WATER AND SANITATION
FOR HEALTH PROJECT

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DROUGHT, RURAL WATER SUPPLY, AND EMERGENCY NEEDS IN BOTSWANA

WASH FIELD REPORT NO. 229

FEBRUARY 1988

Prepared for
the USAID Office of Foreign Disaster Assistance
and the USAID Mission in Botswana
WASH Activity No. 428

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under WASH Activity No. 428

by

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and
Jonathan Hodgkin

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ACRONYMS

BRS	Borehole Repair Service
CTO	Central Transport Organization
DEE	Department of Electrical Engineering
DGS	Department of Geological Survey
DWA	Department of Water Affairs
EEC	European Economic Community
GOB	Government of Botswana
IMDC	Inter-Ministerial Drought Committee
LWF	Lutheran World Federation
MCI	Ministry of Commerce
MFDP	Ministry of Finance and Development Planning
MLGL	Ministry of Local Government and Lands
MMRWA	Ministry of Mineral Resources and Water Affairs
MoA	Ministry of Agriculture
MWTC	Ministry of Works, Transport and Communications
NWDC	North-West District Council
ODA	Overseas Development Administration
OFDA	Office of Foreign Disaster Assistance
RAD	Remote Area Dwellers
RSA	Republic of South Africa
SACU	Southern Africa Customs Union
SIDA	Swedish International Development Authority
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WAS	Water Administration Study
WASH	Water for Sanitation and Health
WMU	Water Maintenance Unit
WUC	Water Utilities Corporation

EXECUTIVE SUMMARY

Botswana is now in the seventh year of drought which has severely depleted the groundwater reservoir on which the country depends. Boreholes are drying up in many areas. The situation is particularly critical in the eastern part of the country where higher population densities (greater water need) and hydrogeological conditions make the location of new supplemental drilled wells difficult. This situation has caused substantial disruption of life and caused increased human suffering particularly in rural areas. To date, no human deaths can be directly attributable to the drought due in large part to the continuing effective relief efforts of the Government of Botswana (GOB). These efforts have included a substantial program of trucking water to the most drought stricken villages. During a three month period in late 1987, it became necessary to transport water to Mahalapye, a village of over 30,000. Many rural area dwellers have found it necessary to migrate to villages and towns as crops have failed, livestock died, and traditional water sources dried up. Roughly half of the country's population are now recipients of the GOB's supplemental feeding Program. Livestock mortality is reaching 25 percent with about half attributable to drought conditions. At the end of 1987, mortality reached 35 percent and a 40 percent mortality of draft animals was reported in some areas. Plowing was delayed and planting was late in all areas. A poor harvest is predicted even if normal rains occur during the balance of the season. Recent rains have not eased public water supply problems even though a general greening of the countryside has resulted. An end to the drought is far from assured. If the rains fail now, as they did last year, the water supply situation could easily become desperate.

In direct response to the potable water needs in many areas, the GOB Cabinet has directed the Department of Water Affairs (DWA) to mount an emergency effort to drill new wells in the most severely affected villages. A priority list of 57 villages with a estimated population of possibly 100,000 people has been assembled from a total list of some 800 locations. Failing water supplies, attributed to drought conditions, is cited as the reason for placement of practically all of the 57 villages on the list. Major funding will be by the GOB, from its own reserves. It is anticipated that this emergency program, along with some continuation of other on-going programs will involve all major private sector companies capable of siting and drilling wells. The Director of DWA, Mr. Moremi Sekwale, along with other GOB officials, confirms that constraints include inadequate transportation facilities, lack of well siting capacity, lack of drilling supervisory capacity and, most pressing at this time, the poor condition of DWA well drilling equipment as well as the delays inherent in GOB procedures for procuring spares and technical assistance to address this situation.

At the present time, only one new rotary rig, one 9-year-old rotary rig overhauled in 1987, and one new percussion rig are in satisfactory working order. Eleven others, comprising the entire public water well drilling capability, are in desperate need of major overhaul. DWA has the capability to overhaul and parts in hand, or on order, for overhauling 7 percussion rigs. They have, however, neither the capability to overhaul, nor the budget to acquire parts for 2 USAID provided Schramm and 2 Atlas-Copco air rotary rigs which represent the major part of DWA's potential drilling production. Even in their poorest year, to date, those 4 rotary rigs drilled 4 times the footage accomplished by the percussion rigs. In good condition, each rig should be capable of drilling up to 3.5 wells per month, but, during January, not one well has been completed by any of the four. The records show 138 completed wells in 1984/85, of which 99 were actually drilled by DWA's own equipment. DWA's completed wells fell nearly 20 percent in 1986/87 with 80 completions.

The DWA Director, Mr. Moremi Sekwale, confirmed the poor condition of 4 of DWA's rotary drill rigs and requested that the WASH team report that the overhaul of these four rotary rigs be considered as their first priority in any assistance that they would be recommending. Next of importance was training to minimize rig failures in the future, expatriate manpower to organize and supervise drilling programs and replacement of certain worn-out drilling tools and (fishing) tools to retrieve lost parts.

Other forms of assistance were suggested by the Director but the team considered them to be more long-term and development oriented.

WASH Team's Recommendations for DWA Assistance

The team's recommendations for providing assistance to DWA and estimates of cost for the individual parts of the proposed assistance are enumerated as follows:

a. Rehabilitation of 4 rotary drilling rigs incorporating maintenance training by manufacturers furnished mechanic at an estimated cost of $250,000.

b. An expatriate with knowledge of wells and groundwater development and managerial background to serve in an advisory position for a period of less than 6 months. Estimated 5-month duration with salary, per diem and transportation of some $13,000/month for a total of $65,000.

c. Assistance in providing some part of most necessary replacement drilling tools (for U.S.-provided Schramm rigs only, scheduled for overhaul first, with SIDA assisting on any remaining needs under their next fiscal year budget). An estimate for this assistance is $40,000.

An overall estimate for assistance to DWA - TOTAL $355,000.

Additional Emergency Drought Assistance Recommended

Current planning for prioritizing the list of 57 villages most seriously affected by the drought is hampered by inadequate technical information concerning the water supply schemes in these villages. This is due to the level of training and experience of technicians working in these areas. A short-term consultant should be hired for technical and planning assistance to MLGL's water engineer until the position can be permanently staffed.

Estimated cost for 25 week "bridging" until the funding of permanent position is made is $40,000.

Additional assistance to the North-west District, whose coordination with central governmental agencies is handled by MLGL, is recommended in response to needs of traditional rural dwellers in this, the most seriously affected region over the past year. Assistance is recommended in the form of well drilling and handpump equipping for 6 settlements for which no hand dug water source can be provided.

Estimated costs to carry out this assistance is $95,000.

Overall Recommended Program

The five activities recommended for USAID funding are:

• Rehabilitation of drilling equipment	US$ 250,000
• Short-term technical assistance to DWA	65,000
• Short-term technical assistance to MLGL	40,000
• Drilling of six emergency wells for NWDC	95,000
• Provision for emergency drilling tools	40,000
TOTAL COST	US$ 490,000

Discussions in Botswana indicated that the only means by which the recommendations could be expeditiously carried out was through an agreement whereby USAID would retain funds and pay for materials and services rendered upon certification of completion by GOB.

The WASH consultants believe that the full funding of the above recommendations gives the opportunity to provide momentum to the planning and implementation of the GOB Consolidated Emergency Water Supply Program. The recommended activities provide for the critical initial movement that will help assure the relief from water shortage in this critical emergency period and also assure improved capability to address longer term relief measures.

Chapter 1

INTRODUCTION

1.1 Response to Assistance Request

The USAID Office of Disaster Assistance (OFDA) asked the Water and Sanitation for Health (WASH) Project to send a team to Botswana as a result of the continuation of drought conditions into a seventh year. The purpose of such a visit was to undertake an assessment of potential short-term emergency action which could be accomplished within a 12 month period. OFDA's funding of the team's visit was taken in response to the USAID Botswana request included in Cable Gaborone 5536, dated 14 December 1987.

Phil Roark, Associate Director of WASH, was selected to act as the WASH Activity Manager for the Botswana assignment. On 14 January 1988, Mr. Roark conducted a briefing meeting for the team, comprised of Ralph Preble and Jonathan Hodgkin, who left for Botswana the same day.

1.2 Scope of Work

The team's scope of work requires the preparation of a report that includes, but is not necessarily limited to, the following:

1. An assessment of drought conditions with identification of areas most seriously affected and estimates of the numbers of people and animals at risk in those areas.

2. Consultation with the USAID/Botswana mission, Government of Botswana, and other authorities as needed in reaching an agreement on appropriate actions which OFDA could finance.

3. Recommended emergency relief actions to provide water in the most expeditious manner possible.

During the team's briefing session, a telephone conference call was placed to OFDA. Instructions from OFDA were that the team's assessment was to focus on those action plans needed to address immediate short-term solutions to problems faced in the present emergency. This focus on sort-term emergency assistance was further reinforced by a warning that activities that were essentially of a development nature would not be considered for funding by OFDA. However, there was no objection to identifying potentially worthwhile programs of medium or long-range nature that would not be of interest to OFDA but might be attractive for funding--provided the identification of such projects did not interfere with efforts stipulated in the team's scope of work.

1.3 Initial Team Activities

When the team arrived in Gaborone (Saturday, 16 January 1988) they were able to contact S.A. Holmberg, Principal Hydrogeologist of the Department of Water Affairs (DWA), and ascertain where nearby well drilling activities were in progress. Mr. Holmberg told the team that two rigs were at Palla Road wellfield, which straddles the Tropic of Capricorn, and he offered to accompany the team there the next day (Sunday, 17 January 1988). The team was pleased to accept his offer as another opportunity to view an actual drilling operation was unlikely to be otherwise possible during their stay in country.

Monday (18 January 1988) was a U.S. holiday in Gaborone, but John Roberts, Deputy Mission Director, arranged for a meeting with Pushkar Brahmbhatt (USAID, Botswana Engineer) who accompanied them to his office and provided them with a short briefing and certain relevant documents. Mr. Brahmbhatt later arranged and accompanied them to meetings with Mr. Moremi Sekwale, the Director of the Department of Water Affairs, and Ms. Tswelopele Moremi, the Coordinator of Rural Development at the Ministry of Finance and Development Planning and Chairperson of the Inter-Ministerial Drought Committee. In general, the team was permitted to make their own contacts as team member Jonathan Hodgkin had spent some years in country and was personally acquainted with practically everyone who might be helpful in completing the team's assignment.

1.4 Overview of Report

Chapter 2, Background, provides general information about Botswana, its geographic location, topography, climate, administration, population, and the existing economy. In addition there is a detailed description of the geology in Botswana as well as some specific information regarding the hydrogeology and water resources in Botswana.

Chapter 3, Existing Emergency Situation, gives a description of the current drought conditions, its effects on humans and animals, and drought relief efforts in progress and planned.

Chapter 4, Overview of Water Sector Institutions, explains how the various departments within different ministries function, summarizes donor agencies in the water sector, and further details how non-governmental and private sector organizations interact with water affairs.

In Chapter 5, Assessment of Government Capability, an analysis of the Department of Water Affairs and District Councils is presented.

Chapter 6, Recommendations, details the team's recommendations regarding the level and degree of participation OFDA should consider.

A complete listing of persons whom the team contacted during their stay in Botswana is included in Appendix A and a short account of the two field trips made is reported in Appendix B. Appendices pertinent to subsequent chapters are provided and their titles are noted in the Table of Contents.

A list of references reviewed precedes the appendices.

Chapter 2

BACKGROUND

2.1 Geographic Location and Topography

Botswana is a landlocked country in the center of the South African Plain occupying about 582,000 km^2. A map is given in Figure 1. The mean altitude of the country is about 1,000m above sea level. Along the eastern border of the country 1,200m represents the highest elevation, with the lowest elevation at the confluence of the Limpopo and Shashe valleys. While the topography of the country can be described as generally featureless, major surface features exist in the form of the Okavango Delta Swamps and the Kgalagadi (Kalahari) sand which covers over 75 percent of the country.

2.2 Climate

Botswana is generally described as having a sub-tropical climate with mainly arid or semi-arid conditions. Almost all of the rainfall occurs between October and April. Commonly the rainy season is divided into the early rains (October-December), mid-season rains (January-February) and late season rains (March-April). The greatest amount of rain normally occurs in January, except in the South. Figure 2, reproduced from the 1985-91 National Development Plan shows average annual rainfall and the percentage of variation from these amounts that has been experienced.

Typical mean average monthly temperatures vary from 14° in Winter to 27° in Summer. Annual evaporation varies from 1.7 to 1.9m per year. Evapotranspiration nearly always exceeds rainfall for corresponding ten day periods.

2.3 Administration

Botswana is a parliamentary democracy. There are nine Ministries that fall under the Office of the President (see Figure 3). The Cabinet is made up of members of Parliament, chosen by the President. The Ministry of Finance and Development Planning (MFDP) has overall planning responsibility for all Ministries and oversees the funding of recurrent and development activities.

The Ministry of Mineral Resources and Water Affairs (MMRWA) has overall responsibility for most of the public sector water resource and development activity. The Department of Water Affairs (DWA), the Department of Geological Survey (DGS), and the Water Utilities Corporation (WUC), a parastatal, fall within MMRWA jurisdiction. The Ministry of Local Government and Lands (MLGL), and the separate District Administrations are responsible for the operation of rural village water supplies. A recently completed Water Administration Study suggests that more of DWA's activities, particularly in the areas of design and construction, be decentralized and the District Councils take on more of this work. These changes are not likely to be accomplished soon as there are not sufficient trained engineers and technicians to staff these expanded facilities.

Government agencies within other Ministries operate isolated water supply systems in support of their various functions and programs. In these cases. DWA is called upon to design and install these systems and perform all maintenance and repair. Day-to-day operation is normally left to the agencies involved.

2.4 Population and Social Structure

Botswana's current population is estimated to be 1.2 million. Most citizens are members of Setswana-speaking tribes. There are significant minorities including the Bakalanga in the north-east and the Basarwa and other semi-nomadic peoples in the more remote western areas. Roughly 80 percent of the population live in the eastern part of the country where traditionally water has been more plentiful and the rains more consistent. The western part of the country is overlain with the Kalahari sands and population densities are low.

The Batswana (the people of Botswana) traditionally live in a village setting with portions of the year spent at other locations. During the planting, growing and harvesting season, part or all of the family will live at their agricultural lands areas which are usually several kilometers from the village. Cattle, an important concern of most Batswana, remain at the cattle post, which may be much further from the village.

Villages tend to be well defined, with houses in close proximity to each other. This eases some of the difficulties of water supply as pipe networks of limited extent can be used. The lands areas and cattle posts are much more sparsely populated making public water supply to these areas more difficult. Current water supply programs are targeted towards urban areas and well defined rural villages.

About 45 percent of Botswana's rural population are not currently served by any public water supplies. These people have used traditional water sources which are increasingly unreliable as a result of drought conditions. Many of these people are moving from the rural areas to locations where pumped water exists. This is putting additional pressure on current water supply systems.

2.5 The Economy

In spite of drought conditions, Botswana's economy remains strong. This is due primarily to the contribution of the mining sector. The export of diamonds accounted for over 75 percent of export earnings during 1985 with the export of copper/nickel matte adding another 9 percent. The sale of beef to EEC countries also contributes to the national economy.

Botswana currently has a balance of trade surplus in excess of US$300 million. Although the larger economic picture for Botswana is good, the majority of Batswana, especially in rural areas, remain poor by any standards. Even before the current drought, it has been estimated that 90 percent of all dwelling units produced harvests that were insufficient for their households. The current drought has exacerbated these conditions.

2.6 Geology

The geology of Botswana is complex and while certain areas have been exhaustively studied, like the Karro in the Geological Survey 10 Project extending from 1976 to 1981, and certain on-going studies, large parts are little understood even today. Figure 4 and Figure 5 were published by the Ministry of Mineral Resources and Water Affairs entitled Geological Map of the Republic of Botswana-1984.

The discussion of the overall geology, in its most simplified form, can be separated into four parts. These are:

- Metamorphic and Igneous Basement rocks along the eastern border of the country
- Karro System which covers the major portion of the country. The term Karro is a recognized geologic/ stratigraphic term used to refer to a series of sediments and lava flows in Central and Southern Africa.
- Precambrian Sedimentary and Associated Igneous Rocks of the central south border, the northwest corner of the country and a strip tending northeast and southwest from Ghanzi.
- Kgalagadi Beds covering 75 to 85 percent of the country's land surface.

A brief description of the stratigraphic units noted above, originally presented by Jeffrey Davies, at a Ministry of Mineral Resources and Water Affairs Workshop, is presented in Appendix C.

2.7 Hydrogeology and Water Resources

An understanding of hydrogeology and water resources is extremely important to Botswana. It is generally agreed that water resources are a potential limiting factor to the growth and development of the country. A lack of understanding about the limits of water use from individual well locations and incomplete understanding of use in connection with major village well field operation, under present drought conditions, are contributing to the sense that public water supplies throughout the country are now in a period of crisis.

Mr. Paul Larkin notes, in a presentation at the Botswana Technology Center--a copy of which is provided in Appendix D--that primary aquifers are less common than generally believed. Primary aquifers are aquifers whose porosity is not dependent upon faulting, fracturing or creation of solution channels after deposition which are conditions essentially describing what would be termed a secondary aquifer. There are instances where an aquifer can be a combination of both, i.e. a fractured sandstone.

Studies and understanding relative to hydrogeology and groundwater hydrology starts with how the water enters the aquifer (recharge), its occurrence and movement in the aquifer (storage and permeability) and ultimately how it exits or can be removed from the aquifer. All of these interests are based on the nature of the aquifer (primary or secondary) which is dependent upon a knowledge of the different geologic formations. These formations were described in the previous subsections but the subject is further complicated due to the stratification and differences of permeability and the very nature of different strata within each formation. More specific information on the occurrence of groundwater in specific substratas as described by Mr. Larkin can be found in Appendix D.

Recharge of the aquifers is described below in very general terms. More definitive information on recharge in specific areas of importance is currently under study by the DGS.

In eastern Botswana the Shashe and Limpopo Rivers and their associated tributaries are ephemeral in nature, flowing only after heavy rains. Nevertheless these flood waters recharge the relatively thick sand deposits that frequently occur along the courses of these rivers. The 'sand rivers' form an important local source of water in the eastern part of Botswana.

Within Botswana surface water is freely available only within the North-west and Chobe Districts i.e. from the Okavango River and Delta, Chobe, Linyati and Kwando Rivers and the Zambezi River at Kasane. While some of this inflow recharges the groundwater, much of the inflow into the Okavango Delta is lost by evapotranspiration. What outflow that does occur (an average of $600m^3 \times 10^6$ per annum) flows either along the Boteti River into the Makgadikgadi Pans area or into Lake Ngami. This outflow is extremely variable in quantity and has been non-existent in the last four years.

The largest part of the country, the Kgalagadi, is drained by a sinuous system of dry river valleys which, during former pluvial periods, issued into the former Lake Makgadikgadi. During the present climatic regime little, if any, surface flow takes place along these valleys and, as stated above, none in recent years. Following heavy storms, rainwater accumulates in the dense pattern of 'pans' that are scattered throughout the Kgalagadi area forming a temporary water supply.

Recent studies have indicated that a Kgalagadi sand cover of 6 meters or more will eliminate all possibility of any rainfall infiltrating to and providing recharge to sub- or intra-Kgalagadi aquifers. Any sort-term excess rainfall will be temporarily stored in the sands and utilized in the dry season by the vegetation cover of bush and grass.

Within Eastern Botswana, where the Kgalagadi sand cover is virtually absent, active recharge of aquifers via faults, joints and zones of weathering takes place.

Water Quality data do not seem to be readily available. Some general diagrams of where salinity might be expected appear in the literature but are not necessarily consistent. The Geological Survey maintains a hydrogeological data bank which includes information on water quality. Of primary interest are values of total dissolved solids (TDS) as a value above 1,500 ppm(mg/1) is not considered suitable for human use. A like value for cattle is 5,000 mg/1.

Figure 6 indicates general areas believed to have water that is not suitable for humans (above 1,500 mg/1). Generalities cannot be relied on and water quality can be entirely different between wells separated by only a km or so. Table 1 presents the analytical results from 2 wells separated by little more than a km in Gumare. Substantial differences in a number of constituents are unexplained.

Table 1

ANALYTICAL RESULTS FROM
PUBLIC WATER SUPPLY WELLS

GUMARE - NGAMILAND

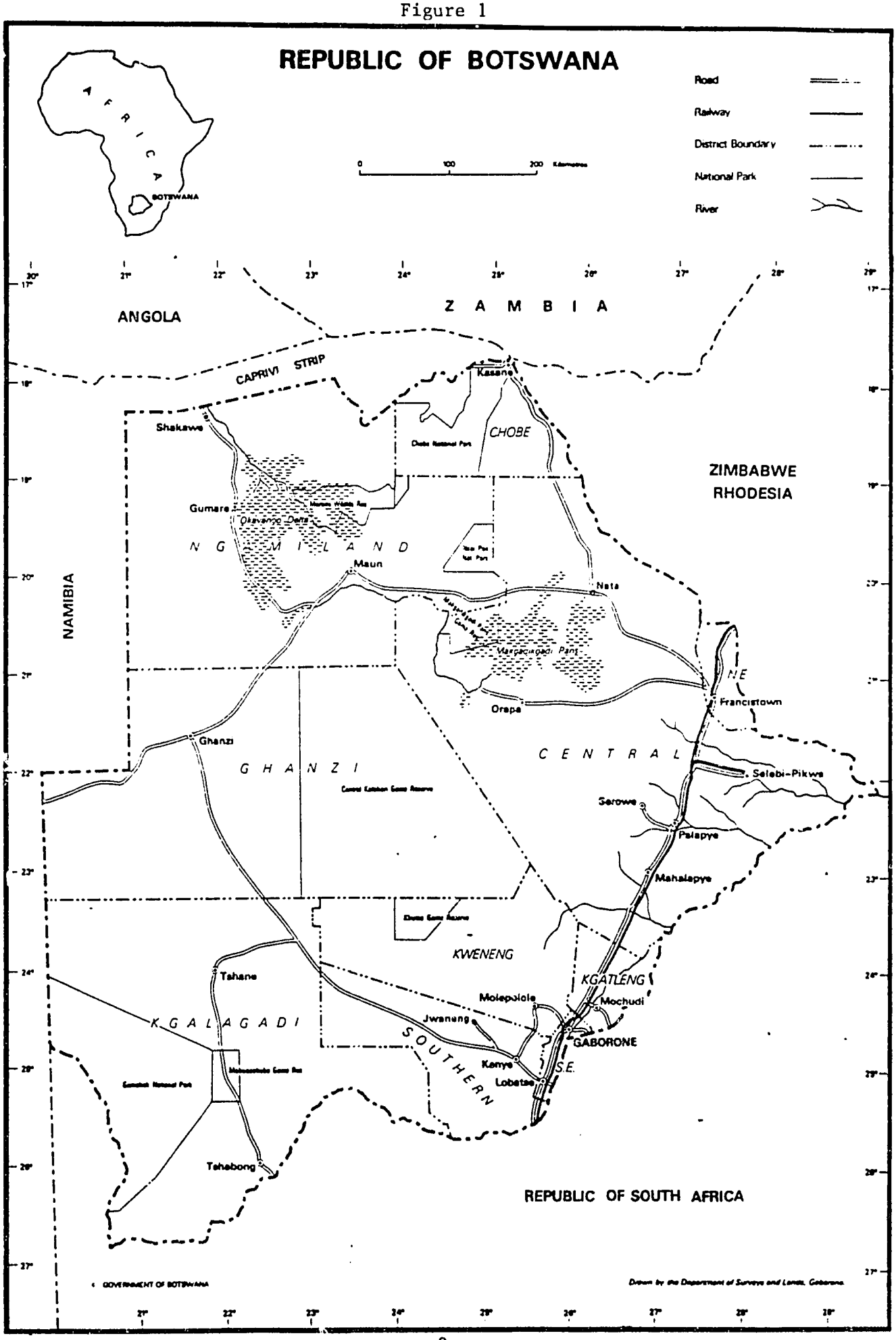
Characteristic	BH 4352(26/3/87)	BH 3203(26/3/87)
PH	-	8.07
Conductivity	1722	6.17
Fluoride	1.5	0.16
Chloride	142	10
Sulfates	250	2.0
Nitrate	0.10(-)	3.0
Potassium	6.00	2.0
Sodium	254	56
Calcium	14.0	20.0
Magnesium	16.0	26.0
Iron	0.01(-)	0.01(-)
Manganese	0.20(-)	0.10(-)
Total Dissolved Solids	1142	460
Total Suspended Solids	6.0	2.0
Total Alkalinity	200	290
Total Hardness	113	203
Total Coliform Bacteria	2.(-)	2.(-)
Fecal Streptococci/100ml	2.(-)	2.(-)

Notes:
1. (-) designates less than
2. Upon visit 23 January, 1988, BH 4352 pumping air and water ($3.8 m^3$/hr per meter reading)
3. BH 3203 measured pumping rate 5.3 m^3/hr after speeding up engine but over last 2 months only averaged 3.5 m^3/hr based on total meter readings and 11 hr/day operation
4. Except for pH and conductivity concentrations through and including Total Alkalinity are expressed in mg/l

Water Resources in pictorial form through a series of 30 map/diagrams by B.H. Wilson in a paper included in the Proceedings of the Symposium on Drought in Botswana 5 - 8 June, 1978 is reproduced in Appendix E.

Now, ten years after the presentation of Mr. Wilson's paper, the continuing studies of the country's water resources have still left many of the questions he posed with incomplete answers. It is generally agreed that the cycles of drought and limited water resources serve to place a severe restriction upon the country's food production, development and expanding population. Consequently, continuing study into water availability and use is all important to the future of Botswana.

Figure 1


REPUBLIC OF BOTSWANA
AFRICA
BOTSWANA
Road
Railway
District Boundary
National Park
River
0
100
200 Kilometres
ANGOLA
ZAMBIA
CAPRIVI STRIP
Kasane
Shakawe
CHOBE
ZIMBABWE
RHODESIA
Gumare
Okavango Delta
NGAMILAND
Maun
Nata
NAMIBIA
Makgadikgadi Salt Pans
Francistown
NE
Orapa
Ghanzi
GHANZI
CENTRAL
Selebi-Pikwe
Serowe
Palapye
Mahalapye
KWENENG
KGATLENG
Tshane
Molepolole
Mochudi
KGALAGADI
Jwaneng
SOUTHERN
GABORONE
Kanye
S.E.
Lobatse
Tshabong
REPUBLIC OF SOUTH AFRICA
© GOVERNMENT OF BOTSWANA
Drawn by the Department of Surveys and Lands, Gaborone

Rainfall

Figure 2

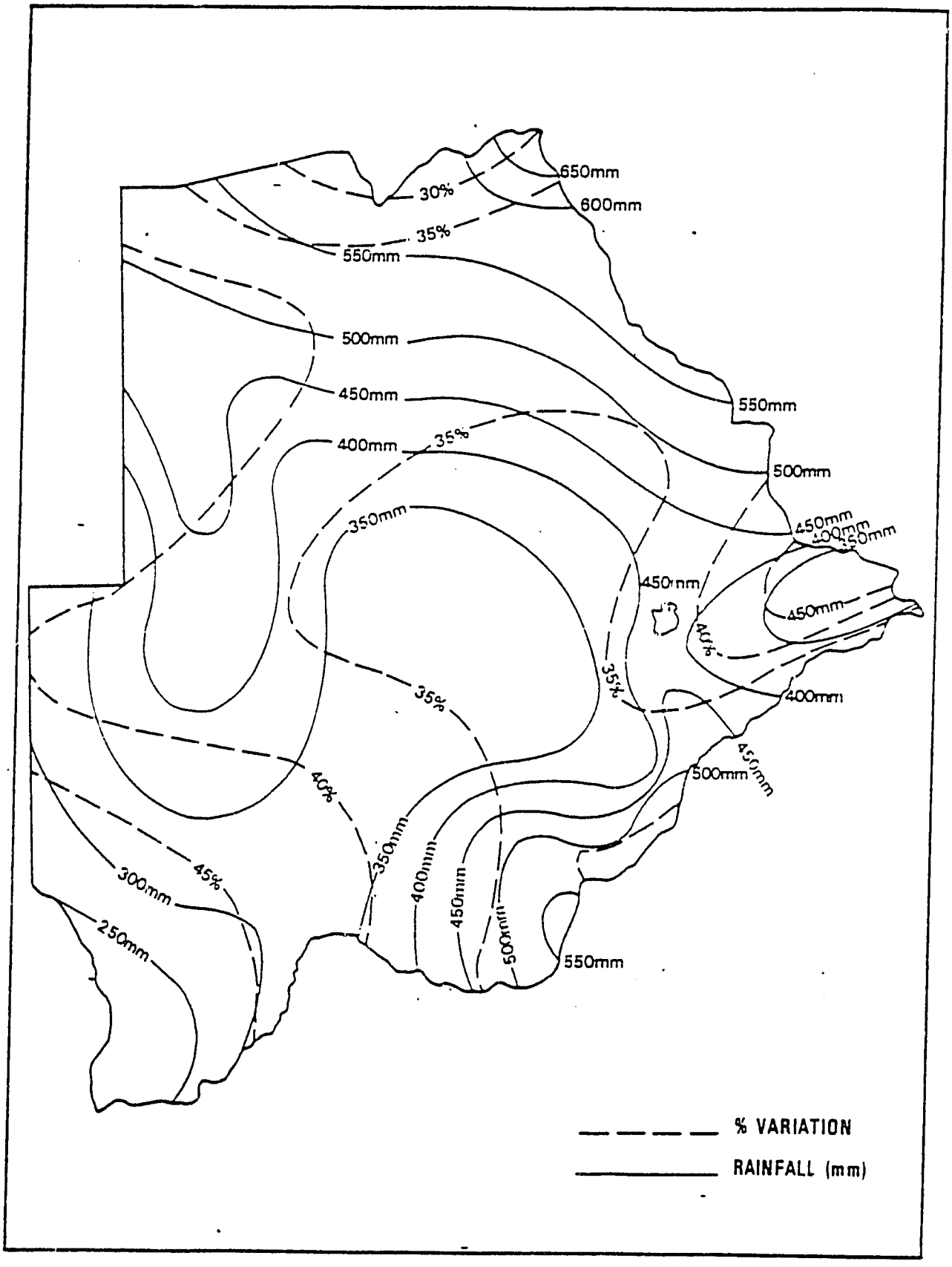
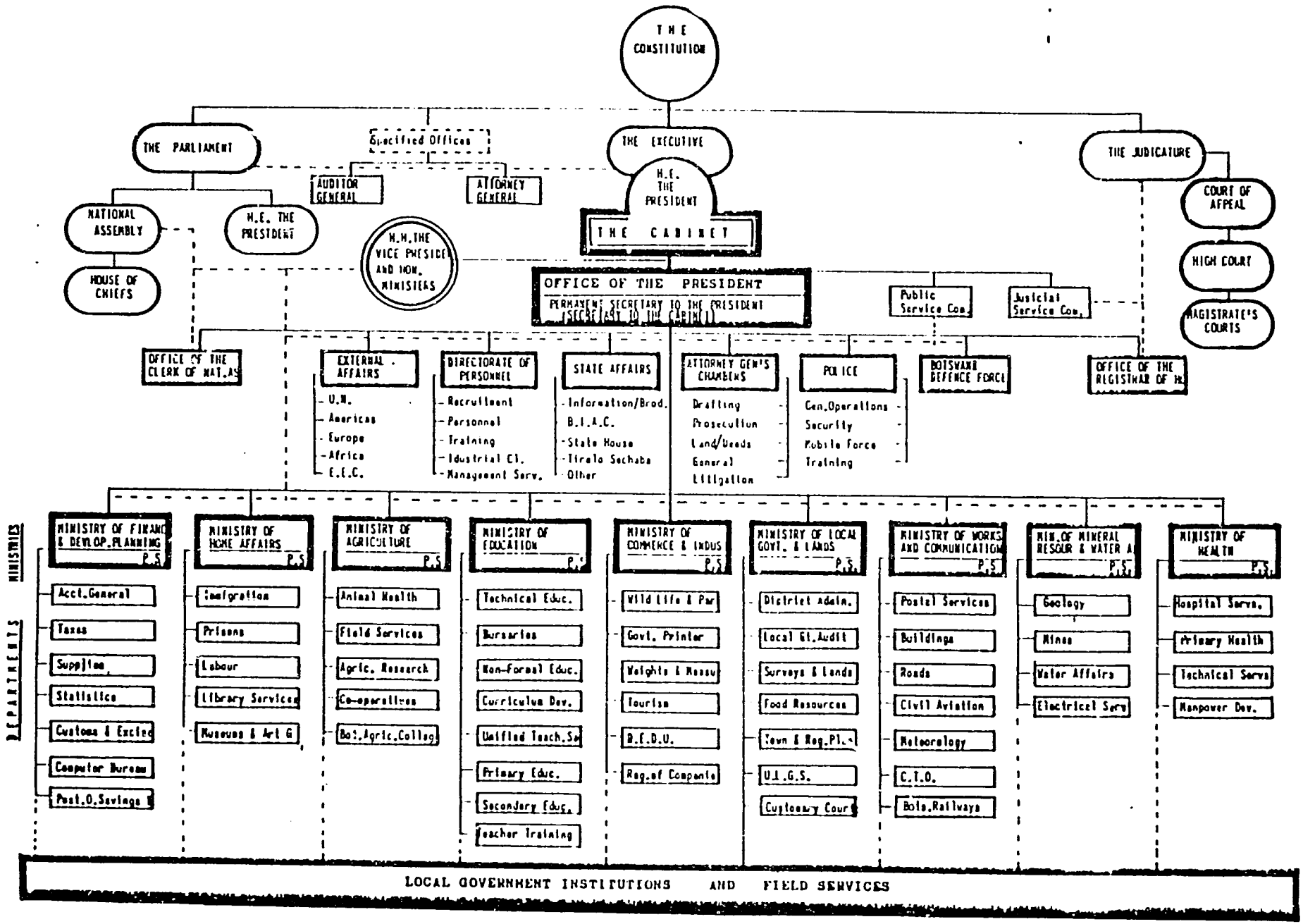
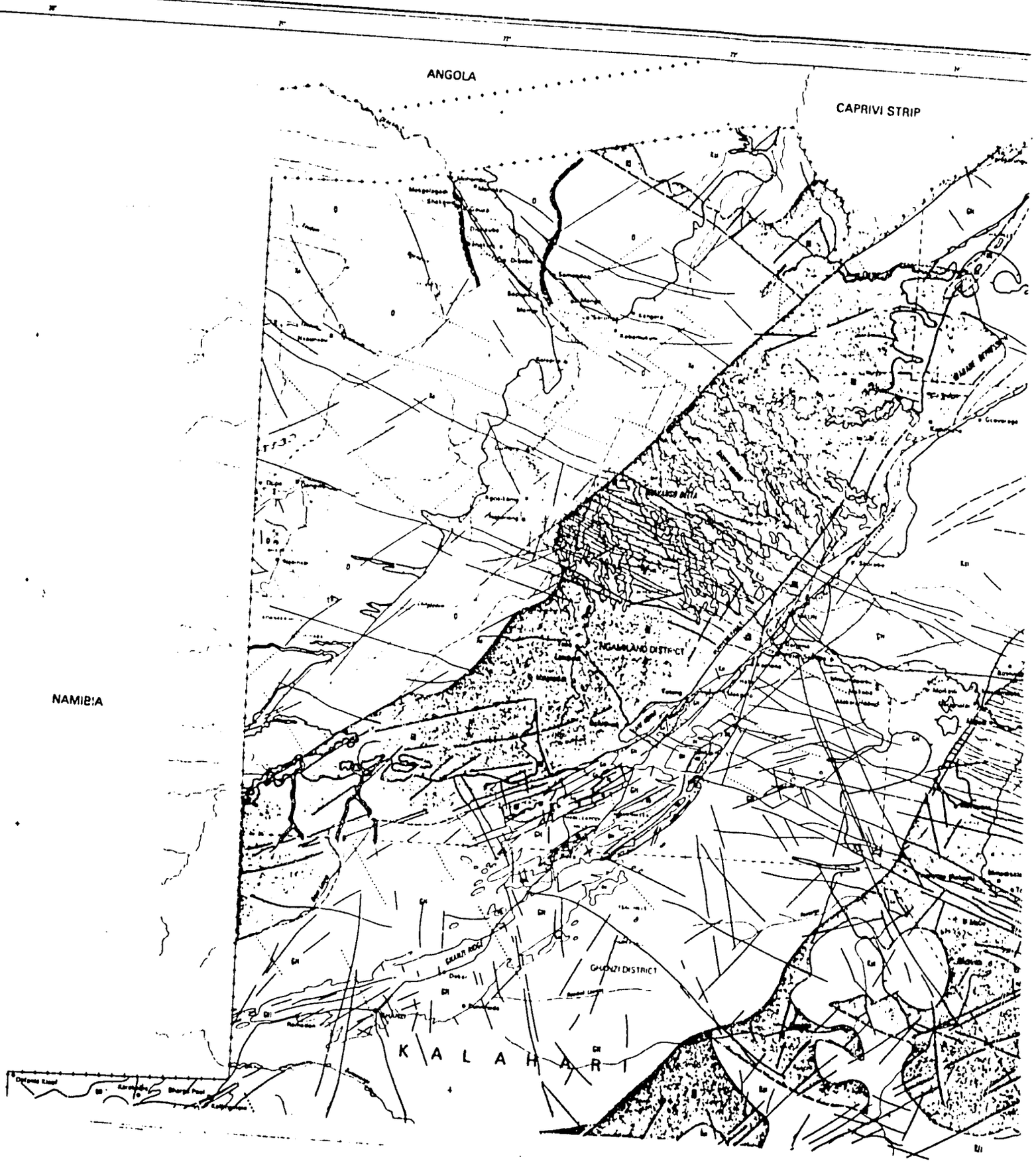


