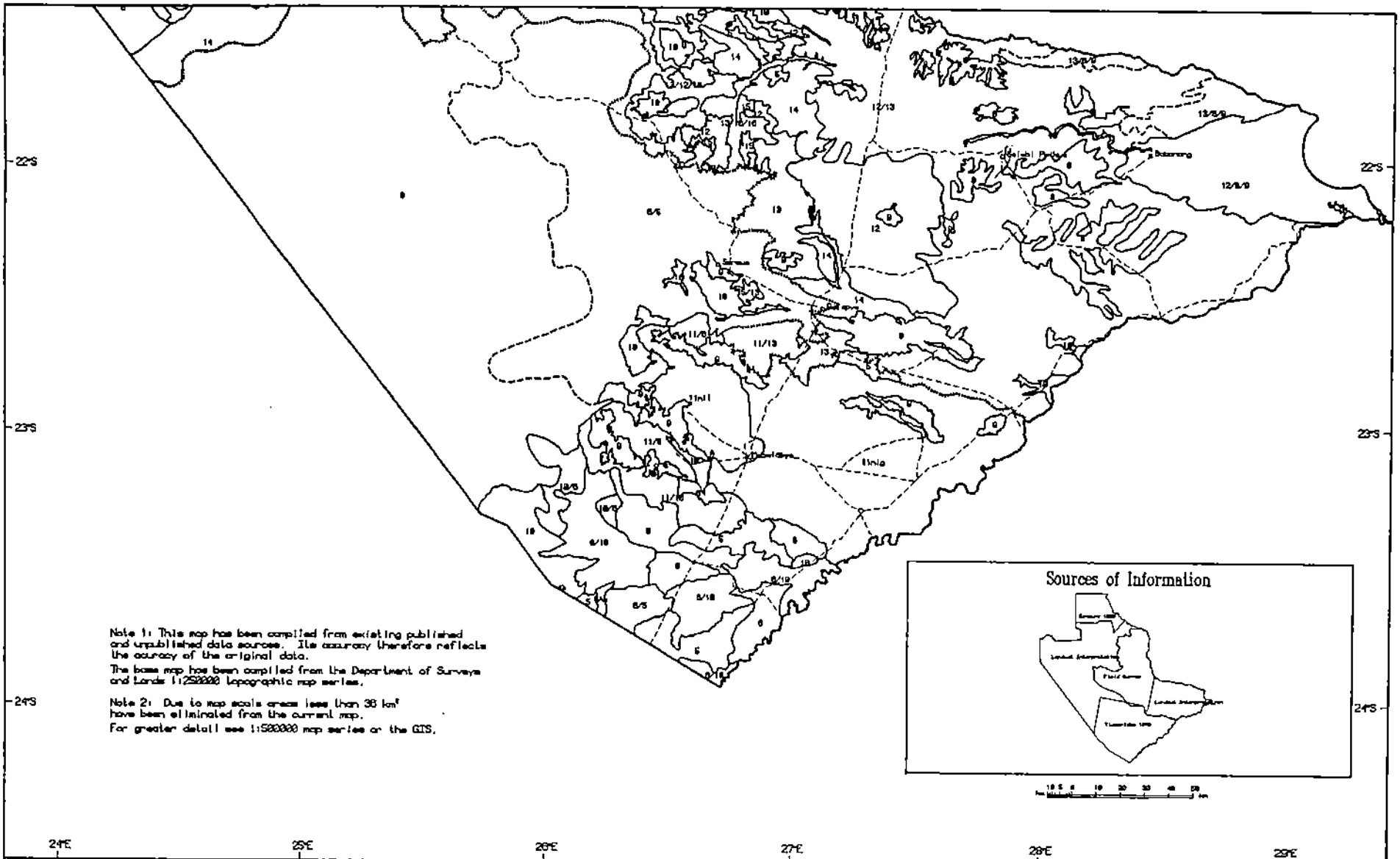
Methodology

Previous mapping of vegetation in the District at a scale useful for this study is limited. In addition to the Timberlake map (1980) and the DHV study (1980), Parry has mapped the communities of the Nata Statelands as part of the draft Nata Statelands Land Use Plan (Ecosurv, 1988) at a scale of 1:250 000. The DHV material was found to be of little use to the mapping, although their ecological findings are of some relevance. Other mapping has been carried out: Central District Land Use Planning Unit, 1989; Parry, 1984; Walker, 1985. The first is at a scale of 1:250 000 but details only range quality; it was consulted for the map derivation but not used for the map. The latter two maps similarly were consulted, but cover only small parts of the District. Additional large scale vegetation mapping has been carried out for Environmental Impact Assessments (EIAs) of various water development feasibility studies (SMEC, 1990; Macdonald and Partners, 1990; Arup 1990). These have been consulted where appropriate but are of no use for regional mapping.

The approach has therefore been to combine a reconnaissance scale map of the previously unmapped area with the information from Timberlake (in the south) and Ecosurv (in the north). The reconnaissance map was constructed from an interpretation of Landsat V MSS FCC imagery from the period May 1989. The imagery was chosen on the following bases:

- The end of the growing season (taking into account the 88/89 rainy season);
- The availability of cloud-free coverage.

Field surveying was carried out (19-27th March and 12+15th April) using roads, cutlines and veterinary cordon fences to check preliminary interpretation. A simplified phytosociological assessment (Braun-Blanquet, - a classification based on plant associations, whereby species in field sites or stands are ranked



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: VEGETATION ECOLOGY

MAP NO: 31

area comprised of a mixed association of *Acacia* spp and *Colophospermum mopane* with riverine vegetation occurring along drainage lines.

Database

Stands and observation points are marked on a GIS coverage. Within this coverage, species lists and relative abundance (where appropriate) can be attached to these points. These are presented in Appendix 3.2. Abbreviated descriptions of vegetation types can be attached to the Vegetation Ecology coverage.

Description

Vegetation types

As outlined in the methodology, vegetation types were distinguished on the basis of species composition. As noted by Timberlake (1980), this provides a better indication of soil type and climate, and thus potential land use value, than a structural approach. The descriptions that follow include any additional information acquired from fieldwork on ecological determinants for these types. This information has been used to cross-check interpretation where possible. The descriptions are principally limited to woody species. Grass specimens were taken at several locations during the field survey. These have been identified at the National Herbarium in Zimbabwe. This information has been appended to the database. It is not included here because similar information is not available for the areas mapped by Timberlake and Ecosurv.

Type 1 **Bare Pan Surfaces**

Vegetative growth is limited by soil salinity or high flooding frequency.

Type 2 **Edaphic Grassland**

An association occurring east of the Gidikwe Sand Ridge, flanking the Boteti River. Essentially broad flat grassland on calcrete, it closely resembles the halophytic grasslands (Type 3) occurring to the east of the Boteti floodplain. Here, however, factors limiting woody plant establishment are duripan-related rather than salinity-related. Soils are very shallow and very sandy.

Type 5 **Burkea/Ochna Savannah**

An association occurring on moderately deep well drained ferralic sandy soils generally derived from Kalahari aeolian beds. South of the Makgadikgadi, the type grades into Type 14, and the diagnostic species rapidly decrease in dominance to the west. The boundary is very indistinct and has consequently been mapped as uncertain by Timberlake and this study. The boundary as mapped is a Landsat tonal distinction that corresponds to the boundary mapped by Timberlake in 1980. Certainly the last *Burkea* which can be observed along the Serowe-Orapa road occurs well east of this line. In the north, the association is interdigitated with *Baikiaea* and *Colophospermum mopane* woodland.

Characteristic Woody Species:

Burkea africana, Ochna pulchra, Ricinodendron rautanenii, Combretum apiculatum, Strychnos pungens, S. cocculoides, Terminalia sericea, Acacia fleckii, Securidaca longipedunculata, Ximenia caffra, Commiphora angolensis, Tarchonanthus camphorata, Bauhinia petersiana ssp macrantha, Croton gratissimus, Lannea discolor, Grewia retinervis. (Dichrostachys cinerea occurs in disturbed areas).

Type 6 **Acacia erioloba Savannah**

A broad association typical of the western and northern Kalahari sandveld and sands of the Makgadikgadi complex. Three end members can be distinguished: *Acacia erioloba* dominated, *Terminalia sericea* dominated and *Lonchocarpus nelsii* dominated. Gradation between the three may be due to varying depths of sand, or to the occurrence of silcrete or calcrete layers in the soil profile. The association varies from an open woodland to savannah, with extensive areas dominated by low shrubs with very sparse trees.

Characteristic Woody Species:

Acacia erioloba, Terminalia sericea, Lonchocarpus nelsii, Combretum apiculatum, C. collinum, Grewia retinervis, G. flava, Acacia fleckii, Bauhinia petersiana ssp macrantha, Acacia ataxacantha, A. nigrescens, Combretum imberbe, C. hereroense, Terminalia prunioides, Ricinodendron rautanenii, Boscia albitrunca, Dichrostachys cinerea, Tarchonanthus camphoratus, Ziziphus mucronata, Acacia hebeclada, Commiphora angolensis, Albizia amara, Maytenus sp, Acacia nilotica, Acacia tortilis (on disturbed land), *Rhus sp, Bolusanthus speciosus, Flueggea virosa.*

Type 9 **Rocky Hill Woodland**

An open woodland typical of rocky outcrops. Drainage and lack of frost are probably the primary determinants of this association. Considerable floristic variation occurs from south to north. Conspicuous differences include: *Kirkia acuminata* and some of the *Commiphora* spp only occur north of Dibete; *Adansonia digitata* is found on hills in rocky dissected terrain in the Tuli area north of Parr's Halt. There is an increase in dominance of *Acacia nigrescens* towards the southern part of the district. Trees tend to be sparsely distributed.

Characteristic Woody Species:

Acacia nigrescens, Markhamia acuminata, Steganotaenia araliacea, Pappea capensis, Commiphora mollis, C. marlothii, Combretum apiculatum, Ficus spp, Sclerocarya birrea, Lannea stuhlmannii, Kirkia acuminata, Canthium burtti, Albizia amara, Lonchocarpus capassa, Croton gratissimus, Erythrina latissima, Grewia resiniflua, Sterculia rogersii, S. africana, Terminalia prunioides, Adansonia digitata.

Type 10 **Acacia Savannah**

A type characteristically occurring on heavy clay soils (vertisols, vertic cambisols, vertic and calcic luvisols) in areas prone to seasonal waterlogging. Some zonation occurs within units, with the lowest lying parts supporting the glandular acacias *Acacia nebrownii* or *A. tenuispina* (recorded by Timberlake in the southern part of the District) as a dense shrubland (*A. mellifera* also occurs here). Where the drainage is slightly better, true savannah occurs, with scattered *A. luederitzii* and *A. nilotica* trees in grassland. Appears to occupy an ecologically similar position to Type 15; the difference may be due to a soil chemistry factor such as sodium availability or pH.

Characteristic Woody Species:

Acacia luederitzii, A. nebrownii, A. tenuispina, A. mellifera, A. stuhlmannii, A.tortilis, A. arenaria, A. nilotica, A. grandicomuta, with *Commiphora glandulosa, Combretum hereroense, Grewia flava*

Characteristic Woody Species:

Colophospermum mopane, Acacia nigrescens, A. erubescens, A. nilotica, Commiphora glandulosa, Combretum apiculatum, Terminalia prunioides, Acacia tortilis, Dalbergia melanoxylon.

Type 14 **Colophospermum mopane on sandy soils**

A mixed type in which mopane occurs with species more typical of shallow sandveld. It occurs on shallower sands with restricted drainage which may be derived from Kalahari aeolian deposits or from in situ weathering of arenaceous or acid rocks. It is also found in areas underlain by calcrete in the northern part of the district, while in the Serowe area, it occurs peripherally on eastern outliers of sandveld. It is thus not confined to any particular physiographic unit. Floristically, it is very similar to type 13, mopane on shallow soils, but shows a higher species richness, and the co-dominants are species more suited to sandy soils. It grades into types 5 and 6, and also into small patches of *Kirkia/Commiphora* woodland occurring on calcrete ridges in the ecotonal area between hardveld and sandveld.

Characteristic Woody Species:

Colophospermum mopane, Combretum apiculatum, Commpihora glandulosa, C. angolensis, Albizia anthelmintica, Terminalia prunioides, Sclerocarya birrea, Croton gratissimus, Commiphora mollis, Terminalia sericea, Acacia erioloba, A. nigrescens, Rhigozum brevispinosum, Acacia fleckii, Adansonia digitata, Acacia tortilis (on disturbed land).

Type 15 **Colophospermum mopane Woodland/Shrubland**

A type occurring on clayey soils (as for type 10) with very limited drainage. Striking because of its almost monocultural character. The difference between shrubland and woodland may be due to stunting of the root systems by expansion and contraction of the soils, to cutting of timber or to duripan horizons limiting root growth. Ecologically occupies a similar position to Type 10.

- Climate

As outlined in the chapter on climate, rainfall varies from 350 mm to 600 mm, with the lowest rainfall occurring in the east. Variability is lower in the higher rainfall areas. Potential evapotranspiration (PET) varies between 2,5 mm/day and 6,5 mm/day, reaching a maximum in early summer, and is probably highest in the east (SMEC, 1987; open water evaporation ranges from 2.7 - 3.3 mm/day in June to 7-9 mm/day in December). The soils in the eastern-most part of the District are shallow and rocky, and consequently the growing environment is very xeric. Clearly rainfall and evapotranspiration exert a profound influence on soil moisture balance. Rainfall control is particularly associated with deep sandy (mesic) soils.

Timberlake (1980) suggests that the extent of Type 5 (*Burkea/Ochna* savannah) might be rainfall-controlled. The limited occurrence of Baikiaea woodland in Central District representing the lower limits of habitat suitability is also probably rainfall-controlled. Ecosurv (1988) note that Baikiaea distribution appears to be limited to areas of >600 mm mean rainfall/annum.

Mean temperature ranges are likely to be most extreme in the east and west of the district; separation of the effects of temperature and frost frequency, intensity and timing is not possible with currently available data. Timberlake notes a southerly limit to the distribution of various species, significant among which are *Colophospermum mopane* and *Kirkia acuminata*, and attributes this primarily to higher mean monthly temperatures and relative freedom from frost. Cole (1982) says there is evidence that mopane cannot survive where the mean temperature for July is <15.5°C or where there are light frosts. The southerly limit of *Colophospermum mopane* is referred to as the "Mopane Line" and is indicated on the map. The distribution of the baobab (*Adansonia digitata*) in the eastern part of the district may also be due in part to temperature. Timberlake also notes that species such as *Kirkia* which prefer well-drained rocky soils can survive outside their temperature/frost range because they tend to be situated on slopes or hills above the lower areas most prone to frost. This and drainage factors probably represent the greatest effect that relief per se has on vegetation distribution (with the exception of microrelief in the Makgadikgadi Pans - see below). In the sandveld to the west and in low-lying areas in the hardveld, frost may be a factor in controlling the size of such woody species as *Bauhinia petersiana* and *Colophospermum mopane* can attain, by regularly killing the aerial parts of shrubs in a way similar to fire.

- Soils

The soils of the district can be divided into three major groups: those of the sandveld, with Kalahari sand as parent material, the lacustrine and alluvial deposits of the Makgadikgadi Pans complex, and those of the hardveld, derived from weathering of the various rock types.

Colophospermum mopane. In Lake Xau these soils support grasslands maintained by seasonal waterlogging. Recent man-induced changes in the flooding regime of this previously very significant grazing resource are leading to progressive encroachment by woody species, notably *Acacia tortilis*. The highest ground in the complex is the sandy fossil beach ridges, which support an open savannah woodland of *A. erioloba* where groundwater is accessible, and a *Terminalia sericea* savannah where it is not.

Worth noting here is that recruitment of deep rooted tree species in sandy habitats may be a phenomenon limited to periods in which there is sufficient rainfall over a number of consecutive years to permit young saplings to develop root systems capable of sustaining them through long dry periods i.e., which reach the long-term water table. This may explain the uniform age of trees in these habitats, and needs to be taken into account in assessing the utilisation potential of these types.

The shallow calcrete layers which so typify many parts of the sandveld often support a low shrub community of *Catophractes alexandri, Rhigozum brevispinosum* and *Sesamothamnus lugardii*. This community does not attain sufficient extent to warrant status as a type, but has been reported as invasive into rangeland in Gantsi District (Parry, pers comm). Some investigation into possible control would be useful.

Under the current climatic conditions, there is little opportunity for deep chemical weathering: soils in the hardveld tend to be shallow and rocky, particularly in the middle (dissected) and downstream reaches of the drainages. Soil depth in the hardveld appears to exert a stronger influence on vegetation than soil chemistry, except in the upper catchments, where patches of heavy clay soils have developed on basalt and shale/mudstone parent rocks. Here, poor drainage and in some places a high content of montmorillonitic (cracking) clays give rise to either a parkland dominated by *Acacia* spp, as in the upper Motloutse catchment, or a shrub/woodland consisting of almost pure *Colophospermum mopane*, like that found in the upper Nata catchment. This difference may be due to a difference in soil chemistry; possibly the Nata vertisols being derived from primarily sedimentary rocks have a higher Na^+ content. Mitchell, in Timberlake (1980) finds that *C. mopane* is associated with sodium-rich soils. It may, however, simply be due to the fact that the Motloutse catchment is close to the southerly *C. mopane* distribution limits.

The soil catena found in much of the hardveld exerts a major influence on vegetation distribution. The well-drained conditions of hill slopes and interfluve ridges support a woodland which exploits moisture and nutrients in fissures and weathering zones. The composition of this woodland depends on other factors, such as temperature. The *Kirkia/Commiphora* association of the central part of the District gives way to an *Acacia nigrescens* dominated association southwards; to the east, *Adansonia digitata* is a conspicuous addition. Further down the catena, as soil depth increases but moisture availability is still low, a denser spread of smaller species like Combretum apiculatum gradually replaces the larger trees. North of the "mopane line", *Colophospermum mopane* starts to appear at the lower fringe of the *Combretum apiculatum* zone. The deeper soils at the bottom of the catena have higher moisture availability (greater storage

- The species is thin barked and therefore fire sensitive. In particular, late season fires in the current typically high fuel load situations are intense and cause 'fire holes' in the canopy which are quickly colonised by further understorey plants, leading to an increased fuel build-up. This not only increases the fire hazard for the next season, but also increases the light/moisture competition for seedlings. Complete protection from fire is not practical; in Zambia, a policy of early burning (April/May) is used to try and reduce fuel loads and suppress the understorey thicket. Trees are entering a dormancy stage and are less likely to be damaged by the cooler burns.

In Central District, the species is at the southern limits of its habitat, so it is likely to be even more sensitive to disturbance. In addition, the lower density stands may contain a higher proportion of understorey thicket due to better light penetration. The issue of fire in these stands, therefore, requires careful consideration.

- Grazing/Browsing

As pointed out previously, the ratio of grazers to browsers in the current herbivore spectrum (mainly cattle and goats) differs considerably from that of the herbivore spectrum with which the vegetation evolved. This must inevitably cause a change in the dynamics of the system, which is compounded by the lower mobility of livestock, and the provision of permanent water sources in previously un-watered areas.

In the uncontrolled situation, heavy grazing pressure not only reduces the fuel load for fires, but also favours annual grasses and forbs. Subsequent encroachment by woody plants is encouraged by reduced competition for light and moisture in the surface layers. In addition, as pointed out by Timberlake (1980), selective grazing at the beginning of the rains (before seed is set) also changes species composition, favouring the more unpalatable species. In general, uncontrolled heavy grazing leads to undesirable changes in the quality of the range. If allowed to progress too far, particularly in combination with inappropriate fire regimes, these changes may be very difficult to rectify.

The effects of wild herbivores are of great significance to the *Baikiaea* woodlands in the northern sandveld. The seed pods are heavily utilised by primates while on the tree; on the ground, seeds and seedlings are eaten by rodents and duiker (Piearce, 1986). These animals are favoured by a dense understorey thicket. Mitchell in Piearce (1986) and others have put the hypothesis that elephant and buffalo play a very important role in the ecology of these woodlands: browsing and trampling tend to keep the understorey in check, reducing the fuel load, and also to bury *Baikiaea* seeds; the *Baikiaea* trees and seedlings are apparently unpalatable to these species (Piearce, 1986). Timberlake (pers comm), however, points out that game population levels (particularly elephant) have historically (in the last 150 years) not been as high as at present - perhaps not high enough to have had this effect. (See also Campbell, 1990).

No field estimates of standing stock were made during this study. The minimum and maximum factors used in Table 3.1 below are derived from McDonald & Partners (1990) and various other sources. Total areas of each vegetation type mapped were calculated using the GIS. The standing stock figures thus show the possible range of woody biomass in each vegetation type.

TABLE 3.1 ESTIMATED STANDING STOCK

Vegetation Type	Area (Ha x 100)	Minimum Stock Factor (t/Ha)	Maximum Stock Factor (t/Ha)	Minimum Standing Stock (tonnes)	Maximum Standing Stock (tonnes)
1	6008	0.0	0.0	0	0
3/1	4382	0.0	0.0	0	0
3	2200	0.0	0.0	0	0
4	269	0.0	1.0	0	26935
5*	3047	0.6	4.0	182829	1218859
6	34798	0.0	0.0	0	3778015
7**	1440	1.7	2.0	244874	288087
8	5715	8.0	30.0	4572117	17145438
9	2567	1.0	8.0	256742	2053936
10	2720	1.0	11.7	271970	3182054
11	7375	1.0	11.0	737486	8112349
12	8144	2.3	15.2	1873069	12378546
13	2127	2.3	7.4	489191	1573919
14	12621	2.3	7.4	2902805	9339460
15	1227	2.0	15.3	245412	1877403
16	278	34.0	63.0	945554	1752055
14Tp/12	42	2.3	11.3	9608	47207
14/6	394	1.7	4.2	66996	165519
10/14	1244	1.7	9.6	205277	1188119
14/12/3	1134	1.6	7.5	181394	850284
14/13	582	2.3	7.4	133782	430430
5/13	78	1.5	5.7	11323	44510
6Ae/16	908	17.5	32.0	1588358	2904426
6/14	525	1.7	4.2	89234	220460
6/5	10060	0.8	2.5	804820	2515064
6/10	2300	1.0	6.4	229960	1471745
2/6	1441	0.0	0.5	0	72062
2/6Ac	1616	0.0	0.5	0	80784
2.10	85	0.5	5.9	4262	49861
10/6	550	1.0	6.4	54995	351967
10/3/16	588	0.3	3.9	17629	229178
15/16	585	2.0	15.3	116980	894895
12/16	2891	2.3	15.2	664897	4394101
12/8/9	2838	6.1	25.1	1731284	7123807
12/13	17502	2.3	11.3	4025497	19777441
11/6	557	1.0	6.0	55674	334042
11/10	798	1.0	11.1	79757	885302
11/13	450	1.7	9.2	76499	413994
13/8/9	967	6.1	22.5	589770	2175381
13/10/16	491	1.1	6.4	53995	314154
13/12/10	781	1.9	11.4	148295	889770
13/8/12	2216	4.2	17.5	930687	3877864
TOTALS	146539			24593021	114566218

* - productivity figures from Caprivi Zipfel research forester Geldenhuys in the mid-seventies - Forestry Division, MOA, pers comm

** - productivity figures from P. Henry (1977) in Chobe District - Forestry Division, MOA, pers comm

Assessment of Wood Resources

More detailed knowledge is required of the production rates and autecology of the more important building and fuel wood species in the district - particularly *Colophospermum mopane*. Also urgently required is a study to determine approximate rates of use of timber.

A detailed survey/enumeration is required of the commercial timber in the District - *Baikiaea plurijuga, Pterocarpus angolensis, Guibourtia coleosperma* and *Ricinodendron rautanenii*.

A study should also be instituted of the *Kirkia/Commiphora* woodland and its synecology, with regard to controlled and sustainable utilisation of the remaining portions of this resource. This type is under increasing pressure due to requirements for agricultural land, fuelwood and timber. In the interests of the maintenance of biological diversity, some protection will become necessary (see below).

Ecological Monitoring

Regular acquisition of satellite imagery is an essential tool for monitoring ecological change in the District. The SADCC receiving station in Harare provides AVHRR data at no charge to member countries. This is an avenue which should be investigated further.

Conservation Areas

In addition to the already existing conservation areas in Central District (Makgadikgadi Pans Game Reserve, Nata sanctuary, the future Serowe sanctuary), consideration should be given to setting aside small areas for the conservation of some of the more important vegetation types. The *Kirkia/Commiphora* woodland is best represented in the area between the Tutume-Maitengwe road and the Dukwe cordon fence. A small portion of this should be protected from wood cutting activities.

Dry and wet season biomass distribution and density maps for seventeen large wild animal species were generated using computerised data bases compiled from DWNP aerial surveys data collected during August 1989 and March 1990. Seasonal changes in metabolic biomass (MB) density and distribution were then mapped based on these data. Biomass conversion values used for mapping are expressed in terms of each species' metabolic biomass equivalent in Live Stock Units (LSUs) where 1 LSU is equivalent to the metabolic biomass of a 450 kg bovine. Conversion values for all surveyed species are listed in Table 3.2.

TABLE 3.2 METABOLIC BIOMASS (MB) CONVERSION VALUES FOR SURVEYED WILDLIFE SPECIES EXPRESSED IN LIVESTOCK EQUIVALENTS (LSEs @ 450 KG / LSU)

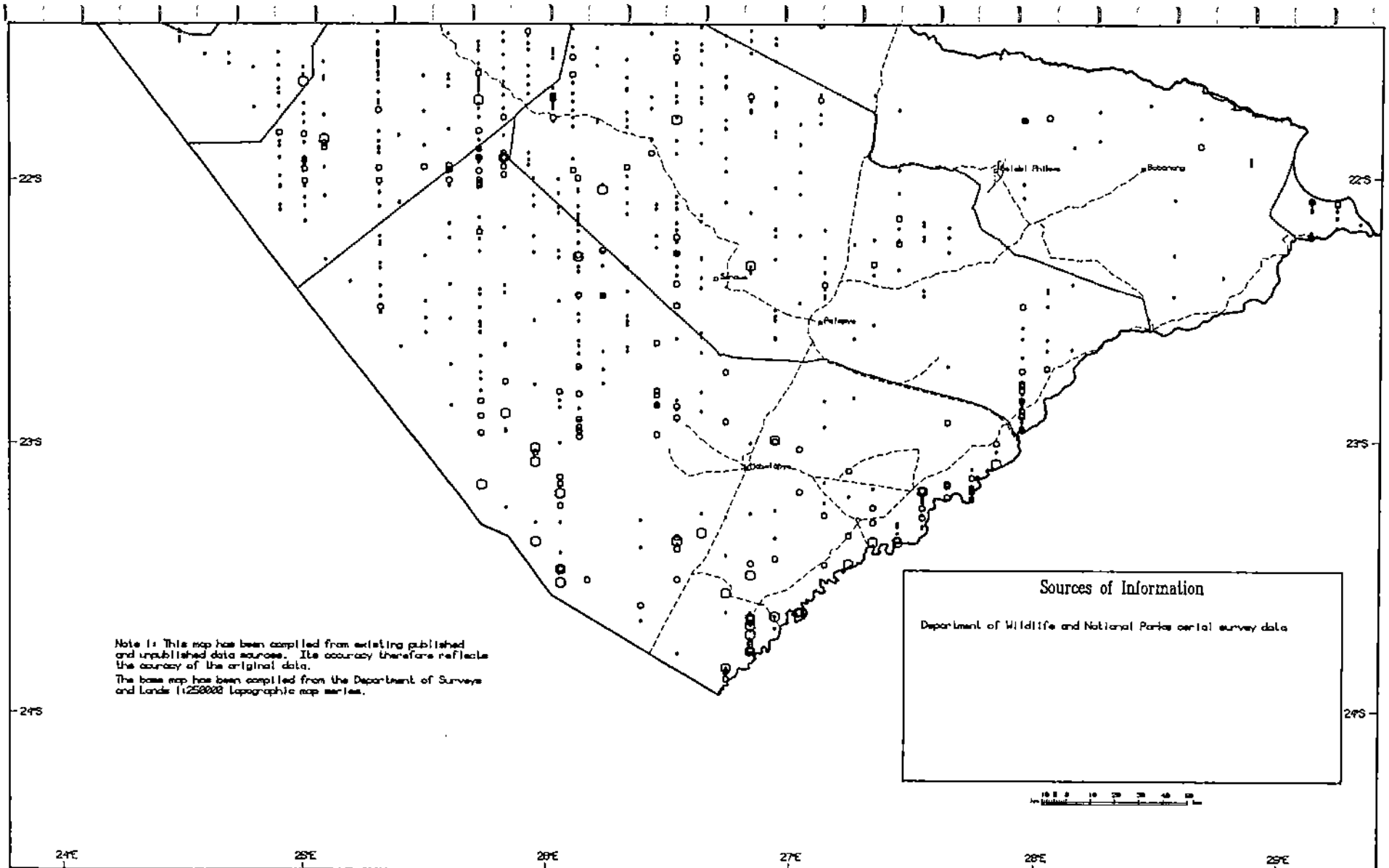
Species	Average Mass (Kg)	Metabolic Biomass (LSEs)
Steenbok	10	0.056
Duiker	10	0.056
Springbok	26	0.115
Impala	40	0.173
Warthog	45	0.175
Ostrich	68	0.236
Hartebeest	125	0.374
Kudu	136	0.398
Gemsbok	150	0.428
Wildebeest	165	0.455
Sable Antelope	185	0.502
Zebra	200	0.532
Roan Antelope	220	0.590
Eland	340	0.792
Buffalo	450	1.00
Giraffe	750	1.44
Elephant	1725	3.67

Approximate range maps were produced for 25 large wild animal species based on results of aerial surveys, interviews with researchers and district residents and review of recent literature.

Controlled Hunting Area (CHA) boundaries for Central District were mapped based on boundary descriptions gazetted under Statutory Instrument No. 93 of 1977.

Presentation

Dry and wet season biomass distribution and density for the estimated combined populations of seventeen large wild animal species are presented on Map Numbers 3.2 and 3.3 respectively. Recent (1990) population estimates for each species by census survey block are presented in Table 3.3.



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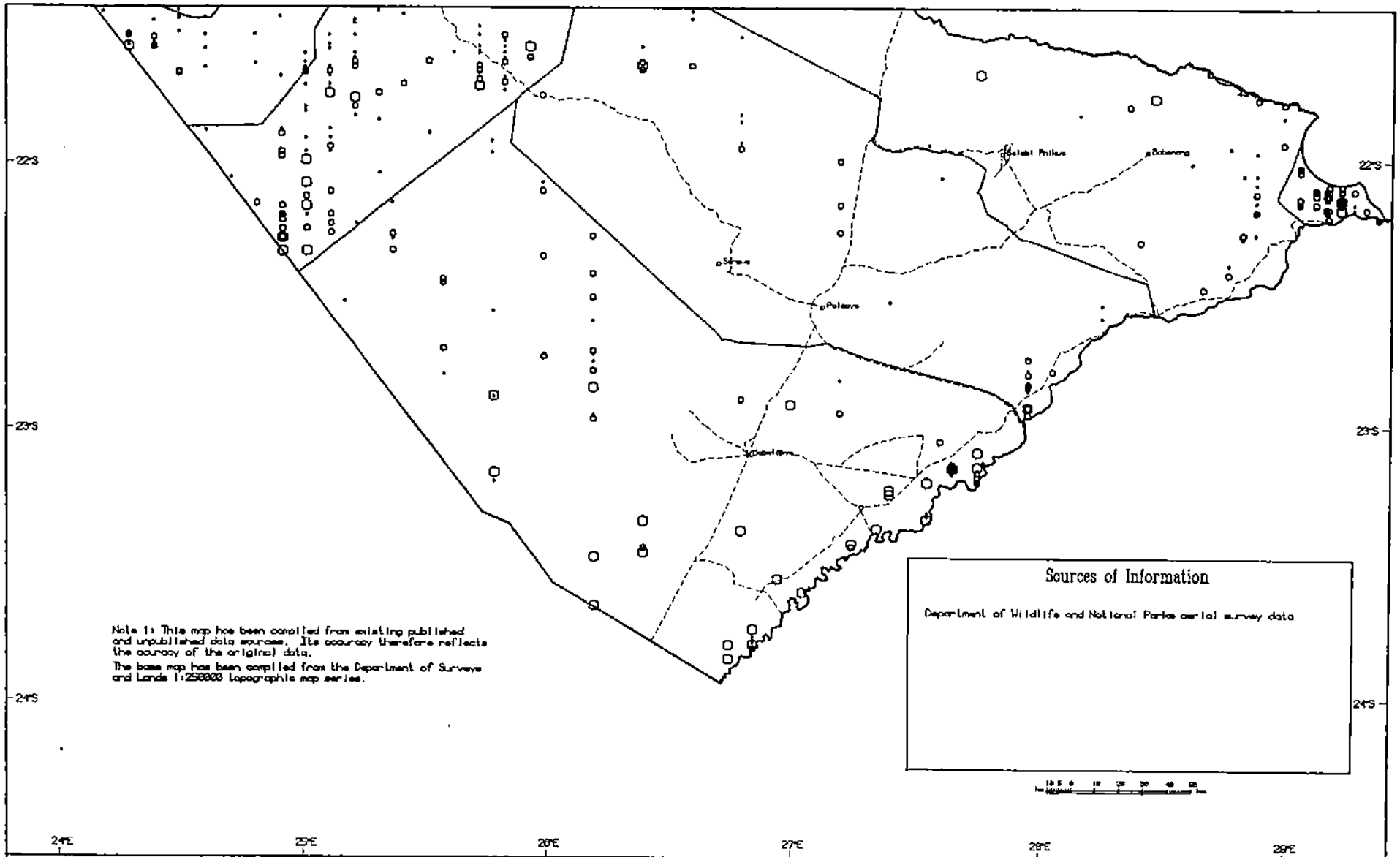
PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: WILDLIFE DISTRIBUTION-TOTAL BIOMASS AUG.89

MAP NO: 3.2



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Botswana

PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: WILDLIFE DISTRIBUTION-TOTAL BIOMASS MARCH 90

MAP NO: 3.3

listed for each CHA in Tables 3.5, 3.6 and 3.7. Live mammal and ostrich capture quotas for CHAs of Central District are listed in Table 3.8.

Description

The general impression gained from biomass distribution and density maps is one of low wildlife densities over most of Central District. Where wildlife population densities are highest they are characterised by extreme seasonal variation, usually the result of surface water availability. Population densities are generally lower and distribution less extensive now, than they were when the first surveys were conducted. Changes in biomass densities reflect declines in populations of most species, (with the notable exception of elephant) during the intervening period, to the end of the recent drought.

Discussion

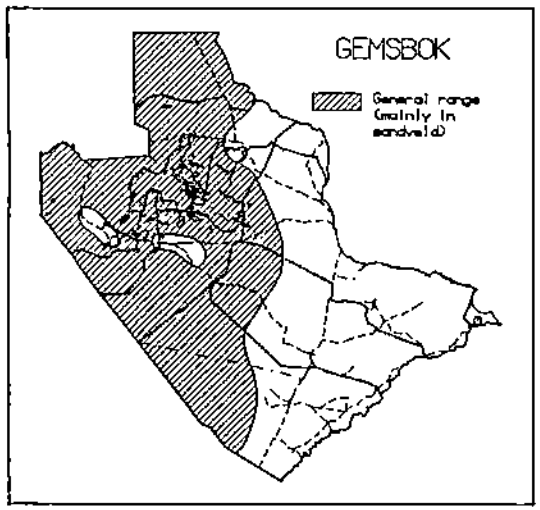
Wildlife Resources

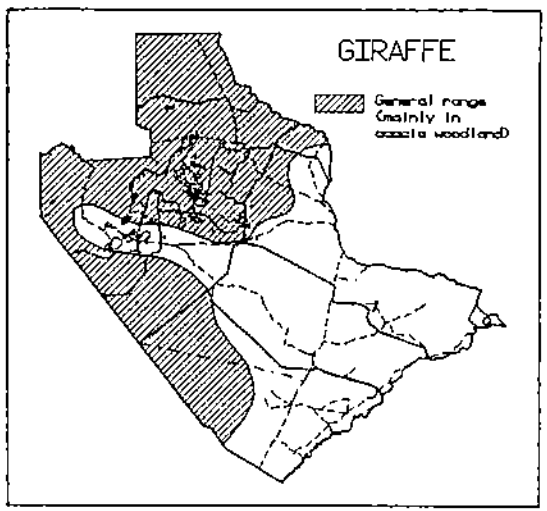
Central District north of 21° S, including the Makgadikgadi Pans Game Reserve and WMA and the proposed Nata State Lands WMA supports highest wildlife population densities and species diversity (Map Numbers 3.2 and 3.3).

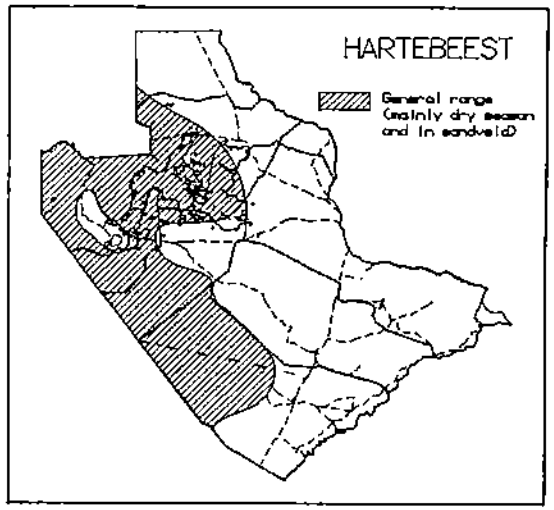
Wet season metabolic biomass estimates increase significantly north of 20° S due mainly to the presence of elephants, which move south and east from the Okavango and Chobe river systems into the Nata Statelands, following the onset of summer rains (Calef, 1987). MB estimates for this seasonal elephant range varied between 0.2 LSE / Km^2 in August 1989 and 4.2 LSE / Km^2 in April 1990.

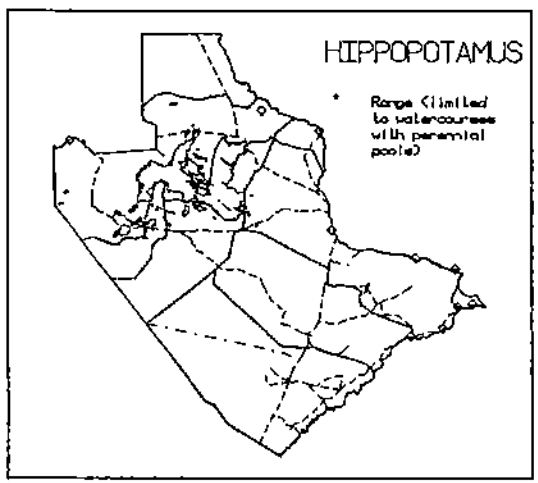
Increased MB densities east of the Boteti River during the dry season are the result of concentrations of zebra and wildebeest, which are normally dispersed throughout the Makgadikgadi Pans Game Reserve, western Ntwetwe Pan and southern Ngamiland Statelands during wet seasons when surface water is readily available. The recent drought reduced both populations significantly, from a combined estimated total of 153 000 animals in 1979 to about 32 000 in 1987 and 12 000 in 1990.

