Stream flow measurement, to illustrate water production in the Verloren Valei Nature Reserve, March 2021

J.J. Coetzee, E. Coetzee, H. Marais

1. INTRODUCTION

Verloren Valei Nature Reserve is a significant water catchment area located on the high-altitude grasslands of Mpumalanga, which falls within the Mpumalanga Drakensberg Strategic Water Source area (Le Maitre et al, 2018). It also contributes to conserving portions of the Steenkampsberg Montane Sourveld Grassland vegetation type (Mucina & Rutherford, 2006). The Verloren Valei Nature Reserve (5893 ha) was proclaimed as a Provincial Nature Reserve in 1983 (Eksteen 2005), and designated as a Wetland of International Importance in 2001, included in the Ramsar List of Wetlands of International Importance (Ramsar, 2010).

Due to its location, the Nature Reserve is rich in unpolluted wetlands, natural springs and streams. The wetlands are fed by precipitation (rain and mist), which slowly drains into the downstream river systems. Water flowing from these natural features, is crucial to sustain live and has enormous value for industry and development. This ecosystem service, delivered by Verloren Valei Nature Reserve, is most likely one of its most important functions.

Stream flow, from streams exiting the Nature Reserve boundary, has been measured during low flow in October 1995. The same method was used to measure high flow during March 2021 (Table.1&2).

2. METHODOLOGY

All of the 11 streams flowing from the Nature Reserve were measured, as close as possible to the fence line (Fig.1).

A section of the stream with more or less equal width and depth with constant flow was selected (Fig.4). The banks on both sides of the selected section was measured and an average distance was calculated. Five width measurements equally spread over the selected section was taken to calculate the average width. The average depth was calculated by taking five measurement from bank to bank on five different places across the selected section, 25 readings. A squash ball has been placed in the water and the time it moved by the stream through the selected section was measured (Fig.6). The ball had to move unconstructively through the section. It was repeated five times to determine average stream flow.

The average stream flow per second was calculated as follows:

Average width x average water depth x average length/average time

Cumec is a measure of the rate of flow commonly used by the irrigation industry. One cumec (m^3/s) is one cubic metre of water flow per second.

The methodology followed certainly have its limitations, however, taking the remoteness and sensitiveness of the area in consideration, permanent measuring weirs is not an option.