Figure 3

Structure of Central Government




ANGOLA
CAPRIVI STRIP
NAMIBIA
NGAMILAND DISTRICT
GHANZI DISTRICT
K A L A H A R I

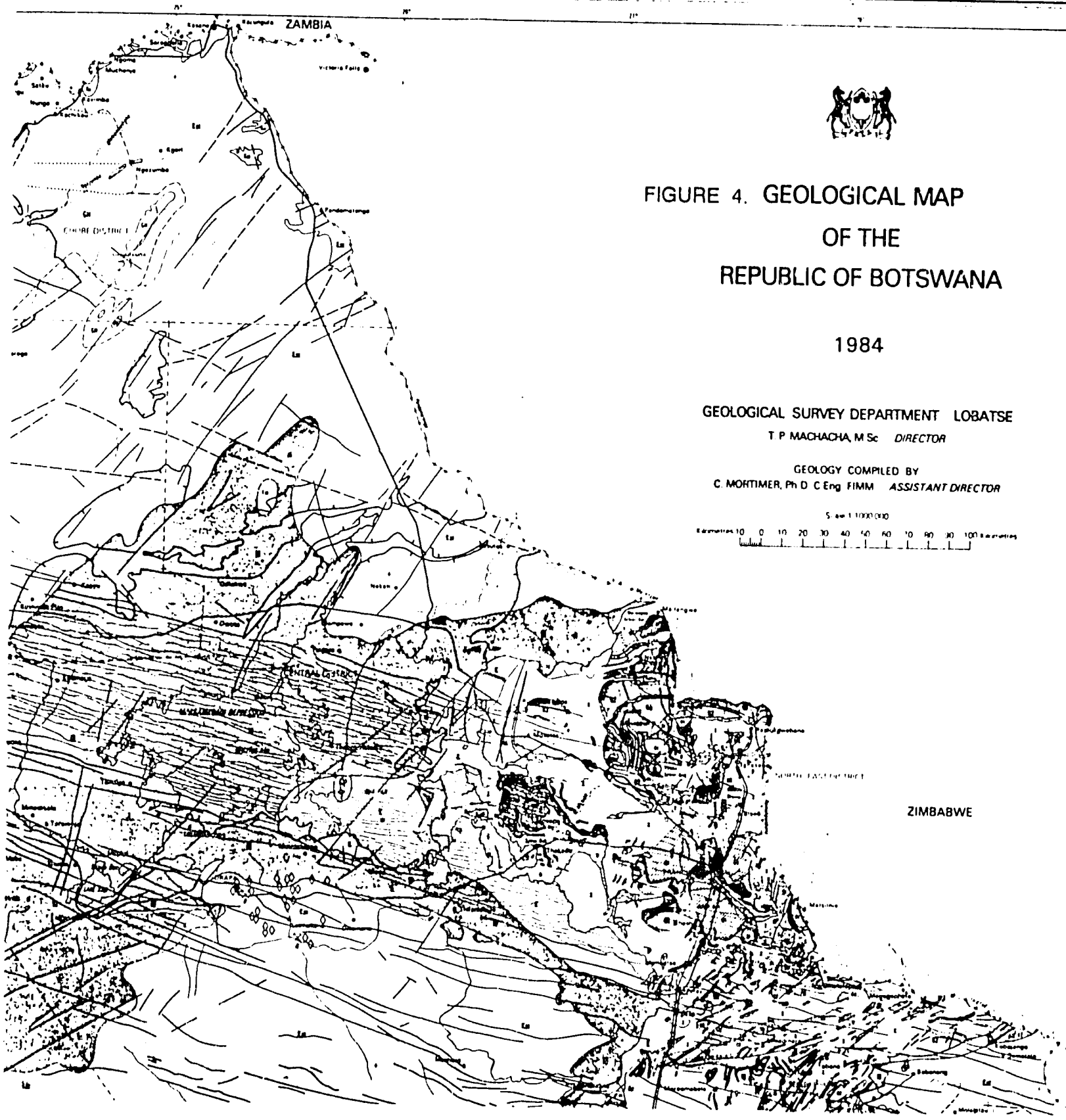


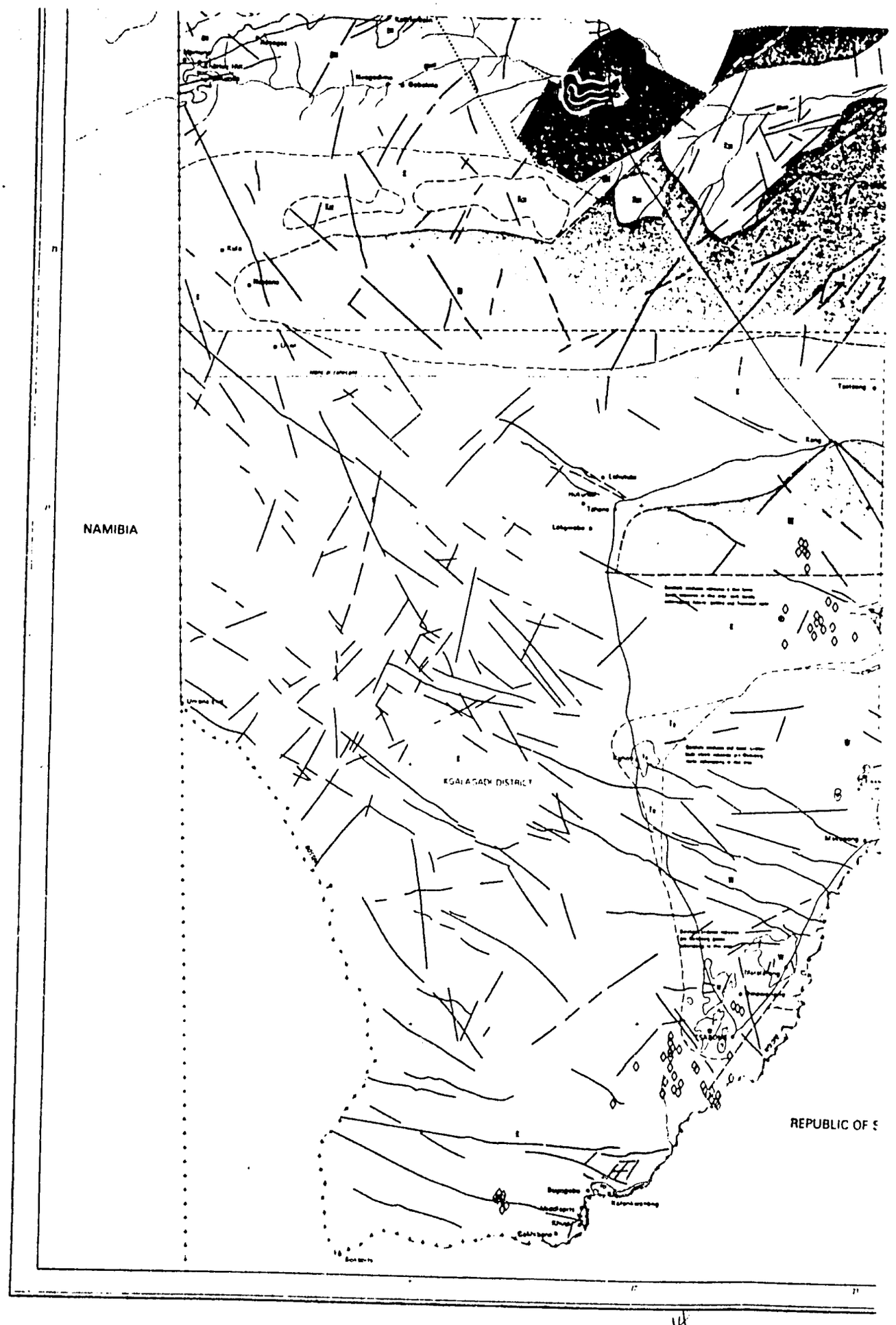
FIGURE 4. GEOLOGICAL MAP
OF THE
REPUBLIC OF BOTSWANA

1984

GEOLOGICAL SURVEY DEPARTMENT LOBATSE

T P MACHACHA, M Sc *DIRECTOR*

GEOLOGY COMPILED BY
C. MORTIMER, Ph D C Eng FIMM *ASSISTANT DIRECTOR*


NAMIBIA
KGALAGADI DISTRICT
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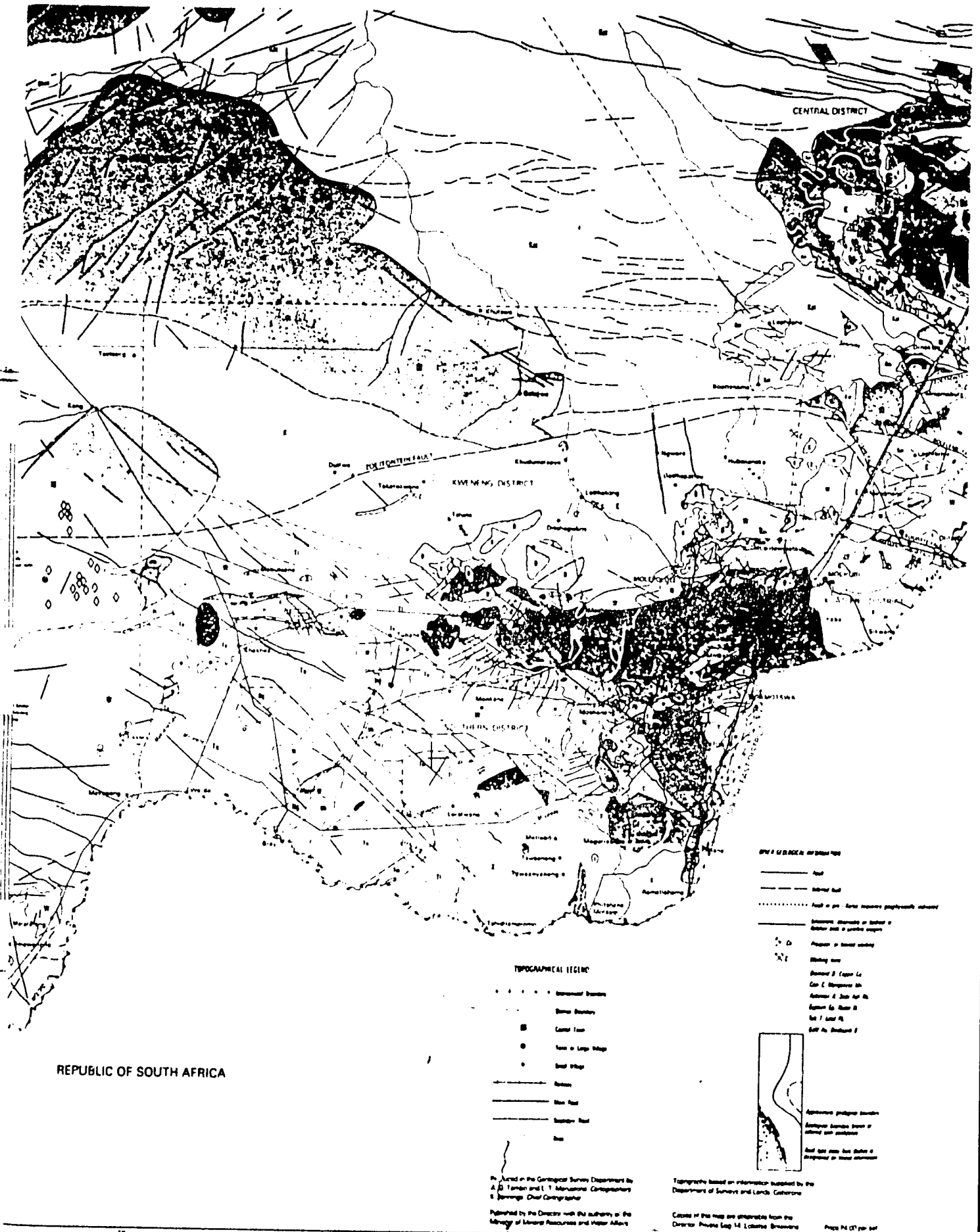

CENTRAL DISTRICT
KWENENG DISTRICT
REPUBLIC OF SOUTH AFRICA
TOPOGRAPHICAL LEGEND

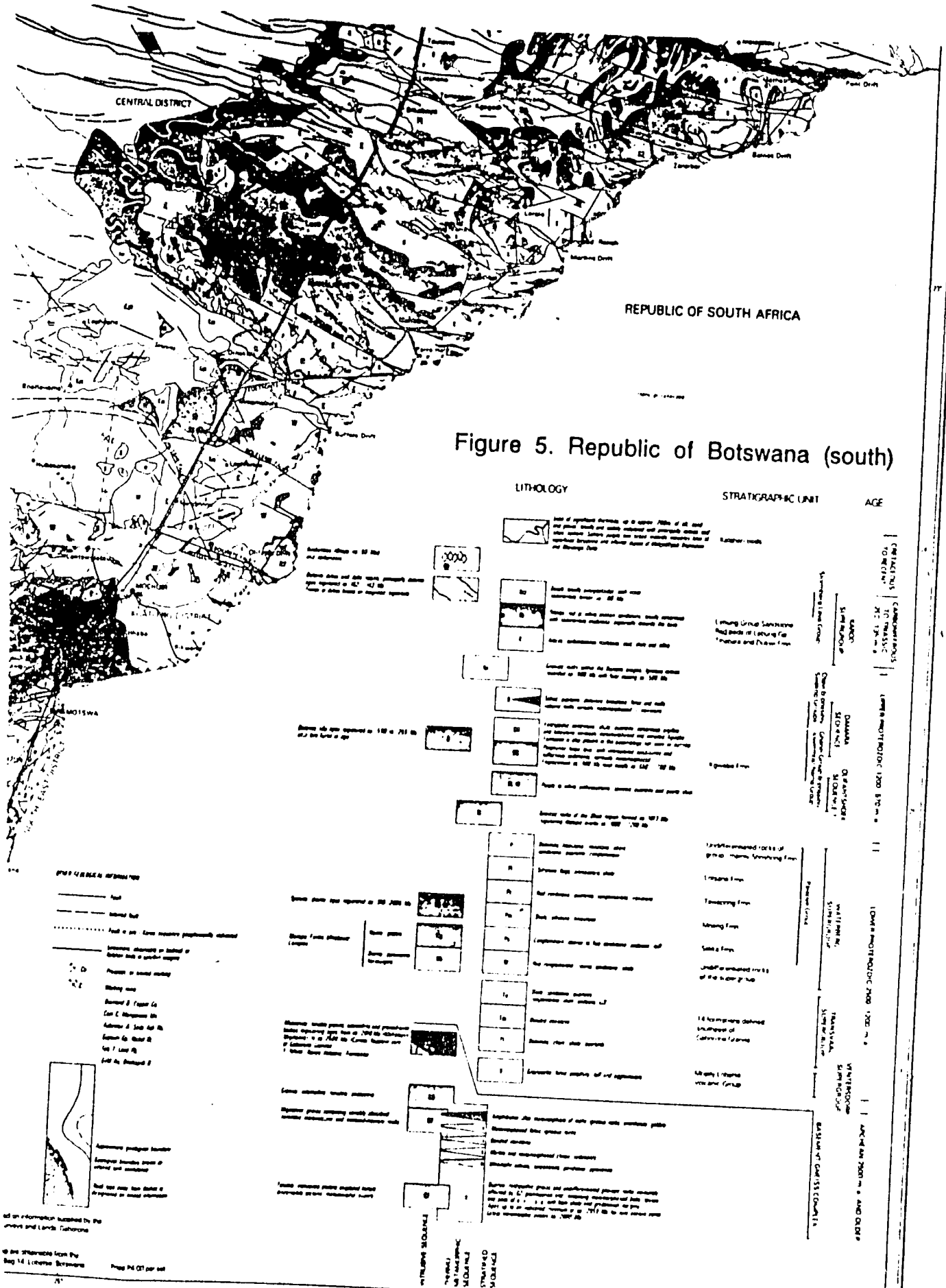
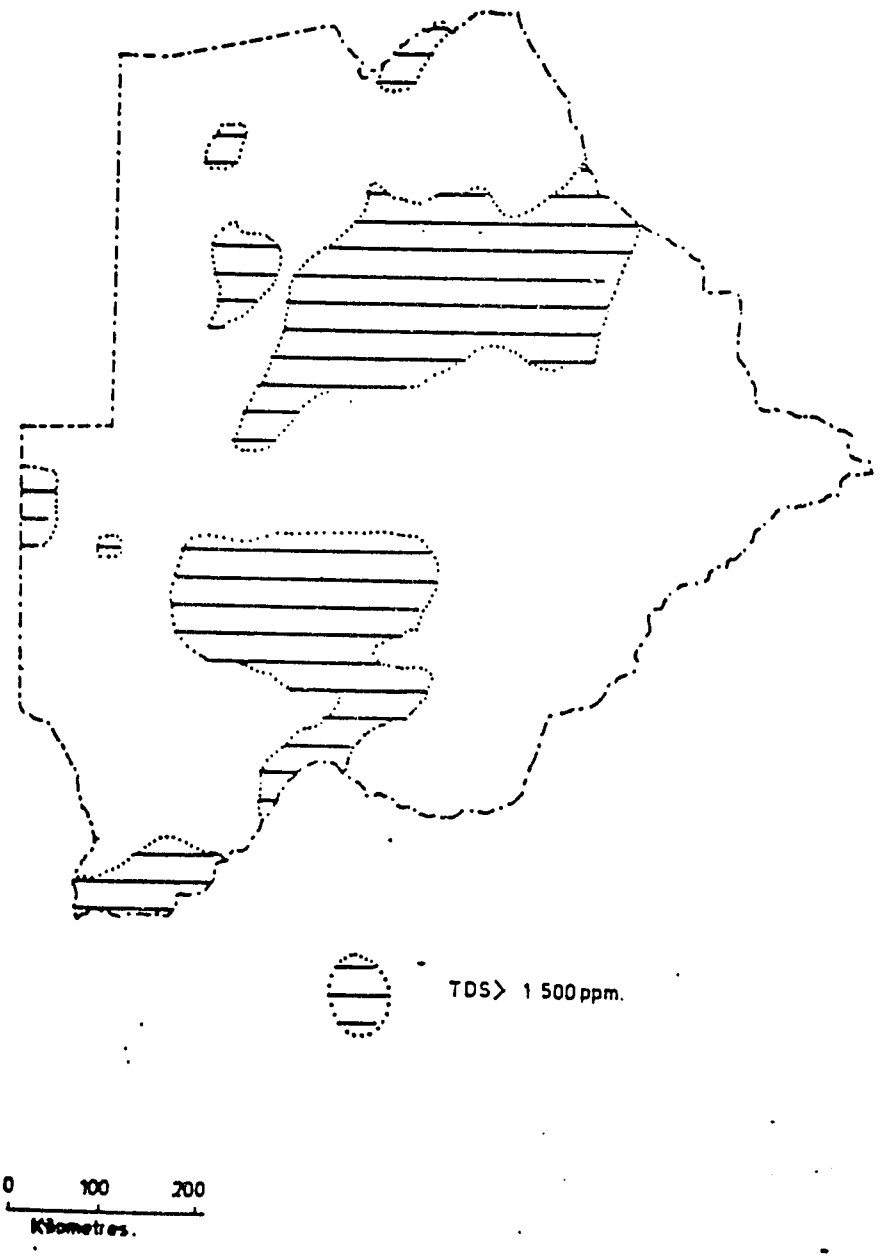


Figure 5. Republic of Botswana (south)

Figure 6

WATER QUALITY



Chapter 3

EXISTING EMERGENCY SITUATION

3.1 Drought Description

1987 was the sixth year of drought in Botswana. During the period from 1981 to 1987, the departure from already low average rainfall for an arid country ranged from 7 percent to 53 percent below normal (see Figure 7). The average deviation for the country over the six-year period was more than 26 percent below normal. The rainy season in Botswana falls during the summer months from October to April. For the success of arable agriculture it is important that the rains be distributed over the three periods as described in the previous chapter. During the six-year drought period, good rains may have occurred during one or more of these periods with complete failure during the remainder of the year. This resulted in massive crop failures and, during recent years, reluctance on the part of farmers to plant. In 1980, before the drought began, 287,000 hectares were planted in sorghum, millet, maize and other crops. By 1984, this figure had fallen by almost 30 percent to 203,000 hectares. In several years good early rains led many to believe that the drought had broken, only to have the rains end completely in January resulting in a disastrous failure over the remaining periods.

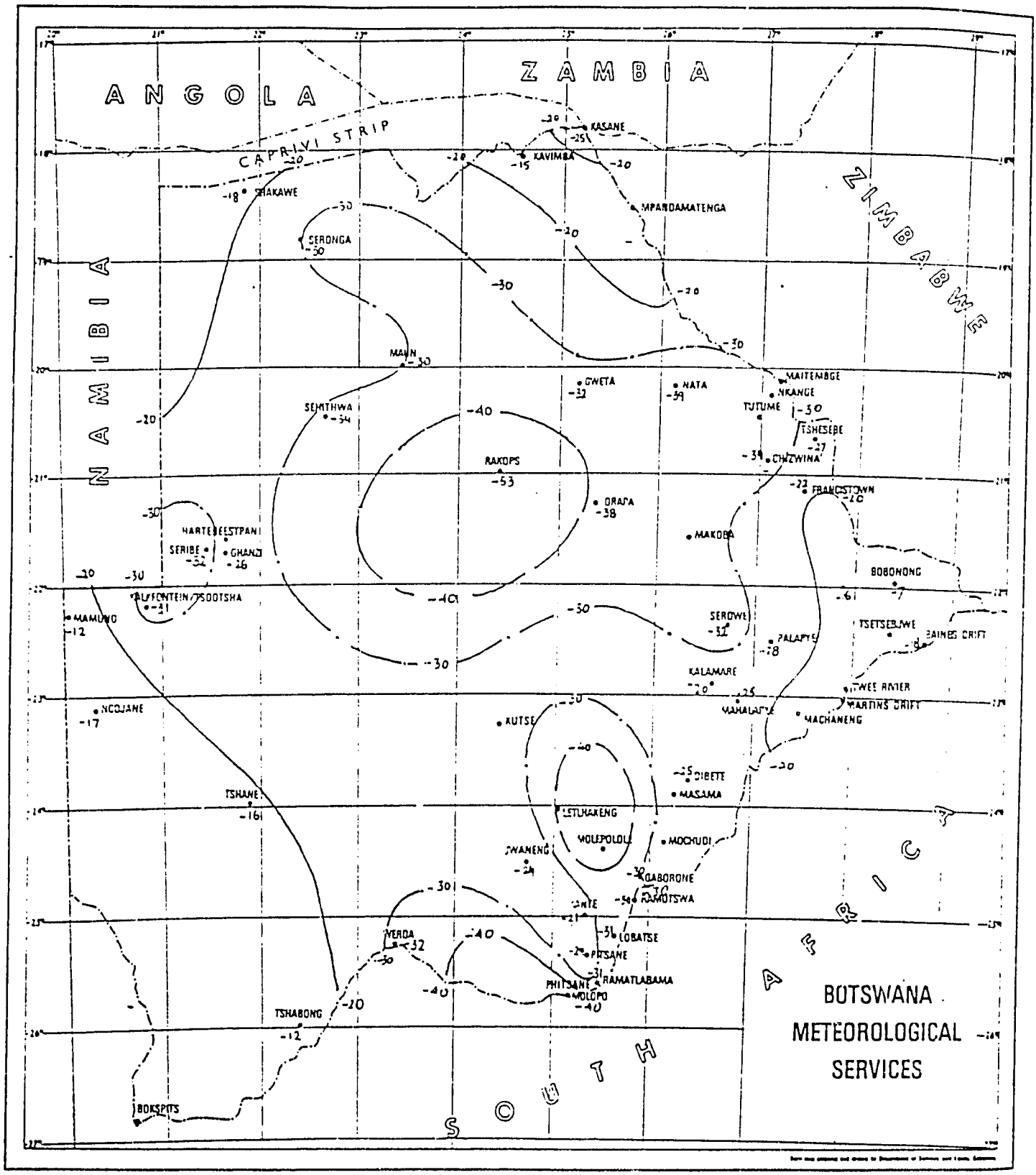
A complete failure of the early rains has occurred during this 1987/1988 rainy season in some parts of Botswana. Ngamiland, Boteti, Bobirwa, and the western parts of Southern and Kweneng districts were particularly hard hit. Livestock suffers as grazing deteriorates, and water sources dry up. This has required movement of cattle of up to 40 km between grazing and water. The cattle mortality in these areas reached 35 percent during late 1987.

In other parts of Botswana, particularly in areas in the east devoted to arable agriculture good early rains have been a hopeful sign, but events as recent as last year, where the rains ended completely in January, have led people to be cautious about predicting the end of the drought. This pattern of adequate rains in some areas and complete failure in others has been typical of this drought cycle.

For all but small areas in the extreme north and northwest of Botswana, rainfall provides the only significant recharge to the groundwater resources of the country. Over longer periods, including drought and non-drought years, the rainfall is probably sufficient to provide aquifer recharge, particularly in areas where the rate of water-extraction is low. However, during longer drought periods, such as is being experienced now, water extraction is likely to exceed recharge and boreholes will dry up. It is estimated that at least 2-4 years of normal rains will be required to provide sufficient recharge to the aquifer to end the current groundwater crisis. Since Botswana depends so heavily on groundwater sources for its water needs, particularly in rural areas, the situation will remain precarious for some years, even if the drought ends now. If the drought does not end, the situation is likely to become quite desperate.

Figure 7

Percentage Departure from Average Rainfall (1981-1987)



3.2 Drought Effects on Humans and Animals

3.2.1 Human Suffering

The Batswana are quick to point out that no human deaths can be directly attributed to drought conditions. This is seriously misleading. Botswana has an admirably-run drought relief program, coordinated by the Inter-Ministerial Drought Committee and a National Early Warning Technical Sub-committee for drought and food security monitoring. This program was begun in 1984, the third year of the present drought. Relief programs during the drought period in the 1960s provided a model for the current efforts.

The current program has enabled the supplementary feeding of over 400,000 people in vulnerable groups and 250,000 primary school children as shown in Table 2 below.

Table 2

SUPPLEMENTARY FOOD RECIPIENTS-1987

Vulnerable Groups		
	Lactating Mothers	43,410
	Pregnant Women	18,935
	Pre-school children	166,421
	Children 6-10 not attending school	75,324
	TB patients	40,679
	Destitutes: A (regular)	5,469
	B (drought induced)	34,272
	Malnourished Children	16,161
Total Vulnerable Group		400,671
Primary School Children		250,280
Total		650,951

Source: MLGL Dept. of Food Resources, 1988.

This program involves over half of the population of Botswana. Within the vulnerable groups, the number of malnourished children has increased over four hundred percent from 1984 to 1987. The number of drought-induced destitutes increased by 25 percent.

At present, statistics concerning malnourishment and illness are compiled on a district-wide basis, not by village. This makes it difficult to ascertain the specific problems that can be attributed to water cleanliness or lack of sufficient supply. It is clear to all concerned that lack of clean water in sufficient quantity contributes to disease, infant mortality, and premature deaths in these areas.

The provision of safe water supplies to drought-stricken villages has been delegated to DWA. The current extent of the rural village water supply program, with its reliance on drilled wells equipped with diesel pumping systems, has been a factor in making potable water available in rural areas. However, the drying of boreholes has affected many of these villages necessitating the provision of new water sources and, in some cases, the emergency trucking of water.

Forty-five percent of the rural population or about 500,000 people (1981 census) are not served by public water supply systems. These people have been seriously affected by the drought. Many of these rural dwellers depend on traditional water sources. As sources have dried up, these people must travel longer and longer distances. Often one-way travel for water is as much as 10 km. The time this takes severely disrupts rural life and normal agricultural, pastoral, or hunting activities. Many have found it necessary to move to be closer to reliable water sources. The populations of smaller, more remote settlements that still have access to a reliable supply of water have increased significantly. Increases of two to three times the 1981 census figure do not appear to be uncommon. In addition to the disruption of life inherent in this population movement, water supplies in these locations are increasingly likely to fail due to the additional water demand.

3.2.2 Wildlife Mortality

Accurate estimates of wildlife mortality are not available. The Department of Wildlife and National Parks does not have a complete census of the wildlife populations. However, it is clear that many wildlife populations have been severely affected. Die-offs of over 50,000 wildebeests and hartebeests were reported in 1983 in the Lake Xau and Mopipi region. This past year, 2,000 carcasses of Zebra and wildebeests were counted along the Boteti near Nxai Pan National Park. About 50 hippos died in the Savuti area before emergency efforts could provide water and forage. Efforts to provide water to these animal populations have been under way for several years with more than a dozen wells drilled or rehabilitated and equipped over the last several years in the national parks. Major funding for this effort has been provided by the EEC. It is understood that these few boreholes cannot provide sufficient water to the wildlife population during these drought years and efforts continue to drill more boreholes.

3.2.3 Livestock Mortality

Livestock mortality due to drought conditions is difficult to assess. Death from disease and pressures induced by the drought complicate extraction of reliable figures. The national cattle population reached a high of 2.97 million in 1982. This figure had fallen to 2.33 million in 1987. This represents a decrease of over 23 percent in 5 years. The death rate during normal years is about 12 percent; during 1987, preliminary figures set the death rate at 23 percent. This would indicate a national increase in cattle mortality of 11 percent due to drought conditions. The off-take from the herd for slaughter has increased from 7.8 percent to over 10 percent in recent years, indicating that the pressures of the drought have induced farmers to reduce herd size in an attempt to reduce drought related mortality. The pressures of drought on livestock are particularly apparent if there are no rains at the end of the dry season. This occurred in some areas in 1987 when the October to December rains failed. Cattle mortality reached 35 percent and the mortality of draft animals reached 40 percent in Northwestern Botswana. The carcasses of these animals, still visible everywhere in these areas, provide a silent reminder of the effects of the drought.

3.3 Current Drought Relief Efforts

In 1984, the third consecutive year of the present drought, a broad based drought relief program was instituted. This was done in response to loss of income, shortages of basic foodstuffs, loss of access to and benefits from livestock, wildlife, and veldfoods, and danger to many communities from the perilous state of water resources. At the national level, relief programs are coordinated by the Inter-Ministerial Drought Committee (IMDC). The committee is assisted by several sub-committees including the Early Warning Technical Committee and the Water Sub-committee. Major components of the Drought Relief program include supplementary feeding programs, labor-based income programs, and drought relief water supply programs.

Drought Relief water supply activities include improvements to agriculturally related water supplies as well as funds for addressing the needs of drought stricken villages. At the beginning of the program a list of 47 villages were identified as requiring Drought Relief assistance. To date, 17 village systems have been completed, 6 more have equipped boreholes but lack proper pipe networks and standpipes, 5 have wells drilled but not test pumped, 13 wells are sited and are awaiting drilling, and 5 are not yet sited or require re-siting.

Progress on this program has suffered over the past several years. In 1986 ten of these emergency wells were drilled and one new water system installed. In the 1987/88 fiscal year only three boreholes were completed for this program.

In addition to the Drought Relief programs, there is a Rehabilitation Program for village water supplies. This program is focused on the need to upgrade and extend water supply systems already in place. In 1985, the drought relief program of DWA included the complete rehabilitation of 12 rural village water supply schemes, the emergency drilling of 23 successful boreholes and the

erection of 46 new water storage tanks. The need to upgrade and expand these systems results in part from the current drought conditions that have placed additional burdens on water supply systems already in place. These burdens include increases in population due in part to movement of drought affected people to water supplies. This additional water need has required higher than design rates of water abstraction causing excessive drawdown in the wells. To date about half of the complete rehabilitations, two thirds of the emergency drilling and almost all of the new tank installations are complete.

Over the past several years, these programs have been included as part of DWA's overall operations which have also included the on-going rural village water supply program, well drilling and equipping for other governmental agencies, location of well fields for major villages and operation of these major village water supplies.

3.4 Planned Drought Relief Efforts

During the latter part of 1987, it became clear that these drought relief efforts were insufficient to meet the growing emergency needs. In response to the failure of the early rains of the 1987/88 rainy season (October-December 1987), particularly in the western part of the country, the Cabinet of the Government of Botswana has directed MMRWA and DWA to mount an accelerated emergency program. Emergency requests from the MLGL for rural villages and rural area dwellers, The Department of Roads, the Department of Wildlife and the Ministry of Agriculture have resulted in a list of 850 locations requiring a new successful drilled well. Under normal circumstances, this program would require 12 years. However the Cabinet has instructed that the program be completed in the shortest possible time. Planning is still under way for this program, expected to cost about 12 million Pula. To date the list of needs that should be addressed during the first 13 months of the program reach 304 boreholes at 120 locations or 23 boreholes per month. This list includes the emergency needs of 57 rural villages as well as the needs of the Roads Department and the Department of Wildlife, which DWA was instructed not to omit from this consolidated emergency program (see Appendix F). The 57 villages on the list have a total population of nearly 75,000 people assuming 1981 census figures and normal growth.

DWA anticipates that even with total involvement of all private sector hydrogeologists and drilling contractors capable of the work, and with assistance to overcome constraints of transportation, siting, drilling supervision, and drill rig repair, this program will take more than the scheduled 13 months. The major constraints are seen as:

- lack of adequate technical information from drought-stricken villages to allow initial prioritizing of drilling and water relief efforts
- lack of adequate personnel for siting and drill supervision

- extremely poor condition of the drilling rigs on which successful drilling depends

- transportation difficulties arising from poor road conditions and DWA's lack of control of its transportation fleet.

This initial program will greatly alleviate the water supply emergency in Botswana. However, without assistance, the full success of the program must be considered doubtful. In addition, it should be recognized that this program does not address the emergency water needs of the scattered rural population. In most cases, these people will continue to have to move to reliable sources of water if the drought continues.

Chapter 4

OVERVIEW OF WATER SECTOR INSTITUTIONS

Institutions involved with water sector activities include the government ministries, multilateral organizations, non-governmental organizations and the private sector.

4.1 Government Ministries

The government ministries most concerned about water resource and supply are the Ministry of Mineral Resources and Water Affairs, The Ministry of Local Government and Lands, and the Ministry of Agriculture. The major activities of these ministries are described in the sections that follow.

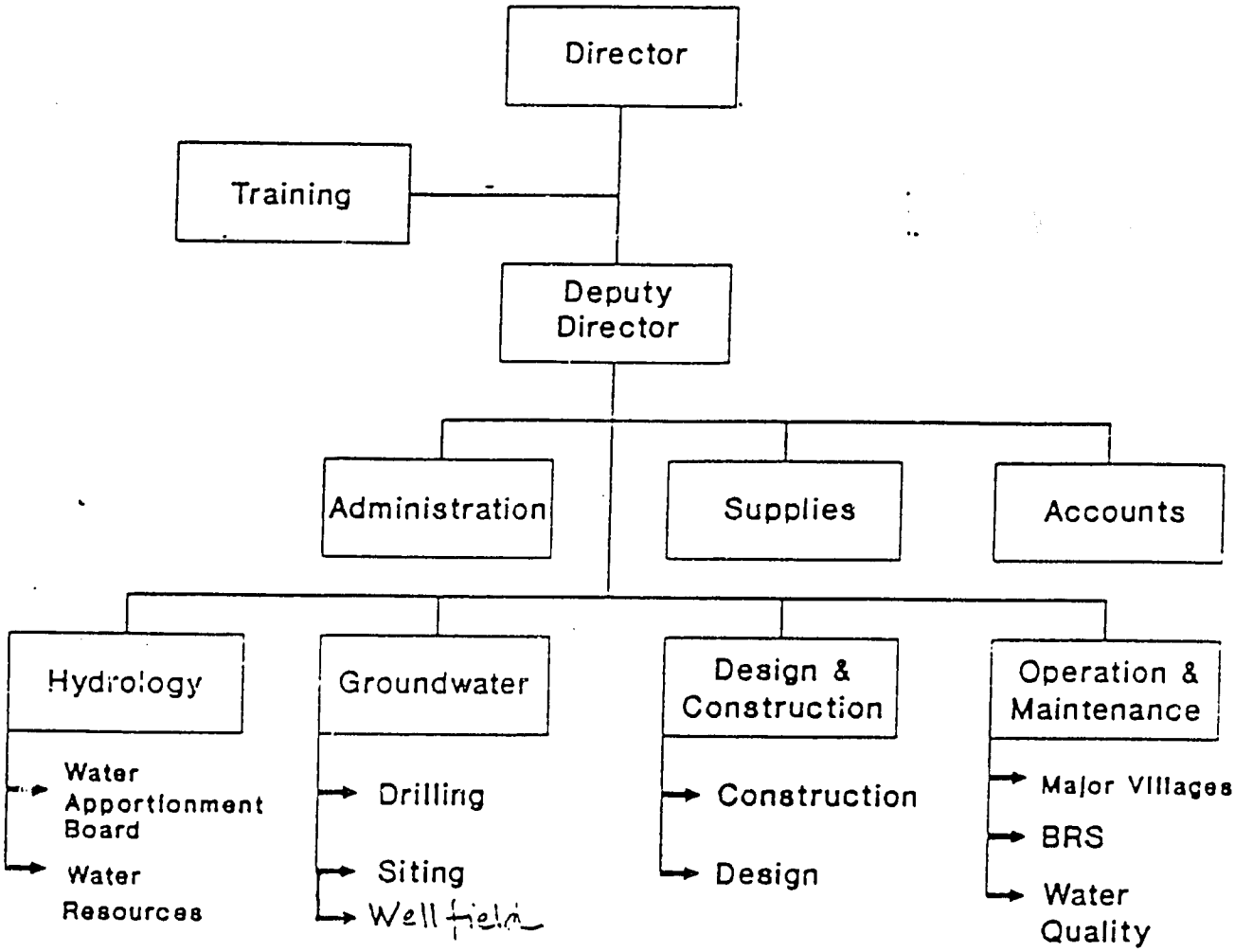
4.1.1 Ministry of Mineral Resources and Water Affairs (MMRWA)

There are two departments and a parastatal organization that report to MMRWA. These are the Department of Water Affairs, the Department of Geological Survey, and the Water Utilities Corporation.

