


Summary review relating to surface water hydrology annual reporting at state party level

For the compilation of a brief synoptic report of the 2020-2021 Seasonal (Annual) Surface Water Hydrology of the Orange-Senqu River Basin

October 2021, internal project report for ORASECOM SWHC

Report nr: 001/2022, Annexure 1

ORANGE - SENQU RIVER COMMISSION
BOTSWANA LESOTHO
ORASECOM
NAMIBIA SOUTH AFRICA
Established 2000

The ***Summary review relating to surface water hydrology annual reporting at state party level*** was commissioned by the Secretariat of the Orange-Senqu River Commission (ORASECOM) with financial and technical support from the Global Environment Fund (GEF) through the United Nations Development Programme (UNDP).

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aqualinks

ORASECOM SECRETARIAT

Summary review relating to surface water hydrology annual reporting at state party level

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ACRONYM LIST

EFR	Environmental Flow Requirements
IFR	Instream Flow Requirements
LHDA	Lesotho Highlands Development Authority
MCM	Million Cubic Metre
NHS	National Hydrological Service
NMS	National Meteorological Service
ORASECOM	Orange Senqu River Commission
RSMC	Regional Specialized Meteorological Centre
SADC	Southern African Development Community
SAWS	South African Weather Service
SPI	Standardized Precipitation Index; SPI = (P-P*) / σ_p where P = precipitation, P* = mean precipitation, σ_p = standard deviation of precipitation. Always computed over certain period.
SPEI	Standardized Precipitation Evaporation Index
SWHC	Surface Water Hydrological Committee
TDA	Transboundary Diagnostic Analysis

1 INTRODUCTION

This report has been prepared in the process of the compilation of a synoptic report on surface water for the Orange-Senqu River Basin (further referred to as 'the synoptic report'), to assess from interviews with the hydrology representatives in the four Member States of the Orange-Senqu River Basin Commission (ORASECOM) what information is needed to be included in the synoptic report and what information is available.

The objective of the project is as stated in the Terms of Reference: "to compile a brief synoptic report of the 2020-2021 surface water hydrology in the Orange-Senqu River Basin and propose a template and format of annual reports by members of the Surface Water Hydrology Committee (SWHC). The report is meant to enable sharing of the information among State Parties and to create awareness amongst the public on the basin's surface water hydrology, and the annual trends and challenges experienced in the various parts of the river basin. The proposed template and format for annual reporting will ensure consistency in the four reports and enable comparison to draw trends in the medium and long term."

It was further explained during the start up phase:

- The synoptic report is only about quantitative hydrology. Water quality, water demand and groundwater and land degradation impacts are excluded from this report. Water quality and groundwater have their own committee within the ORASECOM.
- The SWHC itself has a need for harmonized reporting of all member states. (Input Alfeus Moses, during Namibia interview 28-9-2021).
- Apart from quantitative surface water (flows, water levels, storage), precipitation needs to be reported on. Potential evaporation and transfers of surface water could be included if this is considered relevant by the interviewees.
- The report should be readable within an hour and also has a 'coffee table'-appeal.

It was further emphasized in the SWHC meeting to discuss the draft report (18 October 2021) that:

- The report of 2020-2021 and the structure in the template should not necessarily be perfect yet; it can be further improved over the years.
- Some information, like environmental flow requirements, is not yet
- For this first year it is important to use with readily available information and to report back to the State Parties.

AquaLinks is preparing the synoptic report and the template as per the proposal, see figure below.

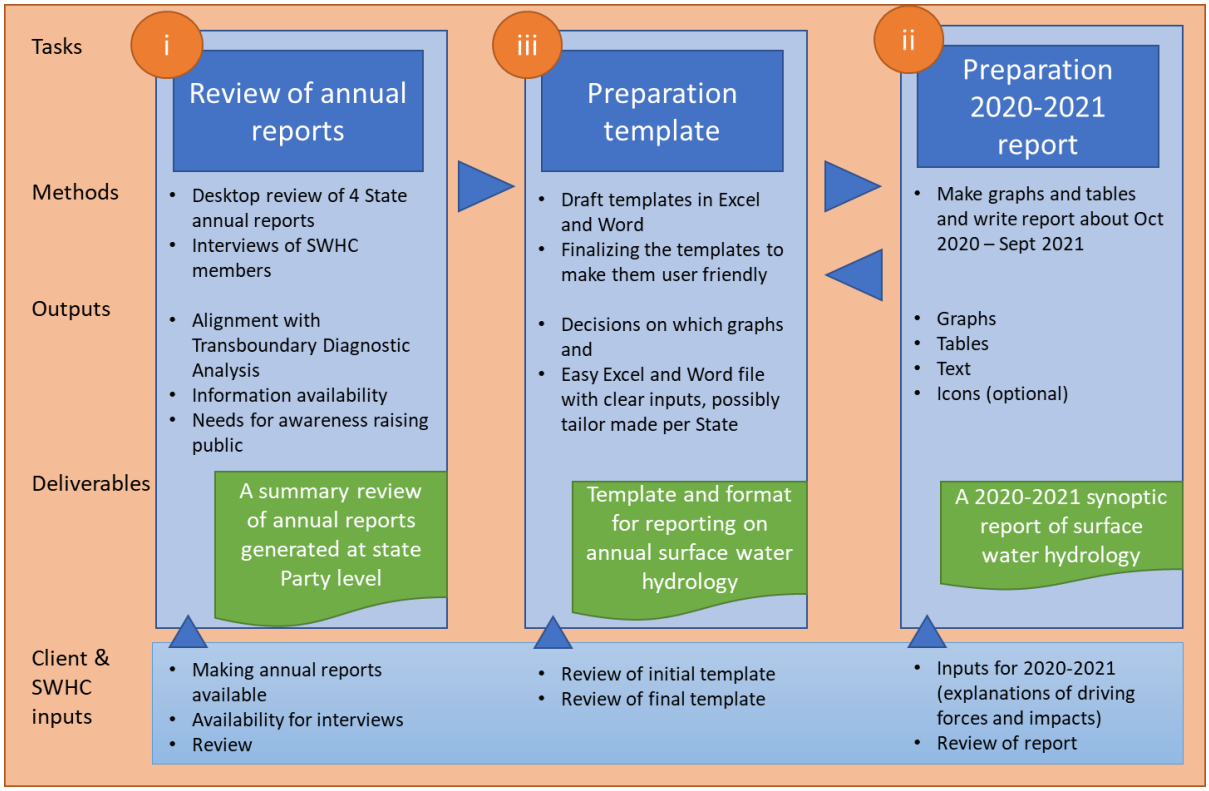

Figure 1: Methodology as in proposal

The report was written on the basis of the start up meeting with Michael Ramaano (project liaison ORASECOM) and Mr Alfeus Moses (Namibia delegation SWHC), the four reports submitted by the Member States, four (group) interviews / brainstorm sessions on the required contents of the synoptic report. This was followed by two SWHC meetings on 18 October and 25 October, to finalize the contents of this report and guide the project further.

The report is set up, following the analysis based on study of annual reports and the interviews:

- **Summary of current annual reports:** What is in the current annual reports that could be of importance to the basin wide annual report?
- **Target readers:** Who is the synoptic surface water report for?
- **Information needs:** What are their questions to be answered? What are questions relevant for one country to be answered by other countries?
- **Information availability:** What information would then need to be in the report? How do you have this information available and when after a hydrological year?

This is followed by a synopsis and proposal for the way forward.

Please note that country names or abbreviations are used instead of “the group of interviewees of xxx”. The countries are mentioned in alphabetical order.

2 SUMMARY OF CURRENT ANNUAL REPORTS

The reports submitted by the four countries as current annual reports are very different. As confirmed in the start up meeting, the intention was to make the synoptic report as much as possible from existing annual reports, but this is not possible due to their huge differences and the limited contents of the reports.

An overview of what each country has available in the annual reports of the countries, is provided below, and screenshots are presented in Appendix B.

Table 1: Overview of contents of four country reports.

Country & type of report	Contents
Botswana (report 2020-2021 on Orange-Senqu)	Short report, possibly compiled for this request. • **Rainfall** - Timeseries of past years monthly rainfall, provided by NMS. • **Measurements** – Locations of weather stations and hydrometric stations. Flow is not yet presented in the report. Two gauges were set up (Lepurung and Bray after cyclone Dineo in 2017), however they are not reported on and also do not have data for 2020-2021. There are no Reservoirs in Botswana, only a few weirs. Flood or drought indexes are not presented.
Lesotho (presentation to SWHC June 2021)	Mainly on developments in infrastructure rather than on hydrology. • **Measurements** – Locations of hydrometric stations is presented, with remark that 19 of 105 are operational. However, it has been confirmed that 4 stations are operational rather than 19 but that the quality of these stations is not sufficient to use them in the 2020-2021 report. Most gauges in Lesotho do not have records after 2018. For the data of the LHDA, the NHS will need to further consult with the LHDA as this is not automatically available within DWS.
Namibia (presentation to SWHC June 2021 & last annual report of 2015-2016)	Quite elaborate report with extensive reference of historical and organisational context. Flood extent pictures of few years back are also shown. It seems an update of a previous report. • **Flow** – Timeseries of annual totals at key stations and flow rates (m^3/s) timeseries since eighties. Mainly reporting on SADC-HYCOS stations. • **Levels** – Plot of maximum, minimum and mean water levels (stage) at certain key gauges, over the hydrological season, but for the whole historical time series, not for the past hydrological year. • **Reservoirs** – Dam content in comparison to full supply capacity since beginning 1990s. No operating rules shown.

Country & type of report	Contents
	• **Floods** – Some locations with flood extents are presented, but not from year of reporting. • **Droughts** – Verbal description of the past year. • **Measurements** – Extensive reporting on measurements, in particular added ones, and data management systems.
South Africa (annual report 2019-2020 for whole country)	Elaborate report for 64 stations in whole country, but some information aggregated for whole country and more elaborate in terms of groundwater than in terms of surface water. • **Rainfall** – Country wide maps of total rainfall during hydrological year and as % of normal rainfall during hydrological year. Additionally, country wide maps of rainfall pattern, provided by Agricultural Research Council, not by NMS (SAWS). • **Flow –** Cumulative monthly totals at key stations throughout the past hydrological year, as well as the previous three seasons, in comparison to cumulative mean flow. • **Reservoirs –** Only aggregation of all dams in country against full supply storage of all dams in country together, but with display of summed storages for each week, for past hydrological year and three previous hydrological years. • **Droughts –** Maps of Standardized Precipitation Index (SPI) for the past 12 months, for each of the 12 months of the hydrological year. Unclear colour coding in comparison to SPI. No inclusion of evaporation rates.

3 TARGET READERS

In the interviews, the following groups of interested parties were identified, apart from SWHC members themselves. It needs to be emphasized that the target readers of a river basin wide report are not necessarily the ones which read the state reports as well, as it is even on a larger scale. Target readers are those that need to understand the bigger picture of their (potential) impact on other parts of the basin and/or how they are impacted by other parts of the basin.

The interviews resulted in the following inputs on target readers. During the interviews it was striking that all countries started with private sector interested parties, rather than other interested parties. Table 2 provides an overview. This table is also meant to inform ORASECOM communications unit and SWHC to compile a distribution list, once the 2020-2021 report is finalized.

Table 2: Overview of target readers.

