Development of Citizen Science Water Resource Monitoring Tools and Communities of Practise for South Africa, Africa and The World

Appendices

June 2018

Dr Mark Graham and Dr Jim Taylor.

APPENDIX A: TABULATED SUSTAINABLE DEVELOPMENT GOALS

Sustainable Development Goals		SDG Number and Detail		Citizen Science relevance
Goal 1	**End poverty in all its forms everywhere**	1.4	Access to natural resources	Profile the importance of ecosystem services, ecological infrastructure and natural capital
		1.5	Build resilience to climate change, environmental shocks and disasters	Capacity building and appropriate technologies for resilience
Goal 2	**End hunger, achieve food security and improved nutrition and promote sustainable agriculture**	2.4	Maintain ecosystems that strengthen adaptation to climate change. Improve land and soil quality	Community level agricultural livelihoods support
Goal 3	**Ensure healthy lives and promote well-being for all at all ages**	3.9	Prevention of air, water and soil pollution	Human capacity development. Citizen science monitoring
Goal 4	**Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all**	4.1	Quality education	Schools programme Accredited and non-accredited training
		4.4	relevant skills, decent jobs and entrepreneurship	Green Economy
		4.7	promote sustainable development (ESD) Sustainable lifestyles	Provide demonstrations of SD and Sustainable livelihoods Include teacher training (4.c)
Goal 5	**Achieve gender equality and empower all women and girls**	5.a	Rights to economic resources including natural resources	Include gender focus in all of our projects including understanding and access to water
Goal 6	**Ensure availability and sustainable management of water and sanitation for all**	6.1	Access to safe and affordable drinking water for all	Capacity development with focus on water; Catchment protection and restoration; monitoring and reporting on water quality
		6.3	Improve water quality	
		6.4	Water use efficiency	
		6.5	Integrated water resource management	
		6.6	Restore water related ecosystems	

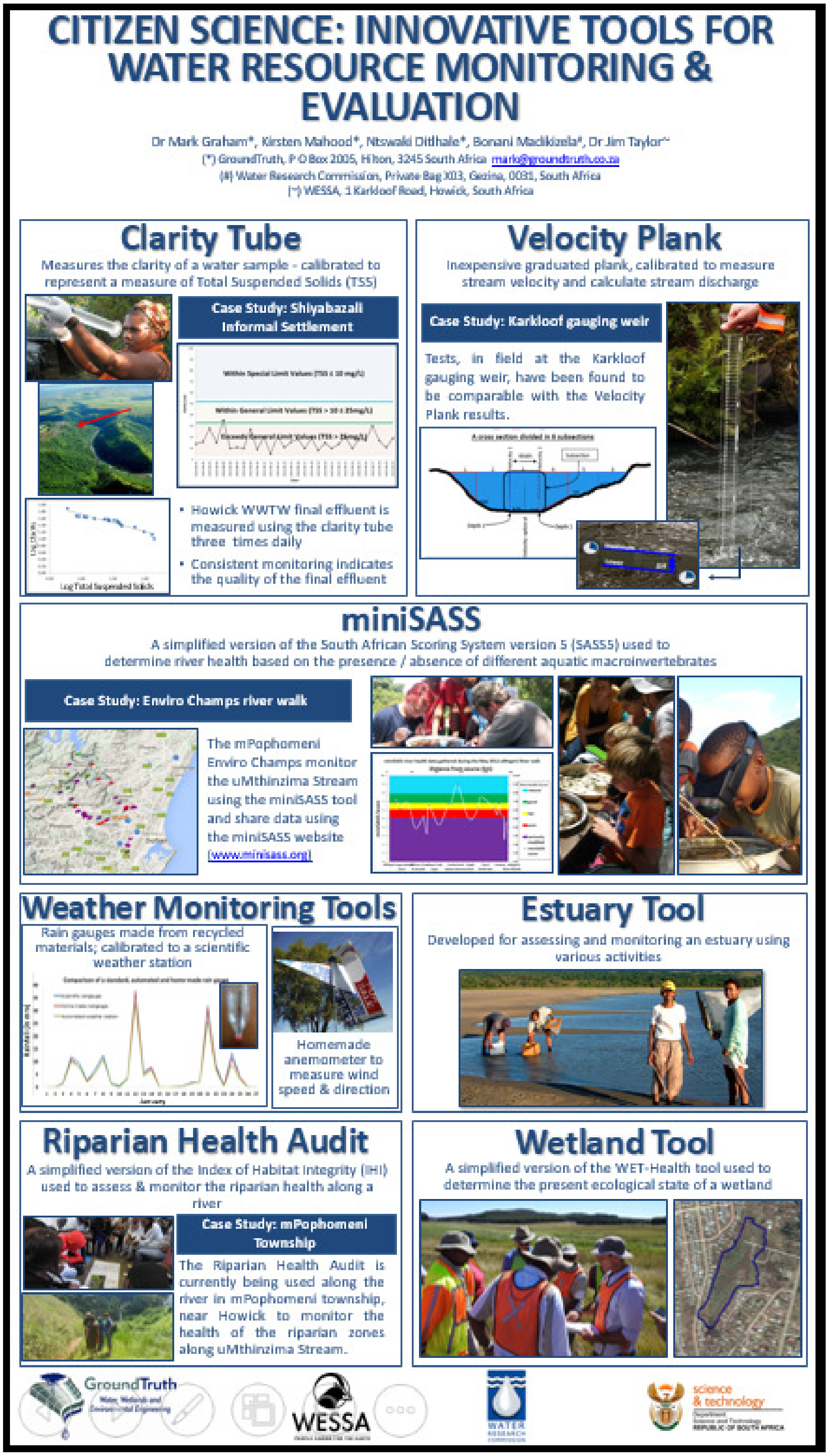
		6.a	Capacity building support in water participation in local communities in improving water and sanitation management	
		6.b		
Goal 7	**Ensure access to affordable, reliable, sustainable and modern energy for all**	7.2	Increase renewable energy	Alternative technologies?
		7.3	Improve energy efficiency	
		7.a	Clean energy	
		7.b	Sustainable energy	
Goal 8	**Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all**	8.4	Global resource efficiency. Decouple economic growth from environmental degradation	Build a green economy through capacity development, sustainable technologies, green jobs and sustainable livelihoods
		8.9	Promote sustainable tourism	
Goal 9	**Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation**	9.1	Sustainable and resilient infrastructure	Emphasise ecological infrastructure
		9.4	Clean and environmentally sound technologies	Demonstrate alternatives
Goal 10	**Reduce inequality within and among countries**			
Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable**	11.1	Access to basic services	Ensure affordability by protecting ecological infrastructure
		11.3	Sustainable urbanisation	Demonstrate sustainable alternatives
		11.4	Safeguard cultural and natural heritage	Projects that protect natural heritage
		11.5	Reduce water related disasters	Capacity development for risk reduction; Water quality and flow monitoring
		11.6	Reduce environmental impact of cities. Air quality and waste management	Capacity development focused on separation at source
		11.7	Green spaces	Community involvement in green spaces
		11.a	Environmental links (linking urban life to	Awareness raising

			natural resources)	
		11.b	Resource efficiency, adaptation to climate change	Capacity development and alternative technologies
		11.c	Sustainable resilient buildings	Alternative technologies
Goal 12	**Ensure sustainable consumption and production patterns**	12.1	Sustainable production and consumption	Consumer Education
		12.2	Sustainable management of natural resource	Community mobilisation; Working For….
		12.4	Chemical and waste management to protect air, water and soil	Capacity building and monitoring
		12.5	Waste reduction, recycling and reuse	Community programmes
		12.6	Companies to adopt sustainable practices	Partnerships with corporates
		12.8	Sustainable Development and lifestyles in harmony with nature	Sustainable Livelihoods Consumer Education
		12.b	Tools to monitor sustainable development impacts	Citizen Science; audit tools
Goal 13	**Take urgent action to combat climate change and its impacts***	13.1	resilience and adaptive capacity to climate related hazards	Capacity development, sustainable livelihoods and appropriate technologies
		13.3	Education, awareness raising and human capacity development	Education, awareness raising and human capacity development
		13.a		Note: look to access Green Climate Fund
		13.b	Raise capacity for effective climate change related planning and management	Capacity development for local leaders
Goal 14	**Conserve and sustainably use the oceans, seas and marine resources for sustainable development**	14.1	Reduce marine pollution, including nutrient pollution	Monitoring of outflows from rivers and drainage pipes
		14.2	Sustainable manage and protect marine ecosystems	Accreditation and recognition of appropriate practices

		14.5	Conserve coastal and marine areas	
		14.7	Sustainable use of marine resources	
		14.a	Improve ocean health and marine biodiversity	
		14.c	Conservation and sustainable use of oceans	
Goal 15	**Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss**	15.1	Ensure conservation, restoration and sustainable use of freshwater ecosystems including forests, wetland, mountains and drylands	Integrated catchment management including capacity development, sustainable livelihoods;
		15.2	Sustainable management of forests	
		15.3	combat desertification	
		15.4	Ensure conservation of mountain ecosystems including biodiversity	
		15.5	Reduce the degradation of natural habitats, loss of biodiversity.	Alien clearing programmes; restoration projects; sustainable management
		15.7	End poaching of flora and fauna	Keystone and iconic species
		15.8	Reduce the impact of invasive alien species on land and water ecosystems	Alien clearing programmes; restoration projects; sustainable management
		15.9	integrate ecosystem and biodiversity values into planning	Promote the importance of ecosystem services and ecological infrastructure through courses. SEA and SEMP development
		15.c	increasing the capacity of local communities to pursue sustainable livelihood opportunities	Capacity development for sustainable livelihoods. Alternative livelihoods demonstrations

Goal 16	**Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels**			
Goal 17	**Strengthen the means of implementation and revitalize the global partnership for sustainable development**	17.7	Promote the development, transfer and use of environmentally sound technologies	Demonstration of sound technologies;
		17.9	Effective capacity building to implement the sustainable development goals	Capacity development with SDGs built into them
		17.14	Enhance policy coherence for sustainable development	Integrated Development Plans; EIA and Strategic Environment Management Planning
		17.16	Global partnerships for sustainable development	Build on existing partnerships
		17.17	Promote civil society partnerships	Promote civil society partnerships
		17.18	Capacity building to increase availability of high quality data	Capacity building based on citizen science (giving away the tools of science)

APPENDIX B: WISA POSTER ON CITIZEN SCIENCE TOOLS



APPENDIX C: WORKSHOP REPORT TEMPLATE

Development and Innovative Use of Community-Based Water Resource Monitoring Tools to Research and Mainstream Citizen Science and Improve Trans-Boundary Catchment Management

Date & Location

21st October 2016
EThekwini Northern WWTW, Durban

Participants

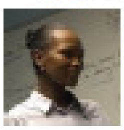
A total of 24 participants, including workshop leaders.

