

Investigation into availability of surplus water in the Leeu catchment

1. Introduction

This report determines the availability of water in the upper Leeu catchment located in the Koue Bokkeveld, Western Cape. The primary purpose is to determine if there is sufficient runoff to support the increased capacity of a farm dam (Langrug 1) located on the farm Sterkwater as shown in Figure 2.1. The report firstly identifies the location of the relevant quaternary catchment, flow gauge location and details and the location of the Environmental Water Requirement (EWR) site. A description of the hydrological model development follows which has relevance to the establishment of the EWR as well as the WRSM model version used in this analysis.

The determination of water availability comprises of several analyses. Firstly, a comparison of the EWR and the observed record at E2H007 is undertaken. Thereafter, the present-day WRSM configuration is used to determine water availability. The WRSM was used to generate flows into relevant dams in the upper reaches of catchment and a reservoir simulation was undertaken to identify the following issues:

- If sufficient water is available to fill the proposed increased capacity of Langrug 1 Dam.
- The impact of reduced runoff into the downstream Wydekloof Dam.

2. Quaternary Catchment Location

- The Leeu catchment comprises quaternary catchment E21G
- Outlet of quaternary catchment is measured by DWS flow gauge E2H007
- See map of quaternary catchment (Figure 2.1) and table of flow gauge details below.

Figure 2.1 Location of the Leeu catchment

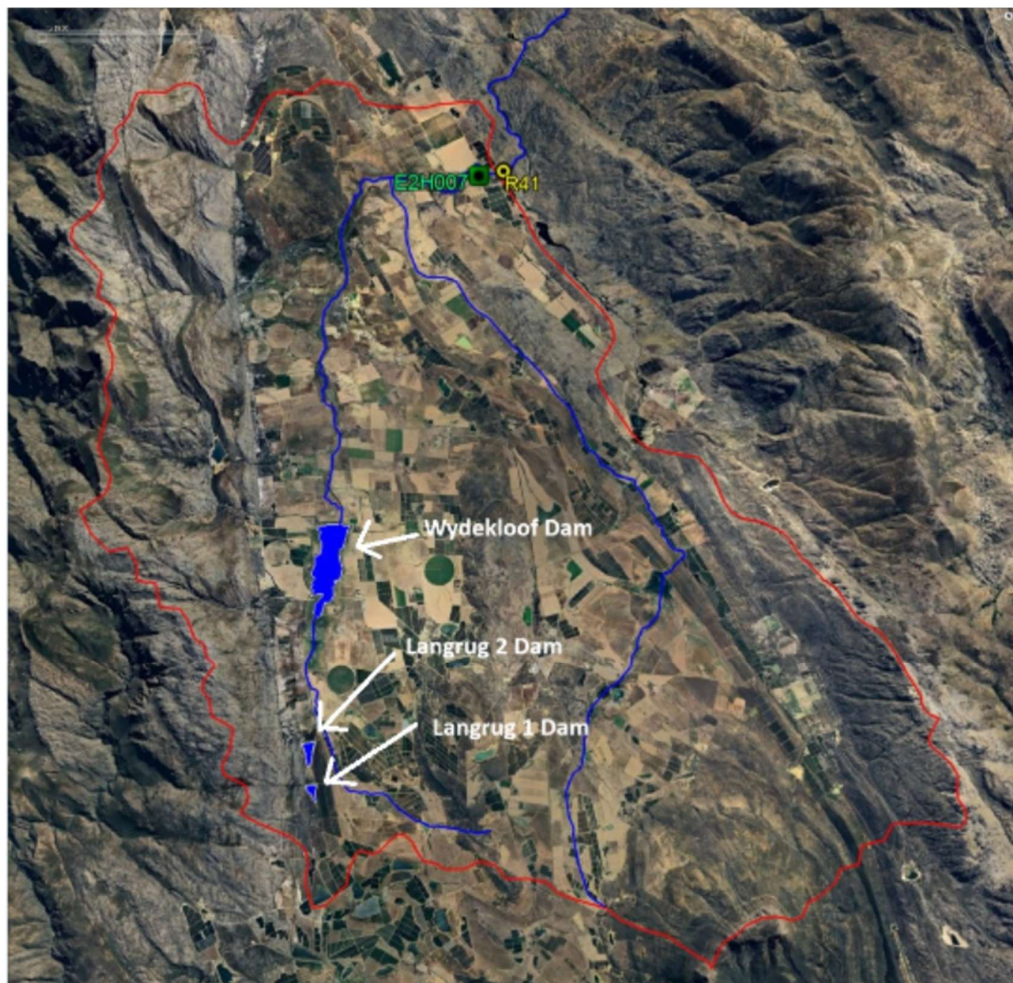


Table 2.1 Flow gauge details of E2H007

[Home](#)

Data retrieval: Data are continuously updated and reviewed. To limit server overheads and download time, limits per query are **7000** records (or **1** year of data) for primary data and **20** years of data for daily data. Do multiple queries to retrieve the full record.