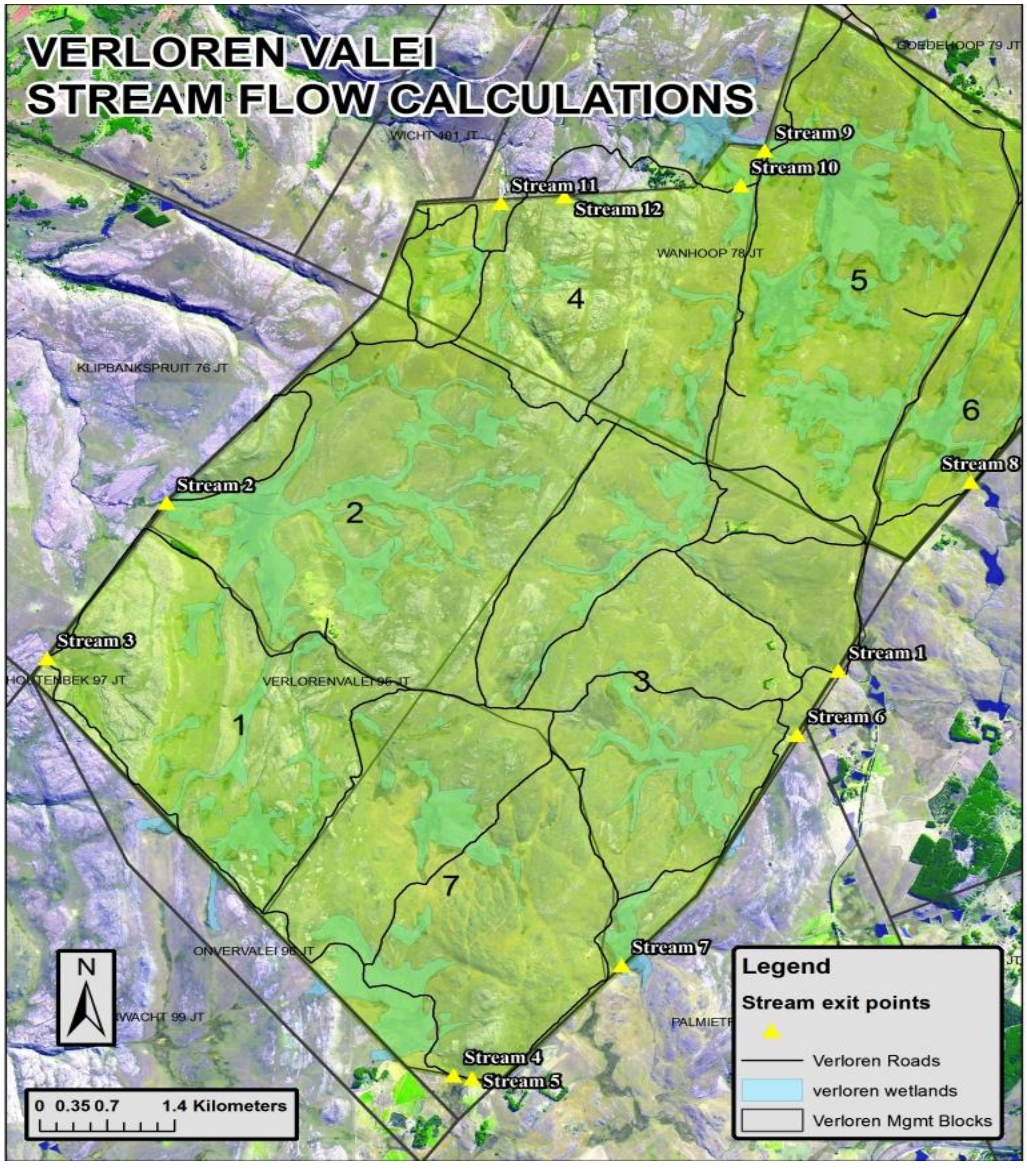

Figure.1 Verloren Valei stream flow calculation survey points

3. RESULTS

Data collected, were calculated to express stream flow in cumec. Cubic meters per second, litres per second and litres per 24-hour period.

Table 1: Results of the calculations done on the data collected during March 2021.

Stream	Cumec	Lt/sec	Lt/24hour
1	0.476516	476.51629	41171007.14
2	5.195568	5195.5681	448897083
3	0.160151	160.15128	13837070.67
4	0.121789	121.78922	10522588.55
5	0.021709	21.708792	1875639.598
6	0.202909	202.90867	17531309.29
7	0.070303	70.302743	6074156.976
8	0.320302	320.30235	27674122.77
9	0.174107	174.10724	15042865.7
11	0.16621	166.20968	14360516.66
12	0.039209	39.208541	3387617.922
Grand Total	**6.948773**	**6948.7729**	**600373978.3**

When measured, 6948 m^3/s or 600 million litres (600 mega litres) of water per 24 hours flows from the Nature Reserve into the downstream river systems.
Stream flow varied from 21.7 L/s in the smallest contributor in the most southern corner of the Nature Reserve, to 5195 L/s at the Klipbankspruit on the western boundary (Fig.3.)

4. DISCUSSION

The reserve is situated on a watershed between the Olifants and Crocodile drainage systems. The west flowing streams are tributaries of the Steelpoort River, which is part of the Olifants River system. The head waters of the Crocodile River (Fig.5), is in the south-east corner of the reserve and the east flowing streams flows into the Lunsklip River, which is a tributary of the Crocodile River. (Fig.2)