SDG's addressed

1,2,3,4,5,6,7,8,9,10,11, 12,13,14,15,16 & 17

Workshop Team

Dr. Jim Taylor
WESSA

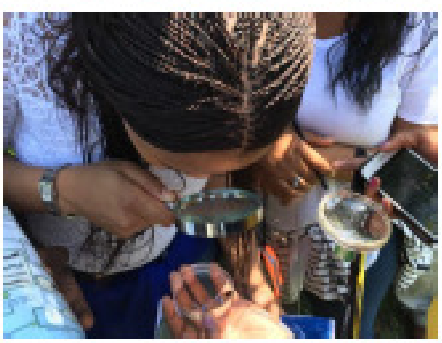


Ntswaki Dithlale
Ground Truth

Workshop Description

The main purpose of the day was to introduce Action Learning on a local level through the citizens science tools. The day started with introductions where the participants also got the opportunity to describe their expectations for the work shop. The day continued with an introduction the the Sustainable Development Goals and an small activity to make the group a bit more familiar with the different SDG's. To continue, the miniSASS was introduced. Before going to the stream the different tools where introduced to the group. Outside by the little stream the group used the net to collect bugs which was identified with help from the field guide. The clarity of the water was also measured with help from the clarity tube. The different indicators showed the current state of the stream which was later discussed inside. The participants and the leaders of workshop discussed the new way of learning and also if the different expectations of the day were fulfilled.

Workshop Images

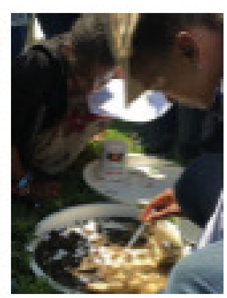


Main Impacts

The group attending the workshop got introduced to Action Learning which can help them work with their communities in a different and a more efficient way.

Notable Achievements

The group was very happy with the day and felt that they had learnt a lot about Action Learning and miniSASS.



APPENDIX D: LIST OF WORKSHOPS

Year	Month	Title of event	Activity type	Organisation/s or person	No. of attendees	Description of activity
2013	August	Palmiet River Watch Introduction to miniSASS	Practical activity	Gary de Winnaar and Anelile Gibixego (GroundTruth); residents along the Palmiet River	17	Residents were provided with background info on the miniSASS tool; later residents were given the opportunity to conduct a miniSASS assessment on the Palmiet River.
2013	October	Pelham miniSASS Day	Practical activity	GroundTruth and Pelham Grade 7 pupils	23	Grade 7 pupils were provided with an overview of miniSASS, with some background info on stream ecology principles. The pupils were then taken to a local stream to do a formal miniSASS study. The study also formed part of a Masters project, conducted by Samiksha Singh (UKZN).
2013	October	Palmiet River Watch miniSASS Day	Practical activity	Anelile Gibixego and Mahommed Desai (GroundTruth); residents along the Palmiet River	18	Residents were provided with background info on the miniSASS tool; later residents were given the opportunity to conduct a miniSASS assessment on the Palmiet River.

2013	December	Enviro-Champs Dissemination Workshop	Dissemination Workshop	DUCT / WESSA / Enviro-Champs from PMB (Ashdown, Sobantu and Imbali)	35	Water and Sanitation, meetings in Mpophomeni (visit to sewerage pump sites /discussions with plumbers. Then traced the sewer line to Howick WWTW. Here a tour was conducted before a visit to the Howick Falls where a Mandela wreath was laid before a visit to Shiyabazali where all learnt how to use the clarity tube. Dissemination Workshops were then held at uMngeni Valley.
2014	January	LHPA phII: Specialist feedback: Macroinvertebrates	Dissemination Workshop	GroundTruth	??	
2014	February	Save Midmar: Water quality drivers and trends within tributaries feeding into Midmar Dam	Dissemination Workshop	Mark Graham	??	
2014	February	International Dissemination Workshop on Education for Sustainable Development	Dissemination Workshop	Jim Taylor	28	Facilitated an Education for Sustainable Development Dissemination Workshop for Leaders in Education in Gaborone. We have 28 Directors /Deans and Principles of Colleges with us here. I shared the citizen science project with them and invited them to experiment with the tools.

2014	March	Greyton House Village School River Day	Practical activity	Teachers from Greyton House Village School	?	Different grades from the school, from pre-primary up to Grade 7 were assigned a river to assess water quality. These rivers included the Scholtz, Gobos, Noupoort and Riviersonderend Rivers. Each grade used a range of different tools to assess the quality of the rivers, including a miniSASS assessment.
2014	March	National Water Week-launch of the Adopt-a-River Campaign	Dissemination Workshop	This event involved the Department of Water affairs, Water Research Commission, GroundTruth, Department of Science and Technology and WESSA's Eco-schools.	?	As part of the nationwide celebrations the Deputy Minister of Environmental Affairs, Miss Rejoice Mabudafhasi went to Tshikali River for the launch of the Adopt-a-River Campaign. Ladies of the Matsila village alongside the minister, participated in conducting a miniSASS on the Tshikali River.
2014	March	International Day of Action for Rivers: miniSASS training	Training	The Alexandra High School EnviroClub attended the miniSASS training and practical.	30	School children attended a day of miniSASS training on the Blackburrow Spruit (Pietermaritzburg).
2014	March	Groen Sebenza Provincial River Health Day	Dissemination Workshop	Groen Sebenza pioneers from 7 different organisations; WESSA; GroundTruth	49	The day consisted on discussions around water resources and a training session on miniSASS

2014	March	Aquatic Ecology Course	Training	Included a group of people from “Environmental Rural Solutions” and municipal officials	15	The course focused on introducing attendees to the theory of aquatic ecology. Practicals included an introduction to miniSASS, the clarity tube and the Index for Habitat Integrity (IHI).
2014	May	KZN Water Week	Dissemination Workshop	DWA, WESSA	??	Learners were educated about the distribution of water in South Africa. They measured the quality of the Injusuthi River using miniSASS.
2014	May	miniSASS Meeting/Workshop	Dissemination Workshop	Bonani Madikizela (WRC), Mark Graham (GroundTruth), Derrick Kotze, Simon Bruton (GroundTruth), Shaan Nienaber (Dept. Sc. & Tech.)	5	Identifying the key development needs and requirements for the miniSASS app.
2014	May	How to write a research proposal?	student support group meetings	Mr Mike Ward (WESSA)	16	Mr Mike Ward (WESSA) presented on how to write a research proposal. This meeting focused on introducing the students to the WRC project and to provide support for their personal research projects.
2014	June	Healthy Rivers-Healthy people: Citizen Science for sustainable water management in a climate stressed society	Dissemination Workshop	Sponsored by the British High Commission and involving most of the project research team	12	Providing insight into the WRC project, with an introduction to the key tools and interventions that require testing.

2014	June	Centre for Environmental Rights (CER) Dissemination Workshop in Potchefstroom and the North West Province	Dissemination Workshop	Residents from Sannieshof and surrounds (North West Province); Dissemination Workshop programme facilitated by the Centre for Environmental Rights (CER), Lawyers for Human Rights (LHR) and with support from the Konrad-Adenauer-Stiftung Foundation. Dr Mark Graham (GroundTruth) provided information and training on how to monitor the health of the Harts River.	50	Residents were provided insight into their environmental rights; practical experience was also provided on how to conduct a miniSASS sample. See summary article on this work: http://www.kas.de/wf/doc/kas_39270-1522-2-30.pdf?141030080738.
2014	June - July	Water Research Commission Youth Summit	Dissemination Workshop	Organised by WRC and facilitated by GroundTruth; attendees included students and delegates.	210	Students from a wide variety of backgrounds and schools attended the summit- teaching the attendees on water resources in South Africa. Practical theory on miniSASS was conducted during the course of the summit; including a display on how to use the clarity tube.

2014	June		student support group meetings	Dr Jim Taylor (WESSA)	26	Student Water Symposium- students presented on their various current projects
2014	June	Governance of water resources - an overview of Ostrom's Social-Ecological Systems (SES) concept.	student support group meetings	Mr Duncan Hay (UKZN)	24	Presentation to students by Mr Duncan Hay (UKZN) on: governance of water resources, an overview of Ostrom's Social-Ecological Systems (SES) concept.
2014	June	Introduction to the aims and objectives of the WRC project and how the research topics of the students might align with these.	student support group meetings	Mrs Liz Taylor (DUCT)	17	Members of the research team (project K5 2350) introduced the aims and objectives of the project to the students, in order to see whether their research topics align with the project.
2014	July	WESSA EcoSchools mini-conference	Dissemination Workshop	GroundTruth	18	GroundTruth provided training on miniSASS in a designated session, to interested teachers and other educators.
2014	July	Using Citizen Science to Evaluate the Ecological Integrity of South African Rivers: Various case studies and current research initiatives	Dissemination Workshop	Mark Graham	??	

2014-Jul-11		An introduction and overview of Social Learning theory (Wals).	student support group meetings	Dr Jim Taylor (WESSA)	21	Presentation by Dr Jim Taylor (WESSA) on Social Learning Theory (Wals).
2014	July	DUCT/Green Trust GIS Project for the Umngeni-Msunduzi Catchment	Dissemination Workshop	GroundTruth and DUCT	??	
2014	August	Student Learning Session: “How to find useful and relevant references?”	student support group meetings	Prof Mathieu Rouget (UKZN)	6	This was the first meeting of the student learning series, in which key research principles/practices were taught to the students. For this meeting the topic was: "How to find useful and relevant references?"
2014	September - October	SADC Citizen Science Network Training Symposium	Symposium	Facilitated and hosted by WESSA and GroundTruth. Supported by the Department of Water and Sanitation (DWS). Sponsored by the British High Commission (BHC).	55	A group of delegates representing different SADC countries attended. Theory and training included an introduction to the various citizen science tools, including miniSASS, the clarity tube and IHI.
2014	September	Youth Water Dissemination Workshop- Mpophomeni Sanitation Education Project (MSEP)	Dissemination Workshop	Louine Boothway facilitated the Dissemination Workshop under the MSEP project.	45	Students and other interested individuals from local EnviroClubs were shown how to use miniSASS. Students were then allowed to test their skills practically on the Mthinzima stream.

2014	October	Ecological Infrastructure Dissemination Workshop	Dissemination Workshop	Traditional Leaders from the uMgungundlovu district municipality (Group 2); held at Amanyavu	33	
2014	October	Ecological Infrastructure Dissemination Workshop	Dissemination Workshop	Traditional Leaders from the uMgungundlovu district municipality (Group 1); held at Mafunze	34	
2014	October	Centre for Environmental Rights (CER) Dissemination Workshop	Dissemination Workshop	CER staff; GroundTruth	30	A background presentation was provided on miniSASS, providing some key concepts on aquatic ecology. CER staff were then provided the opportunity to conduct a miniSASS assessment on the Harts River. Practical demonstrations were also provided on how to use the clarity tube.
2014	October	Cata Village Community Dissemination Workshop- miniSASS training and stream ecology Dissemination Workshop	Dissemination Workshop	Cata Cultural Village; Dr Mark Graham (GroundTruth) and Dr Jim Taylor (WESSA)	10	Members of the Cata Cultural Village (Eastern Cape) were shown how to conduct a miniSASS assessment, following a brief introduction to aquatic ecology.
2014	October	SASS5 Training: Citizen Science Tools	Training	Mark Graham	??	

2014	October	Cata Village Community workshop: miniSASS training & stream ecology Workshop	Dissemination Workshop	Mark Graham	??	
2014	October	Introduction to Stream Ecology	Dissemination Workshop	Mark Graham	??	
2014	October	River Health Monitoring (miniSASS) & Citizen Science Workshop North West Province: case studies and current research initiatives	Dissemination Workshop	Mark Graham	??	
2014	November	New Generations Plantations	Dissemination Workshop	International foresters and members of NGOs (e.g. WWF); GroundTruth	40	A group of foresters from different countries took part in a miniSASS training day, as part of a weeklong forestry training course organized by WWF and Mondi.
2014	November	Workshop	Dissemination Workshop	Representatives from different countries across the globe	??	WESSA partnering with UNESCO in the Global Action Programme (GAP) on the Education for Sustainable Development (ESD). This initiative forms part of the steps to achieve the Sustainable Development Goals (SDG's).

