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Drought mitigation for water security: Interim Operating Rules for the Lower Olifants River

Progress and Reflection Report: September to November 2016

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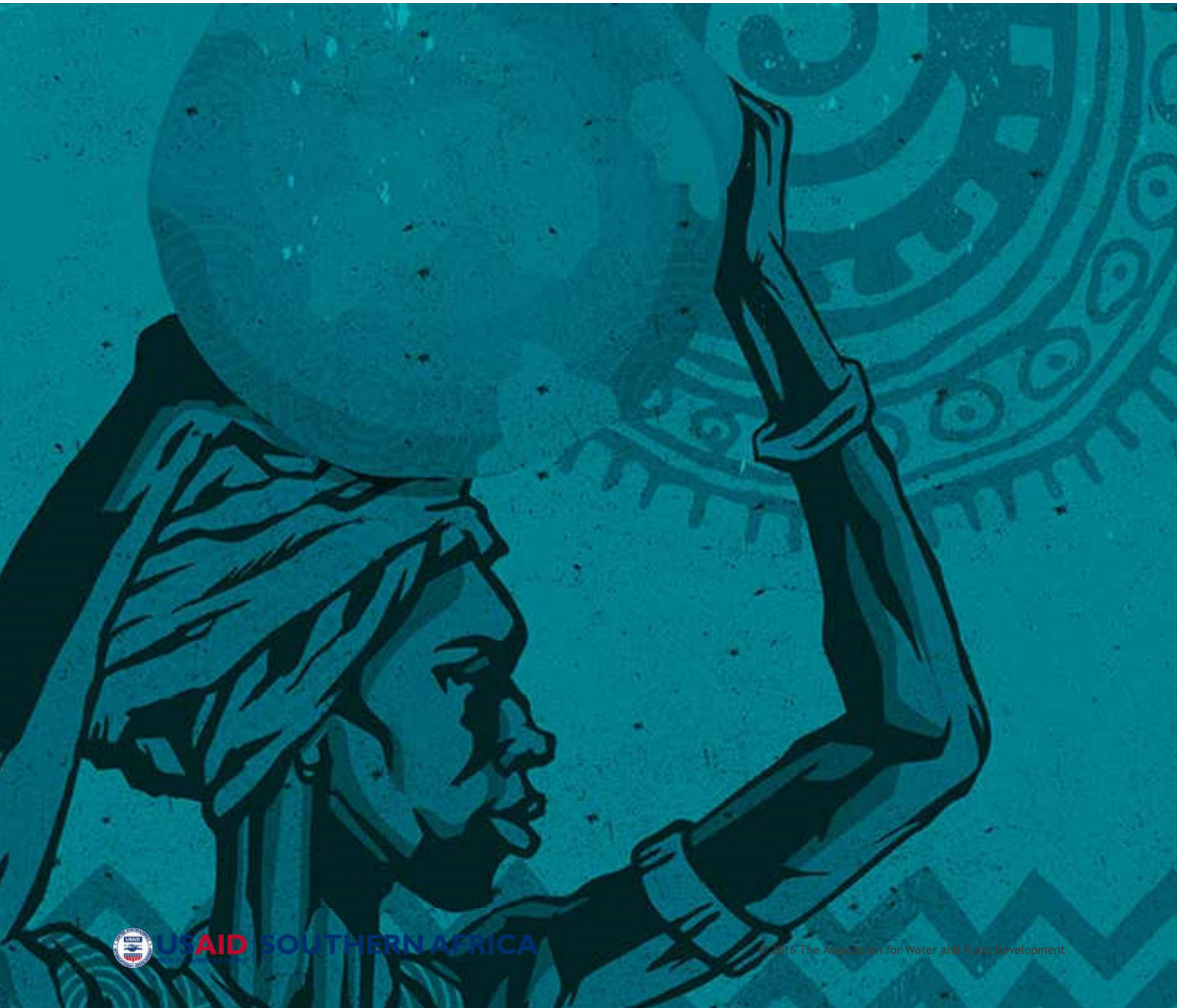

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Executive summary

Despite excellent legislation associated with the National Water Act (1998), the Olifants River is regularly non-compliant with the legal requirements of the Reserve and environmental water requirements (EWR). Serious concerns were raised in January 2016 when the flow of the Olifants River at Mamba weir (B7H015) dropped close to 1$m^3s^{-1,}$ representing **less than 25% of the EWR** at 99% assurance. Collaborative efforts and rapid response through the LOROC with includes KNP, AWARD, DWS and Lepelle Northern Water (LNW) managed to reverse the declining trend. Following agreement from DWS Act. DG to shift some of LNW demands from the Blyde to De Hoop Dam, flow releases were determined using the AWARD/RESILIM-O De-Hoop release model. These were tested and adjustments were made accordingly. In the main, compliance with the Reserve requirements was met from 23rd September to 18th October 2016. As part of the process, agreements were also secured from commercial farmers for no uptake of the additional flows. Post release sampling indicated significant improvements in water quality and riverine health within the KNP. This indicates that such a management system can greatly improve IWRM for the Olifants under extreme stress conditions. These are anticipated to increase under climate change. This report summarises progress and lessons.

1. Background

Despite excellent legislation associated with the National Water Act (1998), the Olifants River is regularly non-compliant with the legal requirements to meet the Reserve[1]. The Reserve provides water to meet basic human needs and also includes the Ecological Reserve (sometimes called the EWR[2]), which is critical in maintaining longterm river health so as to provide freshwater services to those dependent on it and flows into Mozambique. In the Olifants River there are a number of EWR sites where compliance with the Reserve is measured. In 2005 the Olifants River stopped flowing for 78 days which created major challenges for sustainable water management in the Olifants Catchment and for river health. In the lower Olifants, non-compliance compromises the Kruger National Park and transboundary flows.