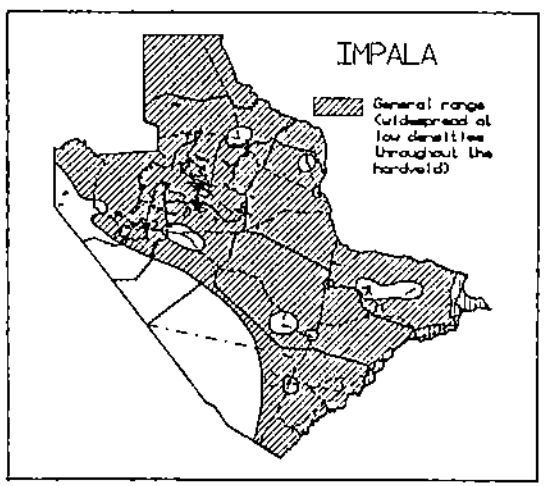
Wildlife population densities have always been relatively low in the sandveld region of western Central District owing to low rainfall, soil fertility and hence carrying capacity. Wildlife populations have been further depleted through the combined effects of displacement by livestock, movement restrictions, drought and, to a lesser extent, hunting pressure. Impacts were particularly severe in the case of migratory wildebeest and hartebeest which have suffered population reductions in excess of 90% since 1980. Other more drought tolerant species were also affected to a lesser extent. The majority of wildlife sightings displayed for the sandveld region, particularly during the dry season survey (Map Number 3.2), represent solitary steenbok or duiker with MB

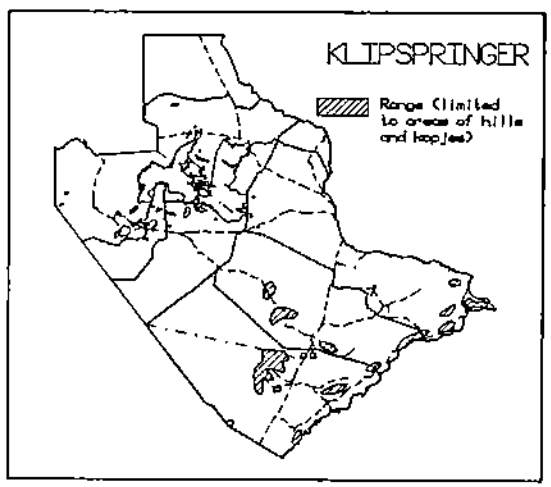












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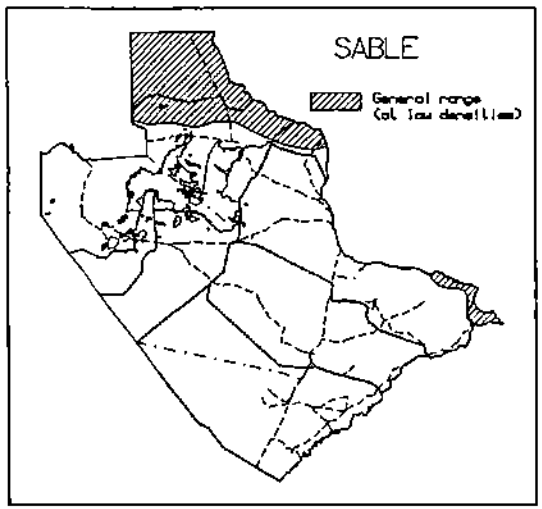
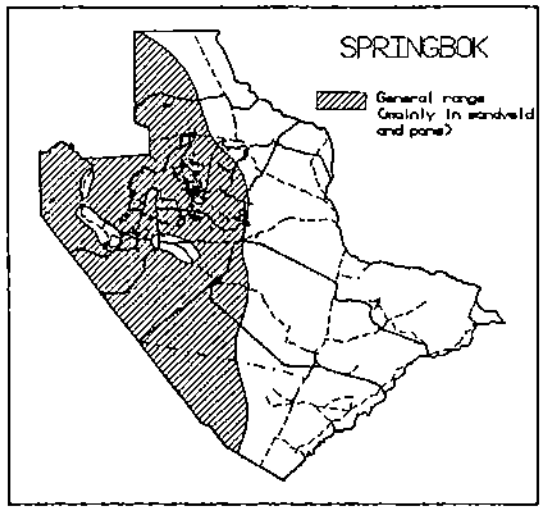
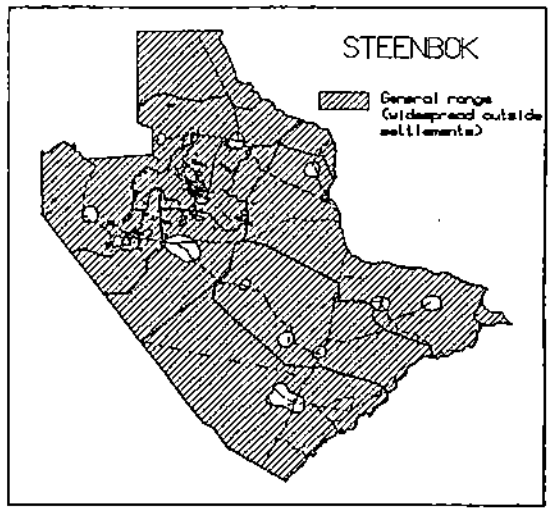
PROJECT: CENTRAL DISTRICT PLANNING STUDY

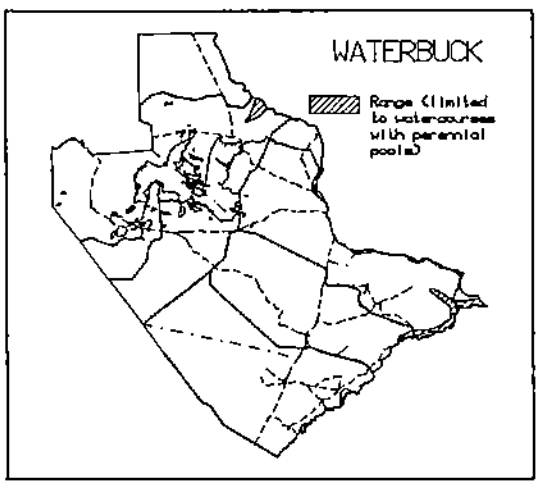
MAP TITLE: WILDLIFE LOCATIONS

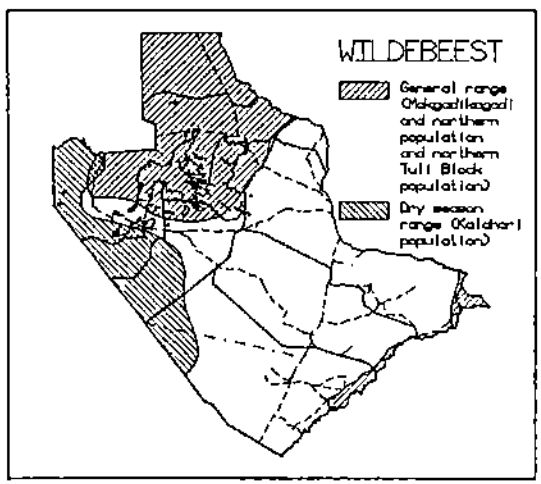
MAP NO: 3.4b

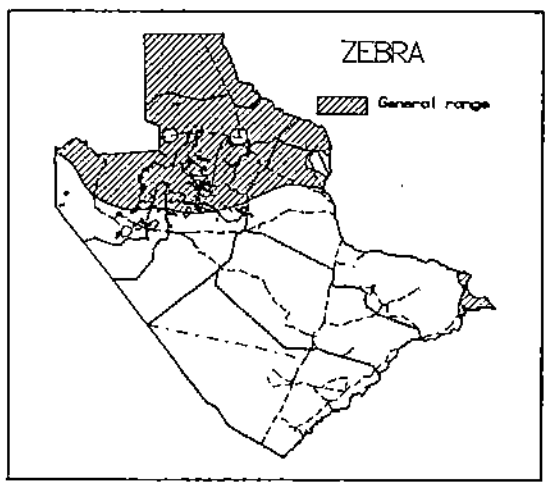












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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: WILDLIFE LOCATIONS

MAP NO: 3.4d

TABLE 3.4 CONTROLLED HUNTING AREAS (CHAs) CURRENTLY HELD UNDER LEASE BY SAFARI OPERATORS IN CENTRAL DISTRICT.

	CHA	Operator Holding Lease	Annual Rental Fee (paid to Govt)[1]
3	Masame[2]	Vira Safaris	P 5 400
4	Tamafupa[3]	Hunters Africa	P 8 000
10	Boteti	Safari South	P 3 000
25	Odiakwe	Guides & Outfitters	P 8 000
26	Nata	Guides & Outfitters	P 8 000

Notes:

1 Central Government receives rental fees for all CHAs leased on Stateland.
2 Less than 10% of CHA 3 falls within Central District.
3 Approximately 80% of CHA 4 is in Central District while the remainder is in Chobe District.

Wildlife Management Areas

Two proposed Wildlife Management Areas located in Central District (Makgadikgadi WMA and Nata Statelands WMA) have been approved in principal by the CDLUPU and Central District Council, but have not been gazetted. The WMAs were planned to provide areas in which hunting and other forms of wildlife utilisation can continue to benefit rural populations, and particularly those people living within their boundaries. They are also proposed to serve as wildlife migration corridors, and as buffer zones between areas of wildlife land use in game reserves and parks and livestock grazing in northern Central District.

Game Farms and Private Game Reserves

Nine farms in the northeastern Tuli Block are collectively managed for wildlife and some have been developed for game viewing tourism. The Mashatu Game Reserve (45 000 Ha within this block) is privately owned and operated in partnership with Botswana Development Corporation. Elsewhere in both the northern and southern Tuli Block farms various forms of commercial wildlife utilisation are practiced.

Proposed Wildlife Conservation Areas

Currently proposed wildlife conservation areas in Central District include an area in the eastern Nata Statelands adjacent to Hwange National Park in Zimbabwe, a proposed reserve for black rhinoceros near Paje and a nature reserve in the Tswapong Hills for protection of breeding colonies of cape vultures. The Nata Sanctuary in the northeastern portion of Sowa Pan has been approved and is about to become operational (mid-1992).

TABLE 3.5 CITIZENS' HUNTING QUOTAS FOR CONTROLLED HUNTING AREAS (CHAs) OF CENTRAL DISTRICT (1991 HUNTING SEASON).

	Controlled Hunting Area (CHA) Number					
Species	3	4	10	11	12	25
Buffalo	8	8	0	0	0	15
Duiker	70	160	40	200	110	60
Eland	2	1	0	3	0	0
Gemsbok	0	0	24	30	0	20
Hartebeest	0	0	10	25	0	0
Impala	6	10	0	0	150	0
Kudu	10	5	25	100	50	20
Ostrich	9	20	50	50	0	10
Sable	0	15	0	0	0	0
Steenbok	130	280	80	500	200	100
Springbok	0	0	1450	450	0	0
Tsessebe	0	9	0	0	0	0
Warthog	10	10	10	0	20	0
Zebra	7	10	50	30	0	10

TABLE 3.5 (Contd.)

	Controlled Hunting Area (CHA) Number					
Species	26	27	28	37	38	39
Buffalo	10	0	0	0	0	0
Duiker	40	130	470	120	140	200
Gemsbok	0	10	25	5	0	0
Hartebeest	0	20	40	0	0	0
Impala	0	0	30	50	50	150
Kudu	10	30	60	50	50	100
Ostrich	10	30	50	50	60	50
Steenbok	80	240	860	220	260	150
Springbok	0	50	20	60	0	0
Warthog	10	10	20	0	0	30
Zebra	10	0	0	0	0	0

Game Farming / Ranching

Besides game viewing tourism, commercial activities on game farms in the Tuli Block include ostrich and crocodile farming, recreational hunting and culling of impala and wildebeest. Live mammal and ostrich capture quotas for Controlled Hunting Areas of Central District (1991 hunting season) are listed in Table 3.8.

TABLE 3.8 LIVE MAMMAL AND OSTRICH CAPTURE QUOTAS FOR CONTROLLED HUNTING AREAS (CHAs) OF CENTRAL DISTRICT (1991 HUNTING SEASON).

	Controlled Hunting Area (CHA) Number					
Species	3	4	10	11	12	25
Duiker	10	0	0	0	0	0
Gemsbok	0	100	0	0	0	0
Ostrich	0	0	50	50	50	0
Ostrich Eggs	200	500	1000	1000	0	150
Springbok	0	0	150	150	0	0
Steenbok	15	0	0	0	0	0

TABLE 3.8 (Contd.)

	Controlled Hunting Area (CHA) Number					
Species	26	27	28	37	38	39
Ostrich	0	0	50	150	0	200
Ostrich Eggs	150	750	1000	1000	1000	200
Steenbok	0	0	0	0	0	150

Reliability and Gaps in Data

Since aerial surveys were designed primarily to establish seasonal wildlife distribution patterns and are generally of low sampling intensity (usually 2-5% coverage), most population estimates derived from them are crude and confidence limits are extremely wide (often >100%). Reliability of population estimates is, therefore, moderate at best. While the reliability of distribution data alone can be considered generally good, it does not necessarily indicate areas which may be most important or necessary to the maintenance of wildlife populations.

3.2 ECOLOGICAL ZONING

Introduction

The term ecological zone has been used within this study as delineating areas in which there is some degree of correlation between vegetation, physiography, surficial geology and climate.

Ecological zoning of the District has been carried out to 3 levels of division.

Methodology

The Central District can be divided into three major first order units on physiographic grounds, with distinct topographic, geological, geomorphological, pedological and vegetation characteristics. The divides between these units are defined on superficial geology (extent of Kalahari Sand and lacustrine sediments) where they coincide with major physical divides such as the Mosu and Serowe Escarpments, or the peripheral sand ridges of the Makgadikgadi.

The first order units defined are:

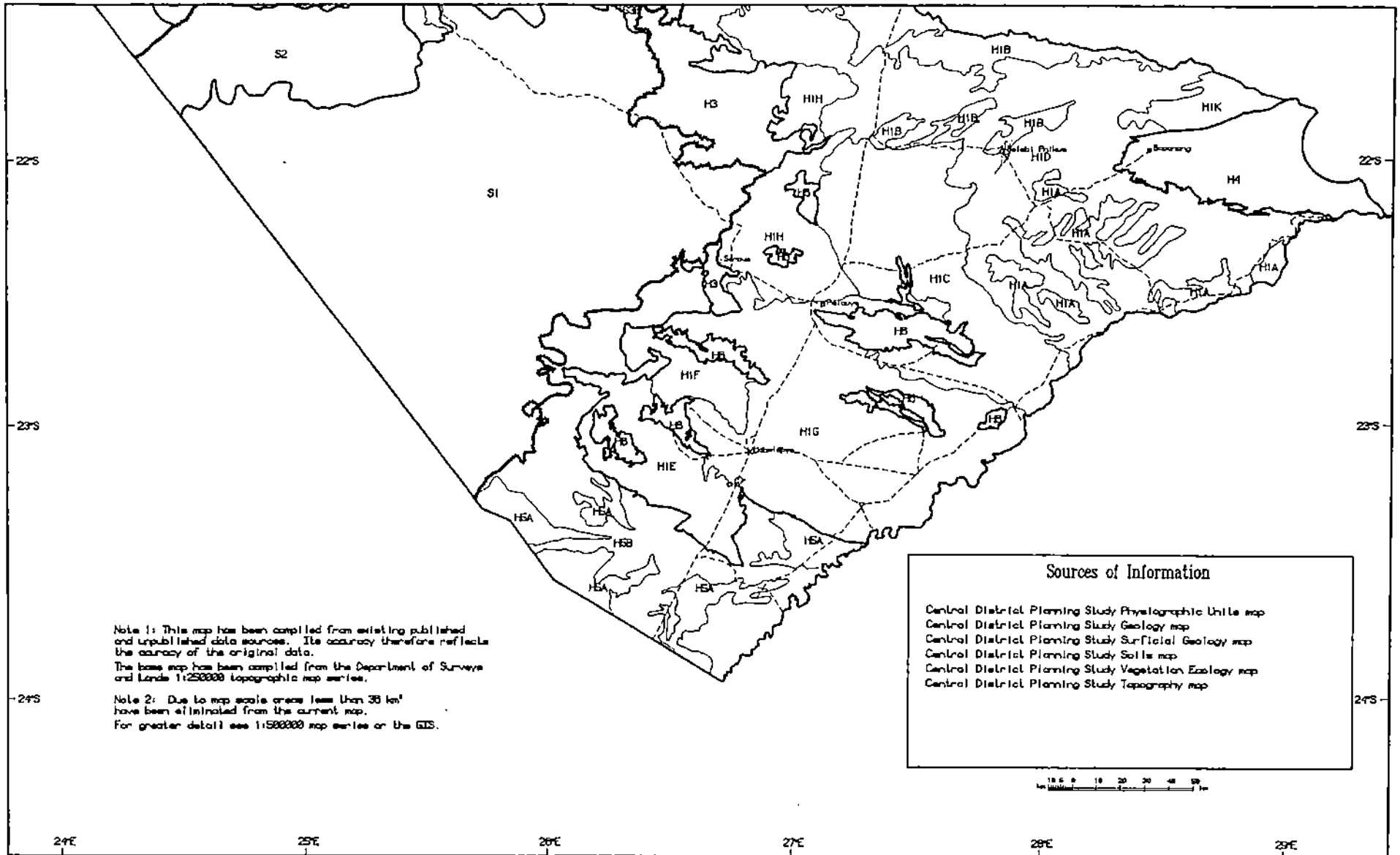
1: H The Hardveld
2: S The Sandveld
3: M The Makgadikgadi Basin

Second order zoning has been based on geology, surficial geology and soils, following physiographic boundaries if these are present. Dominant characteristics are specified. Second order zones are indicated by the first order letter followed by a numeral.

Third order zoning is based primarily on soil and vegetation differences. Third order zones are indicated by the addition of a letter to the second order classification where necessary. For convenience the units have also been described, in general terms, in relation to their erosion potential for both wind and water erosion, without reference to present human impact. This is a guideline only, and should be checked in the field.

Presentation

The Ecological Zoning map is presented on Map Number 3.5.



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: ECOLOGICAL ZONES

MAP NO: 3.5

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
H1H	Sandveld Outlier, Upper Motloutse catchment	AK - 83%	14 - 45% 13 - 20% 6/5 - 15%	Low erosion
H1I	Northern watershed	RG - 86%	13/8/12-35% 12/13 - 35% 8 - 24%	Widespread fluvial At present an extremely degraded area
H1J	Plateau west of watershed	CM - 51% LV - 33%	8 - 31% 12/13 - 28%	Fluvial erosion localised to steep slopes and drainage networks
H1K	Low rocky hills; shallow rocky soils	RG - 79% LV - 18%	13/8/9- 89%	Widespread fluvial

H2 NATA BASIN

Physiography: Heavily weathered plain draining towards the Makgadikgadi, with drainage affected by faulting, tectonism and past lacustrine events; 1200-900m

Drainage: Middle Nata and Mosetse Rivers. Extensive lateral flooding in wet season.

Surficial/geomorphology: Sand, alluvium; some rock and calcrete.

Soils: Major CL, VR (on basalts); minor LV (floodplains), GL, AR. Soil distribution is complex and is dependent on geomorphology.

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
H2	Nata upper catchment; broad flat poorly drained area	CL - 43% VR - 26% LV - 22%	12/16 - 32% 15 - 26% 15/16 - 16%	Localised wind

H3 MOTLOUTSE/LOTSANE UPPER CATCHMENTS

Physiography: Erosional surface 1200-1000m immediately below the Paje Escarpment; active fluvial erosion.

Drainage: Dense network of Motloutse tributaries. Zone of high pan density.

Surficial/geomorphology: Remnant Kalahari Sand, colluvium, rock exposure.

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
H5A	Serorome corridor luvisols	LV - 88%	6/10 - 38% 10 - 29% 6 - 15%	Low
H5B	Serorome corridor arenosols	AR - 95%	6/ 5 - 25% 6 - 24% 6/10 - 21% 5 - 16%	Low

H6 HILL MASSIFS

Physiography: Hills and plateaus rising above the hardveld; 1300-1000m.

Drainage: Steep incised valleys and gorges.

Surficial/geomorphology: Rock exposure.

Soils: LP

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
H6	Hill massifs	LP - 77%	9 - 88%	Fluvial erosion high on slopes, low on plateau surfaces

THE SANDVELD

S1 MAIN SANDVELD

Physiography: Sand plain sloping from watershed towards the Makgadikgadi. Some indistinct dune forms. Dry valleys (especially the Letlhakane) and pans form important ecological sub-units; 1200-1000m.

Drainage: No surface drainage beyond pans and dry valleys.

Surficial/geomorphology: Kalahari Sand, with calcrete and silcrete on drainage features.

Soils: AR, CL

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
S3A	Letlhakane Ridge - upper	CL - 78%	14 - 73%	Wind
S3B	Letlhakane Ridge - lower	LP - 65% RG - 19%	14 - 69%	Wind

S4 NORTHERN DUNEVELD

Physiography: A sand plain with well developed E-W linear dunes; 1100-950m

Drainage: Nunga dry valley with occasional flows (cf 1988). Pans in interdune straats.

Surficial/geomorphology: Kalahari Sand. Strong landscape influence from linear dune field.

Soils: AR, some LV, CL, LP.

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
S4A	Northern sandveld deep ferralic arenosols	AR - 98%	7 - 96%	Low
S4B	Northern sandveld Nxai Pan complex	AR - 46% LV - 21% CL - 19%	12 - 87%	Wind
S4C	Northern sandveld ferralic arenosols	AR - 96%	6 - 65%	Low

THE MAKGADIKGADI BASIN

Defined as the areas below 950m within the Makgadikgadi Basin which have been affected by Quaternary lacustrine processes, and which now posses a distinct set of landforms, soils and vegetation. Some higher land is included between the Mosu Escarpment and the edge of Sowa Pan in unit M7.

M1 PAN SURFACES

Physiography: Altitude 930-890m. Surfaces of major pans now affected by groundwater activity, surface flooding and aeolian processes. Includes saline, clay and grassed pans.

Drainage: Seasonal ponding. Some deltas from inflowing rivers.

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
M3A	Northern Rakops plain	AR - 98%	2/6 - 100%	Low
M3B	Southern Rakops Plain	CL - 73% LP - 18%	2/6 - 75%	Wind

M4 GIDIKWE RIDGE

Physiography: Massive sand ridge (former bay bar) extending north-south, curving to Kedia Hill; 950-920m with some higher dunes.

Drainage: Nil, apart from Boteti and Okwa Gaps.

Surficial/geomorphology: Sand ridge

Soils: AR,CL

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
M4	Gidikwe Ridge	Cl - 65% LP - 19%	2/6 - 33% 6 - 33% 14 - 21%	Low

M5 GIDIKWE PLAIN

Physiography: Old lake floor to the west of the Gidikwe Ridge; 950-920m

Drainage: Former course of the Okwa, some shallow pans.

Surficial/geomorphology: Alluvium, some calcrete and sand masses.

Soils: AR,CL,LP.

Soils: LP,CL Minor AR,GL,CM,RG. Soil distribution is complex and is dependent on geomorphology.

Ecological Zone	Description	% component of Dominant soils	% component of Dominant Vegetation types	Erosion Potential
M7A	East Makgadikgadi calcisols	CL - 67% CM - 27%	14/12/3 - 31% 12/16 - 31%	Wind and fluvial
M7B	East Makgadikgadi regosols/leptosols	LP - 80% RG - 19%	12/13 - 45% 12 - 23%	Wind and fluvial

Reliability and Gaps in Data

As noted on page 3-41 the ecological zoning map has been generated from existing data during the preparation of this study. It is a guideline only, and requires field verification.

4. AGRICULTURAL SUITABILITY ZONING

4.1 AGRO-CLIMATE

Introduction

This section describes the agro-climatic zoning of Central District according to the Length of Growing Period (LGP) concept coined by FAO and described as "LGP is the period between the time the rainfall level becomes higher than half the potential evapo-transpiration (PET) and the time soil moisture reserves are depleted following rainfall level dropping below half PET" (FAO; 1978). The zones defined by the Department of Meteorological Services (DMS) map also take into account the number of dry days and humid days (when rainfall is greater than PET) within the GP.

Methodology

The agro-climatic data from the small-scale national map was digitised for the GIS. The DMS portions relevant to Central District were extracted to produce the Agro-climatic Zones map.

Presentation

The Agro-Climatic Zones are presented on Map Number 4.1.

Description

The zones are defined in terms of LGP and its annual frequency of return, the length of the humid period and its annual frequency of return, and the number of dry days within the season. Zones occurring in Central District are tabulated below:

4.2 AGRICULTURAL SUITABILITY ZONES

Introduction

The definition of suitability zones is aimed at providing a systematic division of the District into areas of relatively uniform agricultural potential. This is dependent on the agro-climate, soil type and other forms of present or potential land use.

Methodology

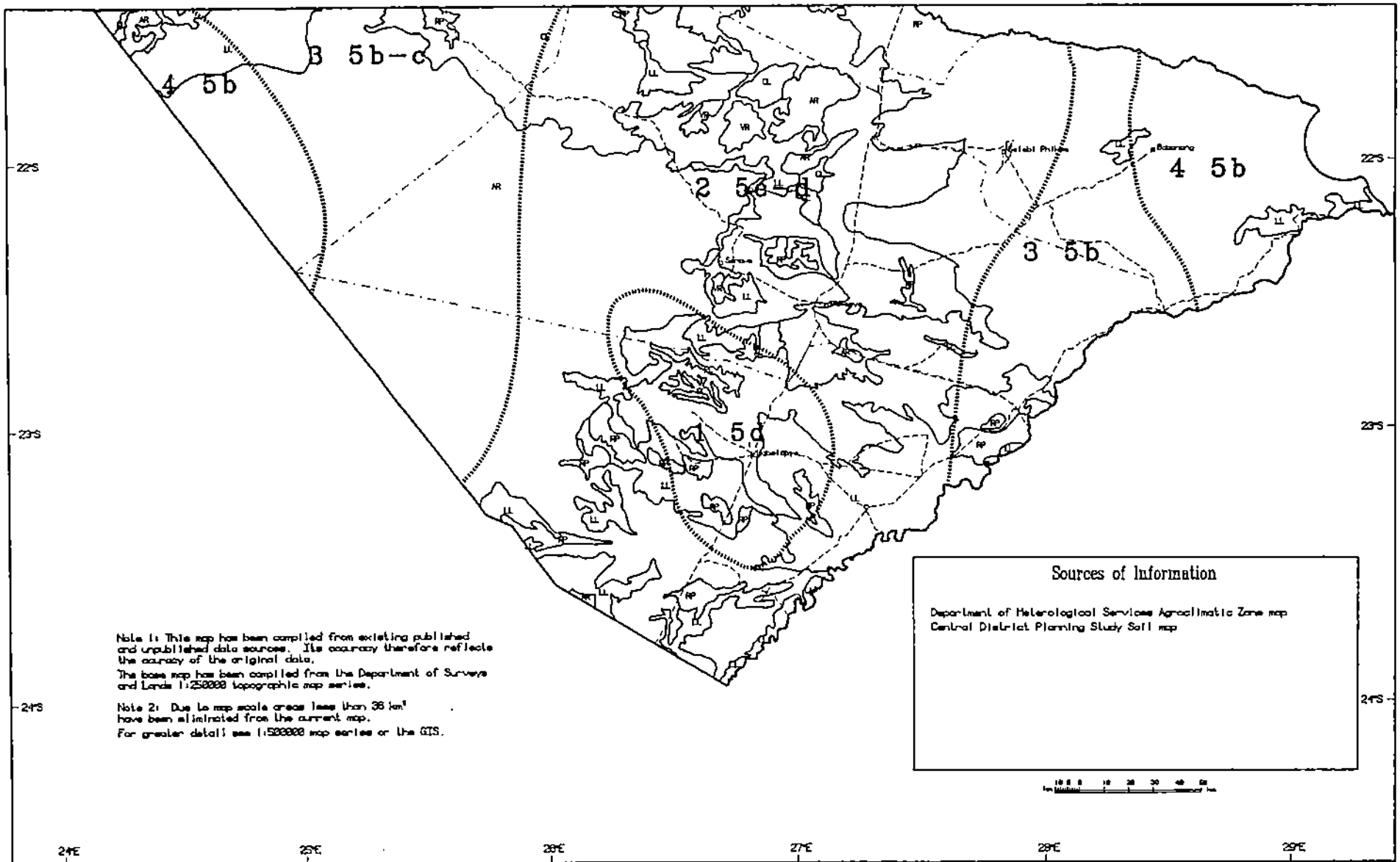
The zoning used here was derived primarily from the Agro-climatic Zoning map and the Soils map. Interpretation of the FAO/MoA soils map together with accompanying pedons and profiles was combined with the agro-climate information using GIS overlay techniques to produce a base map. This was done to provide some indication of potential soil moisture availability in addition to the basic agro-climatological information i.e., to produce a suitability map.

Soils have been grouped on the basis of broad similarities in potential maximum available soil moisture reserve (M_m). Groups distinguished are as follows:

AR	Arenosols;
RP	Regosols, Leptosols and all soils limited by petric, petroferric, lithic or skeletic phases;
FL	Fluvisols
GL	Gleysols;
LL	Luvisols, Lixisols and Cambisols;
CL	Calcisols;
AC	Acrisols;
PL	Planosols (limited by Na^+);
SC	Solonchaks;
SN	Solonetz's;
VR	Vertisols.

Presentation

The Agricultural Suitability zones are included on Map Number 4.1.



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: AGRICULTURAL SUITABILITY

MAP NO: 41

TABLE 4.2 (contd.)

2 5c-d LL	80-100	20-40	20-60	20-40	S1, S4A, S4B, H1C, H1E, H1G, H2, H3, M6A, M6B	Scattered throughout. Good soils. More potential in the north. Many dry days
2 5c-d RP	80-100	20-40	20-60	20-40	S3B, S4B, H1A-H1E, H1G-H1J, H2, H5A, H5B, M6A, M6B	Very extensive. Shallow soils. Moisture availability good, storage dependent on depth . Many dry days
2 5c-d SC	80-100	20-40	20-60	20-40	M1	Excessively saline/calcareous soils
2 5c-d VR	80-100	20-40	20-60	20-40	H2, H3	Nata + Motloutse catchments. Clayey soils. Many dry days
3 5b CL	60-80	20-40	20-60	20-30	H1D, H4	High pH soils. Short GP
3 5b LL	60-80	20-40	20-60	20-30	H1C, H1G	North of Sefare hills. Good soils. Short GP
3 5b RP	60-80	20-40	20-60	20-30	H6, H1G	East. Shallow rocky soils. Short GP
3 5b-c AR	60-80	20-40	20-60	10-30	S3A, M1, M5A, M6A, M6B, M6D	Western sandveld. Sandy soils. Short GP
3 5b-c CL	60-80	20-40	20-60	10-30	S3A, S3B, M1, M2, M3B, M4, M5B, M6A, M7A	Extensive in mid-district. High pH soils.Short GP
3 5b-c FL	60-80	20-40	20-60	10-30	M1, M2	Lower Boteti floodplain. Alluvial soils. River flooding may extend GP
3 5b-c GL	60-80	20-40	20-60	10-30	S3B, M7A	South Sowa pan. Alluvial soils. Short GP
3 5b-c LL	60-80	20-40	20-60	10-30	S3A, S3B, H1J, M7A	Scattered patches. Good soils. Short GP
3 5b-c RP	60-80	20-40	20-60	10-30	S1, S3B, M3B, M6A, M6B, M7B	Shallow soils with duripan.
3 5b-c SC	60-80	20-40	20-60	10-30	M1, M2, M3B	Excessively saline/calcareous soils.
3 5b-c SN	60-80	20-40	20-60	10-30	M2	Mid-Boteti floodplain. Patchy good soils. River flooding may extend GP
3 5b-c VR	60-80	20-40	20-60	10-30	H2	Isolated patch east of Sowa pan. Clayey soils.
4 5b AR	40-60	20-40	20-60	20-30	S1, S2, M5B	Low irregular rainfall. Sandy soils.
4 5b CL	40-60	20-40	20-60	20-30	H1D, M4, M5B	Isolated small patches. High pH.
4 5b LL	40-60	20-40	20-60	20-30	S2, H1D, M4	South of Lake Xau + Tuli corner. Good soils. Low irregular rainfall.
4 5b RP	40-60	20-40	20-60	20-30	H1A, H1D, H1K, M4	Extensive in Tuli corner. Shallow rocky soils; low irregular rainfall.

5 NATURAL, CULTURAL AND HISTORIC SITES

Introduction

Areas or sites of special scenic, natural or cultural significance are identified and described in this section.

Methodology

Information has been obtained from:-

> Archaeology Department, National Museum Monuments and Art Gallery, Gaborone; Curator, Khama III Memorial Museum, Serowe; Ministry of Local Government and Lands/Dept of Surveys and Lands, Ngwato Land Board;

The National Museum Monuments and Art Gallery (NMMAG) records known archaeological sites on 1:50 000 topographic maps which were made available for this study. Details of each site are recorded in files relating to each 1:50 000 sheet. The co-ordinates for each site and details such as the type of site and artifacts excavated have been entered into a data base.

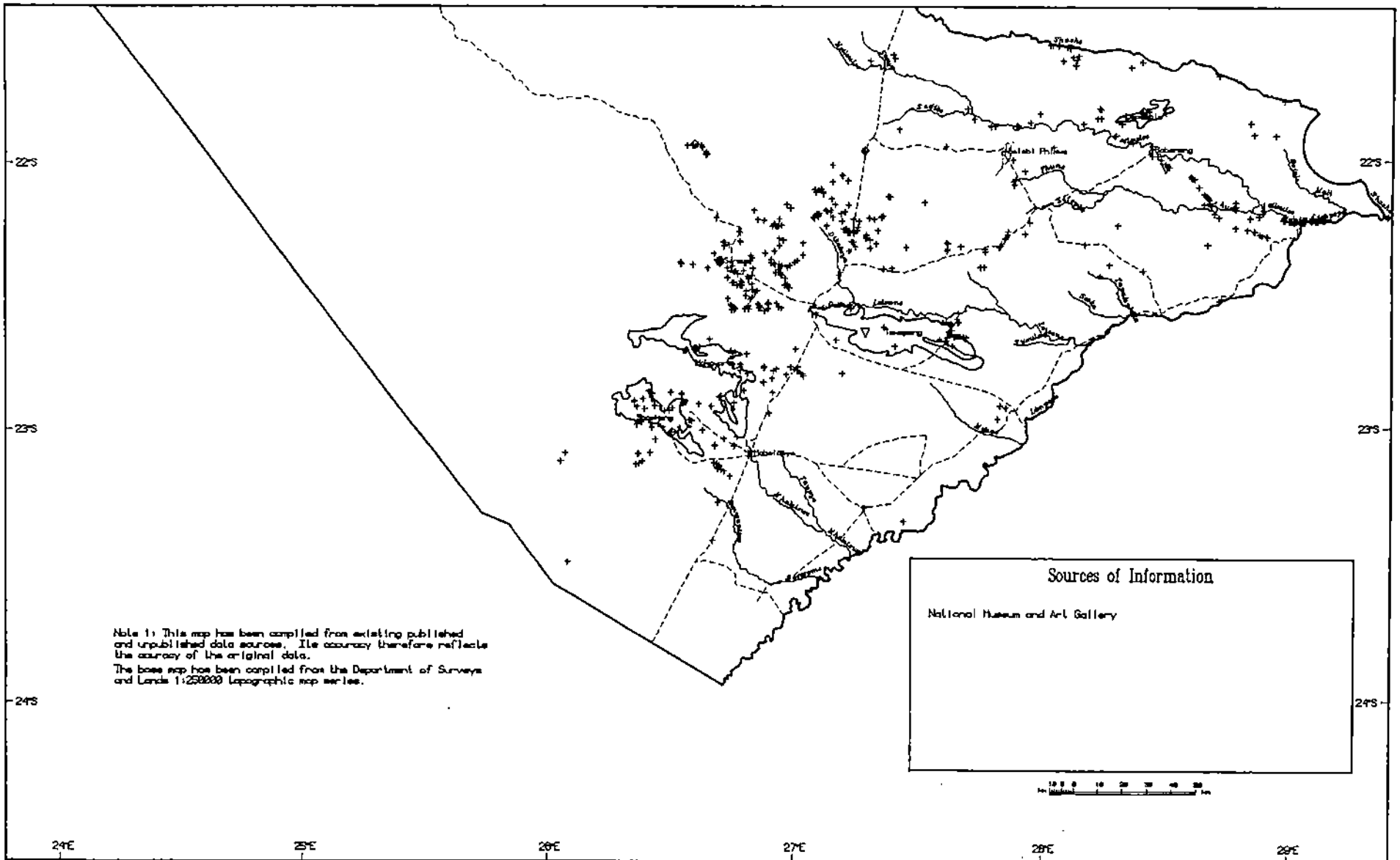
Additional information has been added to this from the other sources listed. Natural features (major pans and rivers and hills of special scenic interest) have been added from the respective map coverages.

Presentation

The Natural, Cultural and Historic Sites map is presented on Map Number 5.1.

In some areas many archaeological sites have been excavated in close proximity to each other, making presentation at a small scale difficult. In the report the sites are mapped at a scale of 1:1 000 000 with each site being represented by a symbol only. This allows the spatial distribution of known sites to be seen in relation to other features such as rivers, roads and settlements.

National Monuments and other important sites which are under protection or are currently being developed are identified separately.



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Areas of Scenic/Natural Beauty

Not all areas of natural beauty have been identified systematically. The DDP IV (draft) mentions the following hill ranges as being of scenic (and archaeological) interest:

Shoshong hills, north of Shoshong;
Mokgware Hills, between Kalamare and Serowe;
Tswapong Hills, east of Palapye;
Lepokole Hills, north of Bobonong;
Makhula Hills, south of Tutume;
Kgwana Hills, north west of Mosetse.

Many of the pans and rivers in the district also fall into this category.

Discussion

There are many areas of archaeological interest in Central District, particularly in the south and east and around the Makgadikgadi Pans. As map 5.1 indicates, many known sites are on hills and along river valleys, where erosion may have exposed artifacts. Other known sites are located along roads and power lines, some of these were discovered and excavated while survey work or construction work was under way. While relatively intensive surveys of archaeological sites have been carried out in a few areas during archaeological impact studies required by such development projects, the bulk of the district remains unexplored. It is therefore important that the existence of archaeological sites should be taken into account when any new development projects are under consideration.

All pre-1902 sites are protected by the Monuments and Relics Act, 1970, but there is still a danger that sites may be unwittingly destroyed by contractors when development work is being carried out.

It is important that when any major development or change in land use is being planned, an archaeological impact assessment should be carried out. The Monuments and Relics Act places the onus on site contractors and construction companies to ensure that archaeological work is budgeted for, planned and completed before they begin work. The discovery of archaeological sites before or during development projects can cause costly delays. Tender documents should remind contractors of their legal obligations and all development projects should be monitored to ensure that developers are fulfilling their obligations under the Act. The National Museum Monuments and Art Gallery can provide more information and assistance, and should be advised in advance of all major development projects in the district. Many undiscovered sites are bound to exist in Central District, and with the limited capacity available for administering the Act, important sites may be destroyed.