2014	December	Umzimvubu Catchment Partnership Programme Forum	Dissemination Workshop	T Dambuza	??	Presentation on miniSASS
2014	December	CWRR Workshop: What's Your Purpose?	Dissemination Workshop	GroundTruth	??	
2014	December	Eco Rangers miniSASS Workshop	Dissemination Workshop	T Dambuza/N Tsheyi/P Cingo	31	Presentation and field work
2014		Citizen Science Tools	Dissemination Workshop	Mark Graham	??	
2014		Grahamstown Mirroring Workshop	Dissemination Workshop	DUCT	??	
2015		WRC Dialogue Workshop	Dissemination Workshop	DUCT	??	
2015-Jan-16		Social learning theory with Prof Arjen Wals- this was an informal citizen science discussion.	student support group meetings	Dr Jim Taylor (WESSA) and Prof Arjen Wals (Wageningen University, Holland)	24	

2015	January - April	TriWaters Tour	River Talks and training	Adventure Kayakers (Franz Fuls; Brett Merchant	Variable depending on community and school	The adventure kayakers facilitated various River Talks during the duration of their tour; the aim was to inform and train various local residents and schools surrounding the Vaal and Orange River on how to use miniSASS.
2015	February	Umsunduzi Officials	Dissemination Workshop	T Dambuza/L Betha/N Mtshali/D Radebe	35	Presentation and field work
2015	February	Women in Water Workshop	Dissemination Workshop	T Dambuza/L Betha/N Mtshali/D Radebe	??	Field work
2015	February	Ecological Infrastructure Dissemination Workshop	Dissemination Workshop	Hosted by WESSA, with training provided by GroundTruth (Dr Mark Graham) and involving most of the project research team; training was attended by local Msunduzi Municipality officials.	15	This event was under the environmental education initiative, including the uMngeni Ecological Infrastructure Partnership (UEIP) - aiming to train delegates in water resources.

2015	February	Capacity for Catchments “Leadership Seminars”	Dissemination Workshop	Numerous groups including traditional leaders, SALGA, CoGTA, Local Government Leadership and Councillors	??	Seminars run by WESSA with support from GroundTruth; The Leadership Seminars included training on the concepts of ecological infrastructure and the practical application of citizen science tools.
2015	February	How to conduct a presentation?	student support group meetings	Prof Mathieu Rouget (UKZN) and Kholosa Magudu (DUCT)	12	
2015	March	FET Water	Dissemination Workshop	T Dambuza/L Betha/D Radebe	??	Poster
2015	March	Government Officials Workshop	Dissemination Workshop	T Dambuza/L Betha/N Mtshali/D Radebe	16	Presentation and field work
2015	March	miniSASS demonstration	Practical activity	Simon Bruton representing GroundTruth, WESSA, the Water Research Commission and the South African Departments of Water and Sanitation, and Science and Technology	35+ including media	At a river directly adjacent to the Forum venue, delegates as well as the general public were shown a practical demonstration of miniSASS and provided the opportunity to apply the citizen science tools themselves.

2015	March	Mpophomeni Sanitation Education Project (MSEP)-tools and interventions Dissemination Workshop	Dissemination Workshop	WESSA, DUCT, various EnviroClubs and GroundTruth. Ms Liz Taylor and Dr Jim Taylor facilitated the Dissemination Workshop.	65	EnviroChampions from Mpophomeni, including members from DUCT and local EnviroClubs attended the Dissemination Workshop. Attendees circulated between different learning stations to learn about different interventions and citizen science tools. These included: EnviroPicture building, Street Theatre, miniSASS and the clarity tube.
2015	March	International Day of Action for Rivers: miniSASS training	Training	School group Enviroclubs attended the training. Schools represented included Epworth High School for Girls, Girls High School, Alexander High and Henryville Primary; including students from UKZN; and members from DUCT.	42	School children and other stakeholders attended a day of miniSASS training on the Foxhill Spruit (Pietermaritzburg).
2015	March	miniSASS training	Training	Toti Conservancy (Amanzimtoti); attendees included local residents; facilitated by Mahomed Desai (GroundTruth).	12	Local residents in Amanzimtoti were trained in how to use miniSASS.

2015	March	ORASECOM miniSASS training	Training	Juan Tedder facilitated the training (GroundTruth)	1	A representative from ORASECOM attended a course on aquatic ecology and miniSASS- with the view to becoming a miniSASS trainer
2015	March	7th World Water Forum	Dissemination Workshop	Simon Bruton (GroundTruth)	??	
2015	March - April	Ecological Infrastructure Dissemination Workshop	Dissemination Workshop	Planners and municipal officials	??	
2015	April	Ecological Infrastructure Dissemination Workshop	Dissemination Workshop	Traditional leaders (eThekwini municipality)	??	
2015	April	miniSASS and WRC Citizen Science Tools Research Project Presentation	Presentation	Simon Bruton representing GroundTruth, WESSA, the Water Research Commission and the South African Departments of Water and Sanitation, and Science and Technology	35 + Media	A presentation within the formal programme of the Citizens Forum within the 7th World Water Forum in in Korea. The presentation was given in two parts; 1 – miniSASS, 2 - WRC citizen science tools research project
2015	April	Leadership Seminar	Dissemination Workshop	T Dambuza/L Betha/N Mtshali/D Radebe	??	Presentation and field work

2015	May	SASS5 and miniSASS training in Grahamstown	Training	DWS, DEARD, PVT Consultant, WRC, Rhodes University	13	SASS5 training course, invertebrate id's, physical sampling demonstrations, site selection training and data capture
2015	May	Citizen Science Catchment Toolkit	Dissemination Workshop	Mark Graham	??	
2015	June	ORASECOM Joint basin survey 2	Dissemination Workshop	ORASECOM	??	
2015	June	ORASECOM Joint basin survey 2	Dissemination Workshop	ORASECOM	??	
2015	June	UKZN Durban - Citizen Science Pa	Dissemination Workshop	Jim Taylor, UKZN	23	Dialogue session with lecturers and students.
2015	June	Copesville Speech to community members with the Deputy Minister of Environment Affairs, Barbra Thompson	Dissemination Workshop	WESSA, Jim Taylor	650	miniSASS as a novel way of involving communities - Verbal presentation in isiZulu.

2015	June	Citizen Science Monitoring of River Health: Latest developments to mainstream miniSASS	Dissemination Workshop	Mark Graham	??	
2015	June	TWLP Training	Dissemination Workshop	N Ndebele/D Radebe	15	Presentation and field work
2015	July	miniSASS training for sugarcane small growers	Training	WWF, 4 x small growers associations	4	MiniSASS training, use of dichotomous keys, data capture and interpretation
2015	July	Youth Water Summit	Dissemination Workshop	Jim Taylor	100	miniSASS field trip.
2015	July	SADC RSAP IV Development Process	Dissemination Workshop	Jim Taylor	32	Water and citizen science - Introduction to tools.
2015	August	National Conservancies AGM	Dissemination Workshop	Jim Taylor, Kirsten Mahood, Ntswaki Ditlhale	22	miniSASS field trip.
2015	August	SADC RSAP IV Development Process	Dissemination Workshop	Jim Taylor	38	Strategy Dissemination Workshop - Sharing of ideas.

2015	August	Ecological Infrastructure/Catchment Partnership Learning Exchange	Dissemination Workshop	T Dambuza/L Betha/D Radebe	??	Poster
2015	September	Swedish Ministerial Field-Trip	Dissemination Workshop	Jim Taylor	6	EE ITP (Training) - International Cooperation
2015	September	RMB Tshikululu Funding and Citizen science	Dissemination Workshop	Jim Taylor, Mike Ward	18	EE/ESD/Funding and policy - meeting to discuss policies and funding relationships including citizen science and miniSASS.
2015	September	South African Citizen Science in a Water Resource Context	Dissemination Workshop	Mark Graham	??	
2015	October	Leadership Seminar	Dissemination Workshop	T Dambuza/L Betha/D Radebe	20	Presentation and field work
2015	November	NGO Introduction to Aquatic Ecology	Training	Women in Leadership and Training	??	
2015	December	WWF Karkloof Irrigation Board Workshop: River flow demonstration day				

2015	December	Adopt Moreletaspruit Workshop: Demonstration of miniSASS and other citizen science tools				
2015	December	Citizen Science Workshop				
2016	February	International Citizen Science Workshop: The next wave in water resource assessment and monitoring				
2016	February	Karkloof Canopy Tours Workshop: miniSASS training day				
2016	March	Mondi/GIZ Youth Leader's Workshop: Environmental Awareness & Safety in Plantations by GroundTruth and Mondi	Workshop and training day	N. Ditlhale & GroundTruth Interns	45 Learners	The day focussed on theory and practicals related to water; waste; fire prevention and safety; and livestock management. The water component included activities on the water cycle and river health assessments using miniSASS, the velocity plank and the clarity tube.
2016	March	Citizen Science tools learning workshop by WESSA and GroundTruth	Workshop	T. Dambuza, N. Ditlhale	20	Introducing various local government members to the Riparian Health Assessment Citizen Science tool

2016	March	WESSA Workshop: Feedback and Dissemination of citizen science tools for Teaching and Learning				
2016	April	Enviro Champs Training Day				
2016	May	Introduction to Aquatic Ecology by GroundTruth, Acacia Operation Services, AECI	Training workshop	N. Ditlhale, K. Mahood, A. Lipheyana, J. Tedder	129	Wise Wayz Water Care Project beneficiaries were introduced to aquatic ecology, the water cycle, where water comes from and the importance of maintaining water quality. Beneficiaries were also trained on citizen Science tools including miniSASS, the clarity tube, velocity plank and *E. coli* swab.
2016	May	Wetland Workshop: Citizen science - Wetland tool workshop				
2016	June	River Health Day at Etete Primary School by GroundTruth, Avon	Workshop and training day	N. Ditlhale	± 15 learners	A day to create awareness about river health. Learners received information on aquatic ecosystems, and learnt about the water cycle to help them understand where drinking water comes from. Learners found out how to distinguish between contaminated rivers and clean rivers by using miniSASS and other citizen science tools. They were taught how to identify various types of pollutants and human activities that result in poor river health.

2016	July	Water Research Commission and friends clean up Moreletaspruit in Pretoria by Water Research Commission, GroundTruth and Friends of Moreletaspruit	Fieldwork	N. Ditlhale, B. Madikizela	WRC has Attendance register	In celebration of Nelson Mandela Day the Water Research Commissions (WRC) hosted a river clean-up of the Moreletaspruit. Additionally, two team also tested the health of the river systems at two different entry points within the park by means of the miniSASS tool kit.
2016	July	Global Participatory Water Management Network Global Participatory Water Management Network	Fieldwork with delegates followed by presentation.	J Taylor	8	Delegates including Roda Nuvunga Luis* (Mozambique), Mandla Malakoana (South Africa), Luana Machado (Brazil) and Elza Sanchez (Bolivia) went to the Sao Joao river, a nearby tributary to the Iguassu River, and did miniSASS. A miniSASS River Health Index of 7.4 which reflects good quality, was obtained.
2016	July	Mandela Day with River Care Teams on Townbush River, Pietermaritzburg by GroundTruth, DUCT, Cascades Mall, WESSA, WWF-SA	Training day	K. Mahood, L. Taylor & A. Lipheyana	± 100	Nine “River Care” Teams from DUCT were introduced to a suite of Citizen Science tools designed for assessing river health and other issues related to water conservation. "Learning stations" were created along the Townbush River, including a demonstration of citizen science tools (miniSASS, clarity tube, velocity plank), how to be an Enviro Champ, how gabions work to stabilize river banks, and the building blocks of life, to name a few. Participants moved from station to station and engage with the various activities.