The Department of Water Affairs (DWA) has responsibility for water supplies outside the main urban/mining centers, surface water investigations, protection of water sources from pollution and aquatic weeds, and overall water resources planning. Within this mandate falls borehole siting and drilling, not only for potable water needs but also for the needs of other government agencies. These agencies include the Department of Wildlife, the Roads Department, and various departments within the Ministry of Agriculture. DWA is also responsible for the design and construction of water supply systems and for the operation of 17 major village water supply systems. The Borehole Repair Service (BRS) section of DWA provides field service to private subscribers and overhauls engines and pumps for major villages. Field service locations and overhaul capability are given in Appendix H.

A DWA organization chart is shown in Figure 8. In 1987, a total of 38 established posts on the civil engineering level, 11 were vacant, 13 were filled by Botswana nationals and the top 14 were held by expatriates. Appendix I lists SIDA personnel and the posts that they held in 1987. In 1988, a few of the posts have been taken over by Botswana nationals including that of the Director being filled by Mr. M. Sekwale in November 1987. Another 10 or 12 expatriates, under local contract to GOB, are employed by DWA and the services of 2 more are provided by the U.K. Overseas Development Authority (ODA). During the last several years, the EEC has provided assistance in the form of three engineers who have been placed in the Design and Construction Section. The UN has provided a hydrologist/water resources planner. The total personnel of DWA is about 350 permanent technical and professional staff (of which 85-90 percent are filled) and roughly 1000 laborers. A further discussion of DWA staff and capabilities is found in Chapter 5.

Figure 8



Department of Water Affairs

The Department of Geological Survey (DGS) has the examination of groundwater sources among its responsibilities. This work includes the regional and local search for groundwater resources, regional hydrological mapping, and maintenance of the borehole registry. A listing of DGS as well as DWA projects through the 1985-1991 National Development Plan period is included in Appendix J.

The Water Utility Corporation (WUC) is a parastatal organization responsible for water supplies in the urban and/or mining centers of Gaborone, Lobatse, Francistown, Selebe-Phikwe and Jwaneng.

4.1.2 Ministry of Local Government and Lands (MLGL)

MLGL is the central Government Ministry that oversees the largely autonomous District Councils. The District Councils, through their Water Departments and Water Maintenance Units (WMU) are responsible for the operation and maintenance of water supply schemes for rural villages. There are currently just over 525 village water supply schemes in place. Almost all of these schemes include a single drilled well equipped with a Lister Engine and Mono pump. Water is piped to an elevated tank in the village and reticulated through a pipe network to standpipes located throughout the village. There are 13 WMUs throughout the country at District centers. Their locations are given in Appendix K. These WMUs are staffed by a mid-level technician, several mechanics and a number of laborers. The total staff per unit is about 15-20. Equipment includes a number of vehicles, 4x4s, 7-ton trucks, and water tankers (total vehicles about 6-10) and a stock of spares and the tools to perform repairs. Normal funding is provided through the GOB recurrent budget and appears adequate for normal operation.

Technical assistance and funding for special projects is provided through the Water Engineer at MLGL. Special projects include District Development Support (for upgrading the WMUs), the Village Water Supply Rehabilitation (for upgrading and expanding water supply schemes in villages that require it), and the Drought Relief Program (for addressing the emergency needs of rural village water supplies as they arise). Details of these programs have already been discussed in Chapter 3.

4.1.3 Other Ministries

There are several other Ministries that affect water supply activities and policies. These include the Ministry of Finance and Development Planning (MFDP), the Ministry of Agriculture (MoA), the Ministry of Works, Transport and Communication (MWTC), the Ministry of Commerce and Industry (MCI) and others that have need of water for their special purposes. A listing of drilled wells operated by other departments and agencies is given in Appendix L.

MFDP oversees the budget process and is responsible for development planning. as a result of the past six years of drought and the ministry's responsibility for rural development, MFDP has taken a leading role in coordinating drought relief activities. These activities include chairing the Inter-Ministerial Drought Committee and coordinating the provision of funds for meeting the emergency water needs for humans and livestock.

The MWTC plays a pivotal supporting role to Government water supply efforts through the Central Transport Organization(CTO). CTO is responsible for providing support services to the entire central Government fleet of vehicles. This includes providing fuel through fuel depots, and all maintenance and repair. In addition, CTO is responsible for fuel and servicing all vehicles operated by DWA for siting, drilling, equipping, and maintenance. The District Councils maintain their own workshops for maintenance and repair of vehicles.

MoA is the largest Ministry user of DWA's service of drilling and equipping boreholes. DWA has installed approximately 200 systems for various agencies within MoA over the years. In addition, MoA is responsible for water supply activities that fall outside formal DWA or MLGL programs. Efforts are underway to introduce a hand dug and shallow drilled well handpump program. Initial funding of US$315,000 has been provided by UNCDF through the UNDP office in Gaborone to purchase equipment. An initial goal is 25 wells per year. The current National Development Plan places increasing emphasis on irrigated agriculture and MoA anticipates continuing to call upon DWA to assist in drilling and equipping boreholes.

The Department of Wildlife and National Parks within the MCI has also called upon the assistance of DWA increasingly in order to help alleviate the difficulties of wildlife water supply during these years of drought. Other Ministries operating water supplies include Ministry of Education, Ministry of Works, Transport and Communications and the Office of the President (for the Botswana Defense Force).

4.2 Multi-lateral Donors

Current multi-lateral aid donors in the water sector include the Swedish International Development Authority (SIDA), the European Economic Community (EEC), the British Overseas Development Administration and others through the Drought Relief Program.

4.2.1 SIDA

By far the most influential assistance over past years has been provided by SIDA. Funds have been made available for technical assistance, manpower development, equipment and special programs. The SIDA program was initiated in 1971 with the aim of contributing towards raising the standard of living of the poorer groups in rural areas. Today the water sector program has three major components--rural village water supply construction through DWA, operation and maintenance including rehabilitation through MLGL and hygiene education and sanitation support to the Ministry of Health.

Water supply construction has included construction of roughly 285 village water supply schemes with about 69 villages remaining in the program. Construction has been planned for 20 schemes per year. This year, due to the efforts focused on drought priorities, it is estimated that only 10-12 schemes will be completed.

The rehabilitation program is focusing on the need to upgrade and extend systems constructed in earlier years of the program. The general lowering of the water table, the drying up of some wells due to the drought and increases in population and migration to villages with reliable water supplies have put unexpected burdens on many water supply programs. This has made location of new water sources and rehabilitation of these systems a high priority.

The water hygiene campaign has focused on community-level health and hygiene awareness so that the benefits of clean water are not lost after the water leaves the tap. These programs have included a large technical assistance component with SIDA personnel in line positions at DWA and MLGL. The previous director of DWA as well as about a dozen other higher level positions are held by expatriates. SIDA has also provided funds for special studies including a water cost and tariff study, a water system design manual, and a National Water Master Plan.

4.2.2 EEC

During the last several years, the EEC has been particularly responsive to needs in the water supply sector. EEC funds have been made available to purchase equipment and provide technical assistance to DWA and the WMUs. Three engineers have been placed within the Design and Construction division of DWA and vehicles have been purchased. Vehicles have included 4x4 Land Rovers and Mercedes Tanker trucks.

4.2.3 Other Donors

Other donors have also been involved These include ODA in the training area, the Netherlands by provision of WMU technicians through volunteer programs, UNDP in provision of emergency assistance to three villages and provision of the hydrologist/planner as mentioned earlier, and German aid has been made available in redesign and rehabilitation of several of the water systems of major villages.

4.3 Non-Governmental Organizations

The only non-governmental organization currently working extensively in the water sector is the Lutheran World Federation (LWF), working closely with the District councils, DWA and the IMDC to coordinate activities. LWF is currently working in ten villages and Remote Area Dwellers (RAD) settlements to provide piped water as government standards require. The capacity of the one water engineer with limited staff at LWF is 2-3 new water supply schemes per year. LWF currently has requests for more than 30 villages and settlements for water systems. Most of these requests come from settlements that fall outside current GOB programs or are not scheduled for inclusion in GOB programs until the next decade. Current LWF water activities and their locations are provided on the map in Appendix M.

4.4 Private Sector Capability

The private sector is involved in almost all aspects of water supply. There are groundwater consultants with extensive experience in Botswana, contract drilling companies, pumping equipment suppliers and equipment overhaul shops. Field servicing of equipment is available through private companies. The cost, however, is high. Government installations are serviced by DWA, then the Borehole Repair Service (BRS) or the District Council WMU. Privately owned equipment is often serviced by so called "bush mechanics". The quality of this service is generally adequate to poor.

There are four local companies with groundwater hydrologists on staff. In the past, most of their work has been on a contract basis to DGS. They have also assisted DWA in borehole siting on occasion. It is anticipated that this component of their work will increase over the next year.

There are currently three drilling contractors operating more than one rotary drilling rig and a number of smaller companies operating percussion equipment. The larger contractors have worked on an 'as needed' basis for DWA and DGS over the past several years. They contend that they are reliable drilling contractors who need to be given the opportunity to work regularly on government programs. However, other reports from District Council officials indicate that they have not performed well when this opportunity was provided (see Appendix B).

Diesel engines, pumps and related hardware are readily available in Botswana. Almost all of this equipment is imported from the Republic of South Africa (RSA). Botswana is a member of the Southern Africa Customs Union (SACU) which greatly simplifies importation of equipment from member countries (RSA, Lesotho, and Swaziland). Because importation of equipment and spares is so easy, private suppliers do not keep large inventories of spare parts. Currently, almost all items not in stock can be obtained within two to three days.

Chapter 5

ASSESSMENT OF GOVERNMENT CAPABILITY

The scope of operations and the capability of DWA and the District Council WMUs are quite different. The capabilities of these two groups are discussed separately below under sub-headings which define current capabilities to respond to emergency water requirements for potable water supply as well as the water needs of other users, including livestock, wildlife and ongoing GOB development activities.

5.1 Department of Water Affairs

As noted in Chapter 3, DWA is essentially responsible for drilling all water supply wells in Botswana. DWA is also responsible for operation and maintenance of major village water supplies. At the present time, this responsibility extends to 17 villages.

5.1.1 Staffing

It is beyond the scope of this assignment to make an analysis of or specific recommendations in connection with DWA staff. However, a few comments may be useful to those generally unfamiliar with the organization. These are:

- Every contact that the team has made is very pleased with the replacement of the former expatriate Director with Mr. M. Sekwale and his appointment has boosted morale throughout the top posts of DWA. However, he is new to the post and will need time to become intimately familiar with all aspects of DWA activity.

- Understaffing and a desire on the part of SIDA to accomplish a much greater degree of localization (replacement of expatriates with Botswana nationals) in the next 2-3 years appears to be a problem without any reasonable prospects for solution. Current GOB thinking appears to be that the recently completed Water Administration Study (WAS), mentioned earlier, does not offer any help in this regard.

- On the operational level, personnel doing the drilling need training. UNDP is sponsoring a 3 month course for 3 drillers to receive training in the U.S. during 1988. There is no such commitment for 1989 to train the remaining 3 drillers responsible for operation of DWA's rotary rigs.

- Training of mechanics is badly needed. Additional staff are also needed. At present there are 2 expatriates and 5 Botswana nationals (only one of whom is deemed truly competent) attempting to maintain 27 pieces of major equipment used for drilling and work associated with well drilling and completion.

- There is adequate capacity at DWA to handle design and construction needs of the emergency program.

5.1.2 Drilling Equipment Performance

Drilling equipment, drill rigs and other major pieces of support equipment amounting to 27 units are identified in Table 3.

The 6 truck-mounted rotary rigs and 8 percussion rigs are normally operated by an 8-man crew. Other support equipment may have crews of 6 to 8 persons. SIDA's 1987 Annual Review, dated March 1987, notes that during 1985/86, DWA's drilling performance decreased from 199 the previous year to 138 "successful" boreholes. The "success rate", i.e., boreholes yielding more than 1.5m^3/hr. was about the same for the 2 years. The above 1985/86 figure of 138 boreholes includes 39 drilled by private contractors so DWA's total is only 99. Verbal communication with Mr. A. Johnson, SIDA Program Officer, revealed that DWA's performance had further dropped to 80 for 1986/87. Statistics on DWA's 1985/86 drilling performance, according to SIDA's 1987 Annual Review, are presented in Table 4.

5.1.3 Condition - DWA Drilling and Associated Equipment

Table 3 identifies the 27 pieces of major equipment maintained by DWA which are used for various purposes of drilling, cleaning, test pumping and rehabilitating water supply wells. At the present time, only 1 new rotary rig, one 9-year-old rotary rig overhauled in 1987 (Rotary II) and one new percussion rig are in satisfactory working condition. Eleven others, comprising their entire public water well drilling supply capability, are in desperate need of major overhaul. DWA has the capability and parts in hand, or on order, for overhauling 7 percussion rigs. It has neither the capability to overhaul or budget to acquire parts for 2 Schramm and 2 Atlas Copco air rotary drill rigs which provide the major part of the potential drilling production. Even in their poorest year, to date, these 4 rotary rigs drilled 4 times the footage accomplished by all the percussion rigs. In good condition, each rig should be capable of drilling up to 3.5 wells per month. Correspondence in AID/Gaborone files regarding replacement of an old drill rig in 1982 noted that the Schramm rig provided by AID in 1979 (under Borehole Drilling AIP 698-410.21) was drilling abut 50 boreholes per year between 1979 and 1982.

Table 3

MAJOR DRILLING AND ASSOCIATED EQUIPMENT USED BY DWA

No of units	Manuf.	Model	Operation	DWA Designation	No unit	Age years	Maintenance needs
1	Schramm	T68SDH	Air rot/air ham.	Rotary 2	1	9	Minor- major overhaul 1987, engine under exchange 1/88
1	Schramm	T68SDHH	Air rot/air ham.	Rotary 6	1	4	Electrical & hydraulic overhaul, engine changed 5/87
1	Schramm	T68SDHH	Air rot/air ham.	Rotary 3	1	6	Major overhaul, engine changed 8/87
1	Atlas-Copco	Rotomec 1302	Air rot/air ham.	Rotary 1	1	5	Major overhaul, spare rebuilt engine available
1	Atlas-Copco	Rotomec 1302	Air rot/air ham.	Rotary 5	1	5	Major overhaul, engine changed 3/87
1	Atlas-Copco	(*)	Rock Quarry/ Crawler Rig	Rotary 4	1	4	Normal maintenance
1	Bomag(**)	B75ODTH	Comb. air/fluid Rotary air hammer capability	Rotary 7	1	New	Normal maintenance
1	Bomag	R800S	Percussion		1	New	Normal maintenance
4	Ruston Bucyrus	60RL	Percussion		4	12	Deck engine replacements, from recurrent budget
3	Ruston Bucyrus	22W	Percussion		3	12	Deck engine replacements, from recurrent budget
4	Dando	800	Percussion/ Used as cleaning rigs		4	3	Normal maintenance
3	Bomag		Test Pump Units		3	New	Normal Maintenance
3	Atlas Copco		Test Pump Units		3	5	Normal maintenance
2	Old small local types		Test Pump Units		2	(?)	(?)

* A separate trailer mounted Atlas Copco 350 cfm/20 bar compressor is maintained for powering the Quarry rig

** A separate trailer mounted Atlas Copco 385 cfm/20 bar compressor is maintained for powering the air operation of the Bomag 750

Table 4

NUMBER OF BOREHOLES DRILLED BY DWA AND PRIVATE CONTRACTORS UNDER DWA CONTRACT DURING 1985/1986

Drilling Rig	Drilled (m)	Drilled Boreholes	Successful Boreholes	Percent of Success
Rotary I	1319	14	7	50
Rotary II	3788	21	12	57.14
Rotary III	4481	30	14	46.66
Rotary V	5151	42	17	40.47
Rotary VI	3488	21	10	47.61
Totals	18227	128	60	46.87
Percussion Rigs (5 operating)	2568	60	39	65
Drilled by Water Affairs	20795	188	99	52.65
BH Drilled by Contractors	10722	74	39	52.70
Total Drilled	31517	262	138	52.67

Note: Rotary IV is an Atlas Copco crawler type quarry rig that is not used for drilling public water supply wells.

The 1987 service record for the drilling rig which required the greatest attention is reproduced in its original form in Appendix N.

5.1.4 Request by Director of DWA for Assistance in Rehabilitating Drilling Equipment

Because of the foregoing, the new DWA Director requested that the WASH team include the overhaul of the 4 rotary rigs in need of such attention as the first priority in any assistance that they recommend.

The need for new special tools for the rotary rigs, training and trials of hydro-fracturing of existing boreholes as a possible alternative to drilling a new replacement well were also discussed and are listed and commented on in Chapter 6.

5.1.5 Design, Installation and Maintenance

DWA currently has sufficient capacity to repair and overhaul pumping equipment. DWA maintains repair crews at most major villages with sufficient spares to assure adequate operation of these water supply schemes. The fact that all major villages are supplied from more than one borehole with stand-by units available helps to minimize vulnerability to equipment breakdown. Centralized DWA repair facilities have the capacity to overhaul 400-500 engines per year. This overhaul service is available to the District Councils and to private individuals as well through the BRS. Neither funds for spares nor procurement is perceived as a problem. Pumps and pumping equipment rehabilitation are not seen as a constraint.

5.1.6 Water Transport

Only in one instance has water hauling been necessary to any of the 17 villages where DWA actually administers the water supplies. From October to December 1987, before the recent rains, water was hauled to Mahalapye. This was accomplished with rail tankers and road haulage. The daily requirement for the village was over $500m^3$. This operation was made possible by leasing rail tankers from Botswana Railways and using DWA road haulage equipment. This program ran smoothly until the recent rains washed away sections of the rail line. Water delivery has been suspended as the Mhalatswe river has been replenished and water is available through river extraction and chlorination. This is not considered a permanent solution and work continues on the completion of the connection to the Palla Road wellfield. This operation makes clear that DWA is able to mount emergency water relief through water haulage. However, in this instance the operation was simplified by proximity to the rail line and a good paved road. If such an emergency situation arose in a more remote village, the difficulties would be compounded and there may be some concern that an adequate program could be mounted. Fortunately, this situation has not yet arisen. On the other hand, at the District level, WMUs have been regularly trucking water to smaller villages as discussed in Section 5.2.3.

5.1.7 Planning

Longer term planning activities are undertaken within the Design and Construction Division with oversight provided by the Director and inputs from other Divisions as needed. Shorter term plans are formulated within each DWA Division. In many cases, it appears that the plans of the Groundwater Division have been optimistic. The deteriorating condition of the fleet of drilling equipment has contributed to failure to meet plan deadlines. Without significant repairs to this equipment, it appears that the plans for the consolidated emergency program are also overly optimistic. Even with fully operational equipment the current plan deadlines appear to be difficult to achieve. With the current DWA Director in place for less than three months, and still learning portions of his job, some assistance on a short-term basis would greatly assist in the planning and initial implementation of the consolidated emergency program.

5.2 District Council WMUs

The District Councils have no capacity to drill or rehabilitate boreholes. All of this work is performed by DWA on the basis of requests from the Districts. The MLGL Water Engineer has an emergency fund that will allow the hiring of private drilling contractors on an emergency basis. Unfortunately, the Government tender process makes this difficult as a formal bidding procedure is required for procurement of over P5000 of goods or services. This usually precludes the use of this emergency fund for borehole drilling.

5.2.1 Staff

As discussed in Chapter 4, each District Council WMU is headed by a Water Unit Technician supported by a staff of mechanics and laborers. These technicians report to the Chief Technical Officer-Works in most districts and to the Chief Technical Officer-Water in the remaining. In the recent past, the Water Unit Technicians posts were largely filled by expatriate volunteers. These volunteers were all replaced over the course of the past year by recent graduates of the Botswana Polytechnic three-year water technicians course. Most of these graduates are young, and although well grounded in technical aspects of water supply, are inexperienced. Some technical and administrative support is available through the Water Engineer placed centrally at MLGL and an additional Water Engineer placed in Central District (at Serowe). The capacity of these two individuals to assist in field-related problems is minimal due to the other demands of their positions. SIDA has recognized this gap and suggested recruitment of a technical assistant to the MLGL Water Engineer who would be field-oriented and able to assist with specific problems. This individual is not yet in place and recruitment is now on hold due to unrelated matters.

The staffing levels within the WMUs appear to be adequate. Most routine repairs are performed without difficulty. Training is needed, particularly for pump operators and some of the mechanics. Improved reporting procedure for faults, both in accuracy and speed, would assist in increasing the reliability of water supply systems. Unusual problems appear to be often beyond the scope of the Water Units to handle. In these cases, the problems are often referred to DWA under an emergency request.

5.2.2 Operation and Maintenance

Over recent years there has been an effort to upgrade the capacity of the WMUs. This has included providing funds for equipment and spares, vehicles, and staff training. This effort has significantly improved the capacities of the WMUs. However, many difficulties remain. These include long distances to pumping stations over poor roads, poor quality of many pumpers, and in some districts a very heavy workload due to the large number of engines and pumps requiring general maintenance or repair. The capabilities of the Water Unit Technicians vary widely. As noted in Subsection 5.2.1, many are young and have limited practical experience in the technical and administrative aspects of water system operation. This has led to some inefficiencies in WMU operation

and misdiagnoses of problems. The quality of pumpers has compounded some of these problems as poor pump operating habits at some sites have led to water shortages that could otherwise have been avoided. The greatest need at the Council level appears to be technical support to the Water Unit Technicians to assist in identifying and solving difficult or unusual problems.

5.2.3 Water Transport

Water is hauled by tanker truck or tractor in many villages. In North-west District, 10 percent of the district's villages are supplied in this way. This is necessary due to the failure of boreholes to yield adequate water for village needs. Discussions with District officials and central government officers indicate that sufficient capacity for water haulage now exists. A recent donation by the EEC has made the purchase of water tankers possible. If the drought continues and more villages need to be supplied by tanker, there may be a need for additional tankers. If it becomes necessary to transport water to larger villages, such as many in the consolidated emergency program, the WMUs will experience extreme difficulty.

5.2.3 Planning

Most planning activities take place at the District level under the direction of the District Council Secretary and the CTO (works or water as the case may be). Requests for assistance and priority for DWA assistance under the Drought Relief Program, the Rehabilitation Program and other programs are channeled through the MLGL's Water Engineer. He must then prioritize activities among the districts and submit requests to DWA. The list of 57 villages referred to previously is a result of this process. Time and schedule constraints make it difficult for MLGL's Water Engineer to visit rural villages and ascertain the seriousness of each village's difficulty. This makes the suggestion of emergency measures, prioritizing and planning difficult. This has become increasingly true as the water supply situation has deteriorated over the last year as a result of the drought. It is clear that a field-oriented technical assistant is an immediate need during this later planning and early implementation of the consolidated emergency program being mounted by the DWA. However, as was noted in subsection 5.2.1, recruitment for an individual to assume such a role is currently on hold.

Chapter 6

RECOMMENDATIONS

6.1 Recommendations on DWA Requests and Problem Areas

The following specific forms of assistance to DWA are briefly discussed following the WASH team's indication of "Endorsement" or "Endorsement Considered Inappropriate". In the latter case the DWA request for assistance may be of great merit but be a development-oriented activity or one requiring a commitment of over 12 months. Endorsement was considered only if the activity was clearly a short-term requirement to meet short-term needs, or provide emergency bridge funding or assistance during the time that GOB's own plans are being finalized and set in motion.

6.1.1 Recondition 4 Rotary Drilling Rigs

Recommendation: Endorse

The WASH team views the fulfillment of this request, which the DWA Director indicated as his first priority relative to needs, to be necessary to achieve any degree of success in the new drought emergency drilling program. Reconditioning might not increase production to equal that of a new rig but should improve it considerably. Presently production is less than 50 percent of capacity.

Basic Program for Reconditioning would include:

All work related to reconditioning of 2 Schramm and 2 Atlas-Copco air rotary drilling rigs is to be carried out in the DWA yard. Reconditioning of a similar rig in a South African facility in 1987 took nearly 2 months but advance planning and dedication to work on one machine without other distractions should permit all 4 rigs to be rehabilitated in less than 6 months after authorization to proceed. The anticipated general schedule is as follows:

a. Up to 3 weeks of training by an Atlas-Copco supplied mechanic/trainer of 3 Batswana mechanics and 3 drillers (primarily hydraulic systems and electricity - from a $10,000 package of training books and mechanical aids on hand in DWA) before reconditioning.

b. Actual reconditioning of Schramm rigs, one after the other, so, to the degree possible, most rigs and crews remain working in the field. The work to be performed by a Schramm furnished mechanic assisted by 3 trained Batswana mechanics. It should be noted that the Atlas Copco Rotomec machines were built to Schramm design and are generally comparable. Drillers who receive mechanical training under (a.) above would not participate. Three to four weeks per rig anticipated as time schedule of reconditioning.

c. Following reconditioning of the initial 2 rigs a new training exercise, with 3 other mechanics and 3 other drillers not trained under (a.) exercise above, would be carried out; following which the 2 Atlas Copco Rotomec rigs would be reconditioned in similar manner to that described above. Note that the above program to the point of starting work on the "Rotomecs" anticipates 9 to 12 weeks permitting sea freight delivery of Rotamec parts, of approximately 8 to 10 weeks. Exercise (c.) is expected to be carried out through a return of the Atlas-Copco mechanic/trainer.

Reconditioning Costs are estimated at $250,000. For details on the cost estimates see Appendix O.

6.1.2 Training for Batswana Mechanics

Recommendation: Endorse

See program described under 6.1.1 above.

Training Costs are included in estimate for 6.1.1 activity.

6.1.3 Additional Training for Batswana Drillers

a. Training should focus on knowledge of basic mechanics and preventive maintenance activities that should be practiced in field operations to minimize breakdowns.

Recommendation: Endorse

See program described under 6.1.1 above.

Training Costs are included in estimate for the 6.1.1 activity.

b. Drilling techniques-especially mud drilling

Recommendation: Special Case (See comment below)

This activity would normally have been selected for endorsement. However, a 3 month training program for 3 Batswana drillers is being provided by the UN in 1988. It is uncertain if 3 additional drillers will be provided like training in 1989 but such a future activity was felt to be beyond the terms of reference for the team to consider.

c. Providing drillers with new techniques or providing new equipment which would overcome the problem of 40 to 50 percent of boreholes drilled not yielding sufficient water to meet delivery standards for setting a pump.

Recommendation: Special Case (See comment below)

This activity has two different interests.

One: Driller training in the U.S. under the UN program is likely to provide training in well development where a somewhat better success rate might be anticipated.

Two: Improved well performance by utilizing special high-pressure rock fracturing (hydrofracturing) equipment was previously tendered by DWA and rejected as the 2 tenders received were not comparable. WASH may be interested in providing comments on the procedures proposed in the original tender document and follow-up reporting but any interest implied by the WASH team in connection with this work at this time was felt counter-productive as it might just delay a decision to proceed.

6.1.4 Flush Joint Well Casing

Recommendation: Endorsement Considered Inappropriate Not seriously considered for OFDA assistance.

This is temporary casing, screwed together, which can be used during advancement of the borehole by percussion drill rigs. Mainly used in the U.S. for diamond core drilling and installation of small diameter wells for hazardous waste monitoring and not by U.S. drillers using percussion rigs where welded joint casing (now practiced in Botswana) is customarily used.

6.1.5 Drilling Bits and Fishing Tools

Recommendation: Special Case (see comment below)

During the week ending 6 February 1988, a Shramm representative is scheduled to inspect two Shramm drilling rigs for needed replacement parts necessary for their rehabilitation. He has been asked to review needs for lost and worn out tools necessary for the efficient operation of these machines, including fishing (retrieval) tools. A list and costs have been promised to be telexed to WASH on either the 8th or 9th of February for OFDA's consideration.

Costs are expected to be delivered as noted above from Schramm for OFDA's consideration. A tentative estimate of costs, totaling $40,000, is presented in Appendix P.

A similar assessment for Atlas Copco equipment is expected later with any needs following normal GOB procurement procedure.

6.1.6 Expatriate Borehole Drilling Supervisors in Field Operations

Recommendation: Endorsement Considered Inappropriate With Exception of One Short-Term Consultant to Fill Interim Period

The WASH team considers this intervention a long-term commitment which, in their view, is needed but is beyond the terms and conditions of their instructions to consider in detail.

It is also their understanding that such an activity may be funded by other donors. A request for this assistance was made to Australia which may or may not be interested.

6.1.7 Assistance to Organize Stores

Recommendation: Endorsement Considered Inappropriate

The WASH team recognizes the difficulty that DWA has with organizing and maintaining stores. Particularly in light of the fact that DWA must depend on the Department of Supplies in the Ministry of Finance and Development Planning. This division of authority complicates matters considerably. However, this is a matter that must be resolved within the GOB and the departments involved.

6.1.8 Assistance in Solving Transport Problems

Recommendation: Endorsement Considered Inappropriate

This is one of the single largest difficulties that DWA faces. CTO (within the MWTC) is responsible for the entire fleet of vehicles that DWA operates. This means that DWA has little control over one of the functions on which it depends. CTO has priorities that go beyond DWA needs including Ministry of Health, the Botswana Police, etc. In addition, CTO mechanics have little experience or training on the Swedish Scania trucks which are so important as support vehicles for drilling and well equipping operations. Vehicle problems were cited almost every time that DWA limitations were discussed.

Although it is clear that these problems need to be addressed, it is an issue which must be solved within the GOB. The IMDC has recognized the difficulty and is in a position to assist in finding a solution to the problem. Purchase of new vehicles was not considered by the WASH team.

6.1.9 Assistance with Electrical Maintenance and Repair

Recommendation: Endorsement Considered Inappropriate

DWA operates a substantial amount of electrical equipment, both as part of the drilling operations (generators and electric pumps) and for pumping water for major villages. The responsibility for maintenance and repair of this electrical equipment lies with the Department of Electrical Engineering (DEE). No electricians are seconded to DWA so that their electrical needs can be attended to immediately. This separation of responsibilities has caused some problem and delay in DWA operations. The Director of DWA has noted that three different Government Departments are involved with operation and repair within the drilling fleet. DWA operates the equipment and repairs the deck engines, DEE is responsible for the high voltage electrical systems, and as noted above CTO is responsible for the vehicle.

As before, the resolution of these problems must remain with the GOB. No appropriate action can be suggested by the WASH consultants.

6.1.10 Provision of Short-Term Planning Assistance to the Director of DWA and the Groundwater Division.

Recommendation: Endorse

The DWA Director has indicated a serious need for assistance, at a senior level, for a person who can quickly become familiar with the DWA's drilling capabilities, recognize the obvious and less obvious problems that stand in the way of better progress in borehole completions and can develop a responsible plan of drilling operations. He would, for the most part, be filling an advisory role but he would need a broad long-term association with all phases of water well work and management from being capable to institute proper record keeping forms to participation in contractual negotiations.

The WASH consultants recommend that short-term technical assistance be provided to the Director in the form of a drilling program manager with broad experience as described above.

An estimate of cost to provide 5 months of assistance would be $65,000.

6.2 Recommendations on Requests from the MLGL Water Engineer

6.2.1 Provision of Short-Term Technical and Planning Assistance to MLGL's Water Engineer.

Recommendation: Endorse

The need for a field-oriented technical assistant to the Water Engineer at MLGL was recognized as long ago as March 1987. Recruitment for such a post was a recommendation of the Annual Review of the Village Water Supply Program at that time. To date the position has not been filled due in large part to bureaucratic procedures although movement towards recruitment is being made. The planned scope of work for the technical assistant is to assist the Water Engineer and the District Council Water Unit Technicians by visiting villages

and assisting in problem identification and solving as well as assist in planning and administrative matters. With the growth of the present water crisis, the need for field liaison and field assistance has become much more important. Clear plans and goals require a thorough understanding of the conditions in villages in the most drought affected areas.

It is recommended that a technical assistant be provided on short-term basis for a period of six months to assist the MLGL water Engineer in emergency planning, prioritizing and field-related problem solving during the current planning stages and early implementation stages of the consolidated emergency program.

Provision of short-term technical support is estimated at US $40,000. See Appendix Q for tentative scope of work and detailed budget.

6.3 Recommendations on District Council Requests

6.3.1 Provision of Drilled Wells to Remote Settlements in North-west District

Recommendation: Endorse

During the past year, North-west District has been particularly affected by drought conditions. Effort have been underway for several years to provide water to smaller settlements not currently included in other water supply programs through a dug wells program. Because of the water levels in this area, it is one of the few places in Botswana where such a program could be successful. In a number of remote locations hand digging of wells was attempted unsuccessfully due to striking bedrock. Water is currently being transported to at least one of these locations at great difficulty and expense to the District Council. The provision of drilled wells to be equipped with handpumps in six of these settlements would greatly relieve the disruption of life inherent in the efforts to bring water from great distances, and/or the cost and complication to the District in trucking water to these settlements.

It is recommended that a local drilling contractor be engaged to drill wells in Samedupi, Dobe, Chikumuchu, Thamacha, Tsodilo, and Magope in North-west District. In these settlements dug wells have proven impossible. The inclusion of six villages reduces the overall mobilization required and provides an incentive for the contractor to respond.

Estimated cost for providing six drilled wells and handpumps for NWDC is estimated at US $95,000. Cost details are included in Appendix R.

6.4 Summary of Recommended Activities

Five activities have been recommended for inclusion in the USAID-funded program. These are as follows:

• Rehabilitation of drilling equipment	US $250,000
• Short-term technical assistance to DWA	65,000
• Short-term technical assistance to MLGL	40,000
• Drilling of six emergency wells for NWDC	95,000
• Provision for emergency drilling tools	40,000
Total Cost	US $490,000

6.5 Implementation of Recommendations

After development of the WASH team's recommendations, the question of how to implement them was raised at a meeting with Mr. C. Tibone, Permanent Secretary/Ministry of Mineral Resources and Water Affairs. In anticipation of such a question a meeting had been held with Mr. N. Jones, Financial Officer/ Central Tender Board, and a subsequent meeting with Mr. J. Chompa, Asst. Comptroller/USAID/Botswana. The conclusion from these meetings was that the only expeditious way to provide prompt assistance was for USAID to make payments directly to suppliers and contractors upon certification from respective GOB Directors of Departments who were recipients of such assistance that materials had been furnished and/or services performed.

The actual procedure would be for the respective GOB departments to solicit and accept proposals. Proposal solicitation would need to be accompanied by a copy of an agreement between GOB and USAID stipulating USAID payment on certification of completion by GOB so respondents are aware of payment terms.

Technical assistance could be handled in like manner, through direct hire or through the WASH Project.

PHOTOGRAPHS

Photo 1. Subsidized Animal Fodder Stockpiled at Maun

Photo 2. Animal Remains Can be Seen Throughout North West District Council Area

Photo 3. Water Tank at Thamache Filled Twice a Week Requiring a 250 km Round Trip by Tanker Truck

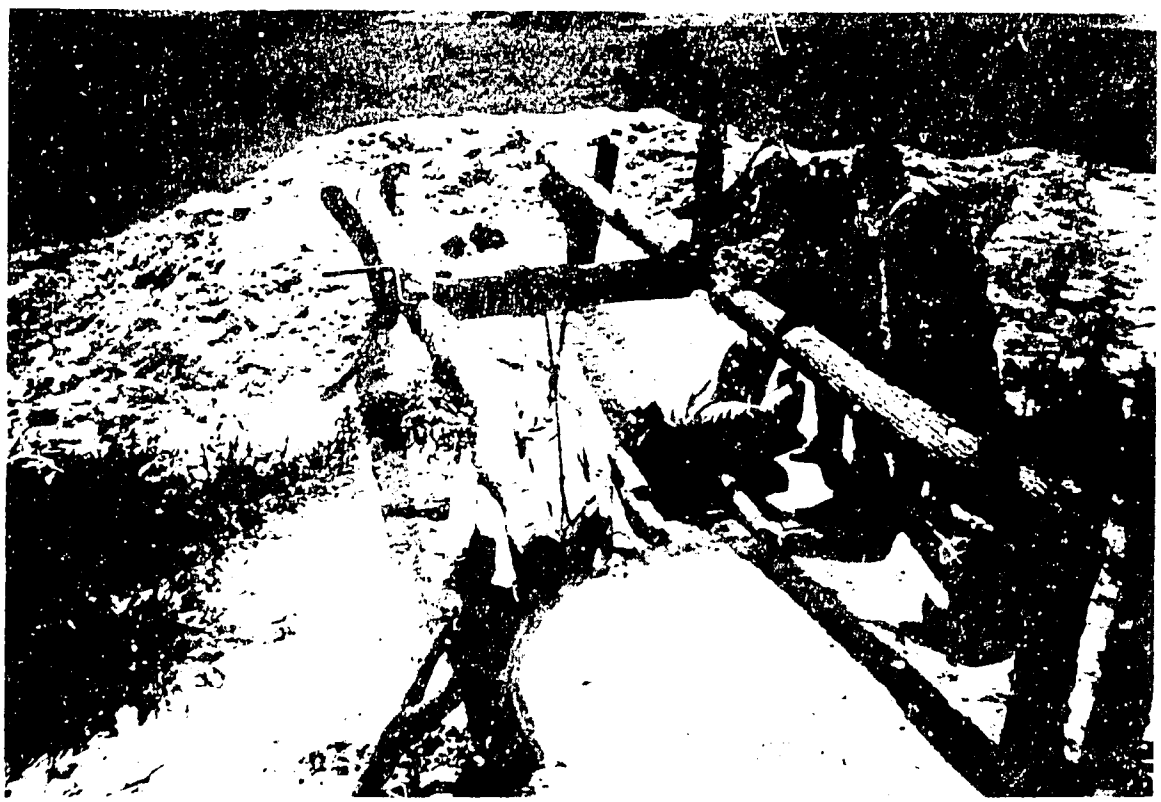


Photo 4. Dry Well East of Thamache Being Inspected by North West District Council Project Officer.

