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SUPPORT TO PHASE 2 OF THE ORASECOM BASIN-WIDE
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
Work Package 2:
Extension and Expansion of the Hydrology of the Orange-Senqu Basin

Improvements of Gauging Network and Review of Existing Data Acquisition Systems

February 2011

ORASECOM

The *Support to Phase 2 of the ORASECOM Basin-wide Integrated Water Resources Management Plan* Study was commissioned by the Secretariat of the Orange-Senqu River Basin Commission (ORASECOM) with technical and financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ) in delegated cooperation with the UK Department for International Development (DFID) and the Australian Agency for International Development (AusAID). The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) implemented the study.

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in association with

SUPPORT TO PHASE 2 OF THE ORASECOM BASIN-WIDE INTEGRATED WATER RESOURCES MANAGEMENT PLAN

Work Package 2:

Extension and Expansion of Hydrology of the Orange-Senqu Basin

Improvements of Gauging Network and Review of Existing Data Acquisition Systems

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APPROVALS

For the Consultants: ______________________________

RS MCKENZIE
Managing Director: WRP Consulting Engineers

For ORASECOM: ______________________________

L THAMAE
Executive Secretary: ORASECOM Secretariat

Study Name	**Support to Phase 2 of the ORASECOM Basin-wide Integrated Water resources Management Plan**
Report Title:	***Improvements to Gauging Network and Review of Existing Data Acquisition Systems***
Submitted by:	WRP Consulting Engineers in association with Golder Associates, DMM, PIK, RAMBOLL and WCE

REPORTS, WPS AND OTHER DELIVERABLES SUBMITTED	**TYPE**	**No.**
Overall Study		
Inception Report	Report	004/2010
Overall Project Executive Summary	Report	013/2011
Work Package 1: WATER RESOURCES MODELLING OF THE ORANGE-SENQU BASIN		
Strengths and Weaknesses of Existing Models	WP	005/2010
Setting up and Testing of the Final Extended and Expanded Models; Changes in Catchment Yields and Review of Water Balance	Report & WP	001/2011
Modelling software and datasets	Software	None
Capacity Building and Setting up the Models in each Country; Process of Continuous Review	WP	003/2011
Work Package 2: EXTENSION AND EXPANSION OF HYDROLOGY OF ORANGE-SENQU BASIN		
Improvements to Gauging Network and Review of Existing Data Acquisition Systems	WP	005/2011
Extension of Hydrological Records	***Report***	***006/2011***
Hydrological Database o	Database	None
Work Package 3: INTEGRATED WATER RESOURCES QUALITY MANAGEMENT PLAN		
Development of Water Quality Monitoring programme and Data Management Framework	Report	007/2011
Development of Specifications for the Water Quality Model	WP	006/2010
Work Package 4: CLIMATE CHANGE IN THE ORANGE-SENQU RIVER BASIN		
Downscaling Methodology and Ongoing Climate Modelling Initiatives	WP	007/2010
GCC Downscaling for the Orange-Senqu River Basin	Report	008/2011
Projection of impacts and Guidelines on Climate Change Adaptation Strategies	WP	009/2011
Work Package 5: ASSESSMENT OF ENVIORNMENTAL FLOW REQUIREMENTS		
Literature survey and Gap Analysis	WP	008/2010
Delineation of Management Resource Units	WP	009/2010
Desktop Eco Classification Assessment	Report	016/2010
Goods and Services Report	WP	010/2010
Environmental Flow Requirements	Report	010/2011
Work Package 6: WATER CONSERVATION AND WATER DEMAND IN THE IRRIGATION SECTOR		
The Promotion of WC WDM in the Irrigation Sector	Report	011/2011
Irrigation GIS Database, Interactive Database and Irrigation Scenario Tools	WP	012/2011
Irrigation GIS Database and Interactive Classification Tool	Software	None
Irrigation Scenario Generation Tool	Software	None

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1 INTRODUCTION

1.1 General Context

The Orange-Senqu River originates in the highlands of Lesotho, some 3 300m above mean sea level, and it runs for over 2 300km to its mouth on the Atlantic Ocean. The river system is one of the largest river basins in southern Africa with a total catchment area of more than 850,000km^2 and includes the whole of Lesotho as well as portions of Botswana, Namibia and South Africa. The natural mean annual runoff at the mouth is estimated to be in the order of 11 500 Mm^3, but this has been significantly reduced by extensive water utilization for domestic, industrial and agricultural purposes to such an extent that the current flow reaching the river mouth is now in the order of half the natural flow. The basin is shown in **Figure 1-1.** The Orange-Senqu system is regulated by more than thirty-one major dams and is a highly complex and integrated water resource system with numerous large inter and intra basin transfers.

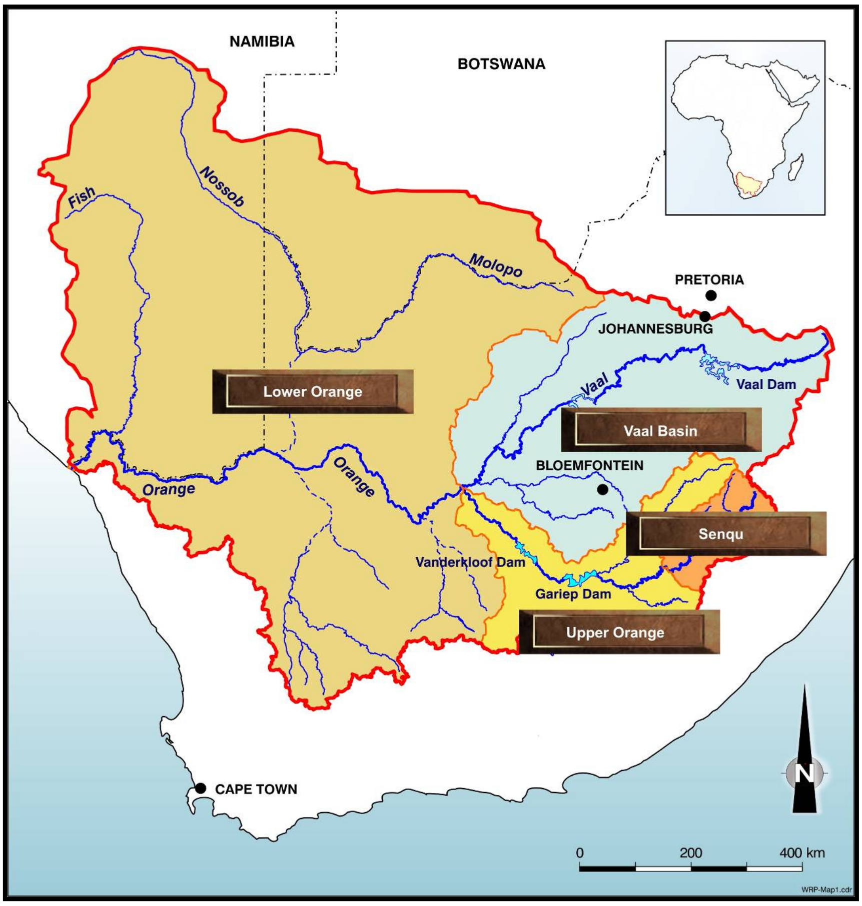


Figure 1-1: Orange – Senqu River Basin

1.2 Management and Environmental Context

1.2.1 General

Management issues, including environmental protection, conservation and sustainable development have to deal with problems relating to both water quantity and quality, potential conflicts between users, pollution sources from industry, mining, agriculture, watershed management practices and the need to protect ecologically fragile areas. The riparian countries have, for some time, recognized that a basin-wide integrated approach has to be applied in order to find sustainable solutions to these problems and that this approach must be anchored through strong political will. The development of this strong political will is one of the key initiatives of SADC, in particular the Revised Protocol on Shared Watercourses and the establishment of the Orange-Senqu River Basin Commission (ORASECOM). These initiatives are intended to facilitate the implementation of the complicated principles of equitable and beneficial uses of a shared watercourse system. It is accepted by all countries that the management of water resources should be carried out on a basin-wide scale, with the full participation of all affected parties within the river basin.

Water supply, in terms both of quantity and quality, for basic human needs, is being outstripped by the demands within and outside of the basin. Meeting the water supply needs of rapidly growing towns and cities, at the same time as having sufficient water of an acceptable quality, to meet existing and proposed irrigation and other demands (including environmental) further downstream, is a challenge for planners, decision makers and stakeholders in the Orange-Senqu river basin.

