Angola Country Report

1 INTRODUCTION

Angola lies on the western coast of Africa and includes a small enclave on the coast, Cabinda, approximately 40 kilometres north of the main territory. The total area of the country is 1,246,700 km^2. The Democratic Republic of Congo to the north, Zambia to the east and Namibia to the south surround it. Additionally, Cabinda borders the Republic of Congo to the north. The country was visited for the present project during the week of 10-15 June 2002.

2 BACKGROUND

2.1 PHYSIOGRAPHY AND CLIMATE

The topography is primarily moderate with a low coastal plain extending inland between 50 to 200 km. This is followed by a variably mountainous ridge running roughly parallel to the coast from north to south. This chain contains the highest elevation in Angola, in Huambo Province at Moco, with an elevation of 2,620 m. East of this ridge the remainder of the country consists of a plateau with gentle topography and elevations between 1000 to 2000m. The majority of the country receives good rainfall of > 1000 mm, concentrated between September and May. The coastal region and the south-east receive considerably less rainfall, generally < 600 mm. The extreme south-west of Namibe Province is a true desert with little to no rainfall.

2.2 WATER RESOURCES

Angola is endowed with substantial surface water resources, with all the major rivers (apart from the Zaire and Chiluango of Cabinda) originating within the country. The majority of rivers rise in the mountainous coastal ridge, with those flowing into the Atlantic being relatively short and those flowing east and north forming longer systems (Cubango and Cuando). Groundwater is utilised for several urban centres on the coast and in the arid southern provinces and is a major source for rural supply. Additionally, small groundwater based systems have recently been developed to assist in the water supply shortfall in growing peri-urban areas. The overall potential of both surface and groundwater is largely untapped, primarily due to long-term instability in the country.

2.3 OVERALL INSTITUTIONAL FRAMEWORK OF WATER SECTOR

The country's first water law is expected to be passed soon and redefines the institutional structure for the water sector. The present organisation is divided between several ministries making effective co-ordination and management difficult. Until recently groundwater was considered to be a mineral resource (controlled by the Ministry of Geology and Mines) However, within the present setup, it is in the process of being transferred (controlled) to the Ministry of Energy and Water. Additionally, some provinces have autonomous water companies (at Provincial Directorate for Energy and Water), set up in 1987, which have direct responsibility in water supply at the regional level, but suffer considerably from lack of trained personnel and sufficient financial support. Their relationship to DNA is not yet clearly defined.

In general, DNA is mandated with provision of rural and urban water supply, which is divided into three departments: Hydraulic, Development and Water Resources Management. In a broad sense, DNA's main activity is the operation and maintenance of existing water supply

systems. Although UNICEF has provided some drilling equipment to DNA's groundwater unit (NAS), the majority of groundwater development is carried out by HYDROMINA, a division of the National Geological Institute (INAGEO) and other private companies. HYDROMINA was created as a state owned groundwater development company after independence following an existing colonial institution of the same name. It has been involved in groundwater assessment as well as development, although it is now mostly involved in drilling operations. Presently, the hydrogeology division of INAGEO carries out most groundwater assessments and siting programs. In terms of the organisational structure, the specific segment of INAGEO involved in groundwater development is the Department of Applied Geology, which has three divisions: Hydrogeology, Engineering Geology and Environmental Geology. The arrangement to be adopted soon will transfer Hidromina to the Ministry of Energy and Water. Thus, all activities related to groundwater exploration and exploitation will be within the same umbrella, for both surface and groundwater.

No practical legal structures related to groundwater development exist, although provisions for this have been made under the 1992 mining law. Based on these provisions, draft regulations have been submitted by the Hydrogeology Division whereby permission will have to be obtained for any groundwater developments and compulsory submission of pertinent hydrogeologic data on completion of the project. This regulation will have to be revised in view of the recent shifts in responsibility, particularly the fact that groundwater in general for drinking is no longer considered a mineral resource, apart from thermal springs and mineral waters.

