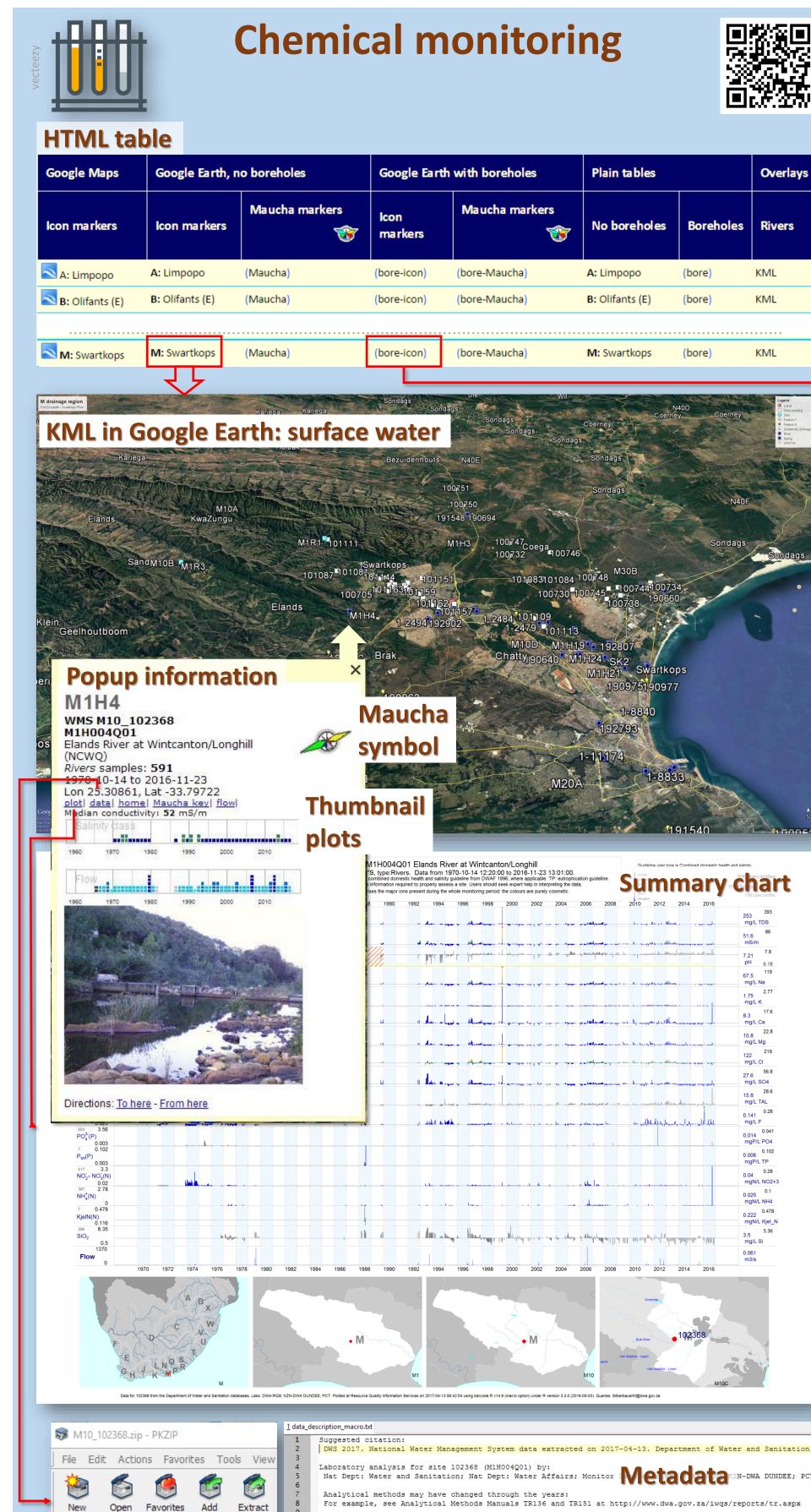
# Innovative ICT tools for water management and science: Data on the web

Internet based data sharing solutions for facilitating water quality data distribution to researchers, stakeholders and policy makers, using R, Google Earth and leaflet