Station
 Leeu River @ Leeuw River
 C.Area km²
 Lat
 Long
 Site Type

Photo

Quality Codes

Recorded data and information							
Station Number-Type	Variable	Component	Start Date	End Date	Volume (Multiples of m³)	Flow (m³/s)	Primary Data
E2H007-RIV	100.00	Leeu @ Leeuw River	1930-04-01	2025-03-11	Monthly Volume	Daily Avg. Flow	Primary Data

☐ Date Volume Format (Non Matrix)

Rating Tables	
DT No (GP Readings)	Date of application
0 (GP Readings)	1930-04-01
3 (GP Readings)	1970-04-15

Flood Peaks	
Monthly max levels/flows	Annual max levels/flows
E2H007pk.csv	E2H007yrpk.csv

3. Hydrology

- The first hydrological study on the Doring River was done by Steve Murray (Ninham Shand,1994).
- This study used the in-house SHELL software developed by Ninham Shand.
- The modelling period in this first study was from October 1920 to September 1991.
- A second study was then undertaken.
- This second study was also undertaken by Louise Dobinson (Ninham Shand,1998) and included conversion of the SHELL software to the WRSM as well as generating present day flows using mid 1995 land-use information.
- A third study (DWAF, 2009) was undertaken and used in the Feasibility Study for the Raising of Clanwilliam Dam. This study also extended the modelling period up to September 2005.
- The latest hydrological time series available on the WRSM2012 portal has been further extended and covers the period October 1920 to September 2010. It is important to note that the EWR analysis was undertaken using the DWAF,2009 study (modelling period 1920-2005) and the WR2012 hydrology was used in this study. A summary of both these studies is presented in Table 2.1.

Table 3.1 Comparison of DWAF,2009 study and WRSM2012 hydrology at E21G.

Hydrological Study	Natural MAR (Mm3/ann)	Present day demand (Mm3/ann)	Present day MAR (Mm3/ann)
1920-2005 (DWAF,2009)	55.2	16.6	38.6
1920-2010 (WR2012)	59.0	15.7	43.3

4. Environmental Water Requirements (EWR)

- The EWR was conducted by Alison Joubert and Cate Brown at Southern Waters.
- It was the first EWR undertaken in South Africa and was conducted on a quaternary catchment basis.
- The gazetted EWR (which is based on the Desktop Model) was obtained from the DWS gazette (DWS, 2016).

- The appropriate information is included in Appendix 1 and summarised below.
- The Leeu is identified as an ecological category D with a natural MAR of 55.2 Mm3/annum.
- 13.2% of natural flow which equates to 7.3 Mm3/annum is required by the EWR (Desktop Model output).
- In addition, 60% of “natural floods in July, August and September” are required.
- This increases the EWR requirement to 38.6% of natural flow which translates to 21.3 Mm3/annum. However, the average monthly EWR output is not available in the gazette.
- This information (the Desktop Model output) was sourced from the consultant (Alison Joubert, Southern Waters) on 30 May 2025 and is summarised in Table 4.1 below.
- Note that the % of natural (38.6%) is the same for the gazette so indicating that the gazetted information is derived from Table 4.1.

Table 4.1 Desktop Model output for E21G (EWR node R41)

Desktop Version 2, Generated on 16/01/2013								
Annual Flows (Mill. cu. m or index values):								
MAR	55.22							
S.Dev.	27.676							
CV	0.501							
Q75	0.278							
Q75/MMF	0.06							
BFI Index	0.322							
CV(JJA+JFM) Index	3.171							
Ecological Category = D								
Total IFR		21.288	(38.6 %MAR)					
Maint. Lowflow		2.332	(4.22 %MAR)					
Drought Lowflow		1.743	(3.16 %MAR)					
Maint. Highflow		4.964	(8.99 %MAR)					
Monthly Distributions (Mill. cu. m.)								
Distribution Type : W.Cape(wet)								
Month	Natural Flows			Modified Flows (IFR)				60% of winter flows required
				Low flows		High Flows	Total Flows	Total Flows Inc Floods
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.	
Oct	4.311	2.621	0.608	0.313	0.313	0.299	0.612	0.612
Nov	2.294	2.46	1.072	0.221	0.221	0.079	0.3	0.3
Dec	0.843	1.398	1.658	0.094	0.094	0	0.094	0.094
Jan	0.284	0.45	1.584	0.041	0.031	0	0.041	0.041
Feb	0.339	1.114	3.285	0.028	0	0	0.028	0.028
Mar	0.433	0.978	2.257	0.027	0	0	0.027	0.027
Apr	1.493	2.887	1.934	0.051	0	0	0.051	0.051
May	5.353	6.683	1.249	0.146	0.021	0.678	0.824	0.824
Jun	10.311	8.901	0.863	0.284	0.093	1.291	1.575	1.575
Jul	11.606	9.449	0.814	0.364	0.206	1.701	2.065	6.9636
Aug	10.615	7.539	0.71	0.396	0.396	0.305	0.701	6.369
Sep	7.339	4.266	0.581	0.368	0.368	0.611	0.979	4.4034
EXPLANATION								
Low Flows	Normal years baseflow (no inter and intra annual high flows)							
High Flows	Freshetts (intra annual high flows only)							
Total Flows	Normal years Baseflow+Freshetts							
Drought Flows	Minimum flow during droughts (baseflow with no freshetts)							
Floods	Inter annual floods							

- In addition to defining the “normal” year EWR, a drought EWR is also relevant.