2.4 ROLE OF GROUNDWATER IN WATER SECTOR

Although the majority of urban centres are supplied from surface water sources, the provincial capitals of Malange, Benguela, Lubango and Namibe, as well as the urban centres of Tobwa and Lobito (with surface water), rely on groundwater. In general, groundwater use is concentrated in the southern and coastal portions of the country where conditions are more arid and surface water less available. Additionally, groundwater is being increasingly developed for local systems to augment urban supply in the rapidly growing peri-urban areas, particularly Luanda. An estimated 1 million people in Luanda are not covered by the existing network, but are supplied through private tanker trucks, which fill from the Bengo River and sell the largely untreated water. The level of water service in urban areas is estimated to be 60% (down from 85% in 1980).

Rural areas with developed water supply systems rely on boreholes, wells (with and without handpumps), spring catchments and occasionally surface sources. In areas where existing water supply systems are no longer working or have not been developed, surface water is most often relied on. Present rural coverage is estimated to be 20% (up from 10% in 1981). UNICEF, in co-operation with the National Directorate For Water (DNA), has been primarily responsible for funding and logistical support for rural water supply development since 1978. Various NGOs are also active in rural water supply as part of localised projects.

Another major use of groundwater is for livestock in the southern provinces. Water supply for livestock watering is co-ordinated by the Ministry of Agriculture. It is estimated that cattle number of the order of 3 million in these areas. Water is supplied through boreholes and wells equipped with either manual or powered submersible pumps. In a 1973 survey there were 943 boreholes and 319 wells for such systems. The present number is not available, but based on recent figures available from Cunene Province, where 125 out of 607 systems are functioning, the current number of operable systems is likely less than the 1973 figure. Additionally, individual farmers and ranchers also commonly construct boreholes and wells in these areas

privately. Due to the favourable conditions for livestock rearing in the south, demand for further groundwater development will probably be considerable.

Only limited research has been conducted concerning groundwater and no national resource estimates have been completed. However, based on the presently identified potential and the limited level of existing development, it is safe to assume that only a very small portion of the national groundwater resources are being used.

In terms of surface water, the level of availability is expected to become stressed (<1,700 m^3/hab/yr) from its present surplus level by the year 2025 (SADC-EU, 1990).

3 GEOLOGICAL AND HYDROGEOLOGICAL FRAMEWORK

3.1 GEOLOGY AND HYDROGEOLOGY

Angola can broadly be divided into three main hydrogeologic regions: an eastern, highland and coastal belt. Data density for much of the country is quite low, however, resulting in considerable uncertainty in terms of hydrogeologic conditions especially the eastern areas.

The eastern region covers approximately two thirds of the country and extends from the eastern border to the mountainous coastal ridge. It is underlain by Tertiary to Recent continental deposits of the Kalahari Beds with smaller areas of Carboniferous and Jurassic age Karoo Supergroup units mostly in the northwest. A small section of Precambrian units is also present in the far eastern border. Topography is moderate and rainfall is considerably higher in the northern regions than toward the south. This results in a generally increasing depth to water table from north to south, with some areas in the south having completely dry Kalahari Beds. Yields are commonly low to moderate (1 - >5 l/s) and success probability decreases considerably from the wetter north to the drier south. The bulk of development in this zone is in the south-eastern section.

The highland region is underlain predominately by Precambrian granites as well as ultrabasic rocks, with lesser sedimentary units in the northwest. Rainfall is highest in this region, aside from the extreme south, primarily due to the higher elevations present in this region. Yields are generally low, mostly <5 l/s, but, locally yields can be high (up to 50 l/s).

The coastal belt is underlain primarily by sedimentary deposits, ranging from Carboniferous to Recent ages. In general the most consistently productive aquifers are present in this zone, although water of high mineralisation is more common, generally associated with salt bearing formations.

3.2 NATURAL GROUNDWATER QUALITY

Groundwater quality is mostly acceptable although chemical analysis is not conducted regularly, especially in rural areas. As mentioned above, some of the coastal sedimentary formations have a high degree of mineralisation due to lithologic characteristics. Although not presently monitored or evaluated, there has been a reported decline in water quality in the coastal portion of Namibe Province, most likely related to salt water intrusion. Other urban and rural water supply schemes using groundwater in the coastal belt have no reported salt-water intrusion presently.