Target reader group	Comment if provided	Input by (B=Botswana etc.)
Private Sector		
Mining	No specifications were given of companies.	B, N
Farmers	• Namibia: In particular the wine farmers along the lower Orange. • SA: In particular the farmers in the upper Orange catchment.	B, L, N, SA
Tourism sector	In particular lodges along the river.	B, N
Public Sector		
National	These were not mentioned in interviews, but Ministries of Water and Ministries of Environment might be interested, while for Lesotho and South Africa also the Ministries managing power generation should be targeted for the impacts of power generation (hydropower, cooling water, cleaning water of solar plants) and the energy-water nexus. (see also:	SA
Municipalities	• For water supply, but also for water levels and flood risks.	B, L, SA
Parastatals	These were not mentioned as answers during the interviews, but as providers of data Namibia Water Corporation (NamWater) and Lesotho Highlands Development Authority were mentioned. As a suggestion from AquaLinks, in South Africa, probably BloemWater, Sedibeng Water, Rand Water, ESKOM should be targeted for them to understand the river basin picture.	AquaLinks
Other stakeholders		
River forums (with representatives of above)	The Lower Orange River Forum was mentioned as a possible target reader. Similar forums, such as the Vaal Dam Reservoir Forum, could also be targeted as well.	N

Water Users Associations	The bigger water user associations, for which releases are made from the Reservoirs, could be potentially targeted for understanding the bigger picture of international river basin management. Such associations are: the Orange-Vaal Water User Association, Vaalharts Water Users Association, Kakamas Water Users Association.	AquaLinks
Those interested in the environment (NGO's)		N, SA
Researchers	• SA: Mainly from Universities in the region.	SA
Internal ORASECOM	The report will serve for internal SWHC communication	N
	It could be expected that groundwater committee, water quality committee and communications section, as well as others in ORASECOM organisation	

The following general remarks were made in terms of target readers:

- **Is surface water report stand alone not confusing for stakeholder?** During the interview with Namibia it was regarded as confusing that readers would get a separate report on surface water hydrology, while the links with water demands, water quality, land degradation and groundwater are so important to make.

4 INFORMATION NEEDS

From the explanations during the interviews of the information needs of different target readers, different questions were compiled that could be answered by a synoptic surface water report. The overview in Table 3 provides insight to what extent such questions may be relevant for certain users.

The following general remarks were made in terms of information needs:

- **Users interest in water use/demands:** While water demand is not part of the scope of this report, there is also no committee on water demands. This might however be of interest to ORASECOM stakeholders also from an international perspective. The Namibian government would be interested to what extent new licenses have been given out in a year in South Africa or Lesotho. (input Namibia)
- **Looking back:** Comparison in the reports can be done with the Mean Average for different parameters and for three years previously (input NHS Botswana, current annual report South Africa).
- **Hind-casting:** There was no real need expressed for hind casting, i.e. comparing the seasonal forecasts of the previous season, with the reality of it.
- **Time series versus cumulative:** South Africa produces graphs cumulatively. Namibia finds timeseries more informative but could also understand that both timeseries and cumulative need to be included.
- **Frequency of report:** The report also informs the SWHC which meets half yearly. It could be useful to already prepare a draft in June at the end of the wet season before the SWHC meeting and then update at the end of the hydrological year. However, this may create extra work (input Namibia).
- **Measurements reporting:** The annual reports provide insight in data availability, but this is not a concern for the target readers as it is not about the surface water as such and therefore not in the table below. However, the decline of the surface water measurements is a concern and all opportunities to raise with a wider community may need to be used (input Namibia). However, for the NHSs it is useful to have information on the status of the gauges in the other countries to their disposal.

Table 3: Overview of questions that target readers might want answered

Type	Which questions to answer? Legend colour coding: Suggestion during interviews Suggestion by AquaLinks - not mentioned in interviews	Private				Public sector			Other (incl representatives of People & Planet)				
		Farmers	Mines	Industry	Tourism sector	National gov	Local gov	Parastatals	River Forums	Water User	Those for	Communities	Researchers
Precipitation	What has been the rainfall / precipitation over the past year?	2	2		2								2
Precipitation	How does the rainfall compare to mean average rainfall?	2	2		2								2
Precipitation	How does the annual rainfall compare to the seasonal forecast that was made?					2				2			2
Evaporation	What has potential evaporation been over the past year?	2											2
Flows	What was the seasonal pattern of flow in comparison to previous years and mean year? (TDA concludes there is less fluctuation)	2	2	2	2	2	2	2	2		1	2	1
Flows	*What has been the flow over the past year at the intake points of municipal water supplies?*						1						
Flows	How do the flows in this year compare to previous years? (full time series)				1					2	1		1
Flows	*How much were the flows coming from Lesotho via Senqu River?*					1							
Flows	How do the flows compare to the environmental flow requirements at different points?					1					1		
Flows	*How much does the Fish River in Namibia contribute to the flow in the lower Orange?*					1							
Flows	*What is the flow at the mouth of the Orange? (TDA concludes currently less than 50% of naturalized flow at mouth, which is RAMSAR site)*					2					1		
Reservoirs	How have the dam storage levels of the main dams been in comparison to previous years?							2	2				
Reservoirs	What have the reservoir releases of the main reservoirs over the past year?	1											1
Reservoirs	*What have been the releases for farmers in the Middle Orange system?*	1								2			
Reservoirs	How has reservoir operation been done in comparison to reservoir operating rules? (including demands for water – vs dam releases for hydropower generation)					2	2	2	2		2		
Transfer schemes	How much was transported in and out of the basin and between different catchments in the basin via transfer schemes?							2	2				
Water levels	How do the water levels in this year compare to previous years?				1		1						
Floods	What is the extent of floods? (TDA concludes there is reduced frequency of small floods - this may impact nature)						1				1	1	1
Droughts	Where and to what extent were there droughts?	2	2	2	2	2	2	2	2	2	2	2	2

5 INFORMATION AVAILABILITY

The timing of the compilation of the report depends on the different countries having information available. For the data that needed to be received from the NMSs, such as precipitation, the interviews did not give conclusive dates on when this could be made available. For floods and droughts, this was also not specified, but it might make sense to use global databases for this, to have a similar approach for the whole basin. To compare flows with environmental flow requirements, these need to be available, therefore these are also included in the overview of data availability, in Table 4 below.

An overview is presented in Table 4. Data formats are different between Botswana and South Africa, while other countries did not submit their data formats.

In the SWHC meeting of 18 October, it was confirmed that Environmental Flow Requirements information may be available but cannot be shared yet in the synoptic report, as these flow requirements are scientifically determined but have not been promulgated by the Member States.

In the SWHC meeting of 25 October, it was mentioned that previous reports had patched data records, but it was decided that the reports would be based on data records provided by the Member States.

Table 4: Overview of contents of four country reports.

Country	Conditions on data availability
Botswana	It is not exactly known when data of the flow gauges are available, but the stations are automatic. Data are available in Hydstra. Only weekly reports are exported from the database regularly, but this is for dams and gauges outside of the Orange-Senqu basin. Currently delineating new catchments in GIS and studying historic droughts. • **Flows** – Timeseries of the two stations Leporung and Bray installed after cyclone Dineo (2017). However, both stations are not available for 2020-2021. • **Levels** – Timeseries of the two stations installed after cyclone Dineo (2017). • **Reservoirs** – Not applicable. (Environmental flow requirements also not)
Lesotho	There are no current data available from the NHS, only historic data before 2018. The Hydstra license has expired and data are therefore only available in Excel. Data from LHDA are separately available, in the formats of LHDA. Therefore: • **Flows, Levels, Reservoirs** – Not available, unless LHDA can provide theirs. • **Environmental flow requirements –** Not clear during interview, but Instream Flow Requirements (IFR) policy for the LHDA was made in 2003

Country	Conditions on data availability
	according to IFR website and the last annual report published on website was of 2015/2016, with 9 IFR sites, but 2 reported on being the releases of Katse and Mohale dam. The 2003-2004 report also describes the required monthly releases, for five different classes of hydrological years.
Namibia	Data of NHS of hydrological year can be made available **end of November**. Data are available in Hydstra. However, it is noted as a concern that the field work funds have been low in the past year and seem to get lower, with proper maintenance and checks on the flow gauges in the Orange-Senqu not having happened in quite some time. • **Flow** – Flow data are available in different time steps, but usually monthly timesteps are used. While there are more stations, data are prepared for • **Reservoirs** – Dam Levels are available • **Environmental Flow Requirements** – Those interviewed do not know if they are available.
South Africa	Data of NHS of hydrological year can be made available **in December, when the draft annual report is out**. However, for the purpose of this 2020-2021 report, verification of data from the Orange-Senqu could be put earlier, so that this report can be delivered earlier. • **Flow –** Most of the stations that are operational are measuring releases of reservoirs. The annual report does present 48 gauging stations, of which 15 (including reservoirs) are in the Orange-Senqu Basin. However, these 15 are not consistent with the stations reported in the Orange daily operational information system, or with the Instream Flow Requirements sites, or with the sites mentioned in the Transboundary Diagnostic Analysis as important. Daily totals and monthly totals are how the data are commonly extrapolated from Hydstra. • **Levels** – Outputs of Hydstra provided as usually used, already have a transfer to the discharges, not the levels. • **Reservoirs –** Derived from DWS website: Data are available daily for dams on a weekly basis, and for Vaal, Bloemhof, Gariep, Van der Kloof even more than daily (inflow, outflow, capacity). However, no operating rules are on the websites. • **Environmental flow requirements –** Not discussed in meeting but scientifically determined for several locations (Louw and Koekemoer, 2010), see Appendix C.

6 DECISIONS ON THE WAY FORWARD

In the SWHC meeting on 18 October 2021, recommendations were discussed, accepted or amended. In the SWHC meeting on 25 October 2021, the decisions for the way forward were presented to the SWHC (including additional members participating in the meeting). As a result of both meetings, the following was concluded on the way forward to compile the 2020-2021 report and the template for next years:

1. The Table of Contents set up cannot yet be concluded (the Consultant is free to propose) and does not have to necessarily be aligned with the 'State of Rivers' report on water quality with headings formulated as questions (or as sub-title).
2. The questions presented in Table 6 inform the basis for the report. Some questions, as specified in that table, are not yet being addressed by the 2020-2021 report but will be in the Template, for consideration in follow up years. These questions are related to:
    a. environmental flow requirements, as not yet promulgated by Member States
    b. operating rules of reservoirs, as not readily available within the NHSs
    c. flash floods, as not readily available within NHS and also not in the Regional Specialized Meteorological Center (RSMC) Pretoria, therefore will not be included in the 2020-2021 report but could be included in follow up reports.
3. While this project produces a report, the information in it will also be put into the water information system (WIS), which currently is being revitalized. The information for the 2020-2021 report will therefore also be handed over as GIS maps and separate graphs that can be edited, for information that is as such available, to make it possible for ORASECOM to include this information in the static annual update of the WIS.
4. Precipitation and Potential Evaporation data are shown as monthly maps and derived from international available databases, to cover the full basin in a consistent manner, and to not be dependent on delays due to data to be received from National Meteorological Services (and Agricultural Research Council for South Africa). Links to data sources will be included in the template for easier follow up in consecutive years.
5. For flow records where there are data for the period 1961 - 1962 to 1990 – 1991, the mean of these records will be included in the graphs, to have a similar record period for all stations, to assess changes to the hydrological regime. The 1961 – 1991 period s in line with the recommendations of WMO as a historical base period for climate change monitoring and most gauges selected for the report have records in this period.
6. Flow and reservoir data needed to compile the report are latest provided by the NHSs to the Consultant by end of November, after which the Consultant will start preparing the report.
7. The selection of gauges proposed is presented in Table 5 (also provided in Excel with analysis) and in (also provided as *.kmz file to be opened in Google Earth), and is done on the basis of:
    a. All points relevant according to the Transboundary Diagnostic Analysis;
    b. For Botswana, there are no gauges available for the 2020/2021 year. Lepurung is not working currently;

c. For Lesotho, the gauges on Mohale and Katse dam as well as the releases as provided by LHDA which are also guided by IFRs (2) as well as gauges available which represent quite a large area (i.e. SG3 for Orange Senqu and MG23 and CG22 for Caledon river .
d. For Namibia all gauges in their annual report (4) including Hardap and Naute dam, as in schematic of main Orange-Senqu infrastructure, as well as Ai-Aish gauge (+1) that is the most downstream gauge on Fish River and requested in SA interview, as well as Neckartal Dam and Auob River at Gochas and Stampriet.
e. For South Africa, analysis was done on the basis of gauges reported in annual report. However, most of these were not mentioned in the online Orange Senqu monitoring system (link) or as important gauges in the TDA, or indicated in the report of ORASECOM on extension of hydrological records, or as indicated by the IFR locations. The recommendation is to include a) all gauges relevant according to TDA, b) gauges relevant for IFR that could be traced in the the online database of DWS, c) main dams and weirs and transfers according to main schematic of Orange-Senqu (see Appendix E) and the online daily gauges reported in the Orange Senqu monitoring system, as well as d) gauges relevant for transboundary management with Lesotho.