1.2.2 ORASECOM

Southern Africa has fifteen transboundary watercourse systems including the Orange–Senqu system. The Southern African Development Community (SADC) has adopted the principle of basin–wide management of the water resources for sustainable and integrated water resources development. In this regard, the region recognizes the United Nations Convention on the Law of Non-navigational Uses of International Watercourses, and has adopted the *“Revised Protocol on Shared Watercourse Systems in the SADC Region”*. Under this Revised Protocol, a further positive step has been the initiatives towards the establishment of river basin commissions in order to enhance the objectives of integrated water resources development and management in the region, while also strengthening the bilateral and multilateral arrangements that have been in existence for some time. The Orange–Senqu River Basin Commission (ORASECOM), which was established on 3 November 2000, in Windhoek, Namibia, is a legal entity in its own right.

The highest body of the ORASECOM is the Council, consisting of three permanent members, including one leader for each delegation from the four riparian states. Support from advisors and ad hoc working groups can be established by the council. The main task of the Council is to *“serve as technical advisor to the Parties on matters relating to the development, utilization and conservation of the water resources in the River System”*, but the council can also perform other functions pertaining to the development and utilization of water resources as agreed by the various parties.

1.3 Context of the Study and this Report

1.3.1 GIZ Support to SADC and ORASECOM

The overall goal of the GIZ-supported ‘Transboundary Water Management in SADC’ programme is to strengthen the human, institutional, and organisational capacities for sustainable management of shared water resources in accordance with SADC’s Regional Strategic Action Plan (RSAP). The programme, which GIZ implements on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), and in delegated cooperation with the UK Department for International Development (DFID) and the Australian Agency for International Development (AusAID), consists of the following components:

- Capacity development of the SADC Water Division;
- Capacity development of the river basin organisations (RBO); and
- Capacity development of local water governance and transboundary infrastructure.

The activities of this Consultancy: *"Support to Phase II of the ORASECOM Basin-wide Integrated Water Resources Management Plan"*, being undertaken by WRP (Pty) Ltd and Associates, contributes to Component 2 above. The work of Phase 2 comprises six work packages, as briefly outlined in Section 0 below

1.3.2 Support to Phase 2 of the ORASECOM Basin-wide Integrated Water Resources Management Plan

Objectives of the Overall Consultancy

The main objectives of this consultancy are to enlarge and improve the existing models for the Orange-Senqu Basin, so that they incorporate all of the essential components in the four Basin States and are accepted by each Basin State. These models must be capable of being used to meet the current and likely future information needs of ORASECOM. These needs will likely encompass additional options to achieve water security in each Basin State – including changing configurations for water supply and storage infrastructure - and ensure that ORASECOM is able to demonstrate that its operations are aligned with the principles embodied in the SADC Water Protocol.

The Six Work Packages

In order to contribute to the realisation of the above-mentioned objectives, the project includes six work packages as outlined in **Table 1-1.** The first of these work packages is central to Phase 2 of the IWRM Plan and will also be at the core of the final plan to be developed in Phase 3. In work package 1 the WRYM water resources simulation model is being updated and expanded to cover the entire basin.

Table 1-1 Summary of Work Package Objectives and Main Activities

Work Package	Main Objectives	Main Activities
WP 1: Development of Integrated Orange-Senqu River Basin Model	To enlarge and improve existing models so that they incorporate all essential components in all four States and are accepted by each State	• Extension and expansion of existing models • Capacity building for experts and decision-makers • Review of water balance and yields • Design/initiation of continuous review process
WP 2: Updating and Extension of Orange-Senqu Hydrology	Updating of hydrological data, hands-on capacity building in each basin state for generation of reliable hydrological data including the evaluation of national databases,	• Assessment of Required Improvements to the Existing Gauging Networks. • Capacity Development • Extension of Naturalized Flow Data • Review of Existing Data Acquisition Systems, proposals on basin-wide data acquisition and display system.
WP 3: Preparation and development of integrated water resources quality management plan	Build on Phase 1 initial assessment to propose water quality management plan, based on monitoring of agreed water quality variables at selected key points	• Establishment of protocols, institutional requirements for a water quality monitoring programme, data management and reporting. • Development of specifications for a water quality model that interfaces with the system's models. • Capacity building to operate the water quality monitoring system and implement the water quality management plan.
WP 4: Assessment of global climate change	Several objectives leading to assessment of adaptation needs	• Identification of all possible sources of reliable climate data and Global Climate Model downscaling for the Orange-Senqu Basin • Scenario assessment of impacts on soil erosion, evapotranspiration, soil erosion, and livelihoods • Identification of water management adaptation requirements with respect to observed/expected impacts on water resources • Assessment of major vulnerabilities and identification of measures for enhancing adaptive capacities
WP 5: Assessment of Environmental Requirements	Several objectives leading to management and monitoring system responsive to environmental flow allocations	• A scoping level assessment of ecological and socio-cultural condition and importance • Delineation into Management Resource Units and selection of EFR sites. • One biophysical survey to collate the relevant data at each EFR site and two measurements at low and high flows for calibration. • Assessment of the Present Ecological State and other scenarios • Assessment of flow requirements, Goods and Services, and monitoring aspects.
WP 6: Water Demand management in irrigation sector	To arrive at recommendations on best management practices in irrigation sector and enhanced productive use of water	• Establish a standard methodology for collecting data on irrigation water applied to crops, water use by crops and crop yields. • Document best management practices for irrigation in the basin and finalise representative, best-practice demonstration sites through stakeholder consultation • Consider and assess various instruments that support water conservation/water demand management.

The other work packages are both self-standing and intended to provide inputs to an improved and more complete water resources simulation model for the whole basin. The model will be enhanced by a more complete hydrology (WP2), better and more complete water quality information (WP3), allowance for climate change impacts and adaptation (WP4), inclusion of environmental flow requirements at key points (WP5) and modelling of scenarios with improved water Background to Work Package 2 and this Report.

1.3.3 Background to work Package 2 and this Report

Work Package Objectives

The central objective of this Work Package is to produce updated and extended hydrological sequences for the basin as a whole. This will help to address certain deficiencies with the existing hydrological data sets which are not consistent throughout the Orange-Senqu River basin. To ensure that the hydrological data sets are easily accessible for any future work, they will be incorporated into an appropriate database system with proper referencing.

In addition to the main objectives mentioned above, the hydrological data sets for the river basin should ultimately be improved through the following:

- Recommendations on the upgrading of gauging stations and associated systems and processes;
- Provision of appropriate Capacity Building in a number of key areas to be agreed with each basin state;
- Recommendations on appropriate protocols and procedures for data collection and data sharing throughout the whole basin; and
- Agreement on a proposed data acquisition and display system to be available to, and adopted by, all four basin states and covering key stations basin-wide.

The main tasks of Work Package 2 were as follows:

1) Provision of appropriate Capacity Building in a number of key areas to be agreed with each basin state;
2) Recommendations on appropriate protocols and procedures for data collection and data sharing throughout the basin;
3) Proposals on data acquisition and display system to be available to and adopted by all four basin states;
4) Assessment of Required Improvements to the Existing Gauging Networks; and
5) Extension of Naturalized Flow Data.

This Report

This report provides details on activities 2) to 4) above.

2 REVIEW OF NATIONAL DATA ACQUISTION SYSTEMS

2.1 Introduction

The focus of this paper is on surface water quantity. The issue of water quality is dealt with in Work Package 3.

In summary, the following aspects have been investigated in this section:

- Gauging network, spatial coverage and performance;
- Institutional responsibility/structure;
- Measurement and on-site data storage;
- Data collection and transmission;
- Data Processing and quality control;
- Discharge calculations (ratings etc.);
- Field Measurements (gauging, surveys etc) for discharge verification; and
- Data storage, updating and dissemination.

2.2 Gauging Networks

2.2.1 General

The gauging network for the whole basin is shown in Figure 2-1. Figure 2-1 also provides an indication of the type of station, whether it is open or closed. The symbols representing the stations have also been sized according to the length of record. As expected, the network is most dense in the areas of highest runoff production. Many of the longest records are to be found in these areas.