4 DATA ACQUISITION

4.1 INSTITUTIONAL FRAMEWORK FOR DATA COLLECTION

The institutions and personnel contacted as part of this project are summarised in Table 1.

Table 1. Institutions and Personnel Contacted in Lesotho

COMPONENT	INSTITUTION	PERSONNEL
General GW Information Monitoring Data (GW) Hydrogeological Mapping	DNA Water Supply Department	Mr. Pedro Silva Mr. Quaresma Ms. Elsa Ramos
General SW Information	DNA Water Resources Department	Mr. Paulo Emílio
Monitoring Data (SW)	DNA Hydrology Division	Mr. Paulo Emílio Mrs. Luzia Conceição
General GW Information Monitoring Data and investment (GW)	UNICEF	Mr. Maciel Freitas
Monitoring Data (rainfall)	Meteorological Services INAMET	Mr. (Director Inamet)
Mapping: topographic, infrastructure, boundaries	Land Surveys and Physical Planning (IGCA) Instituto de Geodesia e Cartografia de Angola)	Mr. Jose Manuel
Monitoring Data (Water Supply) Luanda only	EPAL	Ms. Lourdes Tito
General Geological Information updating of Maps Including GW information	Instituto Geológico de Angola	Dr. Cassange Dr Elmar Paniev (IGEO Consultant)

GW: groundwater
SW: surface water

There is no formal institution responsible for data collection related to groundwater. However, DNA carryout annual field surveys of the operational status of water supply systems, including boreholes and hand dug wells, to assess the level of water supply coverage. This information is used to produce an annual report indicating the situation in each province.

During these field campaigns, data collected includes location of borehole or hand dugwell, number of beneficiaries, depth of the borehole, static water level, type and mark of pump, name of responsible person and maintenance record over the year. This information is used to compile an annual report summarising total number of existing point sources by province, inventoried sources and provides an operational status of evaluated sources.

Another institution collecting data related to groundwater is Hidromina. Hidromina maintains a digital database in Geodin.2 with information related to boreholes drilled by the company. This database contains basic information generated during drilling and contained in technical reports.

There has been no surface water hydrometric monitoring since the 1970's. In 2002 DNA resumed the production of an annual bulletin using data from 1970 and is planning to start recovering the destroyed hydrometric monitoring network.

5 GROUNDWATER INFORMATION SYSTEMS

5.1 HARDWARE AND SOFTWARE

5.1.1 National Directorate for Water

Since 1996 DNA have carried out an annual inventory of water supply sources and produces annual reports about operational status of these water points. Information collected in the field is kept in paper form in the DNA archive for future use (**Table 2**). As mentioned above, the hydrogeologic data collected during these inventories is only borehole location, depth and water level. The bulk of information is only related to operational status of boreholes.

Table 2. Summary of DNA Information Systems

Database / Source	In use	No. of records	Format	Useable[1]	Comments
DAS – Annual inventory report	yes	3618	paper	no	They don't have any data base. Well records are compiled in table as summary information.

[1] Easily useable for the regional hydrogeologic map

5.1.2 HIDROMINA

Data from over 3,000 boreholes is presently maintained in paper files at the HYDROMINA office in Lubango. These data have also been entered into Geodin.2 database package (**Table 3**).

The majority of borehole records are from HYDROMINA activities, with very little information from other groundwater development projects. As mentioned previously, the lack of data access from other agencies and organisations involved in groundwater development is expected to be addressed in the new regulations and reinforced through planned departments like the one at DNA for Licensing and Monitoring.

Table 3. Summary of DNA Information Systems

Database / Source	In use	No. of records	Format	Useable[1]	Comments
INAGEO - Hidromina	yes	> 2500	Digital (Geodin2.0)/ paper	yes	Information about maintenance is not available

[1] Easily useable for the regional hydrogeologic map

5.2 DATA SAVED

5.2.1 DNA

Currently DNA only stores general information related to operational status of borehole and other water sources in paper format. Their reports contain very limited hydrogeological data and therefore are of minimal use in terms of a regional map. The depth to groundwater data, dyanamic water level (estimate of specific yield) and location of boreholes would be the main data of interest for the regional map. As discussed in Section 5.2.2, unlike the Hydromina database, the data covers almost all of the country. DNA maintains a surface water database in Hydata software with information generated from various gauging stations up to the 70's after which monitoring ceased.