South Africa's Department of Water and Sanitation has water quality data going back to the 1970s and earlier. The information covers more than 50000 sites and comprises about 1 million records, mostly collected at river, dam, canal and borehole sites. Developing water quality maps until the 1980s was a manual process, with infrequent updates because of the effort required. Since the 1990s, DWS has used various IT methods for summarising the data on the Internet. The first spatial information environment was Esri's ARC/INFO (Esri, 1999), using Arc Macro Language scripts to generate HTML pages for the Internet, and eventually KML files for display in Google Earth (Silberbauer & Geldenhuys, 2008). By 2010, the combination of R scripts, Google Earth and leaflet proved to be more efficient. The RODBC package imports data from the Informix water quality database (WMS) and R maptools (Bivand & Lewin-Koh, 2013) provides additional static mapping functionality. The results are accessible on <u>www.dwa.gov.za/iwqs</u> - or scan the QR code.



Here are examples of methods for visualising chemical, microbial and eutrophication data.





# **Microbial monitoring**

National Microbiological Monitoring Programme for Surface Water

### Select an option:

#### NMMP objectives

To provide information on the status and trends of the extent of faecal pollution, in terms of the microbial quality of surface water resources in priority area

To provide information to help assess the potential health risk to humans associated with the possible use of faecally polluted water resources

NMMP products

Bi-monthly reports grouped by nineteen 2004 Water Management Areas. Bi-monthly reports grouped by nine 2012 Water Management Areas.

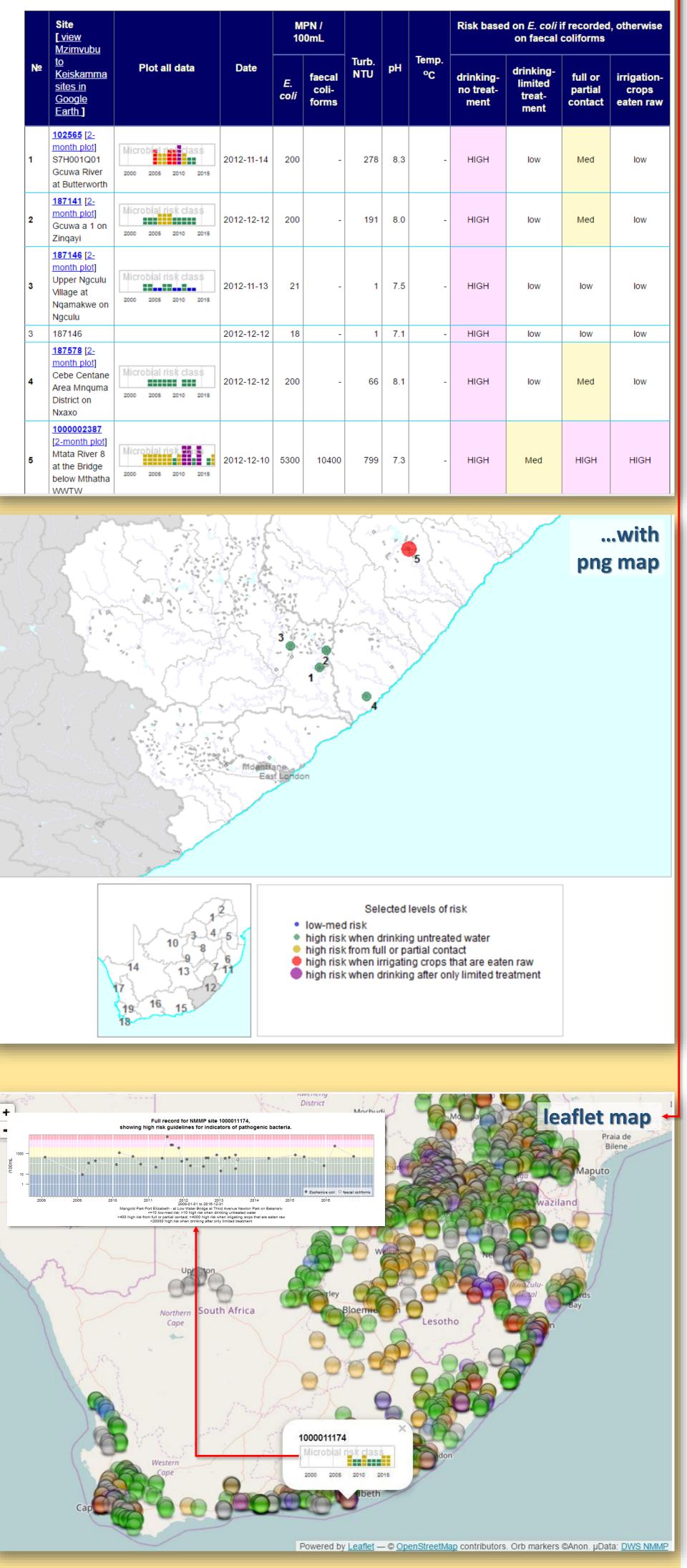
Map of all NMMP hotspot sites. Map of all surface water sites that have microbial data.