8. The NHSs will confirm before end of October if the proposed gauges have available data for 2020-2021.
9. The NHSs have confirmed that the data can be provided in the formats in the Excel-sheet on formats.
10. Environmental flow requirements comparisons will not be used in 2020-2021 as they are not promulgated yet.
11. For all gauges approved to be included, the NHS of the four different countries will supply end of November:
    a. For river gauges:
        i. Coordinates (if not already available, see Excel-sheet)
        ii. Period of available verified data (if not already available, see Excel-sheet)
        iii. Monthly flow totals (MCM/month) for full record of available data, upto 30 September 2021
        iv. Daily flow totals (MCM/day) for full record of available data, upto 30 September 2021
    b. For reservoir records (may be more than one)
        i. Coordinates (if not already available, see Excel-sheet)
        ii. Full Supply Capacity (if not already available, see Excel-sheet)
        iii. Period of available verified data (if not already available, see Excel-sheet)
        iv. Weekly records of storage amounts in MCM for full record of available data, up to 30 September 2021

v. Inflows and Outflows (including releases) of monthly amounts in MCM. In case releases of the reservoirs are not provided with the reservoir records, downstream gauges that are representative are provided.

vi. For the 2020/2021 season no comparison is made with the reservoir operating rules as these are not easily available. For other years this can be considered.

12. For purposes of answering the identified questions, the following displays will be used as presented in Table 6.

Table 5: Proposed gauging stations of which time series / statistics will be included in the synoptic report

		Analysis											Conclusions			26				26
													26	12	9	5	0	2	9	15
Code	**Description**	**Crucial according to TDA**	**Crucial according to interviews**	**Added as a result of 18 October meeting**	**Namibia (in report 2015-2016)**	**Botswana (not in report 2019-2020)**	**LHDA (IFR report)**	**For IFR (Louw and Koekemoer, 2010)**	**SA (in annual report 2019-2020)**	**SA daily records Orange system**	**ORASECOM extension of data (2011)**	**in DWS database**	**Will be included in 2020-2021 report**	**Res**	**Riv**	**Transfer**	**Botswana**	**Lesotho**	**Namibia**	**South Africa**
Lepurung	Lepurung (data not reported on but available)					X							Not av.							
Bray	Bray (data not reported on but available)					X							Not av.							
Katse dam	Katse dam						X	X					1	1				1		
Mohale dam	Mohale dam						X	X					1	1				1		
CG70	Mohokare basin - West (not official description)												Not av.							
MG21	Makhaleng												Not av.							
SG3	Senqu		X										Not av.							
0497R01	Naute Dam				X								1	1					1	
0492R02	Hardap Dam				X								1	1					1	
Unknown	Neckartal Dam			X									1	1					1	
3124M01	Gochas on Auob River			X									1		1				1	
3124M02	Stampriet on Auob River			X									1		1				1	
Unknown	Ai-Ais on Fish River		X										1		1				1	
0484M01	Orange River at Noordoewer				X								1	1					1	
0485M02	Orange River at Sendelingsdrif				X								1	1					1	
0480M01	Orange River at Blouputs				X					X			1		1				1	
D8H014	Orange River at Blouputs												Same as 0480M01							
D1H022	Wilgerdraai		X										1		1					1
C9R002	Vaal River @ Bloemhof Dam	X							X	X	X		1	1						1
C9R003	Vaal River @ Douglas Weir	X							X				1	1						1
C1R001	Vaal River @ Vaal Dam	X							X	X	X		1	1						1
D1H009	Orange River @ Oranjedraai		X							X	X	X	1		1					1
D3R002	Orange River @ Gariep Dam	X							X	X	X		1	1						1
D3R003	Orange River @ Vanderkloof Dam	X							X	X	X		1	1						1
D8H003	Orange River @ Vioolsdrif	X						X (EFR004)					1		1					1
D3H032	Orange-Fish tunnel inlet from Gariep									X			1			1				1
Unknown	Katse-Vaal tunnel inlet									X			1			1				1
Unknown	Zaaihoek Dam to Grootdraai Dam												1			1				1
Unknown	Driel to Sterkfontein Dam												1			1				1
Unknown	Assegaai to Grootdraai												1			1				1
D7H014	Orange River @ Kakamas South Neusberg							X (EFR003)				X	EFR							
D1H011	Kraai River @ Roodewal							X (EFRK7)				X	EFR							

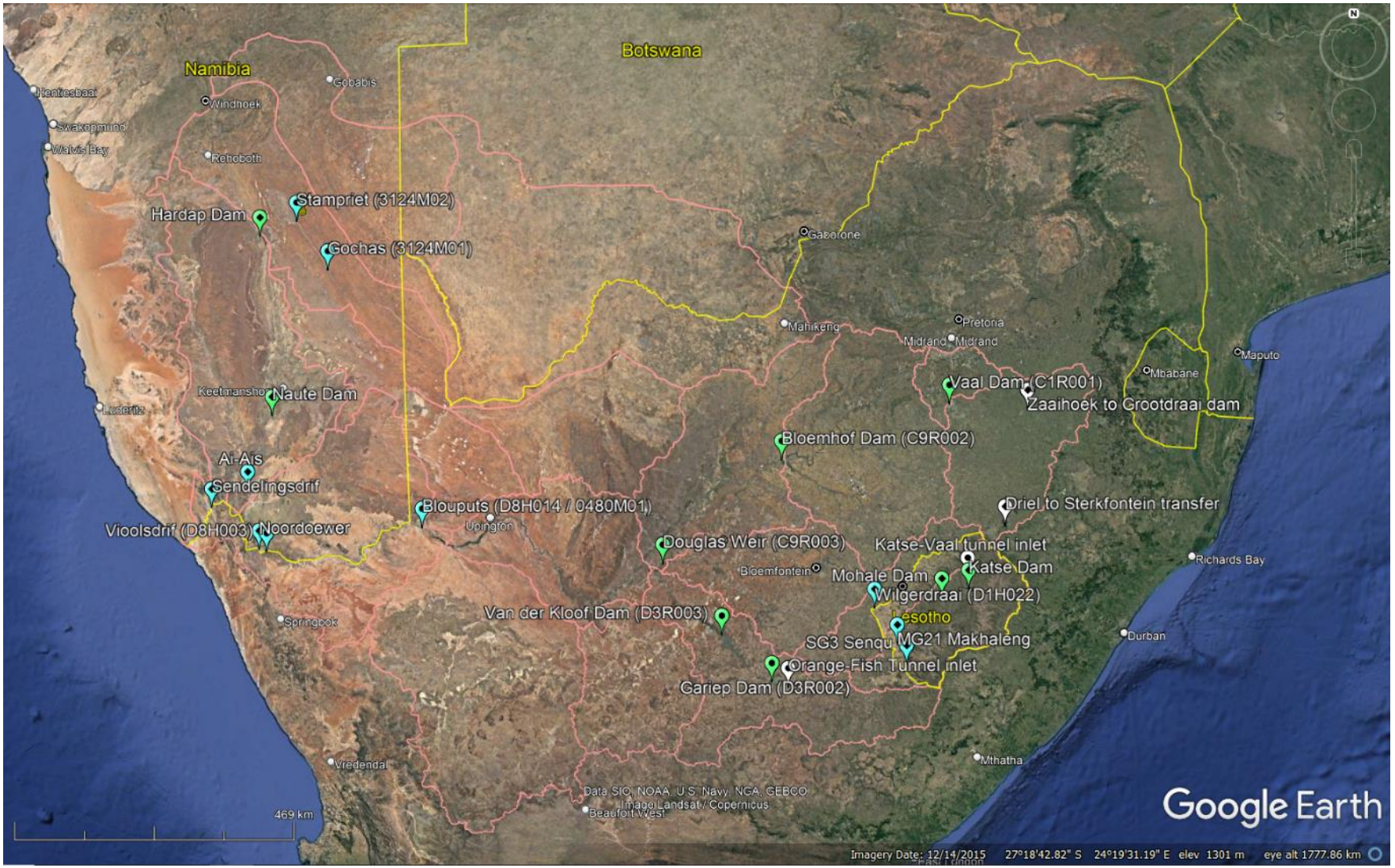

Figure 2: Gauges to be included in the 2020-2021 report (blue = river gauge, green = reservoir/weir gauge, white = transfer; circle is exact location known, square is location estimated.)

Table 6: Proposed way of answering the questions.

Which questions to answer?	How will the information be displayed?
What has been the rainfall / precipitation over the past year?	Map of satellite Derived Rainfall annual totals from FAO WAPOR.
How does the rainfall compare to mean average rainfall?	Map, if ORASECOM can provide a map of the Mean Areal Precipitation (MAP), then the difference with the MAP can be shown as well.
How does the annual rainfall compare to the seasonal forecast that was made?	Mentioned in text, based on map above and SARCOF forecasts.
What has potential evaporation been over the past year?	Map, if available via SADC Climate Services Centre, otherwise Actual Evapotranspiration via FAO Wapor.
What was the seasonal pattern of flow in comparison to previous years and mean year? (TDA concludes there is less fluctuation)	Timeseries (Namibia) or cumulative (South Africa) or both of hydrological year, with previous 3 years and with mean for total record, as well as mean for 1961-1990.
>> What has been the flow over the past year at the intake points of municipal water supplies?	In text based on graphs of volumes provided.
How do the flows in this year compare to previous years? (full timeseries)	Graphs, in two forms (1) normal timeseries, of past year monthly totals, with also shown previous 3 years historical min and max values. (2) cumulative, similar to in 1 but without the min and max values.
>> How much were the flows coming from Lesotho via Senqu River?	In text. As data from Lesotho are missing for 2020/2021, it needs to come from station Oranjedraai (D1H009).
How do the flows compare to the environmental flow requirements at different points?	For South African sites: Graph of 10%, 50% and 90% assurance levels flows with real flow. For Lesotho sites: dependent on 2003 policy (to be received)
>> How much does the Fish River in Namibia contribute to the flow in the lower Orange?	In text, based on Ai-Ais flow (Fish River) and Sendelingsdrif (downstream confluence).
>> What is the flow at the mouth of the Orange? (TDA concludes currently less than 50% of naturalized flow at mouth, which is RAMSAR site)	In text, based on Sendelingsdrif.
How have the dam storage levels of the main reservoirs been in comparison to previous years?	Graphs of each of the 13 reservoirs selected, of FSC, operating rule and timeseries over the past year and previous three years.
What have the reservoir releases of the main reservoirs over the past year?	Timeseries graph of releases in Mm3 from main dams, of past hydrological year and previous three years, as well as max and min.
>> What have been the releases for farmers in the Middle Orange system?	In text. Discussion of dams supplying them, in case this information is available.

Which questions to answer?	How will the information be displayed?
How has reservoir operation been done in comparison to reservoir operating rules?	Included in graphs for storage levels of main reservoirs.
How much was transported in and out of the basin and between different catchments in the basin via transfer schemes?	Cumulative graphs of the five selected transfers of past hydrological year and previous three hydrological years.
How do the water levels in this year compare to previous years?	Graphs, for the river locations only, showing past hydrological year and three previous hydrological years as well as Max and Min and Mean.
What is the extent of floods? (TDA concludes there is reduced frequency of small floods - this may impact nature)	Pictures of specific flood events, using https://floodmapping.inweh.unu.edu/ for locations and events indicated by SWHC. Flash flood maps will not be included as not available from RSMC Pretoria.
Where and to what extent were there droughts?	Maps of 12 month SPI from SADC Climate Services Centre and maps of 12 month SPEI (from https://spei.csic.es/ but on Thornthwaite instead of Penman-Monteith Evaporation equation as Penman-Monteith not available yet soon after hydrological year).
Which questions to answer?	How will the information be displayed?
What is the status of the gauging network?	List of stations and a classification of currently operational and reference period of available data.

