

**Supplementary material**

**Assessment of the physicochemical characteristics of surface waterbodies in a region earmarked for shale gas exploration (Eastern Cape Karoo, South Africa)**

*Annah Mabidi<sup>A,B,C</sup>, Matthew S. Bird<sup>A</sup> and Renzo Perissinotto<sup>A</sup>*

<sup>A</sup>South African Research Chairs Initiative, Shallow Water Ecosystems,  
Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth 6031, South Africa.

<sup>B</sup>Africa Earth Observatory Network, Nelson Mandela Metropolitan University, PO Box 77000,  
Port Elizabeth 6031, South Africa.

<sup>C</sup>Corresponding author. Email: [annahanusa@gmail.com](mailto:annahanusa@gmail.com)

**Table S1. List of the waterbodies sampled in this study**

Latitude and longitude at the centre point of each site are provided in decimal degrees. The vegetation type (*sensu* Mucina and Rutherford 2006) within which each waterbody occurred was used as a fine-scale proxy for the underlying geology specific to each site. All sites were sampled twice (November 2014 and April 2015) with the exception of sites W48 and W117, which were only sampled in November 2014

Water body type	Site code	Latitude	Longitude	Altitude (m)	Vegetation type
Dam	A1	-32.921278	24.260071	674	Eastern Lower Karoo
Dam	MZ27	-32.237188	25.460087	1228	Karoo Escarpment Grassland
Dam	T1	-31.949062	26.18231	1279	Queenstown Thornveld
Dam	W6	-32.999809	24.505765	537	Sundays Thicket
Dam	W23	-32.626008	24.684467	582	Eastern Lower Karoo
Dam	W36	-32.003417	25.142233	1194	Eastern Upper Karoo
Dam	W56	-32.491048	25.318032	1175	Karoo Escarpment Grassland
Dam	W45	-32.316885	24.679974	1311	Karoo Escarpment Grassland
Dam	W87	-32.294236	24.274062	796	Eastern Lower Karoo
Depression wetland	A2	-32.619112	24.183249	731	Eastern Lower Karoo
Depression wetland	MZ30	-32.149391	25.49982	1008	Karoo Escarpment Grassland
Depression wetland	T2	-31.932568	26.079092	1217	Tarkastad Montane Shrubland
Depression wetland	T3	-32.166526	25.676791	930	Tarkastad Montane Shrubland
Depression wetland	W2	-33.027906	25.494876	616	Eastern Lower Karoo
Depression wetland	W25	-32.603381	24.651856	598	Eastern Lower Karoo
Depression wetland	W27	-32.494572	24.299996	661	Eastern Lower Karoo
Depression wetland	W27B	-32.507438	24.655214	654	Eastern Lower Karoo
Depression wetland	W68	-31.955212	26.196083	1275	Queenstown Thornveld
Depression wetland	W93	-32.457843	24.094083	738	Eastern Lower Karoo
Depression wetland	W110	-32.626712	24.192674	725	Eastern Lower Karoo
Depression wetland	W115	-32.943724	24.265472	669	Eastern Lower Karoo
Depression wetland	W117	-32.981841	24.345178	641	Eastern Lower Karoo
River	Delports	-32.972683	24.695368	385	Sundays Thicket
River	MZ17	-32.286219	25.412386	1434	Karoo Escarpment Grassland
River	MZ18	-32.284753	25.42182	1417	Karoo Escarpment Grassland
River	W22	-32.640334	24.691929	578	Sundays Thicket
River	W29	-31.914737	24.787045	1357	Eastern Upper Karoo
River	W48	-32.375479	25.46477	1204	Karoo Escarpment Grassland
River	W53	-32.497168	25.427859	1028	Karoo Escarpment Grassland
River	W62	-32.001047	25.980677	1066	Tarkastad Montane Shrubland
River	W69	-31.985479	26.217119	1228	Queenstown Thornveld
River	W86	-32.291238	24.25339	788	Eastern Lower Karoo
River	W113	-32.916513	24.259611	680	Eastern Lower Karoo