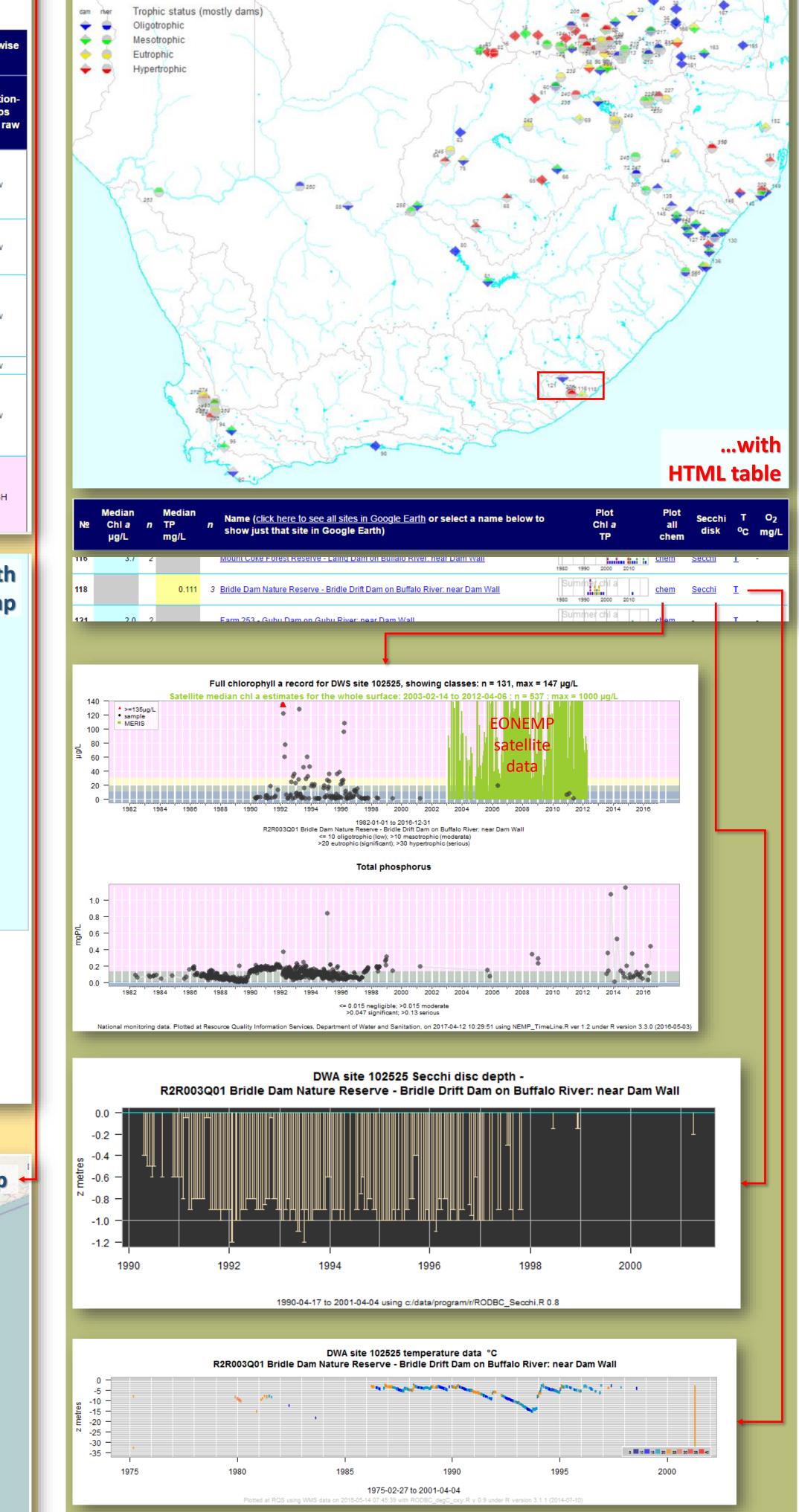
Scripts used for generating the above NMMP products.