6. POPULATION AND SETTLEMENTS

Introduction

This section describes populations and settlements in Central District and is based on provisional data from the 1991 Census.

In view of the fundamental importance of this chapter to the delineation of DPUs, the data limitations are discussed under Methodology rather than at the end of the chapter.

Methodology

There are several sources of data on settlements; the 1981 Census Guide to the Villages of Botswana, GRAS, the National Settlement Policy and the maps for the 1991 Census. In view of the 1991 Census maps being the most recent source of information, the settlement locations have been taken from the 1991 map but because the list of localities has not been released, the locality names contained within The Guide to the Villages of Botswana was used.

The limitations of the 1991 Census data include:

1. The Census maps used the 1:50 000 topographic sheets where available and the 1:250 000 sheets elsewhere (the western part of the Serowe/Palapye Sub-district and Boteti Sub-district). Where the 1:250 000 sheets have been used the mapping is not as accurate.

   Each locality marked on the Census maps was digitised. In the case of larger settlements, the centre was taken to be where all the tracks converged. For smaller settlements it was decided, as a rule, to digitise the top of the hut drawn by CSO. This could introduce a locational error of up to +/- 10km, particularly in the areas where the 1:250 000 maps were used. This is not a major problem for this study (although it will make location in the field difficult) as most do not have significant populations.

2. In the course of the Census a number of localities were found which had not been mapped. These have not been marked on the Census map and therefore we do not have them digitised. It is estimated that this could affect population estimates by approximately 10%.

3. CSO is preparing an update to the 1981 Guide to the Villages of Botswana that should become the basis for future work.

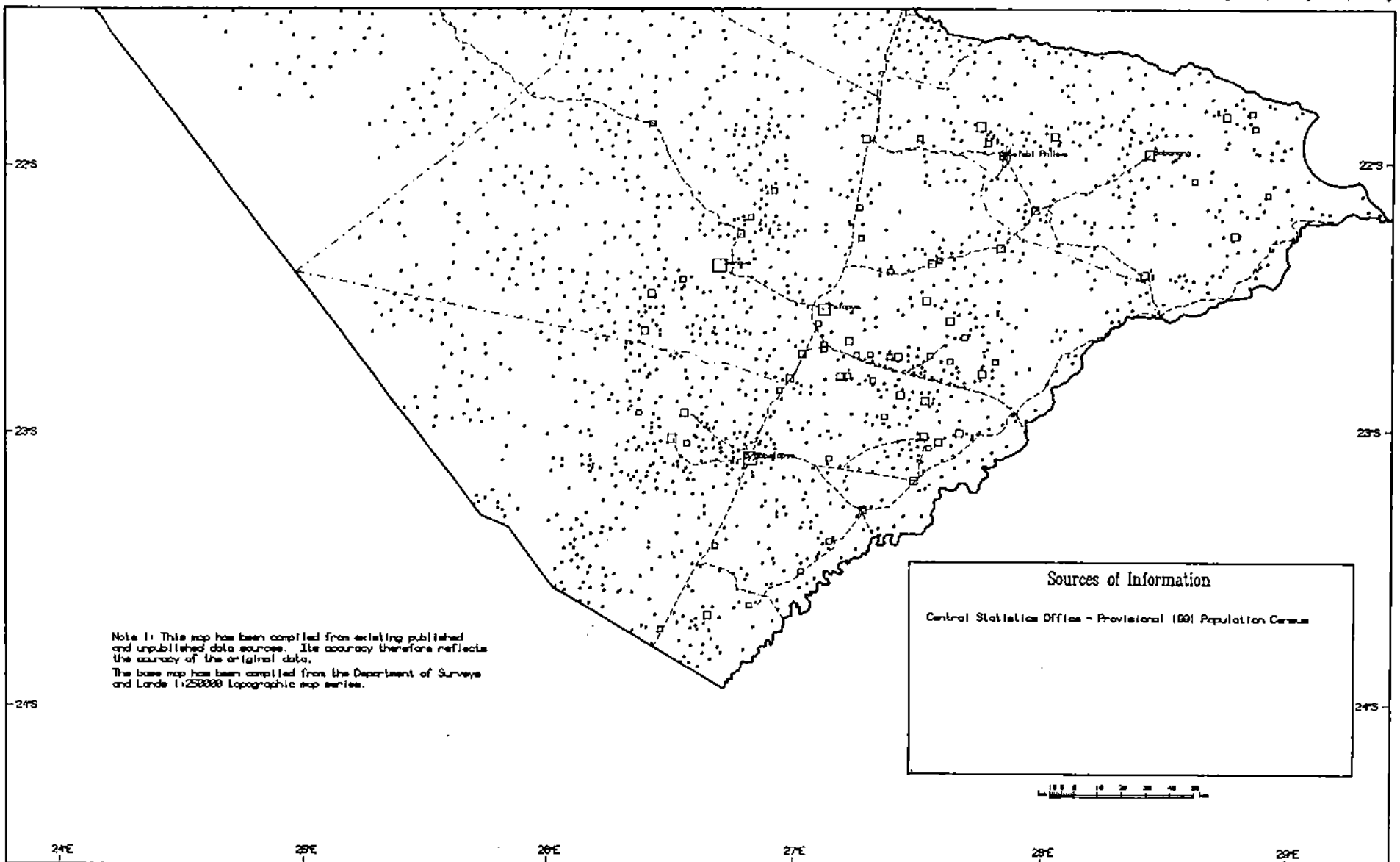

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TABLE 6.1 SETTLEMENT CLASSIFICATION CENTRAL DISTRICT[1]

Category	Population Criteria	No. of Settlements 1981	1991 (Preliminary)
Primary	20 000+	2	2
Secondary	10 000 - 20 000	0	3
Tertiary I	5 000 - 10 000	4	4
Tertiary II	1 000 - 5 000	42	51
Tertiary III	500 - 1 000	58	63
Other	<500	2000+	2000+

[1] From Provisional 1991 Census Data, not including Orapa or Selebi Phikwe

Tables 6.2 and 6.3 summarise the 1981 and the preliminary 1991 population data by Sub district and by major and intermediate villages (CSO data and classification). It should be noted that CSO considers Palapye to be an urban settlement.

TABLE 6.2 POPULATION PER SUB-DISTRICT (1981 and 1992)

Sub district	1981	1991 (Preliminary)	Percentage Growth
Palapye	9 594	17 131	78.6
Serowe (excluding Palapye)	82 634	111 300	34.7
Mahalapye (including Tuli)	82 982	95 566	15.2
Bobirwa	46 436	53 472	15.2
Boteti	26 405	35 473	34.3
Tutume	75 277	99 753	32.5
Total (including Palapye)	323 328	412 695	27.6

TABLE 6.3 POPULATION PER MAJOR AND INTERMEDIATE VILLAGES (excluding Palapye) 1971/1981/1991

Census District	Enumerated Population 1971	1981	1991	Percentage Changes 71-81	81-91
SEROWE/PALAPYE (excluding Palapye)					
Serowe	15 364	23 661	30 706	54.0	29.8
Lerala	982	1 766	3 781	79.8	114.1
Maunatlala	442	1 470	2 278	232.6	55.0
Moiyabana	786	1 407	1 787	79.0	27.0
Thabala	624	1 242	1 551	99.0	24.9
Paje	768	1 216	1 415	58.3	16.4
Mogapi	376	1 089	1 280	89.6	17.5
Mabeleapudi	715	1 067	865	49.2	(-18.9)

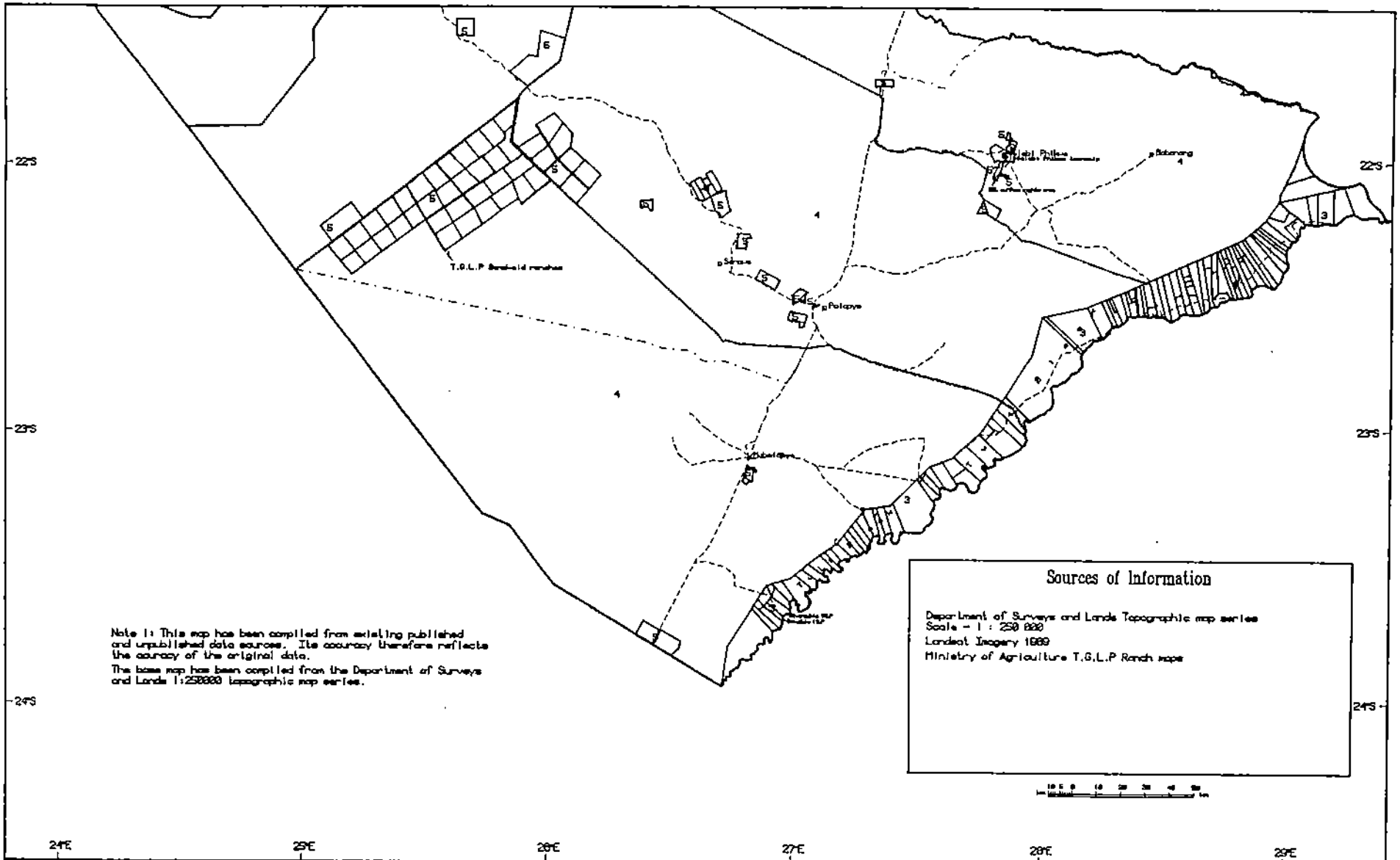
TABLE 6.3 (Contd.)

Census District	Enumerated Population 1971	1981	1991	Percentage Changes 71-81	81-91
BOTETI (Contd.)					
Maatshumo	325	636	759	95.7	(19.3)
Mosu	515	578	558	12.2	(-3.5)
Makalamabedi	263	537	884	104.2	64.6
Kedia	-	-	619	-	-
TUTUME					
Tonota	5 204	6 566	10 881	26.2	65.7
Tutume	644	3 736	10 042	480.1	168.8
Maitengwe	1 783	3 436	4 861	92.7	41.5
Nkange	624	2 721	3 051	336.1	12.1
Gweta	855	1 521	2 701	77.9	77.3
Dukwe	-	1 407	2 509	-	78.3
Shashe	896	1 306	1 114	45.8	(-14.7)
Nata	470	1 303	2 750	177.2	111.1
Matobo	891	1 242	1 210	39.4	(-2.6)
Nswazwi	600	1 135	1 721	89.2	51.6
Mathangwane	432	1 106	2 512	156.0	127.1
Dagwi	180	1 023	1 279	468.3	25.0
Marapong	-	951	1 393	-	46.5
Mosetse	234	892	1 451	281.2	62.7
Senete	660	851	1 952	28.9	129.4
Barolong	482	845	1 259	75.3	49.0
Changeta	127	785	1 137	518.1	44.8
Shashe-Mooke	290	709	1 451	144.5	104.7
Mandunyane	302	671	1 294	122.2	92.8
Sebina	792	665	1 750	(-16.0)	163.2
Chadibe	-	539	742	-	37.7
Mafungo	905	538	886	(-40.6)	64.7
Matsitama	135	503	770	272.6	53.1
Makobo	-	358	756	-	111.2
Dzoroga	-	354	626	-	76.8
Borotsi	-	636	818	-	28.6
Mokubilo	-	279	667	-	139.1
Nshakashokwe	239	147	1 033	(-38.5)	602.7
Zezuru	-	463	500	-	8.0
Goshwe	-	768	799	-	4.0

Discussion

The relative growth rates for the Sub-districts are not easily explained and a detailed analysis is beyond the scope of this study.

Bobirwa and Mahalapye Sub-districts have the lowest growth rates. The former might be explained by slow recovery from the recent drought years and consequent migration from the rural areas to the larger villages and Selebi Phikwe. The low growth rate in Mahalapye Sub-district might also be due to drought but also due to more rapid development of Palapye. Investment in Mahalapye has been inhibited by the poor water supplies until recent years when the Palla Road wellfield was commissioned.



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Botswana

PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: LAND TENURE

MAP NO: 71

Footnotes:

1) Including Government livestock management unit
2) Excluding Daukome Quarantine Camp (see note in text regarding mapping of Sandveld TGLP Ranches)
3) See note in text regarding mapping of Setata Quarantine Camp

Note: Although not specified in the terms of reference, it was decided that major blocks of leasehold land should be mapped and described separately. It will be noted that some of the blocks of land listed have no area provided. Areas marked with an * have not been included in the Land Tenure map (7.1). This is because accurate location information could not be provided by Land Board in Serowe or by Department of Surveys and Lands in Gaborone. Tribal leased areas marked with a + have been mapped as accurately as possible from Land Board lease agreements where these could be found, but further checking of the actual area fenced may be necessary in the field.

Sources: Central District Land Use Plan (draft 1985); Serowe Land Board; Dept. of Surveys and Lands; District Administration Serowe; Central District Planning Study (GIS).

STATELAND

There are three areas of state land in the District, the Boteti State Lands and the Nata State Lands and Sowa Township. There are also two smaller areas of state land:- Selebi Phikwe Township and Baines Drift Reserve.

The Boteti State Lands comprise Ntwetwe Pan and the land west of the Pan up to the Boteti River. The eastern border of the area is the eastern edge of Ntwetwe Pan, which has proved difficult to map as described below. The area is approximately 8 602.5 km² (source GIS). The boundaries between State and Tribal land are not fenced, and often not demarcated. The borders are therefore not always honoured by local residents, either intentionally or unintentionally. District authorities may also unintentionally allocate land on the wrong side of the boundary. There is a proposal to tribalise a portion of land near Kubi, but the implications still need careful consideration.

The Nata State Lands extend from 10 km north of Nata, northwards to the district boundary. The area covers approximately 13 976.8 km² in total (source GIS). Some of the area is leased out and this is described separately below.

Selebi Phikwe Township covers an area of 47.3 km² (source GIS) and falls within the Bobirwa Sub-District.

Baines Drift Reserve comprises 25.1 km² (source GIS) of state land in the Tuli Block.

Authority over State land is vested in the Office of the President. The day to day administration of State land has been passed to the District Commissioner, but legal long term use of State land is obtained through Department of Surveys and Lands. State land areas which are held partly or predominantly under leases are described below.

that a team would be checking this information in the field in late January 1992. This was too late for inclusion in this report. Once the information becomes available, re-positioning of the TGLP ranches on the maps may be necessary.

Mining leases which give sub-surface mining rights are held for several areas in Central District (see Mineral Occurrences Section 2.1.1 Table 2.2). Surface rights to the land must be applied for separately from the Land Board, and these do not necessarily coincide with the mining lease areas. The major surface rights areas which are associated with mining activities are shown. These are Sowa Pan, Selebi Phikwe, Morupule, Orapa/Letlhakane (also security areas).

The airstrip, prison and BDF Camp at Selebi Phikwe are located outside the township on land held under tribal leases. The Morupule Power Station is located on land held under tribal lease.

Reference to Dukwe Refugee Camp having been detribalised or leased has been seen in written documents, but no evidence of this could be traced at Department of Surveys and Lands nor at the Land Board in Serowe.

Within Palapye, an area on which housing related to the Morupule project (BPC) has been built is leased from the Land Board. Botswana Housing Corporation have also leased land for a housing project and depot in Palapye.

There is a Botswana Defence Force Camp covering 25,9 km² (source GIS), south of Paje.

Land for other Government uses such as schools, hospitals, Government offices or Government housing projects is leased from Land Board by Government. Areas leased by Government have a 99-year lease agreement; most of them against a nominal fee of P5 per annum. Department of Surveys and Lands has a computerised list of all areas of tribal land which Government is leasing, but the sizes and exact locations are not recorded. These can be obtained in some cases by reference to DSL's files. Most of the leased areas are too small to map at the scale used.

Land for special projects in tribal areas is also leased by individuals, groups or companies. Most of these areas are too small to indicate on the map. Individuals may also convert their customary grants of residential plots to (optional common law) leases. They can then borrow money to develop them more easily from financial institutions. This occurs particularly in the major villages - Serowe, Palapye, Mahalapye etc.

7.2 LAND USE

Introduction

This section deals with land use in Central District. The major types of land use which are identified and described are settlements, cultivated land (dryland and irrigated), grazing (communal and leasehold areas), horticulture and forestry. Uses such as game reserves and Wildlife Management Areas are described in the Wildlife Resources Section (3.1.2). Mining lease areas are described in the Mineral Occurences Section (2.1.1).

Methodology

Information has been obtained from officers in the following organisations, Government Ministries and Departments: Department of Surveys and Lands, Ministry of Local Government, Lands and Housing; Department of Town and Regional Planning, Ministry of Local Government, Lands and Housing; District Administration, Central District; Regional Agricultural Office, Central Region, Serowe; Ministry of Agriculture; National Institute of Research and Documentation.

Other Sources of Information were Department of Surveys and Lands, 1:250 000 Topographic Maps, various dates; Landsat Imagery, 1989.

Presentation

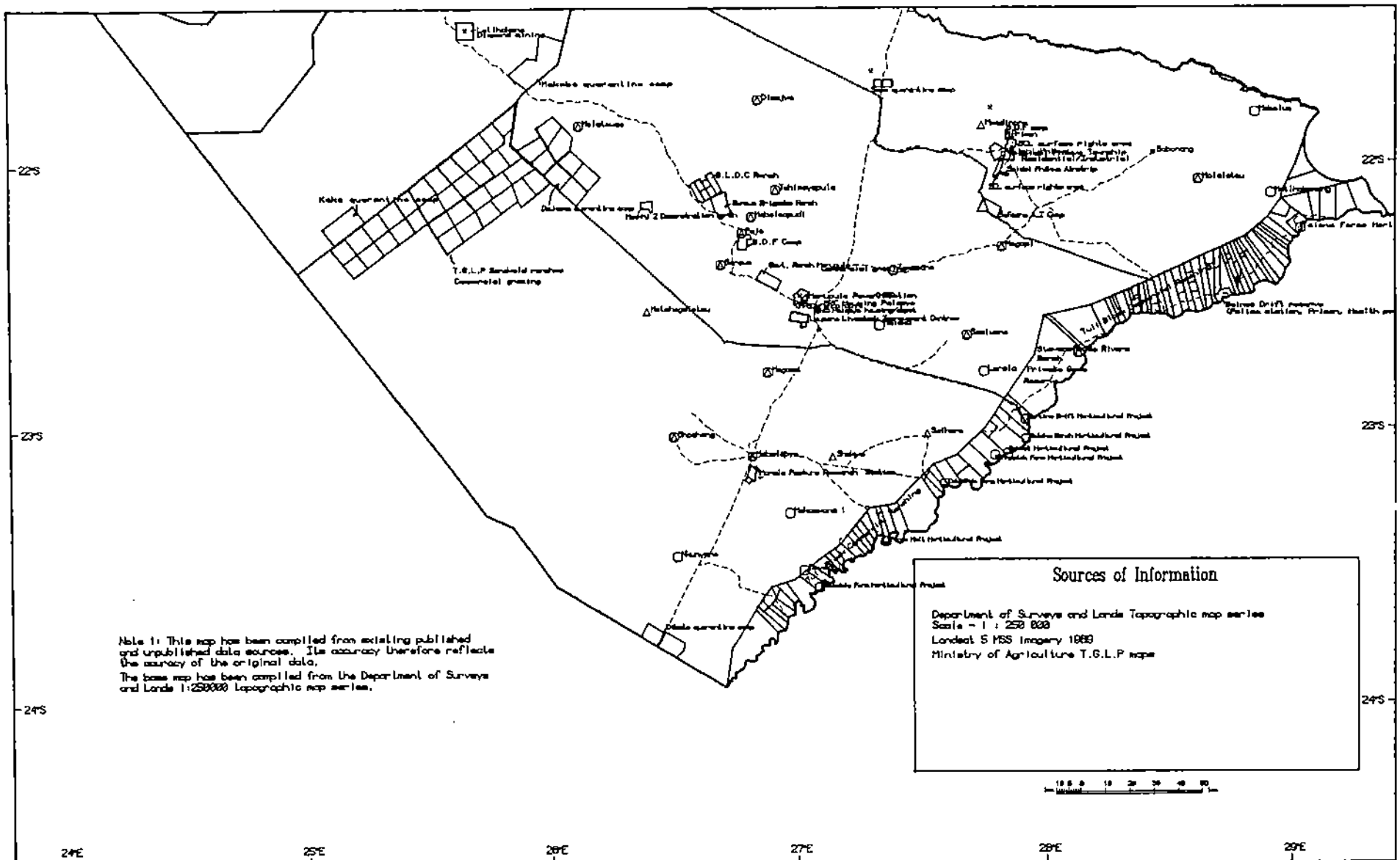
Maps

The following maps are presented:

.	Land Use	Map Number 7.2
.	Cultivated Lands	Map Number 7.3
.	Veterinary Cordon Fences	Map Number 7.4

Data Base

Forestry and horticultural areas on Tribal Land have been entered into a data base related to the villages in which they are located.



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: LAND USE

MAP NO: 72

posts (but excluding Selebi-Phikwe, Orapa and Sowa) is estimated at approximately 430 km² (0.3% of the total District area) using a rough estimate of 0.1 hectare per person.

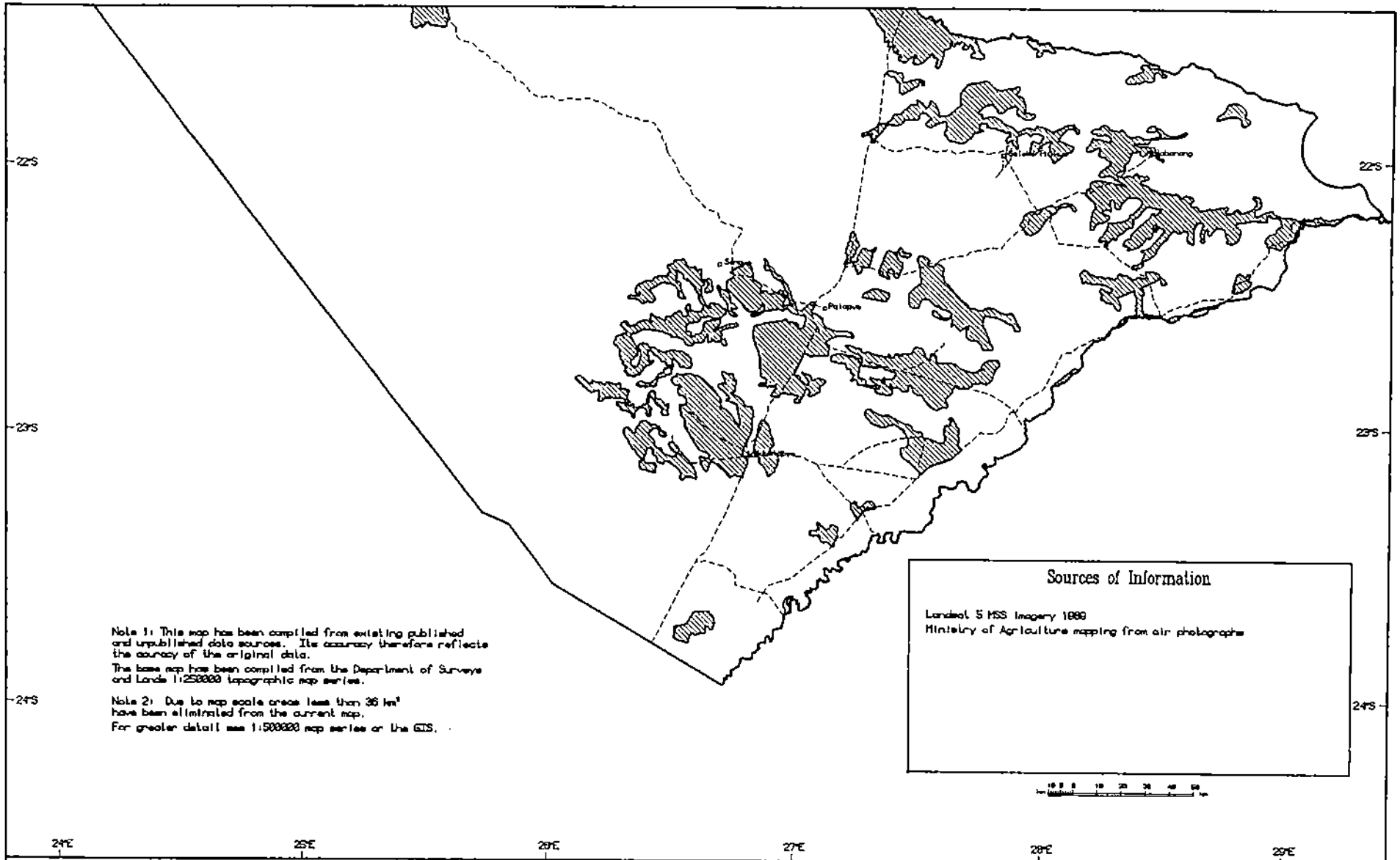
The villages have grown without the benefit of modern town planning procedures. Therefore incompatible land uses are often located in close proximity to each other. Furthermore, services such as schools, clinics and shopping centres are often not well located in relation to the populations which they are designed to serve. Upgrading of these villages (improving roads, providing piped water and reticulating electricity) is a costly exercise. However, government, through MLGLH, has embarked on a programme of major village planning and upgrading in order to make these villages (Serowe, Palapye, Mahalapye) an attractive alternative to the urban areas for investors.

Serowe, Palapye and Mahalapye will in the future be gazetted as 'planning areas'. This will not affect land tenure in the villages, but the controls of the Town and Country Planning Act 1977 over land use will apply. Development plans have already been prepared for these villages, but once the Act comes into force, statutory procedures for plan approval and for subsequent developments will have to be followed. Advisory plans will be prepared for smaller villages as the need arises.

Land use within Selebi Phikwe planning area is controlled by the regulations of the Town and Country Planning Act 1977. Under the Act, development plans must be prepared for the whole planning area. In the case of Selebi Phikwe, the planning area covers an area which coincides with the mine lease area. As can be seen from the land use map (Map Number 7.2), the planning area takes in the township (State Land) and an area of Tribal Land (on which uses such as the airport, prison, BDF camp and BCL surface rights area are located).

Baines Drift Reserve in the Tuli Block is used for various Government purposes such as a police station, prison and health post.

In terms of overall district land use planning, as settlements expand conflicts with agricultural land uses inevitably occur. Villages have generally grown up at least in part because of the availability of good agricultural land (in combination with a good water supply), and their expansion therefore threatens agricultural production. Although returns per hectare on arable agriculture are low, it is still felt that the best agricultural land should be protected from urban development for as long as possible. Detailed soils information would assist in this process.



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The availability of ARAP subsidies over the last few years has encouraged the clearing of land, which has not always been put to productive agricultural use. ARAP has now been discontinued, but continuing assistance to farmers is provided under ALDEP (draught power, provision of implements, fences and construction of rain water tanks).

It is has not been possible to classify arable land as cultivated, fallow or abandoned. Because of factors such as drought or lack of draught power, a farmer may not be able to plough land for several years, even though he intends to do so in the future.

Table 7.3 below shows the areas of dry land farming which fall within tribal, state and freehold land (source GIS).

TABLE 7.3 AREAS OF DRY LAND FARMING

Tenure	Area (km^2)
Tribal land	16 091.6
State land	106.2
Freehold land	380.4
TOTAL	16 578.3

Irrigated Agriculture

The best opportunities for irrigated agriculture are located along the sand rivers in the north east of the district, especially the Limpopo, Motloutse, Shashe, Tutume and Maitengwe rivers. However, there are no large scale irrigation projects in the communal areas.

A form of irrigated agriculture is practised in the Botetl area. This is known as molapo farming. Crops are planted on the wet river flood plains after the annual floods have receded. Yields are significantly higher than dryland farming (500-800 kg per hectare). Molapo farmers have the potential to harvest two crops a year. It is very difficult to quantify the amount of land being put to this use, as even in the field it is difficult to differentiate between molapo and dryland fields. This is especially so downstream of Rakops (Tsienyane). Upstream of Rakops, molapo farming takes place right in the river beds. If the Boteti is dammed at Sukwane, molapo farming downstream will be curtailed.

The molapo farming is carried out on both sides of the Botetl River (ie. partly within the Botetl State Land area).

In addition to the obvious problem of obtaining sufficient water, a lack of management skills impedes the success of such projects.

Other horticultural projects are found on freehold land within the Tuli Block. The BDC Talana farms project has been described above under 'irrigated agriculture'. Other projects in mid-1991 were as follows(source: Ministry of Agriculture):-

TABLE 7.5 IRRIGATED HORTICULTURAL PROJECTS IN THE TULI BLOCK

Project	Ownership	Area (ha)	Produce
Seleka Farms	BDC	12	
Arizona		2.25	Citrus
	private	8.7	Citrus
Babedi	"	15	Vegetables
Sunnyside	"	10.5	Citrus (Also Forestry project for production of poles - 12,5ha Eucalyptus)
Martins Drift Farm	"	7	Citrus/Vegetables
Dovedale	"	4	Vegetables
Parr's Halt	"	4	Vegetables
Machaneng-Oakland Farm	"	0.7	Citrus

Marketing of fruit and vegetables has been difficult from the Tuli Block because of poor road connections to the rest of Botswana. Road access is generally better to South Africa, and some farmers sell there as they are able to get higher prices. However, restrictions on this have been imposed. There are two major roads projects scheduled to begin in late 1991 in the area, and when they are completed access should be much easier.

Water for irrigation comes from boreholes or from rivers. However, the Limpopo forms the international border and the South Africans have dammed most of its tributaries on their side.

Forestry/Woodlots

There are a number of small woodlots and orchards within the tribal areas, usually located close to villages. Table 7.6 below describes some of these.

There are considerable areas of indigenous forest in the northern Nata State Lands. The area stretches from the 72 km road marker along the Kazungula road to the 147 km road marker (19° 45" south). In the east they stretch to the Zimbabwe border, and in the west, for 80 kms from the road. The two most valuable species are Mukwa and Mukusi (Zambezi) Teak.

Two companies hold concessions to harvest and mill timber in the area. These are the Marulamantsi Saw Mill and Timber Milling Botswana (Tamafupa Timber Concession). The former operates two concessions on the western part of the Nata-Kazungula road. One is wholly within the Nata State Lands, while the other extends into the Sibuyu Forest Reserve. The second concession is on the eastern edge of the road and also extends into the Sibuyu Forest Reserve. The concessions were granted without the source being assessed. There is little known about the present availability and regenerative capacity of the main species. It is understood that the Ministry of Agriculture's Forestry Division is looking into the question of timber resource depletion in the area.

Some timber milling is carried out on two of the Nata State Land ranches. Some of the timber is being processed to the stage of furniture manufacture in the area, while the rest is exported as round logs.

Wild animals, especially elephants cause damage to trees. However, it is thought that they also play a significant role in encouraging forest regeneration.

The forestry concession areas cover an area of 2 075 km² (within the district) (source:GIS).

Mixed farming

Mixed farming is especially likely to occur in the areas surrounding settlements.

Some of the land which has been identified as dry land farming is actually in mixed farming use. Blocks of fields (often fenced to protect crops from livestock) have cattle grazing in-between. The advantage of this is that draught power is readily available for ploughing. However, conflicts between land uses may occur if fields are not fenced off from livestock. In some areas a change in land use from pastoral to arable farming is occurring. This is particularly likely to occur around growing settlements where lands areas are being lost to residential and associated uses.

Mixed farming also occurs within the Tuli Block. The dominant form of land use is cattle ranching, while other land uses include private game reserves, a crocodile farm and horticultural schemes.

The problems with mapping the TGLP ranches have been described in the Land Tenure section.

Nata State Land Ranches

The Nata State Land ranches cover a total area of 1 768.1 km². Average ranch size is 63 km² (source: GIS).

There are twenty-seven (27) ranches available on leases, while government has one ranch in the area as a Livestock Management Unit (for demonstration purposes). Two ranches are occupied by squatters (PP 4 and PO 12) one of whom has carried out considerable developments. There is a one km² government service centre (K 34) within one of the ranches (PO 6).

All the available ranches have been allocated, but only 12 were occupied in mid-1991. A number of problems have to be overcome in order to succeed with ranching in this area. Firstly, wildlife conflict with domestic animals. Secondly, water is saline. Thirdly, although range conditions are generally good, the grass is low in nutrients for cattle. Supplementary feeding is therefore necessary. Fourthly, it is necessary to quarantine cattle before they can be marketed in BMC in Francistown, where most of the allocatees come from.

The environment is regarded by MoA officers as being difficult for cattle ranching. Between the ranches, a poisonous plant, Mogau is commonly found, and this has inhibited the expansion of ranching.

The Commonwealth Development Corporation used to lease a ranch in the area, but moved out in the early 1960s because of similar problems which the local farmers are facing now. Nevertheless, the people who are actively farming are mostly managing reasonably well according to MoA officers. Two or three have management problems.

The area may be more suited to wildlife ranching and it is understood that MLGLH has looked into this.

Tuli Block ranches

The Tuli Block is made up of freehold ranches. The most recent published document on land use in the Tuli Block is Samboma's The Survey of Freehold Farms (1982). At that time there were 183 ranches. However, much unregistered subdivision is known to go on. This was confirmed by Mazonde's 1987 research (which was of a more sociological nature). Many Batswana own small 'camps' which consist of two or three paddocks which have been bought from larger farms. During mid-1991 the MoA was carrying out a survey of land use in the Tuli Block, but information was not available in time for inclusion in this report.

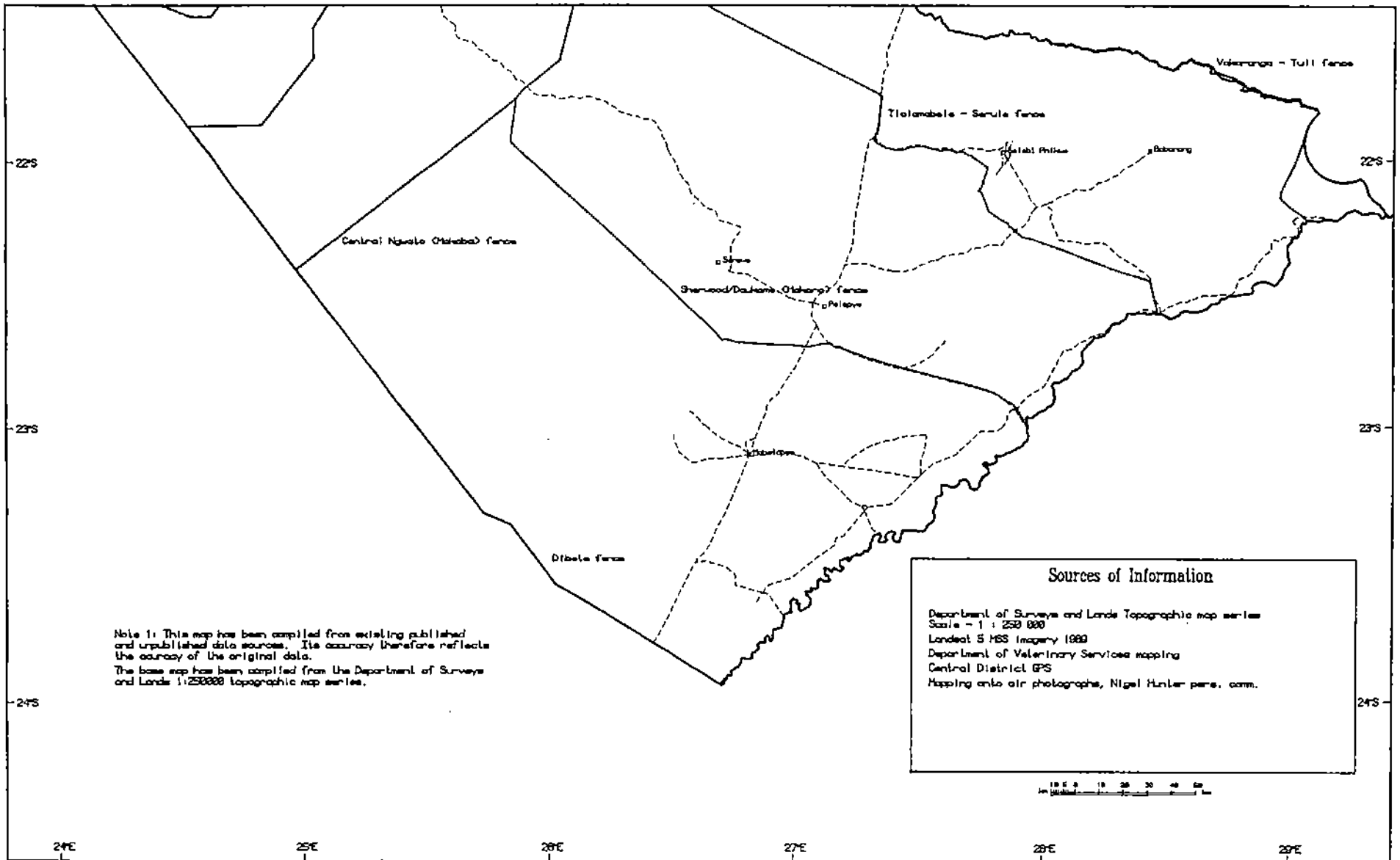
Near Machaneng there is a malt and sorghum milling operation. There is a Council primary school on freehold land at Moletji, and a health post at Talana Farms.