Photo 5. Tanker Truck Used in Delivery of Water to Drought Distressed Villages in North West District Council Area

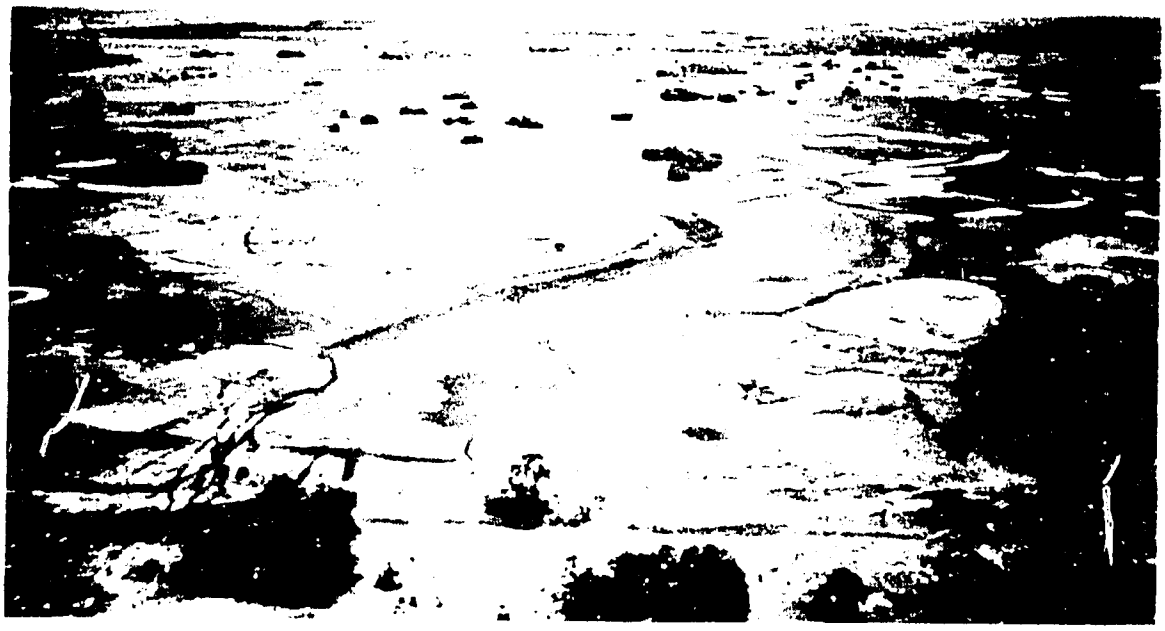


Photo 6. Okavango Delta Turned Partially Green by a Few January 1988 Rains - Early Rains (Oct.-Dec.) Entirely Absent

Photo 7.

Interior of Typical Well Pump Station

Photo 8.

Schramm Drilling Rig "Rotary 2" Waiting Installation of Rebuilt Diesel Engine.

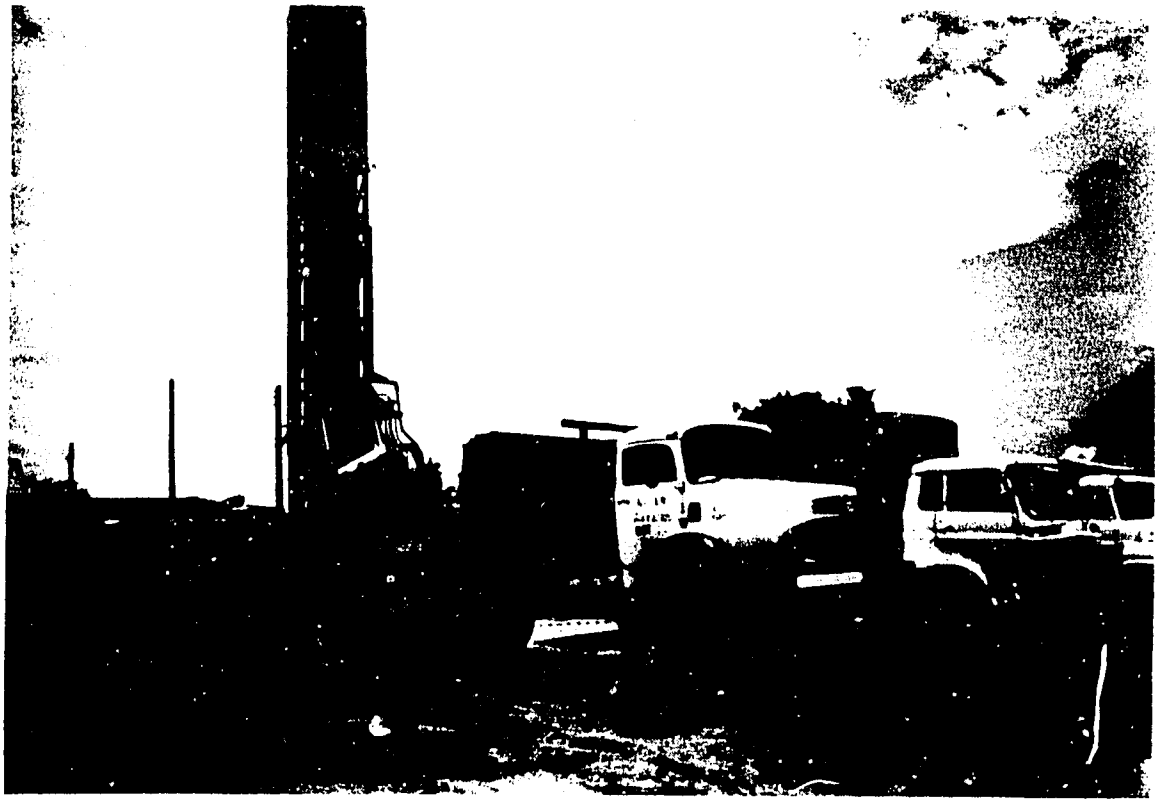


Photo 9. Central Vehicle Repair Facility on Gaborone

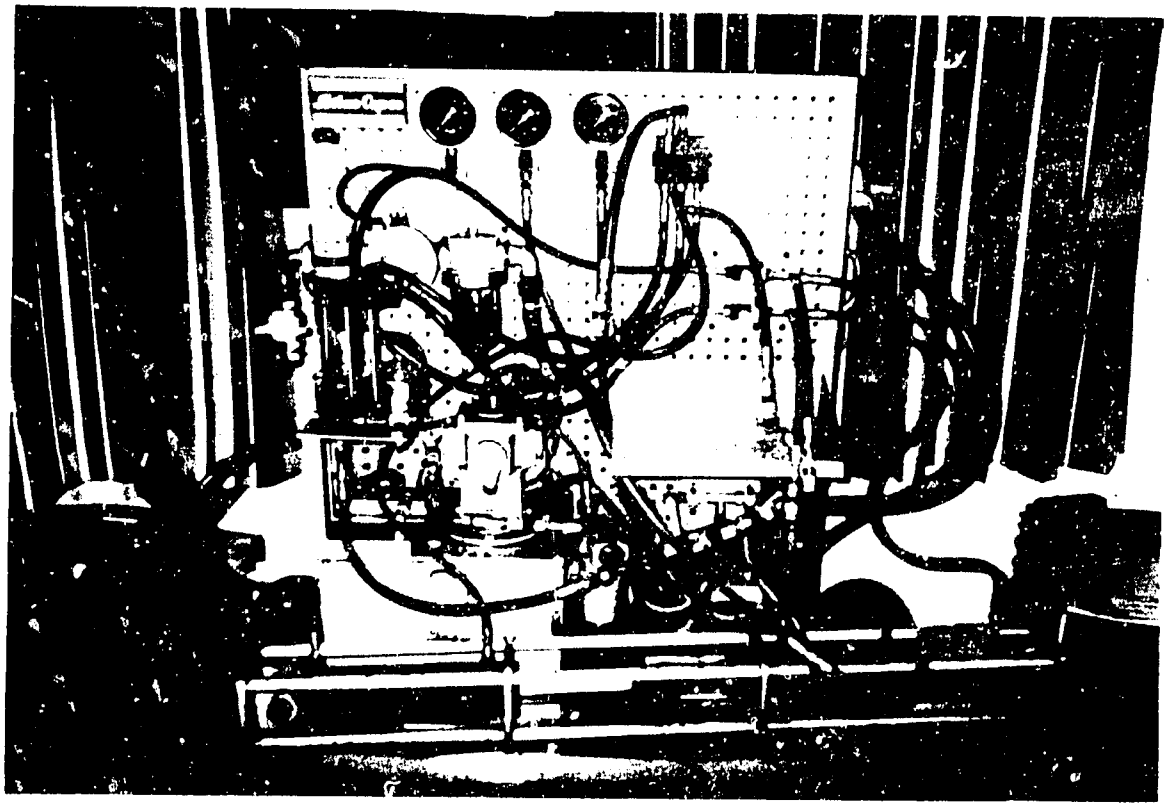


Photo 10. Atlas-Copco Hydraulic Training Board for Well Drilling Rig Repair and Maintenance Training

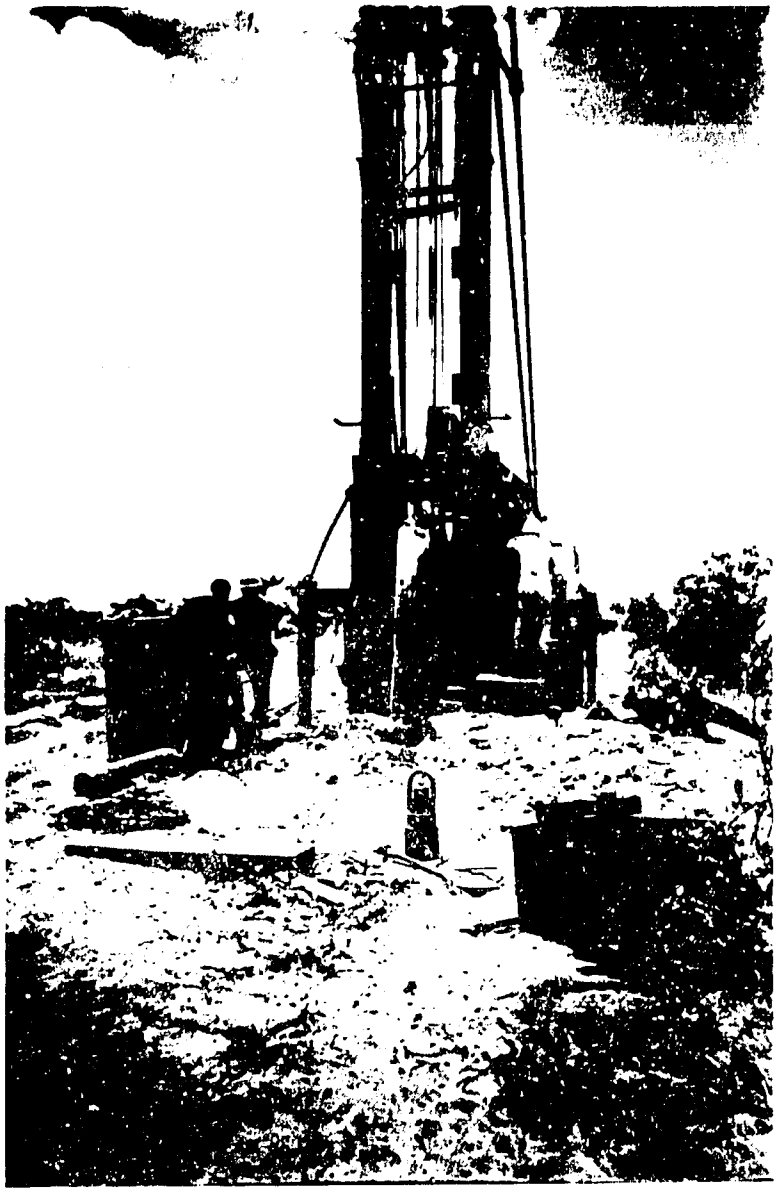
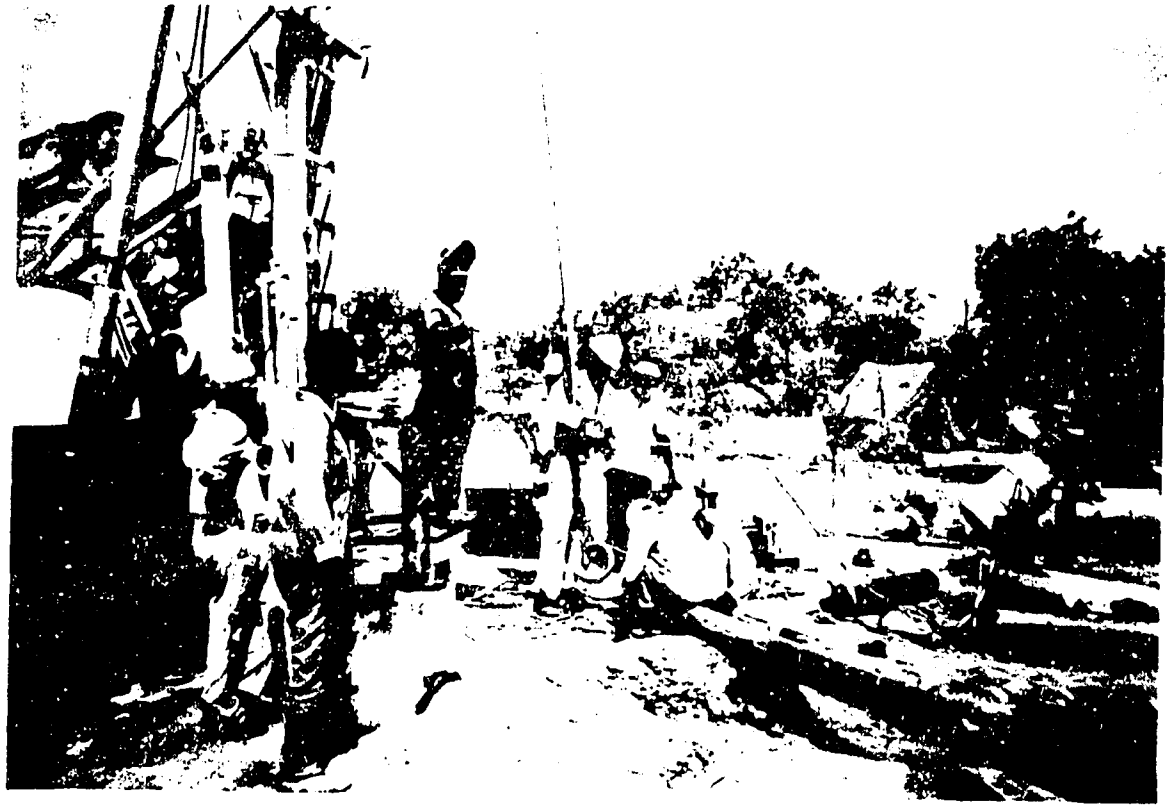


Photo 11.

New Bomac Percussion Drill Rig

Photo 12.

Well Cleaning rig Installing Well Liner of Slotted Pipe in Newly Drilled Well



Photos 13 and 14.

Well Dug by Villagers in
North West District Council
3-4 km East of Thamache

Photo 15. Hand-dug Well at Samedupi Abandoned as Bedrock Encountered without Finding Water

Photo 16. Successful Hand Dug Well with Hand Pump East of Maun at Matsaudi

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REFERENCES

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APPENDIX A

Interviews and Contacts

USAID/BOTSWANA

John Hummon	Mission Director
John Roberts	Deputy Director
Pushkar Brahmbhatt	Mission Engineer
Janak Chopra	Asst. Comptroller

Ministry of Mineral Resources and Water Affairs

Charles Tibone	Permanent Secretary
Jeff Walker	Finance Officer
Mirza Jahani	Planning Officer
Theo Kausel	Planning Officer
Moremi Sekwale	Director, DWA
Sigourd Holmberg	Principal Hydrogeologist, DWA
Jan Furengren	Principal Water Engineer, Design & Construction, DWA
Lennert Nilsson	Senior water Engineer, Design & Construction, DWA
Rolf Bergstrom	Senior Hydrogeologist, DWA
Joseph Sheridan	Rig Mechanic, DWA
Phil Robinson	Drilling Instructor, DWA
F M Masobe	Drill Forman, DWA
Seepi Molefe	Drill Forman, DWA
Hudson Komanyane	Drilling Supervisor, DWA
K.B. Morokwe	Borehole Inspector, DWA
Christos Ntshitang	B.R.S. Workshop Manager,DWA
S. Nidamarty	Hydrogeologist, DWA
C. Molosiwa	Acting Sr Hydrogeologist, Siting, DWA
Bertil Anderson	Senior Training Officer, DWA
Mr. Chabanga	Officer in Charge, DWA, Maun
Mr. Rathako	Officer in Charge, Water Supply, Maun
R. Kalse	Chief Technical Officer, Water Supply North, D.W.A
H. Janzer	Coordinator Drought Relief Program, DWA
E Selaolo	Senior Hydrogeologist Geological Survey

Ministry Of Local Government and Lands

Christer Lindblom	Water Engineer
C. Petje	Principal Administration Officer, RAD
G. Tidi	Acting Director, Department of Food Resources

Ministry of Finance and Development Planning

T.C. Moremi	Coordinator of Rural Development and Chairperson Inter-Ministerial Drought Committee
Norman Jones	Financial Officer, Central Tender Board
Diana Callear	Coordinator of National Food Supply and Sec. Inter-Ministerial Drought Committee

Ministry of Commerce and Industry

K.T Ngwamotsoko	Director Department of Wildlife and National Parks
M. Nchunga	Principal Biologist, Department of Wildlife and National Parks

Ministry of Works, Transport and Communications

D. Dambe	Agrometeorologist, MET services

Ministry of Agriculture

R. Gulubane	Water Engineer
G. Akafekwa	Department Director, Department of Disease Control
H. Mokobo	Chief Technical Officer, Communal Areas Management Unit
G. Singh	Head, Agricultural Statistics Unit
E. Makonteraka	Field Assistant, Thamacha

District Council

F. Mogotsi	Secretary, North-west District Council
L. Masalila	Planning Officer, NWDC
Mike Waterman	Senior Technical Officer Water, NWDC
Lars Elvenes	Project Officer, Wells, NWDC
K. Kemelo	Technical Assistant-Water, Gumare
T. Sekolo	Tirelo Setshaba, Thamacha
Peter Smith	Water Engineer, Central District Council

Donor Organizations

Finn Gunnerod	Field Officer/Volunteers-NORAD
Peter Healy	Water Engineer, Lutheran World Federation
Phanuel Glalah	Program Officer-Lutheran World Federation
Anders Johnson	Program Officer, SIDA
Hans VonSponek	UN Representative

Private Contractors and Local Consultants

Lars Hedin	Managing Director TGB Drilling
Paul Larkin	Managing Director Aquatech
John Farr	Director Geotest
Hans Kattstrom	Sales Manager, Scan African Trading
P. Ncube	Director, Specialized Drilling
Mr. Daniels	IPTC, Botswana (Agents for Schramm Drilling Equipment)

APPENDIX B

Trip Report

Trip 1

Participants:

Ralph Preble and Jonathan Hodgkin, WASH Consultants, and Sigourd Holmberg, Principal Hydrogeologist-DWA

Places Visited:

Palla Road wellfield, 125 km north of Gaborone along the Francistown Road

Date and Itinerary:

One day visit by car, January 16, 1988

Purpose of trip:

To inspect ongoing drilling and test pumping at the Palla Road site and evaluate field operation of drilling equipment.

Notes from Visit:

At the first site visited, a DWA crew was installing casing at Borehole No. 5763 located about 3 km south of the Tropic of Capricorn and visible from the Francistown road.

At this site, 6 inch slotted steel casing was being installed to insure that the somewhat unstable rock formations did not collapse in the future after a pump had been set. The operation was being carried out utilizing Cleaning Rig No. 3 which is essentially a percussion drilling rig. This equipment was manufactured by Atlas Copco and is designated as Model D800. The equipment and operation was in charge of Drill Foreman - Mr. F. Masube, who commanded an 8 man crew.

It was reported that bedrock was at a depth of 58m, total hole depth was 200m and static water level (non-pumping) was at 70.4m. Also, that it was installed as a exploratory borehole from which the original drilling crew anticipated a potential pumping rate of 20 m^3/hr when actually pump tested.

At the second site visited, recovery was being measured at borehole No. 5765 subsequent to completion of test pumping. This borehole was located about 2 km north of the Tropic of Capricorn and like borehole No. 5763 was visible from the Francistown Road.

At this location, an Atlas Copco pump setting rig, designated Test Pumping Unit (TPU) No. 3 was on site to set and remove an electric driven submersible pump used for test pumping. At this location 12 inch casing had been set to a depth of 78m and an 8 inch diameter well drilled to a depth of 144m with a static water level reported at a depth of 53m. A 72 hour pump test had been completed and the person on site was recording recovery levels at one hour intervals.

At the third site visited, a DWA crew was completing the drilling of the last borehole in the well field. This borehole was designated borehole No. 5760 and was located to the north of No. 5765 and 3 or 4 km to the west of the Francistown Road. This borehole was being drilled by a new Bomag R800S percussion drilling rig. At this location bedrock was at a depth of 13m below which an 3 inch diameter hole was being drilled to a predetermined depth of 151m. The 8 man crew at this location was under the direction of Drill Foreman - Seepi Molefe.

Trip 2

Participants:

Ralph Preble and Jonathan Hodgkin, WASH Consultants joined by Mike Waterman, Senior Technical Officer Water, North-west District Council (NWDC) and Lars Elvenes, Project Officer, Wells, NWDC

Places Visited:

Villages and settlements in North-west District- Maun, Gumare, Samedupi, Matsaudi, and Thamacha

Dates and Itinerary:

Preble and Hodgkin departed by air from Gaborone to Maun January 22, 1988. They were joined by Waterman and Elvenes in Maun. Preble, Hodgkin, and Elvenes visited Samedupi and Matsaudi on the afternoon of January 22. Preble, Hodgkin, Waterman and Elvenes visited Gumare and Thamacha on January 23. Hodgkin returned to Gaborone 23 January. Preble returned 24 January.

Purpose of Trip:

To inspect first hand the effects of the drought in the areas most affected during the latter part of 1987 and to discuss possible assistance with District officials.

Notes From Visit:

Visit to North-west District Council:

Met NWDC Secretary, Mr. F. Mogotsi, and conferred with NWDC planning officer, Mr. L. Masalila, CTO-Water, Mr. Waterman, and Project Officer, Wells, Mr. Elvenes.

Mr. Waterman explained that NWDC is responsible for the operation and maintenance of village water supplies for the whole of Ngamiland and Chobe areas. This included about 48 villages with public water supplies. The most distant of these is Beetsha, nearly 600 km from Maun on dirt and sand tracks that are impassable at some times of the year. The District is subdivided into three sub-districts with additional offices in Kasane and Gumare (see Map Chapter 2).

At present water is being trucked to 5 villages (Bodibeng, Bathatogo, Tubu, Phuduhudu, and Thamacha). Delivery to Thamacha, the most difficult of the sites, requires two round trips of about 500 km each week with a 6,000 liter tanker truck. Due to the drought conditions, many people are migrating to the villages and settlements in the district with public supplies. The populations of many locations has doubled during the drought years. Emergency drilling of boreholes for some of these villages are many months behind schedule. Private drillers contracted to perform some of this work have not yet arrived.

Mr. Elvenes, the Project Officer, Wells, is a Norwegian volunteer. His project falls under the authority of the CTO-Water. Over the past several years, the Hand Dug Wells Project has sought to dig wells in smaller settlements and equip them with handpumps. The current capacity of the hand dug wells group is approximately 20 per year. Sites for wells are chosen from petitions submitted by the village and decisions are made based on the likelihood of finding water at shallow depths and on the need of the village. Near the Okavango Delta, sweet water can often be found at depths of less than 25 meters. In at least six villages (including Thamacha) wells have been unsuccessful because rock formations have been encountered. Six such sites were cited. Thamacha, Samedupi, Dobe, Chikumochu, Tsodilo and Magopa. The population of these villages as of the 1981 census was 850. We were assured that there were many more people than that in these settlements and that many more would move there when water was available. Many of these settlements are far from other reliable water sources and trips of up to 10 km must be made by many people in order to collect water.

The District Planning Officer told us that there had been some recent rains and the land looked green, but the water supply situation was still bad. He anticipated that Xanga, a village of about 400 north of Shakawe may need to have water trucked soon.

Visit to DWA offices-Maun

Met Mr. Chabanga, the Officer in Charge of DWA-Maun and Mr. Rathako, Officer in Charge of the Maun Water Supply. The purpose of the visit was to determine if they monitor the water level in wells used for Maun water supply. The water levels in drilled wells used in rural villages is not monitored. DWA-Maun, is monitoring water levels, but only have done so for a short period of time. They explained that the current wellfield was completed only several years ago and was predicted to provide sufficient water for 5 years without recharge. Now, they are having difficulty with the water supply and can deliver only 65 percent of the design capacity.

When questioned about major water supply problems, they responded that drilling and transportation were the major constraints.

Field visits to Samedupi and Matsaudi:

Mr. Elvenes provided transportation to these two sites, one a failure of the dug well program and one a success.

At Samedupi, we inspected an unsuccessful dug well. The well had been dug to about 20 meters and rock had been struck. The site was about 30 meters from a riverbed. There was some stagnant water in the river, the result of recent rains and several cattle were drinking. Mr. Elvenes explained that when there was water, people rolled 50 gallon drums into the water to fill them and rolled them up to 5-7 km to their homes. We saw many carcasses of dead cattle at the site, the remnants of the livestock die-off at the end of 1987.

At Matsaudi, the situation was much different. An India Mk II copy (Pumpenbose) had been installed in a dug concrete lined well. The water level was about 25 meters. During our short visit two people came to collect water. This was the middle part of the day when water collection is normally slow.

Visit to Thamacha:

Early on 23 January, Preble, Hodgkin, Waterman and Elvenes flew to Gumare. We were met by a NWDC driver and proceeded to Thamacha. Upon arrival, we met a Ministry of Agriculture field assistant and a young student performing his Tirelo Setchaba service in the village. All adults appeared to be away. Communication difficulties prevented prior notification of village leaders of our mission. We were told that the adults were at the lands, plowing and preparing for planting after the recent rains (this activity normally takes place some months earlier). It was clear that the drinking water supply problem was still serious as abut 3,000 liters remained in a 9,000 liter temporary tank in the village. The village, with an estimated population of 200-300 uses about 3,000 liters per day. A tanker truck had been dispatched from Maun the previous day, but had not yet arrived.

We asked to see the water source used if the tanker did not arrive as scheduled. We were shown an open pit with brown and clearly polluted water some 3.5 km from the village. We also inspected the failed hand dug well. It was between 25 and 30 meters deep and lined to that level. Progress had been stopped because rock had been struck. The cost and complication of water trucking to this village along with the distance village residents were required to walk for unsuitable water if trucked supplies were disrupted made it clear that village water supply needs to be addressed in another way. We were told that there were many settlements like this who were not so fortunate as to have delivered water.

Visit to Gumare:

We visited Mr. K. Kemelo, the Technical Assistant-Water in charge of the Gumare water sub-depot and water supply for the village of Gumare as well as for 17 other villages in North-west Ngamiland district. He explained that Gumare, with an estimated population of 2,320, is supplied from two drilled wells. Shortages of water have occurred beginning in 1985. The village has been without water on several days already in 1988. June and July 1987 were particularly difficult months. Both wells were visited. Borehole 3203, the more productive of the two wells were were told, was equipped with a Lister 8/1 engine running quite slowly and pumping 3.5 m^3/hr. Mr. Waterman increased the engine speed until 5.3 m^3/hr was being pumped. The consultants were not certain if this increase would cause the well to be overpumped. Borehole 4352, equipped with a Lister ST-1 engine was pumping air and water (3.8m^3/hr by meter reading). It was clear that with the current situation, sufficient water can be pumped for the village population provided no mechanical problems occur. If there is a breakdown, the situation could become serious as there is little possibility to truck water to a village of this size given the road condition in the area.

A back-up borehole was requested as early as 1985. And Gumare has been placed on the list of villages with emergency needs. However, to date, the private contractor who is supposed to drill in the area has not arrived. The most recent DWA schedule indicates that drilling was to have taken place in November, 1987. To date, there has been no action in Gumare.

APPENDIX C

GEOLOGICAL DESCRIPTION - DAVIES

Excerpt from: Workshop on Uses and Abuses of Hydrology
8-9 March, 1979
Selected papers - Published by:
Planning Unit
Ministry of Mineral Resources and
Water Affairs

By Jeffrey Davies
Dept Geological Survey

V. GEOLOGY

Fundamental to the study of the hydrogeological assessment of an area is a knowledge of the geology of that area. That the geology of Botswana is complex, and large parts are little understood due to the ubiquitous Kalahari sand cover must be realized. For the purposes of this lecture a much simplified picture of the geology of Botswana is presented. The stratigraphic column has been divided into four:-

1. Metamorphic and Igneous Basement
2. Precambrian Sedimentary Strata and Associated Igneous Rocks.
3. Karro System
4. Kalahari Beds.

See Fig. II.

V.1 Metamorphic and Igneous Basement

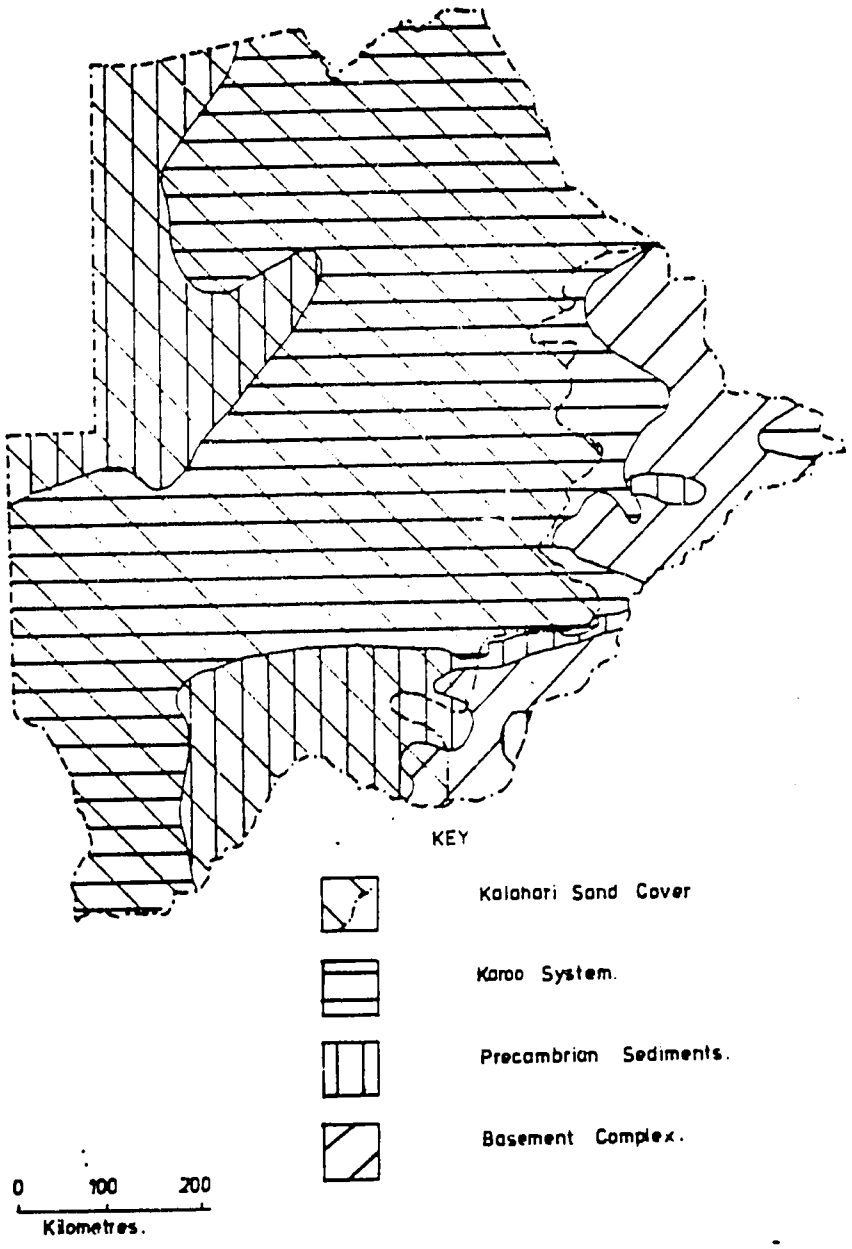
These rocks include the high grade metamorphics and associated igneous intrusives of the Limpopo Mobile Belt. The metamorphic strata include highly folded and faulted metamorphic augen gneiss and amphibolitic schist. They form the characteristic kopje and platform scenery of eastern Botswana. In south-eastern Botswana occur massive granite intrusions e.g. the Gaborone Granite and the Mathethe Granite, that have been intruded into grey and pink felsites.

V.2 Preca Brian Sediments

Within the southern half of Botswana a series of very old quartzites, shales siltstones and dolomites occur unconformably overlying the basement igneo sand metamorphic rocks. These sedimentary strata are of late recambrian age belonging to the Transvaal and Waterberg systems. They form very compact indurated series of strata many hundreds of metres thick. Within these strata occur the manganese and asbestos deposits of the Moshaneng and Kanye areas, while the basal Black Reef Quartzite series is a much attenuated extension of the gold bearing quartzite reef of the Witswatersrand.

GEOLOGY

Fig. II



The younger orange-red Waterberg quartzites form typical scarp features, e.g. the Tswapong Hills and the hills to the south west of Molepolole.

V.3 The Karroo System

Karroo type rocks have a widespread occurrence within Botswana, underlying much of the Central, Northern and Southern Kalahari. Within Botswana the Karroo is composed of the following members:-

1. Dwyka Series
2. Ecca Series
3. Cave Sandstone
4. Stormberg Lavas

The basal Dwyka Series is composed mainly of a sequence of varves and tillites of glacial origin.

The Ecca Series is a sequence of black carbonaceous shales, siltstones, white quartzose sandstones and grits, and coal seams. All of the country's main exploitable coal deposits are found within this series of strata.

The Cave Sandstone stage is composed of fine grained sandstones and siltstones. Cross bedding and ripple marks are common sedimentological features occuring within these sediments. These rocks are well exposed in the area south and east of Bobonong.

The Stormberg Lavasare a thick sequence of basaltic lavas the underly much of the Central Kalahari. They are seen to crop out in the Pandamatenga, Serowe and Bobonong areas, where they are seen to be amygdaloidal in character, the gas vesicles being commonly infilled with agate.

V.4 The Kalahari Beds

The Kalahari Beds Mantle some 75% of the land surface of Botswana. They are a sequence of gravels, red clays, various evaporites and dune sands, up to 200m thick. The surface expression of these deposites is extremely variable. Calcrete and silcrete deposits are of widespread occurence being found along the floors of fossil valleys and pans. The dune sands occur as a widespread ubiquitous cover whose movement has now been halted by vegetative cover. Some mobile sand-dunes still occur within Botswana e.g. in the far south west where elongate seif dunes are actively encroaching upon the Molopo River valley.

V.5 Structural Geology

The main structural elements are:-

1. The Limpopo Mobile Belt

2. The east-west faculting that has affected the Precambrian sediments.

3. The north-east, - south-west faulting that has affected the deposition of the Karroo sediments and the Kalahari sediments and is still active within the Okavango area of Ngamiland.

APPENDIX D

HYDROGELOGICAL DESCRIPTION - LARKIN

2 PHOTOVOLTAICS FOR PUMPING

2.1 GENERAL HYDROGEOLOGY FOR BOREHOLES

Mr P. Larkin
Aqua Tech.

Aquifer Distribution and Yields

Aquifers are usually defined as saturated rocks which yield water in sufficient quantities to be a source of supply and can be divided into two types, secondary and primary.

A primary aquifer is one in which porosity is due to interstitial spaces formed during deposition, for example, pore spaces in sandstone. This includes the weathering horizon where saturated.