2.3 Network Expansion and Improvement

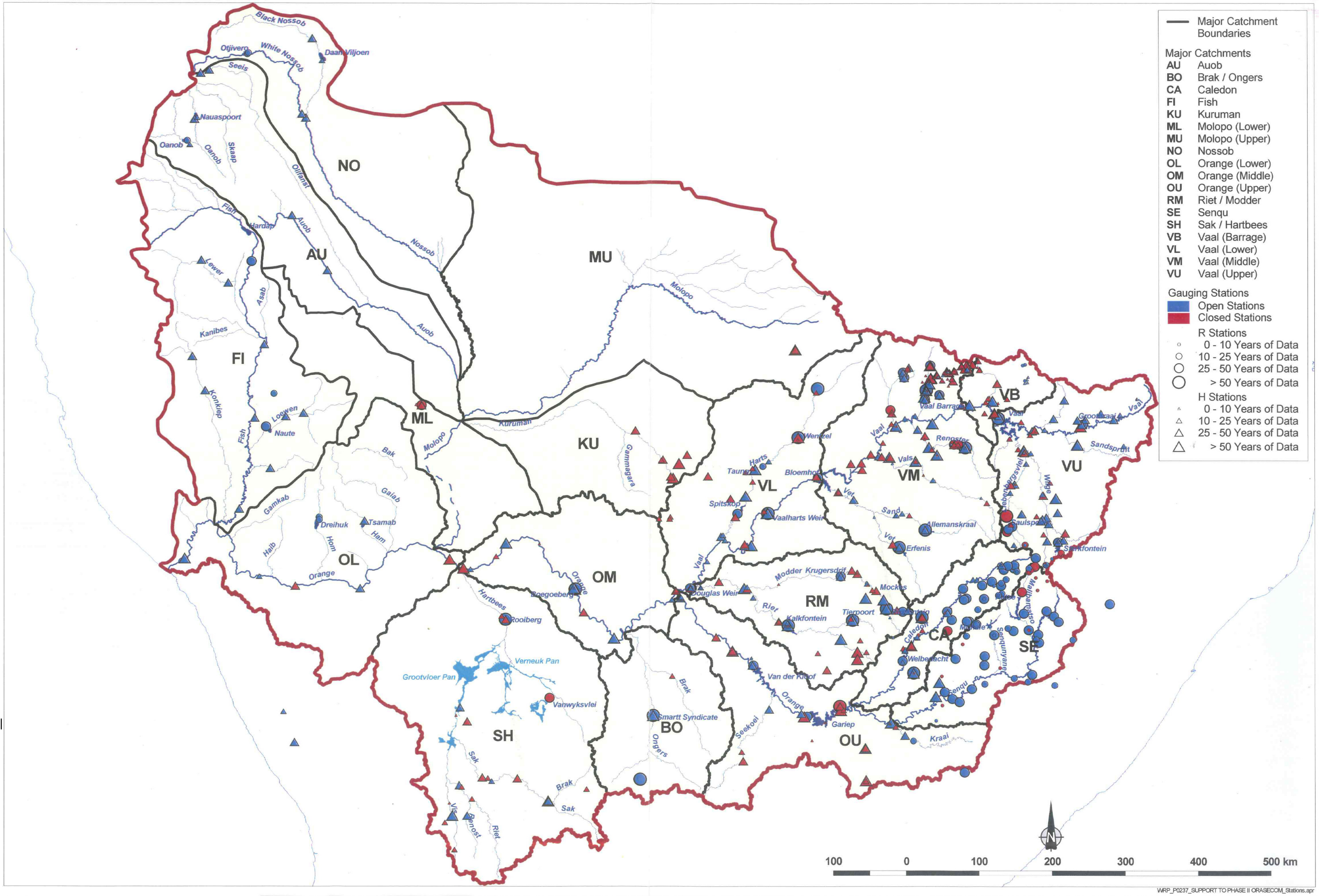
While a higher density network is always desirable, it is clear that budgetary constraints and a shortage of personnel to maintain such a network, makes it difficult to consider realistically. More important is that the existing key gauging stations are adequately maintained and that their ratings are constantly checked and improved where possible. This will require investment into personnel and capacity building and into improving operations.

Low flow measurement is a critical issue, especially in the Lower Orange. A new weir, which will be capable of accurately measuring low flows, is currently under construction at Sendlingdrift on the joint South African/Namibian border.

Namibia has also proposed the installation of a data collection platform and real-time transmission system at Noordoewer, on the bridge, and to rate the station using concurrent water levels and the discharges from the Vioolsdrift weir. They also propose constructing a gauging station at the Orange River mouth. Other requirements in Namibia include the expansion of the real-time system at existing stations, including the Hardap and Naute Dams. Rehabilitation of the important flood warning weir at Gras is also critical. A new station on the Fish River is proposed. This should be situated at the Maltahohe road crossing, downstream of Hardap Dam, and would provide the best indication of flow in the Fish River, taking into account spill from the Dam and contributions from the key tributaries immediately downstream of the dam.

In Lesotho a number of stations are in poor condition and require repair and upgrading. The generalization of loggers is also necessary.

ORASECOM could play a role in supporting joint gauging exercises between countries. These would be particularly useful on the Lower Orange, where Namibian and South African teams could work together. This concept facilitates transparency and also allows agreement to be reached on rating curves for key stations.



INTEGRATED WATER RESOURCES MANAGEMENT PLAN PHASE II
FOR THE ORANGE-SENQU RIVER BASIN

Gauging Staions for the Senqu-Orange River Basin

Figure 2-1

2.4 Institutional Responsibility/Structure

2.4.1 General

In all four countries the acquisition of hydrological data are primarily the responsibility of the Hydrological “Unit” (Directorate, Department, Division etc) in each country. However there are also some other organizations which collect hydrological data such as NamWater in Namibia.

2.4.2 Botswana

At the time of the last of three visits to the Hydrology Division in Botswana there was still no formalized structure in place to undertake all steps of the data collection through to data dissemination process. Efforts were underway to establish a data processing group but those identified to form part of this data unit were still unsure of their role in the data chain. The majority were quite new in the Department and had no or very little actual hydrology field training.

At present data are being collected by technicians and taken to the different regions, where ‘data capturers’ update the records in excel spreadsheets or in A4 forms. It is only at the end of the Hydrological year that the data are sent to Gaborone, where the data group will then have the responsibility of updating the information on Hydstra.

2.4.3 Lesotho

Data from the Hydrological stations in the Orange River basin are collected by a number of technicians and given to an established data processing unit. This unit functions quite well and it is their responsibility to ensure that all the data capturing is completed and updated in Hydstra.

2.4.4 Namibia

The institutional set-up is well-defined in Namibia and has been operating for many years. Existing problems are largely due to lack of staff and a relatively rapid staff turnover. New field technicians require training and time to build up their knowledge of the network.

All fieldwork related to the collection of hydrological data are led by a single Chief Control Technician. This post is currently filled. The Chief Control Technician is supported by six technicians, although only four of these posts are currently filled.

Each of the six posts (four filled) is allocated to a technical assistant who in turn is supported by 4 additional personnel particularly during field station “check and service” trips. Each of the technical assistants is responsible for a “service” region, of which there are seven in the country. The Fish River and the stations on the Orange River and tributaries flowing directly into the Orange River, are part of “South” service region. Assistance is provided by “Basin Officers”, who are currently part of the Hydrology Division structure. This is a recent development and includes the establishment of a Basin Officer in Keetmanshoop.

2.4.5 South Africa

Introduction

The operation and maintenance functions of hydrological monitoring stations in the Orange River Basin are managed by the regional offices of Northern Cape, Orange Free State and Gauteng.

Each region is fully responsible for their data and its integrity. Technicians are responsible for the maintenance of the instrumentation, be it mechanic or electronic. They must also ensure that observers are correctly trained and are capable of carrying out their duties. Depending on the region, the task of data collection and data processing is mainly the responsibility of Auxiliary Officers. In some cases, technicians are also involved in the processing of electronic data.

Gauteng Region

The office is managed by a Control Industrial Technician. The Office Manager is supported by three technicians, one of whom is in charge of all the technicians and Control Auxiliary Service Officers.

The personnel structure in the Gauteng Region is as follows:

- Office Manager (Control Industrial Technician);
- Three technicians;
  - one in charge of all the technicians and Control Auxiliary Service Officers;
  - two each have an area of responsibility and must ensure the proper running of all the activities in their region. They assist with any problems in the regions, data read-outs, and arrange / coordinate urgent maintenance tasks;
- Four Control Auxiliary Officers, two assist with all light maintenance activities. They are involved in the read-out of data, visits / inspections and coordination of larger maintenance at stations. The third does data read-outs, inspections and all light maintenance in his region. The fourth Control Auxiliary Officer does checking of processed data and archiving;
- One Chief Auxiliary Officer conducting registration and processing of data, assisted by one Principle Auxiliary Officer and two Senior Auxiliary Officers;
- One Auxiliary Officer: collecting water samples, changing graphs and read out of logger data; and
- Three Data Collectors: these officers collect water samples, attend to the changing of graphs and read-out of logger data.

Free State

The office is managed by a Control Industrial Technician. The office manager is supported by the personnel structure:

- Three Chief Industrial Technicians who between them are responsible for Upper Orange, Upper Vaal and Middle Vaal. Technicians do the station and instrumentation maintenance, collect electronic data and process all river electronic data. (currently five vacant technician posts.)

- Four Control Auxiliary Services Officers: of these one is involved in Data Management and the other is responsible for the Upper & Middle Vaal (currently there are two vacant posts: one in data management and the other in the Upper Orange)
- Five Auxiliary Services Officers: two involved in data management. A third post in data management is current vacant. The other two are responsible for the Middle and Upper Vaal.