 NMMP Mzimvubu to Keiskamma 2012-11-01 to 2012-12-31 - WMA ver. 2004
 HTML ta

 Home| Report list| Notes| ← Prev|Next→
 Home| Notes| ← Prev|Next→

	<b>Eutrophication monitoring</b>
ter resources in priority areas. rater resources.	NEMP products       Select an option:         The NEMP provides periodic assessments of eutrophication in South Africa:         • Web-based reports         • [Six-monthly summer and winter reports]         • Automatically generated depth-time plots in a table         • Automatically generated depth-time plots in Google Earth         • R scripts that generate the web reports         • [2003 state of eutrophication table: Archive document]         • [2003 state of eutrophication report: Archive document]         • The Cyanolakes Earth Observation for NEMP website has a series of chlorophyl II a and cyanobacterial analyses, mainly for a retrospective study using the European Space Agency MERIS sensor, which was active from 2002 to 2012. Information from the European Space Agency's Ocean and Land Colour Instrument (OLCI) became available in 2017, and is also visible on the EONEMP site.
HTML table	Eutrophication data, winter 2016 eutrophication potential (mostly rivers) Negligible Moderate Significant Serious





		19         20           20         21           21         Abb           22         23           23         mon           24         Ca-           25         C1-           26         DMS	17-04-13 06: reviations: _variable_ab Diss-Water Diss-Water -Tot-Water	41:48 using a	nit_abbr mo	on_variabl mg/L mg/L mg/L	le_name mea	asure_unit	t_name mo	on_variab Calciu Chlori Dissol	ole_id m ide ived Majo	or Salt	:5
De_b         institutior         preservat           0         DWA-RQS         HGCL2	8.334         120.7           7.9         120           7         99           8.1         100           6.8         110           6.3         100           5.4         48.2           7.3         11	04         270.207           0.1         253.459           0.4         213.087           0.5         210.671           0.3         219.303           1.7         197.443           96         203.224           2.6         477.902           24         257.086	52.3         1.3           49         0.12           40.4         0.20           42         0.45           43.4         0.00           42.6         0.46           41.1         0.26           64.3         0.20           48.2         0.42	9 2.574 #N/. 7 2.2 #N/. 1 1.2 #N/. 8 1.7 #N/. 5 1.4 #N/. 6 1.9 #N/. 4 1.9 #N/. 8 9.6 #N/. 8 1.9 #N/.	A         12.333           A         10.1           A         8.9           A         8.5           A         9.5           A         8.8           A         8.8           A         20.8           A         11.5	Na_Diss_VNH4 75.335 72 57.2 58.6 56.5 55.3 54.5 54 67.2 76.1	0.05         0.0           0.05         0.0           0.05         0.0           0.05         0.10           0.05         0.00           0.05         0.00           0.05         0.00           0.05         0.00           0.05         0.00           2.78         3.29           0.05         0.0	5 #N/A 5 #N/A 5 #N/A 3 #N/A 5 #N/A 5 #N/A 5 #N/A 8 #N/A 5 #N/A	DH_Diss_VPO 7.81 7.5 7.5 <b>Dat</b> 7.3 7.4 8.5 7.6 7.3 7.6 7.3	0.01	2.13         12.           1.148         1           2.2         1           1.7         1           1.4         1           1.7         1           1.8         1           1.7         1           3.5         7           1.5         1	311 30 10.6 11.6 11.9 13.1 16.5 13.8 73.4 1 11.4	Diss_Station ( ).272 M1H004Q1 22.3 M1H004Q1 16.7 M1H004Q1 17.5 M1H004Q1 5 M1H004Q1 18.9 M1H004Q1 18.9 M1H004Q1 27.1 M1H004Q1 18.9 M1H004Q1 18.9 M1H004Q1
Elands Rive	er @ Wint	canton	C.Area	394 k	m² Lat	-33.79	727	Long	25.3	09	Si	ite Ty	pe <mark>RIV</mark>
		_									-		f m³)
Constant of the second s			Contraction of the second	ondags	Ule	Han Second	Wit		2000		the for	14- P.L	Legend 804
ogle Ea	Kariega arth: Hol	Karlega grou		Bezuidenhouts	N40E	Sondags Sondag	35- Sonda	Coerney gs Sondag Sonda		N40D Coerney	Coe	erney	Legend OD Control Powber Control Pow
oogle Ea Museungu d M10B	A P170266	16292	16 16173141617 24 Swartkops 176716 <sup>63</sup>	Bezuidenhouts 1725-1729 24 161729 162347 162347 162338 168620 168620 168620 168620	N40E 162346 <sup>3</sup> 1481246 04176788 162377 162377 16862 177 16862 177 16862 177 177 177 177 177 177 177 17	Sondag 160204 3 527 Coeg 25 162336 52367 16 5054	108 10 108 11 52365	Sonda 97 162333 00264112 4113 1 46 58 55	101 95 M30B 66 27/1	162342	Coe Son	N40F dags	Lend Conney nords Conney nords