A secondary aquifer is one where porosity has been formed or modified by post depositional processes such as faulting, fracturing and dissolution of the rock by circulating groundwater, for examples fractured granite and solution cavities in dolomite.

Of course, an aquifer may be a combination of both types, for example, fractured sandstones.

In Botswana, the majority are either secondary or a combination of both.

True primary aquifers are less common than previously believed and are probably restricted to the following:

- Sand rivers and old river channels along major river drainages (these are often interconnected). They occur in eastern Botswana where major rivers sandy beds derived from the crystalline basement. Examples are the Metsemotlhabe and Shashe Rivers.

- Kalahari beds, which cover 85% of the country. However, the aquifers are generally restricted to gravels and old river channels, except where there is higher and more reliable rainfall and consequently more extensive aquifers occur, especially where calcrete and silcrete outcrops. Further aquifers occur in the Kalahari beds underneath and immediately around the Okavango Delta.

- Some areas of the Cave Sandstone may be primary aquifers, particularly just north of Serowe. This may be due to an extensive period of weathering before deposition of the overlying younger rocks.

- Interflow zones in the Stormberg lava.

- Weathering zones overlying all units. These are generally restricted aquifers that are caused by preferential weathering along fault and major joint zones. Extensive "basins of decomposition" have been reported in the upper surfaces of quartzites in Lobatse and Kanye areas and the Stormberg lavas.

Secondary aquifers occur principally in grantic and metamorphic rocks of the Basement Complex in eastern Botswana. These are crystalline rocks and hence have no intergranular porosity. Other rock units with secondary aquifers are:

- The Ghanzi beds in western Botswana.

- The Waterberg Supergroup in Southern and Eastern Botswana where aquifers occur in shale beds and sandstones. The sandstones had been interpreted as primary aquifers but more recent have shown it to comprise secondary aquifers.

- Dolomite in southern Botswana where dissolution cavities have occured along fracture zones.

- Units of the Pretoria Group, principally shale and quartzite.

- Ecca group sandstone and minor shales. These were previously thought to be primary aquifers but a recent re-interpretation of the Jwaneng wellfield has shown this to be a secondary aquifer system and this is probably true for the remainder of the country.

- The Cave Sandstone behaves as a secondary aquifer in the Serowe, Orapa and Kweneng districts although it is likely to have subordinate primary characteristics.

- Fault zones in the Storm Lavas are known to be secondary aquifers.

- Shattered zones around the intrusive dykes are often secondary aquifers.

An interesting feature of secondary aquifers is that recent work in Scandinavia has shown that 80% of groundwater in secondary aquifer systems occur in subvertical fault and fracture zones.

Combination of primary and secondary aquifers occur principally in the Cave Sandstone and Stormberg Lavas but may also occur in the Ecca Sandstone.

Jennings (1974) analyzed statistics for 2500 boreholes in various geological units and these are summarized in Table 1. He included average yields for the various geological formations (excepting sandrivers) and ranked them - see Table 2.

These figures can be used as a general guide although boreholes sited carefully in fault zones could result in much higher than average yields.

The highest producing aquifers are within the Pretoria Group, the Dolomite Group and the three main aquifers of the Karoo Supergroup - the Stormberg Lava/Cave Sandstone contract, the Ecca Group and the Stormberg Lava. The poorest aquifer is the Kanye Volcanic Group.

Static Water Levels and Water Level Fluctuations

The static water level is the depth to the water table or piezometric surface. Again, Jennings (1974) has summarized this data which is included in Table 1. The shallowest depth the static water level is in the Kalahari beds (18.09m), followed by intrusives (19.20m) and the Kanye Volcanic Group (20.62m) whereas the deepest is in the Ecca Group (65.25m).

However, the static water level is not necessarily encountered at the top of the aquifer. At the recharge area, the aquifer is said to be unconfined (the aquifer is under atmospheric pressure) and changes in water level correspond to changes of the volume of water in storage.

Confined aquifers occur where groundwater is confined under greater than atmospheric pressure. Water level fluctuations result mainly from changes in pressure rather than changes in storage volumes.

If a confined aquifer is heavily pumped, it may become locally unconfined. An important point is that water will flow down the hydraulic gradient. Flow directions can be deducted from piezometres surfaces which are contour maps of the altitute of the static water level realtive to a datum (normally mean sea level).

Natural variations in the static water level can be caused by many factors and are usually divided into long term, seasonal and short term fluctuations. Pumping effects are superimposed on these.

Long Term Fluctuations

Natural Recession

In the absence of recharge, water levels decline until the piezometric surface is essentially horizontal. This depends on the hydraulic conductivity of the aquifer and the hydraulic gradient. Natural

recession has been measured in the Serowe area where a constant decline of 0.16m per year occurs.

Seasonal Fluctuations

Marked long term seasonal fluctuation occur as a consequence of the wet and dry seasons and the large rainfall variability. In good rainfall years, the water table at Lobatse has risen by 4 to 5 metres, although in recent years there has been little or no recharge.

Short Term Fluctuations

Water level fluctuation in response to duirnal variations in barometric pressure and earth tides have been noted but these are small (1 to 10 cm) and are of no significance. Similar variations have been noted in response to seismic events.

Natural variations of the static water level in Botswana are probably only significant in sand river aquifers. These are generally thin (1 to 10 metres) and are recharged during river flow. Subsequently they lose water to evapotranspiration and subsurface flow down gradient. This can result in lowering of the water level by 2 to 3 metres each dry season which can drastically reduce the amount of water in storage.

Borehole Hydraulics

There are four factors controlling the yield and pumping water level of a borehole:-

- the aquifer transmissivity Tm which is the aquifer permeability multiplied by the aquifer thickness.

- the aquifer storage coefficient S which is the amount of water yielded per unit decline in the static water level per unit area of the aquifer.

- This applies to confined aquifers were water is released due to aquifer compaction. In unconfined aquifers, water is released by gravity drainage and the ratio of the volume of water released to the volume of the aquifer is referred to as the specific yield.

- Well losses. These are due to turbulent flow at the well/aquifer interface and can be minimized by properwell construction and development techniques. As these are very site specific, they will not be considered further, except to note that they can cause appreciable extra draw down of the pumping water level.

- The available drawdown which is that vertical distance between the static water level and aquifer,

The first three can be evaluated by pumping tests, in which the borehole is pumped for a specified period at controlled rates and the water level measured at logorithmic intervals. The data is analysed using graphical or mathematical techniques.

Viak (1984) interpreted pump test data for a number of aquifers in Botswana and the transmissivity, storage coefficients and specific yields are summarized in Table 2, together with average available drawdown.

Transmissivities vary from 0 to greater than 4000 m^2/day with the largest values being obtained in dolomite at Ramotswa and the Ecca at the Jwaneng Wellfield.

In homogeneous primary aquifers Tm should not vary greatly, but in secondary aquifers, major fracture systems can enhance the transmissivity by several orders of magnitude. The larger range in values therefore shows that the majority of aquifers are dominantly secondary.

The storage coefficient and specific yields have typical values for confined and unconfined aquifers, the latter being several orders of magnitude greater than the former.

The Ecca Group has the greatest average available drawdown (31.8m) followed by the Stormberg Lava/Cave Sandstone contact and the Stormberg Lava (both 23.5m) The least available drawdown is within the Kalahari beds (4.86m).

The effects of varying the transmissivity and storage coefficient has been simulated using the equation and are shown in Figure 2. Drawdowns have been calculated for a 24 hour period, with wellfield of 11.9m^3/h and distance from the well of 0.01m in each case. Iniatially the transmissivity was set to 0.5m^2/hour (=12m^2/day) and the storage coefficient to 0.005, which resulted in a rapid drawdown, reaching about 29 metres in 24 hours. In the second case the transmissivity was increased ten times and the storage coefficient held constant, resulting in much smaller drawdown, reaching a little over 4 metres at 24 hours.

In the third case the storage coefficient was increased by slightly more than 100 times and the initial transmissivity used. However, the drawdown at 24 hours was about 28.5 metres.

This clearly shows that variations in transmissivity has a much greater effect than variations in storage coefficient. In low transmissivity aquifers a rapid drawdown to pump inlet can be expected unless there is a relatively large available drawdown.

Conversely, for any aquifer, doubling the available drawdown doubles the permissible yield. This has

Conversely, for any aquifer, doubling the available drawdown doubles the permissible yield. This has obvious implications for depth at which pumps should be set.

In the primary aquifers, pumps are commonly set at the aquifer base, or beneath it in a sump. The latter is general practice in sandrivers. In thick primary aquifers the pump may be set about 1/3 of the aquifer thickness above its base to minimize costs.

In a secondary aquifer it is normally set at the highest yielding fracture, which is the maximum permissible drawdown.

However, there is another factor to be taken into account in secondary aquifers and that is, overburden pressures tend to close joints and fractures (or reduce transmissivity) at depths in excess of 120 metres. The optimum depth at which to intersect the aquifer is then about 100 to 120 metres below ground level which limits available drawdown to approximately 80 - 100 metres.

It is apparent that borehole yields are most sensitive to variations transmissivity, followed by variations in available drawdown and least affected by variations in storage coefficient.

The implication for equipping of "low yielding" boreholes then is that aquifers with greater available drawdown should be sought rather than aquifers with high storage as previouly suggested (B.T.C. 1984).

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TABLE 1 Statistics for 2500 boreholes in previous geological formation (after Jennings)

	TOTAL	PERCENT SUCCESS-FUL %	AV. YIELD m^3/h	AV. SUCCESS-FUL	DEPTH ALL m	AV. WATER STRUCK m	DEPTH SWL m	AVERAGE AVAILABLE DRAWDOWN m
BASEMENT COMPLEX	472	57.2	4.34	56.58	57.99	34.32	23.20	11.12
KANYE VOLCANIC GROUP	57	42.1	1.56	58.43	51.97	31.17	20.62	10.55
GABORONE GRANITE	87	42.5	2.93	61.97	65.52	43.63	28.54	15.09
VENTERSDORP SUPERGROUP	25	76.0	3.23	74.51	71.63	38.55	29.85	8.7
TRANSVAAL SUPERGROUP DOLOMITES & BLACK REEF	74	82.43	11.90	69.62	70.78	35.92	28.22	7.7
TRANSVAAL SUPERGROUP PRETORIA	78	87.17	12.51	113.29	116.27	57.5	44.58	12.92
WATERBERG SUPERGROUP	209	75.11	4.55	86.27	86.6	40.35	27.57	12.78
GHANZI GROUP	71	59.15	5.88	62.83	66.79	41.07	31.92	9.15
STORMBERG LAVA	154	97.4	6	72.21	76.64	38.65	26.63	12.02
STORMBERG LAVA/ CAVE SANDSTONE CONTACT	154	97.4	7.64	109.07	109.37	61.32	37.82	23.5
CAVE SANDSTONE	76	64.77	4.74	111.66	105.05	67.72	54.66	13.06
ECCA DWYKA	250	42.20	6.16	137.72	115.82	97.05	65.25	31.08
DIABASE DOLORITE INTRUSIVE	99	42.42	3.89	65.85	60.83	30.79	19.20	11.59
KALAHARI BEDS	169	65.07	6	36.26	41.45	23.05	18.09	4.96

TABLE 2 Average yields for various geological formation

FORMATION	AREA	T	S	SY	AVERAGE AVAILABLE DRAWDOWN	AVERAGE YIELD
		m^2/h			m	m^3/h
WATERBERG SANDSTONE	KANYE	(5) - 37		0.05	12.78	4.55
	JWANENG	10 - 15				
STORMBERG LAVAS	MOSUBEA	3.1 - 48.6			23.5	7.64
	LEPHEPHE	66.5 - 737				
	DIKGOGANG	0.09- 2.35				
	SITE 4	12.5 - 29	$8 \cdot 10^{-3}$	0.02		
	KWENENG	0.3 - 3				
META-VOLCANIC		(<78)			11.12	4.34
GRANITE		(<78)	$3 \cdot 10^{-5}$		11.12	2.93?
ACID LAVA		9 - 11		0.066	12.92?	12.51?
QUARTZITE	LOBATSE	2 - 15		0.032	12.92	12.51
ARCHEAN GNEISS	PHIKWE		$3 \cdot 10^{-5}$		11.12	4.34
GABORONE GRANITE	KANYE	<12			15.09	2.93
	MOCHUDI	14 - 20				
DOLOMITE	RAMOTSWA	6.5 - 500	$5 \cdot 10^{-4}$	.0027.058	7.7	11.9
	KANYE	49.7 - 4350				
	LOBATSE	43 - 741		.001-(.49)		
		? - 778				
	JWANENG	12 - 540				
TIMEBALL HILL SHALES		10 - 69			12.92	12.51
CAVE SANDTONE	SEROWE	1 - 73	$1\text{-}7 \cdot 10^{-4}$	.024-.036	13.06	4.74
	ORAPA	3.2 - 74	$1.8 \cdot 10^{-5}$ to $2.8 \cdot 10^{-4}$			
	KWENENG	7 - 9				
	TSIA		$5.2 \cdot 10^{-4}$	(0.65)		
	MORUPULE	7 - 71				
BASALT/ CAVE SANDSTONE		50 - 80			23.50	
ECCA	KWENENG	0.2 - 40	$5.8 \cdot 10^{-5}$ to $2.4 \cdot 10^{-3}$	.02-.16	31.80	6.16
	JWANENG	200 - 3000				
	MORUPULE	0.3 - 1.4				
MUDSTONE/ SHALE	JWANENG	16 - 110			31.80	6.16?
QUARTZITIC SILTSTONE	JWANENG	1 - 5			31.80	6.16?

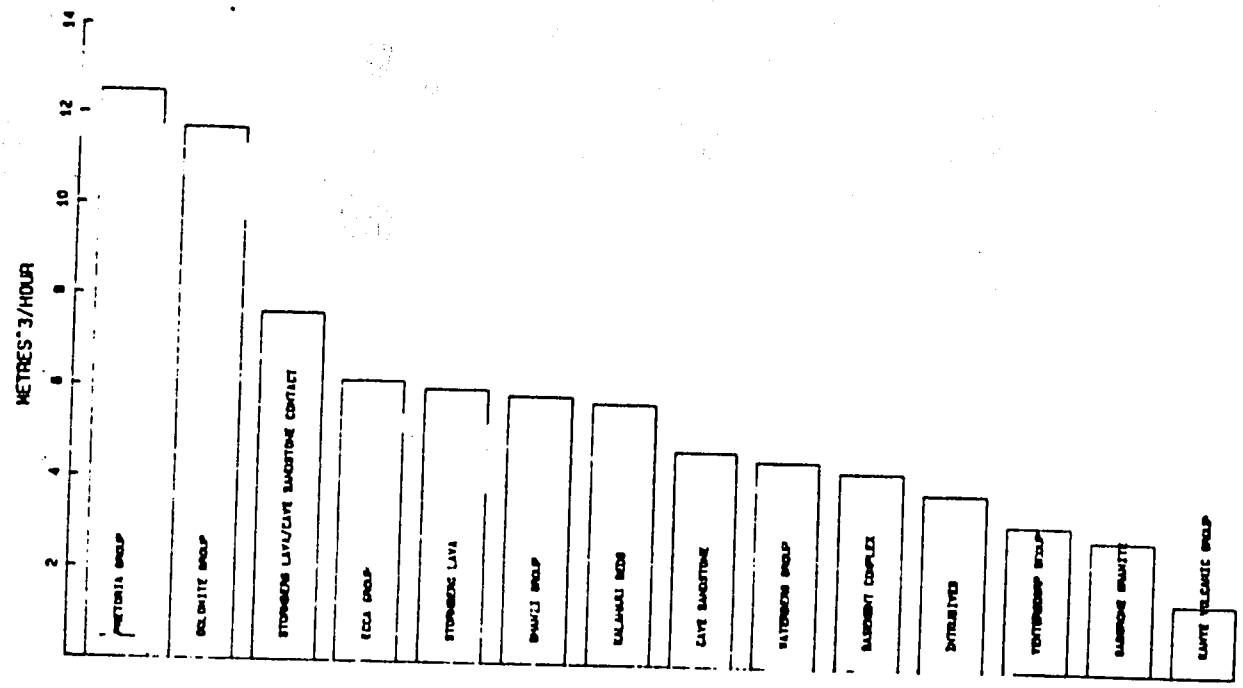


FIGURE 1 Average yields of different geological formations (Jennings 1974)

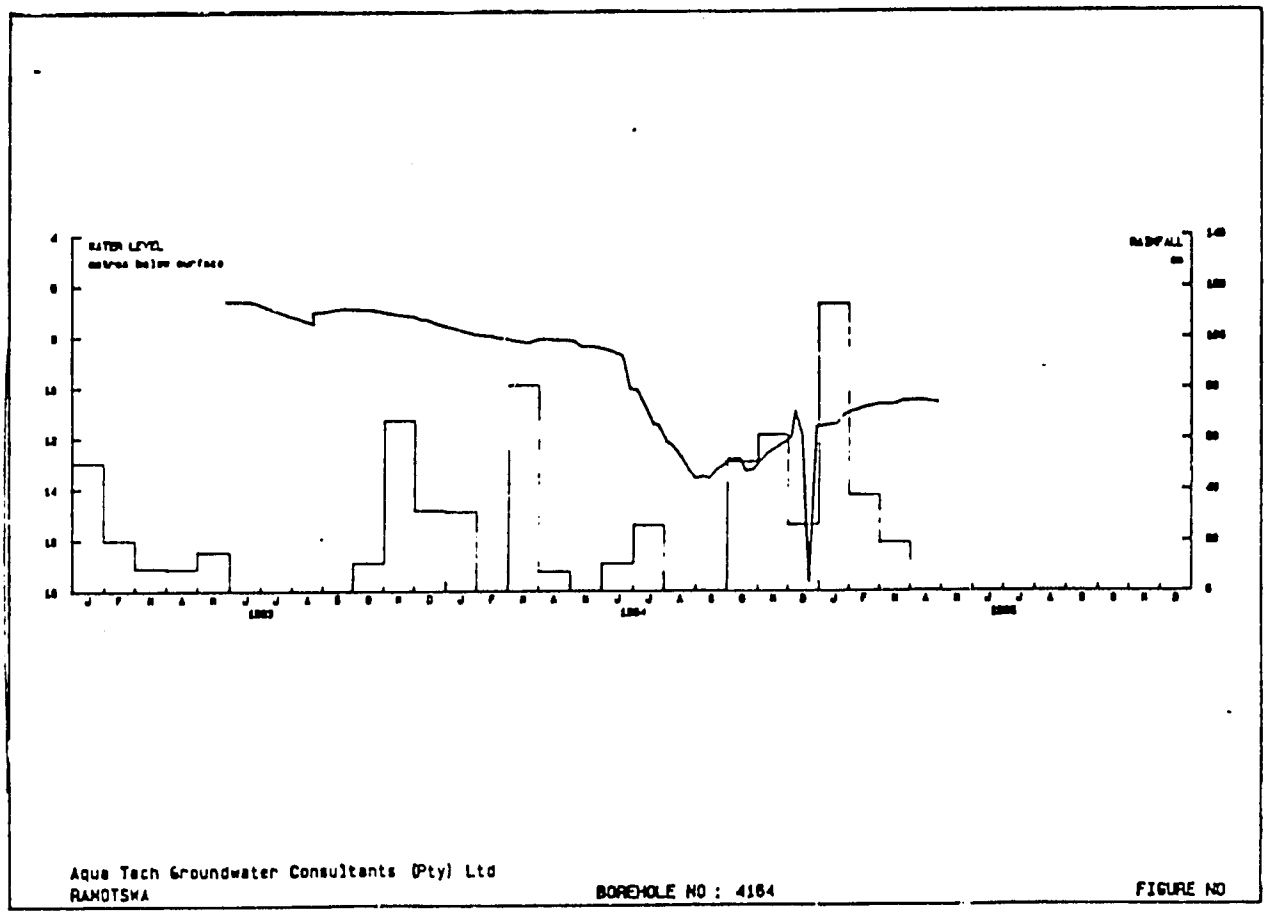
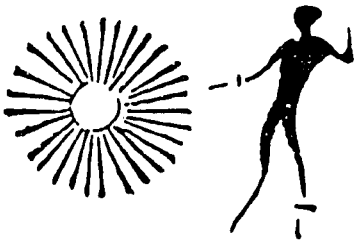


FIGURE 2 Water level response to rainfall events and three months pumping



2.1.1 Summary of discussion

It was pointed out that submersible pumps are not best suited for use in inclined boreholes. However, Mono pumps can also be used in boreholes up to 30° inclination provided that the borehole is straight. Most inclined boreholes are not straight.

It is difficult to say whether areas with high salinity are localised. It was concluded that in general a good recharge rate gives low salinity (Eastern Botswana) and a low recharge rate gives a high salinity (Kalahari). In some areas (e.g. Ramotswa well field) the influence of recent rains had a measureable influence on the recharge rate and caused a rise of water levels in boreholes.

The average borehole depth(not water level) in Eastern Botswana is approximately 100 m whereas west of Jwaneng the borehole depth is up to 300 m. However, water levels vary substantially within areas.

Excerpt from: Proceedings of Photovoltaic Workshop
6 - 9 August, 1985
Botswana Technology Centre

APPENDIX E

A Mini-Guide to the Water Resources of Botswana

by B.H. Wilson

This paper consists of a series of annotated maps and diagrams and is intended to be suggestive rather than conclusive. It is published by kind permission of the Permanent Secretary, Ministry of Mineral Resources and Water Affairs. The author wishes to thank all those who have helped him.

Note: The reader is asked to look first at the diagram or subject matter within each box before referring to the footnotes beneath it.

NOTES AND REFERENCES

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13. *Ibid.*, Fig. 38.
14. Van Straten, O.J. (1961) *Chemical composition of groundwaters of Bechuanaland.* Rec. Geol. Surv. Bech. Prot., 1957/58.
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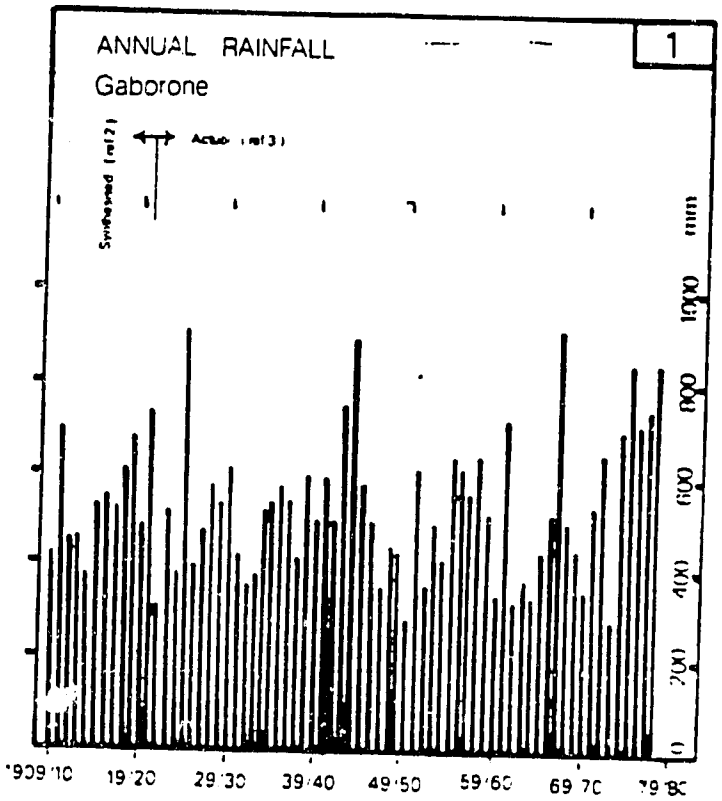
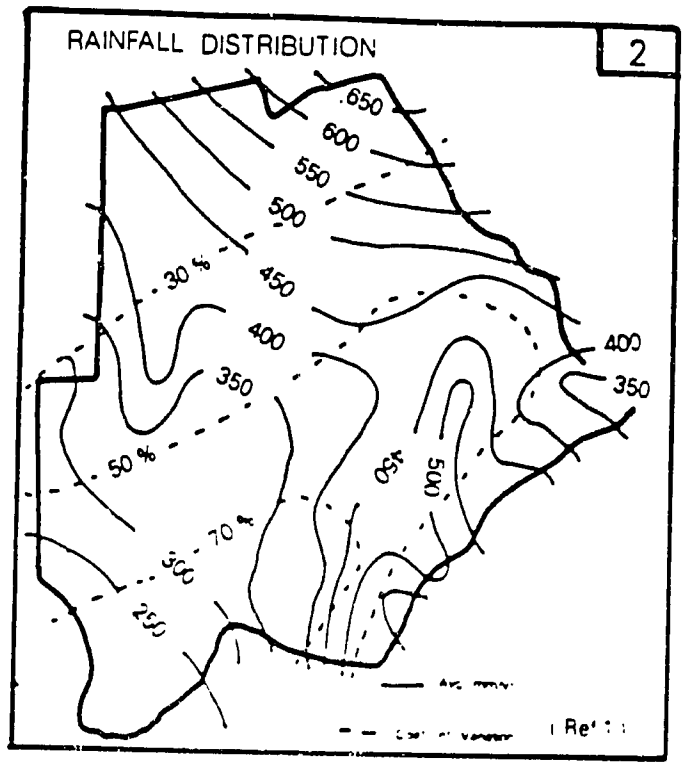
17. Lund, B.G.A. and Ptnr. (1977) "Water resources reconnaissance of the Lower Metsemotlhaba and Lower Ngotwane rivers, stage II."
18. Kweneng Rural Development Association (1973/74) "A Hafir (Tank) Dam." (Molepolole).
19. Tribal Grazing Land Programme, Provisional maps of district water resources. (Gaborone: Ministry of Agriculture; Dept. of Town and Regional Planning):

Central Dist.	DTRP 6. 10-13 a & b, 1978
SE	A.44, 47, 50, Feb. 1977
Kweneng	135 Draft 1, 1977
Southern	DTRP 6.90-2 Draft, April 1977
Kgatleng	DTRP 6.40-5 Draft, April 1977
Chobe	A.102 1977?
NE	129 Draft, July 1977
Ngamiland	A.112 Draft, July 1977
Ghanzi-Kgalagadi	April 1977

(*Note:* Information from these maps was supplemented from Ref. 13 and occasionally other sources.)

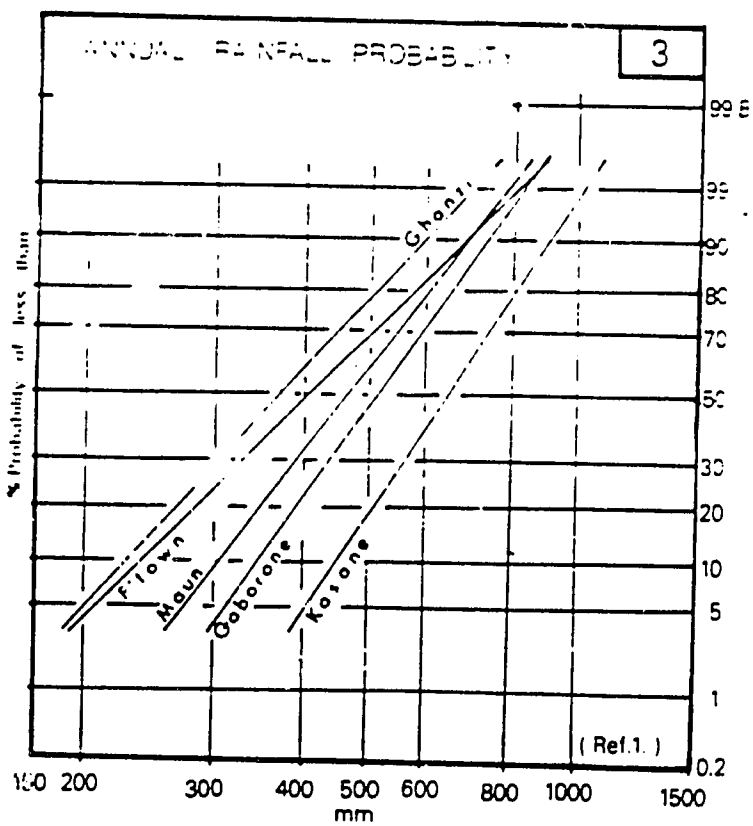
20. Ministry of Agriculture. Land utilization. Unpublished wall map.
21. AOC Technical Services (1965) "Reconnaissance soil survey of the Shashe Dam Irrigation Scheme." (Johannesburg).

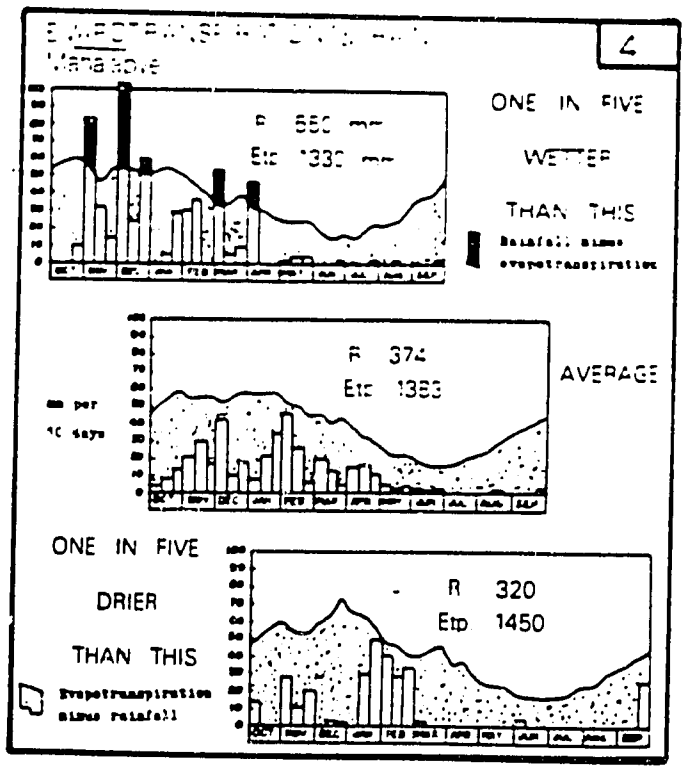




Can we modify rainfall? Experiments elsewhere give no grounds for serious hope in Botswana.

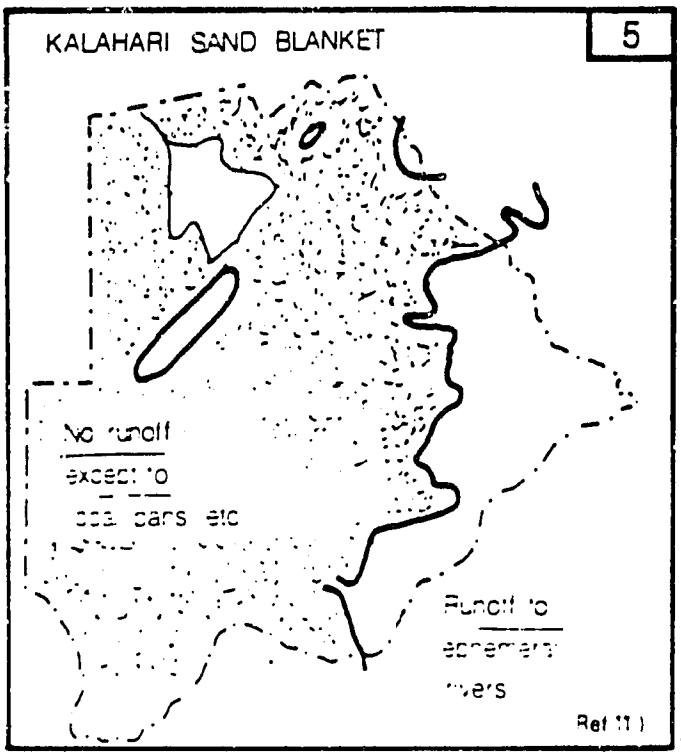
Will there be climatic change? Perhaps.





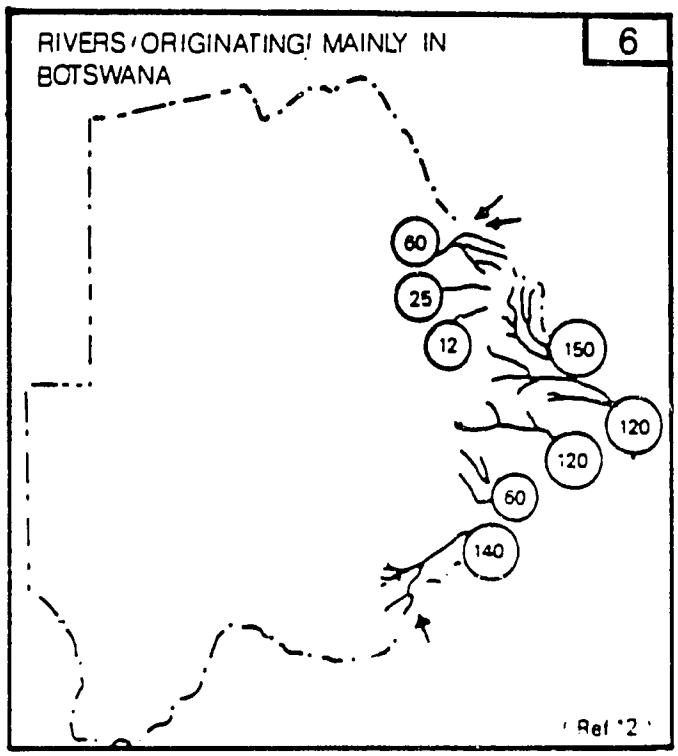
A typical example (though based on a short record) for a short green crop with 77% open water evaporation (Ref. 1).

For mini-droughts causing crop wilting within season see Refs. 4 & 5

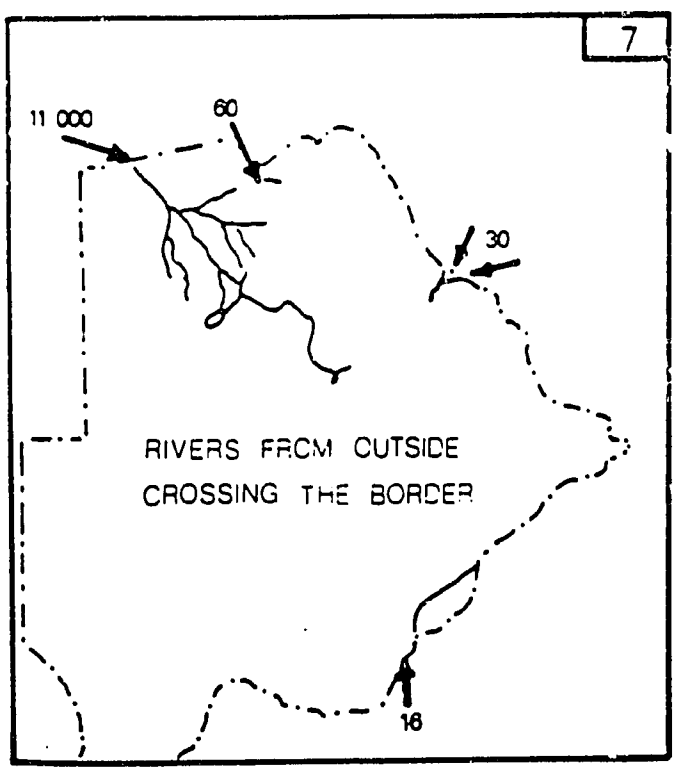


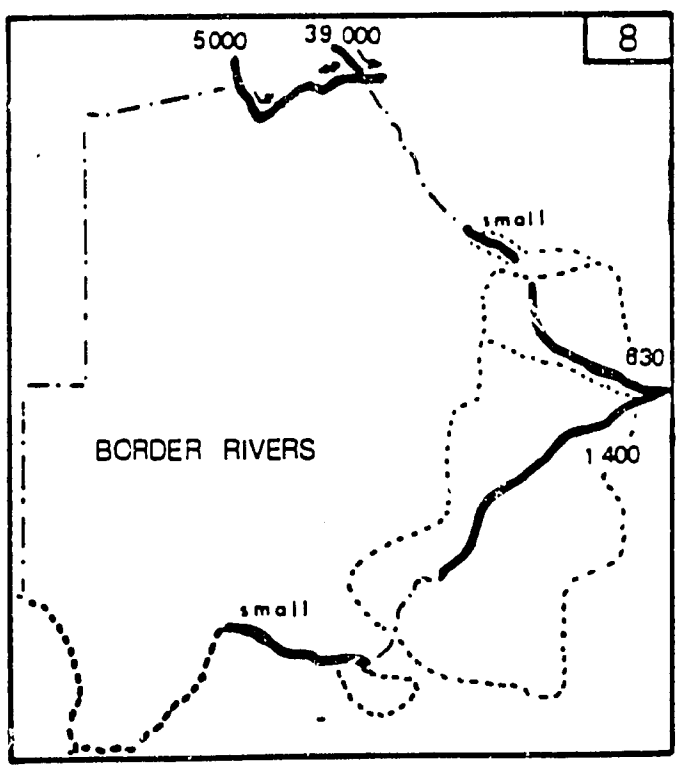
It is also possible to increase and collect runoff on a small scale. See Refs. 6 and 3

The Kalahari has mostly fine sand cover, with occasional shallow calcrete, etc.