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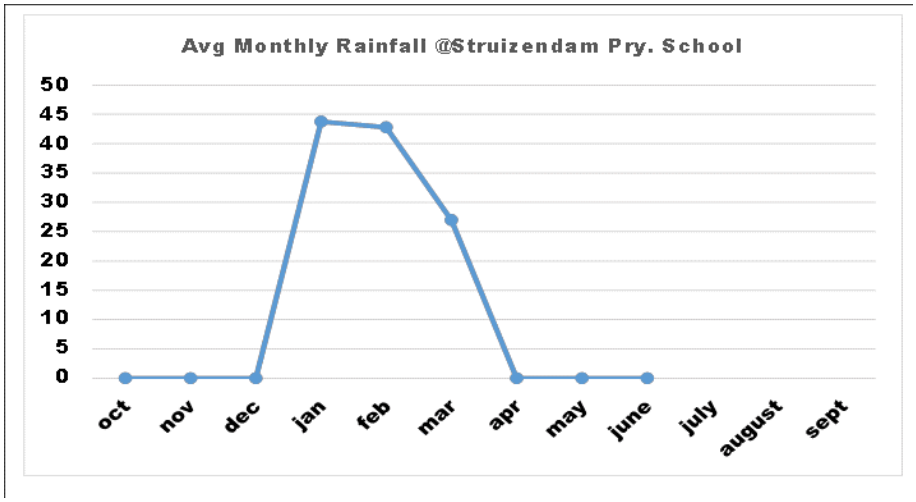
APPENDIX A: PARTICIPANTS IN INTERVIEW SESSIONS

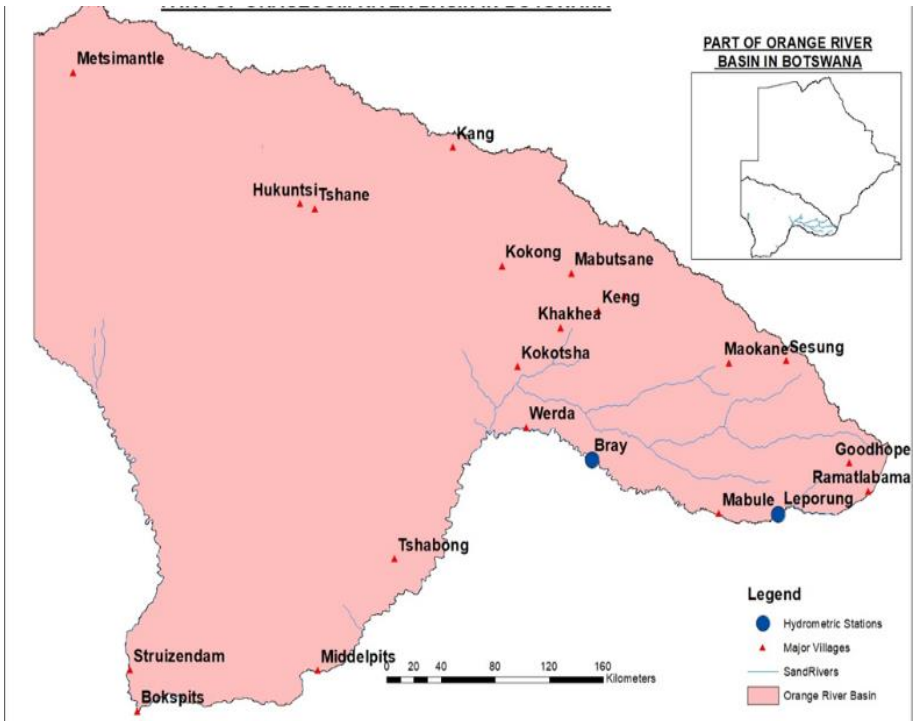
Country	Conditions on data availability
Botswana	• Tshegofatso Mosate (Member SWHC) • Tsholofetso Meshack (Senior water engineer)
Lesotho	• Molefi Pule (Member SWHC)
Namibia	• Alfeus Moses (Member SWHC) • Geraldine Diergaardt (Data Manager) • Helvi Akwenye (Flood expert)
South Africa	• Musariri Musariri (Manager DWS and member SWHC_ • Nemaxwi Phathutshedzo (Responsible for compiling of surface water report) • Dr Portia Leah Mokoena (Production Scientist- Surface and groundwater division)) • Lalumbe Lindelani (Production Scientist- Surface and groundwater division DWS) • Masha Makgwale (Candidate Scientist-Surface water division DWS)

APPENDIX B: SCREEN SHOTS OF INFORMATION IN THE ANNUAL REPORTS

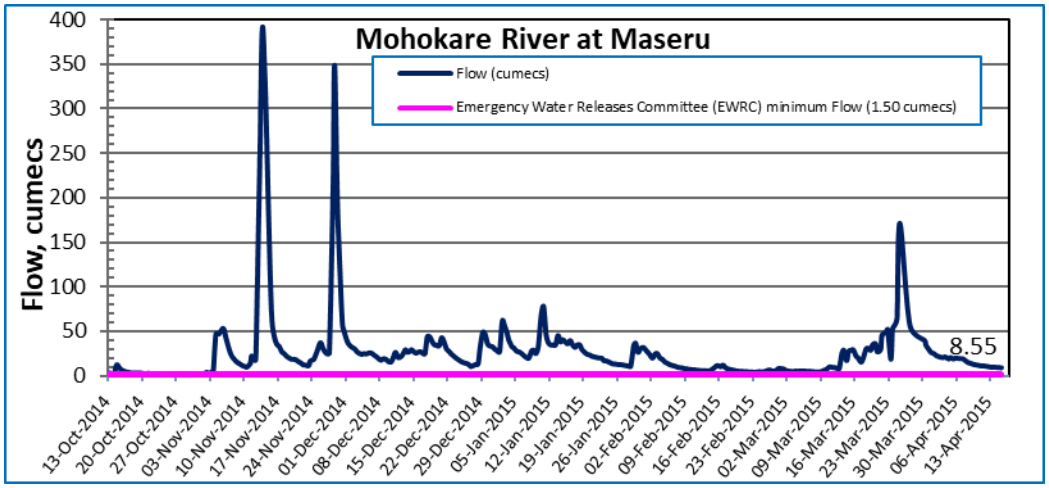
These screenshots are included to possibilities of presenting information.

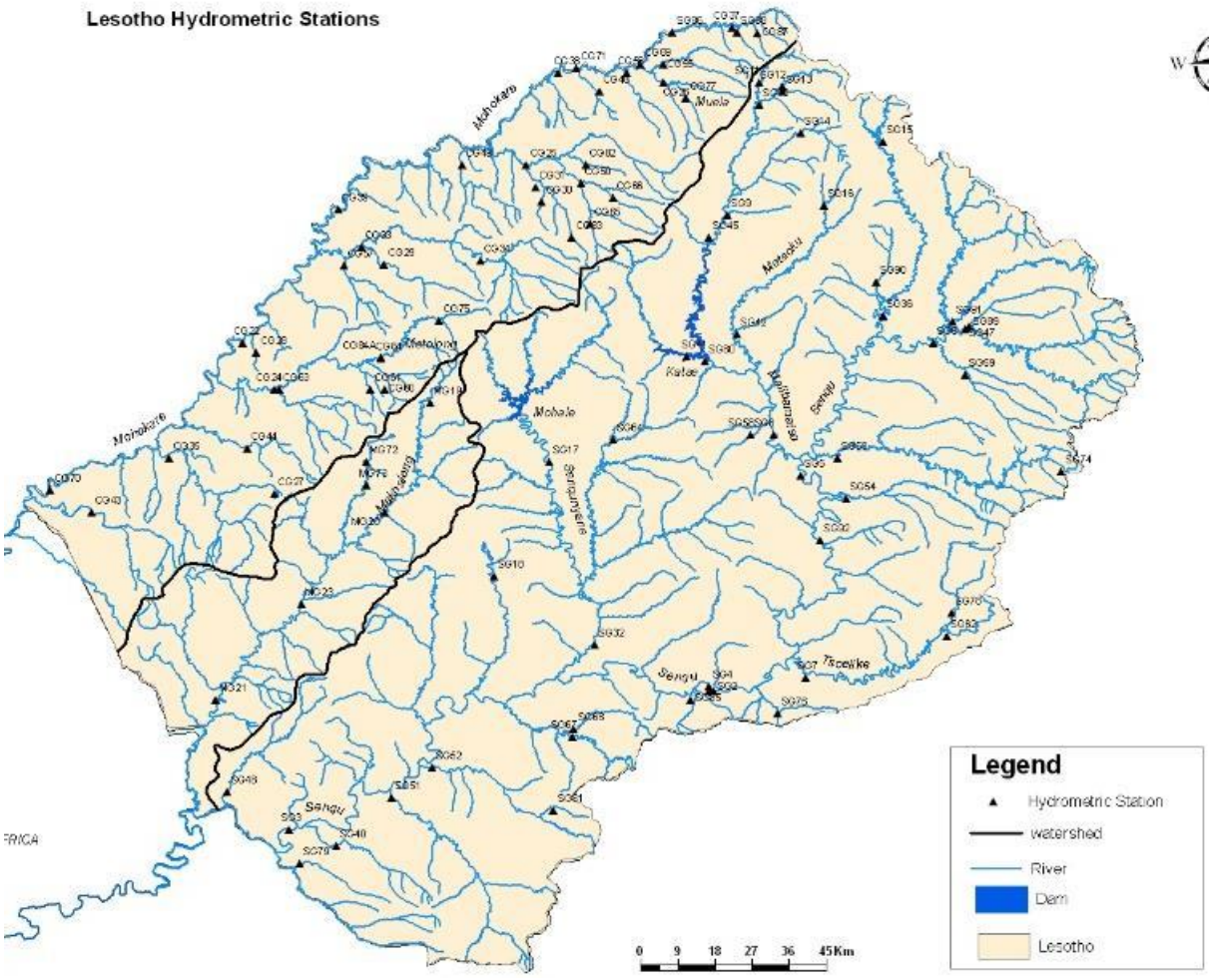
Botswana





Lesotho


Mohokare River at Maseru
Flow (cumecs)
Emergency Water Releases Committee (EWRC) minimum Flow (1.50 cumecs)
Flow, cumecs
400
350
300
250
200
150
100
50
0
8.55
13-Oct-2014
20-Oct-2014
27-Oct-2014
03-Nov-2014
10-Nov-2014
17-Nov-2014
24-Nov-2014
01-Dec-2014
08-Dec-2014
15-Dec-2014
22-Dec-2014
29-Dec-2014
05-Jan-2015
12-Jan-2015
19-Jan-2015
26-Jan-2015
02-Feb-2015
09-Feb-2015
16-Feb-2015
23-Feb-2015
02-Mar-2015
09-Mar-2015
16-Mar-2015
23-Mar-2015
30-Mar-2015
06-Apr-2015
13-Apr-2015


Lesotho Hydrometric Stations
Mohokare
Mohale
Matsoku
Senqu
Legend
Hydrometric Station
watershed
River
Dam
Lesotho
0 9 18 27 36 45Km