M10 KwaZungu d M10B 42 42	A P170266 Elands	16292 162576 50 16	16 1617314617 24 Swartkops 17671663 61737 M10 170710 32373170711	Bezuidenhouts 1725 161729 162347 162347 M3 162338 168620 168620 168620 168620 1686776 365 C 230 Swarth 162374 113 316 31	N40E 162346 3 14812460 A176788 162377 9: 170504 16862 1605 17 3744 6894 6894	Sondag 8626 160204 3 52 Coeg 25 162336 52367 16 3054 27 17 3054 27 1738 M10	100 108 112 112 108 108 108 108 108 108 108 108 108 108	Sonda 97 162333 00264112 4113 1 46 58 5 62350162 0p \$ 1623 173065	101 95 M30B 66 27/1	162342 62354 15	Coe Son 98	J.J.	Lend Calorina transformation Calorina transf
	o DWA-RQS HGCL2 O DWA-	0       DWA-RQS HGCL2       8.334       120.7         0       DWA-RQS HGCL2       7.9       124         0       DWA-RQS HGCL2       7.9       124         0       DWA-RQS HGCL2       7.9       124         0       DWA-RQS HGCL2       8.1       100         0       DWA-RQS HGCL2       6.8       114         0       DWA-RQS HGCL2       6.3       107         0       DWA-RQS HGCL2       5.4       102         0       DWA-RQS HGCL2       7.3       1         0       DWA-RQS HGCL2       8.7       1         0       DWA-RQS HGCL2       8.7       1         Elands River @ Wint	19       20         20       21         21       Abb         22       23         23       mon         24       Ca-         25       C1-         26       DMS         0       DWA-RQS HGCL2       8.334       120.704       270.207         0       DWA-RQS HGCL2       7.9       120.1       253.459         0       DWA-RQS HGCL2       7.9       94.2       13.087         0       DWA-RQS HGCL2       6.8       110.3       219.303         0       DWA-RQS HGCL2       6.3       101.7       197.443         0       DWA-RQS HGCL2       5.4       96       203.224         0       DWA-RQS HGCL2       7.3       124       257.086         0       DWA-RQS HGCL2       8.7       149       285.97    Elands River @ Wintcanton Flow (link to Flow (link to	19       2017-04-13 06:         20       Abbreviations:         21       Abbreviations:         22       mon_variable_ab         24       Ca-Diss-Water         25       C1-Diss-Water         26       DWA-RQS HGCL2         0 DWA-RQS HGCL2       8.334         10 DWA-RQS HGCL2       7.9         10 DWA-RQS HGCL2       7.9         11 DUX-RQS HGCL2       7.9         12 DWA-RQS HGCL2       8.1         10 DWA-RQS HGCL2       6.8         10 DWA-RQS HGCL2       6.8         10 DWA-RQS HGCL2       6.8         0 DWA-RQS HGCL2       6.8         0 DWA-RQS HGCL2       6.4         0 DWA-RQS HGCL2       6.4         0 DWA-RQS HGCL2       7.3         10 DWA-RQS HGCL2       7.3         10 DWA-RQS HGCL2       7.3         10 DWA-RQS HGCL2       8.7         10 DWA-RQS	19         2017-04-13 06:41:48 using s           20         Abbreviations:           23         mon_variable_abbr measure_un           24         Ca-Diss-Water           25         C1-Diss-Water           26         DMS-Tot-Water           26         DMS-Tot-Water           26         DMS-Tot-Water           26         DMS-Tot-Water           26         DMS-Tot-Water           27         1201         253.459         49           0 DWA-RQS HGCL2         7.9         1201         253.459         49           0 DWA-RQS HGCL2         7.9         1201         253.459         49         0.127         2.2         #N/A           0 DWA-RQS HGCL2         7.9         1201         253.459         49         0.127         2.2         #N/A           0 DWA-RQS HGCL2         6.8         110.3         210.671         42         0.458         1.7         #N/A           0 DWA-RQS HGCL2         6.4         110.3         219.303         43.4         0.05         1.4         #N/A           0 DWA-RQS HGCL2         5.4         96         203.224         41.1         0.264         1.9         #N/A           0 DWA-RQS HGCL	19       2017-04-13 06:41:48 using script bard         20       Abbreviations:         22       23         mon_variable_abbr measure_unit_abbr measure_unit_abbr measure         24       Ca-Diss-Water         25       C1-Diss-Water         26       DWA-RQS HGCL2       8.334         0 DWA-RQS HGCL2       7.9       120.1       253.459         0 DWA-RQS HGCL2       7.9       120.1       253.459       40.4       0.201       1.2       #N/A       8.5         0 DWA-RQS HGCL2       7.9       120.1       253.459       40.4       0.201       1.2       #N/A       8.5         0 DWA-RQS HGCL2       6.8       