Rivers



Natural depression wetlands



Dams

**Fig. S1.** Images of the three typical waterbody types sampled in the Eastern Cape Karoo region.

**Table S2. Habitat structure, physicochemical, biological and hydromorphometric variables measured in November 2014**

All physicochemical and biological values are means taken across the subsamples for each site (see ‘Materials and methods’ in the main paper). D, dam; ND, natural depression; R, river; CV, complex vegetation; SV, simple vegetation; BU, benthic unvegetated; LU, land-use impact; DO, dissolved oxygen; Temp, temperature; Cond., conductivity; DIN, dissolved inorganic nitrogen; DIP, dissolved inorganic phosphorus; NTU, nephelometric turbidity units; TSS, total suspended solids; POM, particulate organic matter; P Chl-*a*, pelagic chlorophyll-*a*; B Chl-*a*, benthic chlorophyll-*a*; MD, maximum depth; SA, surface area

Site Code	Water body type	CV	SV	BU	MA	LU	DO (mg L <sup>-1</sup> )	pH	Temp. (°C)	Cond. (mS cm <sup>-1</sup> )	DIN (µM)	DIP (µM)	Turbidity (NTU)	TSS (mg L <sup>-1</sup> )	POM (%)	P Chl- <i>a</i> (mg m <sup>-3</sup> )	B Chl- <i>a</i> (mg m <sup>-2</sup> )	MD (m)	SA (m <sup>2</sup> )
A1	D	0	0	4	0	2	6.60	7.68	22.81	0.05	2.86	9.62	155.10	50.10	17	0.11	6.51	0.80	3384.40
MZ27	D	1	0	3	0	1	7.48	8.90	22.68	0.31	1.43	0.06	10.20	11.87	61	0.64	13.78	3.53	67809.00
T1	D	2	0	2	0	2	8.71	8.39	26.81	0.10	1.43	2.00	75.80	56.80	30	48.48	42.46	0.52	1852.70
W6	D	0	2	2	0	3	20.41	10.03	26.06	0.16	5.00	8.07	292.80	190.60	65	68.64	58.35	0.80	4163.80
W23	D	0	0	4	0	3	7.13	8.22	26.89	0.34	182.77	14.63	745.30	47.08	20	6.20	36.92	0.35	5366.30
W36	D	3	0	1	3	2	8.97	8.40	26.06	0.48	1.43	0.71	1.10	3.11	70	2.89	1006.81	1.47	16713.49
W45	D	4	0	0	3	2	14.53	10.17	24.03	0.32	0.71	0.10	2.20	3.48	87	1.36	281.70	3.17	33859.23
W56	D	3	0	1	3	2	13.33	10.52	22.42	0.22	8.57	0.77	15.00	19.03	32	15.63	57.42	1.57	18738.69
W87	D	4	0	0	3	2	9.30	10.64	22.80	0.87	3.57	0.23	0.00	4.08	65	1.53	69.33	1.41	22557.00
A2	ND	2	0	2	0	1	9.96	9.08	23.09	0.04	2.86	2.68	132.80	68.23	37	104.96	22.44	0.58	3384.10
MZ30	ND	0	0	4	0	0	6.07	8.53	27.74	0.10	72.82	3.29	1282.70	496.50	11	71.04	10.17	0.13	1505.80
T2	ND	3	0	1	2	2	8.11	7.87	30.93	0.11	2.14	5.75	76.30	17.68	52	24.90	57.74	0.38	326.26
T3	ND	0	0	4	0	3	14.81	9.90	28.70	0.05	10.00	1.58	49.10	41.30	79	95.68	33.36	0.50	2100.00
W2	ND	2	0	2	0	3	9.28	8.48	22.03	0.15	6.43	2.68	168.70	60.67	20	5.06	19.42	0.41	668.80
W25	ND	4	0	0	3	2	9.09	8.68	27.77	0.08	0.71	0.81	14.00	4.63	92	6.44	95.56	0.40	192.00
W27	ND	1	0	3	0	2	5.27	8.28	18.19	0.19	5.00	4.39	62.10	56.68	16	13.68	41.32	0.29	1343.70
W27B	ND	1	0	3	0	2	4.16	8.53	29.29	0.08	5.00	12.72	152.80	68.23	13	4.82	8.93	1.10	3053.50
W68	ND	0	2	2	0	2	8.06	8.52	23.79	0.04	6.43	1.90	229.60	38.60	21	27.62	12.71	0.60	2096.90
W93	ND	1	0	3	0	2	11.43	9.61	29.73	0.17	7.14	1.68	1315.00	108.44	11	0.30	36.03	0.10	401.20
W110	ND	0	0	4	0	3	7.80	8.74	23.23	0.22	25.70	18.69	1257.40	164.77	10	30.37	33.07	0.25	6158.00
W115	ND	3	0	1	0	2	6.32	7.56	26.43	0.09	0.71	13.82	38.00	11.55	29	4.42	11.73	0.56	1136.50
W117	ND	1	0	3	0	1	8.13	8.51	23.48	0.05	2.14	14.66	92.50	25.35	19	0.19	4.35	0.45	580.86
Delports	R	2	0	2	2	2	14.32	9.47	29.70	2.40	0.71	0.68	1.60	25.87	56	5.89	181.12	0.53	550.00
MZ17	R	2	0	2	3	0	7.79	8.90	21.02	0.30	1.43	0.23	2.90	51.08	15	1.43	18.69	0.17	113.76
MZ18	R	2	0	2	1	0	7.96	8.66	18.10	0.33	0.00	0.00	0.30	2.12	54	0.50	10.89	0.73	186.33