2016	July	Mandela Day Workshop: Cascades				
2016	August	Biodiversity Stewardship KZN Learning Exchange WWF-SA in collaboration with Emvelo KwaZulu-Natal Wildlife	Presentation and demonstration	L. Betha, T. Dambuza		After a discussion of ecological infrastructure T Dambuza gave a demonstration of the clarity tube and miniSASS. The demonstration was done with the aid of a PowerPoint presentation that showed images of the process. Equipment was made available for participants to handle.
2016	August	Wetlands Citizen Science Tool Testing Workshop, GroundTruth, EDTEA	Workshop	N. Dumakude	51	A workshop hosted by a WRC funded student to introduce the Wetland tool to various stakeholders and to test the ability of the stakeholders to use the tool, as part of her Masters research.
2016	August	SAEON Workshop: Citizen science engagement				
2016	September	North Darfur Government Exchange Programme, DUCT, WESSA	Workshop & exchange programme	L. Taylor	65	Forty-five members of a North Darfur delegation visited the Mpophomeni Enviro Champs near Howick in KwaZulu-Natal. The day started with a meet and greet, including a miniSASS presentation. The group visited an upstream section of the Mthinzima Stream, and divided into groups to participate in conducting a miniSASS assessment and clarity tube test on the river. Participants from Darfur concluded that citizen science tools such as miniSASS would be relevant in North Sudan!

2016	October	miniSASS Poster Session, Environmental Education Association of Southern Africa (EEASA)	Workshop	T Dambuza, J Taylor	20	The workshop was a poster session designed to introduce participants to miniSASS and to get feedback on enablers and inhibitors to the use of the tool.
2016	October	Citizen science in the SADC region: Cutting edge changes in social learning for wise water management, Environmental Education Association of Southern Africa (EEASA)	Workshop	J Taylor	18	The workshop clarified how action learning is becoming an inclusive vehicle for supporting social change for sustainability. The citizen science tools have been found to support most of Sustainable Development Goals (SDG's)! The workshop invited participants to try out and explore a range of citizen science tools such as the velocity plank, clarity tube and miniSASS.
2016	October	eThekwini North WWTW Introduction to Citizen Science Tools, GroundTruth, WESSA		J. Taylor, N. Ditlhale	24	The main purpose of the day was to introduce the education division of eThekwini Department of Water and Sanitation to Action Learning on a local level through the citizens science tools
2016	October	WRC Workshop to discuss the strengthening of citizen science in Southern Africa				

2016	December	Indian Ocean / WESSA workshop on Education for Sustainable Development GroundTruth, WESSA	Workshop	A. Liphenyana, M. Levi	8	Following the International Foundation for Environmental Education Eco School Conference, in Johannesburg, five participants from different islands in the Indian Ocean attended a workshop on Education for Sustainable Development (ESD) as part of a three day workshop with the theme of the SDG's Eco-Schools and Citizen Science. The different tools that were demonstrated included the Clarity Tube, Velocity Plank and the French version of miniSASS. The participants then tried the tools for themselves.
2017	July	International Citizen Science Workshop: Citizen science in action - water resource assessment and monitoring				
Ongoing	November	River Health Monitoring (miniSASS) & Citizen Science UKZN Hydrology Honours Students: Case studies and current research initiatives	Dissemination Workshop	GroundTruth	10	

	Ongoing	Baynespruit River rehabilitation project, involving local schools for miniSASS monitoring	Rehabilitation	Msunduzi Municipality, the uMngeni Ecological Infrastructure Partnership (UIEP) and local schools	N/A	Support and input into the monitoring (miniSASS) of the Baynespruit River rehabilitation passing through urban areas of the Msunduzi Municipality
			Dissemination Workshop	SADC	??	Water Dissemination Workshop
2013		Ecological Infrastructure: An innovative approach to water resource management in the Umgeni catchment, South Africa	Dissemination Workshop	Graham Jewitt on behalf of the Umgeni Ecological Infrastructure Partnership	??	

APPENDIX E: LIST OF CONFERENCE PRESENTATIONS

NAME OF CONFERENCE	COUNTRY	NAME OF PRESENTATION	PRESENTED BY	DATE
eThekwini Municipality Biodiversity Forum	South Africa	Using Citizen Science to Evaluate the Ecological Integrity of South African Rivers: DUCT case study	Dr Mark Graham	November 2013
WRC Review Meeting (inaugural)	South Africa	Citizen Science Catchment Toolkit	Dr Mark Graham	April 2014
IASWS 2014 Conference	South Africa	Using Citizen Science to Evaluate the Ecological Integrity of South African Rivers: Various Case Studies and Current Research Initiatives	Dr Mark Graham	July 2014
Environmental Education Association of Southern Africa Annual Conference	Namibia	Reflections on the current and emerging ESD issues and practices informing the post Decade of Education for Sustainable Development framework programme.	Jim Taylor	September 2014
River Health Programme Symposium	South Africa	Using Citizen Science & The Ecological Integrity of South African Rivers: Various case studies and current research initiatives	Dr Mark Graham	November 2014
Symposium for Contemporary Conservation Practice	South Africa	Ecological Infrastructure – the value of healthy riparian zones for freshwater ecosystem conservation – theory, practise and application	Dr Mark Graham	November 2014
WRC Water Currents Policy Series	South Africa	miniSASS Citizen Science River Health Monitoring	Dr Mark Graham	November 2014
SLUSH	Finland	Use of CS tools for potential investment opportunities into Africa	Dr Mark Graham	November 2014

Ecosystem Research & Innovation Symposium	South Africa	River Health Monitoring & Citizen Science UKZN: Case studies and current research initiatives	Dr Mark Graham	February 2015
7th World Water Forum	South Korea	Citizens' Monitoring of River Health	Simon Bruton	March 2015
Forum of Forums Workshop	South Africa	DUCT/GroundTruth/WRC Citizen Science Research Project	Dr Mark Graham	April 2015
WRC Review Meeting (Second)	South Africa	Citizen Science Catchment Toolkit	Dr Mark Graham	May 2015
Youth Water Summit	South Africa	miniSASS and citizen science	Jim Taylor	June 2015
SASAqS 2015	South Africa	Citizen science key note: South African citizen science in a water resource context	Dr Mark Graham	July 2015
SASAqS 2015	South Africa	Citizen science monitoring of river health: Latest developments to mainstream miniSASS and allow a broader spectrum of society to contribute to the growing national picture of river health	Dr Mark Graham	July 2015
SASAqS 2015	South Africa	Citizen science plenary: The Global Situation	Dr Mark Graham	July 2015
SASAqS 2015	South Africa	The water clarity tube: Development and application in citizen science water resource monitoring	Mahomed Desai	July 2015
Botswana Environmental Education Conference	Botswana	Citizen science tools	Jim Taylor	August 2015
SA National Education on Sustainable Development Consultation	South Africa	SADC, EEASA and Social Change	Jim Taylor	August 2015
SADC Regional ESD Consultation	Zimbabwe	Environmental Education and Social Change	Jim Taylor	September 2015

Forum for Forums: WAT-INDABA	South Africa	A forum of forums: Responding to proposals to revitalise catchment management forums	Dr Mark Graham	October 2015
Wetland Indaba	South Africa	Can citizen science play a role in wetland assessment and management?	Kirsten Mahood	October 2015
Wetland Indaba	South Africa	A method for assessing wetland ecological condition based on land-cover type	Donovan Kotze	October 2015
UNESCO Workshop on Developing an Education Support Strategy for Southern Africa	South Africa	How we ensure that we deliver on the SDG's as a region	Jim Taylor & Moussa-Elkadhum	October 2015
Education for Sustainable Development Expert-Net Conference: Mexico	Mexico	Citizen Science for Sustainability: Water Monitoring & miniSASS	Jim Taylor	November 2015
IWA Winery Conference Stellenbosch	South Africa	The development, use and application of citizen science tools to monitor wastewater and effluent within the wine industry – from farm to factory	Dr Mark Graham	November 2015
Stepping Up to Sustainability: A SADEC Partnership	Botswana	The Sustainable Development Goals: Citizen Science for Sustainability	Jim Taylor	February 2016
WISA	South Africa	Citizen science: Innovative tools for water resource monitoring and evaluation	Ntswaki Ditlhale	April 2016
Water Institute of Southern Africa Biannual Conference	South Africa	Paper: Mainstreaming miniSASS into a scalable citizen science tool to improve community involvement in water resource management in southern Africa and the world!	Dr Mark Graham	May 2016

Water Institute of Southern Africa Biannual Conference	South Africa	Poster: Citizen Science: innovative tools for water resource monitoring & evaluation	Ntswaki Ditlhale	May 2016
UNESCO IHE	South Africa	Development of citizen science tools in Southern Africa and their local application to water resource management	Dr Mark Graham	June 2016
COWM Conference	Italy	Close and local water monitoring: Citizen science tools to evaluate and monitor river health to support management processes	Dr Mark Graham	June 2016
COWM Conference	Italy	Amazing Results When a Water Sector Corporate Partners with Local Communities to Care for Local Water Resources!	Dr Mark Graham on behalf of Molebatši Letswalo	June 2016
Monash South Africa: Water Research Node Seminar	South Africa	Drought and Water Risk: Action Learning & Citizen Science Tools	Jim Taylor	June 2016
International Eco-Schools Conference	South Africa	Eco-schools, the SDGs, Citizen Science and sustainable lifestyle choices	Jim Taylor	October 2016
Mondi SCR	South Africa	Corporate social & Environmental responsibility	Ntswaki Ditlhale	November 2016
Education as a driver for the Sustainable Development Goals	India	Citizen Science for Sustainability: Water Monitoring & miniSASS	Jim Taylor	
Fountain Hill Estate	South Africa	Upper uMngeni Integrated Catchment Management Plan: Investigation of WQ drivers and trends, identification of impacting land use activities and management and monitoring requirements	Dr Mark Graham	October 2017

Fountain Hill Estate	South Africa	Capacity for Catchments	Dr Mark Graham	October 2017
WRC Symposium	South Africa	Citizen Science: The next wave in water resource management	Ntswaki Dithlale	September 2017

APPENDIX F: LIST OF PUBLICATIONS

Year	Writer	Subject/Title	Publication
2014	Taylor, J.	Shaping the GAP: Ideas for the UNESCO Post-2014 ESD Agenda.	SAGE Publications. Journal of Education for Sustainable Development (Los Angeles, London, New Delhi, Singapore and Washington DC) www.sagepublications.com Vol 8(2): 1–9 10.1177/0973408214548369
2015	Dambuza, T. and Taylor, J.	African Citizens Monitor River Health: the Stream Assessment Scoring System.	USA National Water Monitoring News acwi.gov/monitoring Sprint 2015
2014	Jonsson, A. and Klasander, K	Mpophomeni Enviro Champs: A qualitative study about an Environmental Champions project's attempt to manage water issues in a South African township	An evaluation study. University of Jonkoping, Sweden.
2014	Kolbe, A.C.	Citizen Science & water quality in the Umgeni Catchment area, KwaZulu-Natal, South Africa.	Unpublished Masters Thesis, Queens University, Ontario.
In press	Madiba, M	Evaluation of the enablers and constraints of the uptake and use of the citizen science tools for the improvement of transboundary catchment/water resources management: The case study of South Africa, the Umngeni municipality and Emfuleni municipality.	Interim draft report towards a PhD study. Rhodes University, Grahamstown.
2016	SADC	Regional Strategic Action Plan (RSAP IV) 2016-2021.	SADC, Gaborone
2016	Taylor, J.	miniSASS study at Foz du Iguassu - 29th July 2016: A short report by Jim Taylor (WESSA South Africa)	Unpublished report to the Global Participatory Water Network, Foz du Iguassu, Brazil.