Namibia

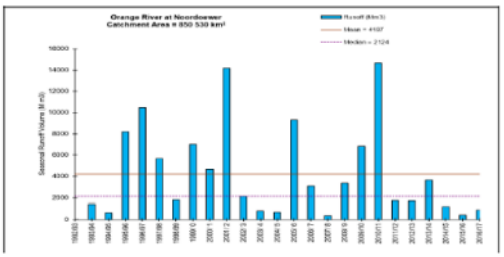


Figure 8.2.1.1: Orange River at Noordoewer

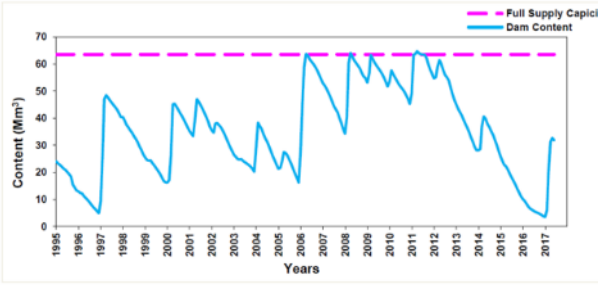


Figure 8.4.1.1: Swakoppoort Dam

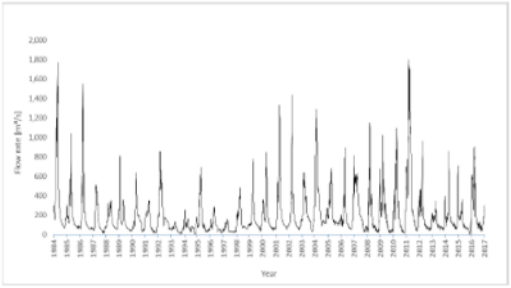
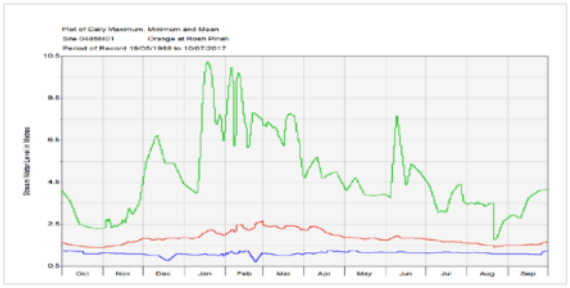
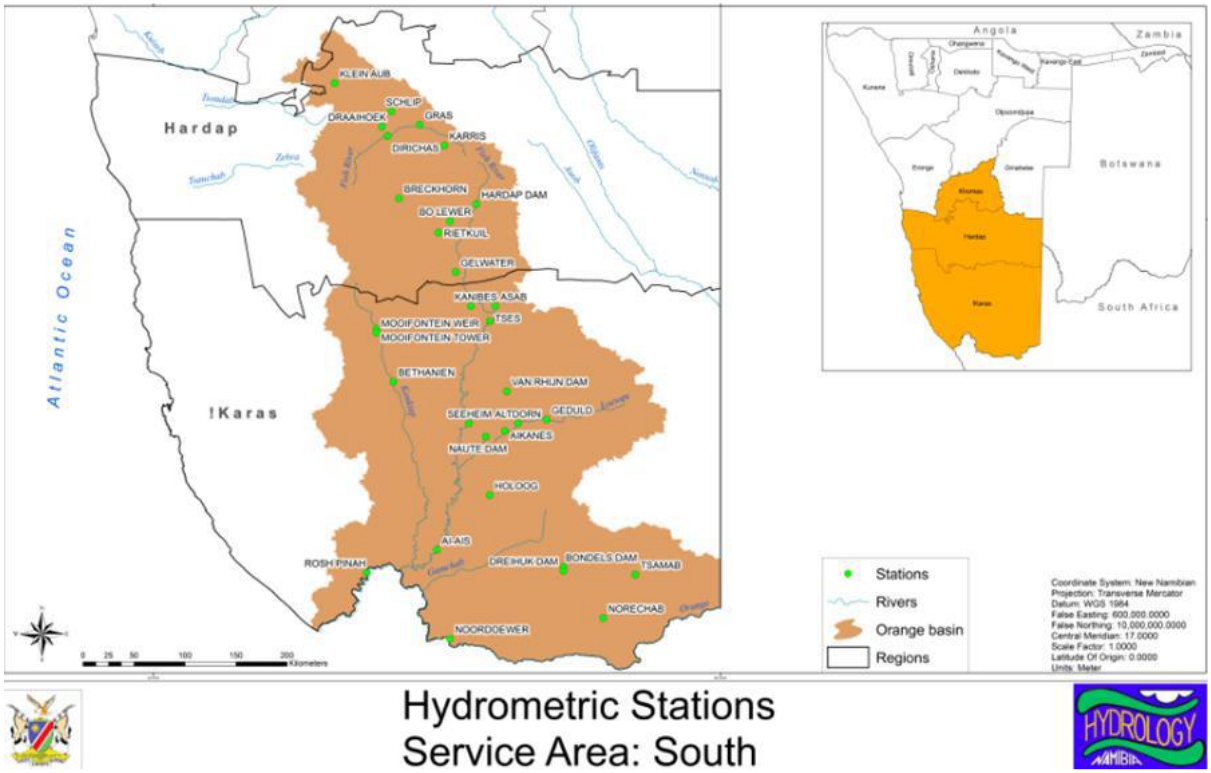


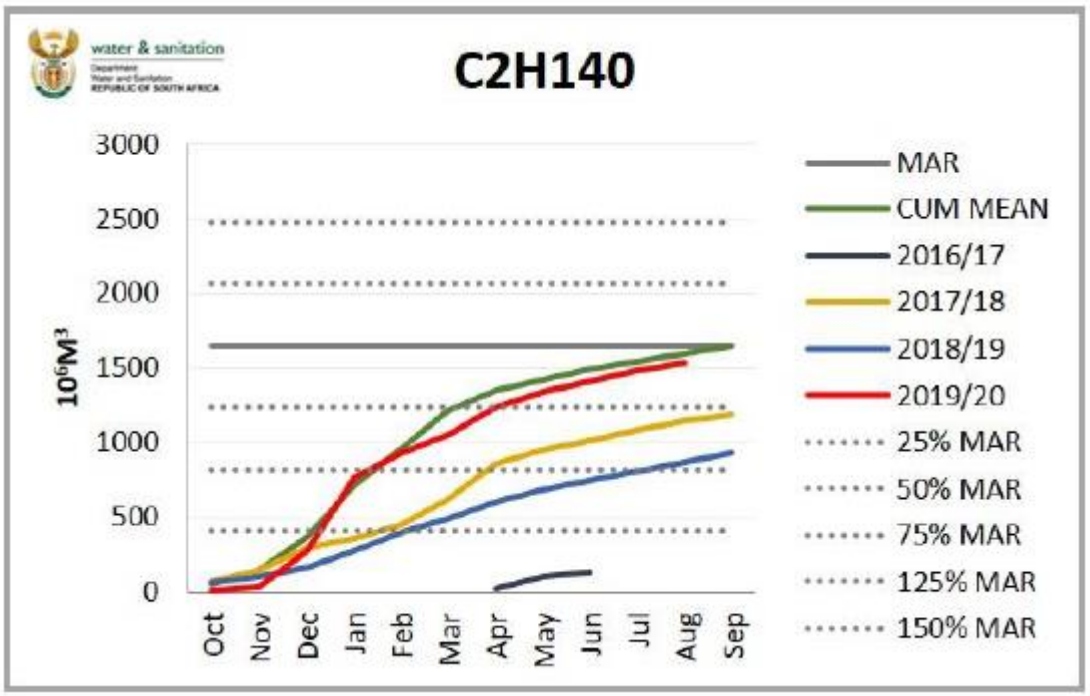
Figure 6.2.2: Flow rates for Kunene river at Ruacana

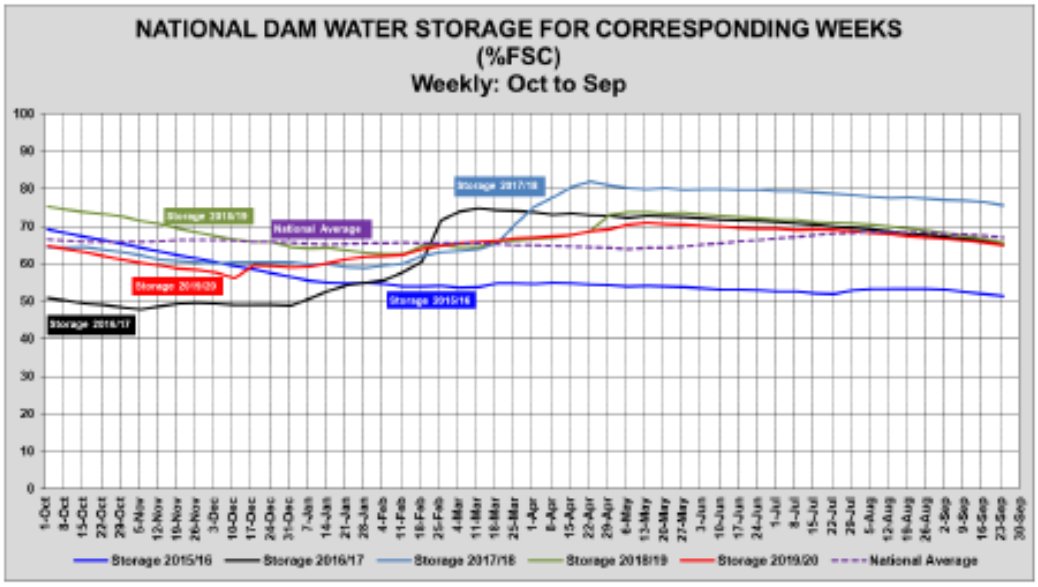




Hydrometric Stations
Service Area: South

South Africa





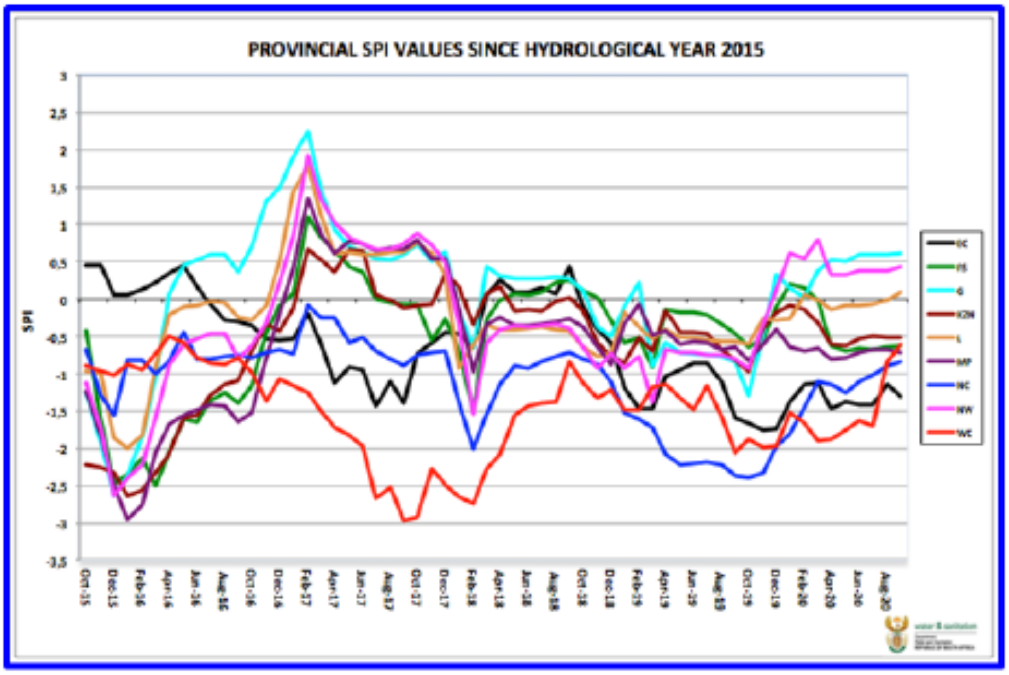
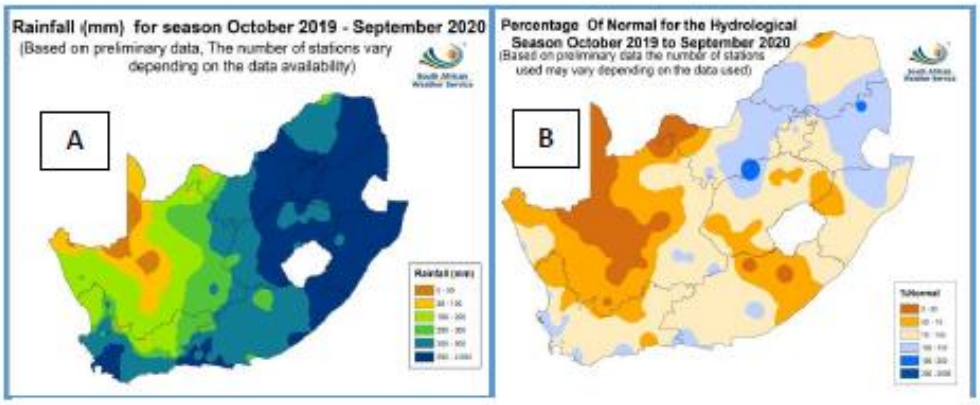