Given this history, the extreme drought conditions linked to the El Nino of 2015-16 was of particular concern for water resources management. Serious concerns were raised in January 2016 when the flow of the Olifants River at Mamba weir (B7H015) within the KNP dropped close to 1 m^3s^{-1}. This value was alarming since it represented **less than 25% of the EWR** at 99% assurance (i.e. the drought 4.3 m^3s^{-1}). In response a technical committee was established between key sectors in the lower Olifants region, including the Department of Water & Sanitation (DWS; Water Resources Planning System & Olifants proto-CMA), Lepelle Northern Water[3], Kruger National Park[4], AWARD[5] (RESILIM-Olifants), Ara-Sul[6], Phalaborwa Mining Complex[7] and local municipalities and water user associations. This is now established as the Lower Olifants River Operations Committee (LOROC).

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[1] Set and gazetted through the Reserve Determination process
[2] EWR – Environmental Water Requirements
[3] Lepelle Norther Water is a water board under the Water Services Act. It operates the Phalaborwa Barrage which abstracts water from the Olifants River for the Ba-Phalaborwa Municipality and for the mines. Its raw water allocation is 64,000 Ml/a. Present consumption is estimated at 25,000 (domestic) and 15,500 Ml/a (industrial). Releases are made from the Barrage to meet the Environmental Water Requirements
[4] The KNP monitors the flow and EWR status of all the Lowveld rivers
[5] AWARD through the RESILIM-O programme (funded through USAID), monitors flows and EWR status along the Olifants River. Through the 5-year RESILIM-O, AWARD supports good governance of the Olifants Catchment, both in Mozambique and South Africa
[6] Ara-Sul is the Catchment Management Agency in Mozambique that is responsible for the Limpopo Basin (amongst others)
[7] This complex comprises Palabora Mining Co., Foskor Ltd. and Bosveld Phosphates (industry)

The LOROC was initially established as an emergency technical committee to alleviate river flow and water supply challenges during drought in the lower Olifants River, it has through this process developed a terms of reference for operational water resources management as endorsed by the Olifants proto-CMA. This in order to provide collaborative decisions and responses to flow and water quality issues especially in times of extreme stress such as that currently being experienced. Such responsivity is an essential element of strategic adaptive management particularly given that conditions of extreme drought and flood are more and more likely under predictions from climate change (downscaled GCM for the Lowveld at Phalaborwa; AWARD, internal report 2016).

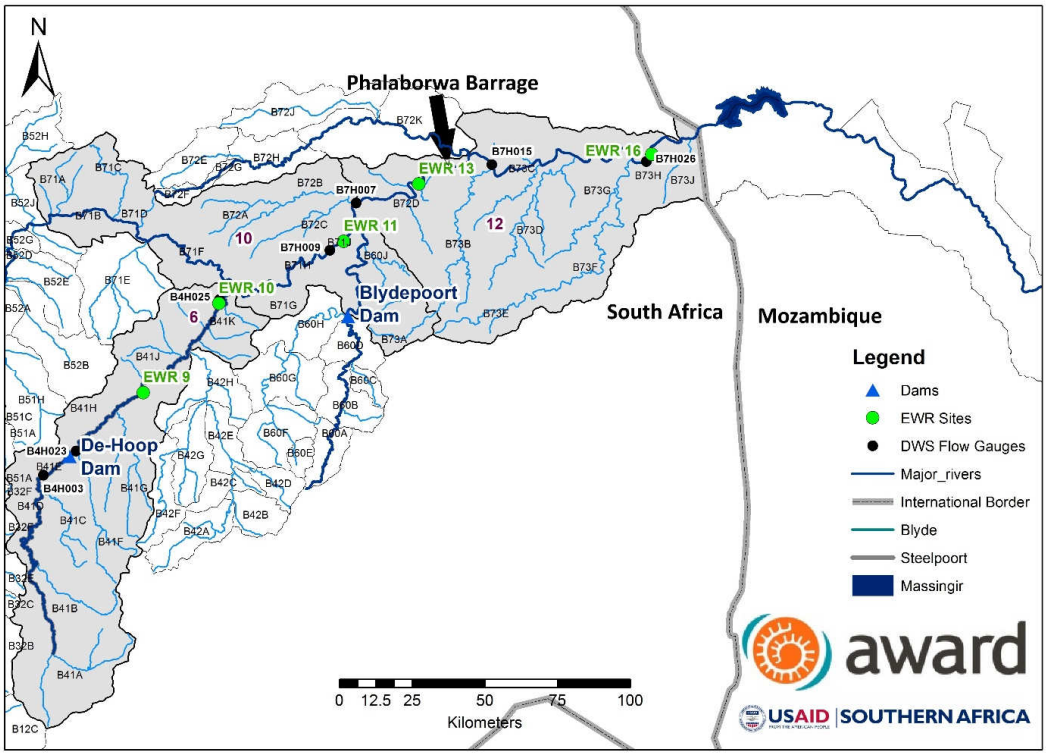

Figure 1 The Lower Olifants River Basin. The key EWR sites (where compliance against nationally determined benchmark can be monitored) that are near a gauge station are indicated. Flows at EWR 16, as the most downstream site, effectively drive the EWR system. Note that B7H015 (Mamba) is the gauge against which EWR compliance is tracked

Table 1 Key gauges and EWR sites

Gauge number	Gauge name	EWR site	River	Comment
B4H023	De-Hoop Release	EWR9	Steelpoort	Key to track releases volume from De-Hoop
B4H025	Taung	EWR10	Steelpoort	Key to track losses and lag time from De-Hoop along the Steelpoort
B7H009	Finale	EWR11	Olifants	Key weir however weir not functional
B7H007	Oxford	EWR13	Olifants	Key weir to advise if releases need to be increased from De-Hoop
B7H015	Mamba	EWR13	Olifants	Key weir to track flows to ensure sufficient flow is being released from the barrage to meet EWR at Balule (B7H026)
B7H026	Balule	EWR16	Olifants	Key weir to track compliance as well as cross-border flows to Mozambique

2. Overview of process and progress

Given this background the LOROC subsequently proposed the following which were approved by the Acting Director-General (Mr Sifiso Mkhize) of DWS in July 2016.