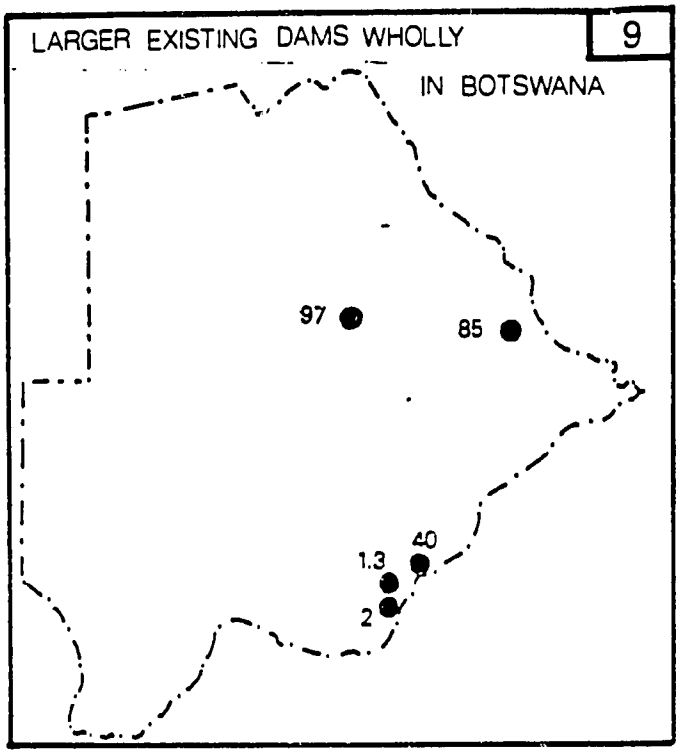
Approx. mean annual runoff shown in millions of cubic metres.

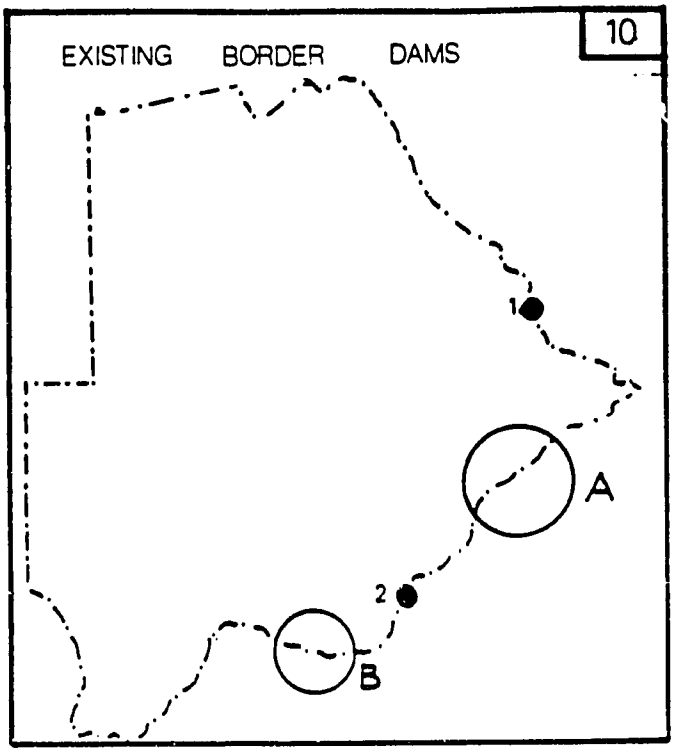




(Refs. 9, 10, 12)
This map shows internal and external catchments where relevant.

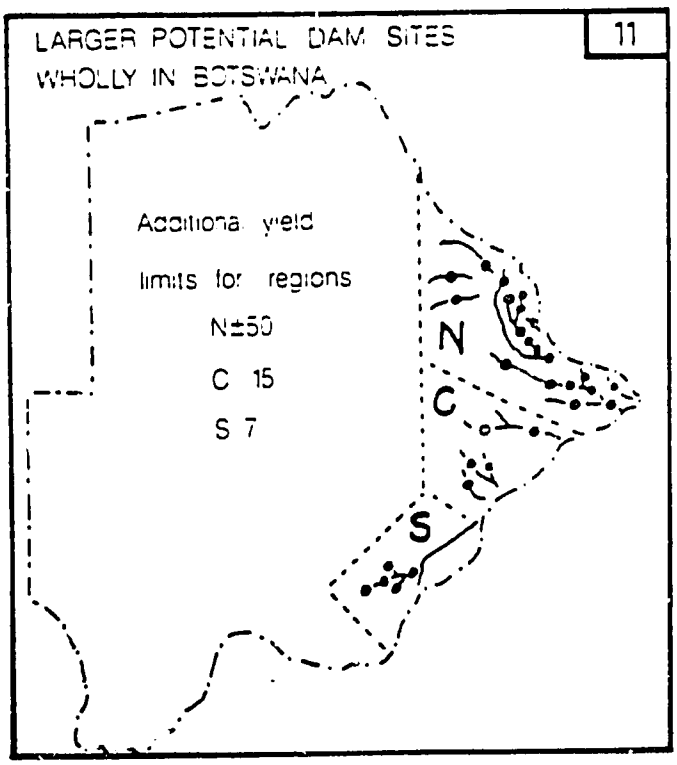
Approx. mean annual runoff shown in millions of cubic metres.

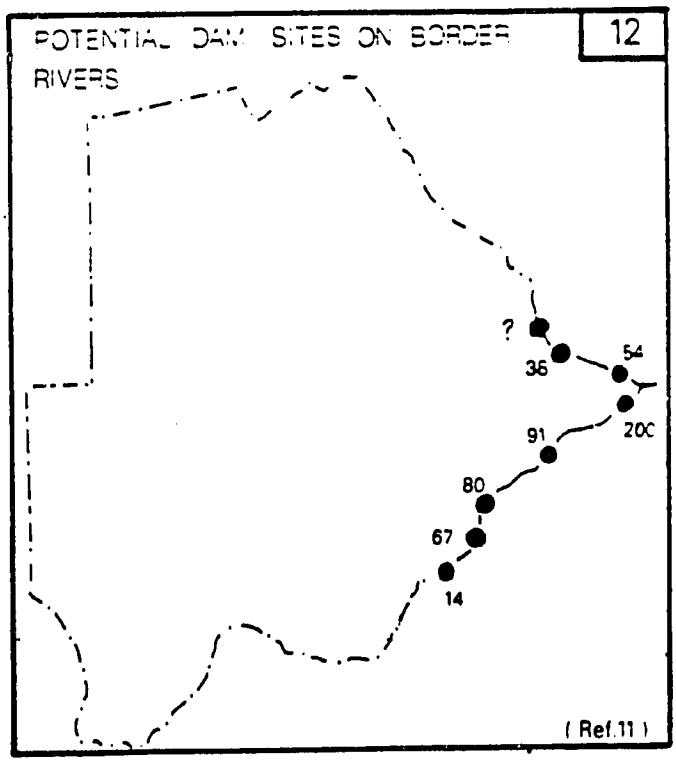




A. Many farm weirs on Limpopo.
B. Six stock dams on Molopo.

Storage capacities shown in millions of cubic metres.



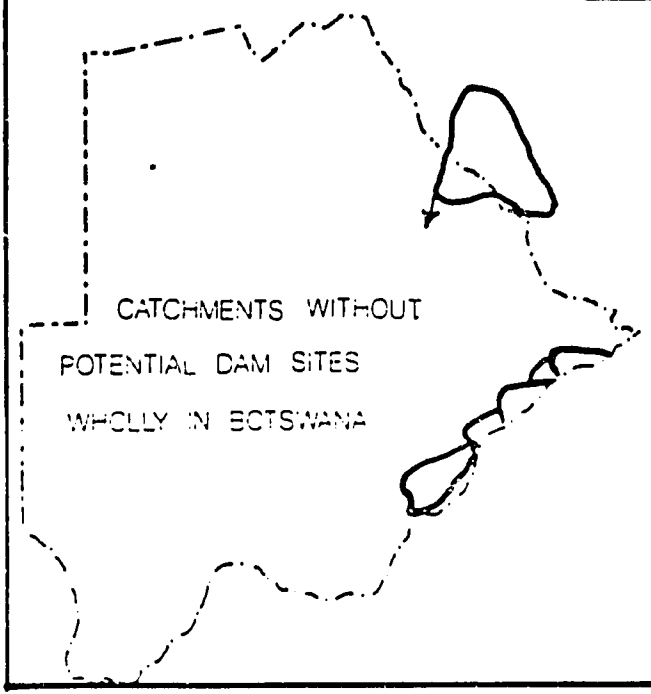


Information mainly from Gibb (Ref. 11), also Lund (Ref. 17).

Approx. yields (shared with neighbours) shown. Upstream yields to be subtracted for multiple construction.

Potential yields shown in millions of cubic metres per year.

13



NATURAL PANS

14

There are numerous and widespread natural pans, some fresh, some saline. The fresh ones facilitate grazing for weeks or months following rain.

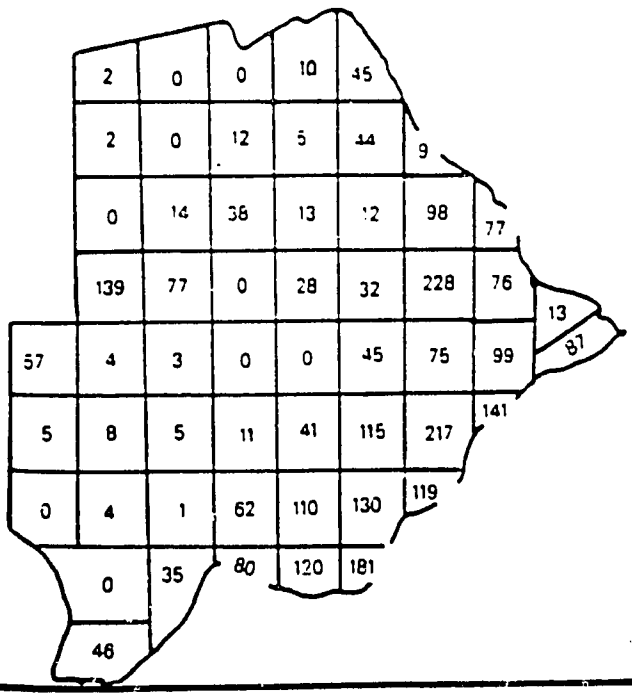
Pans cannot be considered as a drought resource.

They do, however, prove the variability of the Kalahari and the possibility of runoff and storage under certain conditions.

In salty chaos
Of forlorn flamingoes
Must Nata waste'

RURAL BOREHOLES

15

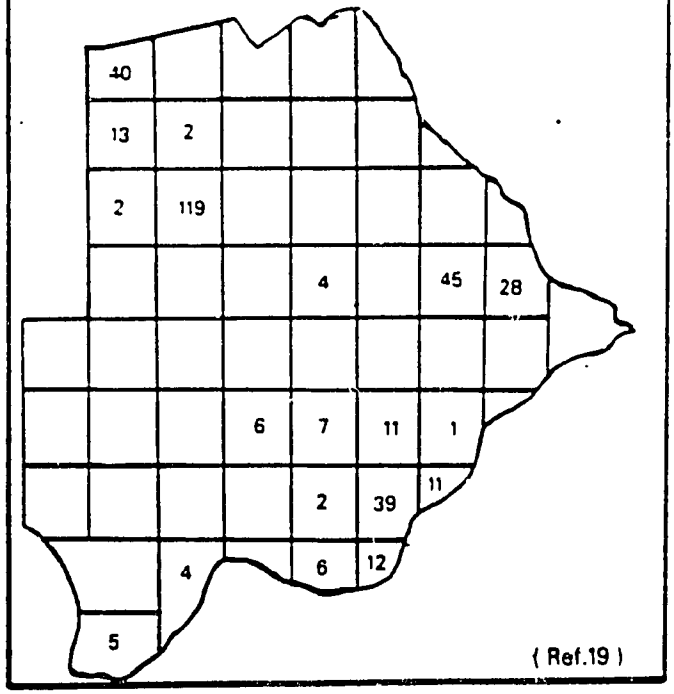


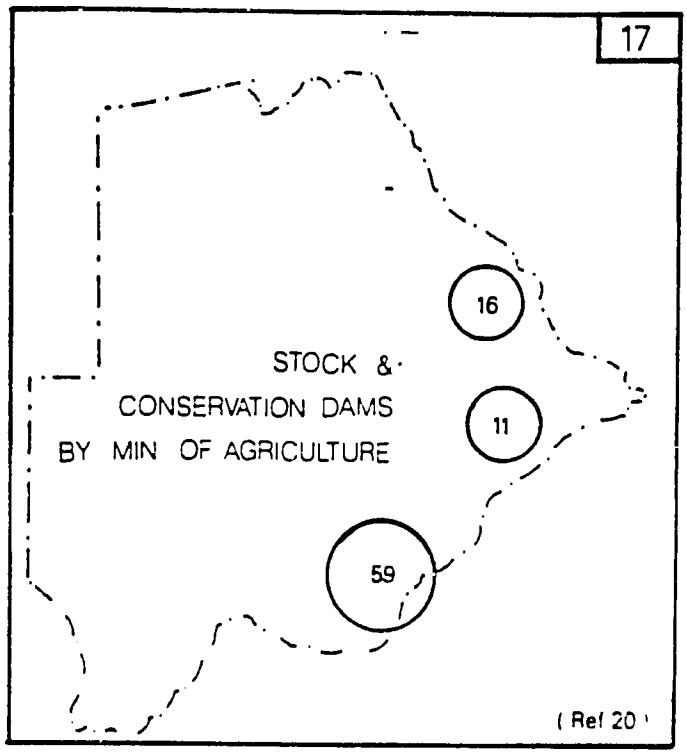
Information mainly from Ref. 19, supplemented by Ref. 13 for N. Tuli Motloutse, Kgalagadi and Ghanzi areas.

Boreholes recorded as blank or saline have not been included.

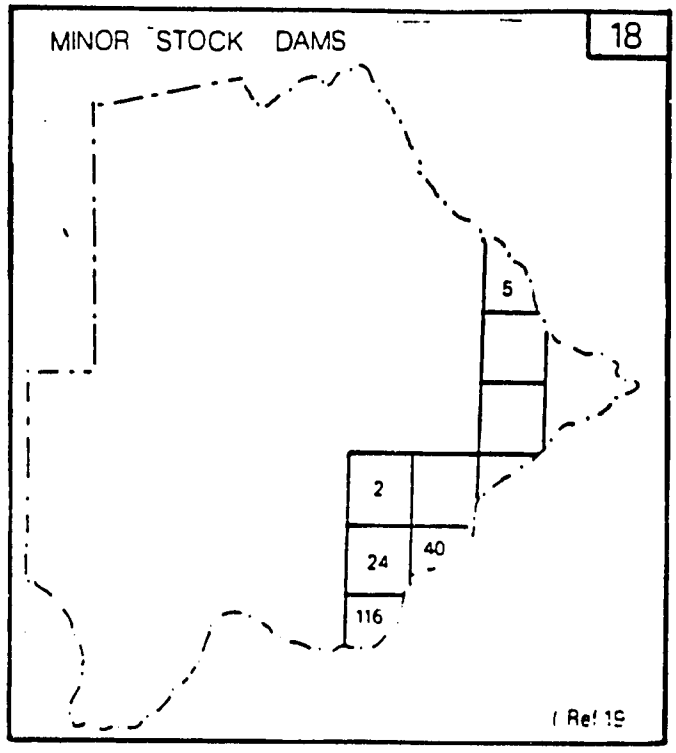
HAND DUG WELLS

16

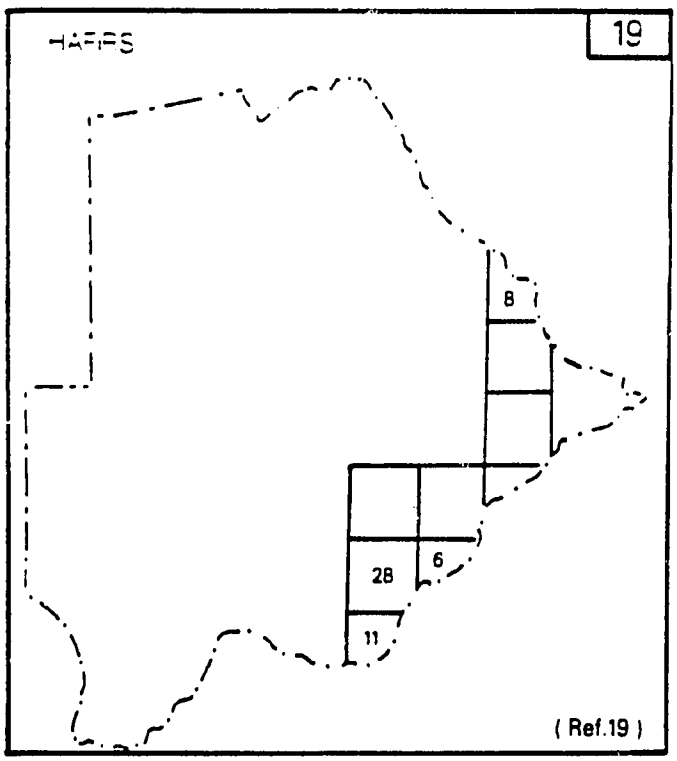




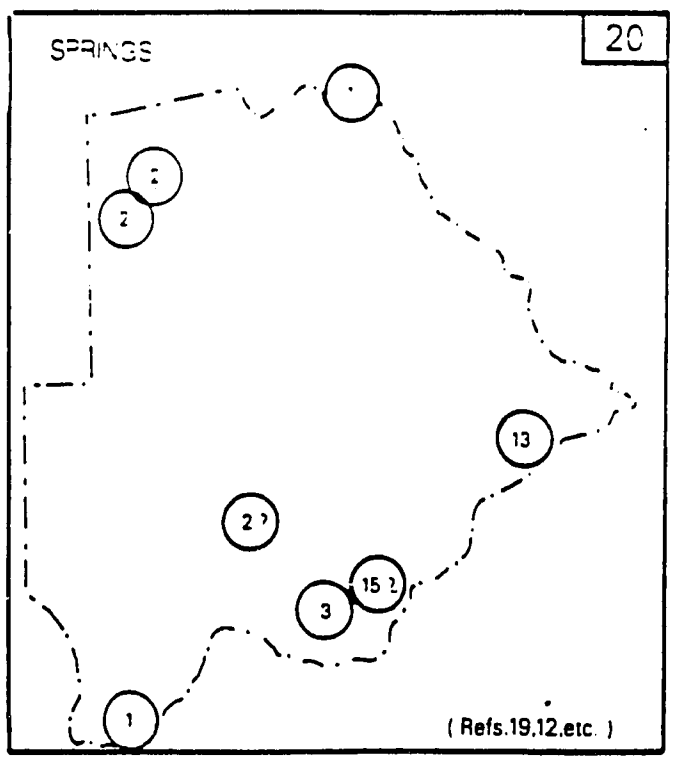
Numbers constructed shown



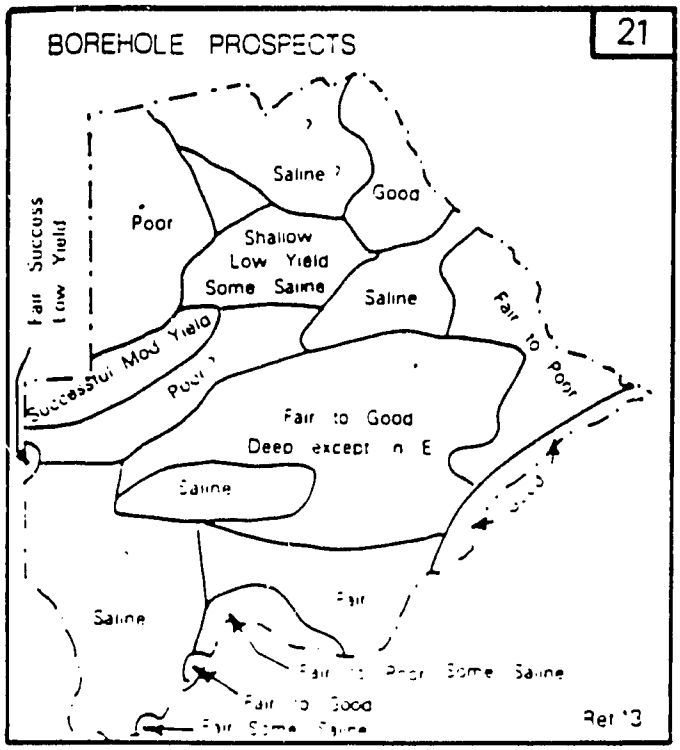
The area contrasts in both Figs. 18 and 19 suggest either inconsistent data collection or geographical differences or latent opportunities.



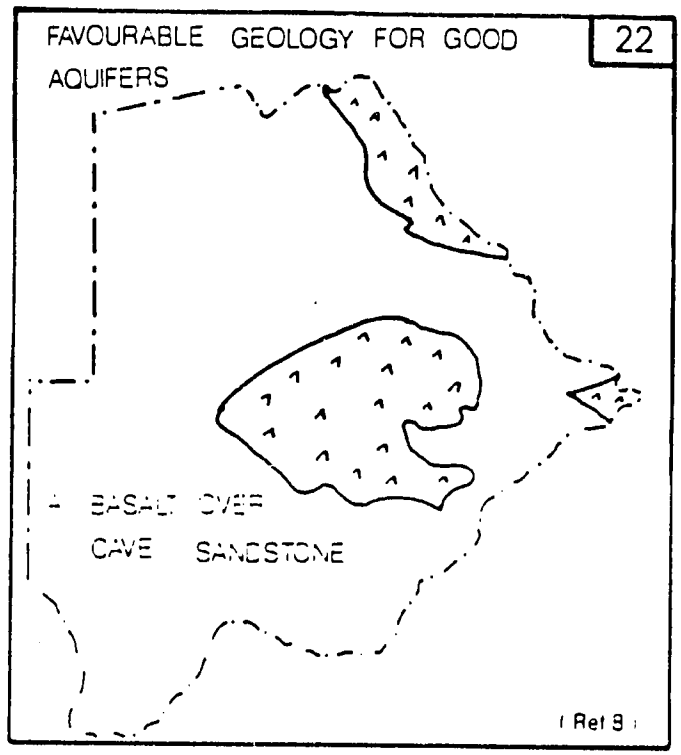
A Hafir is a small excavation to store run-off.



The record of springs is incomplete.

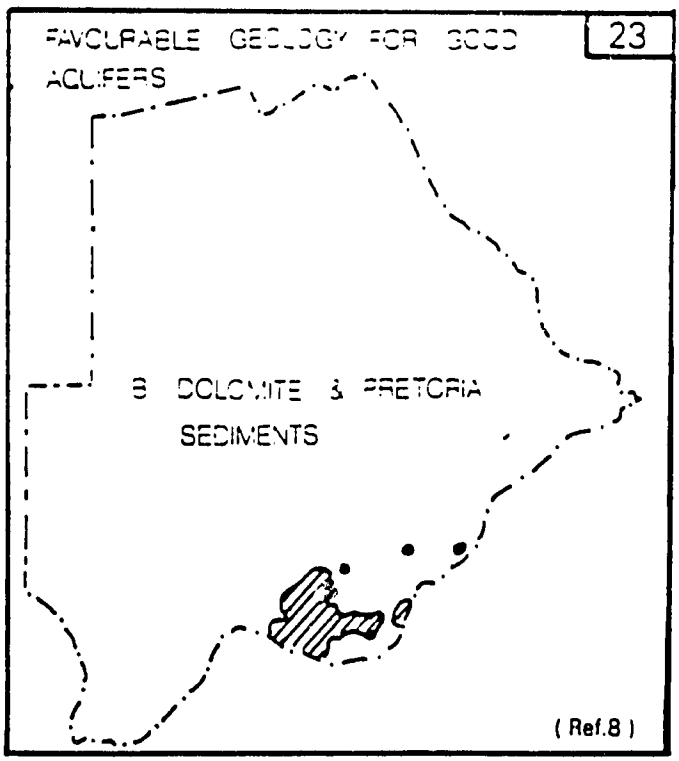


This map summarizes the findings on groundwater of UN BOT 1 Project.

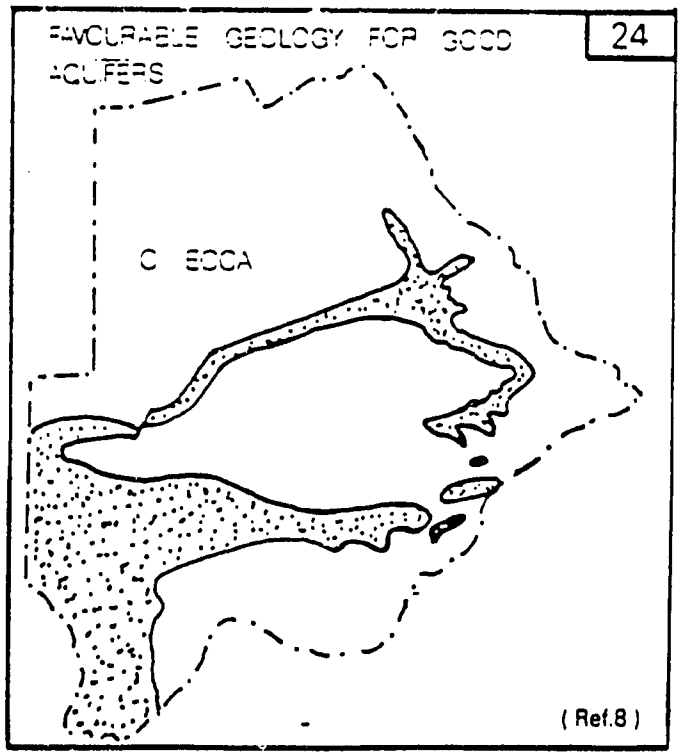


Drilling may be deep and expensive.

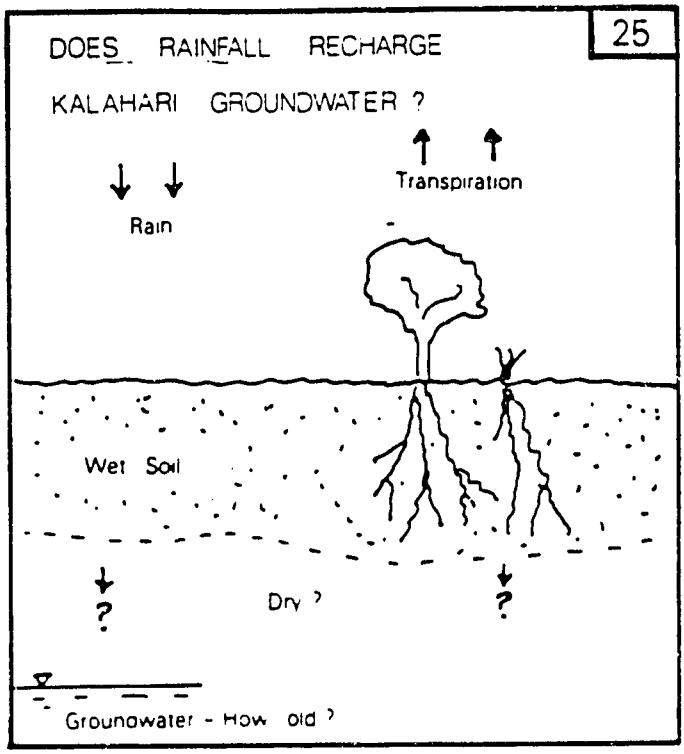
Without good grazing to accompany them, additional boreholes are of little use in coping with drought.



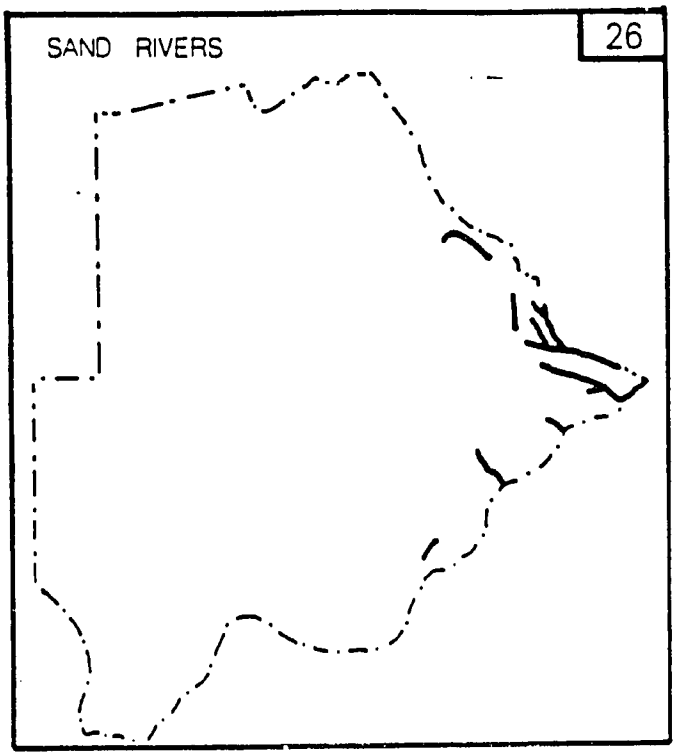
Faults and intrusions make siting difficult. Depth sometimes great.



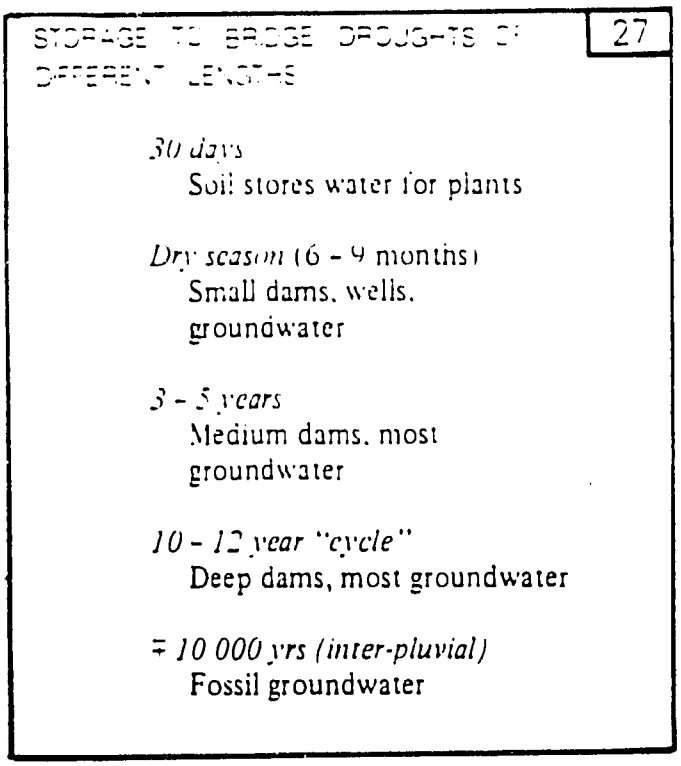
Only some of the Ecca is water-bearing and some is saline. Depths may be great.

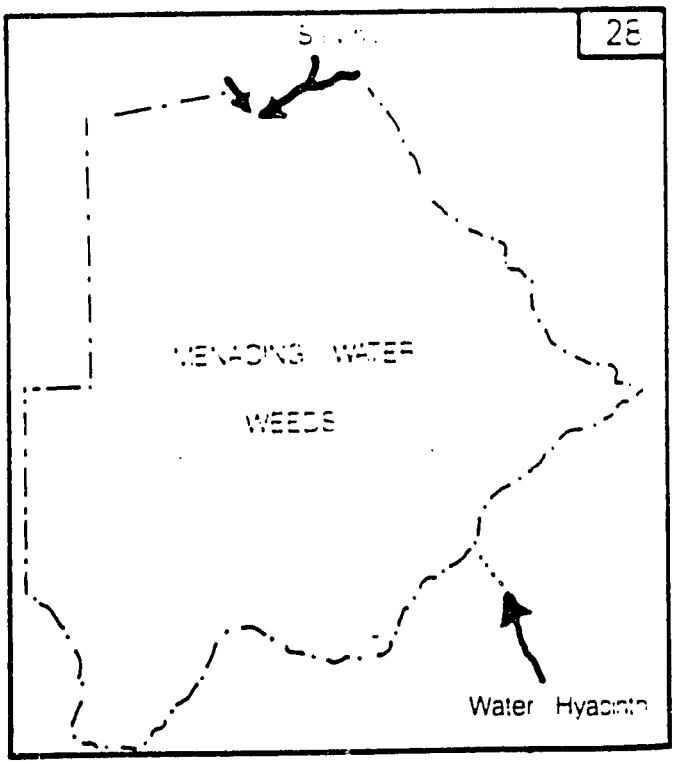


Debenham (Ref. 7) hoped enough.
Van Straten (Ref. 14) said not when sand is more than 9 m deep.
Jennings (Ref. 8) said sometimes recharge is proved.
Isotope dating will provide answers.

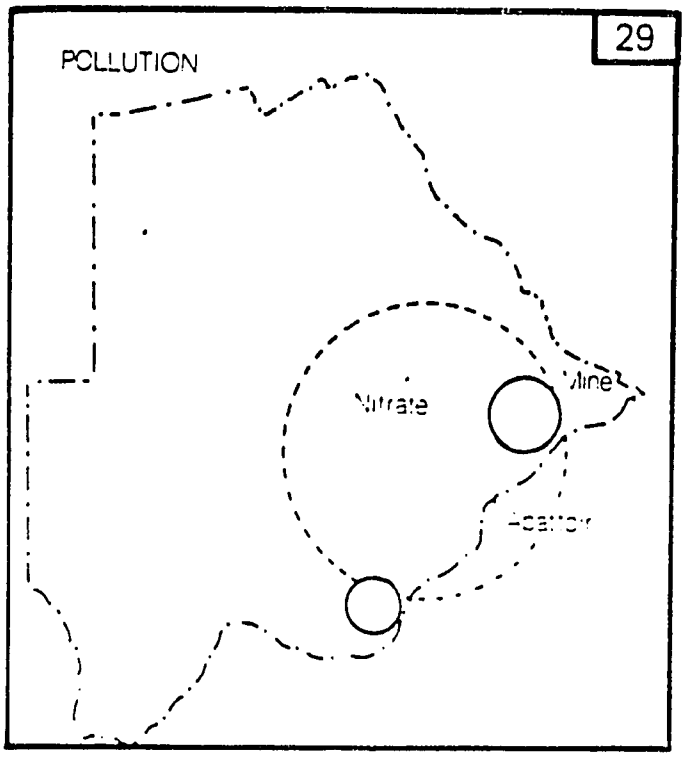


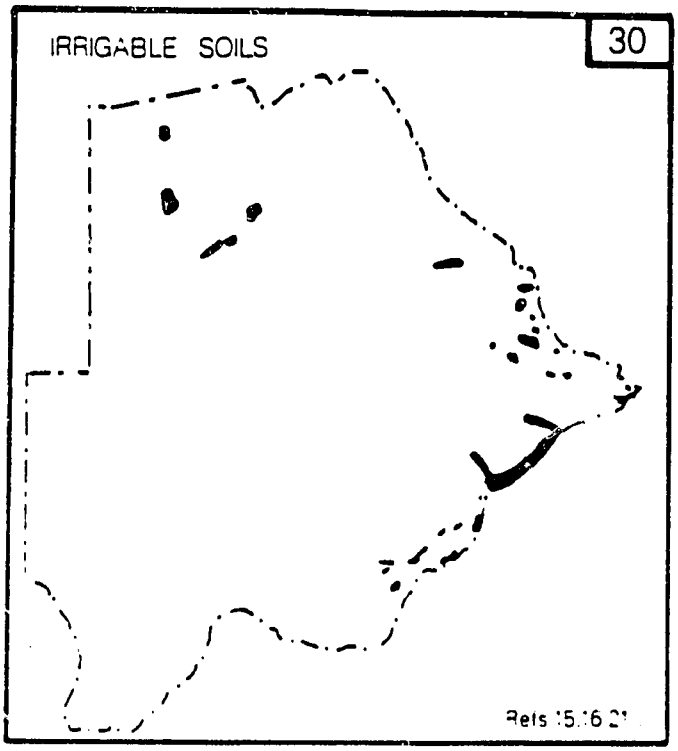
Useful for small to medium local water supplies and irrigation plots depending on depth of sand and watertightness of bed.



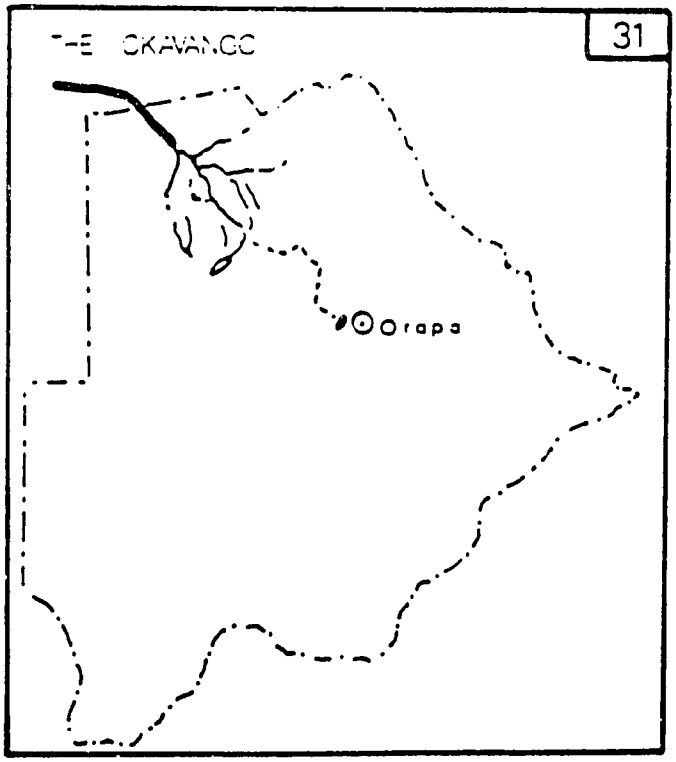


Reflections: Reliable water is expensive.
Reliability is sometimes essential. Is it always . . . ?
Money is easier to store than water.
(For a contrasting line of thought see Fig. 32)





Nitrate pollution from inadequately sealed boreholes or poor sanitation is rather widespread.
Industrial effluents require care.
Occasional boreholes have excess natural fluorine.