- The drought EWR is presented in Table 4.1 above but should also include 60% of the floods during those drought years.
- This raises the problem of defining a drought year as current day flows are impacted by current water-use and a low MAR is not necessarily the result of low rainfall only.
- This is why droughts should be based on either rainfall or natural flows.
- The Pitman Model was therefore configured to generate natural flows for the catchment upstream of E2H007.
- A drought classification using the 10th percentile is generally accepted as the percentile to be used to identify periods when the natural flow is lower than 90% of the simulated natural flows.
- Using a 105- modelling period the driest 11 years in the natural time series were separated into the drought analysis (presented in Table 6.2).
- Table 4.2 identifies the drought years and corresponding natural MAR.
- Using the drought EWR as defined by the Desktop output as well as including 60% of winter high flows during these drought years an increased drought EWR was determined and is presented in Table 4.3

Table 4.2 Drought years and natural MAR (Mm3)

Drought Years	Natural MAR
2016	14.29
1945	20.64
1998	22.49
2003	22.72
2002	23.77
1948	24.54
1942	24.56
1965	25.08
1968	25.82
1927	26.37
1937	28.22

Table 4.3 Drought EWR (Mm3)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
EWR Drought	0.313	0.221	0.094	0.031	0.000	0.000	0.000	0.021	0.093	0.723	1.096	1.288

5. Observed Record Analysis

- The daily observed record at E2H007 was downloaded from the DWS portal.
- Only the most recent data was used (after 2010). This record period was selected as it contains enough data to include annual variability as well as recent enough to reflect present-day water use.
- Missing daily data was patched by interpolation.
- The daily record was then summarised on a monthly basis to enable comparisons with the monthly EWR requirements.
- Table 5.1 shows the monthly flows at E2H007 for the last 16 years.
- Table 5.2 compares the mean monthly flow at E2H007 with the mean monthly EWR

Table 5.1 Monthly flows at E2H007 (Mm3)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2009	M	M	M	0.051	0.04	0.01	0.017	4.112	5.732	3.633	5.596	2.659	M
2010	3.308	0.538	0.033	0.019	0.013	0.010	0.030	0.781	11.603	5.510	6.058	6.793	34.696
2011	1.087	0.171	0.030	0.018	0.015	0.022	0.100	0.334	7.257	6.699	17.865	9.888	43.486
2012	2.645	0.074	0.058	0.039	0.019	0.023	0.659	0.172	12.382	10.893	28.550	21.094	76.608
2013	2.889	0.207	0.019	0.028	0.027	0.066	0.070	0.659	12.499	20.824	15.122	8.177	60.587
2014	1.151	0.045	0.013	0.013	0.011	0.018	0.016	0.018	0.623	2.571	1.323	0.024	5.826
2015	0.020	0.015	0.013	0.011	0.008	0.009	0.011	0.040	3.992	6.929	5.676	2.195	18.919
2016	0.611	0.008	0.013	0.011	0.003	0.003	0.013	0.001	0.105	0.024	0.352	0.028	1.172
2017	0.012	0.010	0.007	0.002	0.000	0.000	0.000	0.019	5.815	7.712	4.841	7.969	26.387
2018	0.630	0.019	0.010	0.011	0.012	0.025	0.018	0.019	0.253	9.004	3.816	0.863	14.680
2019	0.383	0.178	0.012	0.012	0.014	0.013	0.014	0.013	2.073	11.421	13.424	15.549	43.106
2020	1.884	0.184	0.011	0.014	0.025	0.029	0.019	0.771	3.182	16.888	7.896	4.097	35.000
2021	1.299	1.027	1.063	0.041	0.042	0.058	0.048	0.053	1.752	0.376	3.748	2.289	11.796
2022	0.135	0.026	0.019	0.043	0.047	0.046	0.032	0.139	31.023	13.998	12.139	18.224	75.871
2023	4.918	0.107	0.053	0.058	0.037	0.057	0.035	0.011	3.216	38.536	30.823	5.627	83.478
2024	7.858	1.382	0.053	0.036	0.029	M	M	M	M	M	M	M	M
Average	1.922	0.266	0.094	0.025	0.021	0.026	0.072	0.476	6.767	10.335	10.482	7.032	37.972

Table 5.2 Comparison of mean monthly flow at E2H007 and the EWR (Mm3)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
E2H007	1.92	0.27	0.097	0.03	0.02	0.03	0.07	0.48	6.77	10.34	10.48	7.03	37.97
EWR	0.61	0.30	0.09	0.04	0.03	0.03	0.05	0.82	1.58	6.96	6.37	4.40	21.29

- Data in Table 5.2 show that on average there is surplus water available in the Leeu catchment. The MAR of 37.97Mm3 exceeds the EWR requirement of 21.29 Mm3 indicating that there is on average a surplus of 16.68 Mm3.
- The monthly comparison shows surplus winter water (from June to October) is available.

6. Comparison of the WR2012 Model output to the EWR

- The WR2012 model was downloaded from the WRSM portal.
- The simulation period was limited by the catchment rainfall file which ended in September 2010.
- The rainfall file was extended to September 2024 using CHIRPS satellite based daily rainfall.
- The CHIRPS data was bias corrected
- The extended model was then compared to the observed record at E2H007.
- The graphical comparison is presented in Figure 6.1, and the statistical comparison is presented in Table 6.1.
- The calibrated WR2012 model shows that an acceptable calibration is still obtained using an extended calibration period (1970 to 2024).
- The model was then configured to generate present day flows and summarised to compare model mean monthly flows with the EWR to determine the amount of surplus water available in E21G.
- The model output was separated into “normal” years and “drought” years and compared with the required EWR.
- Results are presented in Table 6.2 and show that on average there is 8.63 Mm3/annum of surplus water available during normal years.
- During the 11 drought years that are included in a separate analysis there is a clear indication that the drought EWR is on average exceeded.