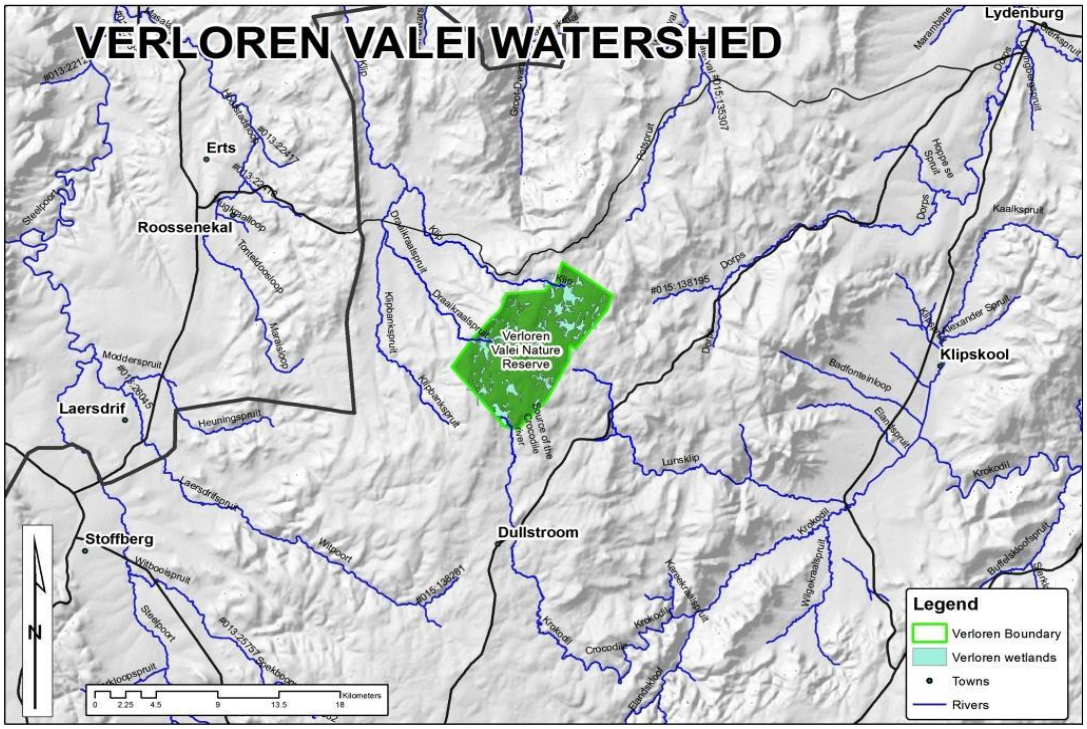

Figure.2. Source of the major rivers systems in the Verloren Valei Nature Reserve

Eleven streams exit the reserve's boundary (Fig.1). Measurements were taken as close as possible to the fence line.

Rainfall data collected by reserve management from Oct 2020 to Feb 2021 showed above average rainfall on the Nature Reserve for the larger part of the 2020/2021 season. (Table.3.Annexure.1)

Stream flow measurements were taken during high flow but not during flooding. Figure 3 shows debris on the fence line at Klipbankspruit on the western boundary, deposited during a Feb 2021 flooding event. This stream delivered 5195 litres per second when measured during high flow.

The interpretation of the results is important. More volumes were produced during the flooding events and production will gradually decrease towards the end of the dry season. A year round estimated value of water production can only be obtained after a few years of biannual (high and low flow) calculations were done.

Figure.3. Measuring the stream flow of the Klipbankspruit

As mentioned, similar calculations were done during October 1995 (Roux, 1995) (Table, 2). The 1995 exercise measured stream flow at all twelve streams. Stream number 10 was not measured during March 2021 as it changed to a vegetated wetland with no channel to measure water flow.

Table 2: Results of the calculations done on the data collected during October 1995.

Stream	Cumec	Lt/sec	Lt/24 hour
1	0.052889	52.888889	4569600
2	0.053198	53.198157	4596320.737
3	0.001884	1.884058	162782.6087
4	0.0099	9.899635	855328.4672
5	0.001232	1.2322148	106463.3557
6	0.007371	7.3708457	636841.0661
7	0.000157	0.1572888	13589.7493
8	0.011618	11.618065	1003800.853
9	0.009852	9.8524132	851248.5042
10	0.001654	1.6542	142927
11	0.014887	14.886578	1286200.378
12	0.001	0.9995002	86356.82159
Grand Total	**0.165642**	**165.64185**	**14311459.54**

These measurements showed a flow of 165 litres per second or 14 million litres (14 mega litres) of water flow per 24 hours when measured (Roux, 1995).

The 1995 measurements were not only done at the end of the dry season but it was also measured after a few years of below average rainfall. Therefore, these figures could be regarded as close to the absolute minimum volumes of water produced by the Nature Reserve.

Verloren Valei is a classic example of the importance of wetlands in good condition and their role and function in the landscape. Water collected in these wetlands, during the rainfall season is slowly released throughout the dry season. Calculations done during October 1995 (at the end of the dry season) after a few year of below average rainfall, showed that all the streams exiting the Nature Reserve, was still flowing (Roux, 1995). Comparative data for 1995 and 2021(Table.4 Annexure 1).

Fig.4. Collecting stream flow data

Fig.5 Head waters of the Crocodile River

Fig.6. Squash ball measuring flow speed

Fig.7. *Drosera burkeana*

Managing the Nature Reserve in a way to ensure a vigorous, healthy, water retaining vegetation layer which contains rare plant species (Fig.7), is crucial for the maintenance of this life supporting ecosystem function (Eco-Africa, 2018).