Site Code	Water body type	CV	SV	BU	MA	LU	DO (mg L <sup>-1</sup> )	pH	Temp. (°C)	Cond. (mS cm <sup>-1</sup> )	DIN (µM)	DIP (µM)	Turbidity (NTU)	TSS (mg L <sup>-1</sup> )	POM (%)	P Chl- <i>a</i> (mg m <sup>-3</sup> )	B Chl- <i>a</i> (mg m <sup>-2</sup> )	MD (m)	SA (m <sup>2</sup> )
W22	R	2	0	2	0	3	7.90	8.92	24.89	0.88	1.43	0.81	30.20	27.85	20	14.28	22.38	0.59	246.60
W29	R	3	0	1	3	2	10.95	8.80	20.80	0.77	3.57	1.84	12.30	65.05	14	2.47	35.87	0.45	122.50
W48	R	2	0	2	1	1	6.98	8.55	21.85	0.75	6.43	1.90	1.20	5.98	65	0.24	6.48	0.99	166.00
W53	R	1	0	3	0	2	7.84	8.95	23.98	0.79	1.43	3.07	31.30	42.80	17	0.91	113.00	0.45	179.65
W62	R	2	0	2	2	3	4.83	8.73	23.60	0.49	2.14	1.32	74.10	29.98	20	16.25	51.60	1.21	645.70
W69	R	2	0	2	2	2	10.48	8.92	24.04	1.12	385.52	35.48	93.60	71.83	20	37.60	444.68	0.55	78.87
W86	R	3	0	1	3	2	9.84	8.85	19.72	1.10	10.71	0.68	0.00	3.63	19	0.76	101.57	0.53	613.30
W113	R	1	0	3	2	2	13.18	8.92	29.33	1.11	1.43	4.86	2.70	7.65	69	1.84	25.78	0.29	202.50

**Table S3. Habitat structure, physicochemical, biological and hydromorphometric variables measured in April 2015**

All physicochemical and biological values are means taken across the subsamples for each site (see ‘Materials and methods’ in the main paper). D, dam; ND, natural depression; R, river; CV, complex vegetation; SV, simple vegetation; BU, benthic unvegetated; LU, land-use impact; DO, dissolved oxygen; Temp., temperature; Cond., conductivity; DIN, dissolved inorganic nitrogen; DIP, dissolved inorganic phosphorus; NTU, nephelometric turbidity units; TSS, total suspended solids; POM, particulate organic matter; P Chl-*a*, pelagic chlorophyll-*a*; B Chl-*a*, benthic chlorophyll-*a*; MD, maximum depth; SA, surface area