Northern Cape

The office is managed by a Control technician. The office manager is supported by the personnel structure some of whom are permanent and some temporary staff. The permanent staff include:

- One Chief Technician - responsible for data collection, scheduled and unscheduled maintenance of gauging sites, data processing and capturing;
- One Control Auxiliary Officer - assists in data collection, scheduled and unscheduled maintenance of gauging sites, data processing and capturing; and
- One Tradesman Aid - implements the light maintenance programme.

Non-permanent staff include:

- One Hydrologist - Graduate Trainee; and
- One Technician - Graduate Trainee.

The Graduate Trainees provide support to the permanent staff members in the data chain and normally fill in the gaps where permanent members cannot. They are provided with training and are also involved in the data chain production work.

The Northern Cape Hydrology component currently has a vacancy rate of 72%, of which only 11% is funded. To cope with the current work load, the structure would need to be filled to at least 80% with the result that only a limited number of key flow monitoring points can be covered at this time.

2.5 Measurement and Data Collection

2.5.1 General

2.5.2 Botswana

There are currently no operational river gauging stations in the Botswana part of the basin.

2.5.3 Lesotho

59% of the river gauging sites in Lesotho are equipped with inlet systems, while the remainder are equipped only with gauge plates and manned by observers who take daily readings. 73% of the sites that have inlet systems are equipped with electronic data loggers and 57% also have mechanical chart recorders. The practice of installing backup data loggers to ensure data integrity is not followed due to insufficient budget to procure the necessary logging equipment. Data logging equipment at all the monitoring stations is housed in vandal-proof cabinets or huts. Data logging frequency for electronic loggers is set at 12-minute intervals.

Typical problems pertaining to measurement and onsite data storage experienced include:

- vandalism,
- run down logger batteries,
- personnel shortages and
- blocked inlet systems (despite regular flushing in many cases)

Measurement and onsite data storage at all reservoir sites are carried out by other institutions such as the Lesotho Highlands Development Authority (LHDA) and the Water and Sewage Authority (WASA)

2.5.4 Namibia

Namibia operates 27 gauging stations in the Fish, Auob, Oanob, Nossob and Orange (small tributaries flowing directly into the Orange River) catchments, of which 8 are reservoir stations. Almost all stations are fitted with recorders and many with electronic loggers. The Hydrology also operates real-time stations at stations on the Fish (Seeheim and Ai Ais) and at Rosh Pinah on the Orange River mainstream. This real-time data are obtained either through GSM transmission or via satellite (EUMETSAT). All of these stations are also fitted with loggers, which are often fitted to separate measurement sensors. In general, the real-time data are not used to build historic records.

Data from stations are downloaded during service trips, which are carried out every two or three months. This includes the collection of charts where chart recorders are still in operation.

2.5.5 South Africa

Introduction

The operation and maintenance functions of hydrological monitoring stations in the Orange basin, within South Africa, are managed by three regional offices. Hydrological monitoring stations include river gauging weirs, natural river sections, reservoir sites, evaporation and rainfall stations at reservoir sites. The regional offices include the Gauteng Hydrometry Office, the Free State Hydrometry Office and the Northern Cape Hydrometry Office. The status of measurement and onsite data storage for the three regional offices are listed below.

Gauteng Hydrometry Office:

River gauging Sites: Stations managed by this regional office are well developed and most stations are equipped with proper inlet systems and gauge plates. All river gauging sites are equipped with electronic data loggers and backup logging devices are also installed at all the sites to ensure data integrity.

Reservoir sites: All reservoir sites are equipped with inlet systems to house data logging devices and have gauge plates. Each reservoir site also has a backup logger installed to ensure data integrity. Evaporation and rainfall measurement also take place at each reservoir for reservoir balance calculations.

Data logging equipment at all the hydrological monitoring stations is housed in vandal proof cabinets or huts. Data logging frequency for electronic loggers are set on 12-minute intervals. Readings from data logging devices are regularly compared and adjusted on site to actual gauge plate readings. Personnel are also able to install and replace data logging devices. The regional office also have sufficient budget available to procure equipment to replace faulty equipment. Typical problems pertaining to measurement and onsite data storage experienced include: vandalism, run down logger batteries, personnel shortages and although inlet systems are typically flushed every 3 months as preventative maintenance blocked inlet systems remains a problem.

Free State Hydrometry office:

River gauging Sites: Stations managed by this regional office are well developed and all stations are 100% equipped with proper inlet systems and gauge plates. All river gauging sites are equipped with electronic data loggers and 35% of all sites are also equipped with mechanical chart recorders. Backup logging devices are also installed at all the sites to ensure data integrity.

Reservoir sites: All reservoir sites are equipped with inlet systems to house data logging devices and have gauge plates. Each reservoir site also has a backup logger installed to ensure data integrity. Evaporation and rainfall measurement also take place at each reservoir for reservoir balance calculations. Evaporation measurements are normally performed with an S-tank or A-pan. These apparatus are only equipped with gauge plates. Observers stationed at the reservoir records daily evaporation, rainfall and reservoir level readings.

Data logging equipment at all the hydrological monitoring stations is housed in proper vandal-proof cabinets or huts. Data logging frequency for electronic loggers are set on 12-minute intervals. Readings from data logging devices are regularly compared and adjusted on site to actual gauge plate readings. Personnel are also able to install and replace data logging devices. The regional office also have sufficient budget available to procure equipment to replace faulty equipment. Typical problems pertaining to measurement and onsite data storage experienced include: vandalism, run down logger batteries, personnel shortages and although inlet systems are typically flushed every 3 months as preventative maintenance blocked inlet systems remains a problem.

Northern Cape Hydrometry Office

River gauging Sites: Virtually all river gauging sites are equipped with proper inlet systems and gauge plates. Only 1% of all sites only have gauge plates. 99% of sites have electronic data logging devices, 10% have mechanical chart recorders and 97% of all sites are equipped with a backup logging device.

Reservoir sites: All reservoir sites are equipped with inlet systems to house data logging devices and gauge plates. 95% of reservoir sites also have a backup logger installed to ensure data integrity. Evaporation and rainfall measurement also take place at each reservoir for reservoir balance calculations. Evaporation measurements are normally done with an S-tank or A-pan. These apparatus are only equipped with gauge plates. Observers stationed at the reservoir records daily evaporation, rainfall and reservoir level readings.

Data logging equipment in general is not housed in proper vandal-proof cabinets or huts and approximately 10% of sites are not safe from flooding. Data logging frequency for electronic loggers are set on 12-minute intervals. Readings from data logging devices are mostly compared and adjusted on site to actual gauge plate readings. Personnel are also able to install and replace data logging devices. The regional office does not have sufficient budget available to procure data logging equipment to replace faulty equipment and to properly maintain these sites. Typical problems pertaining to measurement and onsite data storage experienced include: vandalism, run down logger batteries, personnel shortages and insufficient funds.

2.6 Field Measurements and Station Ratings

2.6.1 General

Regular discharge measurements both to establish and update the stage-discharge ratings at river gauging stations are essential. These are even more important at open section stations, where the ratings are both difficult to establish from theory and which can change due to cross-section instability.

The Lesotho Hydrology Division rarely carries out discharge measurements. The Namibian Hydrology Division carries out discharge measurements from time-to-time on the mainstream of the Orange River, using an acoustic Doppler profiler, but has not carried out gauging on the Fish River or other ephemeral streams for many years. South Africa also gauges the Orange River and some of its perennial tributaries, but the frequency of gaugings has become reduced.

2.7 Data Processing, Data Storage and Dissemination

2.7.1 Botswana

The Department of Water Affairs in Botswana has only recently established a dedicated data processing and quality control data unit in the Gaborone office. The group is responsible for the processing of data and its evaluation, which is done in Hydstra, their hydrological database. The bulk of the data consists mainly of strip charts and gauge plate readings, with only a relatively small amount of electronic data. As no digitizers are available, these charts are manually analyzed and problems interpreted and solved with the results being transferred to returns (A4 forms). This process is far from ideal and many errors are made in the interpretation of chart data.

Many of the individuals that form the data processing group are fairly new to the Department and urgently need hydrological field training. It would be most beneficial if training could be given on the different types of instrumentation available (mechanical and electronic), as well as field conditions that ultimately impact on the quality of data. This knowledge is essential during the data processing phase, where data are analysed for possible problems specific to the different stations.

Training was given in Botswana in September 2009 on their current hydrological database Hydstra (under the SADC-HYCOS project). More recently, in June 2010, training was given specifically on data processing. Progress was slow and a vast amount of training is required not only to get participants familiar with the Hydstra program, but to improve their understanding of data analysis.