Figure 6.1 Simulated flows compared to observed flows at E2H007

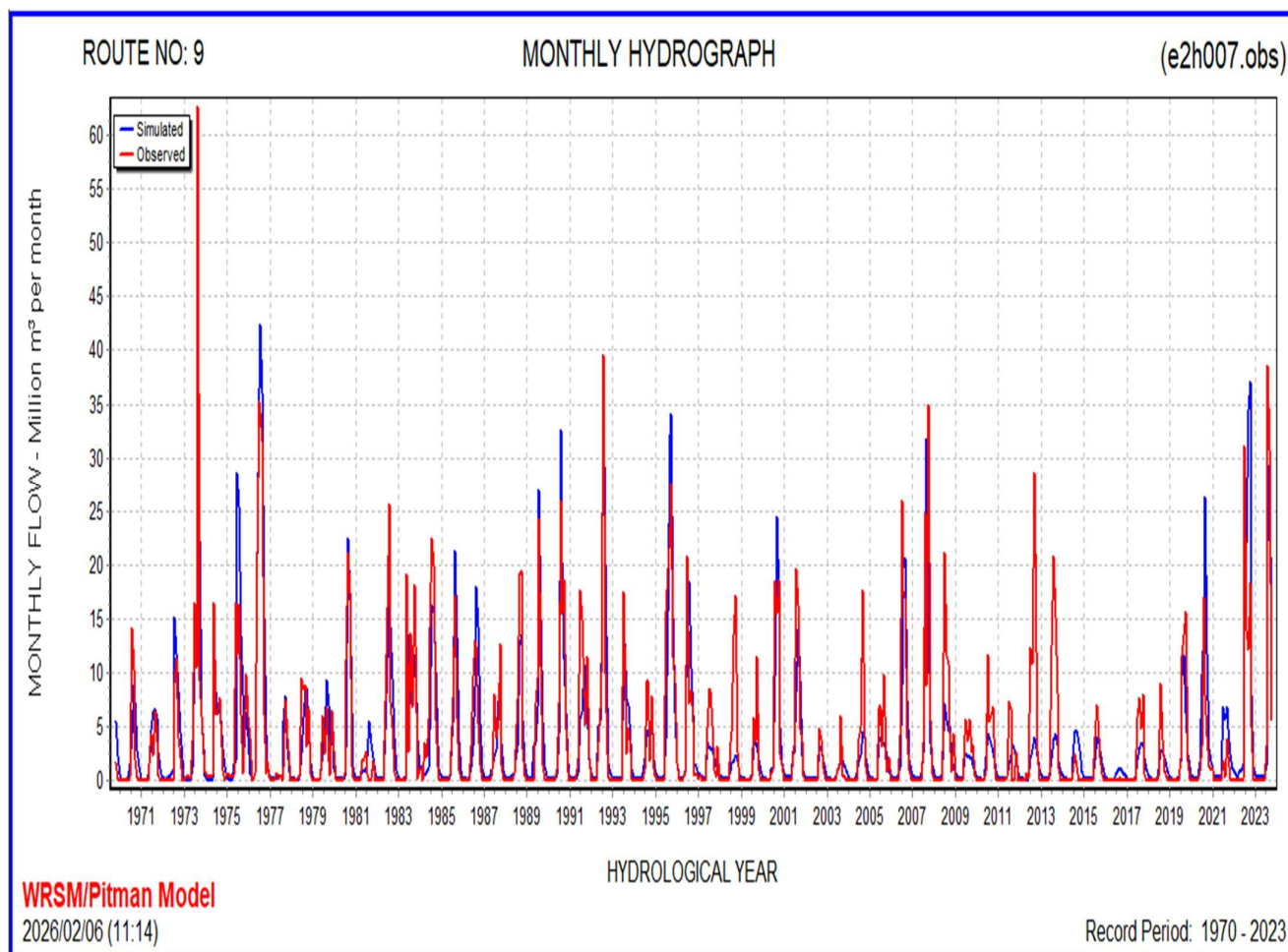


Table 6.1 Statistical comparison of simulated and observed flows

	Observed	Simulated
MAR	45.79	44.27
Mean (Log)	1.55	1.54
Std Deviation	29.14	32.32
Log Std Dev	0.36	0.32
Seasonal Index	51.25	47.49

Table 6.2 Comparison of mean monthly WR2012 flows and the EWR (Mm3)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
Normal EWR	0.61	0.30	0.09	0.04	0.03	0.03	0.05	0.82	1.58	6.96	6.37	4.40	21.29
Normal WR2012	2.62	1.18	0.46	0.18	0.11	0.11	0.36	1.47	4.07	6.14	7.47	5.75	29.92
Drought EWR	0.31	0.22	0.09	0.03	0.00	0.00	0.00	0.02	0.09	0.72	1.10	1.29	3.88
Drought WR2012	2.28	0.95	0.37	0.15	0.07	0.06	0.17	0.28	0.72	1.21	1.83	2.15	10.21

7. Analysis on increased capacity of Langrug 1 Dam and impact on Wydekloof Dam.

- The calibrated WR2012 model (extended simulation period 1920 to 2024) was used to generate flows into the relevant dams.
- Since catchments that contribute flow to these dams are located near the high Mean Annual Precipitation (MAP) associated with the mountains to the west the model was adapted to account for variations in runoff.
- Figure 7.1 shows the location of the high MAP catchment to the west and the low MAP catchment to the east.
- The WR2012 configuration was then adapted to generate runoff from both the high and low MAP catchments.
- Catchment MAP was derived from the latest raster-based MAP data (available on a minute-by-minute grid) and used in the WR2012 update.
- This work was undertaken by undertaken by Beuster Clarke Associates in 2007.
- The new simulated flows were then adjusted to match the original natural MAR.
- Table 7.1 lists the relevant catchment areas, MAP's and MAR's.