2016	Taylor, J. and Taylor, E.	Enviro-Champs: Community mobilization, education and relationship building. In Resilience by Design: A selection of case studies.	International Water security Network and Monash University, Pretoria.
2017	Taylor, J. and Venter, V.	Towards a Sustainable Future: Action Learning and Change Practices.	In African Wildlife & Environment, Vol: 64; pp 37-40. WESSA, Bryanston.
2017	Taylor, J.	Sustainability commons and other innovations in southern Africa.	In African Wildlife & Environment, Vol: 65; pp 50-55. WESSA, Bryanston.
In press	Taylor, J., O'Donoghue, R and Venter, V.	How are learning and training environments transforming with Education for Sustainable Development?	Education on the Move, UNESCO, Paris.
2017	LJ Bannatyne1*, KM Rowntree1, BW van der Waal1 and N Nyamela1	Design and implementation of a citizen technician–based suspended sediment monitoring network: Lessons from the Tsitsa River catchment, South Africa	1Geography Department, Rhodes University, PO Box 94, Grahamstown 6140, South Africa

APPENDIX G: LIST OF STUDENTS AND INTERNS

Table of students with research funded by or directly relating to the project

Surname	Name	Institution	Level of study	Year	Thesis Title
Boothway	Louine	Rhodes University	MSc (Education)	2014	Learning, knowledge and change through participation in a CS project: An evaluative case study of the Mpophomeni sanitation project
Cele	Hlengiwe	University of the Witwatersrand	MSc (Management, public and development management)	2015	CS for water quality monitoring and management in Kwazulu-Natal
Dlamini	Luvuyo	University of KwaZulu-Natal	BSc Hons (Hydrology)	2013	Assessing river heath under forests and natural vegetation using the miniSASS toolbox
Dumakude	Nondumiso	University of the Free State	MSc (Environmental Management)	2017	Assessing wetland health using a newly developed land-cover CS tool for people who are not wetland specialists
Khumalo	Happy	University of KwaZulu-Natal	PhD	2016	A comparative study of the WetHealth tool and the citizen-

					science land-cover based wetland assessment method
Kolbe	Andrea	Queens University, Canada	MSc (Environmental Studies)	2014	CS in the Umgeni catchment area, KwaZulu-Natal, South Africa
Madiba	Morakane	Rhodes University	PhD	2016	Evaluation of the success and barriers of the uptake and use of the CS tools for the improvement of transboundary water resources management
Naidoo	Sashin	University of KwaZulu-Natal	BSc Hons (Environmental Science)	2014	Using the MINISASS and Index Habitat Integrity (IHI) methods to Identify River Health of the Dorpspruit River
Nkomo	Xolile	University of KwaZulu-Natal	MSc (Hydrology)	2017	Using CS Tools to Contribute to Collaborative Water Resource Management: The case of miniSASS

Singh	Samiksha	University of KwaZulu-Natal	BSc Hons (Environmental Science)	2013	Investigating a Grade 7 Implementation of the mini-SASS Method, Using a Social Learning Lens.
van Deventer	Ross	University of KwaZulu-Natal	MSc (Environmental Science)	2012	Impact of land use on water quality and aquatic ecosystem health of stream networks in the upper uMngeni catchment feeding Midmar Dam, KwaZulu-Natal, South Africa

Interns on the project

Name	**Surname**	**Institution**	**Contribution to the project**
Mthandeni	Ndlela	SANBI – Groen Sabenza Intern	Clarity tube testing
Baptiste	Lelong	EPF University - France	Velocity plank research, calibration, testing and development
Manon	Levy	EPF University - France	Rain gauge data analysis and general tool testing
Elodie	Fardoit	EPF University - France	Weather monitoring tools calibration

Claire	De Temmerman	EPF University - France	Weather monitoring tools calibration
Cailyn	Govindasamy	Dept. of Tourism – Tourism World Academy Intern	General tool testing, primarily the clarity tube and velocity plank
Jenna	Taylor	University of KwaZulu-Natal: GroundTruth Intern	Riparian Health Audit, wetland tool, estuary tool, rain gauge, lesson plans development and testing
Nqobile	Lushozi	University of KwaZulu-Natal: GroundTruth Intern	Velocity plank development & rain gauge calibration
Allyson	Mcallistar	Nelson Mandela Metropolitan University: GroundTruth Intern	Weather monitoring tools development & clarity tube research
Nkanyiso	Mzila	University of KwaZulu-Natal: GroundTruth Intern	Weather monitoring tools development and testing

Masters and PhD projects:

LEARNING AND KNOWLEDGE IN A COMMUNITY-ENGAGED CITIZEN SCIENCE PROJECT

Reinetta Louina Boothway

ABSTRACT

The following case study explores the nature of learning and emerging knowledge in a community-engaged citizen science project.

For an understanding of learning in a citizen science project Wenger's (1998) Community of Practice Theory offered a helpful theoretical framework. Drawing on the work of Tabara and Chabay (2013) the Ideal Type (IT) heuristic is used to better understand the knowledge produced and shared by participants in the Mpophomeni Sanitation Education Project (MSEP) community of practice. The question guiding the analysis was whether the knowledge produced and disseminated in the MSEP community of practice can be described as action-enabling knowledge resulting from a process of democratizing knowledge production – a claim made by proponents of citizen science. The findings include the following: Knowledge is not only produced and disseminated by scientists or so-called experts but by a range of knowledge agents who employ their everyday and contextual knowledge in combination with factual knowledge about the problem to produce culturally appropriate 'socially robust' knowledge. Participants in the MSEP demonstrate an action-enabling knowledge that is associated with the evolution of responsibility and as well as ethical and moral underpinnings. By design, the knowledge systems operating in the MSEP is able to provide culturally-appropriate solutions to socio-ecological problems.

CITIZEN SCIENCE FOR WATER QUALITY MONITORING AND MANAGEMENT IN KWAZULU-NATAL

Hlengiwe Cele

ABSTRACT

The citizen science approach has a role to play in the restoration of river health in catchments affected by pollution. Everyone can become involved in monitoring the health of a river, dam, estuary or wetland closest to them. In KwaZulu-Natal, uMngeni and Msunduzi Catchments, voluntary participation in river health initiatives has been adopted by schools, conservancies, NGOs and catchment management forums. The purpose of the study was to explore the perceptions and experiences of the use of miniSASS, a simplified South African Scoring System (SASS) for monitoring river health, in uMngeni and Msunduzi Catchments for the past 15 years. A qualitative exploratory and descriptive study was undertaken through semi-structured interviews and documentary analysis. The researcher selected a sample of ten participants, mainly the active users of the miniSASS citizen science tool in the identified catchments. The finding of the study is that miniSASS is perceived as a valuable educational tool in Msunduzi and uMngeni catchment which has led to local government authorities to respond faster in solving incidents of industrial pollution; address poorly maintained water infrastructure and fix the leaking sewers contaminating water. The

study recommends that an investigation be made on the economic value of citizen science contribution in KZN since there were indications that it has already benefited some of the lodge owners who appreciated the change in the nearby streams.

ASSESSING RIVER HEALTH UNDER FORESTS AND NATURAL VEGETATION USING THE MINI SASS TOOLBOX

Luvuyo Dlamini

ABSTRACT

River health may be defined as a river that maintains its biophysical and biochemical structure and function, in order to support local biota and maintain key processes (CRAES, 2012). The monitoring and maintenance of rivers is essential in sustaining and improving human livelihoods that require the goods and services it generously provides. Monitoring of rivers can be achieved by assessing the factors that influence water quality and macroinvertebrate species. This is an assessment of the health of rivers under forests and natural grasslands using the Mini SASS as an indicator. Mini SASS is an indicator of macroinvertebrate species that is based on SASS. Species have different sensitivities to certain river conditions and their presence or absence in a river reflects the activities of land uses in a catchment. The Mngeni catchment has a vast number of land uses each with its specific influence to rivers and the hydrological cycle as a whole. From the species sampled none of the study sites had the most sensitive species, which are stoneflies. However, only two of the four study sites had other mayflies, which have the second highest sensitivity score after stoneflies. Furthermore, all the study sites had one or more of the low sensitive species such as worms, leeches and trueflies. The management strategies to deal with these river health results are also discussed.

TESTING A NEWLY DEVELOPED CITIZEN SCIENCE TOOL FOR ASSESSING WETLAND HEALTH

Nondumiso Dumakude

ABSTRACT

Over half of South Africa's wetlands have been degraded or lost, and globally, 70% of wetlands have been destroyed. Among other reasons (such as population growth, agricultural activities, urbanisation, etc.), wetlands have been degraded because people generally undervalue them. The general consensus is that the public would protect the wetlands more if they recognised and understood their importance. Moreover, the local people would be in a better position to protect the wetlands if they are able to assess their condition at any given time. This requires assessment tools that are not only accessible to the public, but also produce information that can easily be understood by them. It is against this background that citizen science approaches, which simplify complex scientific information to a level where it can be accessed and understood by non-specialists, are being

promoted in environmental management globally. As part of the project entitled 'Community-based Monitoring Tools and Citizen Science to Facilitate Improvement in Transboundary Catchment Management', WRC Project K5/2350, a research study was commissioned to test one of the tools being developed. The research study was for a Master's dissertation aimed at testing a newly developed wetland health tool for assessors of wetlands who are not wetland specialists. The study focused on determining whether non-specialists will be able to get similar results to specialists, when assessors apply the tool independently.

This study utilized a mixed methodology approach, where both quantitative and qualitative methods were applied to gather and analyse data. The study was conducted at Siphumelele wetland and Ixopo Golf Course wetland at Howick and Ixopo respectively in the Kwazulu-Natal province. The hypothesis tested was that the wetland specialists and the non-specialists would produce similar scores. The data was analysed using SPSS mainly descriptive statistics and analysis of variance.

The results showed that both wetland specialists and the non-specialists can produce similar scores. In relation to the socio-economic factors that affect the inter assessor variability of the scores, the results showed that even though the participants varied in their scoring, the differences were not statistically significant between experts and non-experts, between those with experience with working with wetlands and those without such experience and between those with tertiary education and those with secondary education only.