- The provision of technical support to shift some or all of LNWs demand from the Blyderivierspoort Dam (Blyde Dam) to the De Hoop Dam in extreme circumstances, in order to reduce the pressure on the Blyde Dam. The proviso was that the shift to De Hoop would reduce pressure on Blyde and offer a buffer for the commercial agricultural sector along the Blyde River for the 2016-2017 growing season, and water supply to Maruleng Local Municipality at a high level of assurance (a re-examination of the management options was deemed crucial since the Blyde Dam is also required to contribute a portion of the EWR to the lower Olifants).
- The use of the Decision-Support System (DSS) developed through the RESILIM-O programme (see above) to provide operational support for releases from the De Hoop Dam for multiple users downstream. This is based on the WReMP model (Mallory et al, 2013), which has already been used by DWS.
- The implementation of the 2011 Blyde river operating rules, and an interim operating rule for De Hoop Dam, noting that the dam itself was having a potential impact on the natural baseflow of the Steelpoort River.
- The establishment of a technical team to track a short controlled release (or "slug pulse") from De Hoop Dam to examine the effectiveness of controlled releases for meeting downstream targets (Phalaborwa Barrage, KNP, Flows into Mozambique) in conditions such as these.

The drought mitigation releases were initiated from de Hoop Dam on 23rd September 2016 with a 3 m^3s^{-1} release and was subsequently increased to 3.8 m^3s^{-1} on 14th October 2016 (see later). The rains of early November 2016 brought some relief and requests were made to reduce releases to 1.6 m^3s^{-1}on the 14th November 2016 (based on the Naturalised Duration Curve[8]).

The purpose of this report is to provide an overview of the process and progress and a reflection on the benefits accruing from this intervention. We reflect on its utility in practice and on the potential to embed it with operational integrated water resources management in the Lower Olifants Catchment.

3. Status and lessons learnt

3.1. Reflections on hydrology – lags and other assumptions

The interim operating rule for De Hoop dam used an estimate of 5-7 days lag between De Hoop Dam and the Oxford/Mica gauge (B7H007; see Figure 1). It was quite clear from the first releases that the lag in the Olifants system is considerably less than expected, at approximately 2.5 - 3 days (Figure 2). This has been an important learning outcome, and therefore reveals the benefits of using De Hoop for intermittent augmentation as hydrological conditions vary. In addition, at first there was a concern that there may be unaccounted-for losses due to upstream irrigated agriculture (see Figure 3), and this was included in the

[8] Naturalised data are often used for assessing yields, low flow extremes or trends where there are artificial influences on river flows. This ensures that the analysis represents the flow regime of the catchment rather than the artificial influences which are often highly variable

modelling. The overall losses, based on observed data, between De Hoop Dam and Oxford Weir (Figure 1) for the period (23rd September to 18th October) were estimated at 30%. The Steelpoort River accounted for 10.9% of these losses. Calculating the losses for the Lower Olifants River is hampered by two issues (a) constraints to determining the contributions from Flag-Boshielo Dam reaching the Lower Olifants and (b) lack of data on the contribution from Blyde River. Overall the majority of flows observed at Oxford (B7H007; Figure 4), fell within the range of 1.981 to 2.625 m^3s^{-1}. This was sufficient to meet Lepelle's requirement of their allocated 1.3 m^3s^{-1}, as well as maintaining flows downstream of the barrage at Mamba (B7H015) where the majority of flows ranged between 1.356 to 2.199 $m^3.s^{-1}$ (see Figure 4). This falls within the 50th percentile of flows historically observed at B7H015 (Figure 5).

