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.

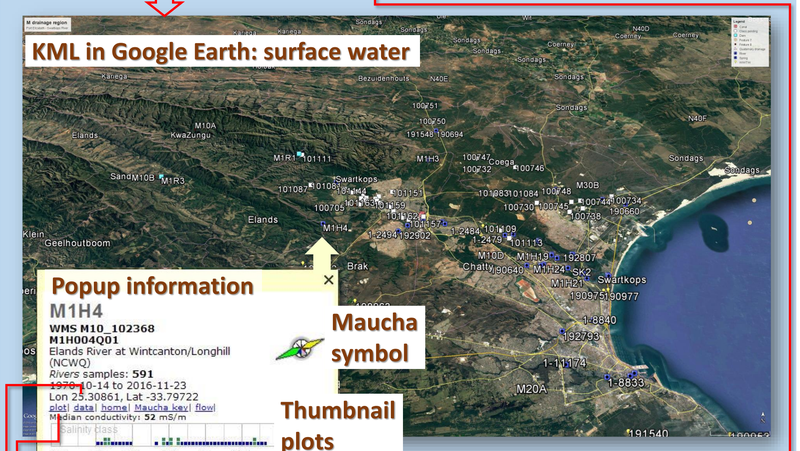
Developing water quality maps until the 1980s was a manual process, with infrequent updates because of the effort required. Since the 1990s, DWS has used various IT methods for summarising the data on the Internet. The first spatial information environment was Esri's ARC/INFO (Esri, 1999), using Arc Macro Language scripts to generate HTML pages for the Internet, and eventually KML files for display in Google Earth (Silberbauer & Geldenhuys, 2008).

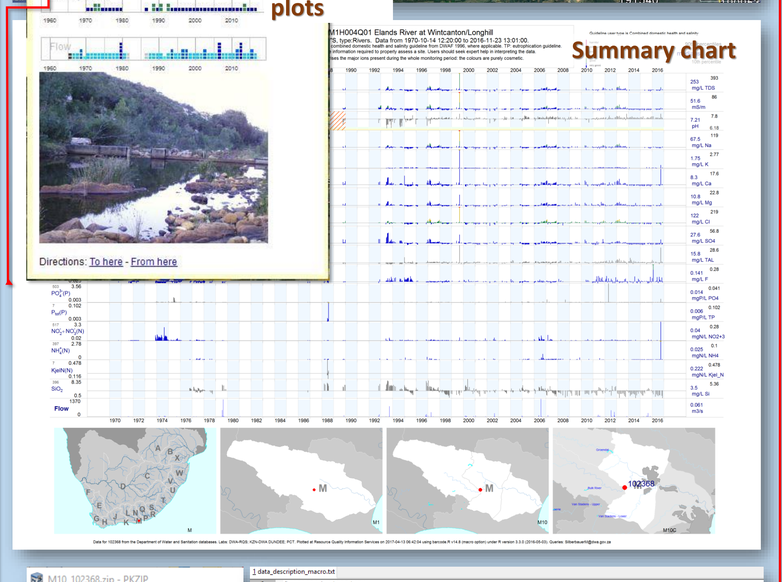
By 2010, the combination of R scripts, Google Earth and leaflet proved to be more efficient. The RODBC package imports data from the Informix water quality database (WMS) and R maptools (Bivand & Lewin-Koh, 2013) provides additional static mapping functionality. The results are accessible on www.dwa.gov.za/iwqs - or scan the QR code.
Here are examples of methods for visualising chemical, microbial and eutrophication data.

Chemical monitoring

HTML table

Google Maps	Google Earth, no boreholes		Google Earth with boreholes		Plain tables		Overlays
Icon markers	Icon markers	Maucha markers	Icon markers	Maucha markers	No boreholes	Boreholes	Rivers
A: Limpopo	A: Limpopo	(Maucha)	(bore-icon)	(bore-Maucha)	A: Limpopo	(bore)	KML
B: Olifants (E)	B: Olifants (E)	(Maucha)	(bore-icon)	(bore-Maucha)	B: Olifants (E)	(bore)	KML
M: Swartkops	M: Swartkops	(Maucha)	(bore-icon)	(bore-Maucha)	M: Swartkops	(bore)	KML





Methods used: R script, RODBC.
Scripts at www.dwa.gov.za/iwqs/wms/data/000key2scripts.asp or

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 areas.

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.