The results showed that non-specialists can actively participate in scientific assessments once they have been exposed to the subject. There is evidence that this tool can be used by both wetland specialists and non-specialists. This tool would also help the non-specialists understand wetlands better. Public engagement in wetland assessments enables the public to be more aware of the impacts and threats associated with wetland and they could act as "watch dogs" based on this awareness.

A COMPARATIVE STUDY OF THE WET-HEALTH TOOL AND THE CITIZEN-SCIENCE LAND-COVER BASED WETLAND ASSESSMENT METHOD.

Happy Khumalo

ABSTRACT

Citizen Science approach has a role to play in the determination of the wetland condition in South Africa. Public participation in wetland health assessment & monitoring can help them interact with authorities and also provide participants with an understanding and insight that can allow them to contribute meaningfully to management of wetlands closest to them. The purpose of the study was to perform a comparative analysis of a more commonly used method, Wet-Health and the newly developed citizen science tool that are used for the rapid assessment of wetland health in South Africa. The new tool was designed to infer impacts on wetlands and their upslope catchments by using land cover types. The Wet-Health method performs the integrated assessment of impacts on four components namely hydrology, geomorphology, water quality and vegetation. In order to achieve the objectives of the study, a researcher managed to purposely select a sample of 6 wetlands that were previously assessed using the Wet-Health tool and employ the new developed tool to assess the health of those wetlands. A comparative analysis of the two methods was performed in various provinces namely Gauteng and North-West. The findings indicated that tool is able

to more or less obtain similar results. Four of the 6 wetlands assessed yielded similar results. These findings present the dawn of a new day in wetland management in South Africa that will enable the public at large to be empowered with skills and knowledge that can aid environmental specialists in data gathering and identification of wetland at risks.

CITIZEN SCIENCE & WATER QUALITY IN THE UMGENI CATCHMENT AREA, KWAZULU-NATAL, SOUTH AFRICA

Andrea Cornelia Kolbe

ABSTRACT

South Africa (SA) is considered to be water scarce under current climatic conditions. As such, the conservation of water quality is emerging as an increasingly urgent challenge as water resources face a growing number of natural and anthropogenic stressors. This thesis investigates how citizen science – the involvement of, and action by, everyday citizens in the collection of data and improvement of water resources- might contribute to the conservation of water quality in SA. The thesis used qualitative research methods, including interviews and participant observation. Mpophomeni Township (within the uMngeni catchment area), KwaZulu-Natal (KZN), SA is used as a case study to better understand the role of citizen science in addressing water quality challenges. Theory U is used as an analytical lens to understand the impact of citizen science as well as the extent to which citizen scientists engage with aspects of social learning and systemic change. Findings indicate that citizen science promotes empowerment and social learning amongst participants, in addition to fostering multi-stakeholder collaboration (on water quality issues), encouraging the establishment of new environmental connections, and enabling a shift in existing government-citizen power relations. Additionally, lack of education and awareness along with minimal or non-existent governmental support as key barriers to citizen science, are examined in further detail.

EVALUATION OF THE ENABLERS AND CONSTRAINTS OF THE UPTAKE AND USE OF THE CITIZEN SCIENCE TOOLS FOR THE IMPROVEMENT OF TRANSBOUNDARY CATCHMENT/WATER RESOURCES MANAGEMENT

The case study of South Africa, the Umngeni municipality and Emfuleni municipality

Morakane Madiba*

PREAMBLE

Firstly, the success of this study is dependent on the two deliverables that include

- fulfilling the deliverable proposed by the leading organisation of this research, i.e. GroundTruth (which is currently sponsoring the study) collaborating with Wildlife and Environment Society of South Africa (WESSA) in their Trans-boundary Ecosystem Management programme for the Water Research Commission submission. The deliverable is about evaluating the successes and barriers/ constraints and enablers of the citizen science tools to improve trans-boundary catchment/water resources management. This deliverable was required to be submitted in a form of a scientific report by November2016 (i.e. one year long). That meant only the pilot study data can be used for this report.

- I will then resume by probing critically the in-depth understanding of the enablers and constraints of the same citizen science tools for the submission of the PhD thesis. This will in addition take two years. Thus, the whole study will take three years for completion.

For these two main goals to be achieved, this study will take a qualitative evaluation inquiry which then requires two phases of data analysis. In regards to the GroundTruth submission I was limited by the context and scope at which I am working in. The title of the study will firstly be dissected into four parts of concepts exploration which includes (i) evaluation of the enablers and constraints of (ii) the uptake and use, (iii) citizen science tools and (iv) trans-boundary catchment/water resources management.

I will explain the concepts enablers and constraints according to the realist evaluation analysis method termed the Context-Mechanism and Outcome relationships/configurations by Pawson and Tilley (2004) with an extension of de Souza's (2013) approach.

The purpose of conducting a pilot study

There have been fewer published, critical and extensive studies, if not any in South Africa, about the uptake and use of citizen science tools for the water resource management let alone in the trans-boundary water resource management field. Recently in 2015 Hlengiwe Cele from WRC wrote a Masters' thesis which highlighted the potential of miniSASS in the water quality management. My analysis of her work laid a foundation for this study. Firstly, her cohort of the study was already established and embedded in the environmental conservation conception in KwaZulu-Natal (KZN) where the citizen science practice of these tools was dominant and more supported (also refer to the miniSASS website). Another critique that this study holds against her work was that the findings were painting a positive picture, neglecting the processes in between, about the uptake and use of the miniSASS, as such to some extent in my study her findings seemed too superficial especially in the school contexts.

Further literature which was useful to lay a foundation for this pilot study was the work conducted by WESSA and GroundTruth (Graham et al., 2014). Their work formed the basis of conceptualising this pilot study, especially around how the relationships of the concepts of (i) social learning and (ii) public participation and (iii) transformation, are expressed over ambitiously in citizen science practice in the context of the trans-boundary water resource management field. However, this study took cognisant of the background of the authors and their surroundings, because their roles and environment seemed to be encouraging especially in KZN. This meant that for me to conduct this study, I needed to wear a different lens and use different attitudes in understanding the constraints and enablers of the uptake and use of the citizen science (CS) tools. For the reason that looking into a situation with one angle of attitude can overlook other critical processes of different magnitudes that are involved.

Hence my position, as an environmental researcher, was challenged in this study. I had to take a position that was real and outside of the norm. A position needed requires me to be realistic, bold, radical, and objective, where self-interest is exempted. One of the reasons to take this position was with the understanding that the uptake and use CS tools cannot be the panacea to the water monitoring systems of the catchments and sometimes to see that I needed to take off the cap of being an environmentalist. For instance, the velocity head-rod is 1 m long, meaning it can only work on stream-depth less than that otherwise it will not be useful. However, in this study I argue that the uptake and use of the CS tool can be useful and be one of the innovative practices that can work together with the systems that already exist - that are either inaccessible or unable to be reduced to specific contexts, e.g. shallow streams – and are unable to catch up with time (Buytaert et al., 2015).

It then became very crucial to carefully understand citizen science practice in particular that of the uptake and use of the water resource management tools, from possible point of views so as to allow the study to produce critical and radical insights that will not overlook a room for improvement. By improvement I include that of social learning – learning through the tools, development of the tools, introduction of the tools, use and uptake of the tools, efficacy and sustainability, empowerment of the citizens / participants, etc. This process of introspection as a researcher is important because water quality issues in South Africa in particular in the study sites of this study are real and require [at least from this study's data] radical actions without sugar-coating the understanding that everyone was affected differently.

I believed using those lenses was going to enable me to reveal meaningful insights that can be 'packaged for different people to participate' [according to their means and if necessary to enable them to reach their potential] to "support development and implementation of citizen science tools in a more sustainable water resource management (Graham et al., 2014). I also hope that insights of this study will enable the society to be "accountable" and move "gradually" "and acting meaningfully – not only as a once off motivation/concern" in a sustainable development direction.

The concept of 'enabler' or 'success' are defined differently by different people (e.g. age, gender, exposure to the water issues), circumstances (e.g. discipline), and positionality (e.g. municipality official, scientist, educator, ordinary citizen), degree of agency, time, space, scale, history (Zoellick, Nelson, & Schauffler, 2012) and "doughnut model of knowledge management by Wenger (2004)" (Graham et al., 2014). These agents form fundamentals of the conceptualisation around the understanding of the concept 'enabler' and 'constraint' in this study. These concepts are important to be explored to avoid the equivocation rationale of this study as I hoped that through their clear understanding this study will reveal insights about different enablers at different levels and the extent at which they can effect change. Therefore, the parameter used to understand the enabler or constraint is that enabler or constraint can be an event or a process. Enabler as a process focused on the following stages: - awareness (e.g. introduction and sharing of knowledge and information), uptake, use, efficacy and sustainability (refer to table2 below). This meant that in every stage there is success but the stage does not always remain successful not always lead to another stage. In order to measure the durability of success of each stage, I will use the parameters time (i.e. relevancy), space, scale, history and context.

**note: Morakane Madiba has not yet completed her project, and so her abstract has not been created.*

ASSESSING THE CURRENT HEALTH OF THE DORPSPRUIT AT SELECTED SITES USING MINISASS AND THE INDEX OF HABITAT INTEGRITY (IHI)

Sashin Naidoo

ABSTRACT

The Dorpspruit is a perennial stream within Pietermaritzburg that is subjected to various forms of urban pollutants which has an impact on the water quality and habitat health of the stream. Storm water drainage and runoff also has a severe impact on the stream in terms of quality and quantity of pollutants and effluents entering the stream. Methods of assessing water quality and habitat health has been developed within South Africa to provide information that can be used for management and monitoring. Obtaining information regarding water quality and habitat health is important, however, this information needs to be shared with the researchers and civil society and uploading results and photographs to web-based systems is an effective way of doing so. Environmental awareness amongst citizens through vectors such as Flickr and Google Earth Outreaches may prove as a tool in achieving environmental sustainability. The miniSASS method provides an indication of the water quality by identifying macro-invertebrates within the water. Other methods such as the Index of Habitat Integrity (IHI) is useful in identifying possible contributors towards poor habitat and ecological health within in-stream and riparian zones of the stream. The miniSASS scores obtained throughout the stream indicated either a poor or very poor ecological condition within the segments of the stream sampled. The presence of mayflies throughout the sampled segments could be due to the stream being affected by organic pollutants. IHI scores varied and the integrity scores were lowest in segments where the Jika Joe informal settlement was present. Custodianship programmes and management of storm water may be effective in improving water quality and environmental health.

ASSESSING WETLAND HEALTH USING A NEWLY DEVELOPED LAND-COVER CITIZEN SCIENCE TOOL FOR PEOPLE WHO ARE NOT WETLAND SPECIALISTS

Nondumiso L Dumakude

ABSTRACT

Wetlands provide humanity with many ecosystem services, such as water purification and supply, flood and climate regulation, tourism and recreational opportunities, coastal protection and provide fibre and fish for human wellbeing. Many countries have strategies in place to protect precious wetland resources due to the increasing human population, agricultural activities and urbanisation that impact upon wetlands. The need to protect wetlands means that there is a need for wetland assessment strategies to be put in place. These strategies require input from the broader population, which implies that citizens must be trained on environmental issues. One of these strategies includes the use of citizen science. Over half of South Africa's wetlands have been degraded or lost, and globally, 70% of the wetlands have been destroyed.

As recent as 2016; Kotze developed augmented a surrogate wetland assessment aimed at enabling those who are not wetland specialists to be able to conduct assessments and resolve wetland health as part of a Water Research Commission project on developing citizen science tools for water resource management.