DNA Database

DNA maintains a database related to surface water with information generated up to the early 70's.

Hidromina Database

Hidromina maintains the only groundwater database in the country. However, since this company is located in the Southern part of the country no visit was possible due to difficult communication. Hidromina reports to INAGEO in Luanda and INAGEO was therefore visited and a broad idea of its database operational status was obtained. In general, Hidromina is well equipped with software and trained geologists and engineers are operating on site.

Hidromina is running a hydrogeological database on Geodin.2 software (the same as that being implemented by the Geological Survey in Botswana), with data generated on its own operation campaigns. No Data from other private companies is not transferred to this database. The data covers mostly the south-western arid to semi-arid part of the country with scarce surface water resources.

Monitoring Database

DNA carried out monitoring annually regarding the operational situation of existing water points sources, boreholes, hand dug wells, public stand post in urban water supply schemes sanitary facilities. This information is used for the annual report and is used in the strategic planning of activities at DNA.

Hardware and Software

Hidromina uses Geodin.2 software on personal computers and DNA produces its reports in Word.

5.2.2 DNA

Groundwater information

DNA collect annual information related to point sources for water supply. The information is collected using a questionnaire or protocol with fields indicated in the table below.

Table 4. Summary of Data Fields: DNA monitoring questionnaire

Field	Units
Village Reference No.	
Name	
Borehole No.	
Coordinates	
Date Drilled	
Depth	
Static water level	
Dynamic water level	Metres
Handpump type and serial number	
Installation Depth	Metres
manufacture year	
Periodically monitored data (year monitoring)	
Date	
Depth	Metres
Static water level	Metres
Dynamic water level	Metres
Pumping rate	l/h
Operational situation	

Table 5. Distribution of DNA Borehole Monitoring Data by Province (2001)

Province	Number of Boreholes	Number of dug wells (cacimbas)
Bengo	34	61
Benguela	59	23
Bié	34	101
Cabinda	18	123
Cunene	579	132
Huambo	30	275
Huila	675	139
K. Kubango	-	18
K. Sul	0	70
K. Sul	26	-
Luanda	18	-
Lunda Sul	2	0
Lunda Norte	0	0
Moxico	0	0
Malange	575	13
Namibe	582	21
Uige	0	0
Zaire	0	0
Total	2632	986

Hardware and Software

Information is stored in paper and summary reports are produced in Word.

5.2.3 Other databases

Hidromina stores information from its field campaigns in digital format using the Geodin.2 software. More than 3 000 records exist in this database following the format proposed by the UN. The fields in the database area summarized in the tables below.

Table 6. Summary of Data Fields: Hidromina database

Field	Units
Village Reference No.	
Name	
Borehole No.	
Coordinates	
Date Drilled	
Depth	
Dynamic Water Level	Metres
Yield (not indicate weather is blow yield or well yield)	
Chemical data	
Lithological information	
Geophysical data (not mentioned)	
No monitored data	

Table 7. Distribution of Hidromina Borehole Data by Province

Province	Number of Boreholes
Cunene	1020
Huila	1055
Namibe	471
Total	**2546**

The table shows the concentration of information in the south-eastern part of the country.

Hardware and Software

Information is stored under Geodin.2 software in personal computer

5.3 QUALITY OF DATA

5.3.1 DNA

Quality of data is variable depending upon the level of staff involved in surveys. There are some reported problems with data collected by staff used in inventory activities. However, for the objectives of the survey it is considered acceptable. Periodically DNA sends its own senior staff for field supervision and compares the information generated in the provinces as a form of quality control. Specific training of personnel for the future data collection for the database is proposed.