5. REFERENCES

Eco-Africa. (2018). Verloren Valei Nature Reserve Integrated Management Plan 2018 to 2021, June 2018.

Eksteen, J.J. (2005). Mpumalanga Parks Board. Condensed management plan for Verlorenvalei Nature Reserve. Final draft, June 2005. 21p

Le Maitre, D., Seyler, H., Holland, M., Smith-Adao, L., Nel, J., Mahery, A and Willhuser, K. (2018). Strategic Water Source Areas of South Africa. WRC Report Number TT 754-1-18. Pretoria

Roux, R. (1995). Mpumalanga Parks Board. Verloren Valei Stream Flow Survey Report Oct 1995. 9pp.

Mucina, L., Rutherford, M.C. (2006). The Vegetation of South Africa, Lesotho and Swaziland, South African National Biodiversity Institute, Strelitzia 19, Pretoria.

Ramsar. (2010). Designated Ramsar Sites: Strategic framework and guidelines for the future development of the list of wetlands of International Importance. Ramsar Convention Secretariat. Gland Switzerland.

6. Annexure:1

Table.3. Verloren Valei 2020/2021 rainfall July to Feb

	Verloren Valei Rainfall					
	Office	**7year mean**	**Witpad**	**7year mean**	**Witrand**	**7year mean**
July	0	**2**	0	**0**	0	**0**
Aug	2	**1**	0	**2**	0	**4**
Sept	0	**18**	9	**17**	1	**20**
Oct	123	**75**	135	**69**	170	**66**
Nov	110	**136**	90	**138**	80	**119**
Dec	125	**169**	115	**193**	105	**197**
Jan	245	**150**	330	**190**	425	**187**
Feb	177.5	**103**	328	**109**	170	**148**
March		**80**		**126**		**141**
April		**61**		**56**		**88**
May		**21**		**14**		**18**
June		**1**		**0**		**0**
Total	**782.5**	**817.63**	**1007**	**914.14**	**951**	**987.952**

Table.4. Comparative data for the 1995 and 2021 calculations

Stream No.	Average dimensions and flow speed								Cumec min		Lt/Sec min		Lt/24 hour min	
	Length m		Width m		Depth m		Time s							
	Oct-95	Mar-21	Oct-95	Mar-21	Oct-95	Mar-21	Oct-95	Mar-21	Oct-95	Mar-21	Oct-95	Mar-21	Oct-95	Mar-21
1	3.80	8	2.38	2.06	0.15	0.332	25.65	11.482	0.05289	0.4765163	52.8889	476.5163	4569600	41171007
2	5.20	7.5	1.48	2.44	0.09	2.114	13.02	7.446	0.0532	5.1955681	53.1982	5195.5681	4596321	448897083
3	2.00	6.5	0.13	1.084	0.03	0.2928	4.14	12.882	0.001884	0.1601513	1.884057971	160.1513	162783	13837071
4	3.10	7.15	1	0.79	0.07	0.5336	21.92	24.748	0.0099	0.1217892	9.899635036	121.7892	855328	10522589
5	3.40	4.8	0.18	0.356	0.03	0.1556	14.9	12.248	0.001232	0.0217088	1.232214765	21.7088	106463	1875640
6	3.50	7	0.8	2.518	0.08	0.3	30.39	26.06	0.007371	0.2029087	7.370845673	202.9087	636841	17531309
7	0.77	4.45	0.11	1.92	0.02	0.222	10.77	26.98	0.000157	0.0703027	0.157288765	70.3027	13590	6074157
8	3.30	8	1.1	0.984	0.09	0.534	28.12	13.124	0.011618	0.3203023	11.61806543	320.3023	1003801	27674123
9	3.80	7.25	1.3	1.146	0.05	0.2448	25.07	11.682	0.009852	0.1741072	9.852413243	174.1072	851249	15042866
11	2.50	7.55	0.9	1.378	0.07	0.2736	10.58	17.126	0.014887	0.1662097	14.88657845	166.2097	1286200	14360517
12	2.00	4.3	0.2	0.634	0.02	0.26	8.004	18.078	0.001	0.0392085	0.99950025	39.2085	86357	3387618
									0.163991	**6.9487729**	**163.9876996**	**6948.773**	**14168532.8**	**600373978**