A local area network is in place and a server was prepared for HYDSTRA implementation in 2009 during the HYCOS project. No backups of Hydstra are undertaken on the server. The system administrator has been advised to perform a backup every week, as well as every month. Copies of the backups should be kept in DVDs and stored off-site.

In 2010, during a brief visit to Botswana, the Hydstra system, which was found corrupt, was restored and left operational.

Since the last visit in June 2010, there has once again been data corruption within the Hydstra system. The DVDs with the full Hydstra system, which were supplied to the Department, could not be located. A second set of DVDs was sent to Botswana via registered post, with instructions on how to re-install the system. Although the Botswana DWA has a large IT department, there is a need for a dedicated person(s) to ensure Hydstra is functional at all times, as well as the presence of a full-time administrator.

Data are analysed in the different regions and the results are sent to Gaborone at the end of each Hydrological year - only then is the data stored in the Hydstra system. This setup is not ideal and suggestions were made to speed up the time between data collection, data storage and processing.

The storing and updating of data in Hydstra is the responsibility of the recently established data group in Gaborone. The group is still new and unsure of their responsibilities. A lot of work needs to be done to improve their Hydrological knowledge. It is not clear who is doing the dissemination – there is no clearly identifiable unit responsible for this function.

Data are analysed at the different regions and the results are only sent to Gaborone at the end of each Hydrological year. The storing and updating of data in Hydstra is the responsibility of the recently established data group in Gaborone. The group is still new and a lot of work needs to be done to improve their Hydrological knowledge.

2.7.2 Lesotho

The Department of Water Affairs in Lesotho has an established data processing / quality control data unit which is entirely responsible for all the data processing. The majority of available data comes from strip charts and gauge plate readings, but there is also a lot of electronic data. One of the challenges is the fact that charts are digitized in an outdated digitizer, which produce 'problem' output files that eventually get imported into Hydstra. Many errors are encountered in the output files, due to the generation of countless negative time steps during the digitizing process, making the 'file cleanup' extremely time consuming. These problems need to be resolved before any data can be imported into Hydstra.

Training was given in Lesotho in August 2009 on their current hydrological database Hydstra (under the SADC-HYCOS project). More recently, in April 2010, training was given specifically on data processing. Even though progress was made, a lot more training is required, not only to get participants familiar with the Hydstra program, but to improve their understanding of data analysis.

The staff's overall knowledge of basic hydrological concepts needs to be vastly improved. Field training is therefore essential, as it will better equip individuals in the interpretation and analysis of data and the many problems encountered.

Data quality control is an area that requires improvement, as it is practically non-existent. The data processing unit carry out data updates but greatly struggle with data analysis – an area which is crucial for correct data processing.

2.7.3 Namibia

Namibia has a well established data processing system. Like the other basin states, they use HYDSTRA. They have a number of empty posts and a lack of capacity at senior level, so quality control presents some problems.

There is no internet-based system through which interested parties can access data online and therefore data are provided on official request.

2.7.4 South Africa

In South Africa, data processing is undertaken in Hydstra, the hydrological database, by the 8 different regions, namely: Western Cape; Eastern Cape; Kwazulu Natal; Gauteng; Mpumalanga; Free State; Northern Cape and Limpopo. HYDSTRA is centralised and runs on a Citrix Server, which allows instant availability of data, not only in the Head Office in Pretoria but between regions as well. The ownership of the data lies entirely with each region and they are totally responsible for the analysis, processing and evaluation of all their data. The vast majority of data are electronic, but mechanical data are still used, either as a backup or as a primary data source, as is the case in the Gauteng region, where vandalism is at its highest. Gauge plate readings are also available, but are used mainly as control points for the purpose of data comparison. Different data sources are available for most stations and are utilised in the interpretation and analysis of data. This allows the data processing unit in each region to identify faulty instrumentation and provides the data processor with enough data to minimise gaps in the data, should one (or more) of the instruments fail.

After the processing of data, the first step in the auditing of data quality is performed in the different regions by the quality control group. The final stage of the data auditing process, for all regions, is undertaken by the Auditing Group located at the Head Office in Pretoria. This group liaises with all the data groups in the different regions and alerts them of possible problems found in the data. Should errors be found in the data, the specific region will re-evaluate and correct the data before once again submitting to the Audit Group based at Head Office.

The data processing of the hydrological monitoring stations in the Orange basin within South Africa is managed by three regional offices:

- Northern Cape: one of the biggest problems in the Northern Cape is the lack of personnel. Data collection and data processing have always been a challenge, as there is only one Control Auxiliary Officer who is responsible for the data from collection to validation. Quality control is partially completed by this very experienced officer, but the region relies mostly on the Auditing Group in Head Office. In the past Head Office has assisted this region with data processing to assist in keeping their data up to date. Unfortunately, this is no longer the case due to the lack of personnel in Head Office. Currently, the Gauteng Region provides assistance with the capturing of evaporation and rainfall data.
- Orange Free State: data are collected by technicians and data collectors and the task of data processing is shared by technicians and an established data processing unit. Electronic data are mostly processed by the technicians and chart data, gauge plate readings, evaporation and rainfall is captured by the data processing unit.
- Gauteng: data are collected by technicians and data collectors but all data processing and quality control is undertaken by the data processing unit. An initial quality control takes place before data are available for auditing in Head Office.

It should be noted that personnel shortage is a problem in all the regions, but through intensive work, they manage to keep their data up to date. Unlike some other countries in Southern Africa, the regions take full responsibility for the collection and processing of both river data and reservoir data, as well as the capturing of evaporation and rainfall data.

The responsibility of data storage, updating and, to a minor extent, data dissemination is undertaken by the eight Regional Offices. They have total ownership of their data and deal with all related questions and queries. The bulk of the data dissemination for all the regions is prepared by the Head Office Auditing team.

3 ASSESSMENT (REVIEW) OF SADC HYCOS

3.1 Introduction

The purpose behind the formulation of the SADC-HYCOS project was the contribution to regional social-economic development by providing the necessary management tools for sustainable and cost effective water resources development, management and environmental protection.

Its main objectives were to:

- Provide SADC with an information system for the sustainable improvement of regional integrated water resources assessment, monitoring and management for a peaceful and sustainable development of the region.
- Assist the participating countries in developing their own national capacity in these fields to allow them to fully participate in, and benefit from, the project.
- Collaborate with other national, regional and international projects and programmes, towards the modernisation, rationalisation and improvement of the efficiency, cost-effectiveness and sustainability of the water resources and related fields information systems in the continental part of the SADC region and at the international level.

The Member Countries during the first phase of the project were Angola, Botswana, The Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe, Mauritius. Madagascar and Seychelles joined the project during its second phase.

SADC-HYCOS was established in 1998 to promote regional cooperation between countries and to set up a regional information system on water resources. The second phase of the project commenced on the1st December 2005 and terminated on the 31st May 2010

3.2 Phase 1

In 2002, two consultants undertook an evaluation of the project's achievements. In the evaluation report the following was noted

- The Project installed 43 out of 50 planned data collection platforms, but some were not operational due to a variety of reasons;
- HYDATA software was provided to all participating countries and training was given on its use;
- A regional electronic network was established and some of the participating countries were provided with computers and email facilities, which improved communication among the participating countries and with the Pilot Regional Centre;
- A regional Database consisting of data from the HYCOS project and Southern Africa FRIEND project was developed;
- There was insufficient training and loss of trained personnel due to high staff turnover;

- The design for SADC HYCOS Phase I network was largely influenced by submissions made by the respective countries;
- There was no development of hydrological products of regional interest;
- It was originally intended to verify the data transmitted from the data collection platforms to the Regional database at the Pilot Regional Centre. This could not be undertaken due to problems with the available hardware and/or software with the result that this activity was not completed.

3.3 Phase 2

3.3.1 Introduction

As a follow up to Phase I, the SADC-HYCOS Phase II Project started in 2006, and was designed to consolidate and expand on the activities initiated during the first phase.

The SADC-HYCOS Phase II Project Objectives:

- The inclusion of new SADC Member States which had not participated in or benefited from Phase 1;
- The undertaking of a comprehensive review of the hydrological observation network throughout the SADC region and proposal of appropriate improvements to meet the various water resources management requirements;
- To ensure that the equipment installed and the water resources information system established were utilised in a sustainable manner;
- The expansion of the observational network with Meteosat data collection platforms or other types of hydrological stations as required, according to the identified needs (i.e. flood monitoring/forecasting on specific rivers, water sharing with downstream users, assessment of the water resource);
- To expand the water resources information system and to ensure ease of accessibility to all countries.

The delay in the implementation of Phase II affected the implementation status of the project. The project only commenced in November 2006, instead of November 2005.