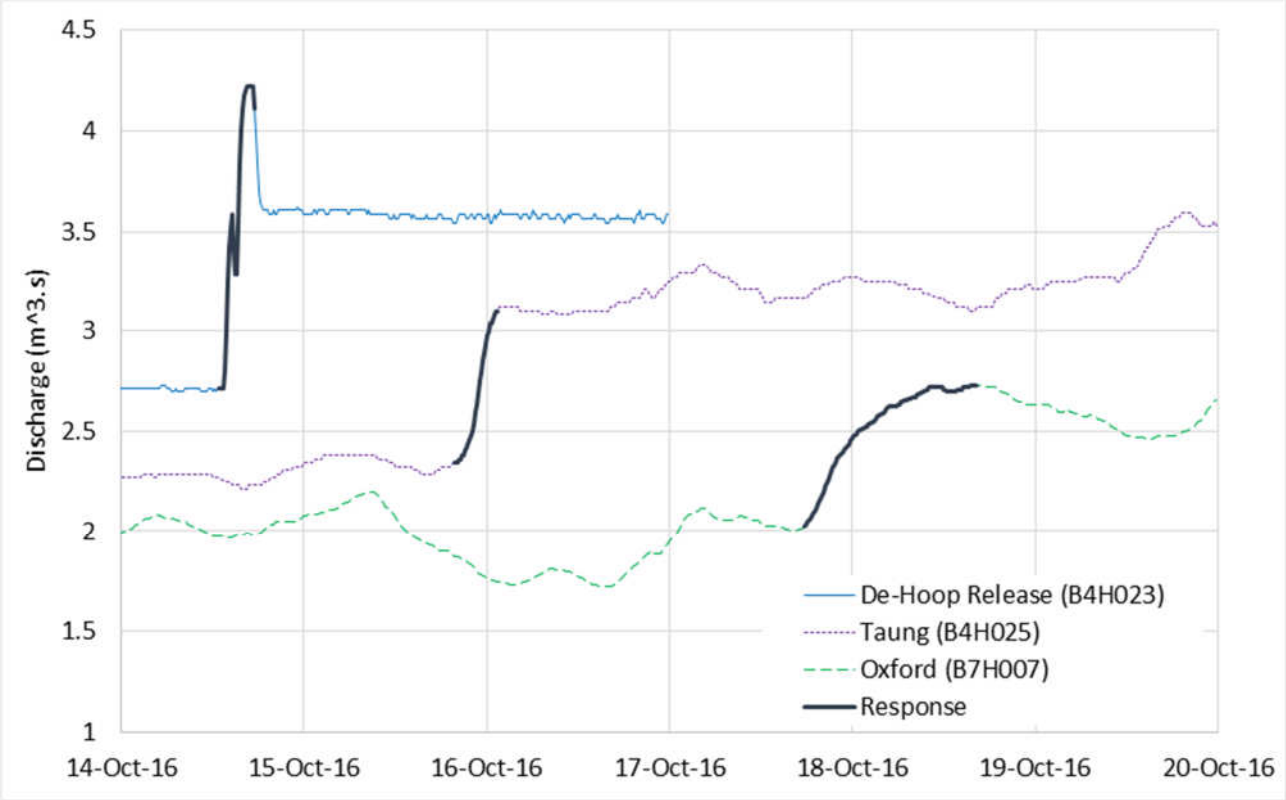

Figure 2 Hydrological responses at key gauging stations in the lower Olifants River over the seven-day period that was used to assess the delays between de Hoop and Oxford and losses. The solid line tracks the same flow 'pulse' or release as it moves down the system

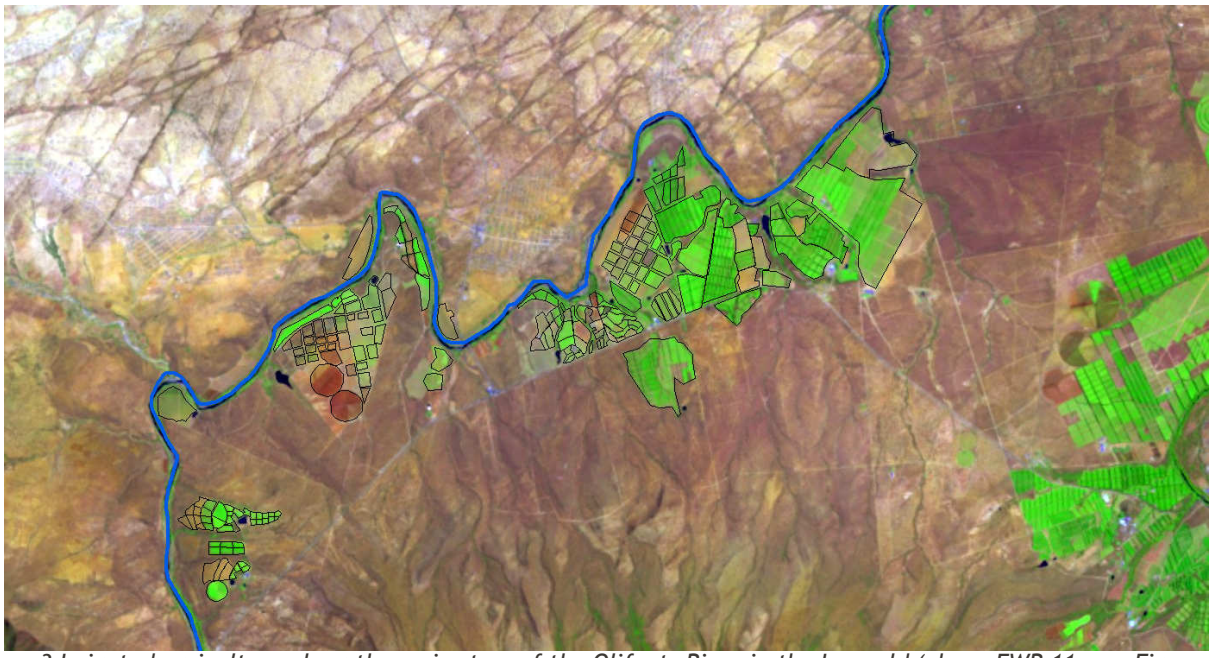

Figure 3 Irrigated agriculture along the main stem of the Olifants River in the Lowveld (above EWR 11, see Figure 1) upstream of Hoedspruit town and the Oxford Weir (B7H007)