Veterinary cordon fences

There are eleven veterinary cordon fences in Central District (Map Number 7.4). These have been erected during the course of the last forty years, (the first one in 1954 and the most recent in 1990/91 as a result of import requirements of the European Community), in an effort to restrict cattle movement and so effect the control of Foot and Mouth Disease.

The fences are positioned as follows:-

NAME	DATE BUILT	DESCRIPTION	SOURCE
1. Dibete Fence	1954/1974/ 1984	Runs southeast along the edge of the Central Kalahari Game Reserve, then continues southeast via Lephepe and Dibete Quarantine camp, then turns north and east at the Notwane River	Department of Surveys and Lands 1:250 000 topo-graphic map series
2. Ngamiland Cordon Fence (Makalamabedi Fence)	1955	Runs north from the corner with the Kuke fence and CKGR boundary to Makalamabedi and across the Boteti River.	1989 Landsat 5 MSS 1:250 000
3. Central Ngwato (Makoba)	1955/1986/ 1987	Runs northeast from a point on the CKGR boundary via Makoba Quarantine Camp, then north to Tlalamabele Gate and along the eastern edge of Sowa Pan, continuing north via Dukwe and Maitengwe Quarantine Camps.	Department of Surveys and Lands 1:250 000 topo-graphic map series + 1989 Landsat 5 MSS 1:250 000
4. Sherwood/Daukome (Makoro Fence)	1977	Runs from Martins Drift west and north west via Mathakole to Malatswae Gate southwest of Makoba Quarantine Camp.	1989 Landsat 5 MSS 1:250000
5. Vakarange-Tuli Fence	1979/1980/ 1982/1983	Runs from Ponts Drift along the edge of the Tuli Block and Tuli Circle. It then follows the International Boundary to a point north of Ngwalila Pan.	Department of Surveys & Lands 1:250 000 topo-graphic map series + Central District G.P.S.
6. Setata Fence	1979/1984	Runs east from a point on the CKGR boundary then north via Orapa to the Mopipi-Mosu Fence.	Mapping onto air photos Nigel Hunter (pers. comm.)
7. Tlalamabele-Serule (Sese Fence)	1981/1982	Runs from Tlalamabele gate southeast to Serule and then continues southeast via Sefhophe to Zanzibar.	1989 Landsat 5 MSS 1:250 000 Phikwe-Serule section Environ-mental Consultants overflight mapping onto Department of Surveys and Lands 1:50 000 map series



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Botswana

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Botswana

PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: VETERINARY CORDON FENCES

MAP NO: 7.4

Wildlife Management Areas/Game Reserves

The north west corner of the Boteti State Lands has been made into a game reserve (Makgadikgadi Pans Game Reserve, area 2 742 km², source: GIS). The game reserve is threatened by encroachment of arable farming, hunting, cattle and grass and fuel wood harvesting. Some molapo fields are within the game reserve. There are problems of poaching near Khumaga and Tsienyane. The people living in the villages along the Boteti suffer from wild animals attacking themselves, their livestock and their crops.

Some of the remainder of the Boteti State Lands are controlled hunting areas (described in the wildlife Section 3.1.2).

There are two proposed wildlife management areas in the District; one for an area around the Makgadikgadi Pans Game Reserve within the Boteti State Lands and one occupying most of the Nata State Lands. The former would have a de jure area of approximately 5 860 km². The latter would be 10 440 km² in size. However the recent construction of the Nata State Land Cordon Fence has reduced this to a de facto area of 8 786 km² (source: DOL Serowe). See the Wildlife section (Section 3.1.2) a for further details.

Other wildlife related land uses are in the Tuli Block. Especially in the northern Tuli Block where there are fewer fences, wildlife farming and wildlife reserves with associated tourist safaris and commercial hunting are found.

The main game reserves are Mashatu Game Reserve and Stevensford Game Ranch (east of Sherwood). North of Sherwood there are a crocodile farm and an ostrich farm. At the end of the 1990 dry season, several farmers raised the height of their perimeter fences to trap game inside their ranches (mainly impala). The game is exploited, but due to market constraints the main activity of these farmers remains cattle farming. Within the game reserves, impala, kudu, elephant and zebra are found.

Hunting and gathering

Wild fruits and other foods and firewood are gathered all over the District. Close to villages, fuelwood is commonly in short supply due to over-exploitation.

Thatching grass is gathered in several parts of the District (in particular, south of Mahalapye and in the Nata area). This land use sometimes conflicts with other land uses such as grazing, especially in times of drought. Grass for stock feeding is cut in Ramatamusa and Ntwetwe Pans.

- Falconbridge (Copper/nickel ore)
- Francistown Clay Brick (Brick Clay)
- Gem (Pty) Ltd (Marble)
- Makoro Brick and Tile (Clay)
- Touch of Class (Salt)

Reliability and Gaps in Data

Information was found on land use throughout the District, at varying levels of detail. There is no data to differentiate between the genuine communal grazing areas which are utilised by poor rural people with a few cattle and smallstock (usually located close to villages) and the large cattle owners who have access to their own boreholes in the communal areas. These two types of land use should be regarded as separate activities for land use planning purposes.

Information on the exact size and location of some of the leased areas within the Tribal Land area proved to be difficult to locate. It must therefore be remembered when talking of areas and percentages of land in various uses that some small inaccuracies are inevitably included in the figures due to the differing quality of different sources of information. Checking of the exact areas which have been fenced in the field will be needed to accurately locate some of these areas.

habitation and are, at current levels of technology and productivity, inherent to the type of land use. The total areas of both categories are as follows:

Code	Type	Area (km^2)	% of District
0	no noticeable land degradation	98 019	66.9
1	degradation primarily by cattle	27 366	18.7
2	degradation threatening to existing land use	21 147	14.4
Total		146 532	100

Discussion

The effects of various forms of land use on the vegetation have been described in the vegetation chapter. Cultivation and its relation to erosion potential are important factors in the progressive degradation of land. This is particularly true in those areas where water erosion potential is high. Soil is a precious commodity in arid environments where soil forming processes are slow and rainfall tends to be intense. Though some degradation seems to be unavoidable, it should remain a point of concern and attention, because degraded arable land can only be replaced by encroachment into other land uses thereby compounding the overall pressure on the environment.

Reliability

The limitations of this map relate directly to the lack of field verification. It is important that some follow-up work is carried out to verify and refine this interpretation. A systematic field survey using the Landsat imagery and the Degraded Areas map could be used to quantify the qualitative ranking used here. This would be an important step in establishing baseline data against which future change can be measured.

7.4 ENVIRONMENTAL POLLUTION

This section describes the known pollution sources in Central District and general activities which can cause pollution.

Methodology

Water and air pollution are the only forms of pollution that are partially documented and readily accessible.

Data on water pollution was abstracted from a recent report (WLPU 1990) and that on air pollution was obtained from the Mines Department's annual Air Pollution Control Reports.

Presentation

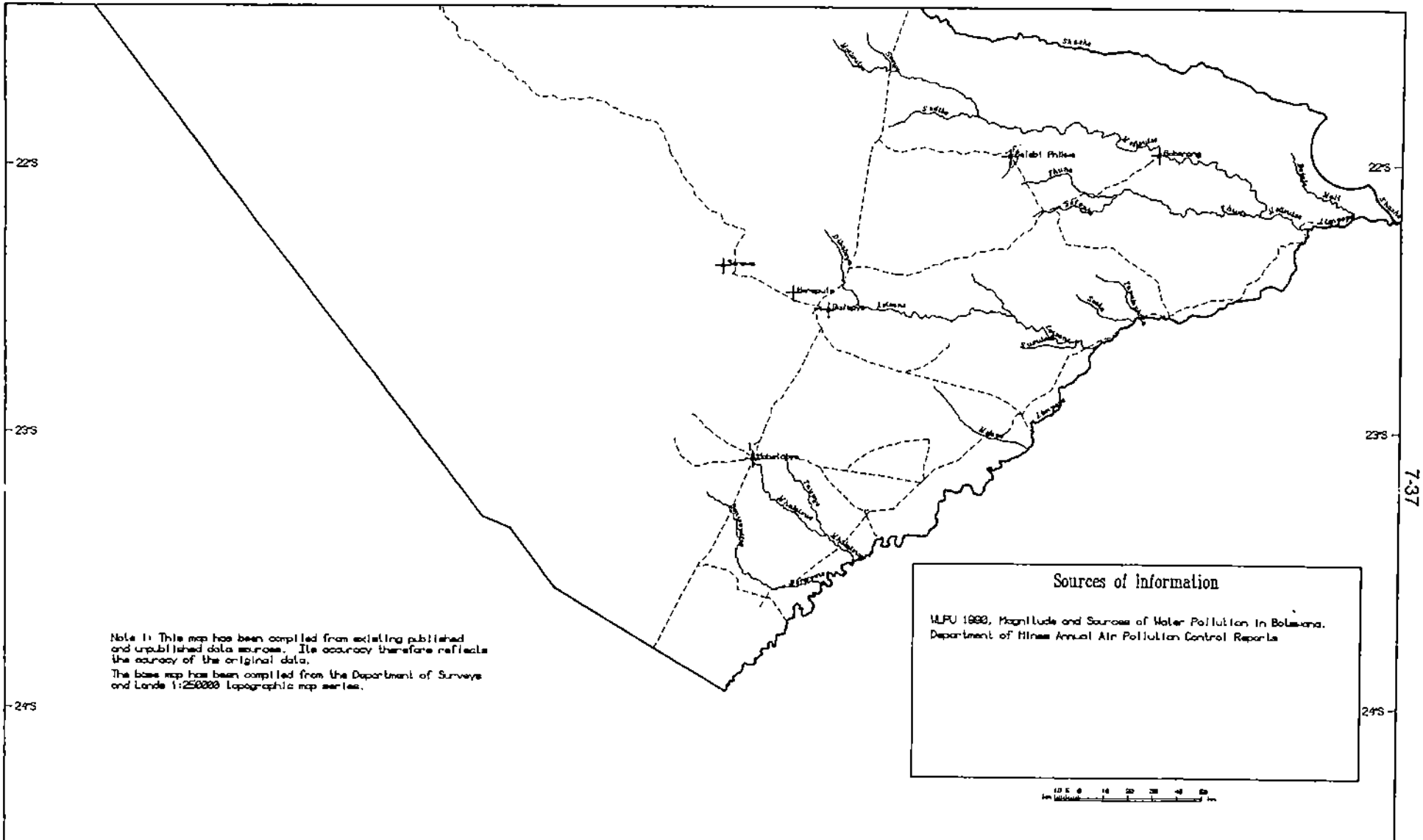
The map showing Localities with Pollution risk is presented on Map Number 7.5.

Description

Water Pollution

The WLPU study was essentially a pilot study to assess the magnitude and sources of pollution of surface water. This resulted in the establishment of a very large computerised data base at DWA. This data base is being continually updated and expanded. The pollution identified in the study may also affect groundwater resources where there is the opportunity for direct or indirect infiltration to aquifers.

Twenty one potential sources of pollution were investigated in WLPU's pilot study. The study was restricted to the major villages and Orapa. The main pollutants were found to be sewage ponds at institutions such as schools, hospitals and prisons. Their findings are contained in Table 7.8, but it should be noted that remedial work may have commenced since the issue of the WLPU report. Further information on these and other sources should be sought from the Senior Engineer (Pollution) at DWA.



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: LOCALITIES WITH POLLUTION RISK

MAP NO: 7.5

As air pollution fluctuates rapidly with time, the Mines Department should be referred to for the most recent information.

Discussion

Water Pollution

There are many possible sources of pollution. Table 7.9 summarises the categories and investigations required from the WLPU report.

However, there are other sources such as improperly designed and/or operated pit latrines and septic tanks, the use of fertilizers in agriculture and large concentrations of cattle at boreholes causing nitrate pollution of the aquifer where the boreholes are not properly constructed and sealed. Aquifers where the watertable is shallow or the overlying soils are very permeable are particularly prone to pollution. Sand river beds fall into this category.

Licensed industries are classified by the Ministry of Commerce and Industry using the Botswana Industrial Classification System, which has been recently modified to take into account potential water pollution and monitoring requirements. The District Authorities should use this information in assessing potential and actual industrial pollution sources.

Air Pollution

Care must be taken in the planning phase of industrial developments to ensure that industries with potential air pollution problems are adequately equipped with pollution abatement facilities, and are sited so that they do not pose an air quality hazard to the surrounding areas.

Reliability

The data presented is considered reliable but only represents a very small proportion of the total number of pollution sources. Further surveys and monitoring is being undertaken by DWA and Department of Mines where required.

TABLE 7.9 (Contd.)

Cat. No.	Category	Investigation required
3.3	Transport & Communication	Oil and fuel storage Spillage Transport of hazardous chemicals
3.4	Transport Repair, Maintenance & Disposal	Spillage and storage facilities for oils and fuels. Also waste oil residues after repairs Battery acid and lead Tyres burned
3.5	Fuel Storage & Distribution	Regulations for storage and transport
3.6	Others	Liquid gas storage
4.1	Livestock	Disposal of chemicals Dips (e.g. dip pits) Intensive poultry or farming
4.2	Arable	Insecticides, herbicides, rodenticides (See Chemist)
4.3	Forestry	As 1.8
4.4	Fisheries	As 1.1 Disposal of rotten and condemned food
4.5	Others	Game Reserves
5.1	Municipalities	Sewage ponds improperly run? Solid waste dumps Abattoirs Roads construction. See 3.2 Pit latrine emptying services
5.2	District Councils	As in 5.1
6.1	Hospitals	Disposal of hospital wastes Any incinerator? If waste is burned where are residues dumped?
	Prisons	Various activities See 1.1, 2.2, 3.2
6.2	Defence	Safe storage of live ammunition and other weapon materials Waste ammunition disposal sites Fuel storage and garage maintenance

Source: WLPU (1990)

8 TRANSPORT

Introduction

This section deals with transport in Central District including roads, public transport, railways, airports and airstrips.

1. ROADS

Methodology

Information has been obtained from officers in:-

Central District Council, Serowe
Department of Surveys and Lands, Ministry of Local Government, Lands and Housing
District Administration, Serowe
Roads Department, Ministry of Works, Transport and Communications.

Roads have been identified on or marked onto the 1:250 000 District Topographic map sheets. Where a road was shown on the 1:250 000 Topographic maps this was used as the starting point. Where possible routes were checked from the Landsat Imagery. In some cases, aerial photography had to be used to find alignments. However, many of the ungazetted earth roads have been built or upgraded under labour intensive or drought relief programmes relatively recently, and some of these roads could not be located. In a few cases, two alternative alignments have been shown as the 'main' route could not be identified.

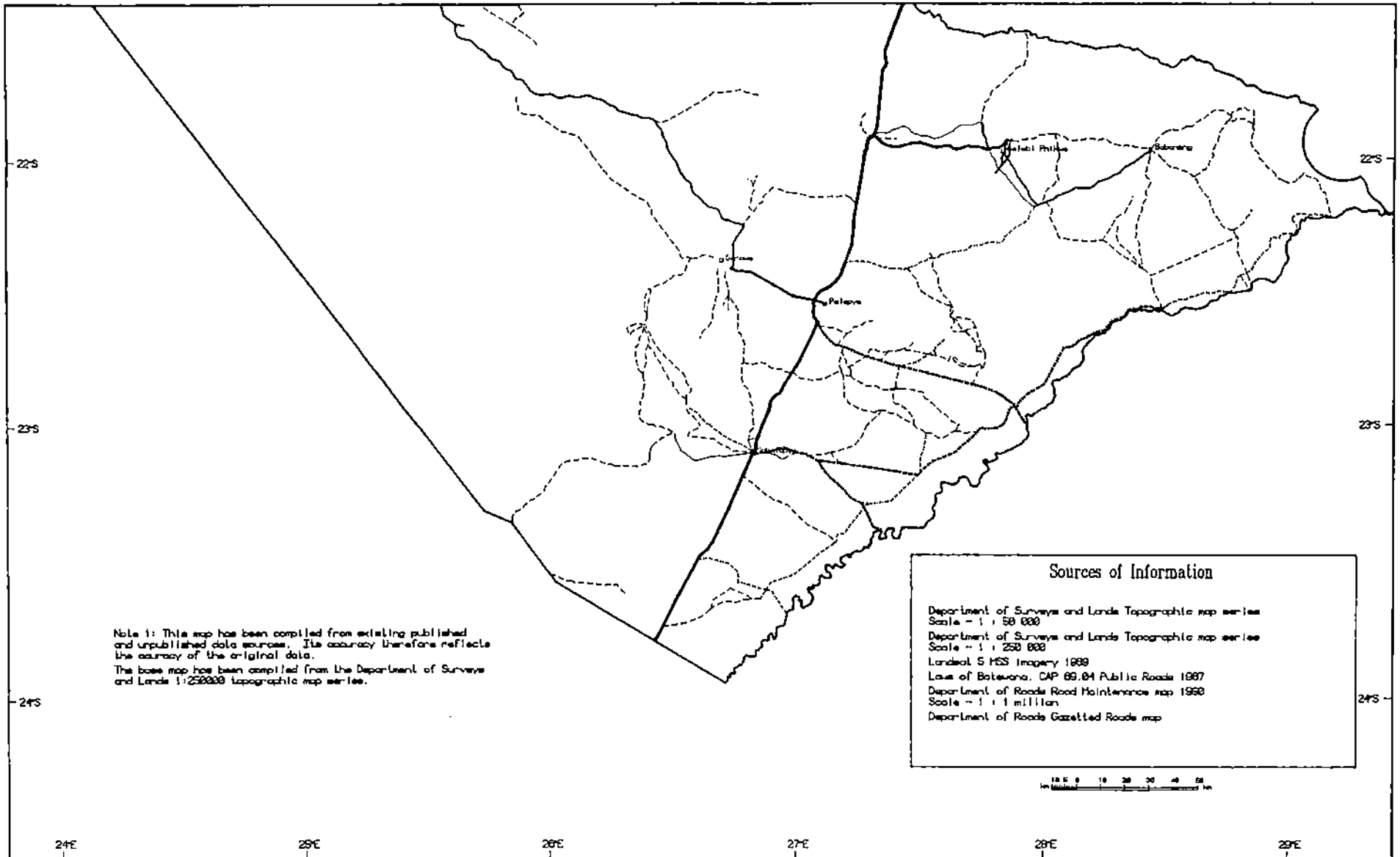
Gazetted and ungazetted roads have been identified using codes for tar, gravel and earth. It has been attempted to map all the ungazetted roads and tracks which are considered by the Central District Council to warrant periodic upgrading or maintenance. Lists were provided by the Council Works Services Department.

Presentation

The Roads Network map is presented on Map Number 8.1.

TABLE 8.2 MAPPED UNGAZETTED ROADS

Road	Road Standard	
Bobonong - Mathathane - Tuli Block	Earth	
Kgagodi - Lerala - Sherwood	Earth	
Paje-Mabeleapudi Tshimoyapula-Topisi	Earth	LI
Maun junction-Marapong-Semitwe (last part not located)	Earth	
Mahalapye - Mmutlane	Earth	
Pilikwe - Radisele	Earth	
Shoshong - Kodibeleng	Earth	
Maun/Francistown - Lepashe (route not clear)	Earth	
Sefhophe - Zanzibar	Earth	
Francistown - Orapa	Part Bitumen/part gravel	
Mabolwe - Kobojango	Earth	
Mabolwe - Semolale	Earth	
Lerala - Majwaneng	Earth	BC
Sepako - Sematlaphiri (not located)	Earth	
Nata - Sepako	Earth	
Sepako - Nata River	Earth	
Kgagodi - Matelwane (not located)	Earth	
Kgagodi - Diloro	Earth	
Matelwane - Tamasane (not located)	Earth	
Palapye/Sherwood - Mhalapitsa	Earth	
Ramokgonami - Palapye/Sherwood	Earth	
Mookane - Dibete	Earth	
Pilikwe - Moshopa	Earth	
Sefhare - Chadibe	Earth	
Moshopa - Sefhare	Earth	BC/LI
Radisele - Mokgware	Earth	
Francistown/Orapa junction - Matsitama	Earth	
Pilikwe-Mokobeng	Earth	BC/LI
Bobonong - Tsetsejwe	Earth	LI
Orapa/Francistown junction - Mmatshumo	Earth	LI
Serowe - Shoshong	Earth	LI
Sebina - Marobela (not located)	Earth	LI
Sebina - Kalakamati	Earth	
Sebina - Nswazi	Earth	
Francistown/Nata-Sowa Township	Bitumen	
Bobonong - Kobojango - Semolale	Earth (Spot improvement)	
Kgagodi - Palapye	Earth	
Serowe - Moiyabana	Earth	
Bobonong - Lepokole (not located)	Earth	
Bobonong - Mashambe (not located)	Earth	
Chadibe - Mokobeng	Earth	
Moshopa - Shakwe	Earth	BC
Kalamare - Mmutlane (not located)	Earth	
Mahalapye - Tautswe	Earth	BC
Palapye - Lecheng	Earth	
Tobane - Sefhophe	Earth	BC/LI
Mopipi - Xhoma junction - Toromoja	Earth	
Toromoja - Rakops	Earth	
Mmatshumo - Mosu - Ntanegate	Earth	LI
Nkange - Changate	Earth	BC/LI
Goshwe - Matobo (not located)	Earth	
Kodibeleng - Otse	Earth	BC
Otse - Mokgware	Earth	
Mmadinare - Polometse	Earth	BC
Moiyabana - Kalamare	Earth	LI
Lecheng - Malaka	Earth	LI
Mahalapye - Kudumatse	Earth	LI
Tutume - Goshwe (not located)	Earth	
Tutume - Mosetse	Earth	LI
Borolong - Mathangwane	Earth	LI
Phikwe - Tobane	Earth	LI
Lepokole - Tshokwe (not located)	Earth	BC
Serowe - Kutswe (needs checking)	Earth	LI
Serowe - Mogatsapoo (needs checking)	Earth	LI
Mokobeng - Sefhare	Earth	LI
Goo-Tau - Mmanaledi	Earth	BC
Mmadipudi - Mmashoro (not located)	Earth	BC
Mabeleapudi - Majwanaadipitse	Earth	BC
Lecheng - Martin's Drift Road	Earth	BC
Ratholo - Majwaneng	Earth	BC



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been the 1:250 000 topographic map sheets, supplemented by use of landsat images and in a few cases, aerial photography and 1:50 000 topographic sheets.

Gazetted roads are maintained by the Department of Roads (DOR), MWTC, while all other roads are the responsibility of the District Council. However, discussions with DOR Officers indicated that the distinction between gazetted and ungazetted roads has become blurred. Some ungazetted roads have been built and/or are being maintained by the DOR, whilst the Department is not maintaining all of the gazetted roads.

Furthermore, some roads have been realigned and tarred, but the old alignments are still legally gazetted, whilst the new ones are not. The DOR are currently (1991) looking into the whole question of "gazetted" roads. A consultancy began late in 1991 with the aim of identifying a 'national' road network and 'local' roads.

One gazetted road, the "Mosveng-Sefhare-Machaneng Loop" has proved impossible to locate. It is described in the legislation, but it is not a road which the DOR maintains today, and it could not be located on 1:250 000 Landsat Imagery, aerial photography or old editions of 1:50 000 topographic map sheets.

The Serowe-Orapa road alignment has been taken from the satellite imagery. Department of Surveys and Lands are (1991) working on incorporating the new alignment onto their 1:50 000 map series, but it will be some time before they incorporate the new alignment into their 1:250 000 topographic maps. Once this is done minor revisions of this road alignment may be necessary.

Serule-Selebi Phikwe - The road from Serule via Mmadinare to Sefhophe is still legally gazetted, and the new one via Selebi Phikwe, with the branch to Mmadinare is not. The old road is no longer maintained by DOR, but it is indicated on our map, together with the new tarred road, via Selebi Phikwe.

Mopipi-Rakops - DOR Officials indicated a lack of detailed design for the alignment of this road when it was tarred. The alignment of the tarred road has therefore been mapped from the Landsat images where possible, but District and DOR officers were also consulted. The actual gazetted road is the road to the South of Lake Xau via Kedia. This is also shown on the roads map. Central District Council does some maintenance work on the section between Kedia and Xhumo.

Rakops-Makalamabedi - The description in the gazettement notice is very vague, but it appears to follow the route of a track which is shown on the 1:250 000 sheets, going north west from Rakops to the cordon fence which forms the District Boundary, and thence north along the fence for 21km to Makalamabedi. District Officers did indicate that this route is used by some travellers, but it is not maintained by the DOR DSL 1:1 000 000 maps show the 'main road' as going north from Rakops along Boteti river, and then following the river around to the west. This road is also not maintained by the DOR. Central District Council

Access to the Tuli Block area will be improved dramatically once the new Sefhophe - Martin's Drift and Bobonong - Mathathane - Lekkerpoet roads have been constructed. This is part of Government's strategy to encourage increased agricultural production in the Tuli Block and improve marketing channels between that area and the rest of Botswana. The economic diversification of Selebi Phikwe will also be facilitated. Access from the rest of the District has previously been better to South Africa and Zimbabwe than to the rest of Botswana.

8.2 PUBLIC TRANSPORT

Methodology

Information was obtained from officers in the Transport Division of the MWTC.

Description/Discussion

The main hubs of public transport in Central District are Mahalapye, Palapye and Selebi Phikwe. There are also routes with their origins and/or destinations outside Central District which serve settlements within the District.

The following statistics (Tables 8.3 - 8.5) are taken from the 1989 Transport Statistics (Transport Statistics Unit, MWTC, 1991, Transport Statistics 1989, CSO. Gaborone).

TABLE 8.3 VEHICLES WITH 'D' (PUBLIC TRANSPORT) PERMITS BY BASE OF OPERATION

Location	Number of Taxis	Number of Minibuses/Buses
Serowe	6	7
Palapye	2	12
Mahalapye	1	19
Tutume	-	7
Selebe Phikwe	105	52
Central District (elsewhere)	-	85

Note: (A 'D' permit entitles the holder to use the authorised vehicle(s) for the carriage of goods and passengers for hire and reward and own account.

Other routes which are served by public transport are given in Table 8.7 below.

TABLE 8.7 FREQUENCY OF SERVICE ON ADDITIONAL PUBLIC TRANSPORT ROUTES

Route	Frequency
Selebi Phikwe-Bobonong-Semolale	Several per day
Selebi-Phikwe Sefhophe-Tsetsejwe-Mathathane (subsidised)	Several per day
Selebi-Phikwe-Kgagodi-Maunatlala	Several per day
Francistown-Maun via Nata	+/- one per day
Francistown-Kasane via Nata	+/- one per day
Francistown-Tonota	Daily
Francistown-Tutume-Maitengwe	Daily
Dibete-Mookane	Permit issued
Serowe-Letlhakane-Rakops-Makalamabedi	Once a week-bus as far Rakops, then truck; subsidised service.
Mahalapye-Shoshong	No service in mid-1991 due to poor road
Mahalapye-Kalamare	One truck daily
Palapye-Lerala	Once a day
Palapye-Kobojango-Semolale-Merry Hill	Once a week
Francistown-Orapa	No service in mid-1991 due to poor road
Palapye-Martins Drift	No transport

Source: Personal communication; Ministry of Works, Transport and Communications.

Public transport is provided by private operators, although in a few cases Government provides subsidies to encourage the provision of services on routes which would otherwise be uneconomical to serve due to poor roads and/or low passenger volumes.

It is clear that poor roads are a major deterrent to operators. Villages away from the tarred roads are not well served by public transport. Low passenger volumes would also make it uneconomical to provide services to much of the west and north of the district.

Reliability and Gaps in Data

The reliability of information is considered to be fair. Although some timetables were available, MWTC were not sure whether they were operating on schedule.

Up-to-date information relating to public transport is not readily available. The Transport Statistics Unit, MWTC compiles figures on public transport permits issued at district and national levels, but not for each route within the district. In any case, the fact that a permit has been issued does not indicate that a service is actually being provided. In some cases, permit holders have pre-empted routes: they do not provide services and are waiting for the roads to be tarred before they begin.

8.4 AIRFIELDS AND AIRSTRIPS

Methodology

Airports, licensed airfields and registered airfields have been entered into a data base. Information has been obtained from Department of Civil Aviation, MWTC.

Presentation

Airports and airfields are presented on the Rail and Air Transport map (Map Number 8.2).

Description

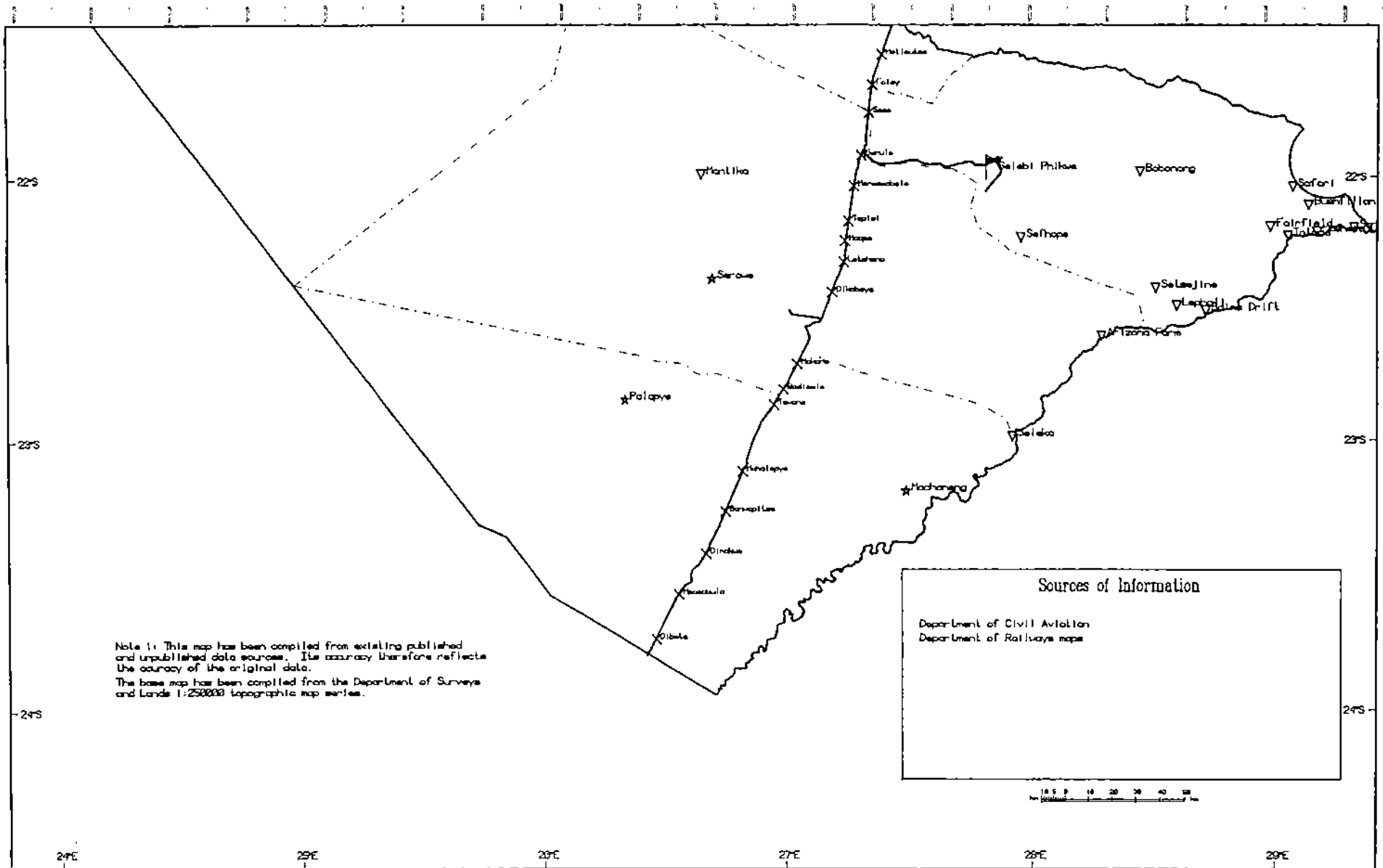
Table 8.8 below shows airports and airfields.

TABLE 8.8 AIRPORTS AND AIRFIELDS

Main Govt. Airport	Secondary Govt. Airport	Private Licenced Airport	Private Registered Airport
Selebi Phikwe	Gweta	Matsitama	Arizona Farm
	Machaneng	Orapa	Baines Drift
	Makalamabedi	Sowa	Bobonong
	Mosetse	Tuli Lodge	Bushfillan
	Nata		Fairfield
	Palapye		Jarwe
	Rakops		Kamkauga
	Serowe		Kaukai
			Lephali
			Mantika
			Mashatu
			Nata River Delta
			Ngami Cordon Fence
			Safari
			Santata
			Sefophe
			Seleka
			Setsejine
			Shashe
			Talana
			Tsigara
			Tsoi
			Tutume
			Whyle

As a main government airport, Selebi Phikwe has the following facilities:- perimeter fencing, a fire service, customs and immigration, a bitumen runway, airport runway lights, identification beacons, a control tower and meteorological facilities.

Secondary government airfields have an attendant. All airfields have a windsock.



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9 COMMUNICATIONS

Introduction

This section covers Electrical Power, Telecommunications, Radio and Postal Services in Central District.

9.1 ELECTRICAL POWER

Methodology

Electric power lines have been digitised from maps provided by Botswana Power Corporation at a scale of 1:250 000.

Presentation

The Communications/Power map is presented on Map Number 9.1.

Description/Discussion

Botswana's main power station is located in Central District, at Morupule, close to the coalfields which fuel it. There is also a power station in Selebi Phikwe (a 65 MW coal fired station). Both power stations are tied to the national grid system. Power generation is according to system load demands and is under control of the National Control Centre. Morupule power station is larger and cost of generation is less than at Selebi Phikwe. Consequently, to minimise cost, the bulk of the country's generation requirement is supplied from Morupule.

There are overhead lines (220kv) from Morupule Power Station to Gaborone, Selebi Phikwe and Francistown. There is also a 220kv line from Selebi Phikwe to Orapa. A 132kv line links Sowa to Francistown.

There are 66kv lines from Morupule to Sherwood, from Selebi Phikwe via Sefhophe to the Tuli Block Backline between Zanzibar and Goedgeluk farms, and from Selebi Phikwe to Shashe.

There are 33kv lines from Morupule to Serowe, from Sefhophe to Bobonong, from Sherwood to Martin's Drift, between Sherwood and Talana Farms, and from Morupule to Mahalapye and south to Dinokwe wellfield supplying water to Mahalapye.