Figure 7.1 Location of the high and low MAP catchments

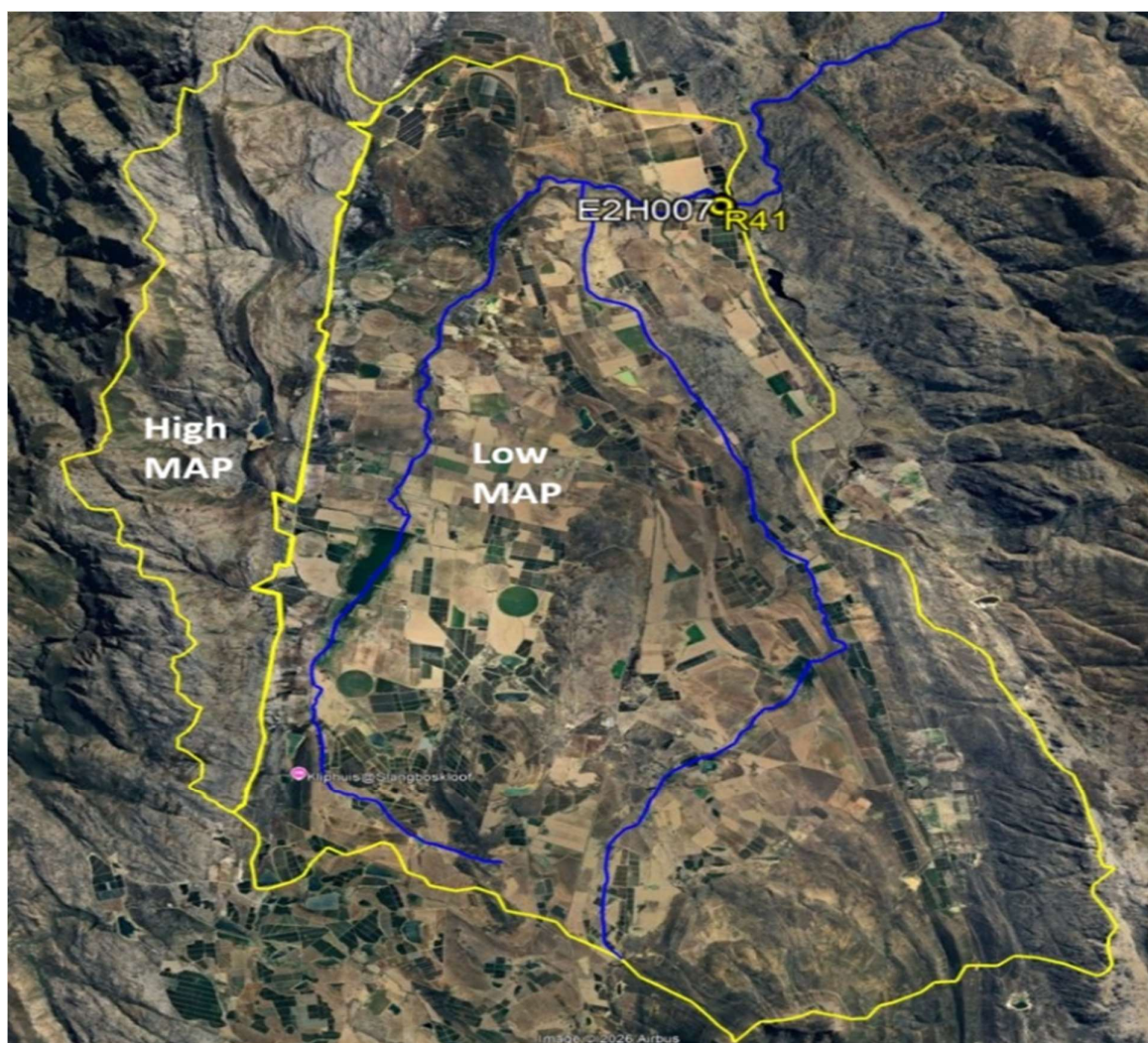
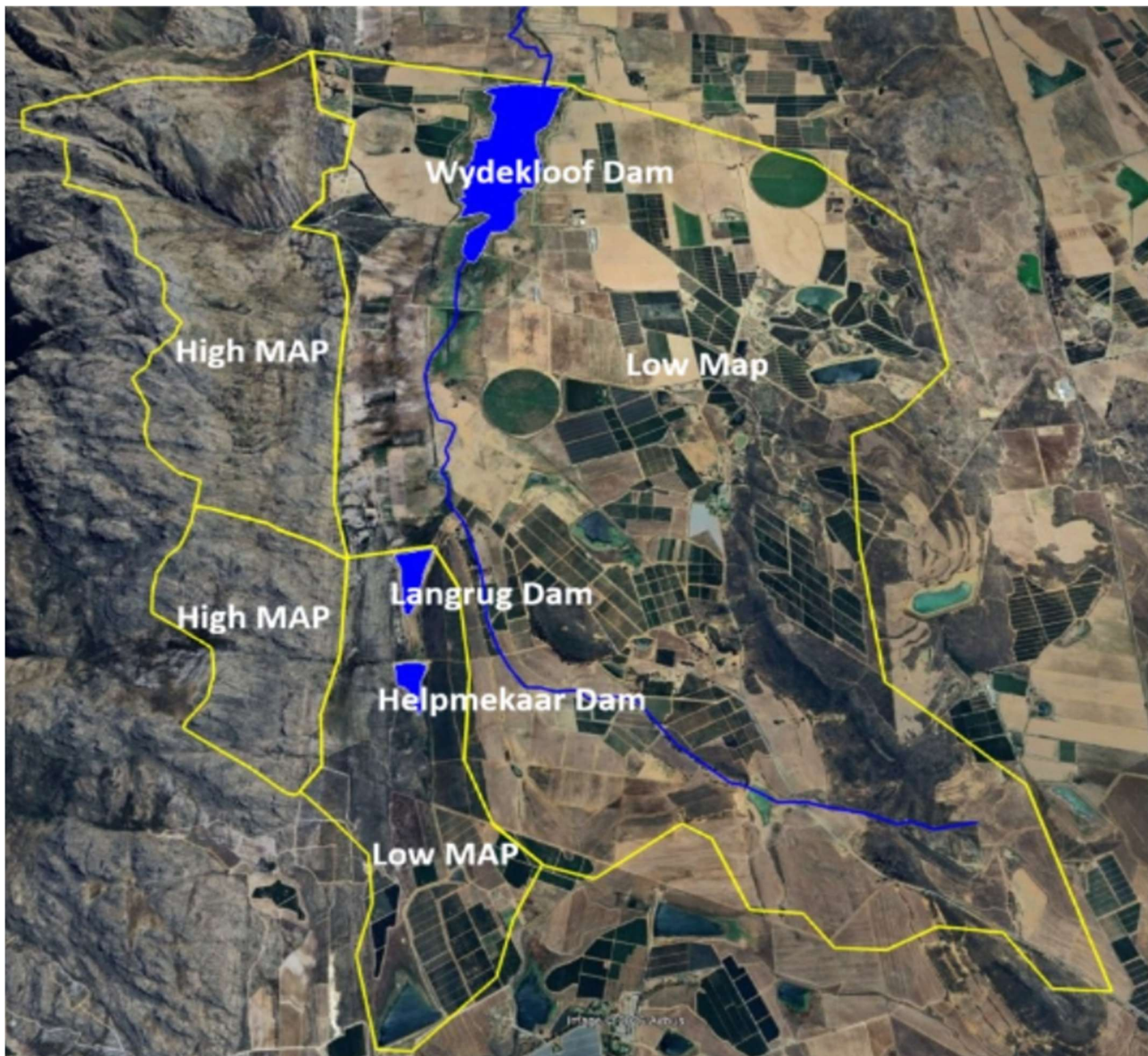