3.3.2 Phase 2 Components

The Phase II Project built on the achievements of Phase I and delivered in four distinct components:

Improvement of the Hydrological Network

Network Design Review

During HYCOS II a comprehensive review of the observation networks was undertaken with the purpose of redesigning stations for real-time and non-real-time reporting to a regional water resources information system, which will be readily accessible to SADC Member Countries.

The first task was the identification of the location the location of the proposed Phase II stations, taking into account the locations of the data collection platforms installed during

Phase I. South Africa pledged to include 11 data collection platforms on various tributaries of the Limpopo basin for flood management and water resources planning. The final network design comprised of 41 data collection platforms, 30 Data Logger Stations, 14 groundwater monitoring sites and portable water quality kits for each country.

The second task under this component was the establishment and operation of this network of key monitoring stations on the transboundary rivers within the SADC sub-region. From the very start of Phase II it was clear that most of the Phase I stations were no longer operational. This was due mainly due to the delay between the end of Phase I and the start-up of Phase II, which negatively affected the operation and maintenance of stations. The delay resulted in an unforeseen six months' rehabilitation programme being added into the component.

A total of 43 stations were visited and 33 rehabilitated, the remaining 10 stations were either washed away by floods, completely damaged by natural causes or vandalised and were to be recommissioned during the installation programme of Phase II stations.

Development of Water Resources Information System

After the collapse of the Project Regional Centre's web server just after the termination of Phase I, the regional database and the SADC-HYCOS website was redesigned and redeveloped.

After the review of the HYDATA software installed in Phase I, HYDSTRA was selected and procured as the new database management system. The upgrade of computer hardware was expected to be completed by the end of the project and, with the support of the Project Regional Centre, it was expected that the majority of the Member States would have had their database management systems upgraded to HYDSTRA by the end of Phase II.

Protocols for data exchange between the regional database and national databases were not be achieved by the end of the project, as they were dependent on the completion of implementation of the new national database system. One of the concerns under this component was the quality assurance of unverified data stored in the regional database. The Hydrological observation data disseminated on the website is contains abnormal values and errors that are caused by faulty data collection platforms. The validation of data has been one of the many challenges experienced by the Member States.

Development of Hydrological products

A number of projects were developed to meet the needs of the various NHSs, which were mainly techniques to gap filling within the hydrological records. The two techniques, MLR (multiple linear regression) and SPLASH (Daily Runoff model) were presented and made available to the NHSs.

The need for a model to forecast and simulate flood events was also identified. The development of this model was initiated but its completion was not achieved during phase II of the project.

Training and Awareness Building

In March 2008, technicians from all the Member States (except Madagascar) attended a workshop given on the operation and maintenance of the data collection platforms. This training was extended to include on-site training. A number of manuals were also developed for in-house training.

Starting in June/July 2009 the data migration and implementation of Hydstra (Hydrological database) took place in Swaziland, Lesotho, Botswana, Mauritius, Mozambique, Malawi and Zambia. A general one-week's training on the Hydstra software was provided in September 2008 to all Member States. Immediately after the implementation of the system, further training was given to the relevant countries on the use of the software. It should be noted that South Africa and Namibia already had the Hydstra system in use for a number of years prior to the SADC-HYCOS project and training was therefore not necessary in these countries.

3.4 Phase 3

The overall objectives of Phase III of the SADC-HYCOS Project were:

- The consolidation of Phase I and Phase II HYCOS installations to achieve a fully functional and calibrated hydrological monitoring network;
- The strengthening of NHSs capability to effectively use established hydrological databases, information systems and hydrological products;
- To assist the participating countries through awareness building and promoting Project activities to strengthen institutional capacity; and
- To assess the status and trend of their national water resources on a continuing basis and to provide adequate warnings of water-related hazards.

After two no-cost extensions, funding to the HYCOS project was withdrawn, rendering the inception of Phase III impossible unless funding is found to sustain the project

3.5 The SADC HYCOS Network

3.5.1 Overview

Figure 3-1 shows the distribution of SADC-HYCOS data collection platforms according to the Network Design Report. These stations measure water levels and rainfall.