5.3.2 Hydromina

Hidromina have very experienced geologists on staff as well as drilling personnel trained by various partners such as the Russians and Italians who played a major role in training the personnel presently active in the division. No specific QA/QC procedure is followed in terms of data collection or data entry in the GEODIN database.

5.4 RESOURCES AVAILABLE FOR MAINTENANCE

Activities carried out by DNA, related to data collection for annual reports receive funds from UNICEF. There are competent personnel at DNA for supervision but there is a lack of an adequate Information System to store information and trained personnel for field work.

6 GROUNDWATER MONITORING

Besides the operational monitoring and coverage assessment there is no monitoring network of groundwater of any sort. DNA collect information related to the sanitary and water supply situation in each province for planning purposes.

6.1 MONITORING NETWORK AND FREQUENCY

6.1.1 National Directorate for Water

Table 8. Summary of DNA Monitoring

Type and number of monitored points	Measured Parameters	Frequency	Comments
2632 Boreholes 982 Wells	Water levels, Yield, operational status, depth, dynamic water level	Annual	Data maintained in paper format

This information is used for determination of the water supply situation in each province and designing of intervention plans for improvement.

6.2 QUALITY OF MONITORING DATA AND QA/QC

No QA/QC procedures are presently implemented, although senior staff periodically accompany field personnel during data collection to improve data quality.

7 HYDROGEOLOGICAL MAPPING

7.1 EXISTING HYDROGEOLOGICAL MAP

No comprehensive hydrogeologic map is available for the country. A preliminary hydrogeologic map at a scale of 1:1 500 000 was completed as part of the SADC hydrologic assessment programme of 1990. This map is based on data from only a small number of boreholes, located almost completely in the southwest and west of the country. Aquifers are divided into three main groups based on the type of groundwater occurrence and seven sub-divisions based on development potential.

7.2 DERIVATIVE MAPS

Two derivative maps are presented on the main map showing rainfall (mean annual) and data coverage. From these maps it is clear that a huge extrapolation of information, based on geological similarities, had to be carried out to produce a national map since data are only available in the south-western part of the country, which covers < 25% of the territory. Both maps are at 1: 20 000 000.

7.3 CLASSIFICATION AND LEGEND OF MAPS

The Map and its legend reflects the bad situation regarding availability of data to produce a National Map. However the legend does include the following items with respective descriptive text:

1. Exploitable yield (in existing boreholes).
2. Aquifer lithologies.
3. Groundwater hydrochemical characteristics (limited to the southwest part of the country).
4. Surface water features (location of rivers and lakes)

The groundwater development pattern is shown as filled polygons in light colours with symbols (points and lines) and hatch patterns signifying different aspects. The details are tabulated in Table 9.

Table 9. Hydrogeological Map Legend Summary

LEGEND	DETAILS OF LEGEND
Aquifers Aquifer extent defined by geology.	a) porous generally unconsolidated formations b) fissured and/or jointed rock c) with limited potential or not significant groundwater occurrence lithology indicated by hatch pattern within hydrogeologic units; colour gives general potential and hydraulic characteristics of each unit
Surface Water	• Rivers • Lakes • Swamp areas • Areas with high risk of inundation
Borehole Yield "Exploitable yield" (not specifically defined on map)	Yield range indicated by size of symbol: large circle >5, small sized circle 1<Q<5 l/s, small sized circle with fill Q< 1l/s
Borehole Details Indicated for selected boreholes	Underneath the circle the depth of borehole is indicated
Captured Spring	
Other Symbols	• Areas with deep aquifers more productive containing mineralized water, dashed line indicating boundary • Areas with high productivity in deep aquifers containing mineralized water, dashes • Fault; thick black solid • Bedrock topography, solid black contour line
Topographic symbols	Topographic symbols include: • International boundaries; • Topographic contours (1000 m interval) • Main towns, villages • Main roads, track, minor track • Railway • Powerline

7.4 EXISTING GEOLOGICAL MAPS

Geological maps of the country are produced by the National Geological Institute (INAGEO). All the maps are available in printed form. The national map dates from 1982 and has never been updated. There are other maps at different scales that cover only small parts of the country. A summary of the geologic mapping is presented in Table 10.