Okavango water is available in virtually unlimited quantity.

Natural outflow from the Delta is unreliable.

Engineering works could ensure reliable outflow to anywhere on the edge of the Delta or Boteti River at moderate cost and without serious ecological consequences.

Transfer to other parts of Botswana would be very expensive unless the quantities were exceedingly large and concentrated. This is unlikely in less than twenty-five years.

APPENDIX F

CONSOLIDATED EMERGENCY PROGRAM

LOCATIONS AND BOREHOLES DRILLING

MONTH	57 VILLAGES		WILDLIFE		ROADS		MAJOR VILLAGES		OTHER VILLAGES		TOTAL	
	LOC	BH	LOC	BH	LOC	BH	LOC	BH	LOC	BH	LOC	BH
1	-	-	-	-	-	-	-	-	-	-	-	-
2	9	18	-	-	2	8	-	-	-	-	11	26
3	8	16	-	-	2	8	-	-	-	-	10	24
4	8	16	-	-	2	8	-	-	-	-	10	24
5	5	10	3	6	2	8	-	-	-	-	10	24
6	5	10	3	6	2	8	-	-	-	-	10	24
7	-	-	3	6	2	8	5	10	-	-	10	24
8	-	-	3	6	3	12	4	8	-	-	10	26
9	-	-	2	4	3	12	5	10	-	-	10	26
10	-	-	6	12	4	16	-	-	-	-	10	28
11	-	-	7	14	3	12	-	-	-	-	10	26
12	-	-	7	14	3	12	-	-	-	-	10	26
13	-	-	5	10	4	16	-	-	-	-	9	26
	35	70	39	78	32	128	14	28	-	-	120	304

TOTAL: 120 LOCATIONS/304 BOREHOLES

APPENDIX G

EMERGENCY BOREHOLE NEEDS AT DISTRICT COUNCIL WATER SUPPLIES

CENTRAL DISTRICT

Serowe-Palapye Sub-distr.

1. Gojwane-Marulamantsi	290
2. Lesenepole	1,250
3. Gootau	1,350
4. Lerala	2,285
5. Mogapi	1,410
6. Majwaneng	650
7. Seolwane	675

Mahalapye Sub-distr.

1. Sefare-Chadibe	1780
2. Selleka-Malete	2325
3. Rammokgonami	2,170
4. Mookane	1,790
5. Makwate	1,130
6. Matlhako	

Tutume Sub-distr.

1. Tutume	850
2. Makobo	460
3. Maitengwe	4450
4. Borolong (Thlalogang)	1,090
5. Mathangwane	1430
6. Sebina	1860
7. Chadibe (North)	700
8. Natale	1,090

Bobirwa Sub-distr.

1. Bobonong	6,100
2. Mabolwe	670
3. Tsetsebjwe	2,030
4. Tobane	900
5. Molalatau	935

Botetisub-distr.

1. Kedia	200
2. Mopipi	1,900
3. Moreomaoto	265

GHANZI DISTRICT

1. West Hanahai	210
2. Bere	200
3. Groot Laagte	200
4. Rooibrak	200

KGALAGADI DISTRICT

1. Middlepits	475
2. Ghakibane	485
3. Hereford	350

KWENENG DISTRICT

1. Dutlwe	835
2. Losilakgokong	415
3. Sojwe	360
4. Hatsalatladi	230
5. Diphuduhudu	200
6. Sorilatholo	200

NORTH EAST DISTRICT

1. Tati Siding	1,800
2. Senyawe	1,280
3. Pobepobe	200
4. Mapoka	2400
5. Ditladi	200

NORTH WEST DISTRICT

1. Phuduhudu	200
2. Gumare	2320
3. Shakawe	2'270
4. Sehitwa	1'880

SOUTH EAST DISTRICT

1. Metsimaswaane	290

SOUTHERN DISTRICT

1. Ranaka	2475
2. Manyana	2590
3. Digawana	2470
4. Musi	200
5. Sese	480

ESTIMATED TOTAL POPULATION

1988 74,500

AS MUCH AS 25% Increase over this figure has been estimated due to drought migration to villages

DWA Operations and Maintenance Division

Major-Village Water Supplies

Village	Est. 1985 Population	Water Prod. M^3/day	Number of Boreholes
Ghanzi	4180	264	3
Kanye	26500	1009	6
Kasane	3030	650	2
Letlhakane	6800	382	4
Mahalapye	28400	964	8
Maun	19600	1461	10
Mochudi	23900	1005	8
Mogoditsane	4080	864	--*
Molepolole	26900	1167	8
Moshupa	8500	366	5
Palapye	12600	739	7
Ramotswa	16500	611	2
Serowe	31000	1741	15
Thamaga	8500	362	2
Tlokweng	8700	483	--*
Tonota	8700	729	3
Tsabong	2260	149	3
Totals	240150	12948	86

*Purchases water from Water Utilities Corporation.

Note: The number of boreholes in operation at any one time varies due to water requirement, borehole yields and equipment availability.

BRS Outstations

Village	Number of Crews	Private Subscriber	Gov't Bh.	1985 Number Repair Trips
Francistown	3	201	83	259
Ghanzi	2	75	32	122
Hukuntsi	2	12	13	36
Letlhakane	2	47	13	36
Lobatse	3	165	31	183
Mahalapye	2	91	13	88
Maun	3	126	56	238
Mochudi	3	108	15	150
Molepolole	4	90	11	75
Palapye	3	45	28	124
Serowe	2	140	2	100
Tsabong	1	16	9	70
Totals	30	1116	306	1481

BRS Workshops:

Total staff 40

Gaborone: Overhauls 400
Maun: Overhauls 50

Source: Small Scale Water Pumping in Botswana - Volume II Diesels
Hodgkin, McGowan, and White, ARD, 1988

SIDA-Posts at the Department of Water Affairs, Contract Periods, Localization of Posts and Requests for successors

Post No BOT-CSS-	Title/Dept.	Name	Total Contract Period	Remarks
86	Director of Water Affairs	Quraishi, Gulam	800308-870930	Localization 1987
Division: Design and Construction				
19	Principal Water Engineer Design	Furengren, Jan	860804-880803	Localization 1990
85	Senior Water Eng.	Granne, Arild	810112-870711	Localization 1989. Successor under recruitment.
129	Senior Water Eng. Contract	Einarsson, Nils-Erik	851229-871228	Localization 1990. Job Description and request for a successor to be submitted to SIDA.
Division: Operation and Maintenance				
115	Principal Water Eng. Maintenance	Nord, Mats	831123-870723	Localization 1989/90. Successor under recruitment.
68	Senior Water Eng. Pollution			Localization 1989/90. Successor under recruitment.
108	Senior Mechanical Engineer			Localization Successor under recruitment
Division: Groundwater				
75	Principal Hydrogeologist	Holmberg, Sigurd	841030-880730	Localization 1990.
101	Senior Hydrogeologist	Bergström, Rolf	860731-880730	Localization 1988/89.
141	Senior Hydrogeologist			Localization 1989/90. Noam Lochovitski approved.

90	Senior Technical Off Rig Mechanic	Larsson, Alf	800317- 870531	Localization 1988/89. Successor under recruitment
125	Senior Technical Off. Rig Mechanic	Sheridan, Joseph	860808- 880807	Localization 1988/89.
30	Drilling Foreman	Lindberg, Assar	791023- 871022	Localization 1988.
92	Drilling Inspector			Localization 1989. Successor under recruitment.
94	Borehole Inspector	Palo, Rudolf	861103- 881102	Localization 1988.
Division: Hydrology				
104	Senior Water Eng. Resources	Krook, Jan-Olov	820315 870630	No further SIDA support.
Division: Training				
35	Chief Training Off.	Andersson, Bertil	870107- 890106	

Source: Annual Review of the Rural Village Water Supply Programme
SIDA, March 1987

NATIONAL DEVELOPMENT PLAN

DGS AND DWA ACTIVITIES

1985 - 1991

GS 01 (101/201) OIL AND GAS EXPLORATION (SLP)

Botswana imports all its oil and gas requirements. It is Government policy to minimise this dependence on imports due to long-run rising prices and insecurity of supply. Survey work has identified two large basins in the west of the country with thick sedimentary deposits which suggest that the basins may be oil and gas bearing structures.

Geophysical and/or geochemical surveys will be undertaken to further evaluate hydrocarbon potential. The results will allow plans to be made for future exploration if potential is established. The information will be passed on to the private sector to stimulate interest.

Initial work will involve reconnaissance survey of the Nosop and Ncojane basins by carrying out a seismic survey along four traverses.

TOTAL ESTIMATED COST P4 960 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	—	2 480	2 480	—	—	—
Recurrent	—	—	—	—	—	—

GS 03 (101/202) TGLP GROUNDWATER SURVEYS (SLP)

The implementation of the Tribal Grazing Land Policy (TGLP) has been confronted with difficulties in a number of areas due to lack of water or water of unsuitable quality.

In recognition of this problem, surveys of the groundwater potential of TGLP ranches will be carried out. Survey areas with groundwater resources of suitable quality situated in or near demarcated TGLP ranches will be identified. The survey will obtain vital information for use in the demarcation of TGLP ranches. The aim of the project is to minimise the capital expenditure of the farmer on borehole drilling by reducing the risk of unsuccessful drilling.

The survey will start in Ghanzi, Kgalagadi and Southern District. Because of competition between livestock and wildlife for water and grazing, wildlife management areas will be included in the surveys. The project is divided into two phases. Phase one will be a desk top study compiling and evaluating all available hydrogeological data. On the basis of this evaluation the most promising areas for groundwater development will be determined. Ranches with no potential will be recommended for de-zoning. Under phase two promising ranch areas will be studied in detail, sites will be selected and boreholes drilled and test pumped. The potential and suitability of the groundwater resources for livestock and/or wildlife watering will be assessed for each area where drilling is successful.

TOTAL ESTIMATED COST P3 000 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	100	1 500	1 600	—	—	—
Recurrent	—	—	—	—	—	—

GS 04 (101/203) GROUNDWATER RESOURCES MONITORING AND RECHARGE STUDIES

Water supplies in Botswana are highly dependent on groundwater resources. The Department of Geological Survey will be undertaking research during NDP6 to determine new sources of groundwater (see project GS 10) but it is also necessary to monitor existing sources.

In order to provide adequate information for long term groundwater resources development and management the Department of Geological Survey will expand the network of groundwater monitoring stations on aquifer systems of actual and potential economic importance. Data will be collected on groundwater reservoirs, response to abstraction and recharge rates. The project will introduce controlling mechanisms on the utilisation of underground water and will look into the feasibility of artificial recharge. The project will also include research to develop optimum techniques for the investigation of fractured rock aquifers basement structures.

Project activities will be undertaken in conjunction with the University.

TOTAL ESTIMATED COST P566 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	151	254	160	7	7	7
Recurrent	10	—	—	—	—	—

GS 08 (101/215) GEOLOGICAL SURVEY BUILDINGS

This project was initiated under NDP4 with the construction of laboratories and workshops at Lobatse. There is till a severe shortage of office space and library space and the Department finds it difficult to fulfill its obligations of providing office space to its staff and bilateral aid staff, storing data and efficiently providing data to the private sector.

Under this project a rock core store will be completed, a new administration block will be built, and an extension to the Library constructed. The project will enable the department to operate effectively and maintain its existing high reputation with the private sector. This is essential if Botswana is to continue to encourage private sector investment in mineral exploration.

TOTAL ESTIMATED COST P676 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	250	350	76	–	–	–
Recurrent	–	13	17	–	–	–

GS 10 (101/218) EVALUATION OF UNDER GROUND WATER RESOURCES (SLP)

During NDP6 the Ministry will prepare a Water Master Plan which will devise short, medium and long term plans for the optimum development of the countrys scarce water resources. There is insufficient information available on underground water resources to enable detailed planning now. Under this project the Department of Geological Survey will investigate and assess the groundwater resources of a number of regions, with priority being given to actual and potential high demand areas. Aquifer units capable of supplying potable water to meet regional demands will be indentified and wellfields delineated. Data generated by the project will allow a planned approach to regional water supplies to be undertaken thus preventing future disruptions in supply which are expensive both socially and economically. Hydrological and geophysical investigations of selected aquifers will be undertaken, followed by drilling of exploration boreholes and test pumping. Groundwater resources will be assessed for recharge balance and groundwater mining supplies. Work will initially be carried out in the following areas: Serowe, Lephephe-Mammabula-Limpopo, Maun, Kanye, Mochudi-Molepolole, Tshane and the Okavango.

TOTAL ESTIMATED COST P8 600 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	2 900	1 700	2 400	1 600	–	–
Recurrent	–	–	–	–	–	–

GS 12 (101/220) AIRBORNE MAGNETIC SURVEY (SLP)

It is Government policy to encourage private sector exploration for minerals by providing basic geological information. A reconnaissance airborne magnetic survey and ground follow-up was successfully undertaken during NDP5 over 80% of the country where the bedrock is obscured by sands.

This project will survey the remaining 20% of the country to provide complete coverage of Botswana. Information will be produced to allow the selection of specific areas for detailed exploration and thus encourage private sector interest.

The work will be conducted in three phases; airbone magnetic survey, compilation and interpretation; evaluation of the survey, selection of areas for airborne electromagnetic exploration; airborne electromagnetic coverage of selected targets, and EM plan maps, production of a combined aeromagnetic map of Botswana and a map of depth to magnetic basement. The Department of Geological Survey will assist the Consultants in the interpretation of data and with the provision of geophysical services.

TOTAL ESTIMATED COST P1 898 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	1 200	588	60	50	–	–
Recurrent	–	–	–	–	–	–

GS 17 (101/233) MINERAL EXPLORATION OF THE KALAHARI (SLP)

Since the Kalahari is covered with thick sands there is little geological information on the Sub-Kalahari basement. A reconnaissance airborne magnetic survey and a national gravity survey yielded much data which required ground follow up work. By 1985 four follow up projects had been carried out by technical assistance teams.

In order to increase geological information available and thus encourage private sector exploration additional ground follow up technical assistance projects will be undertaken. To aid further technical assistance and private sector exploration programmes the Department will undertake ground studies to determine the optimum geophysical exploration techniques for use in the Kalahari and will compile in report and map form relevant geological, geophysical and geochemical data together with satellite images.

TOTAL ESTIMATED COST P500 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	150	150	150	50	–	–
Recurrent	–	–	–	–	–	–

GS 18 (101/237) GEOLOGICAL SURVEY EQUIPMENT

During NDP5 equipment to support the hydrogeology, geophysics, chemistry and mineral dressing sections was procured.

This project will cover the purchase of additional major equipment items necessary for the effective functioning of the Department during NDP6. Priority will be given to a water well drilling rig required for ground water resource evaluation projects, a new mobile laboratory to assist in geochemical and water analyses in the field and a complete data base system for storing borehole information, surveys and exploration data.

Additional staff will be required to initiate the computer system, and train operators. Technical staff will be required to operate the rig.

TOTAL ESTIMATED COST P749 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	16	718	–	15	–	–
Recurrent	–	84	5	–	–	–

GS 02 (101/238) DIAMOND DRILLER TRAINING

Most diamond drilling in Botswana is undertaken by the private sector under prospecting licences but there is a need for the Department of Geological Survey to have drilling capacity to carry out limited research in some areas of the country.

At the moment operational machines in the Department are wholly manned by expatriate drillers who must ultimately be replaced by locals. The

primary objective is to create a strong group of local diamond drillers.

Training in Botswana by an instructor supplied by the Canadian International Development Agency started in 1983 and will continue until 1986, when the best candidates will be sent to Canada for futher specialised instruction.

TOTAL ESTIMATED COST P130 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	1	129	–	–	–	–
Recurrent	–	–	–	–	–	–

WB 03 (101/303) LANDS AREA WATER SUPPLIES

This project appeared in NDP5 but for various reasons was not started. A major constraint for promotion of arable farming has been identified as the shortage of water. It is thought likely that the most appropriate form of water supply will be small scale wells and catchment tanks. This is because households are very scattered, year round reliability is not essential and maintenance could be under taken largely at household level. This project provides for a consultancy study to investigate the most suitable method for small scale water development and the implementation of a programme of supply starting in 1987/88. This project will require close co-operation between the Ministries of Agriculture, Local Government and Lands and Mineral Resources and Water Affairs. Ministerial responsibilities with regard to implementation will be determined following the outcome of the study.

TOTAL ESTIMATED COST P500 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	–	200	75	75	75	75
Recurrent	–	–	20	20	10	10

WB 20 (101/305) HYDROLOGICAL SUPPORT

This programme was started in NDP5 with the installation of water level recorders at five sites, installation of additional raingauges, and the processing and publication of hydrological data and development of computer software. In order to provide adequate hydrological information and management in the whole country the network of gauging stations will be expanded and other surface water assessment will be carried out.

Two gauging stations will be constructed on the Tati and Motloutse rivers. Surveys of reservoirs and dam influences and water quality monitoring in the Okavango and Chobe will be undertaken. Evaporation control experiments will be undertaken to evaluate the various methods of reducing evaporation from reservoirs. The hydrological aspects of introducing cloud seeding will also be examined.

The project will also cover the purchase/replacement of a computer and other necessary equipment.

The investigations into the water sources of sandriver beds programme which started in 1969 will be included in this project. This aspect of the project will concentrate on detailed groundwater fluctuation monitoring and probing to establish safe yields along selected rivers. The probing and monitoring programme is necessary to establish new sandriver bed abstraction schemes for village water supplies.

A field crew will be established and equipped to operate the network of gauging stations for the duration of the plan.

TOTAL ESTIMATED COST P1 500 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	200	350	300	350	100	–
Recurrent	20	–	–	–	70	–

WB 27 (101/307) HYDROLOGICAL STUDIES OF THE OKAVANGO DELTA (SLP)

Phase I of the mathematical model of the Okavango Delta has been concluded. Although it has been developed to a satisfactory working stage, there is a need under Phase II to do more detailed calibration and an extension of the model to other distributories of the Delta. The model will be used to predict outflows from the Delta and to assess the effects of the proposed engineering works in the lower part of the Delta. It would also monitor changes in the flows resulting from these proposed schemes, if they are implemented.

The immediate objective of the project is to develop the model to a final working stage using the extra hydrological data collected since the end of Phase I. Landsat imagery information will also be used to obtain better estimates of active evaporative areas in the Delta. The model development will be undertaken by consultant.

During Phase II the consultant will revise and simplify the model instructions manual written during Phase I.

TOTAL ESTIMATED COST P20 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	20	–	–	–	–	–
Recurrent	–	–	–	–	–	–

WB 10 (101/310) LIMPOPO WATER UTILIZATION STUDY (SLP)

This project was included in NDP5 but no detailed studies were carried out on the Limpopo and Marico. A recent report, the Eastern Botswana Regional Water Study, has not considered the Limpopo in detail. The terms of reference required the consultants only to give a broad picture of the water resources of the Limpopo/Marico and not go into details about the hydrology of this river basin. But the Limpopo/Marico below the Motloutse is still considered as a potential resource for future water development in this part of Botswana and the main purpose of this project is to collect this information along the Limpopo and Marico rivers. It is necessary to obtain this hydrological information before the Limpopo can be ruled out of future water supply schemes in the Eastern Botswana especially for Gaborone water supply and irrigated agriculture in the Tuli Block. More information will be gathered through project WB20 (Hydrologicial Support).

The project will be divided into two phases; feasibility study and design phase. The first phase will take about six months as a desk top study and the second phase will take about two years.

The study will determine whether large scale water development of the Limpopo is economically viable.

TOTAL ESTIMATED COST P300 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	200	100	–	–	–	–
Recurrent	–	–	–	–	–	–

WB 12 (101/312) REGIONAL WATER DEVELOPMENT

The Eastern Botswana Regional Water Study has identified projects which should be implemented during the next plan period if rapidly increasing water demands are to be catered for. Demands are increasing so rapidly within certain regions of Botswana that water sources can no longer be developed in isolation for single demand centres.

The Study suggests that water supply will be concentrated in three population clusters; the Gaborone cluster (including Lobatse, Kanye, Ramotswa, Moshupa, Thamaga, Mogoditshane, Molepolole, Mochudi and Tlokweng), the Central cluster (including Serowe, Palapye, Shoshong and Mahalapye) and the Francistown cluster (including Tonota and Selibe Phikwe). It is estimated that 25% of the rural population within the clusters will continue to rely on local supply from boreholes. For villages outside the clusters local water resources should on the whole prove sufficient.

Within these clusters, responsibility for water supplies is shared between Water Utilities Corporation (which supplies Gaborone, Lobatse, Francistown, Jwaneng and Selibe-Phikwe) and the Department of Water Affairs. The Department of Geological Survey is responsible for the initial groundwater investigation. The Department of Water Affairs will be primarily responsible for the planning of the main regional supply systems but responsibility for implementation and financing of schemes will be shared.

This project allows for the design and implementation of regional water resources development during NDP6 for the Serowe, and Palapye area. This will include development to the Serowe well-field and of transmission pipelines from a main trunk pipeline to serve the main demand centres in the area.

It is assumed that developments in the other two clusters will be undertaken mainly by the Water Utilities Corporation.

It is Government policy that urban water supplies should not be subsidised and during NDP6 steps will be taken to make sure that this policy is strictly adhered to.

In view of this policy, and in view of the fact that the philosophy of water supply is changing from individual supplies to a regional conjunctive approach, it will be necessary to reconsider the institutional framework and the financing of schemes.

TOTAL ESTIMATED COST P9 300 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	–	–	–	3 500	3 500	2 300
Recurrent	–	–	–	–	305	365

WB 02 (101/313) COMPREHENSIVE WATER MATTERS STUDY (SLP)

The 1983 UNEP Clearing-house mission to Botswana and others have recommended the establishment of a central national water authority to improve water development operation, planning and administration in Botswana. At present even though the main Ministry responsibility for water lies with the Ministry of Mineral Resources and Water Affairs there are at least five other ministries and/or parastatals directly involved in water matters. This situation is unsatisfactory since it is difficult to prepare coordinated, efficient water development and operation plans and can also lead to duplication of effort. It is essential that in a country where water sources are so scarce that optimum use is made of the resource.

This project allows for a comprehensive study of the present manner in which the exploration, procurement, distribution and use of water of all kinds in Botswana, including relevant costings, are handled technically, administratively and legally, and the kinds of organisational structures and administrative and legal arrangements necessary to ensure maximum access benefits to all legitimate users on an equitable basis at all times. The recommendations of the study will be used, to re-organise and strengthen the management of water matters in Botswana where necessary.

TOTAL ESTIMATED COST P100 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	100	–	–	–	–	–
Recurrent	–	–	–	–	–	–

WB 14 (101/314) MAJOR VILLAGE WATER PLANNING (SLP)

A project for the provision of coordinated and more reliable water supply systems to designated Major Villages was launched in 1971. By 1982 seventeen (17) Major Village Water Supply Schemes had been completed. These schemes were designed to satisfy water demand in the respective villages 10 years after construction. Rapid population growth and changed socio-economic trends at the villages have, however, placed so much demand on the existing systems that most of them have fallen short of coping with current water demands.

This project intends to use the operational experience gained from existing water supply works to review demand trends, system design parameters and plan for phased upgrading and expansion of Water Supply systems. Environmental sanitation effects due to increased water use will also be investigated and plans for correcting any negative trends made.

Since most of the villages are already experiencing water supply constraints, the planning studies will be executed in the early part of the plan period, since they are a prerequisite for construction work which will be undertaken under the project Upgrading and Expansion of Major Village Water. (WB37).

The project will mainly be executed by consultants under the supervision of the Department of Water Affairs.

TOTAL ESTIMATED COST P800 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	350	350	100	–	–	–
Recurrent	–	–	–	–	–	–

WB 15 (101/315) GOVERNMENT DRILLING AND SITING CAPACITY

The Department of Water Affairs has at present 6 rotary rigs (one very old, and beyond its economic

life), 8 percussion rigs, 1 truck mounted cleaning rig, 5 test pumping units. The 5 rotary rigs normally in operation are capable of drilling 250 boreholes annually; the 8 percussion rigs are capable of drilling another 50 boreholes. Thus the total number of boreholes amounts to 300 per year. Assuming a 40% success rate, 120 successful boreholes can be drilled. During NDP6 the demand for boreholes is expected to increase, in particular as a result of the requirements of the major rural village water supply programme but also as a result of the demands of other departments. Test pumping and cleaning capacities have to be increased. However, it is intended to maintain the drilling capacity at its present level in order to encourage the role of the private sector. The normal useful life of a rotary rig is between 5 and 8 years and that of a percussion rig about 15 years. It will be necessary to replace 3 rotary rigs during the plan period. It will also be necessary to phase out the 8 percussion rigs, replacing them with 5 new units. Three truck mounted cleaning rigs will arrive in 1985.

Four additional test pumping units are required, and since two units are due for boarding a total of six units will be purchased. Additional manpower and geophysical equipment will be required to match the drilling capacity. An increase in computing capacity will be needed for storing and processing data.

TOTAL ESTIMATED COST P4 800 000

P'000	1985/86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	1 200	1 000	800	1 000	800	—
Recurrent	62	264	46	92	294	—

WB 16 (101/316) WATER AFFAIRS REGIONAL BUILDINGS

The Department of Water Affairs has outstations in 20 towns or villages. These outstations are the centres of regional operations for the various divisions such as Construction, Hydrology, Major Village Water Supplies, Borehole Repair Service (BRS) and Drilling. Most of the outstations now suffer from inadequate office, storage and workshop facilities and in some places the various divisions are located at different places within the town/village.

In order to achieve more effective regional operations this project will cover an upgrading of the physical facilities at the outstations. At Maun, Molepolole and Mahalapye the various divisions will be intergrated into one location and at Serowe a new central yard will be developed. New store buildings will be constructed in Mochudi, Kanye, Ramotswa, Serowe, Maun, Tonota, Kasane, Moshupa, Thamaga and Tlokweng. The project will also cover equipment and electrification at the outstations.

TOTAL ESTIMATED COST P2 000 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	825	850	150	100	100	—
Recurrent	—	50	50	8	5	5

WB 07 (101/317) AQUATIC VEGETATION CONTROL

Alien aquatic weeds such as Salvinia Molesta (Kariba Weed) and Eichhornia Crasspipes (Water Hyacinth) are a great threat to Botswana's limited, permanent surface water resources. In particular if Salvinia were to spread from the Kwando/Linyanti/Chobe river system into the Okavango Delta it would result in a major reduction in outflow thus affecting the viability of water dependent projects such as agriculture developments and the security of the Orapa mine water supply. The Department of Water Affairs took over aquatic vegetaion control from the Department of Agricultural Research in 1981 and since then control measures have been restricted to spraying with highly toxic chemicals in fairly narrow areas in the Kwando and Linyati rivers. Chemical spraying has a high recurrent cost and if Salvinia were to establish itself in the delta the costs of control would be probibitively high. Biological control measures are considered to provide the only long term solution to the problem.

This project allows for the establishment of a biological control research programme to find the most effective control to be used in Botswana, which if successful, will significantly reduce the amount of costly chemical spraying. The project also allows for the establishment of better boat control since boat movement is the major cause of spreading weed infestation. This will be in keeping with the latest regulations.

TOTAL ESTIMATED COST P360 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	50	125	125	60	—	—
Recurrent	10	—	—	—	—	—

WB 18 (101/318) OKAVANGO/CHOBE WATER TRANSFERS—FEASIBILITY STUDIES

The Okavango and Chobe river systems are Botswana's only major surface water sources but are located at long distances from the major rapidly increasing water demand centres in the east. The Eastern Botswana Regional Water Study Phase I has indicated that there should be sufficient developable surface and groundwater sources in Eastern Botswana to meet demands until the end of the century, but that major transfers from the Okavango and/or Chobe will be required no later than early in the next century and possibly much earlier if some of the proposed sources in Eastern Botswana are found on detailed investigation not to live up to expectations and/or if large, mining developments with large water demands occur. The project will cover preliminary feasibility and design studies.

TOTAL ESTIMATED COST P330 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	—	150	180	—	—	—
Recurrent	—	—	—	—	—	—

WB19(101/319)APPROPRIATEWATERTECHNOLOGY

The equipment on boreholes for Major and Rural Village Water Supplies in Botswana has been standardised to monopumps driven by diesel engines. During NDP5 research was undertaken into alternative methods of pumping water. A monitoring and evaluation programme of installed test technologies including windmills, solar pumps, animal powered and biogas powered pumps will

continue under the Botswana Renewable Energy Technology Project (BRET) until September 1985.

With the aim of reducing reliance on imported diesel fuel and providing a cheaper method for pumping water, monitoring and evaluation of alternative technologies will continue. Those technologies which prove to be economically superior to diesel pumps will then be installed.

The project will also cover desalination. New posts will be needed within the Department and vehicles will be provided from the BRET project.

TOTAL ESTIMATED COST P120 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	20	20	20	20	20	20
Recurrent	3	12	1	1	1	1

WB 04 (101/320) LEGAL ASSISTANCE ON WATER LAWS (SLP)

The Limpopo, an international boundary river, is an important potential resource for irrigated agriculture and water supply. International discussions have already taken place and a Limpopo Basin Technical Committee has been formed. A bi-lateral technical committee with the Republic of South Africa has been formed. The other international rivers are Chobe, Molopo and Okavango. The Okavango flows through Angola and Namibia before reaching Botswana and international agreements will be necessary if major water developments are to take place.

It is envisaged that expert external legal assistance will be required to assist with international issues during NDP6 initially to focus on issuing of water rights along border rivers but at a later stage to assist with more major negotiations. The project will also allow for the engagement of legal experts required during the implementation and subsequent review stages of the new water legislation.

TOTAL ESTIMATED COST P60 000

P'000	1985 86	1986 87	1987 88	1988 89	1989 90	1990 91
Capital	20	20	20	—	—	—
Recurrent	—	—	—	—	—	—

WB 21 (101/322) OKAVANGO CHOBE DEVELOPMENT

The development of the Okavango Delta and the Chobe River will play an important role in Botswana's future development and growth. Despite the obvious potential of both river systems, particularly for commercial food production, no significant utilization schemes have been implemented. It is now Government policy to develop a strategy to allow Botswana to become less dependent on food imports. The Maun-Shorobe and the Chobe enclave areas could provide 25 percent of Botswanas current basic food requirements if water security is obtained. Other consumers who will be dependent on Okavango out-flows in the future include Maun, Lake Ngami, Orapa, fisheries and the tourist industry. However, the main constraint to such a development taking place will be water availability.

The project allows for a Consultancy to formulate and design an integrated water strategy for the Southern Okavango Delta. This will require topographical surveys, water demand studies, engineering design, economic analysis and ecological impact studies which will result in the design of dredging works, small dams, bunds and other river control works. The main objective is to obtain economically viable, secure water supplies for large scale as well as small scale agricultural development and other existing and potential users in the area. The Gomare CDFA area also has potential for arable agriculture. Therefore the project also allows for a labour intensive river flow enhancement scheme (Thaoge Phase I) to secure water supplies to 1000 hectares of traditionally cultivated melapo to produce food for local consumption.

The Southern Okavango project will be a Consultancy with no recurrent costs. However, it is assumed that if development is proved economically viable then implementation will take place and the capital and recurrent costs of such development will be met by the beneficiaries. The Thaoge Phase I project will be mainly undertaken using locally recruited labour. However, technical manpower will be required for the planning, supervision, and monitoring of the two projects.

TOTAL ESTIMATED COST P3 100 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	1 500	1 600	200	—	—	—
Recurrent	40	25	75	50	—	—

WB 23 (101/323) RE-USE OF WASTE WATER (SLP)

Water is a scarce resource in Botswana. The Eastern Botswana Regional Water Study shows that conjuctive use of both surface and ground water resources will not adequately meet the demand in the Eastern Part of the country by the year 2010. Transfer of water from either Chobe or Okavango will be necessary to satisfy the growing water needs. Since the transfer is extremely expensive it may become economically feasible to recycle water. Treated waste — water could be re-used for irrigation, for replenishment of the reservoir water, for industrial use or for ground-water recharge. However the economic and technical possibility of recycling water in Botswana is not known. A consultancy study to establish the feasibility of such an operation is therefore necessary. The study will take into account aspects of safety and security of operation and will consider the need for pilot tests and further studies.

TOTAL ESTIMATED COST P100 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	50	50	—	—	—	—
Recurrent	—	—	—	—	—	—

WB 24 (101/324) REGIONAL WATER STUDIES AND INVESTIGATIONS

To enable the optimum development of scarce water resources the Department of Water Affairs is producing a long term national Water Master Plan. The Eastern Botswana Regional Water Study Phase I, undertaken in NDP5 to identify water supply projects needed to meet demand in the next five years, is being used as a basis for the

plan. A number of sources of both ground water and surface water have been indentified for investigation and development on a regional scale. The Department of Geological Survey is responsible for investigating ground water resources.

This project allows for all other investigations and prefeasibility studies required for regional water development. The design and implementation of works will be covered under the project Regional Water Developments. Studies required under this project include those pertaining to potential dam sites, trunk pipelines, economic analysis and large scale water development for agriculture. Subsequent regional water developments for main urban areas will not be covered since they will be undertaken by W.U.C. Manpower in the hydrology and water resources division will be increased to supervise and undertake work on this project and to implement the Regional Water Development Project.

TOTAL ESTIMATED COST P2 350 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	50	—	500	1 000	500	500
Recurrent	—	50	5	15	—	—

WB 37 (101/337) UPGRADING AND EXPANSION OF MAJOR VILLAGE WATER SUPPLIES

The present 17 Major Village Water Supplies operated by the Department of Water Affairs were constructed between 1971 and 1982. Due to rapid increase in demand most of these supplies now suffer from insufficient water sources and inadequate distribution capacity.

The project seeks to improve the general reliability of the water supply service at the villages and ensure reasonably consistent supply in future.

The source capacities will be augmented and upgrading works on the existing transmission, distribution and storage facilities will be executed so that at least adequate supply to presently served areas can be sustained,. Administration facilities and consultancies for the supervision of construction works will be provided where necessary.

TOTAL ESTIMATED COST P19 500 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	3 000	3 500	3 000	3 500	3 000	3 500
Recurrent	—	450	560	650	350	200

WB41 (101/341) NEW HEADQUARTERS BUILDING

The Department of Water Affairs (DWA) workload has increased considerably in NDP5 due to the expansion of the village water supplies programme, increased drilling capacity, an improved Borehole Repair Service (BRS) and the need to devote increasing attention to the problem of rehabilitation of major villages. DWA will also take on an additional responsibility of implementing the new water act and possibly be required to construct sewerage systems in the major villages. The expansion of the activities of DWA has naturally been accompanied by increase in personnel. The increase in staff as a result of the general growth of existing functions and added responsibilities will compound the problem of shortage of office facilities.

To enable the Department to effectively carryout its duties this project will allow for an expansion of the existing headquarters building. This project will also provide for better storage and workshop facilities at Headquarters.

TOTAL ESTIMATED COST P2 000 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	100	1 000	700	200	—	—
Recurrent	80	80	—	—	—	—

WB 42 (101/342) VILLAGE WATER SUPPLIES

The construction of water supplies to major and rural villages began in 1972 and at the end of the financial year 1984/85, supplies will be operating in all 17 major villages and in another 213 rural villages. Within the current programme 124 village water supplies remain to be constructed.

Efforts are still continuing to provide all the villages in Botswana with potable water. Due to financial constraints and maintenance capacity of councils the implementation rate of the village water programme has been trimmed from 38 to 20—30 water schemes per annum. The coverage of all the villages with clean and reliable water supplies is expected to be completed during the course of NDP7. A water supply system essentially constitutes a borehole, reticulation to the tank and centrally located standpipes with connections to the school and health post. This programme is important as rural development endeavours by government and local authorities hinge on availability of adequate water supplies.

Once the Department of Water Affairs has constructed a rural water scheme, it hands it to the respective District Council for operation and Maintenance.