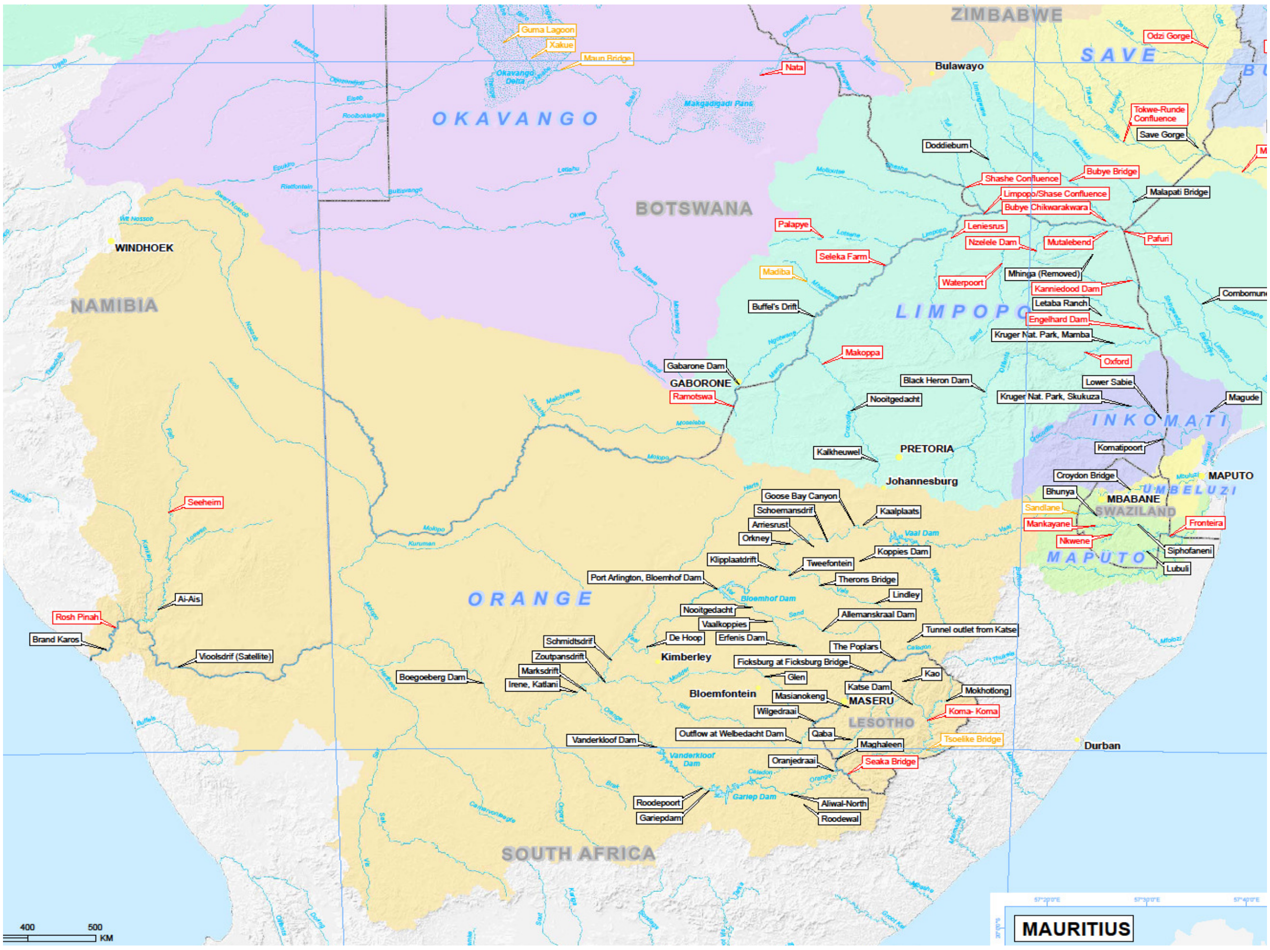


Figure 3-1: HYCOS Stations

3.5.2 Orange-Senqu

Table 3-1 lists the SADC HYCOS stations in the Orange-Senqu Basin

Table 3-1: SADC HYCOS Stations in the Orange-Senqu Basin

COUNTRY	LATITUDE	LONGITUDE	PLACE	RIVER	INSTRUMENT TYPE	HYCOS PHASE
Namibia	-26.501000	17.704000	Seeheim	Fish	DCP	2
Namibia	-28.169000	16.851000	Rosh Pinah	Orange	DCP	2
Namibia	-27.910000	17.490000	Ai-Ais	Fish	DCP	1
Lesotho	-29.583000	28.714000	Koma- Koma	Senqu	DCP	2
Lesotho	-30.376000	27.568000	Seaka Bridge	Senqu	DCP	2
Lesotho	-30.019000	28.714000	Tsoelike Bridge	Tsoelike	DL	2
Lesotho	-29.013000	28.335200	Kao	Malibamatso	DCP	1
Lesotho	-29.291000	28.990000	Mokhotlong	Senqu	DCP	1
Lesotho	-29.871000	27.610000	Qaba	Makhaleng	DCP	1
Lesotho	-29.337222	28.505556	Katse Dam	Malibamatsu	DCP	1
South Africa	-27.010000	26.700000	Orkney	Vaal	DCP	1
South Africa	-26.970000	27.210000	Schoemansdrif	Vaal	DCP	1
South Africa	-27.390000	26.460000	Klipplaatdrift	Vaal	DCP	1
South Africa	-26.740000	27.590000	Goose Bay Canyon	Vaal	DCP	1
South Africa	-27.940000	26.130000	Nooitgedacht	Vet	DCP	1
South Africa	-28.140000	26.420000	Vaalkoppie	Vet	DCP	1
South Africa	-28.120000	26.720000	Bloudrift	Sand	DCP	1
South Africa	-28.290000	27.150000	Allemanskraal Dam	Sand	DCP	1
South Africa	-28.510000	26.780000	Erfenis Dam	Groot-vet	DCP	1
South Africa	-29.030000	23.980000	Zoutpansdrift	Riet	DCP	1
South Africa	-28.950000	26.320000	Glen	Modder	DCP	1
South Africa	-27.480000	26.660000	Tweefontein	Vals	DCP	1
South Africa	-27.610000	27.100000	Therons Bridge	Vals	DCP	1
South Africa	-27.870000	27.920000	Lindley	Vals	DCP	1
South Africa	-27.040000	27.010000	Arriesrust	Renoster	DCP	1
South Africa	-27.260000	27.670000	Koppies Dam	Renoster	DCP	1
South Africa	-28.440000	28.400000	Tunnel Outlet from Katse	Ash	DCP	1
South Africa	-28.520000	24.600000	De Hoop	Vaal	DCP	1
South Africa	-27.670000	25.620000	Outflow from Bloemhof Dam	Vaal	DCP	1
South Africa	-28.710000	24.070000	Schmidtsdrif	Vaal	DCP	1
South Africa	-27.670000	25.620000	Bloemhof Dam	Vaal	DCP	1
South Africa	-30.680000	26.710000	Aliwal-North	Orange	DCP	1
South Africa	-30.160000	27.400000	Maghaleen	Kornet	DCP	1
South Africa	-30.340000	27.360000	Oranjedraai	Orange	DCP	1

COUNTRY	LATITUDE	LONGITUDE	PLACE	RIVER	INSTRUMENT TYPE	HYCOS PHASE
South Africa	-30.830000	26.920000	Roodewal	Kraai	DCP	1
South Africa	-29.510000	28.500000	Katse Dam	Senque	DCP	1
South Africa	-28.700000	28.240000	The Poplars	Little Caledon	DCP	1
South Africa	-29.930000	26.860000	Outflow at Welbedacht Dam	Caledon	DCP	1
South Africa	-28.880000	27.890000	Ficksburg Bridge	Caledon	DCP	1
South Africa	-29.610000	27.070000	Wilgedraai	Caledon	DCP	1
South Africa	-28.680000	28.460000	The Poplars	Caledon	DCP	1
South Africa	-29.910000	26.860000	Webedacht Dam	Caledon	DCP	1
South Africa	-29.160000	23.700000	Marksdrift	Orange	DCP	1
South Africa	-29.990000	24.720000	Dooren Kuilen	Orange	DCP	1
South Africa	-30.580000	25.420000	Roodepoort	Orange	DCP	1
South Africa	-30.620000	25.510000	Gariep Dam	Orange	DCP	1
South Africa	-29.990000	24.730000	Vanderkloof Dam	Orange	DCP	1
South Africa	-29.030000	22.190000	Zeekoebaart	Orange	DCP	1
South Africa	-29.180000	23.580000	Katlani	Orange	DCP	1
South Africa	-29.040000	22.200000	Boegoeberg Dam	Orange	DCP	1
South Africa	-28.760000	17.730000	Vioolsfdrif	Orange	DCP	1
South Africa	-28.490000	16.700000	Brand Karos	Orange	DCP	1
South Africa	-26.730000	27.720000	Kaalplaats	Riet Spruit	DCP	1

3.6 SADC HYCOS Operations

3.6.1 Equipment

All the Hycos stations were initially equipped with instrumentation collectively referred to as a Data Collection Platforms (DCPs). The basic configuration for a typical data collection platform is as follows:

- Electronics for data acquisition and storage (Logging unit);
- Meteosat radio transmitter and directional antenna;
- Power supply device with battery and solar panel;
- 2 water level sensors;
- Tipping bucket rain gauge;
- One water temperature and one conductivity sensor;
- Air temperature sensor; and
- Waterproof housing and connectors.

Due to terrain constraints and sensor cable lengths, the installation of downstream water level and conductivity sensors was not possible at all the stations. The measurement interval of the parameters is 15 minutes and the data are transmitted every hour.

Phase I stations were equipped with the AURORE equipment, but Member States experienced problems with its maintenance, due to the unavailability of spare parts. In Phase II, to resolve the issue of spare parts and provision of backup service, the OTT LOGOSENS equipment was procured for SADC-HYCOS stations.

The inception of a real time data collection system improved the data collection techniques in all the Member States. The system transfers data from the field to the Project Regional Centre for archiving in the Regional Database and dissemination to participating countries. Threats to the performance of the instrumentation may be classified into instrument failure, natural hazards such as floods and lightning, and vandalism or theft of equipment.

The most common problem was the short life span of the water level sensors. On most of the stations the average life span is three years only. One sensor, which now addresses this problem, is the compact bubble-in sensor.

Theft and vandalism played the dominant role in damage to or loss of instrumentation and data. A number of measures were implemented in the Member States to mitigate or combat vandalism.

3.6.2 Data transmission techniques

The SADC-HYCOS data collection platform data transmission system: the data flow is shown in **Figure 3-2.**

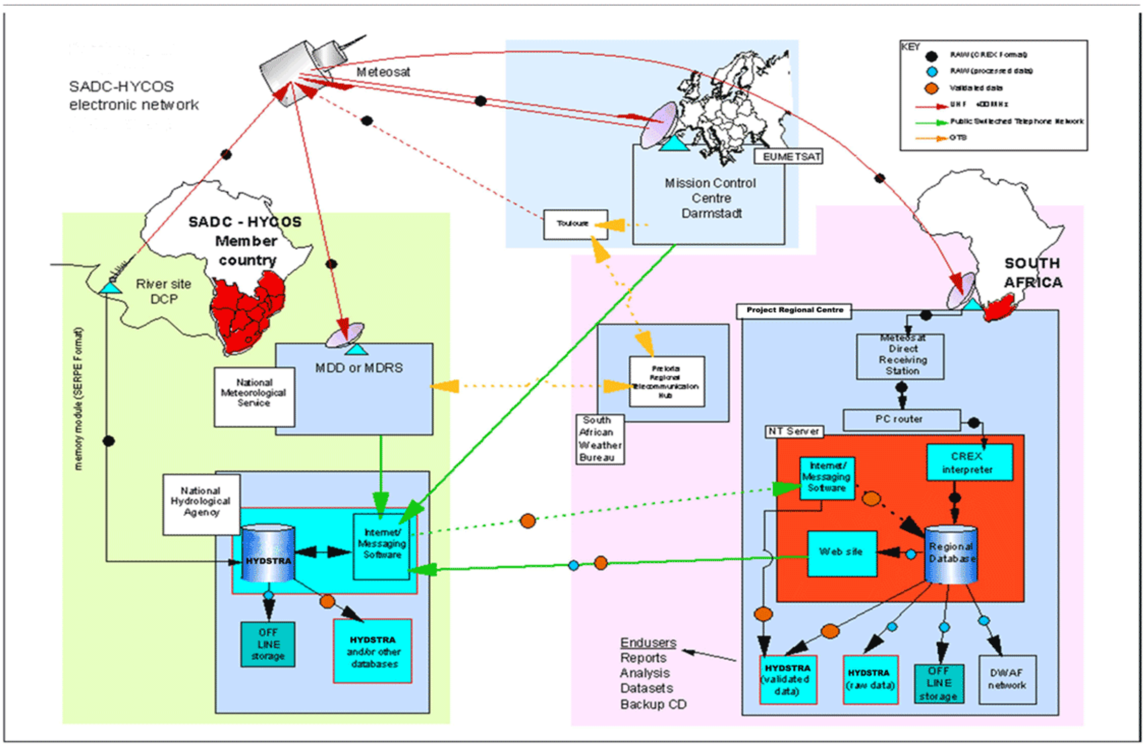


Figure 3-2: Flow of Hydrological Data and Information within HYCOS Regional Project

Each data collection platform is equipped with a UHF transmitter which automatically sends the hydrometeorological data collected at the site to the Eumetsat mission control centre at Darmstadt in Germany. Eumetsat is the operator of the METEOSAT system. Transmissions are in a format (CREX) which is specified by WMO and transmission from each site occurs at times and frequencies allocated by Eumetsat.