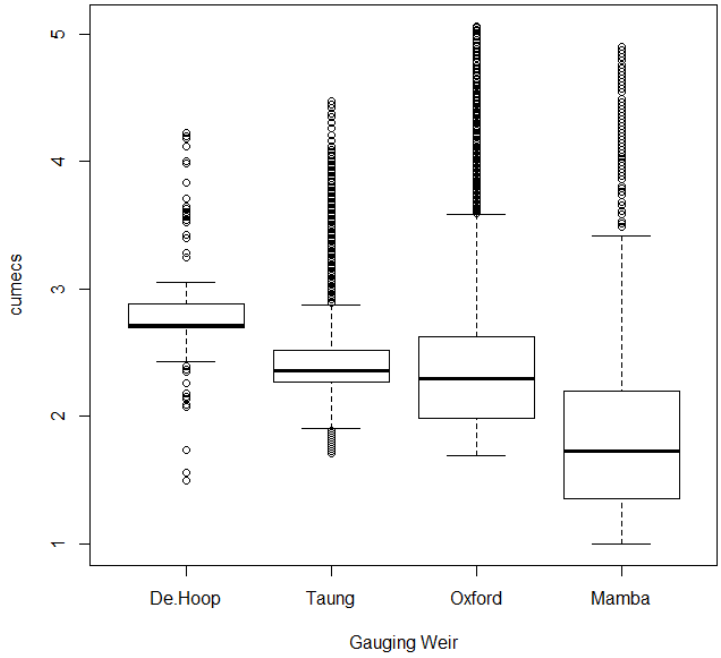

Figure 4 Boxplots representing the range of flows observed at each of the gauging weirs De-Hoop Release (B4H023), Taung (B4H025), Oxford (B7H007) and Mamba (B7H015) between the 23rd September 2016 and 18th October 2016.

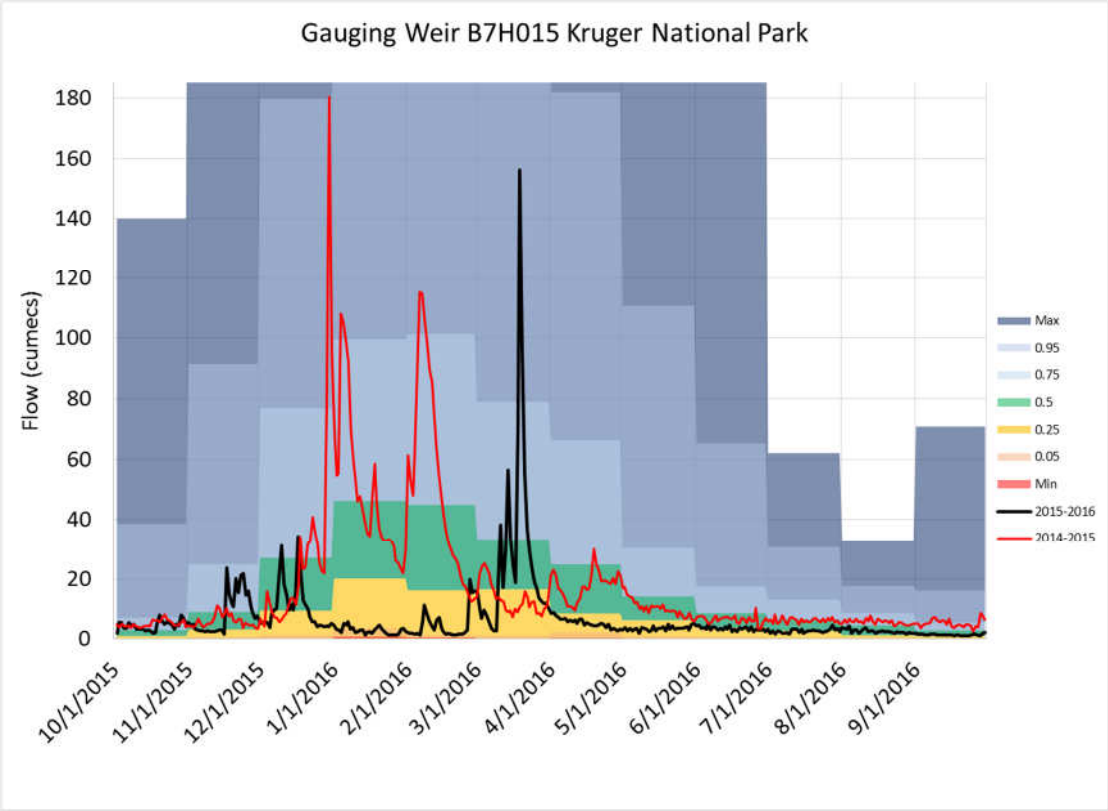

Figure 5 Verified flow observed at gauging weir B7H015 (Mamba Weir) for the hydrological years 2014-2015 and 2015-2016, plotted together within the range of historically observed flows (percentiles).

3.2. Environmental Water Requirements

Compliance with the EWR in the Lower Olifants has been a serious challenge during 2016 as a result of the drought conditions (Figure 5), particularly in January and February. Although flows were largely compliant during most of the winter months, non-compliance was evident with the onset of warm and dry spring conditions from mid-August onwards. With flow augmentation from De Hoop Dam there was quite clearly a recovery in the situation from late September until the time of writing (early December 2016). Although in early November the RESILIM-O early warning was triggered, likely due to non-compliance with the EWR the 99% assurance requirements shifted from 2.15 m^3s^{-1} to 2.98 m^3s^{-1} for October and November, respectively, it was decided not to request additional releases because the seasonal and weekly forecasts suggested rainfall, this did result in the catchment receiving average rainfall for November and inducing the first freshets.

Thus a key benefit of meeting Lepelle's needs was that it facilitated compliance with EWRs, at least to some degree.