The programme is expected to proceed as follows during NDP6 period:

	1985/6	1986/7	1987/8	1988/9	1989/90	1990/1
Planned Construction	20	20	30	30	30	30
Accumulated No of completed Villages	250	270	300	330	360	390

TOTAL ESTIMATED COST P33 000 000

P'000	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Capital	5 000	4 000	6 000	6 000	6 000	6 000
Recurrent	1 190	410	615	615	615	615

Source: NDP VI, Government Printer Gaborone, Botswana, 1985

APPENDIX K

Distict Council Water Units and Departments -1987

Water Departments	
Ghanzi District Main Offices - Ghanzi Sub-depot - Charleshill	23 Boreholes
North West District Main Offices - Maun Sub-depots - Gumare, Kasane	45 Boreholes
Water Units (under Works Departments)	
Central District Water Engineer in Serowe with water units at the five subdistrict office locations	168 Boreholes
1. Bobirwa Subdistrict Main Offices - Bobonong	23 Boreholes
2. Boteti Subdistrict Main Offices - Letlhakane	19 Boreholes
3. Mahalapye Subdistrict Main Offices - Mahalapye	33 Boreholes
4. Serowe-Palapye Subdistrict Main Offices - Serowe	54 Boreholes
5. Tutume Subdistrict Main Offices - Tutume	32 Boreholes
Kalagadi District Main Offices - Tsabong Sub-depot - Hukuntsi	40 Boreholes
Katleng District Main Offices - Mochudi	35 Boreholes
Kweneng District Main Offices - Molepolole Sub-depot - Letlhakeng	70 Boreholes
North East District Main Offices - Francistown (scheduled to move to Masunga)	45 Boreholes
Southern District Main Offices - Kanye Sub-depots - Mabutsane, Goodhope(planned)	78 Boreholes
South East District Main Offices - Ramotswa	16 Boreholes

Source: Small Scale Water Pumping in Botswana, Volume II Diesels
Hodgkin, mcGowan and White, ARD, Burlington, Vt, 1988

APPENDIX L

Government Boreholes

DWA, through its Design and Construction division and BRS, provides design, construction and repairs to boreholes used and operated by other government agencies in other ministries. In most instances the water needs of public-sector users are met by already established urban or rural water systems. The following list of nearly 300 boreholes includes those where water needs are not met in this way. MOA is by far the largest user because of the decentralized nature of its activities. The Roads Division of the Ministry of Works and Communication establishes water points during road construction, and the totals here fluctuate with road building activity. Several boreholes currently at police camps will be handed over to District Councils in the near future.

Office of the President — 13 Boreholes

- Botswana Defense Force
- Police

Ministry of Finance and Development Planni — 11 Boreholes

- Customs and Excise (operated jointly with Immigration)

Ministry of Agriculture — 205 Boreholes

- Department of Veterinary Services
  - Animal Health (Cordon Fence & Quarantine)
  - Trek Routes
  - Tsetse Fly Control
- Agricultural Research
  - Animal Production Research Unit
- Department of Agricultural Field Services
  - Rural Training Centres
  - Division of Animal Production (AI Unit)
- Botswana Agricultural College

Ministry of Home Affairs — 1 Boreholes

- Immigration (see Customs and Excise)
- Prisons

Ministry of Education — 8 Boreholes

- Secondary Education
- Jr. Secondary Schools

Ministry of Commerce and Industry — 20 Boreholes

- Department of Wildlife and Parks

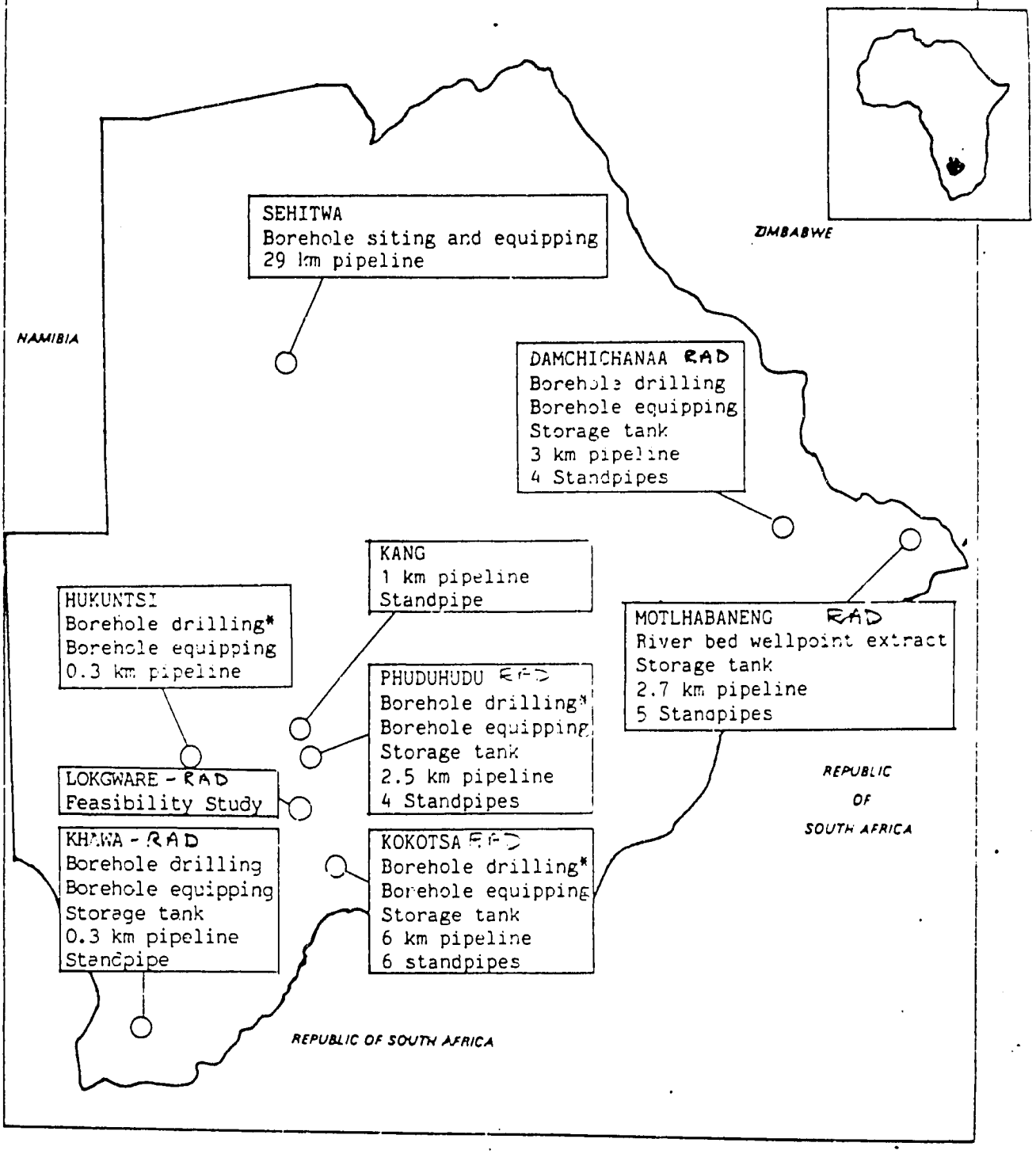
Ministry of Works and Communications Roads	23 Boreholes
Ministry of Local Government and Lands Refugee Camp - Dukwe	4 Boreholes
Ministry of Health Hospitals and Clinics	2 Boreholes

This group represents a distinct population of pumping equipment, as service and repair are provided free of charge for these government boreholes. Therefore, the service history is not likely to include repairs made by informal-sector mechanics, and regular maintenance and service should have been provided by BRS. Unfortunately, certain weaknesses (staff, transport and spares) within BRS have resulted in less than ideal service and, since no charges are made, there is some question about the accuracy of record-keeping as well. However, certain valuable information about engine care and maintenance costs can be inferred from the data available.

Source: Small Scale Water Pumping in Botswana, Volume II Diesels Hodgkin, McGowan and White, ARD, Burlington, VT, 1986

APPENDIX M

THE REPUBLIC OF BOTSWANA



LUTHERAN WORLD FEDERATION. DEPARTMENT OF WORLD SERVICE / BOTSWANA

WATER DEVELOPMENT PROGRAMME 1987

* Completed prior to 1987.

RAD . Remote Area Dwellers Program.

APPENDIX N

SERVICE RECORD FOR ROTARY V

FOR CALENDAR YEAR 1987

NOTE: Totals 19 times that the rig was out of service for repairs. This rig had the worst service record and other rigs recommended for overhaul average 8 or 9 out-of-service periods for repairs.

The following pages are taken from the actual handwritten service record for Rotary V, to illustrate both the frequency of breakdown and informal recordkeeping on repairs.

ROTAMEC 1302 ROT V

NEW INJECTOR AND CABLES FOR WELDING PLANT.

BENSON

16/1/87 ROTARY 5 WAS FITTED WITH A NEW JAW. THE BOLTS ON THE FRAME OF THE JAW WAS RETIGHTENED. NEW BEAM LIGHTS WAS FITTED.

ROMAN MAGRI

23-1-87 . INSTALLED REPAIRED RADIATOR C/W WATER ON SITE TO TEST FOR LEAKS)

25-2-86 INSTALLED REPAIRED RADIATOR STILL LEAKING BROUGHT BACK TO GABS. HYDRAULIC TANK NOT WELDED. DIAPHRAM FOR PRESSURE REDUCING VALVE FIXED TEMPORALY

28-2-86

INSTALLED RADIATOR. DIAPHRAM OK.

ROMAN & WILSON.

6-3-87 THE FUEL TANK WAS FULL OF SAND AND ~~S~~ THE FUEL FILTERS WERE FULL OF DIRT. NEW MEMBRANE WAS FITTED. N°64 SEAL MISSING

~~DENNIS & WILSON~~

COMPRESSOR OVER HEATING ENGINE OVERHEATING. EXHAUST LEFT BANK BLOWING OUT BLACK SMOKE ENGINE COOLER LEAKING.

DENNIS & WILSON.

24-3-87

27-3-87 1) ENGINE CHANGED OUT BY BLACKWOOD HODGE.
2) NEW RECONDITION ENGINE ~~COOLER~~ RADIATOR CHANGED OUT.
3) NEW FAN FOR HYDRAULIC OIL COOLER.
4) UNIVERSAL FAN SHAFT CHANGED OUT
5) MAIN HYDRAULIC PUMP MOUNTINGS RE SHIMED AND NEW BOLTS PUT IN.
6) CHECKED AND REPAIRED ALL LEVERS ON RIG
7) CHANGED OUT BREAK OUT CYLINDER
8) CHECKED OUT SAFTEY SYSTEM, CHANGED OUT RELAYS FOR SOLINOID.
9) CHANGED OUT HYDRAULIC FILTERS AND SEPARATOR FILTER, ALSO A GENERAL SERVICE WAS DONE ON THE RIG BY B/HODGE
10) WELDING MACHINE FIXED AND IN WORKING ORDER.
11) CHANGE OUT LEVEL GAUGE ON RECIEVER, AND SETON NEW PACKING ON FILLER CAP
12) CHECKED AND REPAIRED CAT/PUMP.
13) NEW LUBRICATION P/P INSTALLED
14) GEAR BOX OIL PUT INTO ROTATION HEAD
15) INSTALL NEW ~~ENG~~ OIL PRESSURE SENDER UNIT
16) " " OIL PRESSURE SWITCH TO SAFTEY SYSTEM

M.R. ROMAN

26-4-87

1 REPLACED "V" PACKINGS FOR MAIN AIR HOSE AT ROTATION HEAD.
2 RE-PLACE ROTATION GEAR BOX OIL
3) INSTALLED RADIATOR
4) PUT IN NEW 40 AMP FUSES.

INSTALLED NEW SOLENOID

13-5-87 ~~CAT~~ REPAIRED COUPLING T PIECE FROM MAIN HYDRAULIC PUMP.

18-5-87 ONE - WAY VALVE. WAS ~~WITH~~ INSTALLED AFTER REPAIR, I.E. ONE FROM THE MAIN HYDRAULIC PUMP. THE MAIN HYDRAULIC PUMP WAS FASTENED.

Dwandile

21/5/87 RIG AT SESC / JWANENG

Hour Reading 1745

1) REPLACED 'O' RING AT WINCH/CAT PUMP VALVE
2) RETIGHTENED BOLTS HOLDING OIL COOLER MANIFOLD
3) RETIGHTENED BOLTS AT MAIN HYD PUMP

26/6/87 NEW TEMPERATURE GAUGES OF THE COMPRESSOR IS FITTED. NEW SLOW SPEED IS INSTALLED. THE SAFETY ~~SYSTEM~~ SYSTEM IS TESTED AS WELL.

26/6/87 FAN SHAFT FITTED AFTER MACHING A NEW SHAFT

B. A. RULE

7-7-87 Battery x 2, Starter Motor & Alternator

B. G. Rule

7/7/87 THE SLOW FUEL LEVER IT WAS LONG, WE CUT 8 c.m.

REPLACED TWO BOLTS FOR HYDRAULIC PUMP.

Wilson Thulari
B.G. Rule

2/8/87 ROTARY I

Tried safety system. Take out flexible coupling and take out broken bolt and put in a new key made of 6 sign key.

2/8/87 FITTED "FLEXIBLE NIPPLE" AT MAIN PUMP; AND · FITTED 1¼" X 0.4m EX-TENSION

Data HOUR READING 1876.9.

11/8/87 BLACK WOOD HODGE CHANGED INJECTORS AND SLIPPED IN EXHAUST AND INLET VALVES.

14/9/87

- REMADE "V" PACKINGS
- CHANGED SCANNED VALVE BLOCK - CRACKED
- RENEWED ELECTRIC SYSTEM
- REPLACED FLANGE SCREWS AT ENGINE AND COMPRESSOR JOINT.
- REPLACED GATE VALVE AT HYD. TANK
- FIXED WATER LEAK AT CAT PUMP
- REPLACED SHIMMS (FLAT WASHERS) UNDER BRACKET FOR MAIN HYD. PUMP
- APPLIED LOCKTITE (SVENSK STARK) AT BEARING HOUSING FOR RADIATOR FAN SHROUD.
- EMBL INSTALLED DONALDSON. SYSTEM - PRE CLEANER FOR COMPRESSOR NOT FITTED.!!
- REPLACED "O" RING AT BOTTOM OF COMPRESSOR. — G. FUEL DIA.

HOUR READING 5255.7

18/12/87

- MAIN HYDRAULIC MOTOR WAS CHANGED
- NEW VALVE FOR HYDRAULIC PRESSURE WAS FITTED
- PANEL LIGHT WAS ~~FIX~~ REPAIRED

DRAMATIC CHANGING

14/01-88 OLD HOUR READING 5491.0

① FITTED NEW HOUR METER

APPENDIX O

Rig Reconditioning Costs

Included in Appendix O is a quotation for spare parts for reconditioning of the 2 Atlas-Copco Rotamec drilling rigs. This is a back-up for a quotation from Scan African Trading for:

a. The parts
b. Sea freight delivery
c. Allowance for supplemental parts and air freight
d. Mechanic's time for repairs and training
e. Mechanic's air fare
f. Mechanic's local transport and lodging

The total amounts to. $111,000

However, while total mechanic's time is and appropriate estimate, air fare for condition confirmation trip (extended for 3 weeks training) is not included. . . . . .add 2,000

Also, most training aids in hand. . . . . .deduct 1,000

Also, 10% allowance $7,000 for added parts not on original list may be insufficient. . . . . add 10,000

New Estimated Total $122,000

Estimate from Schramm representative expected to be nearly comparable

APPROXIMATE TOTAL	$244,000
CARRIED ON REPORT	$250,000

QUOTATION

Scan African Trading (Pty) Ltd.

Page No

Customers reference	Date	Reference No
Ralph Preble	28.1.88	88/hko5 014

Consignee/Delivery address	Customer
W.A.S.H. Operations Centre 1611 N. Kent Street Room 1002, Arlington VIRGINIA 22209 U.S.A.	W.A.S.H. Operations Centre 1611 N. Kent Street Room 1002 Arlington VIRGINIA 22209 U.S.A.

Time of delivery	Terms of payment
7 weeks	Against L/c approved by our bank
Terms of delivery (Incoterm 1980)	
Avaialble in Gaborone	

DEAR SIRS!
REFERRING TO YOUR ABOVE MENTIONED INQUIRY WE HAVE THE PLEASURE TO QUOTE YOU AS FOLLOWS
OUR QUOTATION IS IN ACCORDANCE WITH THE TERMS STATED AND THE GENERAL CONDITIONS ENCLOSED WE HOPE THAT OUR QUOTATION WILL BE OF INTEREST AND ARE LOOKING FORWARD TO RECEIVE YOUR ORDER IF YOU HAVE ANY FURTHER QUESTIONS, PLEASE DO NOT HESITATE TO CONTACT US

YOURS FAITHFULLY
SCAN AFRICAN TRADING (PTY) LTD.

General conditions	Validity of quotation
	Two months
Packing	
Estimated gross weight kgs	**Estimated volume M3**

Country of origin	Currency
SWEDEN	US D

Item	Specification	Article No	Quantity	Unit price	Total price
1.	Repr from Atlas Copco Sweden We recommend not less than 10 weeks Price/week		12	1300.00	15600.
2.	Local Transportation max 5000 km Lodging Price/week		12	770.00	9240.
3.	Airfare ADD :- Airfare for spares conformation & training trip			2000.00 2000	2,000.00
4.	Catalogue And Manuals (6) 6 various subjects probably on hand - delete 1,000-		1 each	1,340	1,340
5.	Repairs Overhaul parts per Atlas Copco quote attached				70315.
6.	Sea Freight delivery		8 %		5625.
7.	allowance for additional needs following inspection including air freight 10% of orig. quote 7- possibly too low add			10,000-	7,000.

FOR ESTIMATED TOTAL SEE INTRODUCTION PAGE-1

Broadhurst Ind Estate Lejara Road P O Box 40490 Gaborone Botswana
Telephone 313638/31463B Telex 2638 BD Telefax 312923

Atlas Copco Energy AB

TENDER PROFORMA INVOICE ACKNOWLEDGEMENT

Our date 1988-01-26 Our reference 510 SP 88/033

Your date Your reference

Consigned (Dispatch to)

Customer

WASH OPERATION CENTRE
Att Mr Ralph Preble
1611 N Kent Street
Room 1002
ARLINGTON
Virginia 22209
USA

Prices & Conditions valid until April 30, 1988

Terms of delivery FOB Swedish port

Time of delivery 8-10 weeks

Terms of payment By confirmed irrevocable Letter of Credit opened in the name of Atlas Copco Energy AB, Stockholm, Sweden with Skandinaviska Enskilda Banken, Stockholm, Sweden and confirmed by this bank.

Item	Description	Part No / Product No	Quantity	Price each USD	Price total USD
	Spare parts Rotamec 1302				
	Vane pump - hyd. pump				
1.	Main pump	3960 0000	2	1985:-	3970:-
2.	Vain pump (right)	3965 1834	2	720:-	1440:-
3.	" " (left)	3960 0017	2	680:-	1360:-
4.	Rotation motor	3960 0938	4	1500:-	6000:-
5.	Water inj motor	3960 2314	2	4900:-	9800:-
6.	Brake out cyl	3960 0204-80	2	910:-	1820:-
7.	Trottle cable	3960 1171	4	240:-	960:-
	Hydraulic main pump				
1.	Coupling compl	3960 0022	2	855:-	1710:-
2.	Shaft	3960 0045	2	164:-	328:-
3.	Set screw	3960 0047	4	0:50	2:-
	Connecting parts for vain pump				
1.	Gasket	3965 0253	2	2:60	5:20
2.	Adapter	3965 0252	2	270:-	540:-
3.	Gear	3965 0251	2	172:-	344:-
4.	Coupling	3960 0052	2	51:-	102:-
5.	Plate	3960 0808	2	64:-	128:-

.../2/

0018 9006 21 ACE Dec 87 Printed in Sweden

All deliveries unless otherwise stated in accordance with General Conditions for the supply of Plant and Machinery for export, prepared by the United Nations Economic Commission for Europe as accepted by Atlas Copco (ref 188)

Atlas Copco Energy AB

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Atlas Copco Energy AB
S-105 23 Stockholm
Sweden

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Int + 46 (0)8 716 90 80

Telex
14390
copco s

Telefax
46(0)8 716 59 75

Bank
Skandinaviska
Enskilda Banken
Stockholm

Item	Description	Part No / Product No	Quantity	Price each USD	Price total USD
6.	Bolt	3960 0809	2	1:80	3:60
7.	Screw	3960 0220	4	0:65	2:60
8.	Washer	3965 0140	4	0:10	0:40
	Relief valves and pressure reducing valves				
1.	Relief valve	3960 0431	2	620:-	1240:-
2.	" "	3960 0181-80	2	430:-	860:-
1A.	Spring	3960 1027	4	10:40	41:60
2A.	"	3960 1028	4	8:50	34:-
3.	Check valve	3960 0053	6	212:-	1272:-
4.	Trottle valve	3960 0432	4	135:-	540:-
5.	Non-return valve	3960 0617	2	220:-	440:-
6.	Half speed valve	3960 0885-15	2	68:-	136:-
7.	Non-return valve	3960 0443	2	142:-	284:-
8.	Relief valve	3176 1262-08	2	100:-	200:-
9.	" "	3960 0055	4	31:-	124:-
10.	" "	3960 0054	4	37:-	148:-
11.	Pressure reducing valve	3965 0152	2	565:-	1130:-
	Other spares				
	Winch				
1.	Clutch	3960 0272	2	138:-	276:-
2.	Gasket	3960 0231	4	1:50	6:-
3.	"	3960 0247	4	1:50	6:-
4.	Body	3960 0237	2	144:-	288:-
5.	U-bolt	3960 0267	2	2:10	4:20
	Other spares				
1.	Radiator	2253 0840	1	11840:-	11840:-
2.	Feed chain top	3960 0072	2	2840:-	5680:-
3.	" " bottom	3960 0073	2	3180:-	6360:-
4.	Floating sub	3960 0455	1	3641:-	3641:-

...3/

Item	Description	Part No / Product No	Quantity	Price each USD	Price total USD
	Lever and valve block parts				
1.	Rod	3960 1029	4	18:-	72:-
2.	Washer	3960 1030	16	1:30	20:80
3.	Pin	3960 1031	16	1:-	16:-
4.	Lever	3960 1032	2	54:-	108:-
5.	"	3960 1033	2	54:-	108:-
6.	"	3960 1034	2	54:-	108:-
7.	"	3960 1035	2	54:-	108:-
8.	"	3960	4	102:-	408:-
9.	"	3960 1041	2	102:-	204:-
10.	Rod	3960 1042	2	22:-	44:-
11.	Washer	3960 0424	4	1:30	5:20
12.	Link	3960 0425	6	20:-	120:-
13.	Washer	0301 2178	6	0:15	0:90
14.	Cotter pin	3960 0084-14	12	0:05	0:60
15.	Rod	3960 1046	6	12:60	75:60
16.	Lever	3960 1048	2	54:-	108:-
17.	"	3960 1049	2	54:-	108:-
18.	"	3960 0536	2	54:-	108:-
19.	"	3960 0537	2	54:-	108:-
	Tool kit as per enclosed page				
1.	Tool kit 2	9760 4011-90	3	1460:-	4380:-

Total USD 69277:70

Export packing FOB charges USD 1037:30

Total price FOB wedish port USD 70315:-

ATLAS COPCO ENERGY AB
International Projects and Market Development

Jan Jönsson Sören Persson

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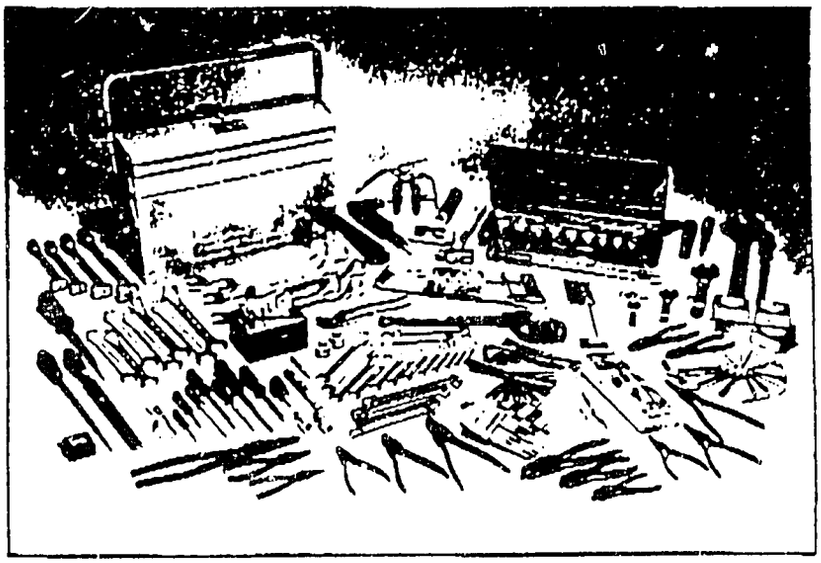
Bank
Skandinaviska Enskilda Banken
Stockholm

T-Q TOOL KIT 2

(for ROC/ROTAMEC drill rigs and XA/XR(H) 210/350, XT 430/570 compressors)

Description	Part No.	Qty
Complete tool set	9760 4011-90	1
Tool box	1221 0407	1
Padlock	Vally 402	1
Combination pliers	Bahco 2621-7	1
Cutting nipper	1528-6" in	1
Motor nipper	Bahco 224	1
Screwdriver	Bahco 689	1
Screwdriver	Bahco 656	1
Screwdriver	Bahco 614	1
Screwdriver	Bahco 613	1
Screwdriver	Bahco 6221 L	1
Screwdriver	Bahco 656	1
Screwdriver	Bahco 560	1
Screwdriver	Bahco 567	1
Screwdriver	Bahco 611	1
Combination swivel spanner	301-½ in	1
Combination swivel spanner	301-9/16 in	1
Torque gauge indicator	Bahco 811	1
Socket turning handle	Bahco 704 A	1
Set 22 sockets		
10-34 mm	Bahco 3683/10	1
Chain wrench	212 C	1
Adjustable spanner	Bahco 669	1
Adjustable spanner	Bahco 675	1
Adjustable spanner	Bahco 672	1
Adjustable spanner	Bahco 670	1
Hex socket screw wrench set, metric	4323 0101	1
inch	4323 0200	1
Socket ½ in	1166 0602	1
Socket ½ in	1166 0701	1
Circlip pliers		
8-25 mm	0993 0207	1
8-25 mm	0993 0702	1
10-25 mm	0906 0204	1
10-25 mm	0996 0709	1
19-60 mm	0993 0306	1
19-60 mm	0993 0801	1
19-60 mm	0996 0303	1
19-80 mm	0996 0808	1
40-100 mm	0993 0900	1
40-100 mm	0996 0402	1
40-100 mm	0996 0907	1
85-165 mm	0993 0504	1



Description	Part No.	Qty
File	7039 0307	1
File	7044 0102	1
File	7044 0300	1
Hacksaw	8862 0105	1
Hacksawblade	5098 0200	10
Plastic hammer	1955 0409	1
Hammer faces	1955 1001	2
Ball hammer	Tor XK 14	1
Vernier caliper gauge	6237 0101	1
Measuring tape	7299 0104	1
Centre punch	1681 0301	1
Set of 6 punches	1672 0104	1
Flat chisel	1633 0300	1
Light tester screwdr	4244 0206	1
Polarity tester	7290 0202	1
Feeler gauge set	2595 0502	1
Knife	K No 1	1
Scraper	1663 0204	1
Double-ended swivel socket spanners		
8x9 mm	1065 0109	1
10x11 mm	1065 0208	1
12x13 mm	1065 0307	1
14x15 mm	1065 0604	1
16x17 mm	1065 0802	1
18x19 mm	1065 1008	1
20x22 mm	1065 1107	1
21x23 mm	1065 1206	1
24x27 mm	1065 1305	1

Description	Part No	Qty
Combination spanner	Bahco PU 6	1
Combination spanner	Bahco PU 7	1
Combination spanner	Bahco PU 8	1
Combination spanner	Bahco PU 9	1
Combination spanner	Bahco PU 10	1
Combination spanner	Bahco PU 11	1
Combination spanner	Bahco PU 12	1
Combination spanner	Bahco PU 13	1
Combination spanner	Bahco PU 14	1
Combination spanner	Bahco PU 15	1
Combination spanner	Bahco PU 16	1
Combination spanner	Bahco PU 17	1
Combination spanner	Bahco PU 18	1
Combination spanner	Bahco PU 19	1
Combination spanner	Bahco PU 20	1
Combination spanner	Bahco PU 21	1
Combination spanner	Bahco PU 22	1
Combination spanner	Bahco PU 23	1
Combination spanner	Bahco PU 24	1
Combination spanner	Bahco PU 25	1
Combination spanner	Bahco PU 26	1
Combination spanner	Bahco PU 27	1
Combination spanner	Bahco PU 28	1
Combination spanner	Bahco PU 29	1
Combination spanner	Bahco PU 30	1
Grease gun	3294 0207	1
Oil can	3328 0207	1
Pipe wrench	6637 0305	1

9819 3866 02 ACE Jun 87

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Stockholm

Atlas Copco Energy AB

TENDER PROFORMA INVOICE ACKNOWLEDGEMENT

Our date 1988-01-21 Our reference 510 SP 88/028

Your date Your reference

Consignee (Dispatch to)

Botswana

Customer

WASH OPERATION CENTRE
Att Mr Ralph Preble
1611 N Kent Street
Room 1002
ARLINGTON
Virginia 22209
USA

Prices & Conditions valid until April 30, 1988

Terms of delivery FOB Swedish port

Time of delivery 8-10 wekks

Terms of payment By confirmed irrevocable Letter of Credit opened in the name of Atlas Copco Energy AB, Stockholm, Sweden with Skandinaviska Enskilda Banken, Stockholm, Sweden and confirmed by this bank.

Item	Description	Part No / Product No	Quantity	Price each USD	Price total USD
1.	Applied Hydraulics I Trainee material	27140	10	135.-	1.350.-
2.	Applied Hydraulics I Course leader material	27141	1	240.-	240.-
3.	Applied Electricity Trainee material	27298	10	165.-	1.650.-
4.	Applied Electricity Course leader material	27299	1	285.-	
5.	Electric training panel type ETP 1, 220 V	8031 0218-38	5	760.-	3.800.-
6.	Applied Hydraulics II Trainee material	28100	10	135.-	1.350.-
7.	Applied Hydraulics II Course leader material	28101	1	380.-	380.-
	Total price				USD 9.055.-
	Export packing and FOB charges				USD 135.-
	Offered price FOB Swedish port				USD 9.190.-

ATLAS COPCO ENERGY AB
International Projects and Market Development

Jan Jönsson Sören Persson

0018 9886 21 ACE Dec 87 Printed in Sweden

All deliveries unless otherwise stated, in accordance with 'General Conditions for the supply of Plant and Machinery for export' prepared by the United Nations Economic Commission for Europe as adopted by Atlas Copco (Jan 1981)

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04/04

APPENDIX P

Drilling and Fishing Tools - Costs

-	FISHING TOOLS FOR RETRIEVAL OF BROKEN OR DISENGAGED TOOLS FROM A BOREHOLE - TOTAL ESTIMATE BY DWA	$10,000
-	AIR HAMMER REPLACEMENT	8,000
-	SHOCK SUB FOR ABOVE HAMMER	1,300
-	SUBS-DRILL PIPE CONNECTORS	700
-	AIR ROTARY BITS/HAMMER BITS	
	$2,000 EACH/8 INCH CARBIDE INSERT $1,000 EACH/8 INCH AIR HAMMER BITS	
	ALLOWANCE FOR BITS, BUTTON BIT GRINDER AND MISCELLANEOUS DRILLING TOOLS	20,000
	TOTAL ESTIMATE	$40,000

APPENDIX Q

Scope of Work and Budget - Technical Assistant MLGL

The Ministry of Local Government and Lands (MLGL) requires a technical assistant to provide field liaison between District Water Unit Technicians and the MLGL Water Engineer. This assistant should be capable of assisting District Water Unit Technicians with specific technical and administrative problems. It is important that he have an intimate knowledge of water pumping practices and government policies in Botswana. Recognition of the need for this post is acknowledged in the agreed minutes between the Government of Botswana and SIDA, 19 March, 1987. To date, logistical details have prevented recruitment.

It is clear that provision of a technical assistant is overdue, especially with the lengthening drought and the need for increased communication on technical matters (between drought stricken villages and the central planning bodies) relating to the consolidated emergency program.

The MLGL/Consultant's Scope of Work is as follows:

The consultant will work under the direction of MLGL's Water Engineer. He will also work closely with DWA's Drought Relief Program Coordinator, District Water Unit Technicians and the Inter-Ministerial Drought Committee (IMDC) performing technical knowledge, assistance and liaison functions briefly described, but not necessarily limited to, as follows:

1. Visit the 57 villages on the consolidated emergency list with the local Water Unit Technician.

2. Inspect the borehole, pumping equipment, reticulation system and tank and measure pumping rate, water level, pump rpm and determine if the pump is pumping air (as Mono pumps can). Other items such as tank conditions, tap leakage also should be noted.

3. Inspect pumper log books, if available, and interview the pumper and village leaders.

4. Suggest further emergency measures that the Water Unit Technicians should take to help alleviate immediate need. This may include trucking water repairing equipment or providing replacements of some system components.

5. Report findings to MLGL, DWA and the IMDC with recommendations for action and seriousness of immediate need in order to help prioritize relief efforts.

6. Be available to visit additional drought stricken villages as necessary to help maximize the effectiveness of the consolidated emergency program.

Time required - 26 weeks

Budget:

Salary		$20,000
Air Fare		1,900
Per Diems		14,400
	Subtotal	$36,300
12% Contingency		3,700
	TOTAL	$40,000

NOTE: Available candidates meeting the requirements of knowledge of water system practices and administrative procedures are known to the Water Engineer at MLGL.

APPENDIX R

GEOTEST (Pty) Ltd.
GEOTECHNICAL, GEOPHYSICAL AND
GROUNDWATER CONTRACTORS

P.O. Box 1502
Gaborone
Republic of Botswana
Telephone 2481/2

ESTIMATES DRILLED WELLS - NWDC

28th January, 1987

Quotation - Borehole Drilling, Ngamiland

1. Six sites have been indicated. 3 are assumed near Maun (Samedupe, Dobe, Magopa), 2 in the Sepopa area (Tsodilo, Tamacha) and 1 has not been located (Chikamucho). The sites near Maun should not present access problems but the others could well be difficult to reach. Our quotation is based, therefore, on the assumption that NW District Council can assure us that access for heavy drilling equipment is possible.

2. Costing Structure

(a)	Mobilisation / demobilisation	
	Gaborone - Maun x 2	P21,000
(b)	Moving to sites tar road	P7/km
	gravel road	P12/km
	sand road	P20/km
(c)	Rig Establishment per site	P450
(d)	Drilling (6½ inch)	P55/m
(e)	Casing (6½ inch)	P46.50/m
	(5. inch)	P37/m (if required)
(f)	Borehole Flushing/Development	P150/hr

3. Quotation

Per Hole exclusive of mobilisation/demobilisation and movement between sites. Assume 40m total depth cased 6½ inch only bedrock (say 15m), plus 2 hours flushing.

Per Hole P3647.50

John L. Farr
Technical Director

APPENDIX S

Scope of Work - Well Drilling Consultant, Department of Water Affairs

The Department of Water Affairs (DWA) in the Ministry of Mineral Resources and Water Affairs (MMRWA) requires an assistant to provide general managerial advice and assistance to the new (November-1987) Director. The area in which such assistance is needed is in contractual relations, well drilling program planning, and general well drilling operations. Fortunately, the new Director is a hydrogeologist who achieved an excellent reputation in his prior position with the Department of Geological Survey and is familiar with the technical aspects related to groundwater occurrence and development.

The position is seen as a temporary assignment, of some five months duration, to provide advice and assistance necessary to achieve a successful start to a six year drought-induced emergency well drilling program. The number of new and replacement wells currently included in the two-year emergency program would require that of all of DWA's drill rigs and all of those of the three major private well contractors be in good condition and fully employed on the program. Unfortunately, not all of the equipment is in good condition. However, the USAID Office of Foreign Disaster Assistance is funding the major overhaul of four of DWA's rigs to assist in the start-up of the emergency program.

The DWA/Consultant's Scope of Work is as follows:

The consultant will work under the direction of the Director of the DWA. He will also need to develop an operating relationship (cooperative partnership) with DWA's Drilling Supervisor, Hydrogeologist's (siting and other functions), Training Officer, Rig Mechanics, and the MLGL's Water Engineer. The consultant's activities would include, but not necessarily be limited to, the following:

1. Coordinate with USAID Mission/Botswana and DWA on the major overhaul of four DWA rotary drill rigs (to be funded by AID) and a limited replacement of tools necessary for efficient operation of the equipment.

2. Maintain liaison with USAID Mission/Botswana in reporting on status of AID-funded drought assistance.

3. It needs to be remembered that the consultant's assistance is of short duration and that his assistance should be predominantly in identifying need and providing advice and assistance to DWA's permanent personnel that will improve efficiency and production. He should resist the temptation to "do it himself;" however, in certain instances (including Items 1 and 2 above) this will be

appropriate and necessary. In addition to the responsibilities identified above, his involvement is expected in the following areas:

- In cooperation with DWA Drought Relief Coordinator, other DWA personnel, and MLGL's Water Engineer, to develop and modify drilling operation planning so as to be responsive to drought water supply priorities with a minimal disruption to overall efficiency of operation.

- Provide oversight of contractual requirements related to the employment of private well drilling contractors and consulting firms who undertake well siting teams and geophysical work. Such oversight is anticipated to involve advice and direction related to the coordination and cooperation necessary between the DWA Finance Officer, Drilling Superintendent, Hydrogeologists, and other DWA personnel and carried out in compliance with predetermined emergency procedures under special agreements with the Ministry of Finance.

- Provide practical procedures for reporting, filing, and summarizing operations to provide historical perspective and accountability to drilling operations and drill rig maintenance. For example, maintenance records which are kept by handwritten note in a notebook should be on standardized forms geared to periodic maintenance procedures, with special forms for extraordinary repairs/replacements, and detailing cause in monthly/yearly summaries to direct future needs for spare parts inventories. Also, drillers' logs should be standardized and reviewed so this information (production, tool needs, bit wear, compliance with field maintenance, etc.) is available for future planning.