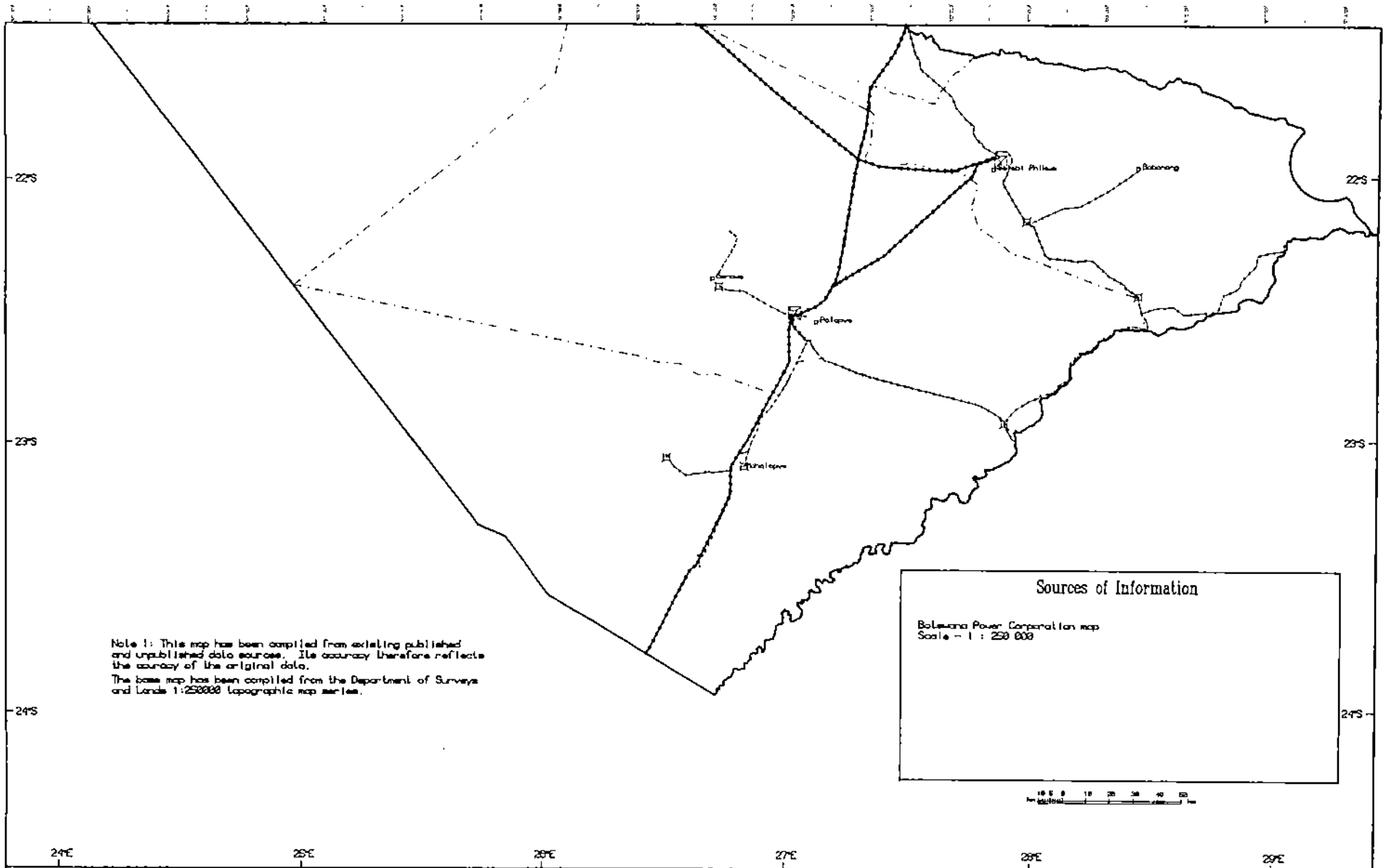

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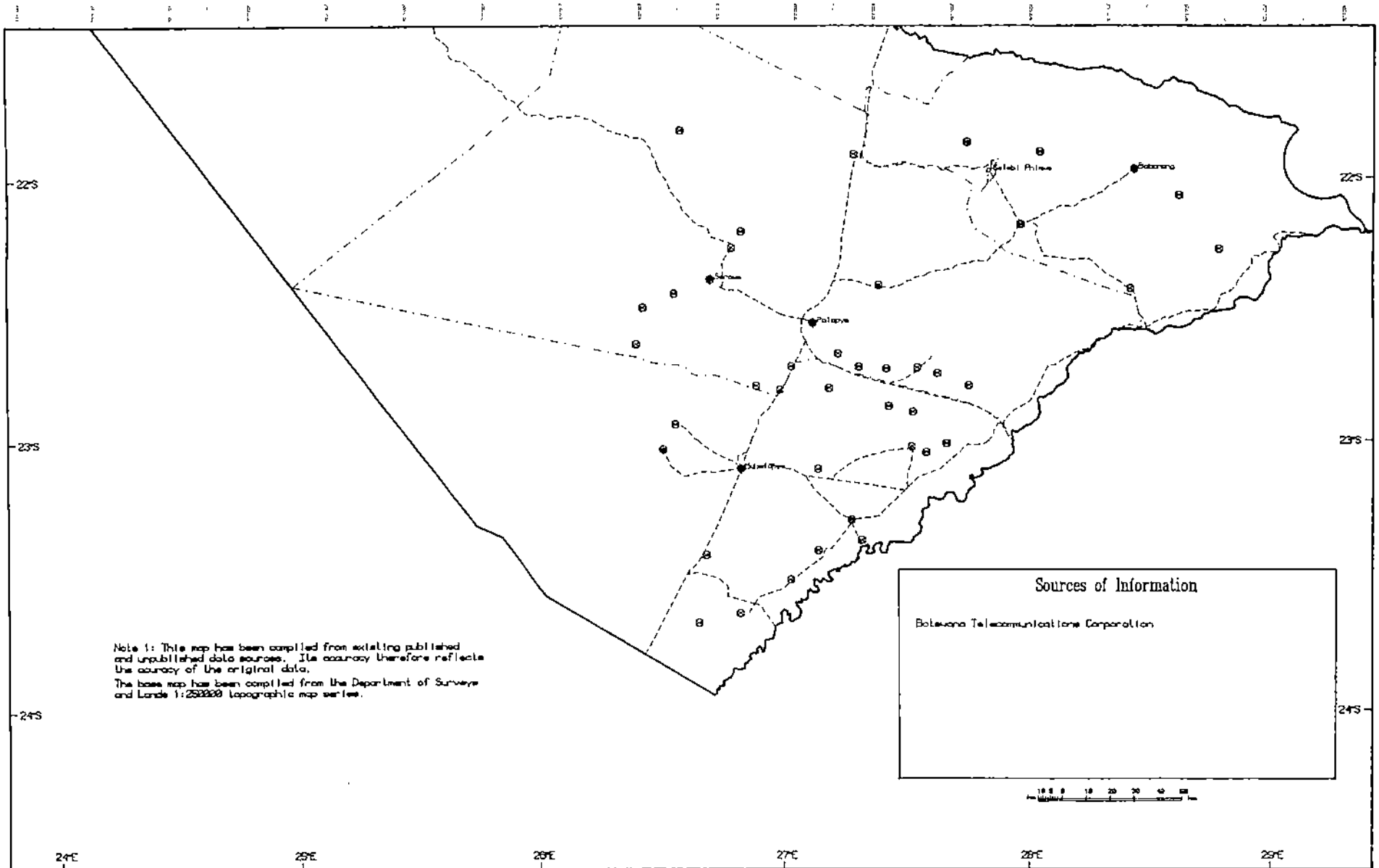
TABLE 9.1 LOCATIONS OF TELEPHONE EXCHANGES

Location	Location
Bobonong	Serowe
Mahalapye	Shoshong
Mmadinare	Tonota
Palapye	Tutume
Selebi Phikwe	

TABLE 9.2 LOCATION OF MICROWAVE TRANSMISSION TOWERS

Location			Location		
Baines Drift			Paje		
Bobonong			Palapye		
Bonwapitse			Palla Road		
Chadibe			Parr's Halt		
Dinokwe Repeater			Pilikwe		
Dovedale Village			Ponts Drift		
Dovedale Farms			Radisele		
Gootau			Ramokgonami		
Gweta			Ratholo		
Kalamare			Repeater 1B	19° 49' 46" S	26° 07' 25" E
Kudumatse			Repeater 2B	19° 29' 08" S	25° 56' 24" E
Lecheng			Repeater 3B	19° 09' 24" S	25° 45' 58" E
Lerala			Repeater 4B	18° 50' 04" S	25° 37' 08" E
Mabeleapudi			Repeater 5B	18° 16' 28" S	25° 15' 19" E
Magapatona			Repeater 6B	18° 00' 04" S	25° 15' 19" E
Mahalapye			Repeater 1A	20° 09' 46" S	25° 52' 31" E
Majwaneng			Repeater 2A	20° 07' 46" S	25° 35' 43" E
Makoro Repeater			Repeater 3A	20° 13' 43" S	24° 55' 10" E
Makoro Village			Repeater 4A	20° 13' 43" S	24° 32' 03" E
Makwati Hill			Repeater 5A	20° 09' 54" S	23° 44' 08" E
Makwati Village			Sebina		
Maope			Sebina		
Mapashalela			Sefhare		
Mathakola			Sefhophe		
Mathambgane			Selebi Phikwe		
Mathathane Repeater			Seleka		
Mmadinare			Serowe Hill		
Mmamabula			Serule		
Mogapi			Serule Repeater		
Mogome			Shakwe		
Mogorosi			Shashe Bridge		
Moiyabana			Shashe Dam		
Mokobeng			Sowa Pan		
Molalatau Repeater			Tamasane		
Mookane			Thune Repeater		
Mosetse			Tlhabala		
Motloutse			Tobane		
Nata			Tonota		
Nshakozhokwe			Tsetsetjwe		
Orapa 1	21° 05' 36" S	26° 58' 41" E	Tutume		
Orapa 2	21° 09' 16" S	26° 37' 24" E	Zanzibar 1		
Orapa 3	21° 16' 46" S	26° 19' 16" E	Zanzibar 2		
Orapa 4	21° 19' 37" S	25° 57' 07" E			
Orapa 5	21° 19' 16" S	25° 38' 39" E			



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: TELECOMMUNICATIONS

MAP NO: 92

9.3 RADIO

Methodology

Information has been entered into a data base relating to villages in which facilities are located. Information was provided by Department of Information and Broadcasting.

Description/Discussion

The location of Radio Botswana transmitters is shown in Table 9.4 below.

TABLE 9.4 LOCATION AND BROADCAST FREQUENCY OF RADIO BOTSWANA TRANSMITTERS

TRANSMITTER	BROADCAST FREQUENCY
Mahalapye	96.6 MHz FM
Mopipi	648 kHz MW
Selebi Phikwe	621 kHz MW
Serowe Hill	99.4 MHz FM

Radio Botswana broadcasts are a useful means of providing information to the people, especially to those who cannot read or to whom other forms of communication are not readily available.

Reliability

Information is considered to be reliable.

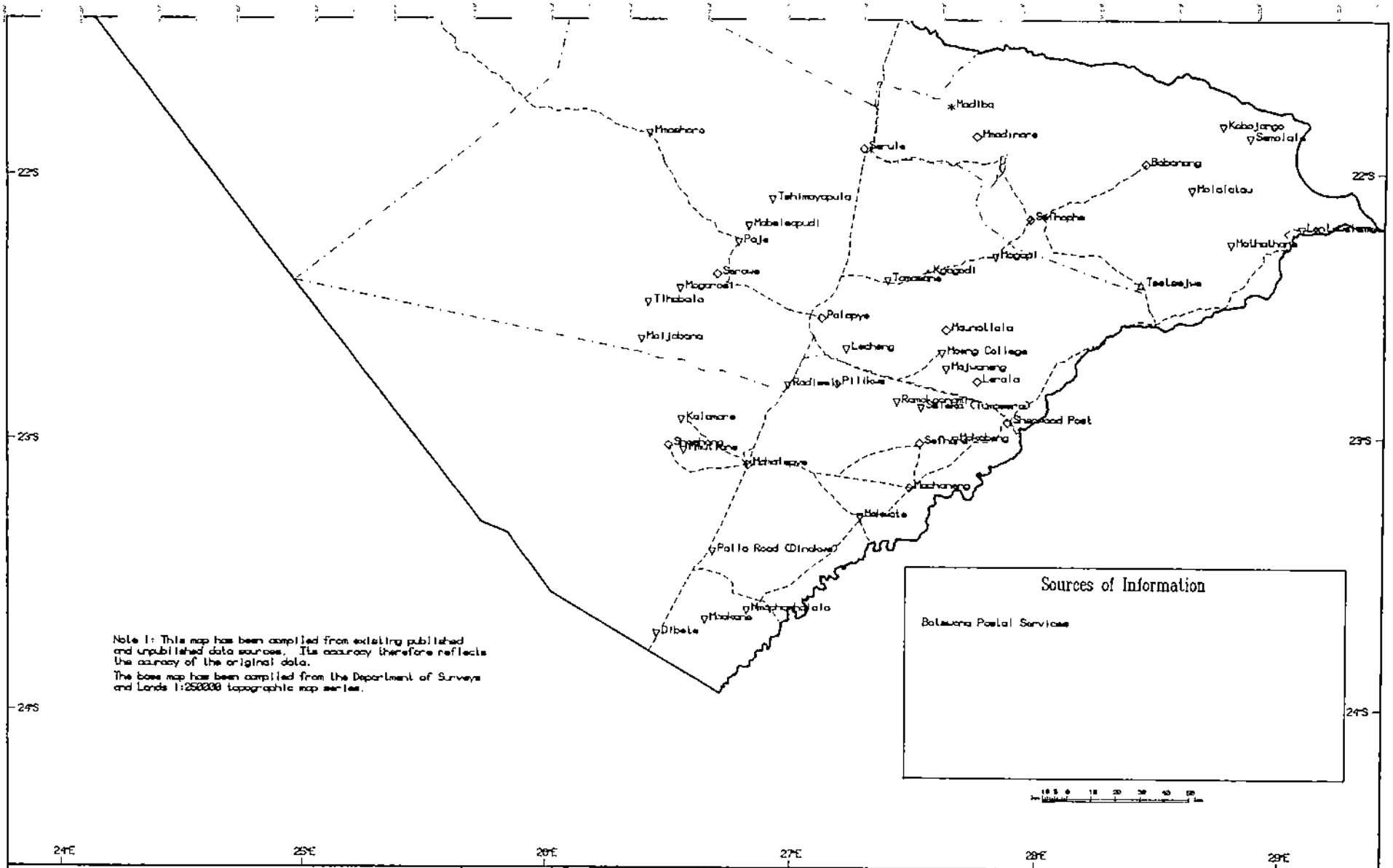
9.4 POSTAL SERVICES

Methodology

Information has been entered into a data base relating to different villages. Information was provided by Botswana Postal Services.

Presentation

The Communications-Postal Services map is presented on Map Number 9.3.



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: COMMUNICATIONS – POSTAL

MAP NO: 9.3

Most parts of the district do have provision for some degree of postal service, although many villages have only a limited range of services. Many villages have post offices only offering basic postal services and money order facilities (ie. savings bank services are not available).

Reliability

The information was considered to be reliable at the time of writing (mid-1991).

10. ADMINISTRATION BOUNDARIES

Introduction

The following describes the administration boundaries and facilities provided by various parastatal institutions, Ministries and their Departments in Central District. They were specified in the Terms of Reference but a few additional ones were added during the study at the request of the Steering Group.

Methodology

Letters were sent to all relevant institutions and follow up calls made to confirm information collected. Where appropriate, the data obtained has been entered into data bases. Where possible, the locations of facilities have been tied to the Census data base which provides digitised locations of almost all settlements in the District. However a match could not always be made and, in these cases the name remains in the data base with a distinguishing code (9999999).

The institutions which have a large number of facilities in the District are Education, Health and Agriculture. Some problems were encountered in tieing the place names to our set of digitised points.

A substantial effort has been made to correct and properly map administrative boundaries but often officials only have a vague idea of where their administrative boundaries lie. However, in these cases and wherever possible, we have mapped our best estimate of the relevant boundary.

Where administrative boundaries used existing boundaries i.e. District, Sub-district, veterinary cordon fences etc, the appropriate line was taken from that particular coverage. Elsewhere it was digitised from a hard copy map. A number of institutions have not formalised or demarcated their administrative boundaries and it is anticipated that the local population will seek the relevant services from the most convenient facility.

Some ministries (see Ministry of Education) have computerised data bases which often indicates additional information. We have not tried to duplicate these data bases as this is beyond the scope of the study.

dBase III was chosen as the data management software not only because of its compatibility with ARCInfo but because it is widely used and relatively easy to use and manipulate data.

The Census data contained digitised location for over 2300 points. Unlike the GRAS coding system our codes do not indicate settlement hierarchy but refer to the Sub-district, enumeration area and have a numerically ordered last digit.

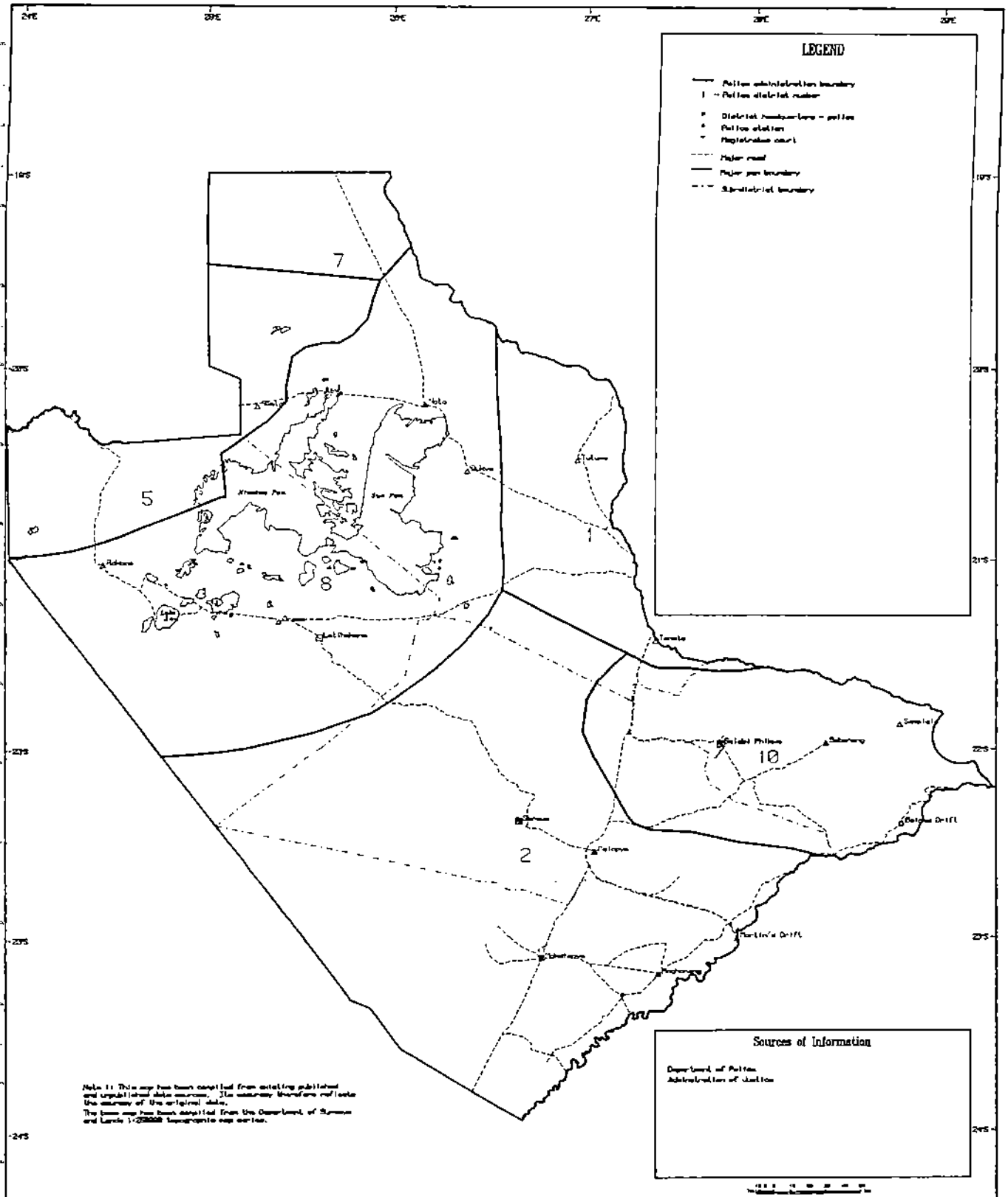
Recommendation

With the advent of the cheap and reliable GPS (global positioning system) continual verification, update and demarcation is possible to a very accurate level. It is strongly recommended that this is done.

As only existing facilities at the time of data entry were included, discrepancies will increase over time if the data bases are not checked and updated regularly.

Selebi Phikwe and Sowa and to a lesser degree Orapa (because of the closed nature) are significant in that they are in the District but not part of it. They do provide a significant number of services and should have their role formalised.

POLICE AND JUSTICE



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: POLICE AND JUSTICE

MAP NO: 10.1

The magistrates in Serowe and Mahalapye visit Letlhakane and Machaneng respectively on a monthly basis and sometimes the magistrate from Palapye sits in Serowe.

Cases come before the magistrates from the Police District in which they preside.

All the magistrates are under the control of the High Court in Lobatse.

Administration Boundaries

Administration boundaries follow the Police District boundaries.

Presentation

The location of Magistrates have been mapped together with the Police (see Map Number 10.1).

10.2.2 Department of Crop Production and Forestry

The responsibility for Central District is shared by two Regional Agricultural Officers in Francistown and in Serowe. Mahalapye serves as a sub-region for Serowe. The specialist staff is based at the sub-regional offices. The Agricultural Demonstrators are grouped into agricultural districts which are headed by a District Agricultural Officer who is assisted by one or two District Agricultural Supervisors.

The country is divided into 6 Agricultural Regions, each Region is divided into districts and the districts are in turn divided into extension areas each one staffed by an Agricultural Demonstrator.

Central District is covered by 2 Agricultural Regions - Central and Francistown.

Agricultural Region	Agricultural District
Francistown	
RAO based in Francistown	Tutume
Central	
RAO based in Serowe	Serowe
	Palapye
	Boteti
	Mahalapye
	Machaneng
	Bobonong
	Selebi Phikwe

The Selebi Phikwe Agricultural District has been very recently demarcated and incorporates parts of Serowe and Bobonong Agricultural Districts.

There is one Rural Training Centre in the District located at Mahalapye.

Agricultural Demonstrators.

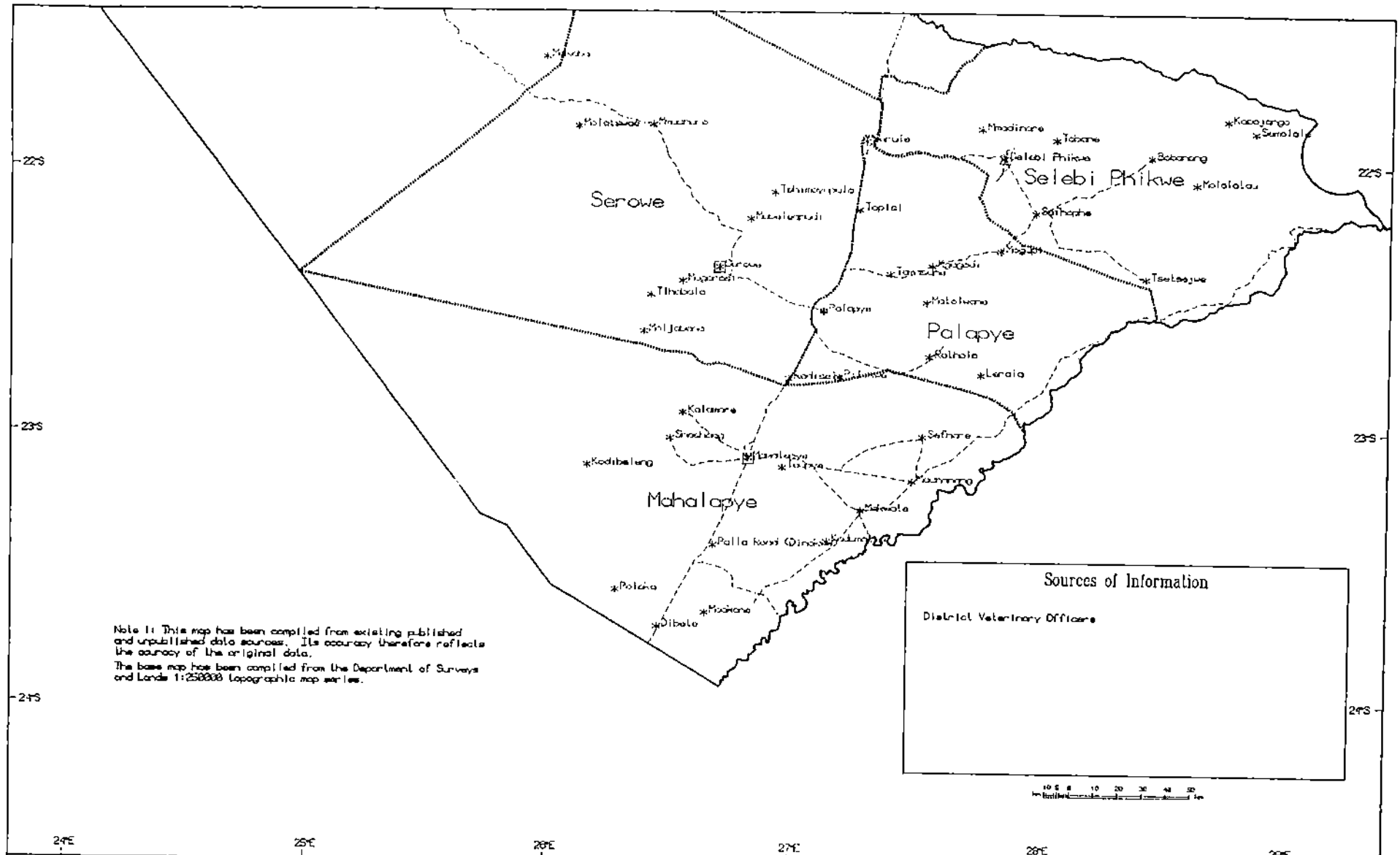
Appendix 10.1 lists the location of the Agricultural Demonstrators.

Administration Boundaries

Administration boundaries do not follow District or Sub-district boundaries.

Presentation

The location of administrative boundaries and officers are presented on Map Numbers 10.2 and 10.3.



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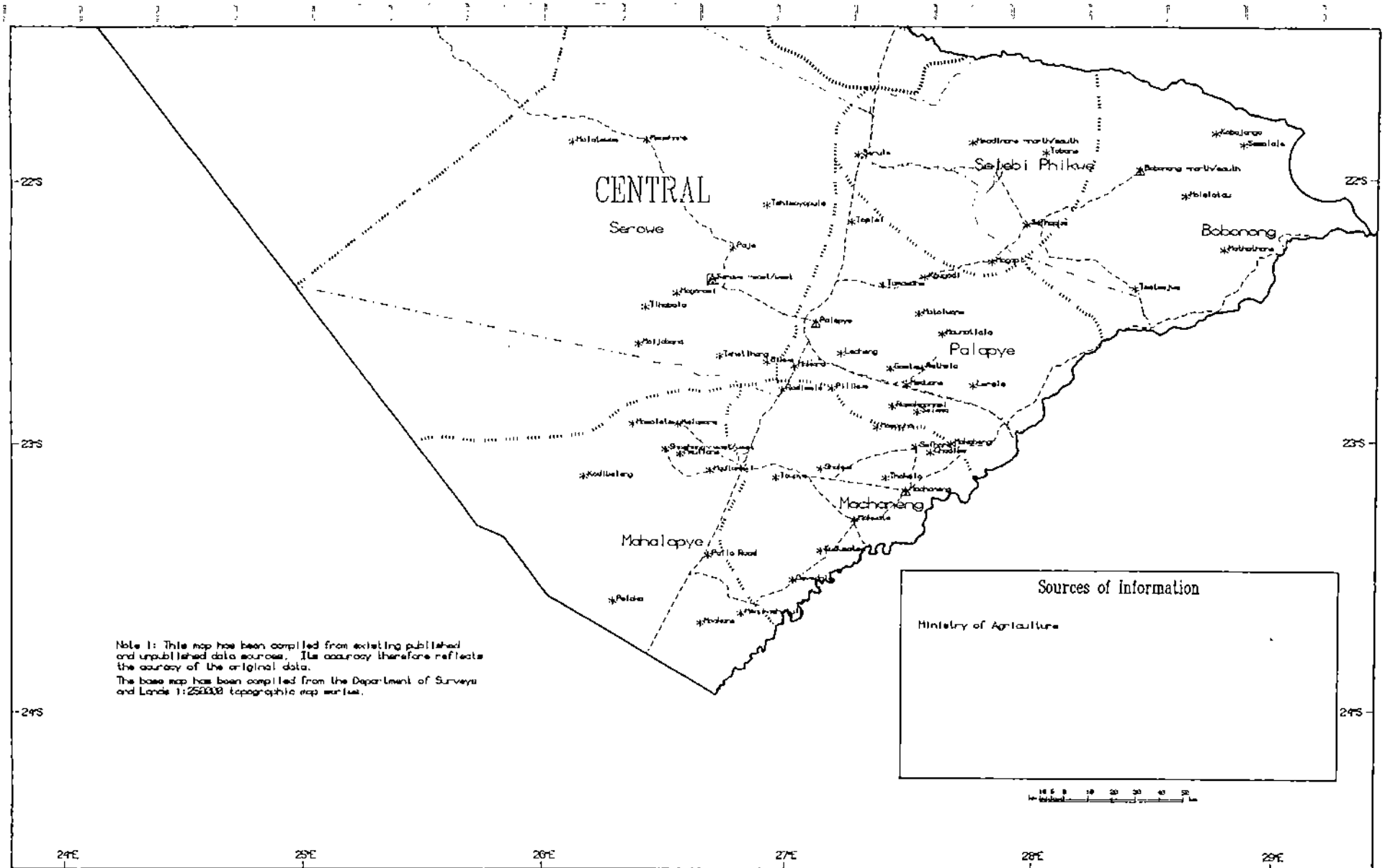
PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: VETERINARY ADMINISTRATION

MAP NO: 10.2



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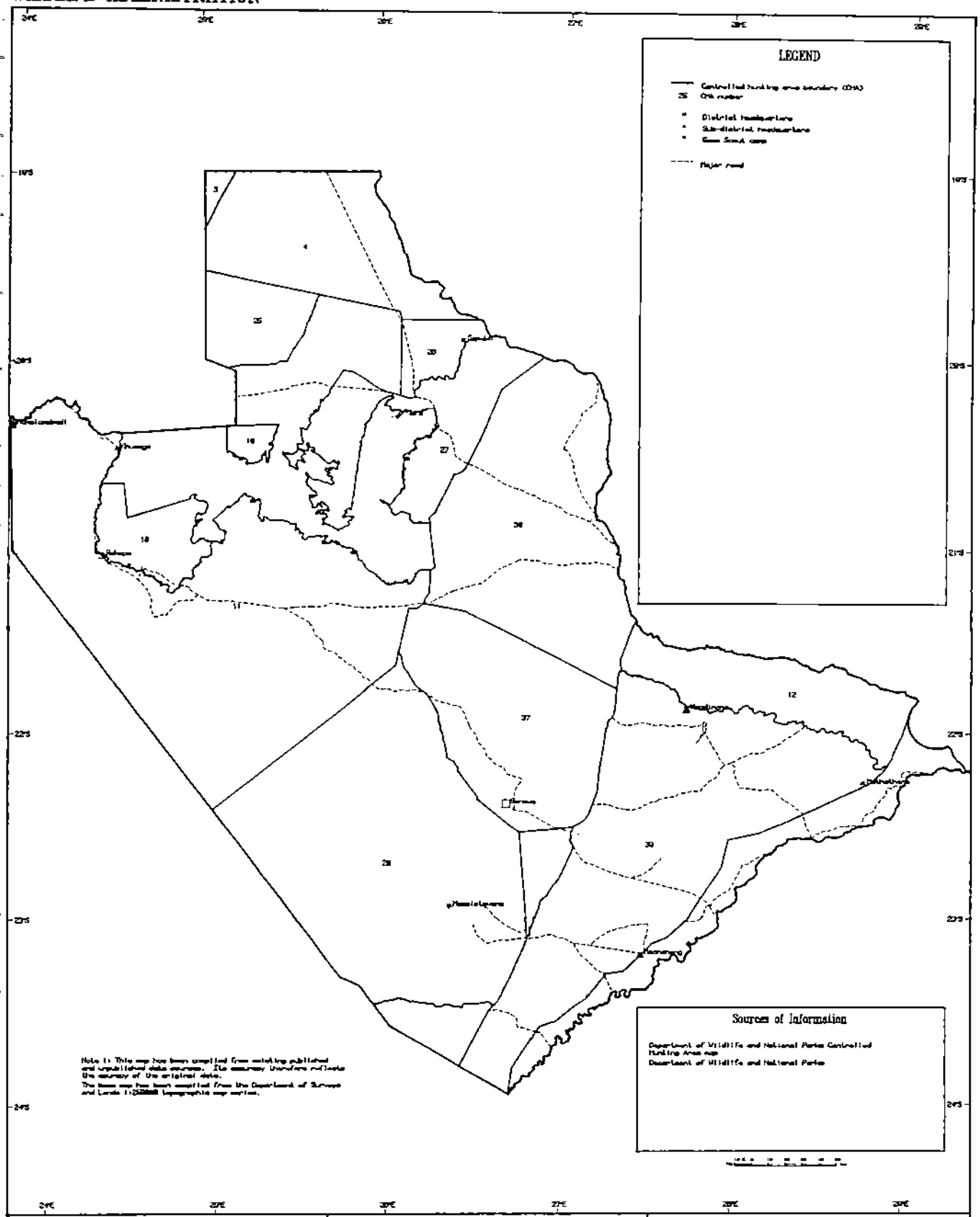
WILDLIFE ADMINISTRATION



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: WILDLIFE ADMINISTRATION

MAP NO: 10.4

10.4 MINISTRY OF EDUCATION

10.4.1 Department of Primary Education

Initially the Education Officer in Serowe supplied a list of all the educational facilities in Central District which was entered into a data base. However, it was subsequently found that the Ministry in Gaborone maintains a computerised data base and this was used instead. A list of the localities with education facilities is included in Appendix 10.1. The locations of most primary schools has been attached to the digitised locations from the Census data base.

The Department operates on a Sub-district basis and has the following number of schools in each Sub-district.

Sub-District	Number of Primary Schools
Bobonong	21
Mahalapye	41
Serowe/Palapye	55
Tutume	46
Boteti	19
Total	182

In mapping the schools some locations could not be found on the existing maps and we presume that there is an alternative spelling or place name, or the schools have been built in lands areas which have not been mapped in the Census.

Administration Boundaries

With a few exceptions administration boundaries loosely follow District and Sub-district boundaries.

Presentation

The location of primary schools is presented on Map Number 10.5.

10.4.2 Department of Secondary Education

There were 48 Community Junior Secondary Schools and 7 Senior Secondary Schools in Central District at the beginning of 1991. The location of these was entered into a data base and is presented in Appendix 10.1.

Administration Boundaries

With a few exceptions, administration boundaries loosely follow District and Sub-district boundaries.

Presentation

The location of secondary schools is presented on Map Number 10.5.

10.4.3 Department of Non Formal Education

The Department of Non Formal Education has officers at the following locations:

Mahalapye
Serowe

Presentation

Due to the limited facilities the data for this Department is not presented.

10.4.4 Vocational Training Centres

There are two vocational training centres in the District, the Serowe Vocational Training Centre and the Palapye Vocational Training Centre.

Administration Boundaries

There do not appear to be any administration boundaries that affect Central District.

Presentation

Due to the limited facilities, the data for this Department is not presented elsewhere.

10.4.5 Brigades

There are eight Brigades in the District which cover a number of activities (Bridec; Annual Report 1990-1991). They are:

10.5 ELECTIONS OFFICE

10.5.1 Electoral Boundaries

There are 12 National Assembly constituencies which represent Central District (not including Selebi Phikwe). They are:

No	Name	Population 1981
8	Sebina & Gweta	23 929
9	Nkange	20 670
10	Boteti	33 211
11	Totota	27 454
12	Mmadinare	27 705
13	Bobirwa	29 292
14	Serowe North	25 328
15	Serowe South	22 581
16	Tswapong North	33 992
17	Tswapong South	28 440
18	Shoshong	22 503
19	Mahalapye	32 467

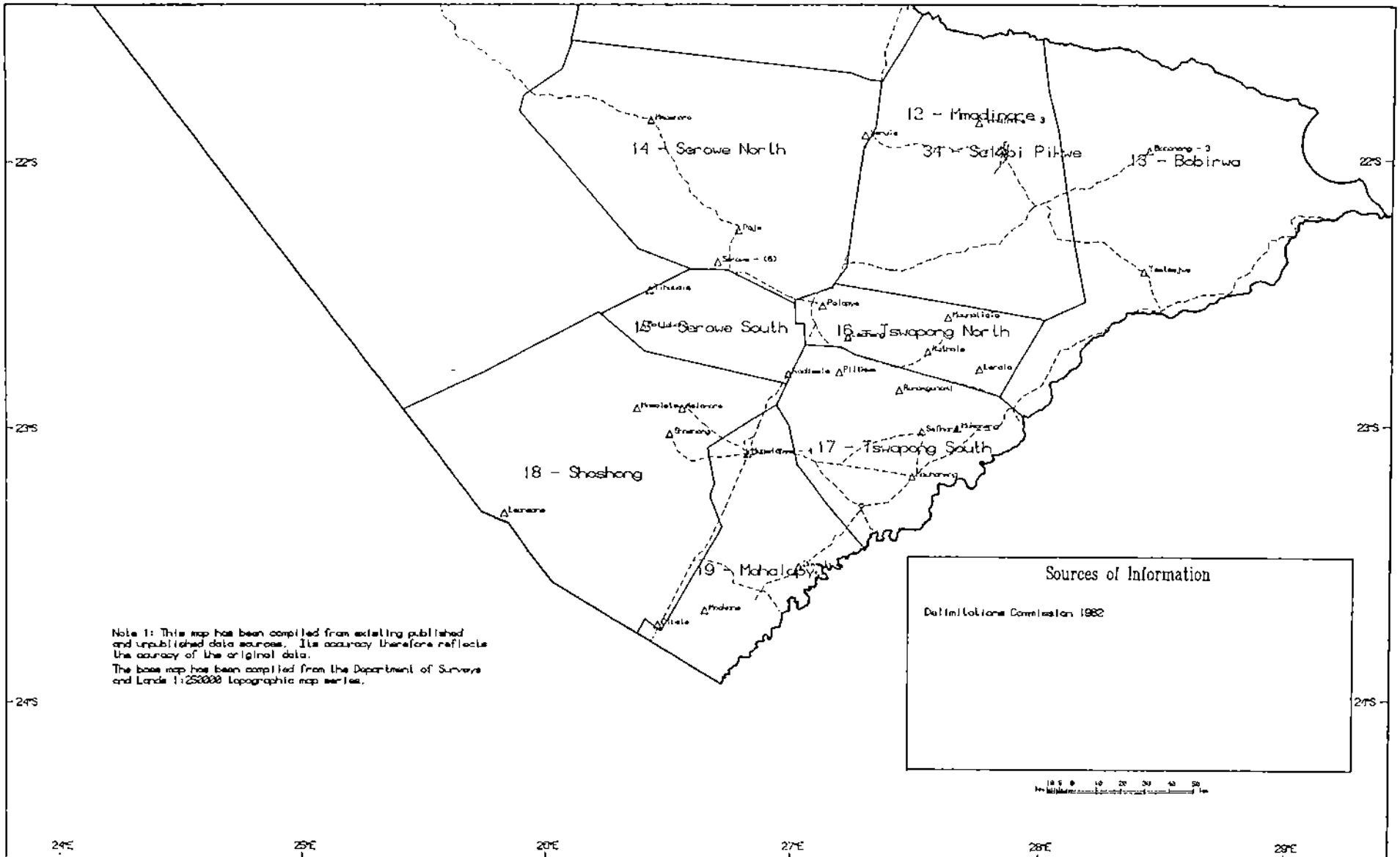
A full description of the boundaries is found in the Delimitation Commission 1982 report.

Administration Boundaries

The constituency boundaries roughly follow the District and Sub-district boundaries.

Presentation

The National Assembly constituency boundaries are presented on Map Number 10.6 which also maps the locality name of each District Council constituency.