Site Code	Water body type	CV	SV	BU	MA	LU	DO (mg L <sup>-1</sup> )	pH	Temp (°C)	Cond. (mS cm <sup>-1</sup> )	DIN (µM)	DIP (µM)	Turbidity (NTU)	TSS (mg L P)	POM (%)	P Chl- <i>a</i> (mg m <sup>-3</sup> )	B Chl- <i>a</i> (mg m <sup>-2</sup> )	MD (m)	SA (m <sup>2</sup> )
A1	D	0	0	4	0	2	4.94	8.33	24.64	0.08	71.39	8.36	478.00	36.22	12	4.46	7.35	0.30	2716.80
MZ27	D	1	0	3	0	1	5.77	8.50	18.11	0.32	12.14	4.94	14.00	5.80	72	1.74	29.95	3.55	69052.00
T1	D	2	0	2	0	2	5.22	7.66	20.52	0.06	17.85	2.16	440.00	131.82	31	13.12	32.44	0.68	1190.30
W6	D	0	2	2	0	3	7.59	9.14	26.36	0.20	19.28	6.59	91.20	32.75	31	36.04	44.15	1.00	2980.00
W23	D	0	0	4	0	3	5.27	8.63	21.74	0.12	2.14	10.49	192.00	20.02	17	2.32	57.30	1.20	16485.00
W36	D	3	0	1	0	2	4.64	8.39	19.79	0.39	0.00	2.39	13.20	6.37	60	8.99	353.01	1.37	11684.00
W45	D	4	0	0	3	2	3.32	9.22	17.86	0.29	7.85	3.68	21.80	2.82	40	5.99	83.08	3.53	35111.00
W56	D	1	0	3	3	2	11.97	10.12	23.48	0.27	33.56	32.38	21.40	39.73	20	32.16	221.54	1.33	11072.00
W87	D	0	0	4	1	2	1.48	8.58	18.02	1.59	162.78	13.40	452.00	98.83	21	6.38	223.77	0.53	9939.40
A2	ND	2	0	2	0	1	1.75	7.20	19.29	0.08	52.12	9.62	781.00	65.53	9	4.28	16.46	0.36	1448.50
MZ30	ND	0	0	4	0	0	3.85	7.61	17.42	0.07	2.14	3.52	1000.00	1255.39	5	24.06	24.41	0.60	3957.40
T2	ND	3	0	1	3	2	7.03	7.43	22.80	0.06	0.00	0.16	140.00	102.58	18	11.24	31.13	0.35	347.40
T3	ND	0	0	4	0	3	5.31	7.84	24.04	0.19	0.00	0.00	1000.00	520.15	17	20.52	69.68	0.28	1260.90
W2	ND	2	0	2	0	3	2.34	7.34	23.92	0.16	0.71	1.58	832.00	126.25	8	4.98	18.02	0.54	995.67
W25	ND	4	0	0	2	2	4.99	8.45	25.83	0.07	9.28	14.40	8.20	4.55	94	14.32	29.35	0.33	173.16
W27	ND	1	0	3	1	2	3.86	7.90	22.48	0.19	0.00	2.03	620.00	92.20	11	7.25	37.88	0.20	1442.90
W27B	ND	1	0	3	0	2	4.02	7.46	19.95	0.08	0.00	3.75	87.70	3.35	73	7.-2	110.89	1.30	2809.60
W68	ND	0	2	2	0	2	3.77	8.51	18.66	0.04	5.71	1.84	68.00	14.07	40	6.72	16.74	1.23	2100.30
W93	ND	1	0	3	0	2	4.25	8.06	19.77	0.15	0.71	0.45	138.00	19.03	22	7.19	48.70	0.78	1053.00
W110	ND	0	0	4	0	3	4.49	7.65	18.66	0.16	155.64	12.37	944.00	52.87	9	5.00	299.85	0.61	8472.10
W115	ND	3	0	1	0	2	1.18	7.27	23.24	0.11	0.00	0.00	388.00	50.22	12	7.64	8.01	0.60	1043.50
Delparts	R	2	0	2	2	2	6.52	8.64	26.18	1.68	1.43	0.00	2.10	6.15	39	3.60	99.28	0.50	415.00
MZ17	R	2	0	2	1	0	5.25	8.35	18.13	0.27	14.28	1.94	7.30	5.81	47	0.35	10.95	0.58	238.90
MZ18	R	2	0	2	1	0	5.79	8.18	15.07	0.28	14.99	11.82	2.90	1.23	62	0.25	84.19	0.62	124.60
W22	R	2	0	2	0	3	4.24	8.03	19.01	0.65	1.43	0.23	891.00	56.28	10	3.04	10.52	1.16	335.00