Figure 5 Historical trends of the 12-month SPI



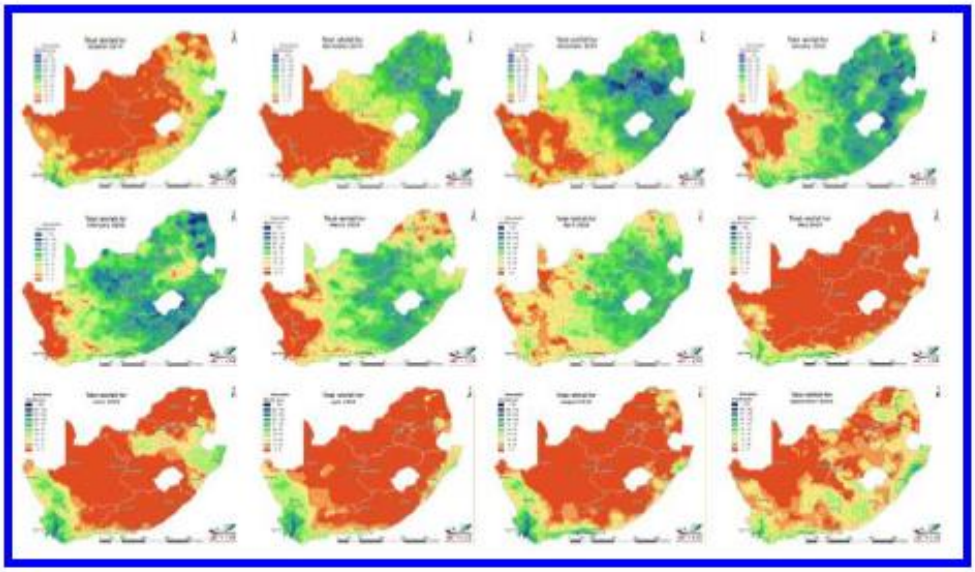


Figure 2 Temporal and spatial patterns of rainfall over the 2019/2020 hydrological year (ARC, 2020)

Mekong River Basin

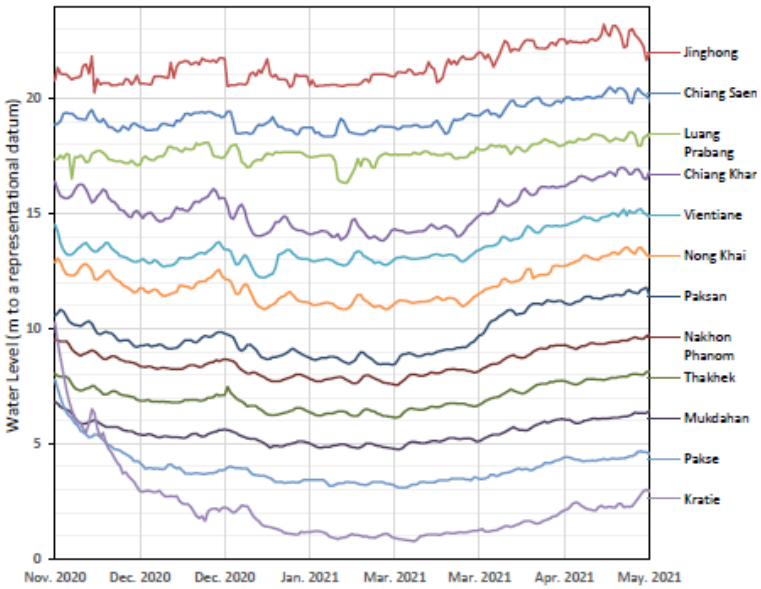


Figure 5. Propagation of daily water level at the main stations for the dry season 2020–2021

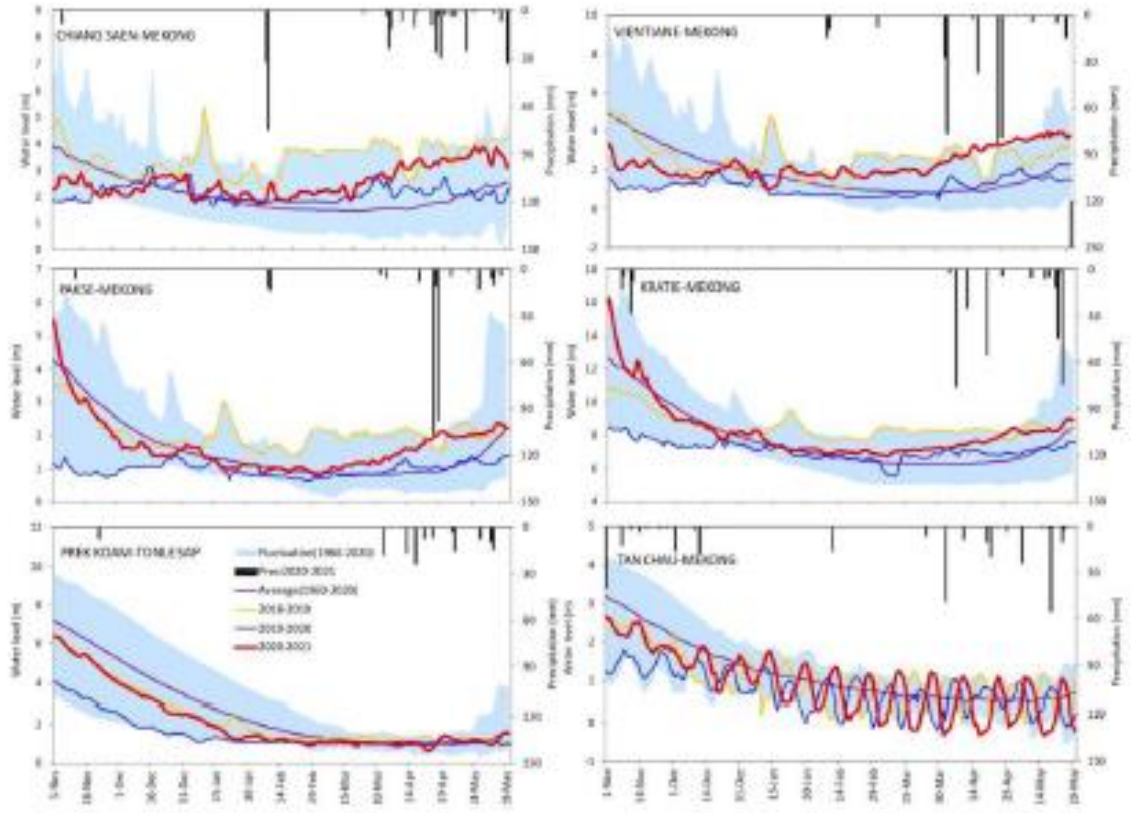


Figure 3. Dry Season Water Level Monitoring at main stations in the Mekong River and in the Tonle Sap Lake (Prek Kdam) for the 2021 dry season

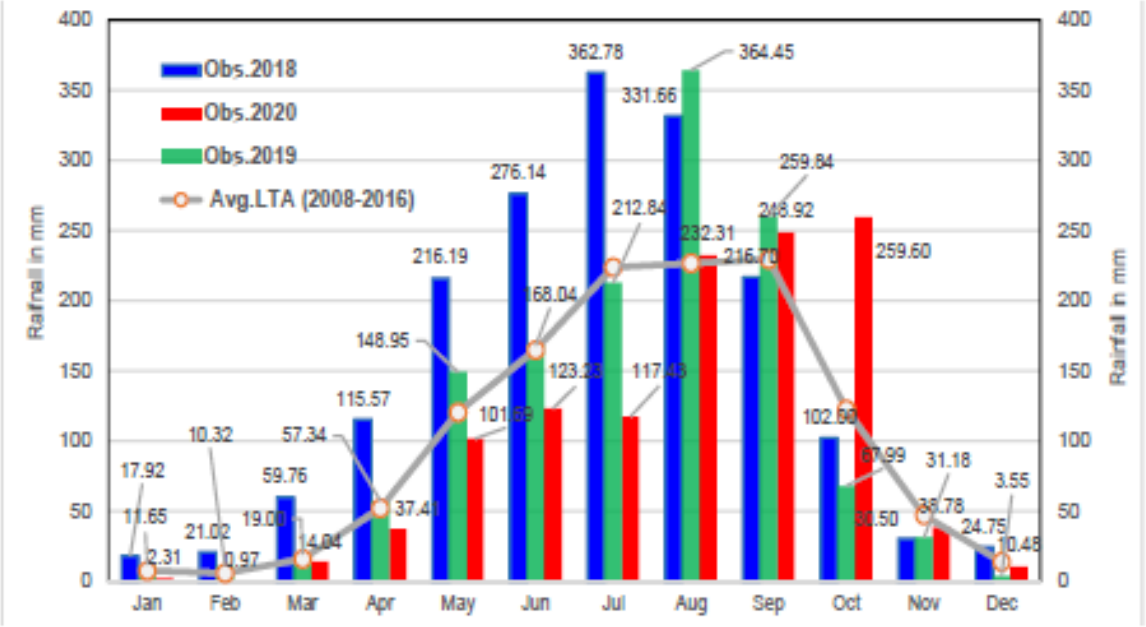


Figure 1. Overall monthly rainfall of 2018–2020 over the LMB, compared to the long-term conditions of 2008–2016 generated and interpolated from 119 stations in the LMB.

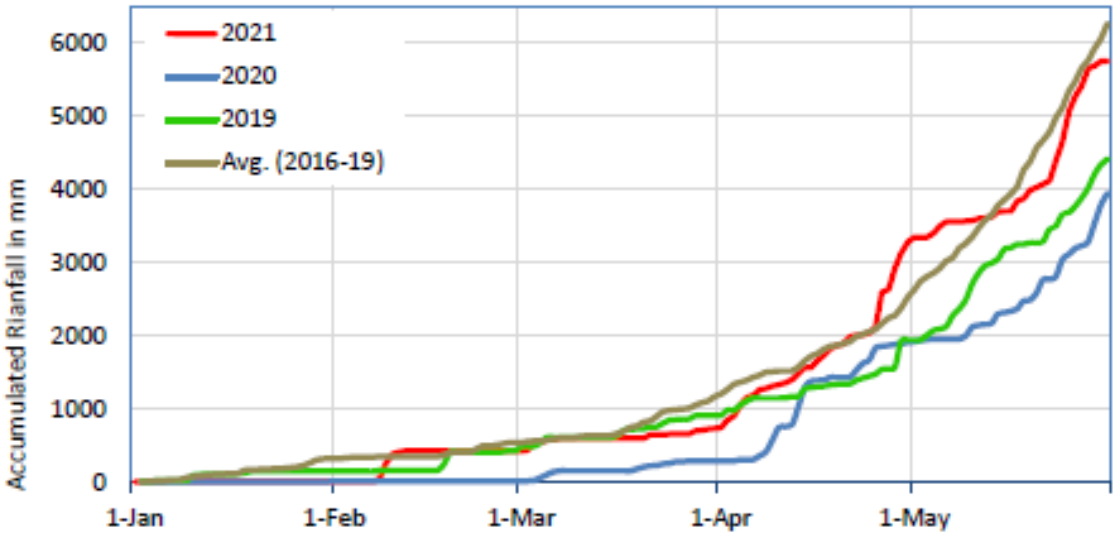


Figure 1. The accumulated rainfall in the Mekong River Basin from January to May, compared with 2019, 2020 and the long-term average