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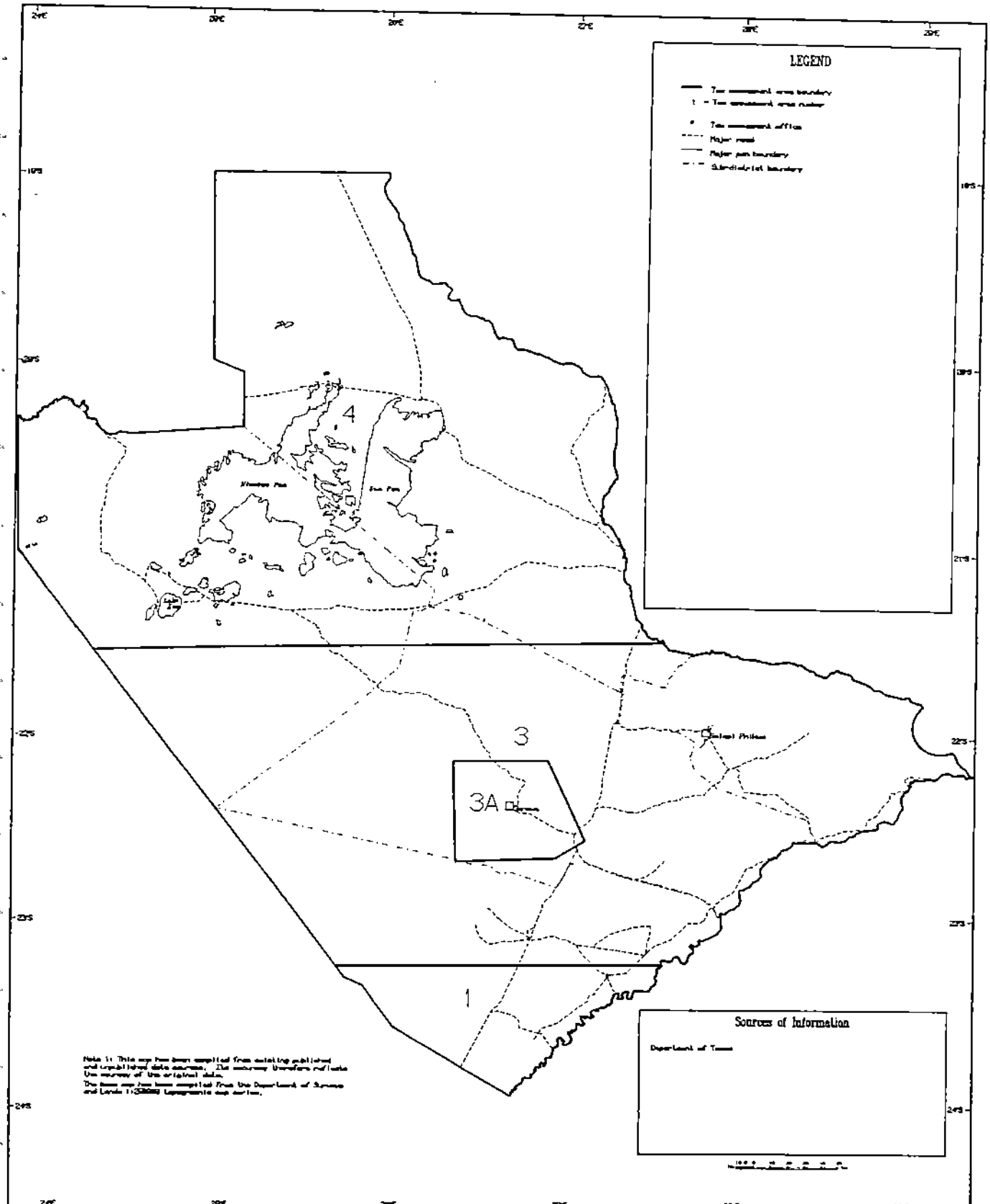
TAX



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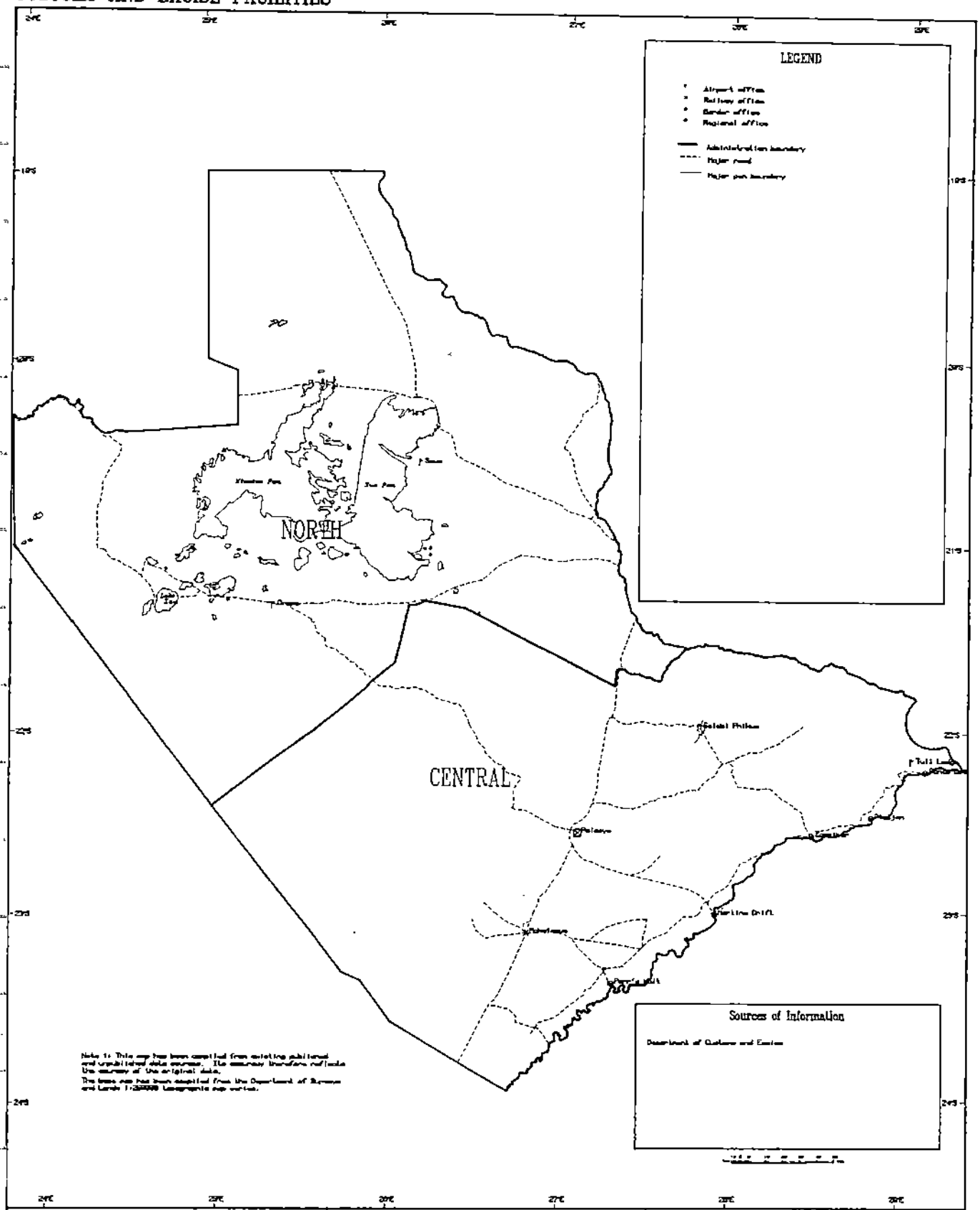
PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: TAX

MAP NO: 10.7

CUSTOMS AND EXCISE FACILITIES



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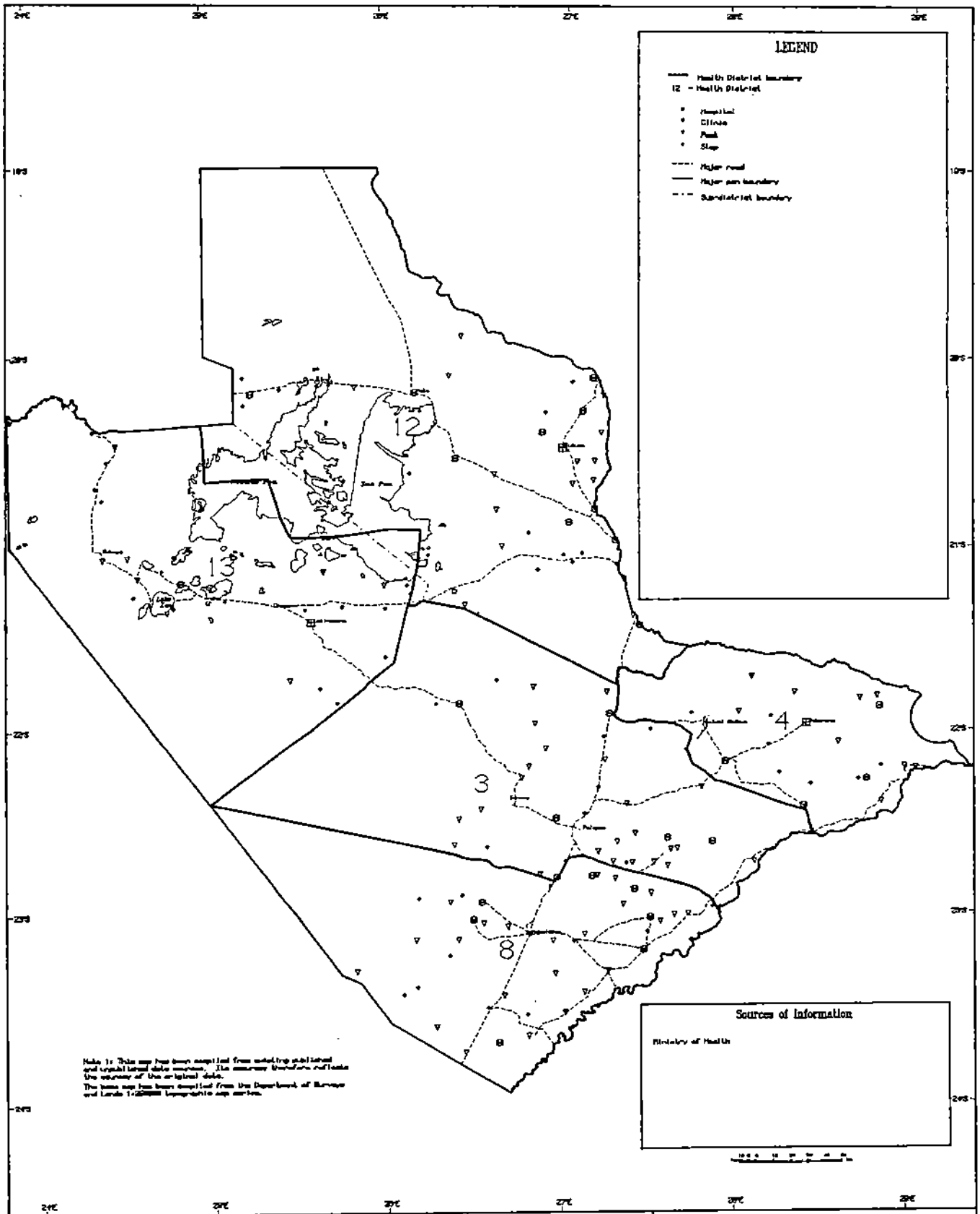
MAP TITLE: CUSTOMS AND EXCISE FACILITIES

MAP NO: 10.8

HEALTH



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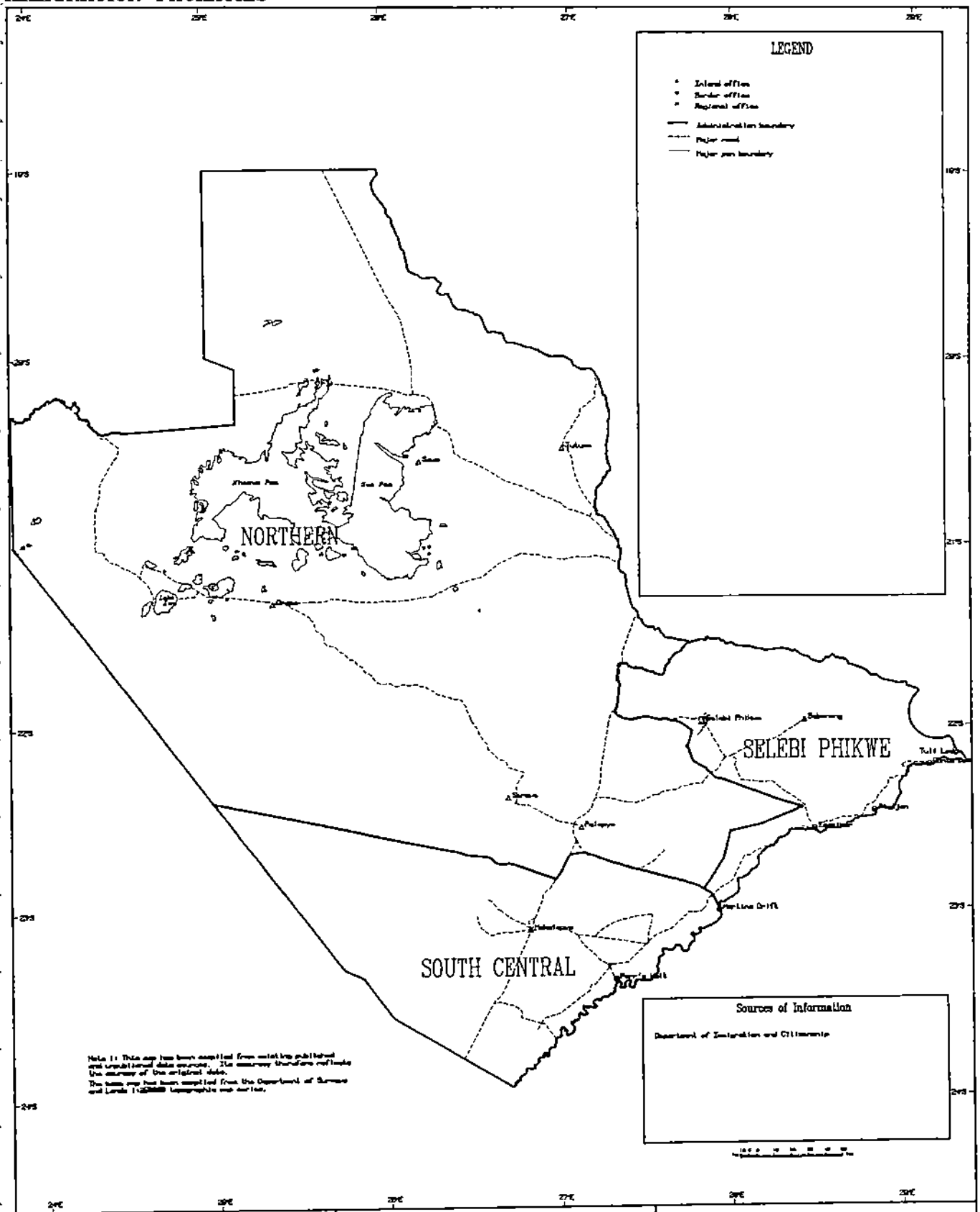
PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: HEALTH

MAP NO: 10.9

IMMIGRATION FACILITIES



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PROJECT: CENTRAL DISTRICT PLANNING STUDY
MAP TITLE: IMMIGRATION FACILITIES
MAP NO: 1010

10.9 MINISTRY OF LOCAL GOVERNMENT, LANDS AND HOUSING

10.9.1 Department of Food Resources

The Department of Food Resources is responsible for the provision of food to primary schools and health facilities.

The Department has divided the country into regions, two of which cover Central District - the North and Central Regions which have Regional Offices at Francistown and Palapye respectively. Each Regional Office supervises a number of depots.

North & Northeast Region - Francistown Regional Office

- Tutume
- Letlhakane

Central Region - Palapye Regional Office

- Palapye and Serowe
- Selebi Phikwe
- Mahalapye

Administration Boundaries

The boundary between North and Central Regions follows the Sub-district boundaries between Boteti and Serowe/Palapye, Tutume and Serowe/Palapye and Tutume and Bobirwa Sub-districts.

Presentation

The above information is presented on Map No 10.11.

10.9.2 District Administration

The District Administration headquarters are in Serowe and there are offices of the District Administration in each of the Sub-district headquarters.

Sub-district	Headquarters
Serowe/Palapye	Serowe
Mahalapye	Mahalapye
Bobirwa	Bobonong
Boteti	Letlhakane
Tutume	Tutume

Administration Boundaries

The administration boundaries follow the District and Sub-district boundaries.

Presentation

The boundaries between Sub-districts are presented on Map Number 10.12.

10.9.3 Tribal Administration

The Tribal Administration in Central District has the following hierarchy

Position	Number
Paramount Chief	1
Deputy Paramount Chief	1
Senior Chiefs Representative	14
Chiefs Representative	23
Headman	84
Arbitration Headman	78

In each settlement which has a Tribal Authority representative ranking higher than an Arbitration Headman there is a representative of the Local Police.

The location of each of the above has been entered in a data base.

Administration Boundaries

Although ultimately the representative of the Tribal Administration is answerable to the Paramount Chief in Serowe, the system follows District and Sub-district boundaries

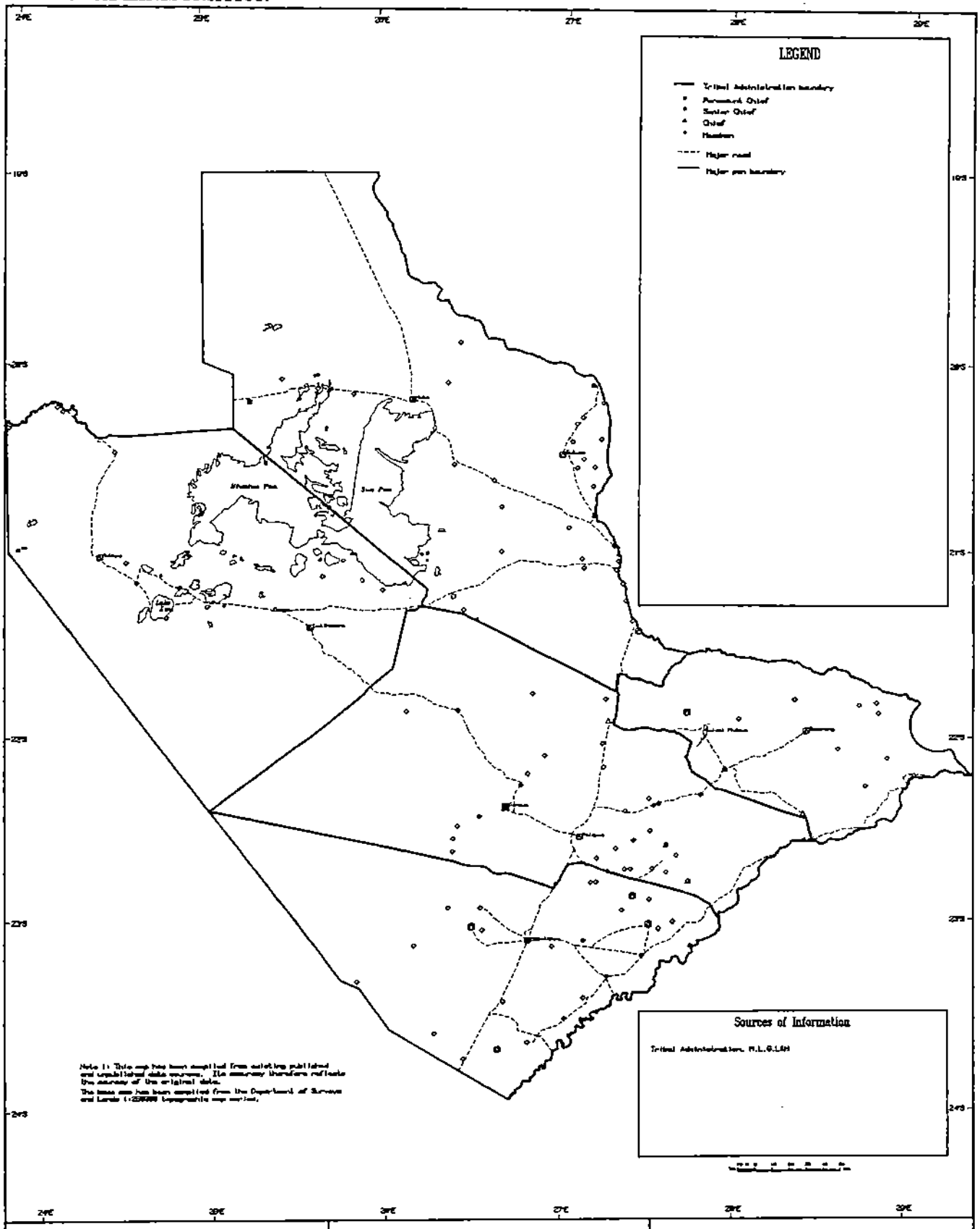
Presentation

The location of a tribal Authority Representative is mapped and presented on Map Number 10.13.

10.9.3 Council

The Central District Council is composed of 60 elected members and 12 specially elected members.

TRIBAL ADMINISTRATION



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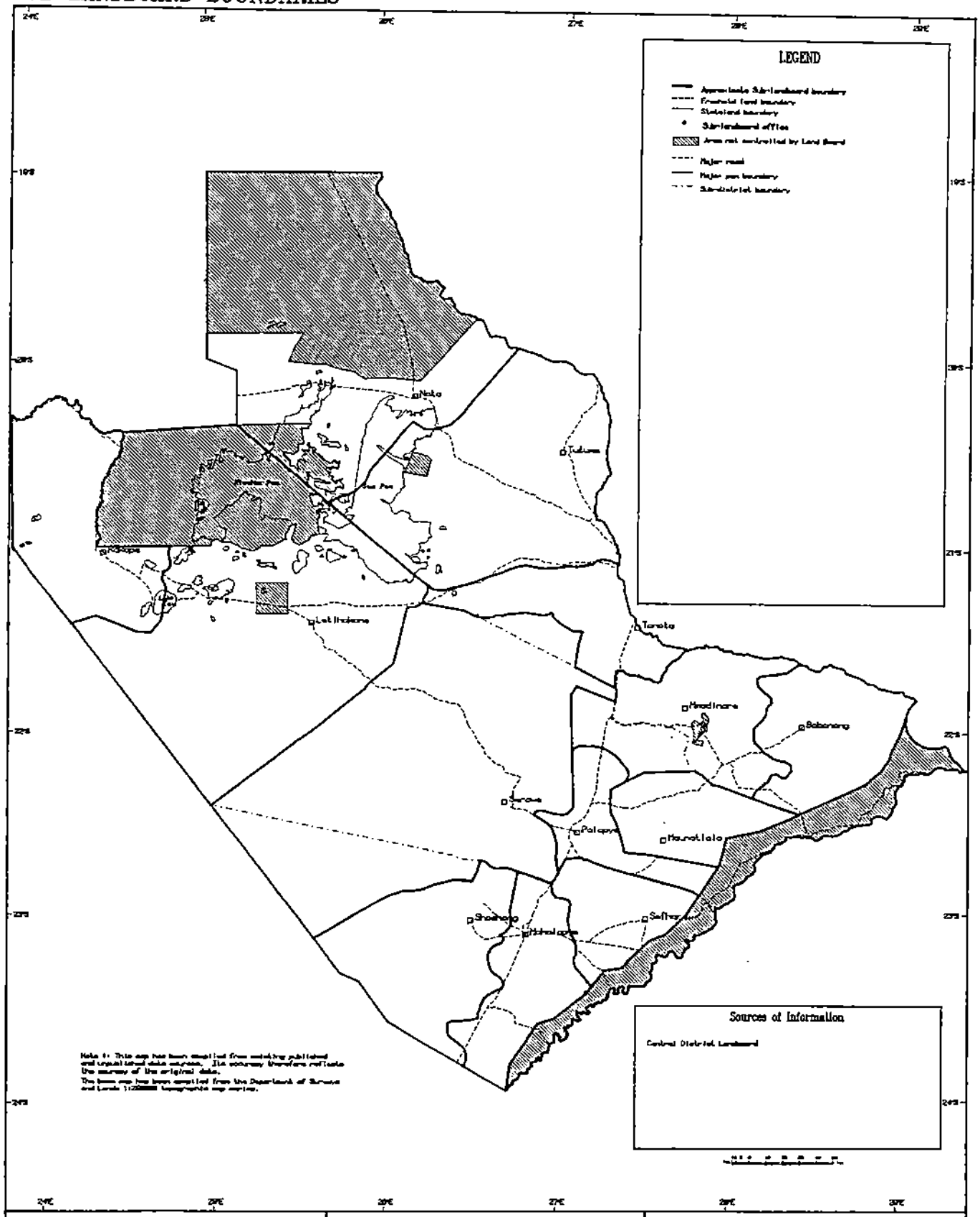
PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: TRIBAL ADMINISTRATION

MAP NO: 10.15

SUB-LANDBOARD BOUNDARIES



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: SUB-LANDBOARD BOUNDARIES

MAP NO: 10.14

10.9.1 Water Supplies

The Council is responsible for providing water and maintaining the supply in a number of settlements in the District. A list of settlements was provided by the water engineer and entered into a data base.

In each Sub-district there is a maintenance crew who are responsible for the whole subdistrict although each subdistrict has been divided into a number of geographic areas.

Administration Boundaries

The boundaries follow the Sub-district boundaries.

Presentation

The location of each settlement with a council water supply is presented on Map Number 10.15.

10.10 MINISTRY OF MINERAL RESOURCES AND WATER AFFAIRS

10.10.1 Department of Water Affairs

The Department of Water Affairs has offices in the Major Villages in which it is responsible for the Water Supply.

Department of Water Affairs maintains the water supply in the following villages:

Bobonong
Letlhakane
Mahalapye
Palapye
Serowe
Tonota

Administration Boundaries

In each of the above settlements there is a maintenance crew who are directly answerable to headquarters in Gaborone.

Presentation

The above information has been presented on the Water Supplies Map Number 10.15.

10.10.3 Water Utilities Corporation

Water Utilities Corporation (WUC), a parastatal of the MMRWA supplies water to Selebi Phikwe from Shashe Dam and will be the agent for the Department of Water Affairs for supplies to Sowa township from the Dukwe wellfield. It also sells bulk water to Department of Water Affairs for the Tonota water supply.

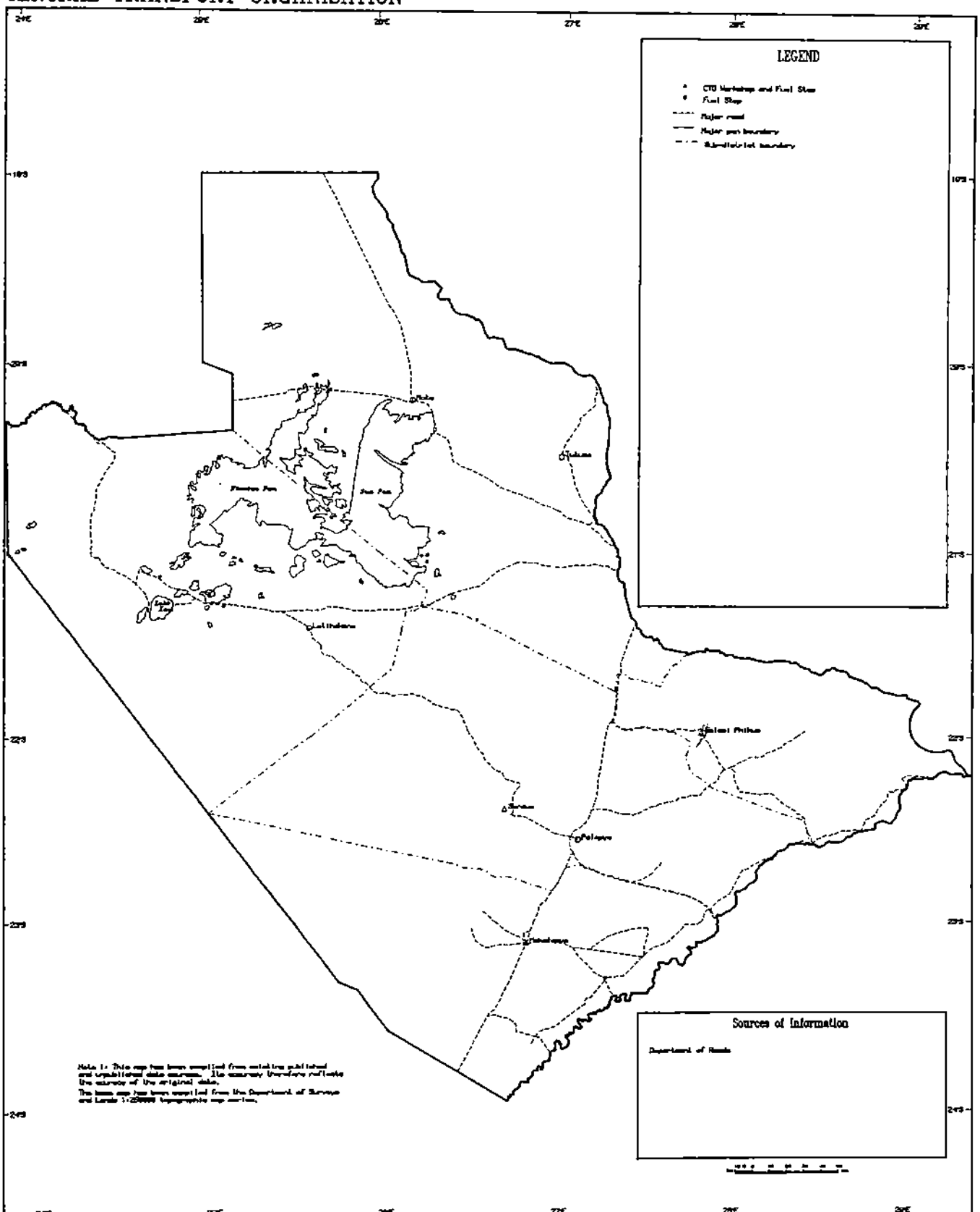
Administration Boundaries

WUC has an office in Selebi Phikwe which handles its business in Central District.

Presentation

Settlements with WUC supplies are presented on the Water Supplies Map Number 10.15.

CENTRAL TRANSPORT ORGANISATION



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PROJECT: CENTRAL DISTRICT PLANNING STUDY

MAP TITLE: CENTRAL TRANSPORT ORGANISATION

MAP NO: 10.16

Presentation

Due to the limited facilities in the District no further presentation has been made.

11 ENUMERATION AREAS

Introduction

This section discusses the Census Enumeration Areas of the CSO and the Geographic Reference Area System (GRAS) devised by the Department of Town and Regional Planning. They are in the same section as GRAS uses the Census Enumeration Areas as the basis for demarcation.

11.1 CENSUS ENUMERATION AREAS

Methodology

CSO prepared maps of the enumeration areas at a scale of 1:125 000 or 1:250 000, depending on which topographic map series was available. In areas where the 1:50 000 sheets were available, they were photographically reduced and mosaiced to produce maps at 1:125 000. For the remaining areas, basically the western portion of the District, the 1:250 000 topographic series was used.

The Census unit provided dyeline copies of these maps which were then digitised for use in the GIS.

Presentation

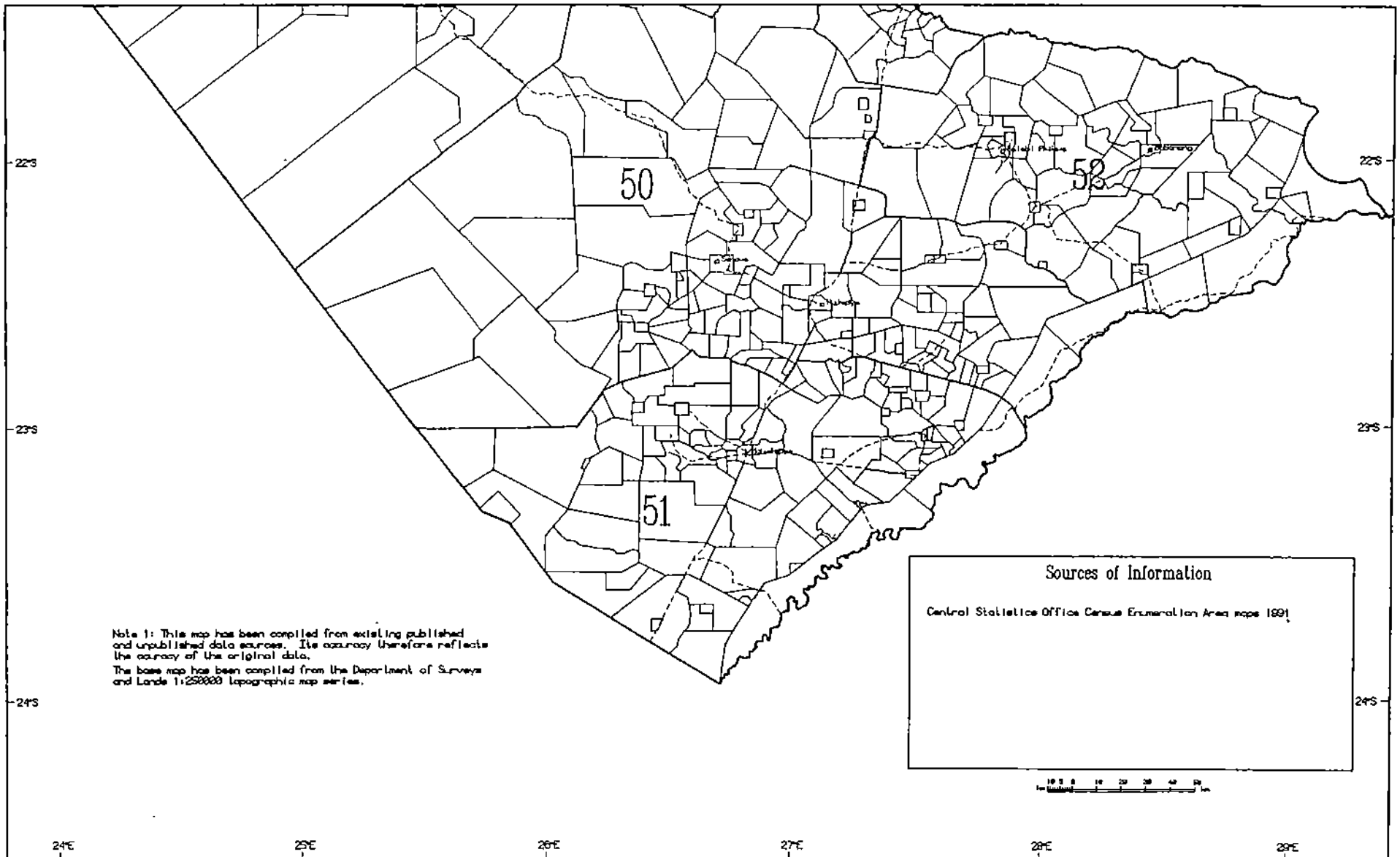
A Census Enumeration Map is included as Map Number 11.1. It shows the Enumeration Area boundaries with the Sub-district boundaries used by CSO highlighted.

Discussion

The Sub-district boundaries used by CSO do not coincide with those used by the District Authorities, CSO has modified boundaries according to areas of influence. This is particularly noticeable at the boundary between the Serowe/Palapye and Mahalapye Sub-districts where a portion of the western Mahalapye Sub-district has been included in the Serowe/Palapye Sub-district.

The 1991 Enumeration Areas coincide to some degree with the 1981 boundaries, although a lot of the boundaries have been straightened.

To facilitate comparison between the 1981 and 1991 Census, an extra digit has been added to the Enumeration Area codes ie EA70 in 1981 became EA700 in 1991. Where a 1981 Enumeration Area has been subdivided, the subdivisions are represented by a sequence of numbers, eg 701, 702, 703 etc.



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A wide variety of information can be incorporated into the system, but at present it focuses on population (1981 figures), population projections, schools and health facilities (up to date information is provided by the Ministries of Education and Health).

12. DISTRICT PLANNING UNITS

Introduction

The overall objective of the study was to divide Central District into District Planning Units (DPUs) in order to harmonise the areas in which extension services and development plans are developed and carried out.

The overall rationale is that the more homogeneous and cohesive the planning area, the easier it will be to implement and manage policies.

Consultation was made with the Central District Council. The final draft of this Section was presented to them and their comments have now been incorporated.

This analysis has been completed using the provisional 1991 census data. It must be noted that this data has been released to the study for working purposes only and that there is a possibility of revision.

The following sections describe the methodology which has been used to define the "building blocks" for the District Planning Units (DPUs), the aggregation (or disaggregation) of building blocks into DPUs.

12.1. BUILDING BLOCKS

Methodology

The underlying philosophy in defining each District Planning Unit was to make it as manageable as possible. As a first step the District was divided into 'building blocks'.

The following criteria was used to define the DPUs 'Building Blocks' and are listed in order of importance:

- Areas of influence
- Land use/tenure
- Population
- Size
- Existing boundaries
- Environmental characteristics

Existing Boundaries

One of the problems of such an exercise is to demarcate areas on the ground. To ease this problem it was decided to use:

- Veterinary cordon fences
- Sub-district boundaries
- Land tenure boundaries

Environmental Characteristic

Finally, ecological zoning boundaries were used if further disaggregation was needed.

To delineate the building blocks, the GIS was used to combine the relevant guideline themes and boundaries described above.

Presentation

The building blocks have been prepared as a single coverage and is presented on Map Number 12.1.

Description

In the Draft Final Report 147 building blocks were presented. Following further discussion with the Steering Group, a number of the larger building blocks were split so that finally a total of 153 building blocks were delineated, reflecting mainly the areas of influence and land tenure.

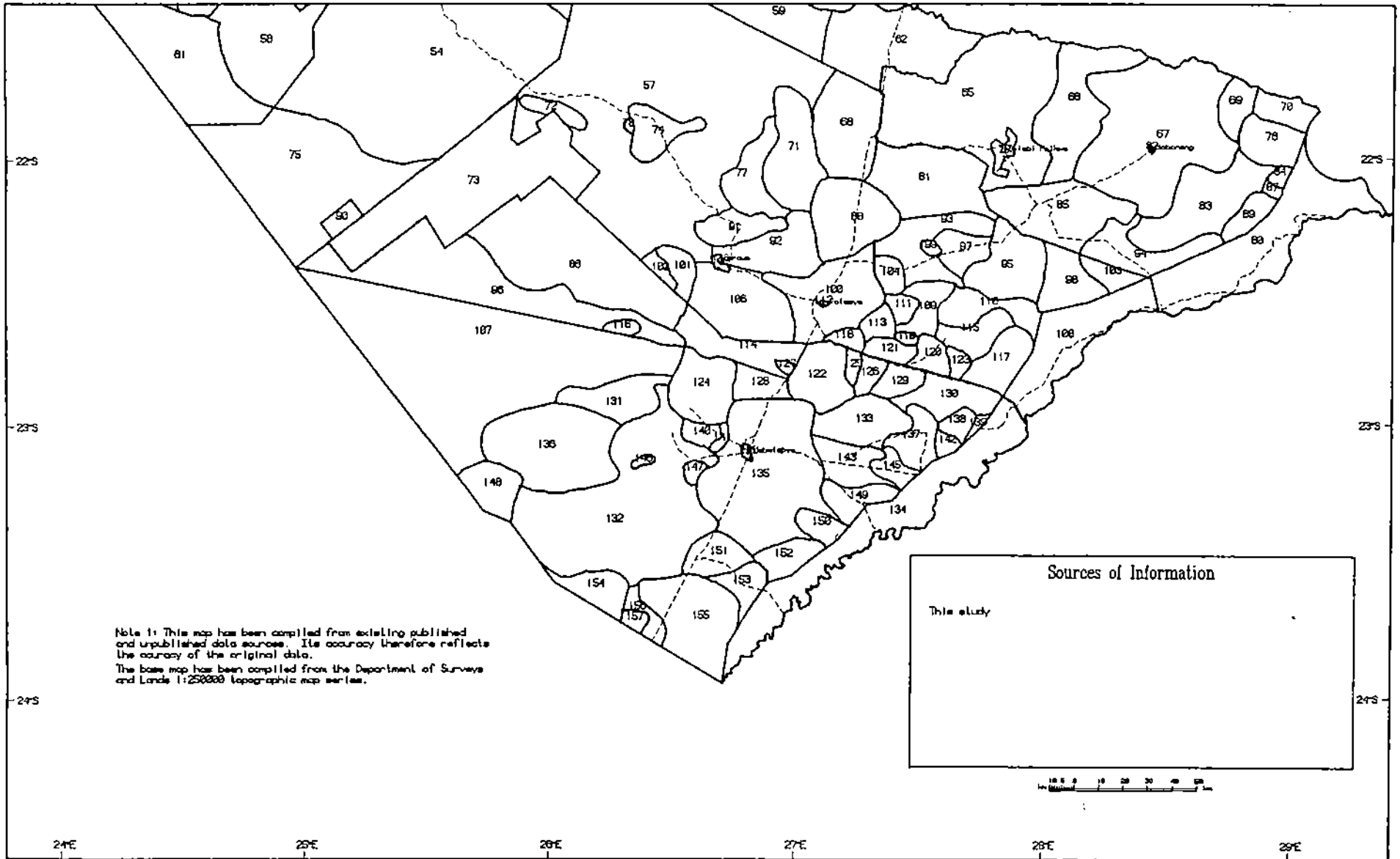
Building blocks containing large villages were subdivided by creating a building block out of the settlement and another of the associated area of influence. In some cases, this area was further subdivided.

Initially the need to respect existing Sub district boundaries led to the following additional building blocks:

- Moijabana - Serowe
- Moijabana - Mahalapye

This was required as Moijabana's area of influence extends across the Serowe/Mahalapye Sub-district boundary.

It should also be noted that areas of influence often reflect the association between the cattle post owner and his village and do not necessarily reflect a similar association as his employees.



Prepared on behalf of Ministry of Local Government, Lands and Housing Private Bag 006, Gaborone Botswana	Produced by Environmental Consultants a division of Aqua Tech Groundwater Consultants (Pty) Ltd P.O. Box 10072, Gaborone Botswana	PROJECT: CENTRAL DISTRICT PLANNING STUDY MAP TITLE: DISTRICT PLANNING UNIT BUILDING BLOCKS MAP NO: 121

The total number of DPUs proposed is 36.