Site Code	Water body type	CV	SV	BU	MA	LU	DO (mg L <sup>-1</sup> )	pH	Temp (°C)	Cond. (mS cm <sup>-1</sup> )	DIN (µM)	DIP (µM)	Turbidity (NTU)	TSS (mg L P)	POM (%)	P Chl- <i>a</i> (mg m <sup>-3</sup> )	B Chl- <i>a</i> (mg m <sup>-2</sup> )	MD (m)	SA (m <sup>2</sup> )
W29	R	3	0	1	1	2	6.24	8.59	17.85	0.77	0.71	2.00	18.60	9.20	25	0.84	38.43	1.48	150.00
W53	R	2	0	2	1	1	5.85	8.67	19.81	0.73	0.00	0.52	29.50	17.52	18	1.69	50.83	0.58	196.90
W62	R	2	0	2	0	3	2.85	7.74	16.75	0.32	0.71	2.84	160.00	49.88	29	8.73	31.23	1.20	645.70
W69	R	1	0	3	0	2	5.16	7.97	17.86	0.41	5.71	0.00	438.00	179.55	9	39.08	30.27	0.35	182.00
W86	R	3	0	1	3	2	4.25	8.11	16.57	1.19	1.42	3.68	0.00	2.38	85	1.30	246.72	0.60	628.50
W113	R	1	0	3	2	2	4.03	8.33	22.43	1.21	0.00	2.62	12.60	3.08	61	2.37	24.69	0.64	248.10

**Table S4. Correlation between TSS and turbidity for each of the three waterbody types in November 2014 (spring) and April 2015 (autumn)**

ND, natural depression wetlands; r, correlation coefficient; \*, significant; NS, not significant

Waterbody type	November 2014	Relationship	Significance	April 2015	Relationship	Significance
	<i>r</i>			<i>r</i>		
Dams	0.833333	Positive	*	0.616667	Positive	NS
ND	0.813187	Positive	*	0.851140	Positive	*
Rivers	0.836364	Positive	*	0.878788	Positive	*



**Table S5. Full statistical output for the results of the Mann–Whitney *U* tests for differences between the November 2014 (spring) and April 2015 (autumn) sampling events in terms of the continuous environmental variables measured across the Karoo depression wetlands sampled in the present study**

Variable	Rank Sum November	Rank Sum April	<i>U</i>	<i>Z</i>	<i>P</i>	<i>Z</i> adjusted	<i>P</i>	Valid N November	Valid N April	2-sided exact <i>P</i>
Dissolved oxygen	238.00	87.00	9.00	3.75311	0.000175	3.75311	0.000175	13	12	0.000037
pH	232.50	92.50	14.50	3.45394	0.000553	3.45527	0.000550	13	12	0.000194
Temperature	216.00	109.00	31.00	2.55646	0.010575	2.55695	0.010560	13	12	0.009556
Conductivity	168.00	157.00	77.00	-0.05439	0.956622	-0.05440	0.956614	13	12	0.978697
Depth	148.00	177.00	57.00	-1.14225	0.253351	-1.14313	0.252986	13	12	0.270124
Total surface area	165.00	160.00	74.00	-0.21757	0.827763	-0.21757	0.827763	13	12	0.851719
Dissolved inorganic nitrogen	200.00	125.00	47.00	1.68618	0.091763	1.69797	0.089514	13	12	0.097642
Dissolved inorganic phosphorus	195.50	129.50	51.50	1.44141	0.149470	1.44224	0.149235	13	12	0.151872
Turbidity	154.00	171.00	63.00	-0.81589	0.414562	-0.81605	0.414472	13	12	0.437102
Total suspended solids	167.00	158.00	76.00	-0.10879	0.913373	-0.10879	0.913373	13	12	0.936162
Particulate organic matter	190.00	135.00	57.00	1.14225	0.253351	1.14225	0.253351	13	12	0.270124
Pelagic chlorophyll- <i>a</i>	180.00	145.00	67.00	0.59832	0.549626	0.59832	0.549626	13	12	0.574293
Benthic chlorophyll- <i>a</i>	151.00	174.00	60.00	-0.97907	0.327546	-0.97907	0.327546	13	12	0.347493