This study, therefore, aims to evaluate the extent to which the newly developed citizen tool can be used by non-specialist to assess wetland health, and the extent to which specialists and non-specialists produce similar scores using the new tool.

The study utilized a mixed methodology approach, where both quantitative and qualitative methods were applied to gather and analyse data. The outcome/ results suggest there was a mean difference of -0.05 in the overall scores between the specialist and the non-specialists with a p-value of 0.809 at Ixopo Golf Course wetland. At the Siphumelele wetland with the overall scores there was a mean difference -0.68, between the specialists and the non-specialists and the p-value 0.656. This concludes that both wetland specialists and the non-specialists produce similar scores.

The results suggest that non-specialists can actively participate in scientific assessments once they have been exposed to the subject, supported by some basic training. There is evidence that this tool can be used by both wetland specialists and non-specialists. Interesting from the results, was that this tool will enable the flow of information to all.

THE USE OF PERIPHYTON AND MACRO-INVERTEBRATES AND THEIR SUSCEPTIBILITY TO CHANGES IN RIVER FLOW CHARACTERISTICS AND NUTRIENT COMPOSITION AS AN INDICATOR OF RIVER HEALTH

Samiksha Singh

ABSTRACT

Freshwater systems are a valuable resource under increasing threat due to pollution from activities such as agriculture, industry, mining and domestic use which can pose a risk to human and animal health and may lead to eutrophication. In South Africa, river ecosystem management has shifted from the improvement of water quality to that of the creation of ecological reserves, ecological health and the improvement of biological integrity. This shift has allowed for the increased use of bio-indicators to determine ecosystem health. Macro-invertebrates, riparian vegetation and fish have been used in the suite of bio-monitoring mechanisms and the setting of environmental reserves. However, there is an increasing need to include periphyton as a tool in river ecosystem monitoring due to their absorptive nature and ability to indicate change environmental conditions.

In South Africa research suggesting algae as bio-indicators has been primary based on the use of diatoms as a bio- monitoring tool. This study aims to determine patterns and trends in periphyton communities in the summer rainfall region of KwaZulu-Natal, South Africa. This is achieved through five sampling sites aimed at determining the relationship between changes in nutrient and flow regimes on periphyton communities. Two sites on the Msunduzi River are comparable as they have similar flow but different nutrient levels, whilst on the Umgeni River the two sites are comparable as they have differences in flow regimes with similar nutrient conditions. The fifth site on the Hlatikhulu River, Kamberg, is used as a reference site. Sampling occurred over the period June 2014 to June 2015 on a monthly basis to collect algal and invertebrate samples and physico-chemical data.

Trends and relationships between physico-chemical and algal biomass were evident. Trends indicated the role rainfall played in increasing river depth and velocity which in turn influenced algal biomass growth and species composition and the effect that seasonality changes had on periphyton communities. Peaks in algal biomass was as a result of

increases in nutrients within a particular system while decreases in algal biomass occurred due to an increase in invertebrate grazers. Sloughing events resulted due to increases in flow and velocity. General trends at all five sites showed peaks in algal biomass in early summer and a lesser algal biomass peak in early autumn. This research suggests that if better understanding of periphyton patterns and trends are established, periphyton can be used as an important bio-monitoring tool and aid in the creating and setting of ecological reserves.

IMPACT OF LAND USE ON WATER QUALITY AND AQUATIC ECOSYSTEM HEALTH OF STREAM NETWORKS IN THE UPPER UMNGENI CATCHMENT FEEDING MIDMAR DAM, KWAZULU-NATAL, SOUTH AFRICA

Ross van Deventer

ABSTRACT

Freshwater in adequate supply and quality is vital to life on Earth; however, land-based activities such as development, agriculture, mining and industry, and their associated contaminants, pose a major threat to the quality of freshwater water resources and health of aquatic ecosystems. The upper uMngeni catchment draining into Midmar Dam is a strategically significant water resource, supplying clean drinking water to the eThekwini, uMgungundlovu and Msunduzi municipalities. The quality of this resource is under threat from current land-based activities such as Mpophomeni settlement and agriculture and emerging threats in the form of the Khayalisha social housing project. Monitoring sites were established in varying land use types in three sub-catchments of the upper uMngeni, to assess water quality and ecosystem health impacts of current land uses on Midmar Dam. A suite of physical, chemical and biological water parameters was sampled in conjunction with SASS5 bio-monitoring to assess the associated impacts. Water quality and ecological condition were highest in forested land use and upstream of Mpophomeni where natural land cover and sparse settlement occurred. Marked declines in water quality and ecological condition were observed at areas under commercial agriculture, indicated predominantly by rises in nutrient concentrations and declines in the SASS5 indices. The most notable declines in water quality and ecological condition were observed at sites downstream of Mpophomeni settlement as a result of severe sewage contamination, indicated by high E. coli counts. Nutrient concentrations downstream of Mpophomeni settlement ranged from mesotrophic to hypertrophic, with nitrogen to phosphorus ratios indicative of nitrogen limitation. Ecological condition remained in the 'seriously/critically modified' category over the study period. Nutrient loads produced by Mpophomeni are the highest of all the land uses, followed by that of commercial agriculture; both should be viewed as a concern, more so when viewed in terms of their compound effect on Midmar Dam water quality. Current water quality draining the commissioned Khayalisha social housing development area is good and although not natural, is of no contamination concern to Midmar Dam. Results indicate that with current land use activities, urban development and agriculture pose a potential threat to the quality of Midmar Dam resource and that further development in the form of the Khayalisha social housing project may replicate impacts already prevailing in Mpophomeni, whereby a principle water resource may be threatened by eutrophication.

APPENDIX H: MINISASS

SITE INFORMATION TABLE	
River name:	Date (dd/mm/yr):
Site name:	Collector's name:
GPS co-ord Lat(S): Long(E):	School/organisation:
Site description: e.g. downstream of industry	Notes: e.g. weather, impacts, flow, etc.
pH: Water temp: °C Dissolved oxygen: mg/l Water clarity: info at www.minisass.org	

GPS co-ordinates as degrees, minutes, seconds (e.g. 29°30'25" S / 30°45'10" E) OR as decimal degrees (e.g. 29.50694°S / 30.75277°E) If you don't have a GPS, upload your results at www.minisass.org, find your site on the map, click to upload your result and the co-ordinates are saved for you!

Scoring

1. On the table, circle the sensitivity scores of the identified organisms.
2. Add up all of the sensitivity scores.
3. Divide the total of the sensitivity scores by the number of groups identified.
4. The result is the **average score**, which can be interpreted into an ecological category given below.

Interpret the miniSASS score:

Although an ideal sample site has rocky, sandy, and vegetation habitats, not all habitats are always present at a site. If your river had no rocky habitats that were sampled, use the **sandy type** category to interpret your scores.

GROUPS	SENSITIVITY SCORE
Flat worms	3
Worms	2
Leeches	2
Crabs or shrimps	6
Stoneflies	17
Minnow mayflies	5
Other mayflies	11
Damselflies	4
Dragonflies	6
Bugs or beetles	5
Caddisflies (cased & uncased)	9
True flies	2
Snails	4
TOTAL SCORE	
NUMBER OF GROUPS	
AVERAGE SCORE (miniSASS Score)	

Average Score = Total Score ÷ Number of groups

Ecological category (Condition)	River Category	
	Sandy Type	Rocky Type
NATURAL CONDITION (Unchanged/untouched – Blue)	> 6.9	> 7.2
GOOD CONDITION (Few modifications – Green)	5.9 to 6.8	6.2 to 7.2
FAIR CONDITION (Some modifications – Orange)	5.4 to 5.8	5.7 to 6.1
POOR CONDITION (Lots of modifications – Red)	4.8 to 5.3	5.3 to 5.6
VERY POOR CONDITION (Critically modified – Purple)	< 4.8	< 5.3

Now, upload your results at www.miniSASS.org or use the miniSASS App (download from the miniSASS website) or send a scan of this page to info@minisass.org!

mini SASS STREAM ASSESSMENT SCORING SYSTEM

miniSASS is used to monitor the health of a river and measure the general quality of the water in that river. It uses the make-up of macro-invertebrates (small animals) living in rivers and is based on the sensitivity of the various animals to water quality.

NOTE: miniSASS does NOT measure the contamination of the water by bacteria and viruses and thus does not tell us if the river water is fit to drink.

Equipment list

- Net (see www.minisass.org)
- white container / tray / ice-cream box
- magnifying glass
- pencil
- shoes/gumboots
- hand wash / soap

www.minisass.org
Version 3.0 – September 2015

Method

The best sites have rocks in moving water (**rocky type** rivers). Not all sites have rocks, but may be largely sandy (**sandy type** rivers).

1. Whilst holding a small net in the current, **disturb** the stones, vegetation, sand etc. with your feet or hands.
2. You can also lift stones out of the current and gently **pick** organisms off with your fingers or forceps.
3. Do this for about **5 minutes** whilst **ranging across the river to different habitats** (biotopes).
4. Rinse the net and turn the contents into a plastic tray. **Identify each** group of organisms using the identification guide (see insert: start with the dichotomous key, then use the identification guide for more information).
5. Fill in the site information and mark the identified organisms off on the scoring sheet (back page).
6. **Add up** the sensitivity scores and determine the **average score**.
7. Interpret your miniSASS score.
8. Remember: **WASH** your hands when done!

https://www.youtube.com/channel/UCub24hwrLi52WR9C24uTbaQ

Don't have a net? Make your own – it is easy!

Take any piece of wire, for example an old clothes hanger, and bend it into the shape of a net. Then tie the netting (which can be any porous material) to the wire with a piece of string. Alternatively cut the bottom out of an ice cream container and staple netting to the bottom. Now you have a net!!

Macroinvertebrates

What are they?

Macroinvertebrates are animals that have no backbone and you can see them with the naked eye.

Why are they used for biomonitoring?

- Different macroinvertebrates have different sensitivities to water quality conditions. More sensitive "nunus" will disappear from a river system where water quality has declined. On the score sheet, the higher the score, the more sensitive the "nunus" are.
- They are generally easy to collect and identify.
- They are relatively sedentary which allows the source of pollution to be detected.
- They indicate the water quality conditions at a site, providing an overall measure of the "health" of a river.
- They provide a picture of recent events affecting water quality at a site.

Why is water quality monitoring & management important in South Africa?

Fresh water is essential for life on earth. Water is also used in all spheres of human life, namely agriculture, industry, biodiversity conservation, sanitation and hydration.

However due to the amount of rainfall South Africa receives, it is classified as a water-stressed country. This means that if we do not monitor, manage and conserve our current water resources, we will be placing them and the population under tremendous stress in the future!

Get ready to put your crab on the map!

Load your site at: www.miniSASS.org

Glossary

Biomonitoring: the monitoring of biodiversity using biological organisms

Biodiversity: diversity within species, between species and of ecosystems

Conservation: the maintenance of environmental quality and functioning

Ecosystem: a complete community of living organisms and the non-living materials of their surroundings

Sedentary: inactive, motionless, not moving

River safety

Take special care in polluted waters. Beware of dangerous animals (crocs/hippos!) and fast flowing waters. Wear protective gear when necessary and wash your hands regularly with soap and clean water wherever possible!!

What can you do?