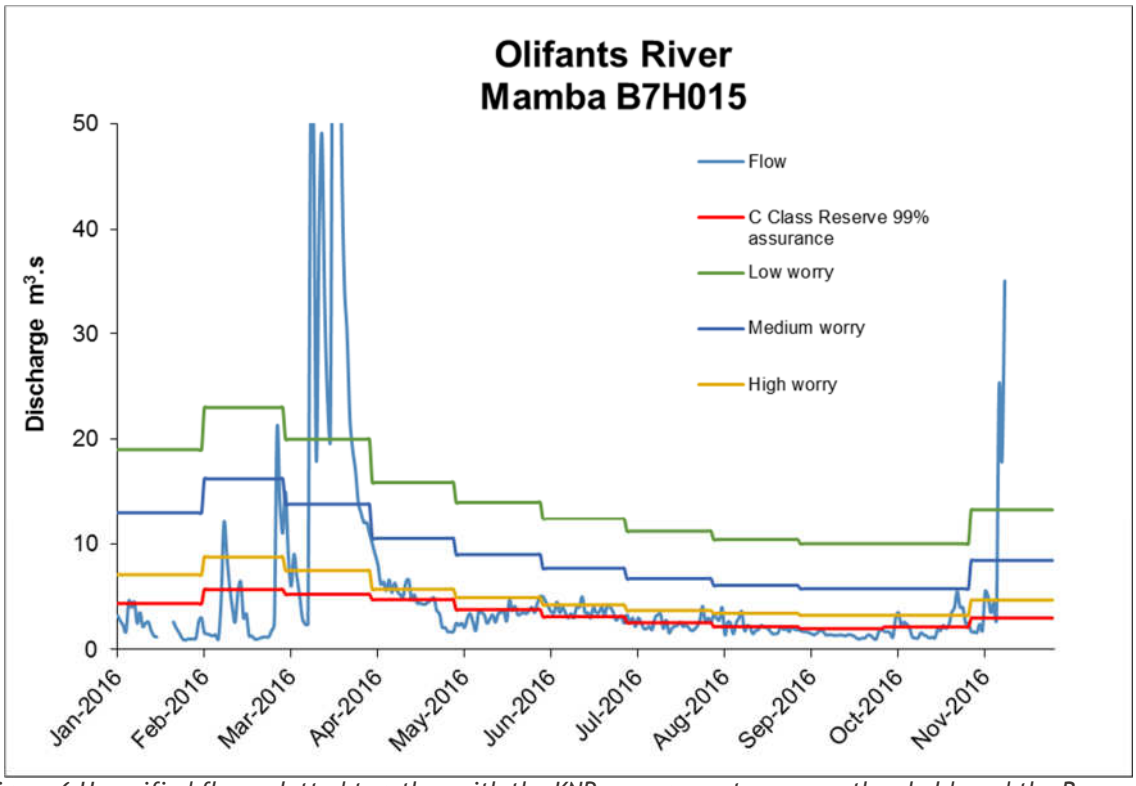

Figure 6 Unverified flows plotted together with the KNP management response thresholds and the Reserve.

Flows were then plotted together with Thresholds of Concern (TPCs) that are used by the KNP to elicit certain management responses (Figure 6). This is useful in that it indicates that whilst flows hovered around compliance for a C Class Reserve, they consistently fell within a 'high worry' category for the KNP. This highlights the importance of monitoring and of the ability to respond rapidly as has been demonstrated by the De Hoop release exercise reported here.

3.3. Water Quality and Biotic Response

In order to assess the impacts of the releases on riverine health, AWARD conducted biomonitoring assessments pre and post the releases from De Hoop Dam (week of 19th September and 21st October respectively). These indicated significant improvements in water quality (TDS; EC) and biotic responses as follows.

Water quality

The results for electrical conductivity measured pre and post the first release from De Hoop Dam are shown in (Figure 7). Although there was a notable decrease in salinity following the dam release, this was expected as the Steelpoort River has a significant dilution effect on the Olifants River. This finding is supported by a previous study during the Middle Olifants South Africa (MOSA[9]) sampling initiative where samples were taken both upstream and downstream of the Olifants/Steelpoort confluence (see Figure 8) to determine the dilution effect that the Steelpoort River has on the main stem of the Olifants River (±42.5% reduction in sulphate concentrations).

9 http://www.southafrica.diplo.de/Vertretung/suedafrika/en/08__Science__Environment/Science/Res__coop/MOSA-IWRM-SA-II.html

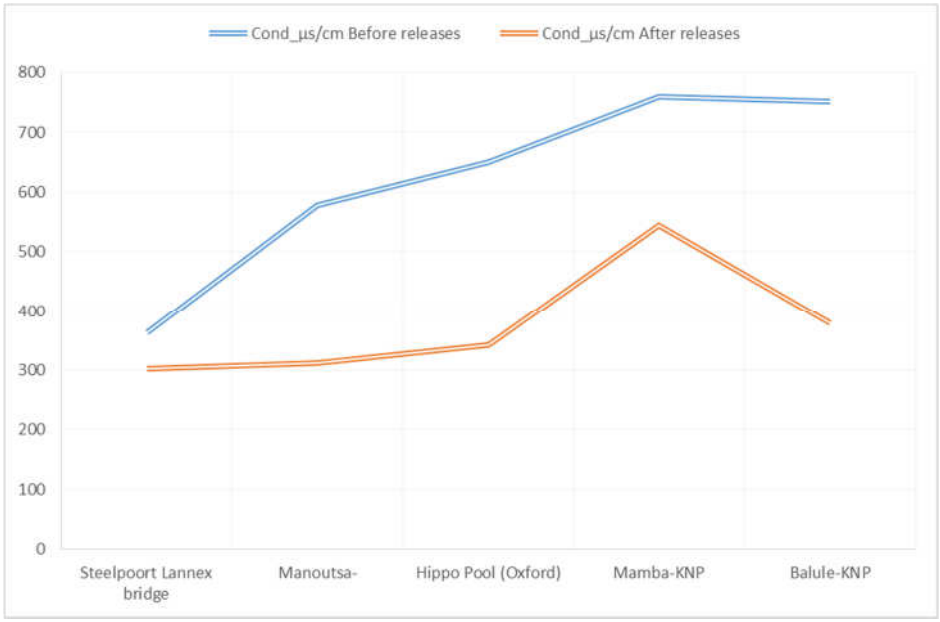

Figure 7 Longitudinal salinity profile from the Steelpoort to the most downstream site, Balule Weir (B7H026) in Kruger National Park. (Manoutsa - B7H009, EWR 11).