Description

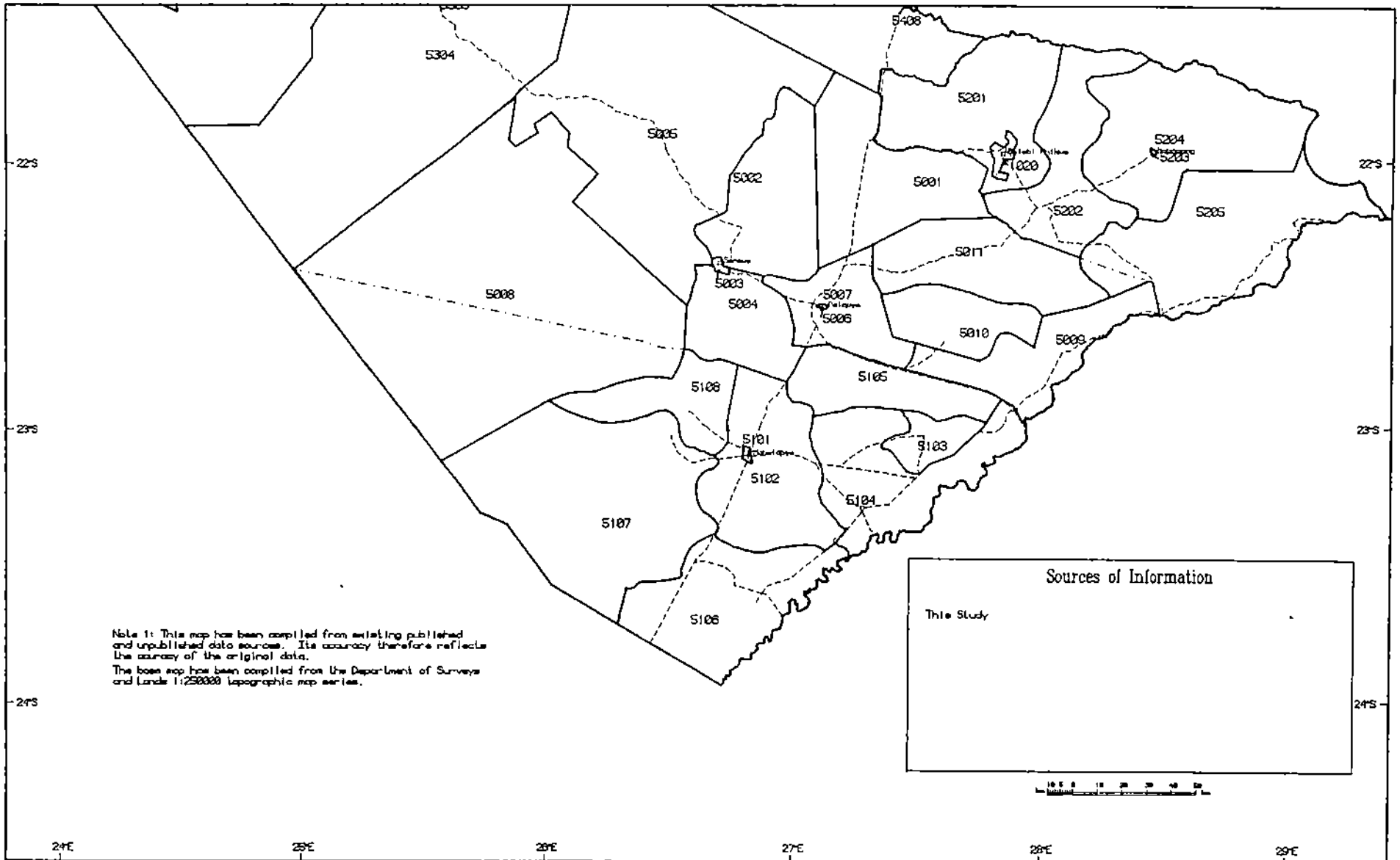
The District has been divided into 36 District Planning Units (DPUs). Their average geographic size is 3 900 km2 and average provisional population is 11 000 people. Table 12.1 summarises the DPUs for each Sub-district together with the provisional 1991 population.

TABLE 12.1

Sub-district		Population Provisional 1991	Number of DPUs
50	Serowe/Palapye	111 300	11
	- Palapye	17 127	- (included in DPUs)
51	Malalapye	95 566	8
52	Bobiwra	53 472	5
	(- Selebi Phikwe	39 769	- (not included)
53	Boteti	35 473	3
54	Tutume	99 753	8
	Total		36

The smallest DPUs has a population of 6 400 while the largest, Letlhakane has a population of 15 120.

Table 12.2 lists all the DPUs by Sub-district and shows the DPUs number, name, area and estimated population based on the 1991 provisional 1991 census data. A further breakdown showing the individual settlements included in the DPUs and allocation of building blocks is included in Appendix 12.1.



Prepared on behalf of Ministry of Local Government, Lands and Housing Private Bag 006, Gaborone Botswana	Produced by Environmental Consultants a division of Aqua Tech Groundwater Consultants (Pty) Ltd P.O. Box 10072, Gaborone Botswana	PROJECT: CENTRAL DISTRICT PLANNING STUDY MAP TITLE: DISTRICT PLANNING UNITS MAP NO: 122

Discussion

The implementation of DPUs will only be successful if accepted at grass roots level. To be accepted the DPUs area selection must reflect the existing social and traditional structures.

A comparison has been made with the DPUs proposed in this report and the GRAS boundaries from the Department of Town and Regional Planning. Basically the concepts are similar. Both studies have relied on Census data to provide boundaries. However, where this study significantly deviates from the GRAS approach is that we disregarded the Enumeration boundaries and concentrated on the 'sphere of influence' which cuts across enumeration boundaries thereby have generating our own boundaries from the Census data.

One of the guidelines at the beginning of the exercise was that the integrity of the Sub-district boundaries would be observed. However, it has become obvious that in two particular cases the Sub-district boundary was artificial and did not reflect the organisations within the District. This is particularly noticeable in the case of the western portion of Serowe/Palapye and Mahalapye Sub-district.

Where possible we have also tried to keep DPUs within the existing Sub-Land Board boundaries.

Implications

Delineation of the DPUs has led to the recommendation of some changes to Sub-district and Sub-Land Board boundaries so that the boundaries of all three are consistent.

Sub-district Boundaries

The boundary between the Serowe/Palapye and Mahalapye Sub-districts should be realigned so that the western portion is moved to the south and runs along the Shoshong Sub-Land Board's western boundary. The Serowe/Palapye Sub-Land Board services this area although it presently belongs to the Mahalapye Sub-district. About 2 000 people will be affected.

The boundary between the Serowe/Palapye and Bobirwa Sub-districts needs to be realigned in the east. The recent census suggests that the people in the Tsetsejwe lands may prefer to belong to Bobirwa Sub-district and it is recommended that a field survey be carried out to accurately demarcate the area. About 500 people will be affected.

13. SIXTH SUB-DISTRICT

Introduction

During the study, the Steering Group requested that the feasibility of a sixth sub-district, based on separating Tonota from Tutume Sub-district and Mmadinare from Bobirwa Sub-district, be examined. However, no criteria or guidelines for determining the viability of a sub-district were established.

The final draft of this Chapter was discussed at a full Council meeting and their comments were taken into account. They accepted the conclusion that the concept of a sixth sub-district centred on Tonota and Mmadinare was not viable, but that the general issue of a sixth sub-district warrants further investigation.

Methodology

It was decided that not only the DPUs - 5408 (Tonota/Shashe) and 5201 (Mmadinare) - should be combined but any other DPU which contained satellite settlements of Tonota or Mmadinare DPU. As a result DPUs 5406 (Chadibe) and 5407 (Mmadunyane) - both in the present Tutume Sub-district - and 5202 (Sefophe) from Bobirwa Sub-district were included (see Table 12.2). Using this method, the combined area is roughly that of the Tonota and Mmadinare Sub-land Boards with the exception of Serule, Chadibe, Mathangwane and Mokibilo

TABLE 13.1 SATELLITE SETTLEMENTS OF TONOTA/SHASHE AND MMADINARE

Tonota Satellites	Mmadinare Satellites
Borolong	Sefophe
Chadibe	Tobane
Mathangwane	
Mmandunyane	
Mokobo	
Mokubilo	
Natale	
Shashe Mooke	

The GIS was used to combine the selected DPUs.

Presentation

Map Number 13.1 shows the Tonota/Shashe/Mmadinare Sub-district option.

Discussion

Having no specific guidelines it was decided that population and area should be the criteria in evaluating the viability of the sixth Sub-district.

TABLE 13.2 SUB-DISTRICT ANALYSIS

Sub-district	1991 Population		Area km²		Longest Distance km
	Before	After	Before	After	
Serowe/Palapye	128 431	128 431	30 925	30 925	357
Mahalapye	95 566	95 566	23 688	23 688	306
Boteti	35 473	35 473	34 956	34 956	268
Tutume	99 753	62 074	43 847	35 284	356
Bobirwa	53 472	36 075	13 115	7 877	150
Proposed	-	55 076	-	13 801	210
Total	412 695	412 695	146 533	146 531	

Table 13.2 above shows that the present Bobirwa Sub-district has the smallest land area and the second lowest population of all the Sub-districts, and is the smallest in terms of both criteria for Sub-districts in the hardveld physiographic province. It also shares the lowest population growth rate between 1981 and 1991 (15.1%) with Mahalapye Sub-district. Tutume Sub-district, on the other hand, is the largest in area and has the second largest population.

The proposed new Sub-district would be virtually the same as the present Bobirwa Sub-district in terms of population and area. It should have a higher population growth rate than Bobirwa Sub-district as it would incorporate a part of Tutume Sub-district which had a growth rate of 32.5% for the ten year period.

The effects on Tutume Sub-district are not severe; it would lose approximately 28% of its population and about 20% of its land area. In fact, a reduction in population and size may be beneficial.

The effects on Bobirwa Sub-district are rather severe; it would lose 32% of its population and 40% of its area. It's low population growth rate implies that the population would not grow at an advantageous rate compared to the other Sub-districts.

It would appear therefore that, in the absence of any objective criteria, the sixth Sub-district would be viable by virtue of its being almost identical in size and population to the present Bobirwa Sub-district. However, although it might be to the benefit of Tutume Sub-district, it would be to the detriment of Bobirwa Sub-district, which would most likely become unviable, and therefore the establishment of a sixth Sub-district based on Tonota and Mmadinare cannot be recommended.

APPENDIX 1.1

TERMS OF REFERENCE

TERMS OF REFERENCE
ASSOCIATED WITH CENTRAL DISTRICT PLANNING STUDY
TB 8/1/12/90-91

1. BACKGROUND

In Central District, boundaries of areas on which district authorities, different ministries and departments carry out extension services and development programmes, do not often coincide.

In order to investigate how these boundaries can be harmonized it is proposed to carry out the Central District Planning Study (CDPS). The overall aim is to arrive at District Planning Units (DPU) as basic areas for coordination of all development programmes and extension services. The DPU's would make a grass-roots approach possible and development could take place more effectively. The idea of DPU's is essentially, to desecrated the district into parts which have a common development strategy or to which such a strategy could be applied. Because Central District is already divided by 5 sub-districts (ungazetted) within which the district institutions operate, it is requested, that this current division of the District is specially taken into account while identifying the DPU's.

The size of the District and the scope of the Central District Planning Study, make it impossible for District Planners to carry out the study. Therefore funds will be requested from the I.G 31 vote to retain a consultant to carry out the work in cooperation with the Central District Land Use Planning Unit (DLUPU).

2. TERMS OF REFERENCE

The consultant will give information on, but not necessarily limit himself to the following:-

2.1 Natural Resource

2.1.1 Climate
- Rainfall (amount and distribution)
- Temperatures
- Evapotranspiration
- Wind velocity

2.1.2 Hydrology
- Watershed
- Streams/Rivers
- Haffir/dams/major pipelines
- Pans
- Boreholes/wells

2.1.3 Hydrogeology
- Water availability
- Water quality

2.1.4. Geology
- Minerals
- Bedrock

2.1.5. Soils
- Types/parent material
- Soil stability

2.1.6 Topography/Morphology

2.1.7 Vegetation
- Types
- Wood resources

2.1.8 Fauna

- Post Officers

2.6 Environmental Pollution/Degradation

2.6.1 Polluting industries

2.6.2 Areas which are chronically overgrazed

2.6.3 Erosion prone areas (cause of erosion)

- Deforested areas.

2.7 Administrative Boundaries

*2.7.1 Ministry of Presidential Affairs and Public Admin.

- 2.7.1.1 Tirelo Sechaba
- 2.7.1.2 Police

*2.7.2 Administration of Justice

*2.7.3 Ministry of Agriculture

- 2.7.3.1 Veterinary Department
- 2.7.3.2 Agricultural Field Services

*2.7.4 Ministry of Commerce and Industry

- 2.7.4.1 Department of Wildlife and National Parks
- 2.7.4.2 Rural Industries Offices
- 2.7.4.3 Tourism

*2.7.5 Ministry of Education

- 2.7.5.1 Department of Primary and Teachers Training
- 2.7.5.2 Department of Secondary Education (Schools)
- 2.7.5.3 Non-Formal Education
- 2.7.5.4 Vocational Education

*2.7.6 Elections Office

- 2.7.6.1 Electoral boundaries

*2.7.7 Ministry of Finance and Development Planning

- 2.7.7.1 Department of Supply
- 2.7.7.2 Department of Taxes
- 2.7.7.3 Department of Customs and Excise

*2.7.8 Ministry of Health

*2.7.9 Ministry of Labour and Home Affairs

- 2.7.9.1 Immigration
- 2.7.9.2 Labour Offices

*2.7.10 Ministry of Local Government and Lands

- 2.7.10.1 Food Resources
- 2.7.10.2 District Administration
- 2.7.10.3 Council
- 2.7.10.5 Land Board
- 2.7.10.6 Department of Surveys and Lands

*2.7.11 Ministry of Mineral Resources and Water Affairs

- 2.7.11.1 Department of Water Affairs

*2.7.12 Ministry of Works, Transport and Communications

- 2.7.12.1 Department of Architectural and Buildings
- 2.7.12.2 Central Transport Organisation
- 2.7.12.3 Post
- 2.7.12.4 Department of Roads

2.8 Central Statistics Office (CO) and G.R.A.S.S. system (DTRP) census units

Information from Section 2.2. up to Section 2.8 should be mapped on overlays. The information may be obtained from the relevant ministries and departments.

APPENDIX 1.2

GEOGRAPHICAL INFORMATION SYSTEM

GEOGRAPHIC INFORMATION SYSTEM

1. Introduction

A Geographic Information System was implemented for the Central District Planning Study (CDPS) to improve the quality of information ultimately provided and to facilitate future evaluation of the data for planning purposes. A GIS will also allow the District Officers to maintain the data base of information without recourse to complete re-compilation of a particular data set. Updates can be made to specific areas, or associated information without changing related data. If necessary a new map of the theme concerned can be produced at minimal effort and cost. The facility to be able to provide maps at any appropriate scale required is also a notable advantage of a GIS in the context of planning.

The objectives of the Consultants in developing a GIS for the CDPS was to provide the most accurate interpretation of existing data to assist in the dis-aggregation of the District into DPU's. The GIS was also used to incorporate a limited amount of new data derived by personal interpretation and field survey. In this study the main emphasis was to utilise the GIS to compile the data together to a common base for map production at appropriate scales. Some analysis was undertaken in the final stages of the project, for ecological zoning and erosion risk, as well as the derivation of DPU's, but GIS analysis for planning purposes will be undertaken at a later stage by MLGL&H. The primary GIS products of this project are:

i) Mapping of Relevant Planning Themes

ii) Provision of Digital Spatial Data Base of Thematic Information.

2. Methodology

The GIS methodology was designed to try and maintain a high standard of quality. The preference was to work at the largest scale possible for a particular theme with due consideration of the reliability of the data. Emphasis was placed on fresh interpretation of the data rather than duplication of existing data. Each data source was evaluated in the context of how it was to be used and in some cases data was actually simplified. Quality control was mainly by inspection of hard copy and comparison between data sets over a light table.

2.1 The GIS System

The CDPS was developed using PC ARC INFO software in accordance with the Government guidelines on GIS compatibility.

In some cases information was digitised directly from paper map copies in which case a higher RMS error was accepted. This was the case for the census mapping (dyeline copies) where an RMS up to 0.007" was permitted due to the quality of the media. Adequate registration to other data sets was still achieved after projection to UTM coordinates.

For the overlay interpretation from satellite imagery and for some of the census mapping, prominent geographic features had to be used as control points (tic marks), in the absence of reliable latitude and longitude marks. River junctions were the most frequently used feature but road junctions were also used. The precise UTM locations of features were obtained from the base mapping already digitised from 1:250 000 DSL maps.

2.3 Analysis

The CDPS required GIS analysis for the determination of ecological zones, agricultural suitability zones and the investigation of erosion potential. The analysis involved the combination of various themes to produce new coverage files containing all combined spatial information including the classification label for each theme. The combined thematic information was then evaluated using dBASE to derive a new classification. Polygon boundaries were subsequently adjusted (removed where necessary) automatically, on the basis of the new classification.

GIS analysis of topographic information was also undertaken to produce a digital elevation model (DEM). A Triangular Irregular Network (TIN) model was built from spot height observations supplied by the Geological Survey of Botswana (unpublished data). Contours were produced from the TIN at 120 metre intervals, to complement existing data. The TINS software module (ESRI Canada) was used for the topographic analysis.

The TINS software was also used to generate Thiessen polygons around locality points from census data. Thiessen polygons delineate boundaries of areas associated with localities simply on the basis of distance. Every point within a polygon is closer to the locality at the centre of the polygon than to any other locality. Thiessen polygons are useful as a means of indicating possible jurisdictional boundaries on the basis of distance alone. It is essential to compare this analysis with other means of boundary delineation. Typically thiessen polygons are useful in delineating urban areas of higher population, but in urban fringe areas and rural areas the polygons tend to be very large. This is because the areal extent of each polygon is dependent only upon the spatial distribution of the observation points and not the values of the observation points.

THEME	COVERAGE NAME	MAXIMUM SCALE FOR MAP PRODUCTION
Erosion Potential	erorisk	1:1 million
Food Resources	foodis	1:1 500 000
Food Admin. Boundaries	foobdis	1:1 500 000
Forestry Projects	forest	1:500 000
Fossil Rivers	fosdis	1:500 000
Geology	geodis	1:500 000
Geology - Kalahari Boundary	kaladis	1:500 000
Geology - Dykes	dykedis	1:500 000
Geology - Surficial	surdis	1:500 000
Groundwater Potential	grddis	1:500 000
Health	hedis	1:1 500 000
Health Admin. Boundaries	headis	1:1 500 000
Hill and Escarpments	hilldis	1:1 million
Hills of Natural interest	shilldis	1:1 million
Horticultural Projects - Tuli Block	hortdis	1:500 000
Horticultural Projects - Remainder of District	horti	1:500 000
Hydrology - Pipelines	pipedis	1:500 000
Hydrology - Reservoirs	revlut	1:500 000
Immigration Admin. Boundaries	immbdis	1:1 500 000
Immigration Facilities	immdis	1:1 500 000
Land Use	usedis	1:500 000
Land Tenure	tendis	1:500 000
Mineral Occurrences	minoccur	1:500 000
Mineral Leases	minleas	1:500 000
Natural, Cultural and Historic Sites	hisdis	1:1 million
Pans - Major	pandis	1:500 000
Pans - Minor	pindis	1:500 000
Peizometric contours	gwlevdis	1:500 000
Physiographic Units	phydis	1:500 000
Police and Justice	polidis	1:1 500 000
Police Administration Boundaries	policdis	1:1 500 000
Pollution Risk - Localities	poldis	1:500 000
Post Offices	postdis	1:1 500 000
Railway Sidings	siddis	1:500 000
Railway Line	raldis	1:500 000
Rainfall - Mean Annual	raidis	1:1 500 000

Maintenance & Development

The spatial data base provided for Central District is only the first stage in development of a functional GIS at district level. Any data base tends to be outdated as soon as it is completed, in much the same way that an academic text is quickly superseded by the latest research. The advantage of a GIS is that it is possible to maintain the information in reasonably current form by regular update. The means by which MLGL&H maintain the Central District data base is an issue which should be urgently addressed. Coordination with other ministries and departments will be important to ensure the latest data available is utilised and to avoid duplication of effort between ministries.

The second issue to be investigated is the development of a query system for the CDPS GIS. The GIS has been used to achieve the analysis and mapping required under this study to establish DPU's, but in addition an opportunity has been created to develop a management information system based on the GIS. This will require considerable effort and should be based on an objective examination of the management needs at district level. A management information system could be developed to serve everyday needs in terms of planning applications, project developments or future resource surveys. Once clear objectives have been defined an information system could be developed. This would probably be best programmed in dBASE, making use of the ARC INFO macro language where necessary for visual display. The definition of objectives is likely to identify a need for further information capture, either of new themes or at a more detailed level than the current data. This is a normal progression in the development of a GIS.

APPENDIX 1.3

PERSONS CONTACTED

PERSONS CONTACTED

Broekhuis, J.	District Officer (Lands), CDLUPU
Burger, K.	Forester, Chobe District
Calef, G.	Sr. Biologist / Elephant Mgmt., DWNP
Campbell, A.	Consultant, Campbell, Main & Associates
Child, S.	DWA
Coulson, I.	Biologist, DNPW, Zimbabwe
Craig, C.	Sr. Biologist / Aerial Surveys, DWNP
Dambe, D.	Meteorological Services Dept.
De Bie-Methorst, D.	DOD, Bobirwa
Gaseitsiwe, D.	Ministry of Commerce and Industry
George, M.M.	Acting Chief Education Officer, Department of Non-formal Education
Gower, T.	Director, Department of Commerce and Consumer Affairs
Halifax, P.	Sir M. MacDonald and Partners
Hanmer, P.	Forestry Div.
Hunter, N.D.	Director, DWNP
Kalikawe, M.	Biologist, DWNP, Central District
Khumalo,	Dept. Veterinary Services
Kooiman, A.	Research Unit Manager, FAB
Lawson, D.	Sr. Biologist / Wildlife Utilisation, DWNP
Le Roux, P.	Mgr., Mashatu Game Reserve
Letlhare, B.	Education Officer, Kalahari Cons. Soc.
Lewambano, K.	DO(L) Bobirwa
	DO(L) Mahalapye
	DO(L) Tutume
Lindsay, K.	Sr. Biologist / Borehole Monitoring, DWNP
Mabiletse, S.	Ministry of Local Government, Lands and Housing
Magatle, K.	Assistant Director, DWNP
Mandevu, I.	Ministry of Agriculture
Mangubo, D.	Sr. Game Warden, Admin., DWNP
Matlabele,	Dept. Surveys and Lands
Matlakele, A.	Department of Surveys and Lands
	Assistant Director, Department of Geological Surveys

APPENDIX 1.4

REFERENCES

Bibliography

Author	Year	Title	Annotation
Abel N., Flint, M., Hunter, N., Chandler, D. & Maka, G.	1986	Cattle Keeping, Ecological change and Communal Management in Ngwaketse. Draft Report, ILCA & MOA.	Communal area grazing patterns (mixed farming area) and environmental change.
Abel, N.	1983	Grazing Patterns Around Pelotshetlha and Shoshong. ILCA, IFPP & APRU(Unpublished).	As per title.
AquaTech Groundwater Consultants	1983	Water Resources Evaluation for Talana Farms. Botswana Development Corporation. Gaborone.	As per title.
Arup Botswana	1990	Lotsane dam feasibility study, Environmental Impact Assessment. Department of Water Affairs, Gaborone.	Describes natural resources of Lotsane River valley and Tswapong Hill and impacts of dam construction.
Arup Botswana, Stuart Scott & Partners	1987	Design report Nata-Maun road. Environmental Impact Assessment. Ministry of Works & Communications, Gaborone.	Impacts include limited discussion of road use on migratory species.
B.P. International Limited	1985	Sua soda ash project environmental impact assessment. Soda Ash Botswana (Pty) Limited.	As per title.
Baldock, J.W.	1977	Resources inventory of Botswana: metallic minerals, mineral fuels and diamonds. (With contributions by Hepworth J.V. and Marengwa B.S.I.Geological survey Department Lobatse.	As per title.
Bhalotra, Y.P.R.	1984	Climate of Botswana. Part I: Climatic controls. Department of Meteorological Services, Gaborone.	
Bhalotra, Y.P.R.	1985	Rainfall maps of Botswana. Department of Meteorological Services, Gaborone.	
Bhalotra, Y.P.R.	1985	The drought of 1981-1985 in Botswana. Department of Meteorological Services, Ministry of Works & Communications. Gaborone.	Historic meteorological records.
Bhalotra, Y.P.R.	1987	Climate of Botswana. Part II: Elements of climate. Department of Meteorological Services, Gaborone.	
Birkenholtz, D.	1967	Makgadikgadi Pan Game Reserve survey. Botswana Department of Wildlife & National Parks. Gaborone.	Qualitative/ground surveys of wildlife populations.
Birkenholtz, D.	1967	A study of the status and movements of big game in the Botletle - Nxai Pan area of Botswana. Unpublished report to Department of Wildlife & National Parks.	Historic record of migration patterns wildebeest, zebra, buffalo populations.
Bookcock C. & Van Straten, O.J.	1962	Notes on the geology and hydrology of the central Kalahari region, Bechuanaland Protectorate. Transactions of the Geological Society of South Africa 5: 125-171.	
Bridec	1991	Annual Report 1990/91 for Brigades Development Centre.	As per title.
Butynski, T.	1973	Botswana wildlife statistics (1968-1973, Pts. I and II). Botswana Government Printer, Gaborone.	Hunting quotes for CHAs of Central District.
Calef, G.	1987	Aerial census of large mammals in northern Botswana, Jan-Feb. and May-June, 1987. Department of Wildlife & National Parks. Gaborone.	Population estimates and distribution information (wet/(early) dry seasons). Livestock numbers.
Calef, G.	1988	Radio telemetry studies of elephant migrations in northern Botswana, 1987-88. Department of Wildlife & National Parks. Gaborone	Elephant movement patterns (seasonal).

Bibliography

Author	Year	Title	Annotation
Department of Town and Planning	1986	Serowe Development Plan. Ngwato Land Board and Central District Council.	As per title.
Department of Wildlife & National Parks	1984	Unpublished quarterly reports (193-84) aerial and ground census surveys of wildebeest populations in the Lake Xau region, northwest Central District. DWNP, Gaborone.	Survey of extent of mortality around Lake Xau (by DWNP biologist and D. Williamson).
Department of Wildlife & National Parks	1987	Aerial wildlife census report (Makgadikgadi region). DWNP, Gaborone.	Population estimates and seasonal distribution (for Makgadikgadi region).
Department of Wildlife & National Parks	1989	Aerial wildlife census data. (Nata, Makgadikgadi and western sandveld regions, Central District). DWNP, Gaborone and Serowe.	Population estimates and seasonal estimates for Makgadikgadi region.
Department of Wildlife & National Parks	1991	Air survey unit annual report for 1990. Unpublished report by Sr. Biologist, Aerial Survey Programme, DWNP, Gaborone.	
East, R.	1984	Rainfall, soil nutrient status and biomass of large Africa savanna mammals. Africa J Ecol., Vol. 22: 245-270.	Relating biomass production-carrying capacities to rainfall, soil nutrient levels.
Ebert, J., Thoma, A., Hitchcock, R. & Oabile, M.	1985	Report and recommendations for land allocation and Basarwa development in the sandveld region of Central District, Botswana.(cyclostyled) Central District Council, Serowe.	Wildlife utilisation by RADs in west Central District, historical perpective.
Ecosurv	1988	The vegetation communities of the Nata Statelands manuscript for Nata Statelands Land Use Plan (in prep).	
Environmental Consultants	1988	Southern District Planning Study (Final Report) MLGL.	As per title.
Environmental Consultants	1989	Mahalapye dam feasibility/preliminary design study, vol. IV - environmental issues report. Department of Water Affairs, Gaborone.	Describes natural resources of Mahalapye River valley and impacts of Dam Construction.
Environmental Services	1986	An evaluation of the Kedia game harvesting project, Mopipi CFDA, Central District, Botswana. Design Study Report, Central District Council, Serowe.	Proposed Wildlife utilisation project evaluation.
Environmental Services	1988	Management plan for Central Kalahari and Khutse Game Reserves, Botswana. World Wildlife Fund, U.K. and Kalahari Conservation Society.	Natural resources of CKGR/West Central District described. Migration patterns discussed.
Environmental Services	1989	Proposed Kedia WMA natural resources and waterpoints survey for Central Distict Land Use Planning Unit, Serowe.	As per title.
FAO-UNESCO	1988	Soil Map of the World: revised legend. World Soil Resources Report No.60.	
FGU-Kronberg	1988	Review of the aerial monitoring programme for the Department of Wildlife and National Parks, Botswana. FGU-Kronberg Consulting + Engr., Koningstein, FRG.	Historic information on survey programmes and results. Proposed methodology for current surveys.
Feely, J.M.	1975	Towards a plan for the eastern Tuli Block, Botswana. Report to the Eastern Tuli Game Protection and Conservation Association. Wilderness Leadership School, Bellair, RSA.	Early management plan for Tuli Block farms by private consultants.
Friederich, H.	1985	Central District land use plan (draft). Central District Land Use Planning Unit, Serowe.	

Bibliography

Author	Year	Title	Annotation
Kalahari Conservation Society	1984	Aerial monitoring of major wildlife species in northern Botswana April - May 1984.	Population estimates and seasonal distribution. Suvery north of 20 degrees south (no vegetation detail).
Kalahari Conservation Society	1985	Aerial monitoring of major wildlife species in northern Botswana, the second survey October - November 1984.	Population estimates and seasonal distribution. (No vegetation information).
Kalahari Conservation Society	1985	Aerial monitoring of major wildlife species in northern Botswana, the third survey, March 1985.	Population estimates and seasonal distribution. (No vegetation information).
Kalikawe, M.	1990	Reports of aerial census surveys of Central District (conducted in September 1989 and April 1990). Botswana Department of Wildlife & National Parks, Gaborone.	Population estimates and seasonal distribution. (Entire district in 1989) (Partial coverage 1990). No vegetation information.
Kreimeyer, R. & Ramonyane P.	1987	A review of industrial minerals in the Serowe - Palapye - Mahalapye area Central District. Geological Survey Department, Lobatse.	
Larsson, F.	1986	Wind Resources in Botswana. Ministry of Mineral Resources and Water Affairs, Gaborone.	
Le Roux, P.B.	1988	Report on the 1988 aerial game census, northeast Tuli Block, Botswana. Mashatu Game Reserve Management Authority.	
Lekgapho	1990	Khama III Memorial Museum. Review 1988-1989 Volume 1, Serowe.	Information on cultural and historic sites.
Lind, P.	----	Shashi - Limpopo rangers' report, 1973/74. Rennies Group Holdings. (Typescript).	Historic data on eastern Central District wildlife populations.
MLGL	1990	National Settlement Policy (draft). Department of Town and Regional Planning, Gaborone.	
MLGL Steering Group, WLPU & Environmental Consultants	1987	Environmental Impact Assessment Kolobeng and Metsemotlhaba Dam and Bokaa Dam. Final Report MLGL, Gaborone.	
MacDonald, M. & Partners	1987	Limpopo water utilisation study, Environmental Impact Assessment. Department of Water Affairs, Gaborone.	Describes natural resources of Limpopo River.
MacDonald, M. & Partners	1990	Motloutse dam feasibility study, Environmental Impact Assessment. Department of Water Affairs, Gaborone.	Describes natural resources of Motloutse River and impacts of dam construction.
Mallick, D.I.J., Habgood, F., & Skinner, A.C.	1981	A geological interpretation of Landsat imagery and air photography of Botswana. IGS Overseas Geology and Mineral Resources Report 56.	
Massey, N.W.D.	----	Resources Inventory of Botswana: Industrial rocks and minerals. Geological Survey Department, Lobatse.	As per title.
Mazonde, I.N.	1985	Problems of financing agricultural production in developing countries: a case study of the freehold ranches of the Tuli Block Botswana. National Institute of Dev. Research and Doc. Gaborone.	EEC markets and the production of arable crops in the Tuli Block.
McNaughton, S.J. & N.J. Georgiadis	1986	Ecology of Africa grazing and browsing mammals. Annual Rev. Ecol. Syst. 17: 39 - 65.	As per title - relates migrations to maintanance requirements (seasonality).
Meissner, H.H.	1982	Substitution values of various classes of farm and game animals in terms of a biologically defined large stock unit. Department of Agriculture. (RSA) Bulletin C.3, Pretoria.	

Bibliography

Author	Year	Title	Annotation
Nchunga, M.L.	1978	A study of the potential for commercial use of wildlife in the Northern Tuli Block. Botswana Department of Wildlife & National Parks, Gaborone.	As per title - 2 aerial surveys of the study area (census data).
Nord, M.	1985	Sand Rivers of Botswana - Phase II. Department of Water Affairs/SIDA. Gaborone.	
Page, B.R.	1990	Some ideas on management and monitoring in the northern Tuli conservation area, Botswana. Northern Tuli Conservation Association.	
Parker, I.C.S.	1975	Census of ostriches in Makgadikgadi Pans, Botswana. Wildlife Services Ltd., Nairobi (for Botswana Game Industries).	First aerial survey of Makgadikgadi, Ntwetwe and West Sowa Pans.
Parris, R.	1971	The ecology and behaviour of wildlife in the Kalahari. Botswana Notes and Records, Special Edition No. 1 96 - 107.	Migration patterns, seasonal requirements, use of pans.
Parris, R.	1976	A study of the major components of the Kalahari pan ecosystem. MSc Thesis, University of Pretoria, RSA.	Migration patterns, seasonal requirements, use of pans.
Parry, D.	1984	Maun - Wildebeest competition in the Lake Xau district, Botswana. BSc (Hons) Thesis. University of the Witwatersrand, RSA.	Competition for grazing and mortality of wildebeest.
Parry, D.	1987	Zebra die in Makgadikgadi. Kalahari Conservation Society newsletter No. 18 4.	Dry season mortality along Boteti and Western Makgadikgadi 1984-86.
Phiri, M.	1991	Nata Statelands land use plan (draft). Central District Land Use Planning Unit, Tutume.	
Piearce, G.D.	1986	How to save the Zambezi teak forests. Unasylva 152 (38: 29-36).	Ecology of Baikiaea woodlands on Kalahari Sands.
Raseroka, B.H.	1975	Past and present distribution of buffalo in Botswana. Botswana Notes and Records, 7: 131-140. Botswana Society, Gaborone.	Historic records of distribution for Central District.
Remmelzwaal, A.	1988	FAO Soil Classification for Botswana. Min. of Agriculture, Gaborone.	
Remmelzwaal, A.	1989a	Soils and land suitability for arable farming of south-east Central District. Field document 7. Soil Mapping and Advisory Services, Gaborone. (FAO/UNDP).	Presents results from soil surveys carried out in S.E. Central District.
Remmelzwaal, A.	1989b	Soils and land suitability for arable farming of south-east Central District. Field document 7, annex 1. Soil Mapping and Advisory Services, Gaborone. (FAO/UNDP).	Describes methods used in investigation and provides detailed descriptions and characterisations of 37 soil types.
SMEC, WLPU, & SGAB	1991	Botswana National Water Master Plan Study. Final Report Vol.6 Hydrology. Department of Water Affairs. Gaborone.	
Samboma, M.	1982	The survey of the Freehold Farms of Botswana. Animal Production Division, Ministry of Agriculture, Gaborone.	Study of the management problems that prevail in all the freehold farms - orientated towards the study of livestock management levels and utilisation of the various freehold farms.

Bibliography

Author	Year	Title	Annotation
Venema, J.H.	1980	Soils of north-eastern Botswana and their suitability for dryland farming. FAO/Ministry of Agriculture.	Progress report on soil survey and mapping programme (FAO/UNDP).
Viljoen, P.C.	1987	Report on an aerial survey of the eastern Tuli Block, Research Section, Kruger National Park, Republic of South Africa.	
Vossen, P.	1987	An analysis of agricultural livestock and traditional crop production statistics as a function of total annual and early, mid and late rainy season rainfall in Botswana. Dept.of Met. Services Gaborone	As per title.
Vossen, P.	1989	Contribution to the validation for Botswana of the agro-climatological concept of 'length of growing period'. Pedologie XXXIX-3 299-316.	The established relations between length of growing period, length of dry period and length of humid period, are used to propose agro-climatological suitability zones for rainfed crop production in Botswana.
WLPU	1990	Maginitude and Source of water population in Botswana. Department of Water Affairs. Gaborone.	As per title.
Walker, B.H.	1985	A preliminary analysis of potential environmental impact of the proposed Sua Pan soda ash project, Botswana. British Petroleum, London.	As per title.
Walker, B.H. and Noy-Meir, I.	1982	Aspects of the Stability and Resilience of Savanna Ecosystems. In: Huntley, B. J. and Walker, B.H. (Eds) 1982 Ecology of Tropical Savannas. Springer-Verlag, Berlin.	
Walker, C.	1977	Elephants of the Tuli. Afr. Wildlife 31 (5): 7 - 9.	Elephant population and movement patterns between Botswana and Zimbabwe.
Wellfield Consulting Services (Pty) Ltd.	1990	Serowe/Palapye Sub-District Water Points Survey. Inception report. Gaborone.	
Wellington, J.H.	1985	Southern Africa. A Geographical Study. Vol 1. Cambridge University Press.	
Wikner, T.	1980	Sand Rivers of Botswana - Phase 1. Department of Water Affairs/SIDA (2 Vols). Gaborone.	
Wikner, T.	1980	Sand Rivers of Botswana - phase I. Department of Water Affairs/SID (two volumes), Gaborone.	
Williamson, D.T. & Williamson, J.E.	1984	Botswana's fences and the depletion of Kalahari Wildlife. Oryx, (19):218 - 222.	Wildebeest and Kuke Fence.
Williamson, D.T. & Williamson, J.E.	1985	Kalahari ungulate movement study. Final report. Frankfurt Zoological Society/WWE/IUCN.	Migrations into Central District. Lake Xau region. Historic information.
Williamson, D.T. & Williamson, J.E.	1986	An assessment of the impact of fences on large herbivore biomass in the Kalahari. Botswana Notes and Records, 13: 107 - 110.	Wildebeest and Kuke Fence.

APPENDIX 3.1

VEGETATION TYPE: RECONCILIATION OF UNITS BETWEEN CD PLANNING STUDY, TIMBERLAKE AND ECOSURV

Appendix 3.1 Vegetation Types - Reconciliation of units between Central District Planning Study, Timberlake and Ecosurv

The following table is a reconciliation of vegetation units between the mapping for the Central District Planning Study, Timberlake's mapping of South Eastern Botswana and Ecosurv's mapping of the Nata Statelands.