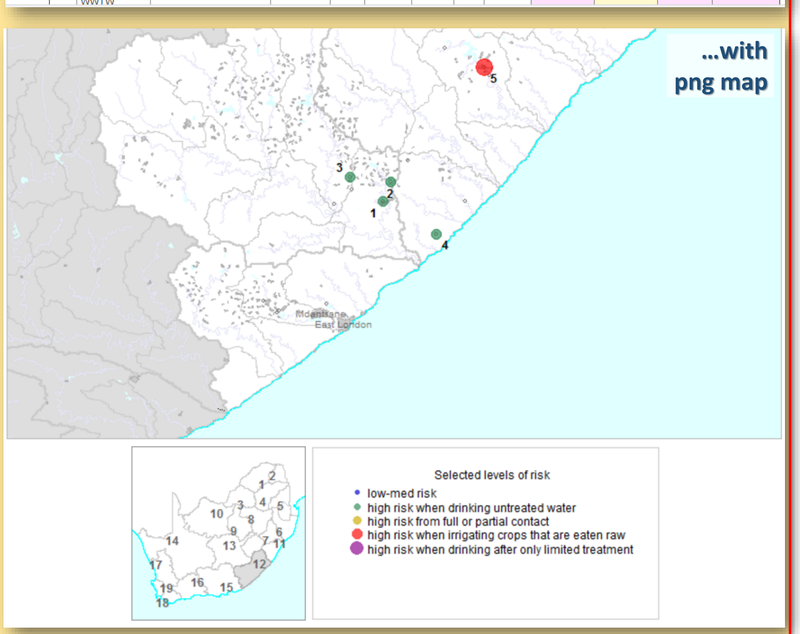
Scripts used for generating the above NMMP products.

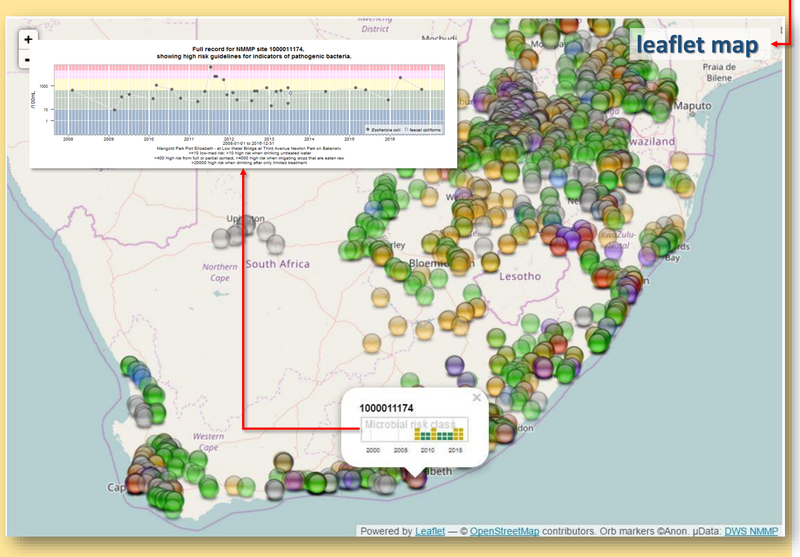
NMMP Mzimvubu to Keiskamma 2012-11-01 to 2012-12-31 - WMA ver. 2004

HTML table...

Home| Report list| Notes| ←Prev|Next→

№	Site [view Mzimvubu to Keiskamma sites in Google Earth]	Plot all data	Date	MPN / 100mL		Turb. NTU	pH	Temp. °C	Risk based on *E. coli* if recorded, otherwise on faecal coliforms			
				E. coli	faecal coli-forms				drinking-no treat-ment	drinking-limited treat-ment	full or partial contact	irrigation-crops eaten raw
1	102565 [2-month plot] S7H001Q01 Gcuwa River at Butterworth	Microbial risk class	2012-11-14	200	-	278	8.3	-	HIGH	low	Med	low
2	187141 [2-month plot] Gcuwa a 1 on Zinqayi	Microbial risk class	2012-12-12	200	-	191	8.0	-	HIGH	low	Med	low
3	187146 [2-month plot] Upper Ngculu Village at Nqamakwe on Ngculu	Microbial risk class	2012-11-13	21	-	1	7.5	-	HIGH	low	low	low
3	187146		2012-12-12	18	-	1	7.1	-	HIGH	low	low	low
4	187578 [2-month plot] Cebe Centane Area Mnquma District on Nxaxo	Microbial risk class	2012-12-12	200	-	66	8.1	-	HIGH	low	Med	low
5	1000002387 [2-month plot] Mtata River 8 at the Bridge below Mthatha WWTW	Microbial risk class	2012-12-10	5300	10400	799	7.3	-	HIGH	Med	HIGH	HIGH