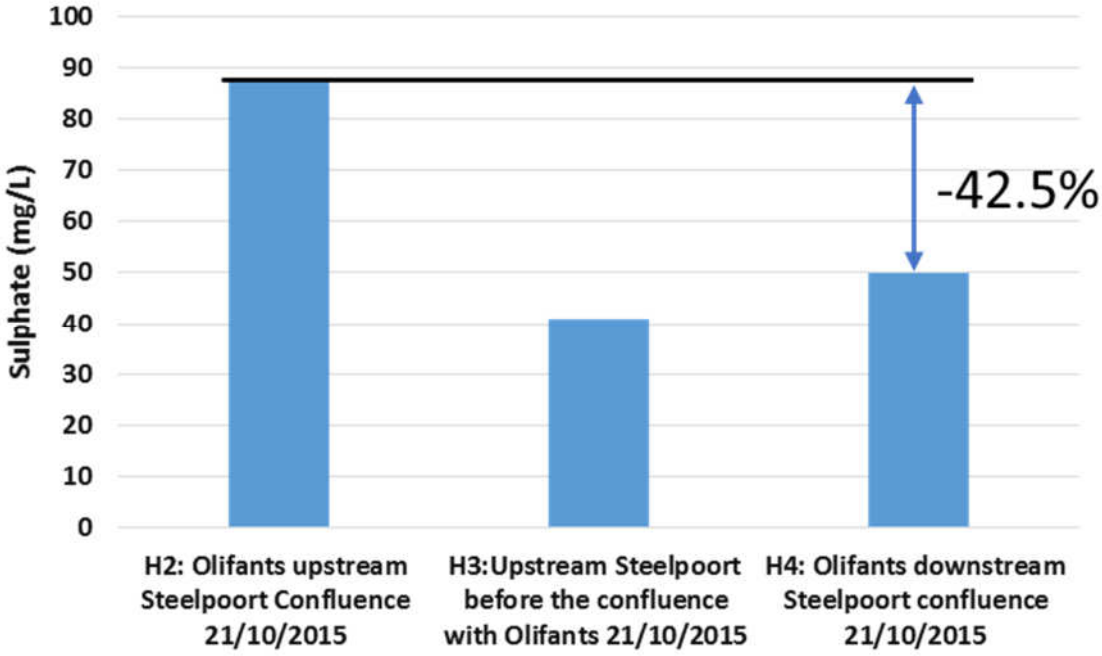

Figure 8 Data from the MOSA project (see text) showing sulphate concentrations for the Olifants/Steelpoort confluence measured on the 21st of October 2015. H2 is Olifants, H3 on Steelpoort and H4 after their confluence. This indicates the dilution effect of the Steelpoort on the main stem of the Olifants River

Biotic Response

The De Hoop Dam releases undoubtedly had a positive impact on the invertebrate populations immediately downstream especially within the Kruger National Park (Figure 9). The nearly two-fold SASS score increase at Mamba Weir and Balule indicates a significant increase in biodiversity (at family level) from the releases as shown in Figure 9. This probably reflects improved water quality and most likely, major improvements in habitat (see Figure 10 and 11).

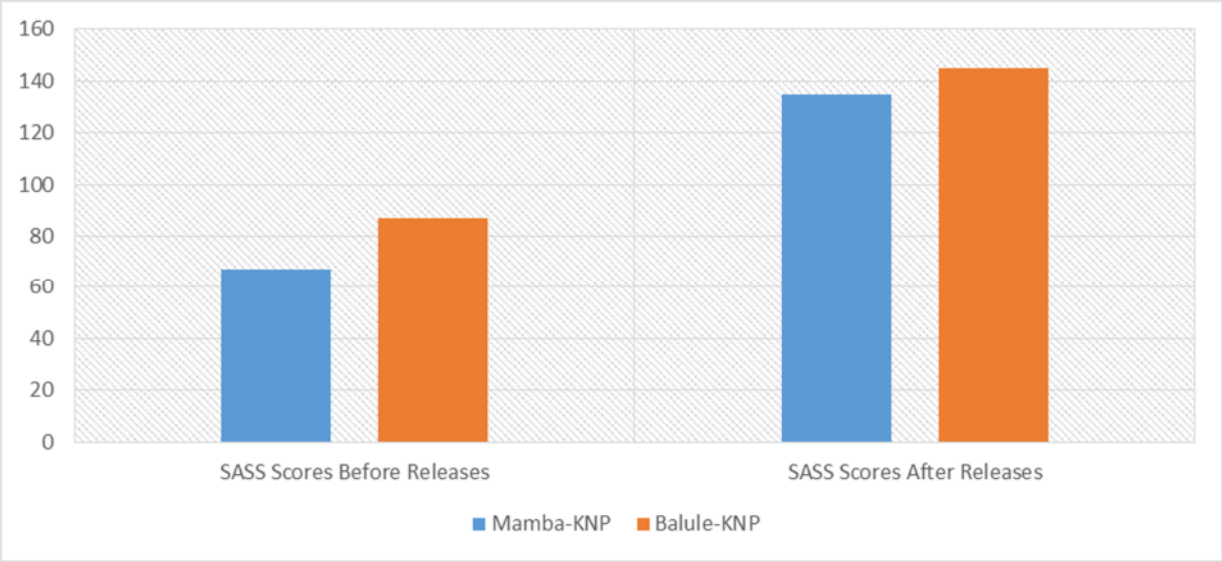

Figure 9 SASS scores before and after De-Hoop dam releases were made

Figure 10 Flow at Balule in KNP before De-Hoop releases were made (<0.4 cumecs)

Figure 11 Flow at Balule in KNP two weeks after the first De-Hoop dam release was made

4. Strengthening Co-operative Governance: Feedback from stakeholders involved

4.1. Summary of roles, responsibilities and actions of key roleplayers

A number of roleplayers were essential in ensuring a rapid response, from planning through to implementation. These will be key for the incoming OCMA as part of management roles, responsibilities and protocols that AWARD hopes to support and hence these are summarised here.