Table 7.1 Catchment areas and MAR of the high and low MAP catchments

	Area (km2)	MAP (mm)	MAR (Mm3)
Original WR2012	266.0	696	60.1
High MAP	46.9	994	19.9
Low MAP	219.1	625	40.5

- The adjusted WR2012 model was the used to generate inflows to the dams.
- The location of the relevant dams and their catchment areas are shown in Figure 7.2.

Figure 7.2 Location of the Langrug 1, Langrug 2 and Wydekloof Dams



Due to the close location of Langrug 1 Dam and Langrug 2 Dam they were modelled as a single dam. The configuration was set up to perform the following tasks:

- Generate flows into the two upper dams and downstream Wydekloof Dam from the high and low MAP catchments.
- Determine the irrigation demands from the 3 dams. The irrigated crop area and was supplied by personal communication. Crop factors, A-pan evaporation and other irrigation parameters from the WR2012 configuration were used.
- The reservoir simulation used capacities as supplied by personal communication.
- A summary of the data is presented in Table 7.2.
- In addition to the irrigation demand supplied directly from Wydekloof Dam a transfer of 2.1 Mm³/annum (weighted during the winter period) was also included.

Table 7.2 Input data for the dam simulation

	Capacity (m3)	Irrigated Area (ha)	High MAP Catchment Area (km2)	Low MAP Catchment Area (km2)
Langrug 1 Dam	390 000	55.0	2.2	3.7
Langrug 2 Dam	775 000	110.0		
Wydekloof Dam	6 110 000	550.0	8.1	34.7

The analysis of the reservoir operation is presented in Figures 7.3 and Figure 7.4 and the statistical analysis is summarised in Table 7.3.