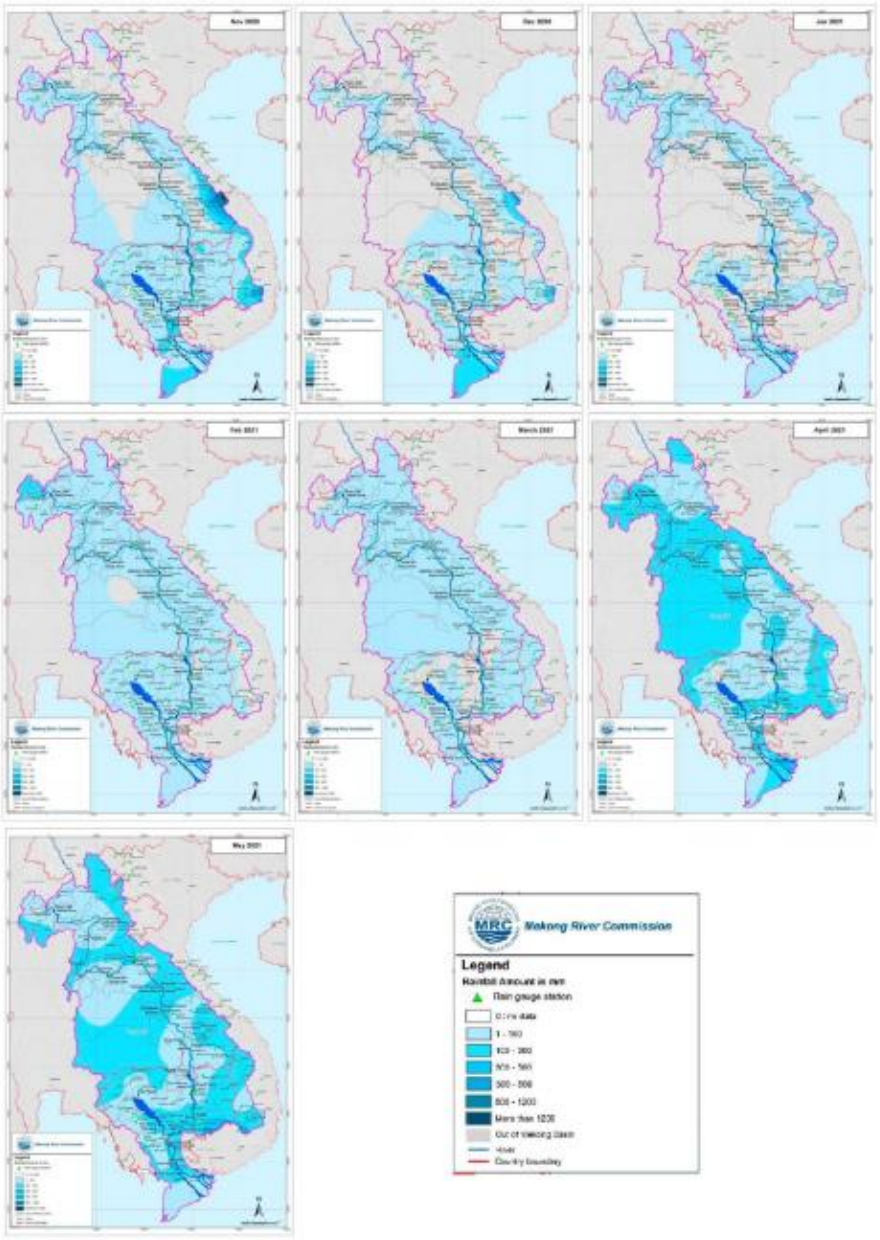


Figure 2. Map of spatial rainfall (mm) for the 2020–2021 dry season

APPENDIX C: ENVIRONMENTAL FLOW REQUIREMENTS

Copied from Louw and Koekemoer (2010). These are presented to show what values are possible to refer to when comparing flows with environmental flows.

Table 1.1 Locality and characteristics of EFR sites

EFR site number	EFR site name	River	Decimal degrees S	Decimal degrees E	EcoRegion (Level II)	Geozone	Altitude (m)	MRU	Quat	Gauge
EFR O1	Hopetown	Orange	-29.516	24.00927	26.01	Lowland	1060	MRU Orange B	D33G	
EFR O2	Boegoeberg	Orange	-29.0055	22.16225	26.05	Lowland	871	MRU Orange D, RAU D.1	D73C	D7H008
EFR O3	Augrabies	Orange	-28.4287	19.9983	28.01	Lowland		MRU Orange E	D81B	D7H014
EFR O4	Vioolsdrif	Orange	-28.7553	17.71696	28.01	Lowland	167	MRU Orange F	D82F	D8H003 D8H013
EFR C5	Upper Caledon	Caledon	-28.6508	28.3875	15.03	Lower Foothills	1640	MRU Caledon A/B	D21A	
EFR C6	Lower Caledon	Caledon	-30.4523	26.27088	26.03	Lowland	1270	MRU Caledon D	D24J	
EFR K7	Lower Kraai	Kraai	-30.8306	26.92056	26.03	Lowland	1327	MRU Kraai C	D31M	D1H011
EFR M8	Molopo Wetland	Molopo	-25.8812	26.01592	11.01	Lower Foothills	1459	MRU UM C	D41A	D4H030 D4H014

Table 24.3 Natural and PD MARs of the EFR sites

Site	NATURAL MAR	Present MAR
EFR O2	10573.7	4629.6
EFR O3	10513.1	4628.5
EFR O4	10335.1	3906.8
EFR C5	56.904	±56.904
EFR C6	1347.96	1134.948
EFR K7	682.5	641.292
EFR M8	10.33	4.42

Table 24.4 Summary of results as a percentage of the natural MAR

EFR site	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
		(%nMAR)	MCM	(%nMAR)	MCM	(%nMAR)	MCM	(% nMAR)	MCM
Virgin MARs									
EFR O2	PES/REC	11.6	1226.55	4.4	465.24	5.4	570.98	15.2	1607.20
	AEC↓: D	5.8	613.27	3.1	327.78	5	528.69	11.3	1194.83
EFR O3	PES: C	8.4	883.10	2.6	273.34	4.7	494.12	11.9	1251.06
	REC: B	17.6	1850.31	3.4	157.37	4.7	494.12	19.2	2018.52
	AEC↓: D	4.1	431.04	2.2	231.29	4.4	462.58	9	946.18
EFR O4	PES: C	6.3	651.11	0.9	35.16	4.2	434.07	8.9	919.82
	REC: B/C	10.1	1043.85	1.3	134.36	4.2	434.07	12.2	1260.88
	AEC↓: D	3.1	320.39	0.8	31.25	3.8	392.73	6.9	713.12
EFR C5	PES/REC: C/D	13.8	7.85	5.8	3.30	11.4	6.49	26	14.80
EFR C6	PES/REC: D	8.8	118.62	0.3	3.40	10.5	141.54	20.1	270.94
	AEC↑: C	15.5	208.93	2.2	29.66	13.1	176.58	26.1	351.82
EFR K7	PES/REC: C	11.4	77.81	0	0.00	8.4	57.33	18.1	123.53
	AEC↑: B	16.5	112.61	1.2	7.70	8.4	57.33	21.8	148.79
	AEC↓: D	5.1	34.81	0	0.00	7.1	48.46	12.9	88.04

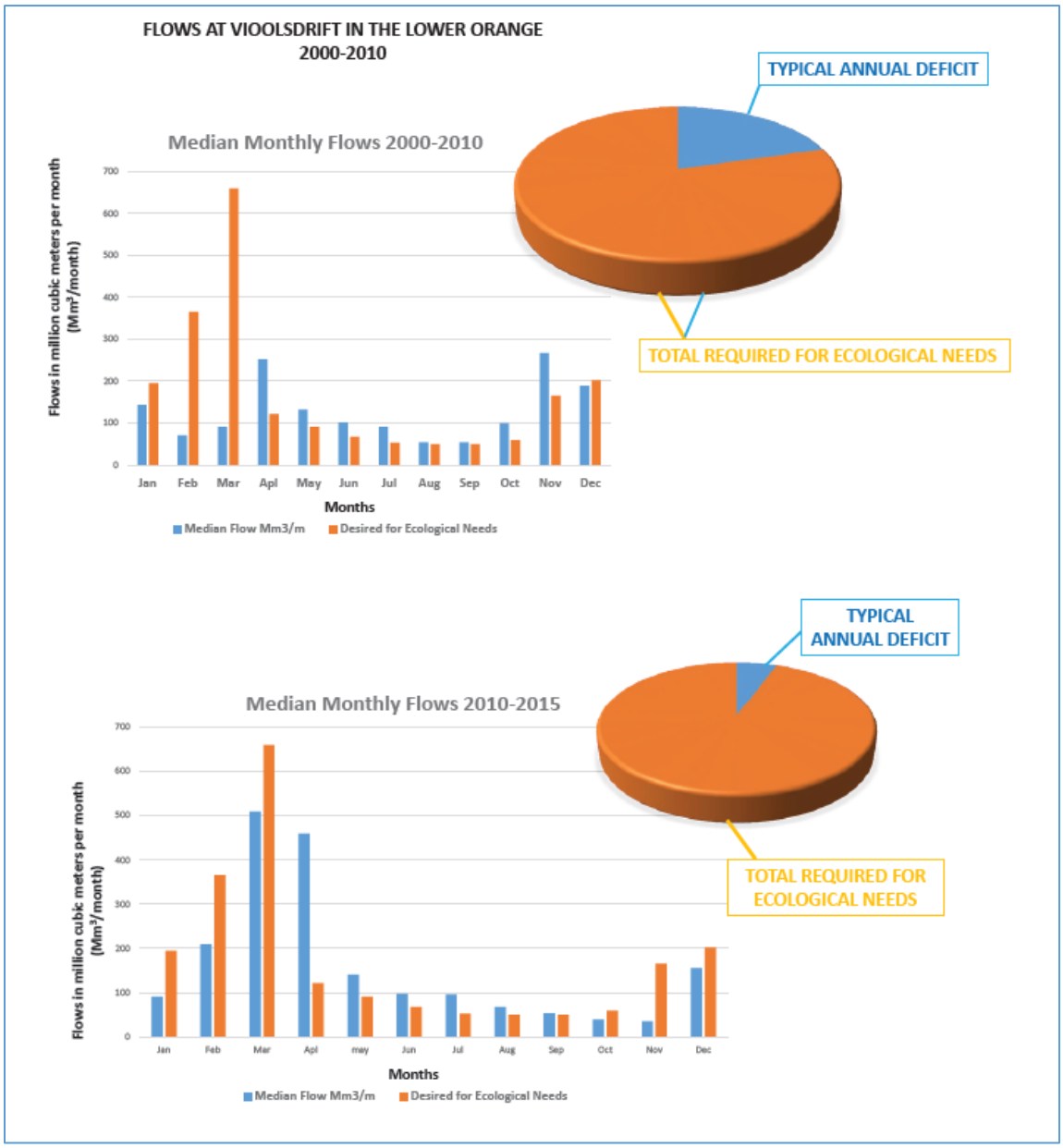
Table 12.11 EFR O4: Assurance rules for REC: B/C

Desktop Version 2, Printed on 2010/11/05
Summary of IFR rule curves for: EFRO4 Natural Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type: Vaal REC = B/C