Together with AWARD, the KNP freshwater team plays an essential 'watch dog' role through monitoring flows and water quality as well as any key challenges (e.g. mining spills) that compromise the health of the river. To his end AWARD has developed a number of tools including a mobile and desktop applications for tracking flows and Reserve compliance. All of these were essential in securing flow augmentation.

Operationally, the LOROC forum offered the platform for planning and rapid response through collaboration and agreement. Various directorates and departments within DWS were key (Acting DG; National Water Resources Planning (North); Systems Operation, Resource Directed Measures, Hydrology, Northern Operations (dam operator), Olifants CMA as well as the water board, Lepelle Northern Water. With facilitation through AWARD, the lower Olifants farmers agreed to monitor water use internally.

4.2. Bulk Water Supply from Phalaborwa Barrage (Lepelle Northern Water)

The Phalaborwa Barrage is the off-take point for supply of water to the Phalaborwa mining complex and the Ba-Phalaborwa local municipality. Lepelle Northern Water is responsible for the bulk supply of water to these sectors. In the past few years they have been facing a number of challenges that were exacerbated during the recent drought. Namely the two major challenges have been a lack of inflow to the barrage as well as a significant sedimentation issue. This therefore, inherently becomes a risk to flows downstream in Kruger National Park. Before the first De-Hoop dam release was made, inflow to the barrage dropped below 1 cumec, which is less than what Lepelle is required to supply and what the barrage is required to release downstream to KNP. As noted by Levy Majadibodu (Scheme Manager Lepelle Northern Water)

> "The release from De Hoop really helped us a lot. Before the release, the barrage level dropped below 308m which is our worry level because intake 1 and 2 are silted. Furthermore, the Ba-Phalaborwa community and the downstream users benefited.
>
> We would like to thank the team for their tireless effort and the cooperation for the DWS. Many thanks"".

4.3. Commercial Agriculture

It is important to recognise that these interim releases from De Hoop were able to alleviate the water supply challenges in the Blyde sub-catchment which has a relatively low yield. The following is reported from that region. One farmers reported benefits for the Blyde WUA as follows:

> "From Blyde and especially the Agricultural sector in the area the releases from De Hoop had the effect that farmers could produce a crop for the coming citrus and mango season. Without the releases, taking into account the level of the Blyde dam since September 2015, no water would have been available for agricultural use. The resulting loss of income for the farming and labour sector would have had a devastating effect on the social and economic welfare in the region.
> We are sincerely grateful towards the Department of Water Affairs in their assistance in this regard."
> Regards Jurie van Vuren (Lower Blyde WUA).

More importantly, one of the conditions specified by the DWS for making releases from the De-Hoop dam was that all the users along the stretch of the Olifants would need to be made aware of the releases so as to ensure there is no uptake of additional flow. The AWARD team met with the Lower Olifants farmers (Figure 4) in regards to this request by the DWS. Some of the issues noted by these farmers included the failure of the Validation and Verification (V&V) process, a lack of communication between DWS and themselves, and the perceived reduction of flows due to De Hoop Dam construction. Indeed some of the benefits using the De-Hoop release model was to highlight unaccounted for losses, which was discussed with the farmers. They agreed they would update their water use and put in place a number of additional arrangements including formalising themselves as water users. For this the farmers made the following agreements:

- The farmers are prepared to pay for their own V&V
- The farmers would like to arrange themselves into a Catchment Management Committee (CMC)
    - They would like to know what is legally acceptable (which AWARD agreed to help with)
- They would like Jurie van Vuuren to help them with the Administration and Representation at meetings along with Phlip Roodt.

4.4. Cross-Border Flows

The third LOROC meeting was held in Mozambique on the 18th of August 2016 at the Ara-Sul offices situated at Massinger Dam. The Mozambican partners were asked to reflect on some of the issues and challenges they have faced during the recent drought. Many of the issues raised are associated with infrastructural issues due to the collapse of their low release pipes. The failure of these pipes meant that once the dam level had dropped below the secondary sluice gate spillway no water from Massinger other than seepage could make its way downstream. The dam has a duality; it can be good for supporting farming downstream when functioning well, but can be quite devastating if there is no flow downstream as is being experienced now. In addition, the dam provides fresh water to Zongoene to mitigate saltwater intrusion, without the freshwater, this area is at risk of soil salinization, making these areas unusable for agriculture in the future. While, infrastructural issues resulted in the inability to release water from Massinger, the flow contribution from the Olifants during the drought period were extremely low (<0.4 m3s-1 at times) (Figure 12).

Figure 12 Photograph of the Olifants River at Balule on the 6th September indicating the extremely low flows

5. Concluding remarks

This report clearly demonstrates the valuable role that collaborative action has achieved to ensure water security through adaptive operational water resources management in the lower Olifants River, during an extremely challenging drought period. All stakeholders that have been part of this process are gratefully acknowledged for their inputs and support to make this a success. It must be recognised of course that further challenges of this nature will remain over the next couple of years due to reduced catchment storage, and as such further constraints are likely to remain for the foreseeable future. It is therefore of utmost importance that learning, actions and outcomes of 2016 are nurtured through a structure such as the LOROC. This is to ensure sustainable river operations in the longer term and to mirror those recent successes made in operational water resources management made in other catchments in the region.