CD PLANNING STUDY	TIMBERLAKE	ECOSURV
Bare Pan Surface		
Edaphic grassland		
Halophytic grassland		Halophytic grassland
Hyphaene savannah		
Burkea/Ochna savannah	A2	Burkea woodland on deep sands
Acacia erioloba savannah sericea	A1, B5, A5	Acacia erioloba, Terminalia and sands on broken calcrete
Baikiaea woodland		Baikiaea woodland on deep sands
Kirkia/Commiphora woodland		
Rocky hill woodland	C1, C2 .	
Acacia savannah	D1, D2, D3	Compact grey soils
Acacia nigrescens/Acacia nilotica savannah woodland	B3	
Colophospermum mopane/ Acacia woodland		Mopane on fine compact soils
Colophospermum mopane on shallow soils	B2	
Colophospermum mopane on sandy soils	A4	Shallow sands/C. mopane trees
Colophospermum mopane woodland/ shrubland		
Riverine woodland	E1, E2	

APPENDIX 3.2

SPECIES LISTS AND RELATIVE ABUNDANCIES

Appendix 3.2 Species Lists and Relative Abundance

The following appendix consists of lists of the woody sp· ·cies and grasses that were found at each stand and observation point visited whilst carrying out the field investigation for the Vegetation Ecology map. Relative abundance was only estimated for the woody species found In the stands.

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Ricinodendon rautanenii
10	o	Combretum psidioides
		Acacia nilotica
		Grewia flava
		Grewia bicolor
11	o	Acacia erioloba
		Tarchonanthus camphoratus
		Ricinodendron rautanenii
		Acacia fleckii
		Dichrostachys cinerea
		Acacia nilotica
		Acacia hebeclada
		Acacia tortilis
		Maytenus senegalensis
		Acacia erioloba
13	o	Burkea africana
		Ochna pulchra
		Bauhinia petersiana
		Rhus tenuinervis
		Dichrostachys cinerea
		Terminalia sericea
		Acacia nilotica
		Grewia flavescens
		Boscia albitrunca
		Maytenus senegalensis
		Grewia retinervis
		Acacia fleckii
		Croton gratissimus
		Rhigozum brevispinosum
		Diospyros lycioides
14	o	Ricinodendron rautanenii
		Commiphora glandulosa
		Cephalocroton mollis
		Grewia monticola
		Rhigozum brevispinosum
		Euclea divinorum
		Euclea crispa
		Grewia bicolor
		Tarchonanthus camphoratus
		Kirkia acuminata
		Combretum apiculatum
		Combretum hereroense
		Euphorbia neochinzii (ingens ?)
		Commiphora mollis

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Colophospermum mopane
		Terminalia prunioides
21	o	Acacia tortilis
		Grewia flava
		Rhus tenuinervis
		Acacia mellifera
		Ximenia americana
		Commiphora glandulosa
		Acacia arenaria
		Acacia nigrescens
22	o	Catophractes alexandri
		Grewia flava
		Combretum hereroense
		Acacia mellifera
		Acacia tortilis
		Acacia nigrescens
		Acacia erioloba
23	o	Acacia mellifera
		Acacia erioloba
		Acacia tortilis
		Tarchonanthus camphoratus
		Grewia flava
24	o	Colophospermum mopane
		Acacia mellifera
		Acacia tortilis
		Combretum hereroense
		Acacia nilotica
25	o	Combretum apiculatum
		Acacia nigrescens
		Combretum imberbe
		Dichrostachys cinerea
		Colophospermum mopane
		Grewia flava
		Grewia bicolor
		Rhigozum brevispinosum
26	o	Ricinodendron rautanenii
		Acacia nigrescens
		Colophospermum mopane
		Burkea africana
		Acacia ataxacantha
		Sclerocarya birrea
		Grewia flava

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Colophospermum mopane
31	o	Colophospermum mopane Terminalia prunioides Acacia nigrescens Acacia erioloba
32	o	Colophospermum mopane Grewia flava Dichrostachys cinerea Boscia rehmanniana ssp foetida Rhigozum brevispinosum
33	o	Acacia mellifera Acacia tortilis Acacia erioloba Terminalia sericea Colophospermum mopane
34	o	Acacia mellifera Acacia tortilis Acacia arenarea Colophospermum mopane Combretum imberbe Rhigozum brevispinosum
35	o	Combretum apiculatum Colophospermum mopane Sclerocarya birrea Commiphora glandulosa Commiphora mollis Acacia fleckii Commiphora mossambicensis Kirkia acuminata Grewia flavescens
36	o	Colophospermum mopane Acacia mellifera Acacia erubescens
37	o	Colophospermum mopane Combretum imberbe Lonchocarpus capassa Sclerocarya birrea
39	o	Kirkia acuminata

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Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Sclerocarya birrea
		Ricinodendron rautanenii
		Commiphora glandulosa
		Acacia nigrescens
		Grewia flava
		Grewia flavescens
		Grewia subspathulata
		Bauhinia petersiana
		Maytenus senegalensis
	50 o	Terminalia prunioides
		Colophospermum mopane
		Acacia erioloba
		Acacia nigrescens
	51 o	Colophospermum mopane
		Acacia erioloba
		Croton gratissimus
		Terminalia prunioides
	52 o	
		Colophospermum mopane
		Acacia grandicornuta
		Ximenia americana
		Acacia erubescens
		Mondulia sericea
		Croton gratissimus
		Acacia ataxacantha
		Boscia foetida ssp rehmanniana
	53 o	
		Colophospermum mopane
		Commiphora glandulosa
		Acacia grandicornuta
		Acacia erubescens
		Boscia foetida ssp rehmanniana
		Croton gratissimus
		Combretum apiculatum
		Rhigozum brevispinosum
		Grewia bicolor
		Dichrostachys cinerea
		Ximenia americana
	54 o	Combretum apiculatum
		Terminalia sericea
		Colophospermum mopane

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Combretum imberbe
		Terminalia sericea
63	o	Colophospermum mopane
		Acacia nigrescens
		Acacia fleckii
		Bauhinia petersiana
64	o	Burkea africana
		Grewia retinervis
		Grewia flava
65	o	Combretum imberbe
		Acacia tortilis
		Acacia nigrescens
		Colophospermum mopane
67	o	Acacia tortilis
		Acacia nilotica
		Acacia stuhlmannii
		Acacia arenaria
		Acacia grandicornuta
		Acacia borleae
		Acacia nebrownii
68	o	Acacia nigrescens
		Zisiphus mucronata
		Acacia tortilis
69	o	Terminalia sericea
		Croton gratissimus
		Acacia fleckii
		Acacia erioloba
		Ochna pulchra
		Bauhinia petersiana
		Burkea africana
70	o	Acacia robusta
		Acacia gerrardii
		Acacia erioloba
		Acacia nilotica
		Combretum hereroense
		Acacia tortilis
71	o	Acacia fleckii
		Acacia tortilis

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
82	o	Colophospermum mopane Combretum imberbe Commiphora hereroense Commiphora glandulosa
83	o	Colophospermum mopane Combretum apiculatum Commiphora glandulosa Rhigozum brevispinosum Acacia nigrescens
84	o	Terminalia sericea Combretum hereroense Combretum apiculatum Acacia fleckii Dichrostachys cinerea Grewia flava
85	o	Commiphora glandulosa Acacia erioloba Acacia nigrescens Combretum imberbe
86	o	Combretum apiculatum Terminalia sericea Euclea undulatum Ozoroa paniculosa Rhigozum brevispinosum
87	o	Acacia nigrescens Colophospermum mopane Combretum apiculatum Terminalia sericea
88	o	Colophospermum mopane Combretum imberbe Terminalia prunioides
89	o	Terminalia prunioides Terminalia sericea Colophospermum mopane
90	o	Albizia harveyi Kirkia acuminata Combretum mossambicensis

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Acacia ataxacantha
		Albizia anthelmintica
97	o	Colophospermum mopane
		Dichrostachys cinerea
		Grewia bicolor
98	o	Acacia nilotica
		Acacia nigrescens
		Acacia tortilis
		Terminalia prunioides
99	o	Colophospermum mopane
		Acacia erubescens
		Acacia erioloba
		Acacia tortilis
		Acacia ataxacantha
		Terminalia prunioides
		Combretum apiculatum
		Acacia nigrescens
100	o	Colophospermum mopane
		Acacia erubescens
		Combretum apiculatum
		Acacia mellifera
101	o	Colophospermum mopane
		Terminalia prunioides
		Acacia fleckii
		Acacia erioloba
		Acacia nilotica
		Acacia nigrescens
		Acacia ataxacantha
		Albizia harveyi
104	o	Kirkia acuminata
		Commiphora mollis
		Vangueria infausta
		Albizia harveyi
		Commiphora glandulosa
		Colophospermum mopane
		Cissus cornifolia
		Terminalia prunioides
		Acacia tortilis
		Combretum apiculatum
		Lannea stuhlmannii
		Dichrostachys cinerea

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Combretum imberbe
115	o	Colophospermum mopane
		Acacia erubescens
		Kirkia acuminata
		Terminalia prunioides
		Lonchocarpus capassa
116	o	Combretum imberbe
		Combretum hereroense
		Zisiphus mucronata
		Terminalia randii
		Acacia erubescens
		Acacia karoo
117	o	Colophospermum mopane
		Combretum imberbe
		Dichrostachys cinerea
118	o	Commiphora glandulosa
		Acacia erubescens
		Acacia nigrescens
		Kirkia acuminata
		Combretum apiculatum
119	o	Kirkia acuminata
		Acacia erubescens
		Commiphora mossambicensis
		Commiphora mollis
		Colophospermum mopane
		Sclerocarrya birrea
		Acacia nigrescens
		Albizia anthelmintica
120	o	Kirkia acuminata
		Combretum apiculatum
		Commiphora glandulosa
		Acacia nigrescens
		Commiphora mossambicensis
		Colophospermum mopane
		Terminalia prunioides
121	o	Grewia monticola
		Commiphora glandulosa
		Dalbergia melanoxylon
		Grewia bicolor
		Colophospermum mopane
		Dichrostachys cinerea
		Combretum apiculatum
		Combretum hereroense

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
130	o	Colophospermum mopane Dalbergia melanoxylon Acacia senegal Commiphora glandulosa Dichrostachys cinerea Grewia bicolor Grewia flava Terminalia sericea Albizia anthelmintica
131	o	Albizia anthelmintica Dalbergia melanoxylon Acacia fleckii Dichrostachys cinerea Colophospermum mopane Acacia nigrescens Sclerocarya birrea
132	o	Commiphora angolensis Bauhinia petersiana Acacia fleckii Commiphora glandulosa Vangueria infausta Acacia harveyi Combretum collinum Combretum apiculatum Grewia bicolor
133	o	Terminalia prunioides Catophractes alexandri Colophospermum mopane Acacia mellifera
134	o	Colophospermum mopane Grewia bicolor Acacia nigrescens Grewia villosa Dichrostachys cinerea Catophractes alexandri Commiphora glandulosa Rhigozum brevispinosum
135	o	Colophospermum mopane Lonchocarpus capassa Acacia nigrescens

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Site no.	Stand/ Obs pt	Woody species and Relative Abundance	>3 m	0.5-3 m	<0.5 m
	8 s				
		Catophractes alexandri		2	
		Sesamothamnus lugardii		2	
		Commiphora angolensis		2	
		C. pyracanthoides		2	
		Aloe marlothii		2	
		Boscia foetida ssp. rehmanniana		2	
		Rhigozum brevispinosum		2	
		Grewia bicolor			
		G. flava			
		Terminalia prunioides			
		Acacia erubescens			
	12 s		>3 m	0.5-3 m	<0.5 m
		Acacia erioloba	2		
		A. fleckii	+		
		Terminalia sericea	+	+	
		Grewia retinervis		1	
		Dichrostachys cinerea	2	1	
		Tarchonanthus camphoratus		1(pockets)	
		Combretum hereroense (glabrus and hairy)		+	
		Grewia flava		+	
		Ziziphus mucronata	+	+	
		Rhus tenuinervis		+	
		Acacia hebeclada			
		Maytenus senegalensis		+	
		Ozoroa paniculosa			
		Acacia nilotica			
		A. tortilis		+	
		Combretum apiculatum	+		
		Elephantorrhiza elephantina			+
		Grewia flavescens var.olukondae			
	38 s		>3 m	0.5-3 m	<0.
		Colophospermum mopane		1	
		Acacia tortilis	1		
		Combretum apiculatum	+	+	
	40 s		>3 m	0.5-3 m	<0 m
		Sclerocarya birrea			
		Acacia nigrescens			
		Commiphora glandulosa			
		Dichrostachys cinerea			
		Albizia harveyi			
		Colophospermum mopane			2

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Site no.	Stand/ Obs pt	Woody species and Relative Abundance			
		Ozoroa paniculosa			
		Colophospermum mopane			
		Acacia fleckii			
		Bolosanthus speciosus			
		Bauhinia petersiana			
		Flueggia virosa			
		Terminalia sericea			
	48 s		>3 m	0.5-3 m	<0.5m
		Colophospermum mopane	2		
		Acacia robusta			
		Grewia villosa			
		Acacia tortilis			
		Boscia foetida ssp. rehmanniana			
		Grewia bicolor			
		Terminalia prunioides	1		
		Dichrostachys cinerea			
		Kirkia acuminata	+		
		Commiphora mollis			
		C. glandulosa			
		C. angolensis			
		Croton gratissimus			
		Acacia nigrescens	+		
	56 s		>3 m	0.5-3 m	<0.
		m			
		Colophospermum mopane	1	2	
		Terminalia prunioides	+	1	
		Combretum apiculatum		+	
		Grewia flava		1	
		Rhigozum brevispinosum		+	
		Acacia erioloba	1	1(2)	
		A. nigrescens	+	+	
		Terminalia sericea	(dead)	+	
		Bauhinia petersiana		+	
		Combretum hereroense		+	
		Rhus tenuinervis		+	
		Grewia monticola		+	
		Ozoroa paniculosa		+	
		Croton gratissimus		+	
		Dichrostachys cinerea		+	
		Mondulia sericea		+	
		Commiphora glandulosa		+	
		C. mollis		+	
		Acacia chariessa			
		Maytenus senegalensis		+	
	59 s		>3 m	0.5-3 m	<0.5
		Colophospermum mopane	1	2	

Site no.	Stand/ Obs pt	Woody species and Relative Abundance	>3 m	0.5-3 m	<0.5
102	s				
		Ricinodendron rautanenii	+		
		Combretum collinum	1	2	
		Terminalia sericea	+	+	
		Acacia ataxacantha	+		
		Bauhinia petersiana		+	
		Cassia abbreviata	+		
		Lonchocarpus capassa	+	+	
		Albizia amara		+	
		Albizia harveyi		+	
		Vangueria infausta		+	
		Combretum apiculatum	+		
		Acacia erubescens	(+)		
103	s		>3 m	0.5-3 m	<0.5
		Markhamia acuminata	1	1	
		Steganotaenia araliacea	+	+	
		Pappea capensis	+		
		Commiphora mollis	3		
		C. marlothii	+		
		Ficus sp.	+		
		Sclerocarya birrea	1		
		Lannea stuhlmannii			
		Kirkia acuminata	+		
		Grewia flavescens		1	
		Canthium burtti	1		
		Albizia amara	+		
		Lonchocarpus capassa	+		
		Croton gratissimus		+	
		Erythrina latissima	+		
		Gardenia resiniflua	+		
110	s		>3 m	0.5-3 m	<0.5
		Colophospermum mopane	1	4	
		Terminalia prunioides	+	+	1
		Acacia nigrescens	+-1	+	
		Commiphora glandulosa			+
		Grewia bicolor			+
		Euclea crispa			+
		Aloe littoralis		+	
		Grewia flava		+	
		Combretum apiculatum			rar
111	s		>3 m	0.5-3 m	<0.5
		Dalbergia melanoxylon	+-1		

Site no.	Stand/ Obs pt	Woody species and Relative Abundance		
		Boscia albitrunca	+	
		Commiphora angolensis		+-1

Site no.	Stand/ Obs pt	Grass species
45	o	
49	o	
50	o	
51	o	
52	o	
53	o	Eragrostis porosa
		Stipagrostis uniplumis
54	o	
55	o	
57	o	
58	o	
60	o	
61	o	
62	o	
63	o	
64	o	
65	o	
67	o	Chloris virgata
		Cymbopogon caesius
		Panicum coloratum
		Setaria incrassata
		Sorghum versicolor
		Sporobolus cordofanus
68	o	
69	o	
70	o	
71	o	
72	o	
74	o	
75	o	
76	o	
77	o	
78	o	
79	o	
80	o	
81	o	Aristida adscensionis
		A. congesta
		A. stipitata
		Cymbopogon caesius
		Digitaria milanjiana
		Enneapogon cenchroides
		Eragrostis rigidior
		Heteropogon contortus
82	o	
83	o	
84	o	
85	o	

Site no.	Stand/ Obs pt	Grass species
		A. congesta
		Eragrostis aspera
		Melinis repens
		Tragus berteronianus
128	o	Aristida adscensionis
		A. rhiniochloa
		Panicum maximum
		Sporobolus cordofanus
129	o	Dichanthium annulatum var. papillosum
		Ischaemum afrum
		Setaria incrassata
		Sorghum versicolor
130	o	Cynodon dactylon
		Enneapogon cenchroides
		Eragrostis porosa
		Stipagrostis uniplumis
		Tragus beteronianus
		Urochloa brachyura
131	o	Aristida congesta
		A. meridionalis
		Cynodon dactylon
		Dactyloctenium giganteum
		Eragrostis rigidior
		Urochloa brachyura
132	o	
133	o	
134	o	
135	o	
136	o	
137	o	
138	o	
139	o	
140	o	
1	s	Aristida congesta
		A. stipitata
		Digitaria milanjiana
		Eragrostis cilianensis
8	s	Aristida congesta
		Eragrostis porosa
		Stipagrostis uniplumis
12	s	Aristida barbicollis
		Stipagrostis uniplumis
38	s	Aristida barbicollis
		Chloris virgata
		Eragrostis porosa

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Site no.	Stand/ Obs pt	Grass species
		Eragrostis superba
		Fingerhuthia africana
		Heteropogon contortus
		Panicum coleratum
		Setaria incrassata
		Sorghum versicolor
73	s	Aristida adscensionis
		A. rhiniochloa
		Enneapogon cenchroides
		Eragrostis porosa
		Tragus berteronianus
94	s	Aristida rhiniochloa
		Digitaria milanjiana
		Heteropogon melanocarpus
		Melinis repens
		Setaria pumila
102	s	Aristida barbicollis
		Eragrostis porosa
		Eragrostis rigidior
		Tragus berteronianus
103	s	Aristida adscensionis
		Brachiaria deflexa
		Enteropogon macrostachys
		Eragrostis aspera
		E. porosa
		Setaria petiolata
		S. pumila
		Tragus berteronianus
		Urochloa panicoides
110	s	Enteropogon macrostachys
		Eragrostis sp.
		Heteropogon contortus
		Sporobolus cordofanus
111	s	Aristida rhiniochloa
		Brachiaria deflexa
		Enteropogon macrostachys
		Eragrostis superba
		Sporobolus festivus
113	s	Aristida adscinsionis
		Enteropogon macrostachys
		Schmidtia pappophoroides
		Urochloa oligotricha
		U. trichopus

APPENDIX 5.1

ARCHAEOLOGICAL SITES

Appendix 5.1 Archaeological Sites

The following sheet is an example of the data base of sites of archaeological or historical significance in Central District (as provided by the National Museum and Art Gallery). More detailed information on archaeological sites in Central District may be obtained from the District Commissioner's Office (District Officer Lands) or the National Museum.

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EXAMPLE LISTING OF SITES OF ARCHAEOLOGICAL SIGNIFICANCE

Number	Site Name	Type	Description	UTM - X	UTM - Y
1	Matsiara	LSA/IA	Flaked stone artifacts, potsherds,stone walls, ground stone.	212000.0	7758600.0
2	Khumaga	LSA/IA	F S Ground stone	240800.0	7734600.0
3	N Zaoga	LSA/IA	F S bone,shell,pot sherds,charcoal fruits,ash middens	229000.0	7707300.0
4	N Zaoga	LSA/IA	F S pot sherds, metal, bone, shell, glass	229200.0	7707900.0
5	Tsoe	LSA/IA	F S, ground stone,potsherds,bone, glass	230100.0	7715000.0
6	Mapundu	IA	Potsherds, charcoal, fruits.	233000.0	7719900.0
7	Mapundu	LSA/IA	F S,potsherds, charcoal, fruits	233400.0	7720500.0
8	Tomane	IA/MSA	G S, potsherds, shell	233600.0	7722100.0
9	Dikwalo	IA	P S, bone, shell stone walls	235900.0	7726000.0
10	Ramokwate	LSA/IA	F S, G S bone, shell, charcoal ,fruits	236600.0	7727200.0
11	Rampatwa	IA	Potsherds,charcoal,fruits	237800.0	7727900.0
12	Rampatwa	LSA	F S, shell	238500.0	7728600.0
13	Sukwane	LSA/IA	F S, P S	226500.0	7685100.0
14	Sukwane	IA	Potsherds	226100.0	7685400.0
15	Sukwane	LSA/IA	F S, P S	225800.0	7686100.0
16	Sukwane	LSA/IA	F S, P S	225700.0	7687100.0
17	Sukwane	IA	P S shell	225500.0	7688000.0
18	Sukwane	LSA/IA	F S, P S, shell	226200.0	7688400.0
19	Sukwane	IA	P S.	226000.0	7689100.0
20	Sukwane	IA	P S.	225700.0	7694300.0
21	Sukwane	LSA/IA	F S, G S, P S, bone.	226100.0	7696500.0
22	Sukwane	MSA/LSA/IA	F S, G S, P S, bone, shell	227000.0	7699200.0
23	Zaoga	MSA/LSA/IA	F S, G S, P S, bone.	228500.0	7701900.0
24	Zaoga	LSA/IA/LIA	F S, G S, P S, metal (adze).	229500.0	7702500.0
25	Zaoga	IA	P S, bone (tool)shell	229600.0	7703200.0
26	Gweta	LSA		319500.0	7766400.0
27	Gutsha	MSA/LSA/Historical	Greens Pan/Baobab, Flaked stone, Ground stone	315100.0	7740600.0
28	Gabasadi	MSA/LSA	Flaked stone,Ground stone	313500.0	7716500.0
29	Ntwetwe Pan	MSA Fossil Bone		312000.0	7727500.0
30	Ntwetwe Pan	MSA		310400.0	7729000.0
31	Kudu Island East	LSA/IA	Flaked stone,pot sherds	378200.0	7689500.0
32	Kubu Island North	LSA/IA	F S, P S,bone (tooth)	378000.0	7690000.0
33	Kubu Island West	LSA/IA	F S, P S	376400.0	7689300.0
34	East Hare Island	LSA/IA	F S, G S, P S.	377500.0	7683100.0
35	West Hare Island	LSA/IA	F S, G S, P S.	376300.0	7683200.0
36	Sua Pan/Toranju/Tswane	LSA/LIA	Settlement valley F S, P S stone walls,(threatened by mining)	414600.0	7716900.0
37	Sua Pan\Torandjo\Tswane	EIA	P S	412200.0	7715200.0

APPENDIX 6.1

SETTLEMENT NAMES

Appendix 6.1 Settlement Names

For reference, settlements with a population greater than 250 in the 1991 Census are listed together with their unique digitized code. The code was used to give the settlements a geographical location and were digitized from the Census maps. It should be noted that the location of some of the smaller settlements is not very accurate.

List of Localities with populations over 250

Locality Name	CENDIS_ID GIS Code
Lepasha	5403103
Lephaneng	5006601
Lepokole	5203501
Lerala	5006701
Lesenepole	5007901
Lesenpole (Matolwane)	5007601
Letlhakane	5100701
Letlhakane	5300101
Letlole (Letloreng)	5102705
Maape (Maope)	5105202
Mabasekwa	5403610
Mabate	5202604
Mabeleapudi	5010101
Mabolwe	5203101
Machaneng	5101801
Maekowane	5202201
Mafungo	5404702
Mafungo Lands	5404802
Magapatona	5404102
Mahalapye	5109501
Maiswe	5206201
Maitengwe	5401701
Majwaneng	5006401
Makadibeng	5202506
Makalamabedi	5302901
Makhubung	5408101
Makobo	5405601
Makobo	5405601
Makoboxana	5301108
Makomotu	5408209
Makoro	5003801
Makuta	5403903
Makutumela	5401002
Makwa	5012006
Makwate	5101701
Malaka	5005601
Malaka	5005602
Malete	5104401
Manaledi/Madiokane	5006003
Mantsibudu	5103902
Maokwe	5005301
Maotakgang	5404301
Marapong	5404501
Masama (Village)	5003101
Masiadieme	5206101
Matapodza	5404801
Matau	5103502
Mathangwane	5405201
Mathangwane Lands	5405101
Mathathane	5202301
Matlhakola	5005702
Matlhakola	5005703
Matobo	5404001
Matsagane	5206901
Matsiro	5400704
Matsitama	5403301
Matulungundu	5401502
Maunatlala	5007401
Metseaela	5300725

List of Localities with populations over 250

Locality Name	CENDIS_ID GIS Code
Ngwapa 1	5103803
Nkange	5401201
Nshakashogwe	5404302
Nshakashogwe Lands	5404401
Nsuswane	5400701
Nswazwi	5404201
Ntala	5404701
Nthane (Village)	5304102
Orapa	101
Otse	5107212
Paje	5010301
Pakame	5006903
Palapye	5004001
Palapye	5106808
Palla Road (Dinokwe)	5100803
Phokoje	5205403
Pilikwe	5105401
Poloka	5107418
Radisele	5012301
Radisele Lands 1	5105601
Rakops	5302201
Ramokgonami	5104701
Ratholo	5006201
Rramohakamme	5407802
Sebalwe	5205806
Sebina	5404601
Sebina Lands	5404901
Sefhare	5103001
Sefhophe	5200901
Segakwana	5003601
Sekgarapane	5006104
Selebi Phikwe	102
Seleka (Tumasera)	5104101
Seletswe	5202402
Semitwe	5405002
Semitwe (Village)	5405002
Semolale	5203001
Senete	5401101
Seoka	5008305
Seoka	5201404
Seolwane	5007201
Sepa La Moriri	5201603
Sepako	5402414
Serowe	5000101
Serule	5012701
Serutswang	5006505
Sesarweng	5008002
Setatse	5005101
Shakwe	5102101
Shashe	5406401
Shashe Mooke	5405901
Shashe Mooke Lands	5405802
Shoshong	5108501
Sokonya (Sukunga)	5105505
Sokwane	5302603
Sokwe	5010405
Sowa	103
Talana Farms	5208138
Tamasane	5009202

APPENDIX 10.1

DATA BASES FOR FACILITIES BY VARIOUS INSTITUTIONS

Appendix 10.1 Data Bases for Facilities by Various Institutions

The following data bases are included in this appendix : Agriculture (VAs and ADs), Council, Education, Health, Tribal Administration and Water Supplies.

List of Localities with Crop Production of Field Services Facilities
(Ministry of Agriculture)

Locality	Agricultural District	Regional Agricultural Officer (Number)	Assistant District Agricultural Officer	District Agricultural Officer (Number)	Agricultural Demonstrator (Number)
Palapye	Palapye			1	1
Palla Road	Mahalapye				1
Pilikwe	Machaneng				1
Poloka	Mahalapye				1
Radisele	Mahalapye				1
Rakops	Letlhakane				1
Ramokgonami	Machaneng				1
Ratholo	Palapye				1
Sebina	Tutume				1
Sefhare	Machaneng				1
Sefhophe	Bobonong				1
Seleka	Machaneng				1
Selolwane	Tutume				1
Semolale	Bobonong				1
Serowe -east/west	Serowe	1	1	1	2
Serule	Palapye				1
Shakwe	Machaneng				1
Shashe	Tonoto				1
Shashe Mooke	Tonoto				1
Shoshong -east/west	Mahalapye				2
Tamasane	Palapye				1
Taupye	Mahalapye				1
Thokolo	Mahalapye				1
Tlhabala	Serowe				1
Tlhalogang	Tonoto				1
Tobane	Bobonong				1
Tonota -east/west	Tonoto				2
Topisi	Palapye				1
Tsetsejwe	Bobonong				1
Tshetlhong	Serowe				1
Tshimoyapula	Serowe				1
Tutume	Tutume			1	
Xhomo	Letlhakane				1
Xhumaga	Letlhakane				1

List of Localities with Veterinary Facilities

Locality	Agricultural District	Senior Veterinary Officer (Number)	Veterinary Officer (Number)	Senior Livestock Officer (Number)	Veterinary Assistant (Number)
Tsetsejwe	Serowe				1
Tshimoyapula	Serowe				2
Tutume	Tutume			1	2
Xhomo	Orapa				1
Xhumaga	Orapa				1

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List of Localities with Educational Facilities

Locality	Primary School (Number)	Junior Secondary School (Number)	Senior Secondary School (Number)	Brigade (Number)	Education Officer
Bobonong	6	3	1	1	Education Officer
Bonwapitse	1	0	0	0	
Borolong	1	0	0	0	
Borotsi	1	0	0	0	
Chadibe	1	0	0	0	
Chadibe	1	0	0	0	
Changate	1	0	0	0	
Dagwi	1	0	0	0	
Dibete	1	0	0	0	
Dimajwe	1	0	0	0	
Dovedale	1	0	0	0	
Dukwe	1	1	0	0	
Gojwane	1	0	0	0	
Goosekgweng	1	0	0	0	
Gootau	1	1	0	0	
Goshwe	1	0	0	0	
Gweta	3	1	0	1	
Ikongwe	1	0	0	0	
Jamataka	1	0	0	0	
Kalamare	1	1	0	0	
Kedia	1	0	0	0	
Kgagodi	1	0	0	0	
Kobojango	1	0	0	0	
Kodibeleng	1	0	0	0	
Kudumatse	1	0	0	0	
Kutamgoree	1	0	0	0	
Lecheng	0	1	0	0	
Lentswelemoriti	1	0	0	0	
Lepasha	1	0	0	0	
Lerala	2	1	0	0	
Letlhakane	3	1	1	0	Education Officer
Maape	1	0	0	0	
Mabeleapudi	1	1	0	0	
Mabolwe	1	0	0	0	
Machaneng	1	1	0	0	
Madiba	0	0	0	1	
Magapatona	1	0	0	0	
Mahalapye	13	3	1	1	Education Officer
Maitengwe	2	1	0	0	
Majwaneng	1	0	0	0	
Makalamabedi	1	1	0	0	
Makobo	1	0	0	0	
Makwate	1	0	0	0	
Malaka	1	0	0	0	
Malatswae	1	0	0	0	
Maokatuma	1	0	0	0	
Maposa	1	0	0	0	
Merapong	2	1	0	0	
Mathangwane	1	1	0	0	
Mathathane	1	0	0	0	
Matlhako	1	0	0	0	
Matlhakola	1	0	0	0	
Matobo	1	0	0	0	
Matolwane	1	0	0	0	
Matsitama	1	0	0	0	
Maunatlala	1	1	0	0	
Mhalapitsa	1	0	0	0	
Mmadikola	1	0	0	0	

List of Localities with Educational Facilities

Locality	Primary School (Number)	Junior Secondary School (Number)	Senior Secondary School (Number)	Brigade (Number)	Education Officer
Seolwane	1	0	0	0	
Sepako	1	0	0	0	
Serowe	19	4	1	1	Regional Educational
Serule	1	1	0	0	
Shakwe	1	0	0	0	
Shashe	0	0	1	1	
Shashe Mooke	1	0	0	0	
Shoshong	3	1	0	1	
Sowa	2	0	0	0	
Tamasane	1	0	0	0	
Taupye	1	0	0	0	
Tlapalakoma	1	0	0	0	
Tlhabala	1	0	0	0	
Tobane	1	0	0	0	
Tonota	6	2	0	0	Education Officer
Topisi	1	0	0	0	
Toromoja	1	0	0	0	
Tsetsejwe	1	1	0	0	
Tshimoyapula	1	0	0	0	
Tutume	6	2	1	1	Education Officer
Two Rivers	1	0	0	0	
Xhomo	1	0	0	0	
Xhumaga	1	0	0	0	
Zoroga	1	0	0	0	

List of Localities with Health Facilities
(Only most senior faciltiy listed)

Locality	Health District	Type of Facility
Maitengwe	Tutume	Health Clinic
Majwanaadipitse	Serowe	Health Post
Majwaneng	Serowe	Health Post
Makadibeng	Bobiwra	Health Stop
Makalamabedi	Boteti	Health Stop
Makoba	Serowe	Health Stop
Makobo	Tutume	Health Stop
Makoro	Serowe	Health Stop
Makwa	Serowe	Health Stop
Makwate	Mahalapye	Health Post
Malaka	Serowe	Health Post
Marapong	Tutume	Health Clinic
Martin's Drift	Serowe	Health Stop
Mathangwane	Tutume	Health Clinic
Mathathane	Bobiwra	Health Clinic
Matlhakola	Serowe	Health Post
Matobo	Tutume	Health Post
Matsitama	Tutume	Health Post
Matulungundu	Tutume	Health Stop
Maunatlala	Serowe	Health Clinic
Metseaela	Boteti	Health Stop
Mhalapitsa	Mahalapye	Health Post
Mmadikola	Boteti	Health Post
Mmakgama	Boteti	Health Stop
Mmanxotae	Tutume	Health Post
Mmapetsa (Mapatse)	Tutume	Health Stop
Mmaphashalala	Mahalapye	Health Post
Mmashoro	Serowe	Health Clinic
Mmatshumo	Boteti	Health Post
Mmutlane	Mahalapye	Health Post
Moeng College	Serowe	Health Clinic
Mogapi	Serowe	Health Post
Mogome	Serowe	Health Post
Mogonono	Mahalapye	Health Stop
Mogorosi	Serowe	Health Post
Moijabana	Serowe	Health Post
Mokgware	Serowe	Health Post
Mokobeng	Mahalapye	Health Post
Mokolwane	Boteti	Health Stop
Mokoswana 1	Mahalapye	Health Post
Mokubilo	Tutume	Health Post
Molalatau	Bobiwra	Health Post
Moletamane	Bobiwra	Health Post
Mookane	Mahalapye	Health Clinic
Mopipi	Boteti	Health Clinic
Moralane	Mahalapye	Health Stop
Moremi	Serowe	Health Post
Moreomabele	Serowe	Health Stop
Moreomaoto	Boteti	Health Post
Morukutshwane	Serowe	Health Stop
Morupule	Serowe	Health Clinic
Mosalakwane	Bobiwra	Health Stop
Mosetse	Tutume	Health Post
Moshakabela	Bobiwra	Health Stop
Mosolotswane	Mahalapye	Health Post
Mosopha	Mahalapye	Health Post
Mosu	Boteti	Health Post
Mosu	Tutume	Health Stop
Mosweu	Serowe	Health Post

List of Localities with Health Facilities
(Only most senior faciltiy listed)

Locality	Health District	Type of Facility
Tsotsoga	Boteti	Health Stop
Tutume	Tutume	Primary Hospital
Two Rivers	Serowe	Health Post
Xhomo	Boteti	Health Post
Xhumaga	Boteti	Health Post
Zaoga	Boteti	Health Stop
Zoronga	Tutume	Health Post

List of Localities with Tribal Adminstration Facilities

Locality	Senior Chiefs Representative (Number)	Chiefs (Number)	Headman (Number)	Headman Arbitration (Number)
Mokobeng	0	0	1	0
Mokoswane	0	0	1	0
Mokubilo	0	0	1	0
Molalatau	0	0	1	0
Molatswae	0	0	1	0
Moletamane	0	0	2	1
Mookane	1	1	1	0
Mopipi	0	0	1	0
Moremi	0	0	2	1
Moreomabele	0	0	2	1
Moreomaoto	0	0	1	0
Mosetse	0	0	1	0
Mosolotswane	0	0	1	0
Mosopha	0	0	1	0
Mosu	0	0	1	0
Motlhabaneng	0	0	1	0
Motlopi	0	0	1	0
Motshegaletau	0	0	2	1
Nalale	0	0	2	1
Nata	1	1	0	0
Nkange	0	0	1	1
Nswazwi	0	0	1	0
Paje	0	0	1	0
Palapye	1	1	0	1
Palla Road	0	0	1	0
Pilikwe	0	0	1	0
Poloka	0	0	1	0
Radisele	0	0	1	0
Rakops	1	1	0	0
Ramokalwane	0	0	1	0
Ramokgonami	1	1	0	0
Rasesa	0	0	1	0
Ratholo	0	0	1	0
Sebina	0	1	1	0
Sefhare	1	1	0	1
Sefhophe	0	1	1	0
Semolale	0	0	1	0
Senete	0	0	2	1
Seolwane	0	0	1	1
Sepako	0	0	1	0
Serowe	1	1	1	1
Serule	0	1	0	0
Shakwe	0	0	1	0
Shashe	0	0	1	0
Shashe Mooke	0	0	1	0
Shoshong	1	1	0	1
Tamasane	0	0	1	0
Taupye	0	0	1	1
Tlhabala	0	0	1	0
Tobane	0	0	1	0
Tonota	1	1	0	1
Topisi	0	0	1	0
Toromoja	0	0	1	0
Tsetsejwe	0	1	0	0
Tshimoyapula	0	0	1	0
Tshokatshaa	0	0	1	0
Tumasera	0	0	1	1
Tutume	1	1	0	0
Xhomo	0	0	1	0
Xhumaga	0	0	1	0
Zoroga	0	0	1	0

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List of Localities with a Water Supply

Locality	Supplier	Council Adminstration Region
Maumo	Council	502
Maunatlala	Council	504
Mhalapitsa	Council	511
Mmadikola	Council	532
Mmadinare	Council	523
Mmadunyane	Council	542
Mmanxotae	Council	543
Mmephashalala	Council	513
Mmashoro	Council	501
Mmatshumo	Council	531
Mmutlane	Council	513
Mogapi	Council	504
Mogapinyana	Council	504
Mogolori	Council	513
Mogome	Council	502
Mogorosi	Council	502
Moijabana	Council	502
Mokganewe	Council	514
Mokgware	Council	502
Mokhungwana	Council	503
Mokobeng	Council	512
Mokokwane	Council	503
Mokoswana 1	Council	513
Molalatau	Council	522
Molatswae	Council	501
Moletamane	Council	522
Moletji	Council	522
Mookane	Council	513
Mopipi	Council	531
Moremi	Council	504
Moreomabele	Council	501
Moreomaoto	Council	532
Mosetse	Council	543
Mosolotswane	Council	514
Mosopha	Council	511
Mosu	Council	531
Mosupe	Council	542
Motlopi & Tsoodobe	Council	532
Motshegaletau	Council	502
Nata	Council	543
Natale	Council	542
Ngwapa 1	Council	512
Nkange	Council	541
Nshakashogwe	Council	541
Nswazwi	Council	541
Orapa	Private	0
Otse	Council	514
Paje	Council	501
Palapye	DWA	0
Palla Road	Council	513
Phakwe	Council	521
Pilikwe	Council	511
Poloka	Council	514
Polometsi	Council	521
Radisele	Council	502
Rakops	Council	532
Ramokgonami	Council	511
Rasesolo	Council	511
Ratholo	Council	503