Table 10 Summary of Available Geologic Maps

Map	Scale	Number of maps
National Geologic Map	1: 1 000 000	1 Produced in 1982
Geological maps	1: 250 000	12 sheets produced before independence + 4 sheets in 1997; 2002 (in process) 1 sheet and another scheduled for next year. Only a small pat of the country is covered
Geologic maps	1: 100 000	Before independence 29 sheets, there are other 7 non published sheets.
Other Maps produced by INAGEO		
Methalonogenic	1: 1000000	1
Cosmogeodinymic	1: 2000000	1
Geomorphologic	1: 2000000	1
Mineral Resources	1: 1000 000	1

There are no digital formats for these maps available of any sort. However it was mentioned that the printing editor (agent) may have some digital form in Portugal (Laboratório Nacional de Investigação Científica Tropical de Lisboa for 1: 1.000.000 map).

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7.5 EXISTING TOPOGRAPHIC MAPPING

The Institute of Geodesy and Cadastre of Angola (IGCA) maintains and sells national and local topographic maps. The national map is at 1: 1,000,000. All maps are outdated and there are no digital formats available. However, it is possible that a Russian company which prints the maps maintains these maps in digital format. It should be mentioned however, that maps at larger scale only cover the western part of the country. A summary of topographic maps is given below.

Table 11 Summary of Available Topographic Maps

Map	Scale	Number of maps
National Map	1: 1 000 000	1
Topographic Map	1: 500 000	22 sheets
Topographic maps	1: 250 000	120 sheets.
Topographic maps	1: 100 000	472 sheets
Topographic maps	1: 50 000	Few available - they cover a small part of the country

8 DATA AVAILABLE FOR A SADC HYDROGEOLOGICAL MAP

Based on the existing data sets and mapping, Table 12 summarises the data available for specific legend items that may be desirable to portray on a regional hydrogeologic map.

Table 12 Hydrogeological Map Legend Summary

LEGEND	SOURCE DATA	PROCESSED DATA	NOT AVAILABLE
Aquifers Aquifer type and extent based on geology		National geology map sheet	
Springs	Spring locations, discharges, EC in INAGEO data in reports		
Surface Water	Raw flow data available (hydata format) with DNA		
Meteorological Stations	Locations and rainfall data with INAMET in printed format		
Borehole Yield	National data with DNA for (exploited yield) and dynamic water level (printed) and with Hydrominas for 3 provinces (digital)		
Borehole Details	Borehole depth in DNA database (printed); Borehole depth, construction details for 3 provinces in Hydromina database (digital)		
Water Level	Nationwide data - DNA (paper); Data for 3 provinces (digital) - Hydromina		
Water Quality	EC for boreholes and wells nationwide (paper) with DNA; chemistry analyses for 3 provinces (digital) with Hydromina		
Well Point Pumping Station	Abstraction rates and locations in 3000 borehole (paper) at DNA		
Other Symbols		Major infrastructure, towns, boundaries available with IGCA (printed).	
Topography		Topographic maps only in paper, plastic print format at present with IGCA.	

Data at DNA might be the same stored at Hidromina since DNA carry out an inventory for all boreholes including these drilled by Hidromina.

9 COMMITMENTS AND CONCERNS

9.1 COMMITMENTS ON CONTRIBUTION TO THE REGIONAL MAPPING PROJECT

9.1.1 INAGEO

Manpower in the Division of Hydrogeology at INAGEO is very limited, but some assistance in accessing and compiling data could be provided.

Staff from the GIS section at INAGEO need training before embarking to any specific project. They have the basic equipment and software but little knowledge in operation.

9.1.2 National Directorate for Water Affairs

DNA has only 1 hydrogeologist but expressed interest in participating in the project. With recently approved restructuring of the water sector, Hidromina will soon come under the responsibility of DNA and therefore DNA's capacity will increase to deal with this project as part of transference of trained staff currently at Hidromina.

9.2 CONCERNS

Member staff at various departments expressed their interest in having a good national map first before embarking on a regional map. However, they agreed that this might be carried out simultaneously with a national map forming part of preliminary work.