Data are retransmitted via METEOSAT to the regional centre in Pretoria, where it is received on a METEOSAT Direct Receiving Station. From the direct receiving station, the data are routed to the computer server hosting the regional database, where the CREX files are automatically interpreted and loaded onto the database, from where the data can be viewed via the Website. Each National Agency is able to manually download data from the stations in its country from the Website, and load the data into their local database, where it can be checked and quality-controlled. Should there be any errors in the raw data, these can be corrected and the validated data returned to the Project Regional Centre in Pretoria for loading onto the regional database.

The major challenge faced is the poor internet facilities in most Member States. Most of the countries face difficulties in accessing data from the regional database and this greatly impacts on data validation and data exchange.

3.6.3 Data storage

The SADC-HYCOS Regional database at the Project Regional Centre

The data loaded onto the regional database can be divided into three main categories: real-time data, historical data and metadata. The real-time data consist of data received in CREX format via METEOSAT. To avoid complications arising from the time differences across the region, all data are stored at GMT.

Some basic automatic checking occurs as data are loaded (e.g. against minimum/maximum limits), which filters out grossly incorrect values. However, the main validation of data are performed by the National Agencies. Data values on the database (and Website) are flagged indicating either raw values or validated data. Within the database, various operations are carried out automatically on a daily basis, e.g. sub-daily values are converted to mean or total daily values, as appropriate, and water levels are converted to flows or reservoir / lake storages using stored rating equation coefficients. At any time, the database contains the most recent sub-daily data, weekly, monthly and the primary datasets (i.e. the raw data).

The historical data provides a longer-term context in which to view the real-time data. The main historical data sets available for the region consist of daily mean flows, and some daily rainfall totals. Due primarily to economic constraints, other meteorological data and water quality data are not generally available. Within Southern Africa, there are also several other data sets which include data for some of the sites at which data collection platforms are installed and, where available, these are being loaded onto the regional database.

The metadata consists of all information which is fixed in time, or only changes infrequently. This includes details of the data collection platforms, project reports, security information for the database, data transmission settings and data quality control information. The majority of this information is provided by the national agencies for loading onto the regional database.

The main route for dissemination of the data collected from the data collection platform network is through the SADC-HYCOS website with address http://www-sadchycos.dwaf.gov.za/sadc.

In addition to the hydro-meteorological data, the SADC-HYCOS website includes descriptions of the WHYCOS and SADC-HYCOS projects, contact details and descriptions of the participating organisations and latest news on the project, as well as links to related sites. Users can select a station by locating the station on a map, by choosing the station from a list, or by searching according to user-defined criteria. Plots can be obtained of all the data types measured at each station, and of the derived data types, such as flow or potential evaporation. The various housekeeping parameters, such as solar panel current and battery voltage, can also be viewed. Data are displayed at daily intervals. Raw data that can be downloaded is available at sub-daily intervals ranging between 12minutes to hourly values.

Local databases in participating countries

Within each country, the main requirement was for purpose-made databases, which could be used off-line for the validation, analysis and long-term, archiving of the data collected during the project. With the exception of the Project Regional Centre and Namibia, prior to Phase II, all countries used the Centre for Ecology and Hydrology's HYDATA v4.1 hydrological database software (IH, 1999) for the initial storage and validation of data from their data collection platforms. In Phase II a new database HYDSTRA was installed in all the countries with exception of Tanzania, Angola, Democratic Republic of Congo and Madagascar.

The local HYDSTRA databases are designed to store all of the available data for each country which is collected and downloaded from the regional database at the Project Regional Centre. The data stored on the database is automatically interpreted, and major errors deleted, upon loading. However, the data are still essentially raw, requiring validation by hydrologists in each country. To help in this work, HYDSTRA includes a number of facilities for checking, quality controlling and editing data. During the project, additional training was provided on data validation techniques for data types not previously measured in real-time in some parts of the region.

At many sites, manual observations of river levels are made two or three times a day by observers, and/or chart recorders are still kept. Observer records can be manually typed into HYDSTRA, and chart records can be digitised and loaded into HYDSTRA using standard file import routines. In addition, at each site, data are archived locally in data loggers, which can be downloaded by portable memory modules every few weeks for reading at head office. For some variables, the logger data are at 12- or 15-minute intervals, rather than the coarser 1-hour or 3-hour intervals used in the METEOSAT transmissions, so there is the option to use these values as the primary data source for computing long-term flow statistics and meteorological conditions. These alternative data sources all provide an independent check on the data from the data collection platform, as well as an essential backup in case of communication errors or data corruption.

3.7 HYCOS Data Sharing protocol

The Project, established in 1998, was a regional component of the World Meteorological Organisation to promote regional cooperation, improve basic observation activities, promote free exchange of data in the field of hydrology and enhance capacity building. Its main goal was the creation of an enabling environment for the management and development of shared water resources among SADC countries and establishing a reliable region-wide hydrological network.

4 FUTURE DATA ACQUISITION AND DISPLAY SYSTEMS

The aim is to set up a display system which provides near real-time and historic data on the key stations around the Orange-Senqu Basin and that these data should be accessible through the ORASECOM website. It is clear, however, that the data collection and processing of data is the responsibility of the national hydrological services and that ORASECOM does not have capacity to become involved in this type of work.

The team considered a number of alternative approaches and concluded that it would be best to build on the existing system operated by DWA South Africa. DWA South Africa already operates an internet-based system through which the user can access water level and discharge data for selected stations. These data are available on a real-time basis and the system works efficiently.

The major advantage of building on the DWA RSA system is that it already includes key stations in Lesotho. In order to make it complete, it would only require the addition of selected stations in the Namibian portion of the basin.

The following actions would be required:

- Selection of key stations in the Fish River. These should include Ai Ais, Seeheim and the Hardap and Naute Dams. In addition a new open section station is proposed at the Maltahohe road crossing;
- On the mainstream of the Orange River. Addition of the Noordoewer Station into the network and addition of a new station at the river mouth;
- Upgrading or addition of new data transmission systems for the above stations. These transmission systems would have to tie in with the existing South African receiving system; and
- Setting up of a link from the ORASECOM web page that would access the DWA South Africa display system but that would be filtered to show only the stations in the Orange-Senqu Basin.

This solution would also support the incorporation of Namibian stations on the Fish River into the South African Decision Support System, which is currently being developed.

5 RECOMMENDATIONS

Gauging Network

While a higher density network is always desirable, it is clear that budgetary constraints and a shortage of personnel to maintain such a network makes it difficult to consider realistically. More important is that existing key gauging stations are carefully maintained and that their ratings are constantly check and improved where possible.

ORASECOM should support initiatives to promote any measures that can lead to the acquisition of more reliable and accurate data. These can include capacity building, technical assistance, supply of gauging and measuring equipment.

Namibia has proposed the installation of a data collection platform and real-time transmission system at Noordoewer and to rate the station using the discharges from the Vioolsdrift weir. They also propose a gauging station at the Orange River mouth. Other needs in Namibia include expansion of the real-time system at existing stations including the Hardap and Naute Dams. Rehabilitation of the important flood warning weir at Gras is also critical as is the addition of a new gauging station at the Maltahöhe road crossing.

SADC HYCOS

While the SADC Hycos project had some success it also had many flaws. In particular, although one of its main aims was to promote the capacity and self-sufficiency of national hydrological systems, the fact that procurement for most countries was not undertaken by the countries themselves through their own systems, meant that the key issue of local capacity in supply and maintenance of equipment was not supported. An important part of the capacity chain lies in the ability of local suppliers to provide back up and support in a timely fashion. Namibia continues to use the EUMETSAT system for data transmission through the SADC framework and has set up a number of new real-time gauging stations on its own, independently of the HYCOS project. This seems like a good direction to take in the short to medium term.

Local Procurement

Following on from the above two points, it is recommended that any future support to the basin state hydrological services in the acquisition of measuring and gauging equipment should be channelled through each basin state’s existing procurement systems. This ensures, or at least promotes, the building of local capacity in maintenance and backup.

Joint Display System

The ORASECOM basin-wide display stem which would display data from key gauging stations basin-wide should be built onto the the existing system operated by DWA South Africa. The information could then be accessed via a link from the ORASECOM web page that would access the DWA South Africa display system but that would be filtered to show only the stations in the Orange-Senqu Basin.

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