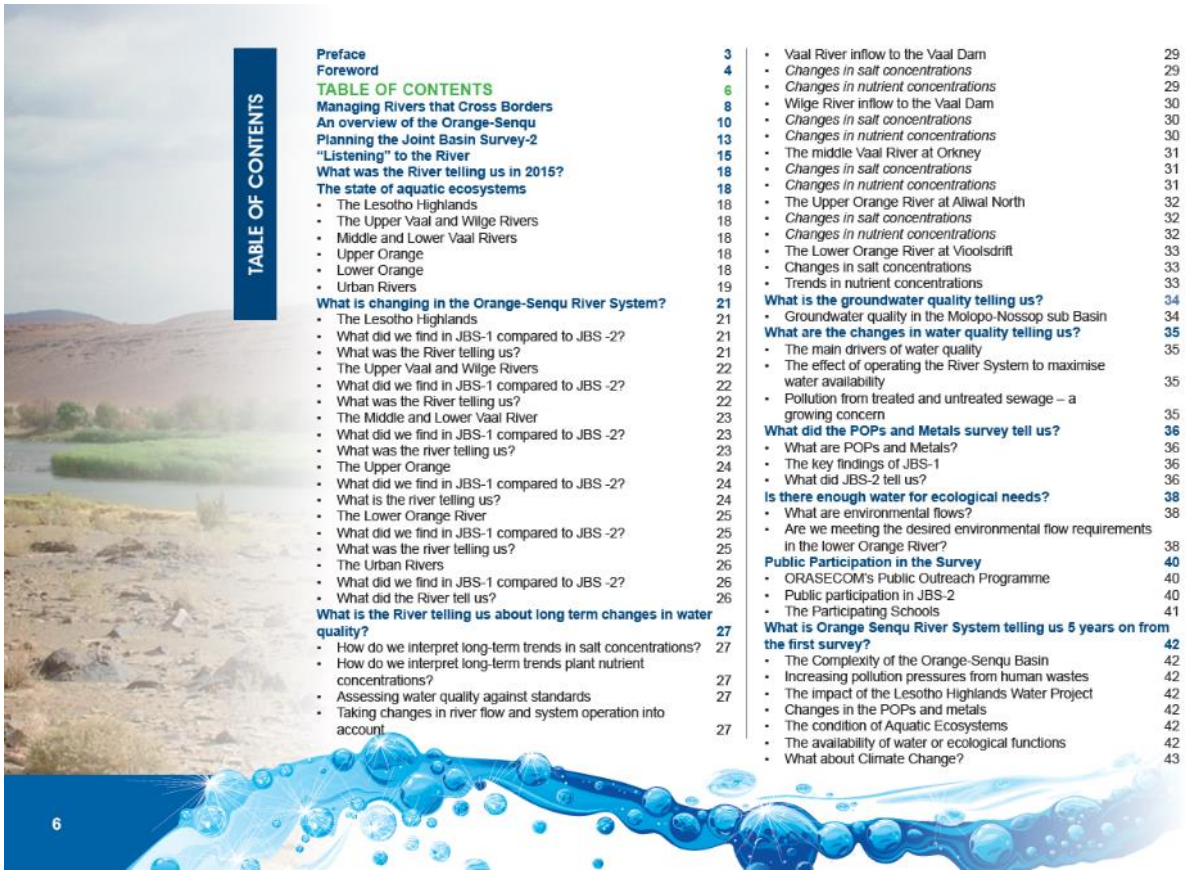
Data are given in m^3/s mean monthly flow

% Points										
Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	31.766	31.447	30.704	29.141	26.200	21.373	14.701	7.399	1.800	0.000
Nov	74.473	69.078	63.966	58.310	48.043	39.468	27.617	14.645	4.699	0.000
Dec	86.512	77.922	69.818	60.962	46.615	35.624	23.222	12.514	6.096	4.514
Jan	85.724	78.848	71.898	63.615	50.112	38.119	24.586	12.902	5.899	4.173
Feb	163.354	142.077	122.406	102.019	72.867	54.170	36.795	24.502	18.278	16.843
Mar	161.737	157.177	147.634	130.898	106.645	78.140	51.650	32.909	23.419	21.231
Apr	61.069	59.224	55.363	48.591	38.778	27.243	16.525	8.942	5.102	4.217
May	44.994	44.266	42.629	39.424	34.059	26.559	18.097	10.790	6.411	5.332
Jun	34.071	33.550	32.377	30.081	26.237	20.865	14.802	9.568	6.431	5.658
Jul	29.066	28.816	28.233	27.005	24.697	20.908	15.672	9.940	5.546	4.289
Aug	26.878	26.632	26.059	24.852	22.582	18.855	13.705	8.068	3.746	2.509
Sep	26.715	26.506	26.061	25.162	23.454	20.449	15.694	9.267	2.218	0.000
Reserve flows without High Flows										
Oct	31.766	31.447	30.704	29.141	26.200	21.373	14.701	7.399	1.800	0.000
Nov	42.999	42.567	41.562	39.445	35.465	28.930	19.900	10.015	2.437	0.000
Dec	43.684	42.929	41.228	37.900	32.328	24.540	15.750	8.162	3.614	2.493
Jan	53.204	52.277	50.189	46.103	39.263	29.702	18.913	9.597	4.015	2.639
Feb	70.452	68.578	64.656	57.777	47.808	36.092	25.204	17.501	13.601	12.701
Mar	69.789	67.935	64.055	57.251	47.392	35.803	25.034	17.415	13.557	12.667
Apr	61.069	59.224	55.363	48.591	38.778	27.243	16.525	8.942	5.102	4.217
May	44.994	44.266	42.629	39.424	34.059	26.559	18.097	10.790	6.411	5.332
Jun	34.071	33.550	32.377	30.081	26.237	20.865	14.802	9.568	6.431	5.658
Jul	29.066	28.816	28.233	27.005	24.697	20.908	15.672	9.940	5.546	4.289
Aug	26.878	26.632	26.059	24.852	22.582	18.855	13.705	8.068	3.746	2.509
Sep	26.715	26.506	26.061	25.162	23.454	20.449	15.694	9.267	2.218	0.000
Natural Duration curves										
Oct	617.290	332.064	230.880	156.915	96.778	68.504	49.507	27.274	11.092	0.000
Nov	905.096	654.931	482.554	354.171	236.273	209.336	152.365	119.425	40.860	0.000
Dec	1002.860	704.824	522.461	396.565	321.263	280.369	194.437	95.456	63.937	4.734
Jan	1252.087	913.206	628.491	503.655	376.613	288.986	208.748	153.655	77.326	24.190
Feb	2063.864	1293.461	898.313	539.790	424.611	305.035	260.007	213.802	119.444	29.882
Mar	1577.203	1023.167	701.430	596.027	472.200	331.343	242.742	190.181	116.629	31.851
Apr	906.879	629.217	411.092	322.631	281.034	241.238	171.188	117.909	67.948	21.323
May	352.830	259.244	192.753	127.412	104.600	78.995	66.577	42.641	28.902	5.619
Jun	188.345	136.535	87.346	72.380	58.627	51.979	39.182	30.687	18.326	9.340
Jul	144.710	97.420	86.962	63.045	43.037	34.353	28.491	22.073	14.490	10.215
Aug	145.128	108.639	79.648	58.830	44.194	30.727	21.408	16.637	11.036	5.238
Sep	218.835	114.934	75.656	54.063	38.171	28.546	20.455	10.683	2.218	0.000

Depiction of comparing flows in State of Rivers report (2015) with environmental flows:


FLOWS AT VIOOLSDRIFT IN THE LOWER ORANGE
2000-2010
Median Monthly Flows 2000-2010
Flows in million cubic meters per month (Mm³/month)
Jan Feb Mar Apl May Jun Jul Aug Sep Oct Nov Dec
Months
Median Flow Mm3/m
Desired for Ecological Needs
TYPICAL ANNUAL DEFICIT
TOTAL REQUIRED FOR ECOLOGICAL NEEDS
Median Monthly Flows 2010-2015
Flows in million cubic meters per month (Mm³/month)
Jan Feb Mar Apl may Jun Jul Aug Sep Oct Nov Dec
Months
Median Flow Mm3/m
Desired for Ecological Needs
TYPICAL ANNUAL DEFICIT
TOTAL REQUIRED FOR ECOLOGICAL NEEDS

APPENDIX D: SET UP STATE OF RIVERS REPORT



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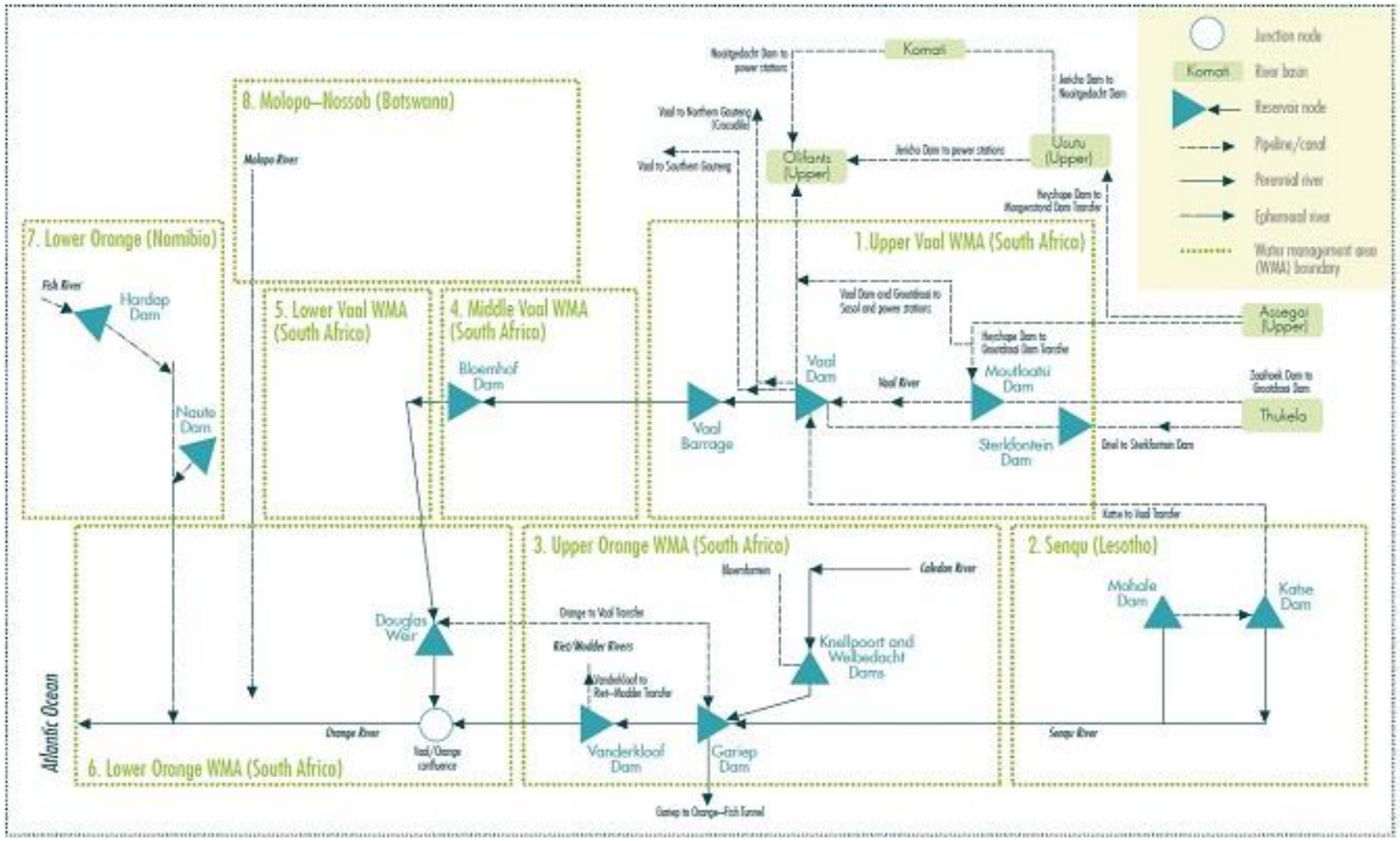
APPENDIX E: OVERVIEWS OF BASIN

Copied from ORASECOM (2012)



Copied from UNDP – GEF (2012)

Copied from Haasbroek et al. (2011)