110.3       210.303       43.4       0.05       1.4       #N/A       9.5         0 DWA-RQS HGCL2       6.3       110.7       197.443       42.6       0.466       1.9       #N/A       8.5         0 DWA-RQS HGCL2       5.4       96       203.224       41.1       0.264       1.9       #N/A       8.5         0 DWA-RQS HGCL2       8.7       149       285.97       56.6       0.11       2.3       #N/A       11.1         Elands River @ Wintcanton       C.Area       394       km² Lat       Start	19       2017-04-13 06:41:48 using script barcode.R v 1         Abbreviations:       abbreviations:         22       mon_variable_abbr measure_unit_abbr mon_variable         24       Ca-Diss-Nater       mg/L         25       C1-Diss-Nater       mg/L         26       DMS-Tot-Water       mg/L         27       DMS-Tot-Water       mg/L         28       DMS-Tot-Water       mg/L         29       DWA-RQS HGCL2       8.34       120.704       270.207       52.31       129       2.574       #N/A       12.333       75.335         0 DWA-RQS HGCL2       7.9       120.1       25.34.59       49       0.127       2.2       #N/A       10.1       72         0 DWA-RQS HGCL2       7.9       120.1       25.34.59       49       0.127       2.2       #N/A       10.1       72         0 DWA-RQS HGCL2       8.1       100.5       210.671       42       0.458       1.7       #N/A       8.5       55.5         0 DWA-RQS HGCL2       6.3       101.7       197.43       42.6       0.466       1.9       #N/A       8       54.5         0 DWA-RQS HGCL2       7.3       124       257.086       48.2       0.428       <	19       2017-04-13 06:41:48 using script barcode.R v 14.8 with t         Abbreviations:       abbreviations:         23       mon_variable_abbr_measure_unit_abbr_mon_variable_name_measure_unit_nabbr_mon_variable_name_measure_unit_abbr_mon_variable_name_measure_unit_abbr_mon_variable_name_measure_unit_nabbr_mon_variable_name_measure_unit_abbr_mon_variable_name_measure_unit_abbr_mon_variable_name_measure_unit_abbr_mon_variable_name_measure_unit_abbr_mon_variable_name_measure_name_measure_unit_abbr_mon_lissigname_name_measure_un	19 201 Abbreviations:       2017-04-13 06:41:48 using script barcode.R v 14.8 with the macro Abbreviations:         22 22 23 24 25 25 25 25 25 25 25 25 25 25 25 25 25	19       2017-04-13 06:41:48 using script barcode.R v 14.8 with the macro option,         Abbreviations:       mon_variable_abbr measure_unit_abbr mon_variable_name measure_unit_name measure_class_water         24       Ca-Diss-Water       mg/L         25       UBS-Tot-Water       mg/L         26       DUS-Tot-Water       mg/L         27       My/A       12.33       70.33       0.05       mV/A         0 DWA-ROSHGCL2       7.9       12.01.23.459       49       0.127       2.2       mg/L         0 DWA-ROSHGCL2       7.9       12.03.274       mV/A       12.03       7.33       0.05       mV/A         0 DWA-ROSHGCL2       7.9       12.04.23.459       49       0.127       2.2       m/A       10.01       72       0.05       0.05       mV/A       7.5         0 DWA-ROSHGCL2       7.9       19.41.24.8       10.05       210.671       44       0.448       1.01       72       0.05       0.05       mV/A       7.5         0 DWA-ROSHGCL2       6.4       10.03       210.671       44       0.44       0.264       1.4       m/A       8.5       5.5       0.05       0.05       mV/A       7.3         0 DWA-ROSHGCL2       5.4       96	2017-04-13 06;41;48 using script barcode.R v 14.8 with the macro option, under R         Abbreviations:         00         10       mon_variable_abbr measure_unit_abbr mon_variable_name measure_unit_name mon_variable_abbr mon_variable_name measure_unit_name mon_variable_name measure_unit_name mon_variable_name measure_unit_name mon_variable_name measure_unit_name mon_variable_name mon_variable_nabser mon_variable_name mon_variable_name mon_variable	2017-04-13 06:41:48 using script barcode.R v 14.8 with the macro option, under R version         Abbreviations:         mon_variable_abbr measure_unit_abbr mon_variable_name measure_unit_name mon_variable_id         Ca-Diss-Nater       mg/L         Calcium         Ca-Diss-Nater       mg/L         Calcium       Calcium         DWA-ROSHGCL2       8.334         10.004 270.207       52.3         10.004 AROSHGCL2       7.9         10.004 AROSHGCL2       6.3         10.012 194 42       0.48         10.004 AROSHGCL2       6.3         10.004 AROSHGCL2       7.3         10.004 AROSHG	1000000000000000000000000000000000000