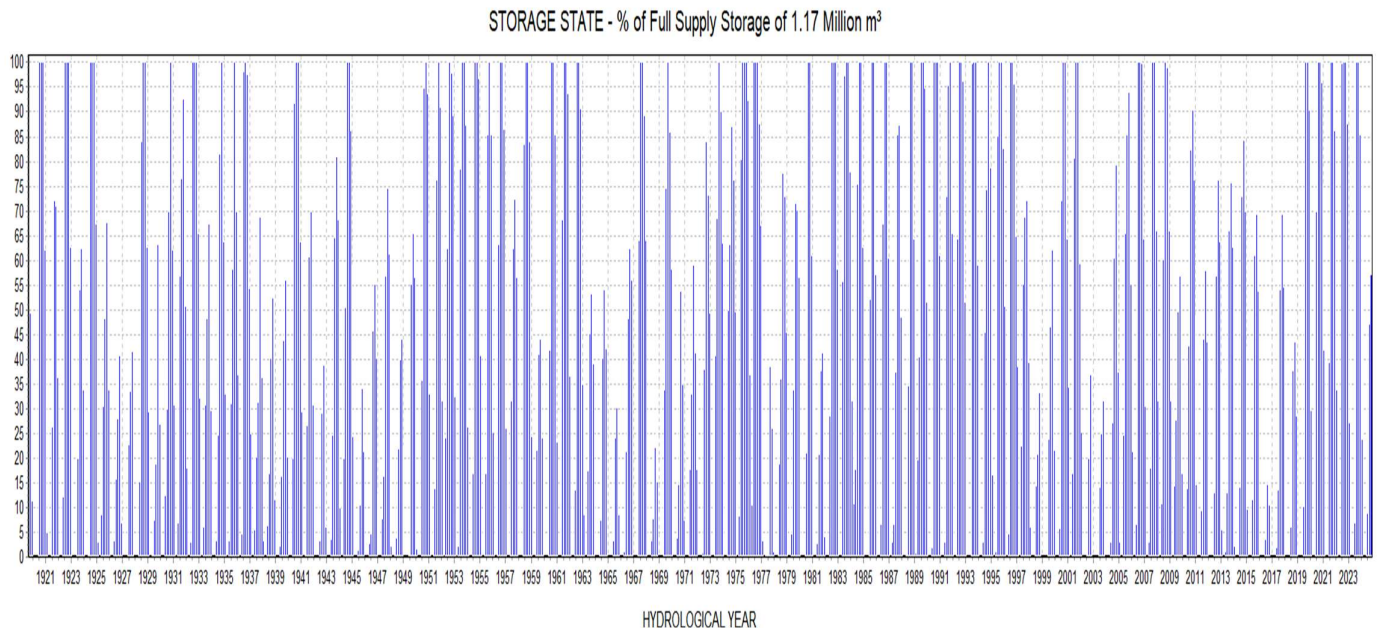
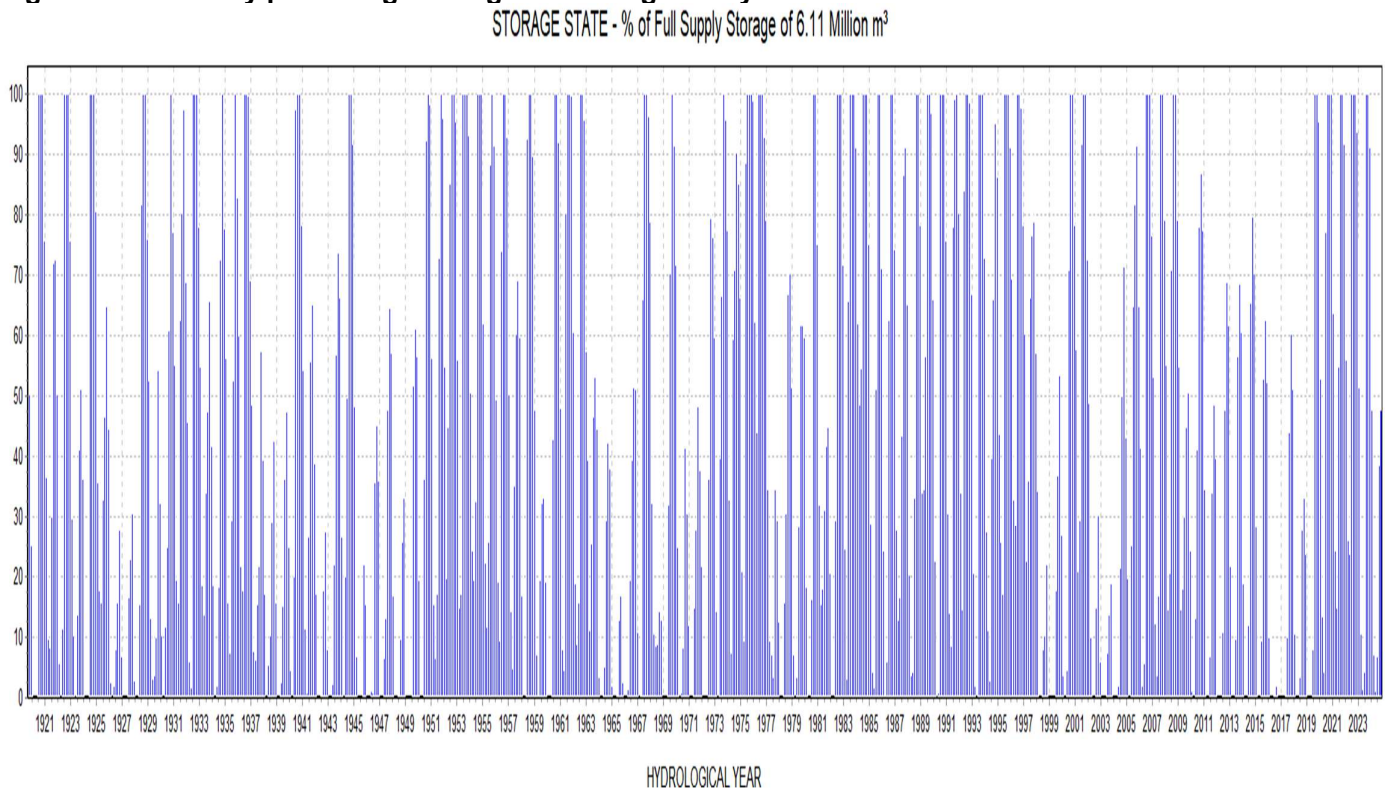
Figure 7.3 Monthly percentage changes in storage of the combined Langrug 1 and Langrug 2 Dams**Figure 7.4 Monthly percentage changes in storage of Wydekloof Dam**

Table 7.3 Analysis of current reservoir function and irrigation supply

	No. of Spill Years	Average Annual Spill Volume (Mm3)	Dam Capacity (Mm3)	Irrigation Demand (Mm3)	Irrigation Supply (Mm3)
Langrug 1 and Langrug 2 Dams	71	1.10	1.165	1.72	1.10
Wydekloof Dam	71	3.31	6.110	5.74	4.61 (+2.01 transfer) = 6.62

The WR2012 model was then configured to include the raising of Langrug 1 Dam from 390 000 m³ to 800 000 m³ (an increase of 410 000 m³). A proportionate increase to the irrigation area was not simulated due to the low assurance of supply under the present-day irrigation demand. The statistical analysis is summarised in Table 7.4.