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

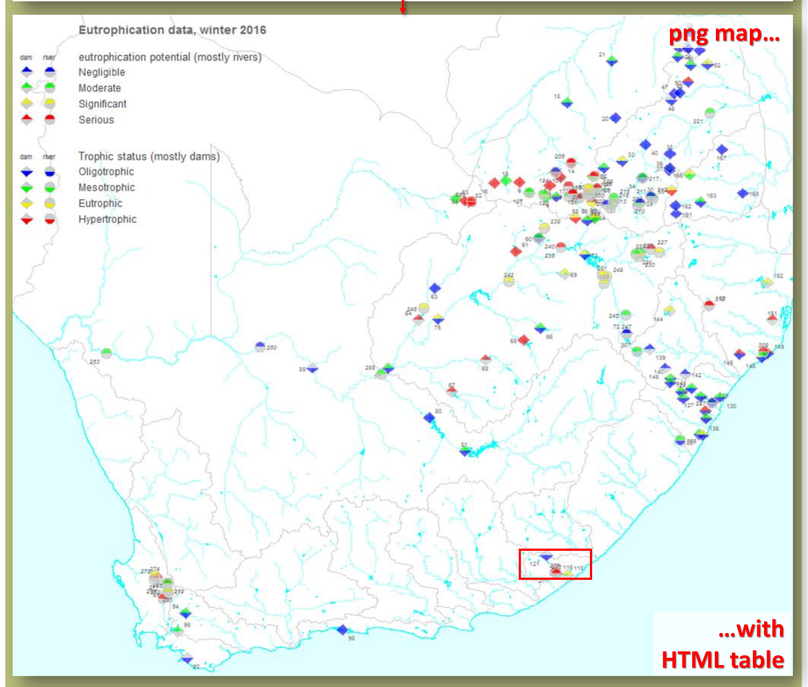
Eutrophication monitoring

NEMP products **Select an option:**

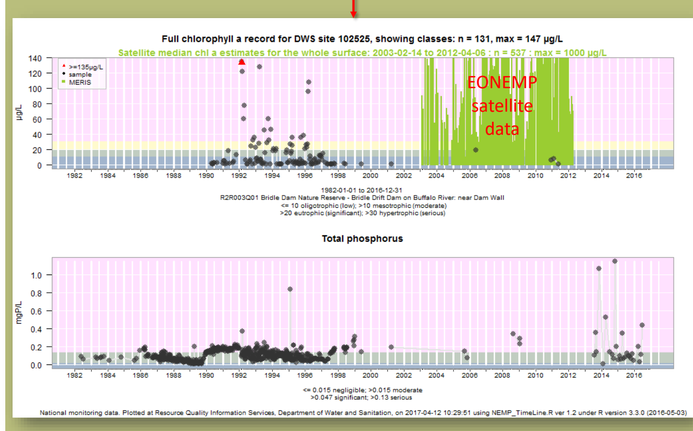
The NEMP provides periodic assessments of eutrophication in South Africa:

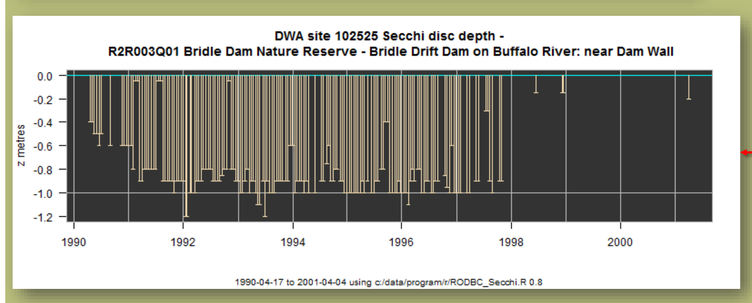
- Web-based reports
  - [Six-monthly summer and winter reports]
  - Automatically generated depth-time plots in a table
  - Automatically generated depth-time plots in Google Earth
  - R scripts that generate the web reports
- [2003 state of eutrophication table: Archive document]
- [2003 state of eutrophication report: Archive document]
- The Cyanolakes Earth Observation for NEMP website has a series of chlorophyll *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.

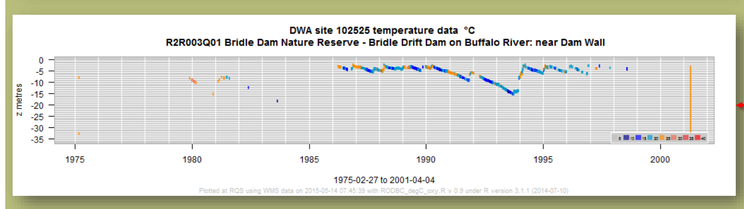
For more on EONEMP satellite data, see eonemp.cyanolakes.com



№	Median Chl *a* µg/L	*n*	Median TP mg/L	*n*	Name (click here to see all sites in Google Earth or select a name below to show just that site in Google Earth)	Plot Chl *a* TP	Plot all chem	Secchi disk	T °C	O_2 mg/L
116	3.7	2			Mount Coke Forest Reserve - Laleni Dam on Buffalo River: near Dam Wall		chem	Secchi	T	-
118			0.111	3	Bridle Dam Nature Reserve - Bridle Drift Dam on Buffalo River: near Dam Wall		chem	Secchi	T	
121	2.0	2			Farm 253 - Gubu Dam on Gubu River: near Dam Wall		chem		T	







Methods used: R script, RODBC, maptools.
Scripts at www.dwa.gov.za/iwqs/eutrophication/NEMP/report/nemp_R.zip 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.

Acknowledgements

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

References

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

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*.