Methods used: R script, RODBC, maptools. Scripts at <u>www.dwa.gov.za/iwqs/eutrophication/NEMP/report/nemp\_R.zip</u> or

Acknowledgements Heartfelt thanks to the generations of samplers, analysts and scientists who collected the information presented here, and much more.



Methods used: R script, RODBC, maptools, R2leaflet Scripts at <u>www.dwa.gov.za/iwqs/microbio/report/R.zip</u> or

Scripts at <u>www.dwa.gov.za/iwqs/wms/data/000key2scripts.asp</u> or



## Discussion

The advantage of using Google Earth as a viewer for water quality data is that it does all the heavy lifting of geographical and perspective viewing in the background, allowing the aquatic scientist to focus on presenting the data.

An open source platform such as the R language is ideal for producing not only the KML files that place the points on the map, but also the ancillary time-series plots, CSV files and static maps.

The data become more accessible, and can be seen in the context of the landscape, land use and other monitoring sites. The contextual information is also essential for planning of monitoring network changes.

Much remains to be done. For example, users now wish to have access to information by means of **mobile devices** with small screens. The current methods are meant for desktop use, and although they are functional on mobile devices, selecting links and viewing maps is not optimised.

More data sources need to be available, for example estuarine monitoring results, biomonitoring results, trace elements and organic compounds. Data interpretations such as load transport, trend analysis and model output should also be accessible.

**Financial constraints** have begun to limit monitoring, so methods for extracting maximum value from such monitoring as may continue in future will become increasingly important.

### References

Bivand, R. and Lewin-Koh, N. (2013). maptools: Tools for reading and handling spatial objects. R package version 0.8-23, URL <u>http://CRAN.R-</u>project.org/package=maptools

Esri 1999. ARC/INFO: Release 7. Redlands, CA: Environmental Systems Research Institute.

R Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <u>http://www.R-project.org/</u>.

Ripley, B. and Lapsley, M. (2012). RODBC: ODBC Database Access. R package version 1.3-6. URL <u>http://CRAN.R-project.org/package=RODBC</u>

Silberbauer, M. J. and Geldenhuys, W. G. (2008). Using Keyhole Markup Language to create a spatial interface to South African water resource data through Google Earth. In *Proceedings of the FOSS4G 2008 conference*.





IAHS 2017 Scientific Assembly 10-14 July 2017 Port Elizabeth, South Africa "Water and Development: scientific challenges in addressing societal issues" – Mike Silberbauer