**Table S6. Full statistical output for the results of the Mann–Whitney *U* tests for differences between the November 2014 (spring) and April 2015 (autumn) sampling events in terms of the continuous environmental variables measured across the Karoo rivers sampled in the present study**

Variable	Rank Sum November	Rank Sum April	<i>U</i>	<i>Z</i>	<i>P</i>	<i>Z</i> adjusted	<i>P</i>	Valid N November	Valid N April	2-sided exact <i>P</i>
Dissolved oxygen	170.00	61.00	6.00	3.45048	0.000560	3.45048	0.000560	11	10	0.000170
pH	172.00	59.00	4.00	3.59131	0.000329	3.59598	0.000323	11	10	0.000068
Temperature	158.00	73.00	18.00	2.60546	0.009175	2.60546	0.009175	11	10	0.007950
Conductivity	132.00	99.00	44.00	0.77460	0.438579	0.77460	0.438579	11	10	0.467855
Depth	101.00	130.00	35.00	-1.40836	0.159026	-1.40973	0.158620	11	10	0.173352
Total surface area	107.50	123.50	41.50	-0.95064	0.341787	-0.95095	0.341630	11	10	0.349369
Dissolved inorganic nitrogen	132.00	99.00	44.00	0.77460	0.438579	0.79121	0.428821	11	10	0.467855
Dissolved inorganic phosphorus	120.50	110.50	54.50	-0.03521	0.971913	-0.03528	0.971858	11	10	0.972539
Turbidity	106.00	125.00	40.00	-1.05627	0.290847	-1.05695	0.290533	11	10	0.314372
Total suspended solids	133.00	98.00	43.00	0.84501	0.398103	0.84501	0.398103	11	10	0.426167
Particulate organic matter	116.00	115.00	50.00	-0.35209	0.724771	-0.35209	0.724771	11	10	0.756444
Pelagic chlorophyll- <i>a</i>	123.00	108.00	53.00	0.14084	0.888000	0.14084	0.888000	11	10	0.917690
Benthic chlorophyll- <i>a</i>	123.00	108.00	53.00	0.14084	0.888000	0.14084	0.888000	11	10	0.917690

**Table S7. Full statistical output for the results of the Wilcoxon matched-pair tests for differences between the November 2014 (spring) and April 2015 (autumn) sampling events in terms of the continuous environmental variables measured across the Karoo dams sampled in the present study**

Pair of variables (2014 and 2015)	Valid N	<i>T</i>	<i>Z</i>	<i>P</i>
Dissolved oxygen	9	6.00	2.665570	0.007686
pH	9	9.00	1.599342	0.109746
Temperature	9	6.00	1.954751	0.050613
Conductivity	9	21.00	0.177705	0.858955
Depth	9	22.00	0.059235	0.952765
Total surface area	9	17.00	0.651584	0.514670
Dissolved inorganic nitrogen	9	10.00	1.480872	0.138642
Dissolved inorganic phosphorus	9	11.00	1.362402	0.173072
Turbidity	9	14.00	1.006993	0.313939
Total suspended solids	9	22.00	0.059235	0.952765
Particulate organic matter	9	6.00	6.000000	0.050613
Pelagic chlorophyll- <i>a</i>	9	19.00	0.414644	0.678403
Benthic chlorophyll- <i>a</i>	9	22.00	0.059235	0.952765

### Reference

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