Table 7.4 Analysis of current reservoir function and irrigation supply

	No. of Spill Years	Average Annual Spill Volume (Mm3)	Dam Capacity (Mm3)	Irrigation Demand (Mm3)	Irrigation Supply (Mm3)
Langrug 1 and Langrug 2 Dams	57	0.28	1.575	1.72	1.26
Wydekloof Dam	71	3.17	6.110	5.74 (+2.0 transfer)	4.61 (+2.01 transfer) = 6.62

Results show that the raising of Langrug 1 and Langrug 2 Dams from a combined capacity of 1.165 Mm³ to 1.575 Mm³ will improve the ability of the dams to supply the existing irrigation requirement (from 1.10 Mm³ to 1.26 Mm³). While the number of spill years decreases from 71 years to 57 years and the average annual spill volume drops from 1.10 Mm³ to 0.28 Mm³ it has very little impact on the downstream Wydekloof Dam. While there is a small decrease in the average annual spill volume (from 3.31 Mm³ to 3.17 Mm³) the upstream water-use has no impact on the supply from Wydekloof Dam.

8. Conclusion

This study shows that there is surplus water available in the Leeu River catchment. Comparisons using the most recent observed record at E2H007 as well as the simulated long term present-day record with the EWR show that there is sufficient surplus water available for upstream development. Furthermore, the raising of Langrug 1 Dam will improve the supply of irrigation requirements from the dam without reducing the supply of irrigation from Wydekloof Dam. The only effect on the hydrology of the Leeu catchment is to reduce the spill from Wydekloof Dam. This reduction is relatively small (0.14 Mm³/annum) when compared to surplus available at the EWR site (8.63 Mm³/annum). The raising of Langrug 1 Dam will have very little impact on the hydrology of Leeu River catchment.

APPENDIX 1 GAZETTED EWR (E21G RELEVANT)

4. SURFACE-WATER - QUANTITY COMPONENT FOR RIVERS

The results for the Reserve determination and ecological categorisation for the Olifants/Doring River System, where the Reserve amounts are expressed as a percentage of the MAR for the respective catchments (cumulative) in terms of section 16(1) of the Act.

Table 4.1: Summary of the quantity component for the Rivers which include the EWR & BHN.

Quaternary catchment	Water Resource	PES	EIS	REC	Ecological reserve (Cumulative) (% MAR)	Basic human needs Reserve (% MAR)	MAR (MCM)	Total Reserve (%MAR)
E10A	Olifants	C	High	C	43.58	0.00	60.475	43.58
E10B	Olifants	C	High	C	44.26	0.01	129.003	44.27
E10C	Olifants	B	Very high	B	51.09	0.00	182.405	51.09
E10D	Olifants	C	Moderate	D	52.38	0.00	233.767	52.38
E10E	Olifants	C	Moderate	D	37.77	0.4	293.467	38.17
E10F (EWR 1)	Olifants	D	Moderate	D	37.77	0.03	355.557	37.8
E10G	Olifants	C	Moderate	D	26.59	0.03	437.273	26.62
E10G (EWR 3)	Rondegat	B	Moderate	B	42.75	0.03	7.411	42.78
E10H	Jan Dissels	D	Moderate	C	19.70	0.00	44.686	19.70
E10J& E10J (Q7)	Olifants	D	Moderate	D	14.90*	0.154	46.205*	15.054
E10K (EWR 2)**	Olifants	E	Moderate	E	9.32	0.00	505.716	9.32
E21A	Kruis	E	Low	C	41.98	0.07	39.425	42.05
E21B	Welgemoed	D	Low	D	23.56	0.161	1.230	23.72
E21C	Winkelhaak	D	Low	C	19.48	0.00	41.939	19.48
E21D	Houdenbeks	D	Low	D	27.72	0.092	50.217	27.81
E21E	Riet	B	Low	B	29.13	0.008	93.772	29.14
E21F	Riet	A/B	Low	B	21.72	0.00	95.862	21.72
E21G	Groot/ Leeu	D	Low	D	38.55	0.04	55.220	38.59
E21H	Twee	A/B	Low	B	70.21*	0.00	55.055*	70.21
E21H	Leeu	A/B	Low	B	64.3	0.00	138.715	64.3
E21J (EWR 6)	Groot	B	Low	B	50.65	0.00	140.463	50.65
E21K	Maatjies	B	Low	B	62.86	0.00	1.819	68.86
E21L	Groot	B	Low	B	50.02	0.00	239.220	50.02

IUA	Quaternary	Node	River	Location for monitoring	Hydrology					
					Month with lowest flow	Mean of month with lowest flow (m3/s)	Instantaneous drought absolute minimum (m3/s) ¹	%nMAR	Floods in addition to Desktop Model	Implications of flood RQOs
	E21L		Groot	E2H002	February	0.017	0.001	48.1	>80% of natural floods for July, August and September	No in-channel dams
	E21J	R38	Groot	EWR Site 6	February	0.010	0.001	48.1	>80% of natural floods for July, August and September	No in-channel dams
				Brandkraals	February	-	0.001	48.1	>80% of natural floods for July, August and September	No in-channel dams
	Tributary of Leeu in E21H	A1	Twee	Twee	February	0.125	0.001	60.4	>80% of natural floods for July, August and September	No in-channel dams
	E21G	R 41	Leeu	E2H007	February	0.010	0.001	13.2	>80% of natural floods for July, August and September	Limited in-channel dams
	E23K	R27	Tankwa	Tankwa	The Tankwa River is ephemeral. Thus minimum lowflows do not apply.			26.4	>80% of natural floods for July, August and September (incremental)	No in-channel dams