As the general public, we play a part in making a difference to managing freshwater resources in our communities. miniSASS has the potential to be a powerful 'red flag' indicator to identify aquatic pollution sources. By using miniSASS we can actively take an interest in the management of the health of freshwater bodies in our community.

Your interest and knowledge can be enhanced by adopting a local river in your community and monitoring it over time, identifying sources of pollution and taking local action to make a difference. You could also encourage more members of the community to take positive action towards monitoring and conserving water.

Contribute to the picture of river quality in South Africa

Download miniSASS resources and upload data at
www.minisass.org or use the miniSASS App

For queries, comments or assistance email info@minisass.org
Also available from Share-Net: www.sharenet.org.za Tel (033) 3303931

History of the miniSASS tool

South Africa is a world leader in biomonitoring techniques using macro-invertebrates. The most successful of these is the South African Scoring System version 5 (SASS5). miniSASS is based on SASS and uses the presence of macro-invertebrates to indicate "river health". Where SASS5 contains over 90 different macroinvertebrate taxa, miniSASS uses 13 taxa, allowing for simpler identification and understanding. miniSASS provides similar indications of "river health" status as the more comprehensive SASS5 assessment, providing a good method to generate useful biomonitoring data. miniSASS Version 1 was developed using roughly 2 000 SASS4 data records. miniSASS Version 2 was based on over 6 000 SASS5 records, making it more robust & more widely applicable in Southern Africa. Version 3 has updated Ecological Categories to be more closely aligned with SASS5 results.

Key words for further reading

macroinvertebrate, benthic, water quality, conservation, biodiversity, river health, aquatic pollution, SASS, taxa, invertebrate classification, ecological monitoring

Additional resources and partners

WATER RESEARCH COMMISSION www.wrc.org.za

WESSA www.wessa.org.za

GroundTruth Water, Wetlands and Environmental Engineering www.groundtruth.co.za

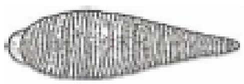
water & sanitation Department: Water and Sanitation REPUBLIC OF SOUTH AFRICA www.dwa.gov.za

science & technology Department: Science and Technology REPUBLIC OF SOUTH AFRICA www.dst.gov.za

Flat worms

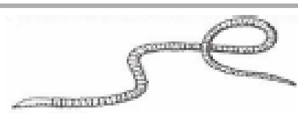
Flat worms are characterised by their flattened shape and soft bodied, worm-like form. They have an arrow-shaped head with two dorsal eyespots and are generally mottled or dark grey in colour. Flatworms move with a gliding action and are generally scavengers or carnivores.

Leeches



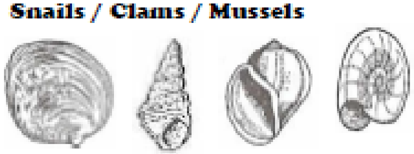
Leeches are segmented organisms that have very flexible bodies. When moving they expand to become long and thin, and then contract to become short and stubby. They have suckers on both ends of the body used for feeding and locomotion. Leeches are variable in colour, from grey, to red-brown and black. They swim with a fast, snaking movement and are found under stones, vegetation and debris.

Worms



Worms are long and segmented, with a cylindrical shape much like small earthworms. Their colouring is usually pink to brown. They are usually seen writhing around in debris, digesting the substrate they fed on.

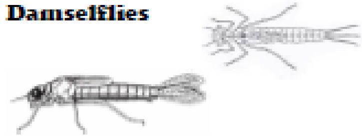
Snails / Clams / Mussels



Snails are molluscs with hard shells that vary in size, shape and colour. Habitats vary, with some snails, such as limpets, clinging to rocks, whereas clams and mussels are found in sand. The more common snails move over stones and vegetation. Some snails are host to bilharzia, a serious health hazard for humans.

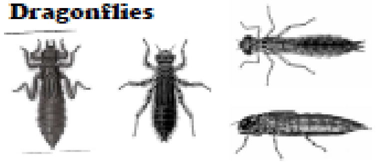
Images not to scale

Damselflies



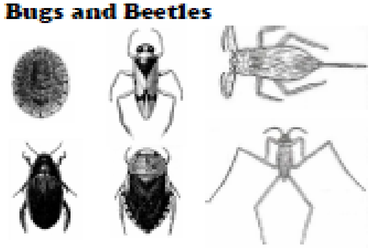
Damselflies have elongated bodies generally with three broad tails/gills on the tip of the abdomen. Damselflies are carnivorous and have a 'mask' over the lower part of the face, which hinges out to reveal a pair of pincers used to catch their prey. They are often found in vegetation growing on the edges of rivers.

Dragonflies



Dragonflies are robust creatures that are stout and have a large head and protruding eyes. Some have short legs whilst others have long legs. They do not have tails, but swim using 'jet propulsion' by forcefully ejecting water from the abdomen. Dragonfly nymphs are usually the largest organisms found in a sample and are the most powerful invertebrate predators in the water.

Bugs and Beetles



Bugs can be defined as having a piercing and sucking beak for mouthparts, and two pairs of membranous wings. Beetles on the other hand have 'jaws' and outer wings that are hardened to protect the inner wings. Some bugs and beetles are well adapted to swimming, such as water boatmen, backswimmers, pond skaters and water striders. Most bugs and beetles are carnivorous, but some feed on algae.

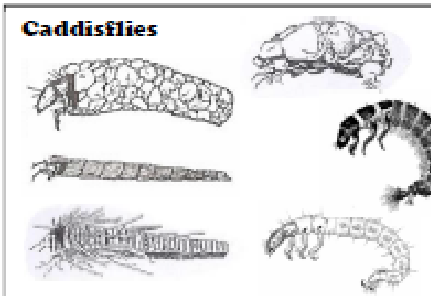
Crabs and shrimps

Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs. Their eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the chance. Shrimps are mostly scavengers or deposit feeders.

Stoneflies

The nymphs of adult stoneflies usually have two long tails and three pairs of legs, each having two claws at the tip. A characteristic feature of stonefly nymphs are the tufts of gills on the side of the body as well as gills between the two tails. Wing pads on the thorax are often dark and obvious. Some species run across the substrate very efficiently and are potent invertebrate predators. Other species are smaller and feed on plant material. Most live in well-oxygenated, clean water.

Caddisflies

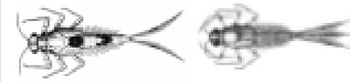


The aquatic larvae of adult caddisflies have a hard head with three pairs of legs attached to an elongated, soft body. Finger-like gills on the abdomen and anal appendages can be seen with the naked eye. Some caddisflies construct portable shelters from sand grains, bits of vegetation and/or silk that are glued together to form a characteristic case shape. Most case-building types cannot swim whereas the caseless types swim freely across the substrate. Some feed on algae and detritus whereas others are predators.

Mayflies

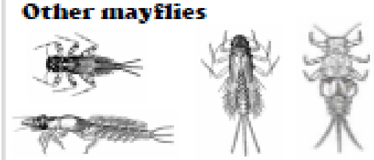
Mayfly nymphs vary greatly in shape and size and can survive for months in the water. However, the adults only live for a day or two. In this time, adults never feed, only mating and lay eggs in the water.

Minnow mayflies



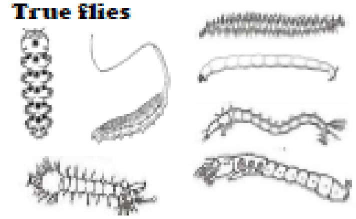
These mayflies have a narrow head and a small, slender, but not flattened body. They have leaf shaped gills on both sides of the abdomen and two but more commonly three tails, depending on the species.

Other mayflies



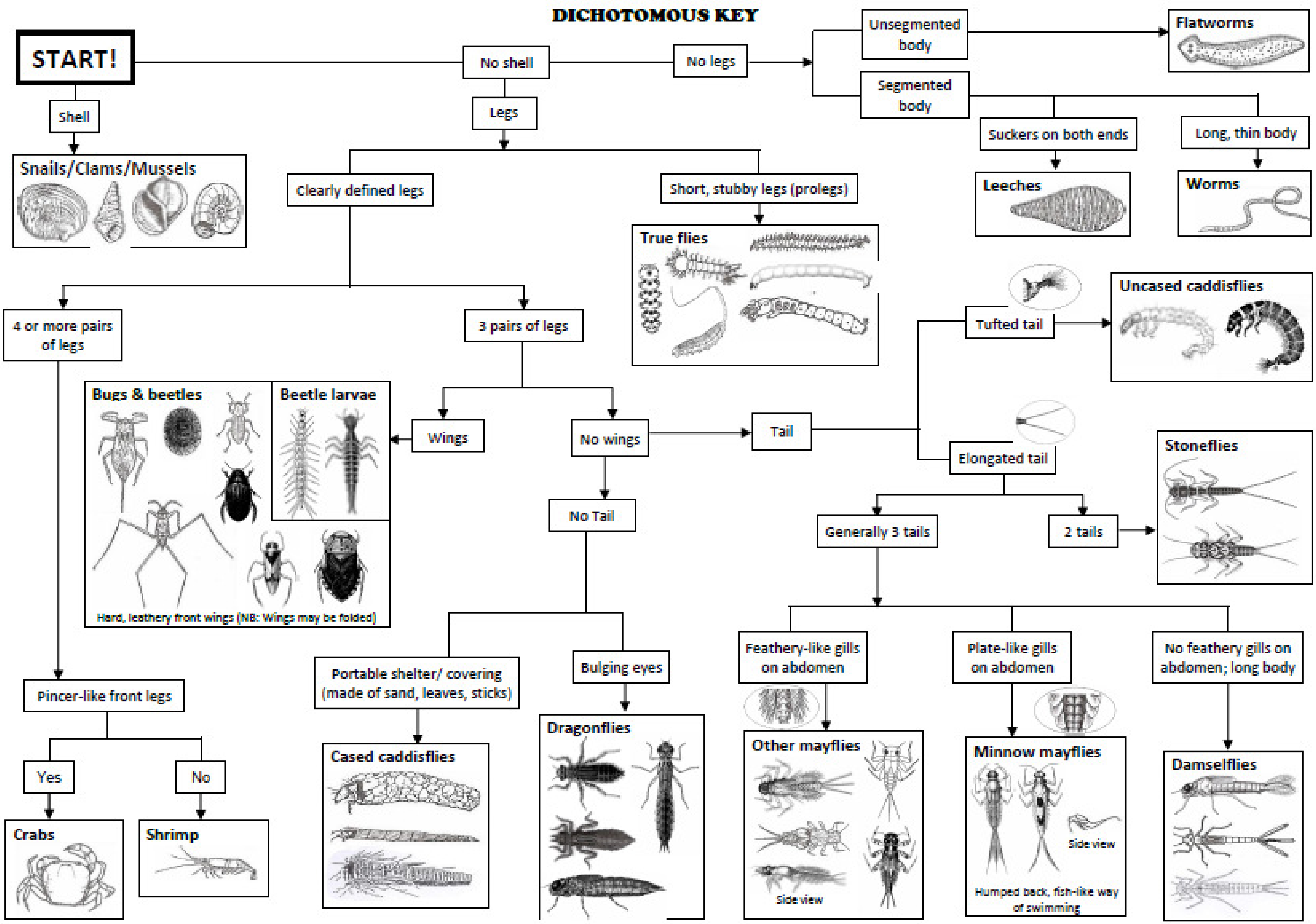
Other mayflies are characterised by an elongated body, large head, well-developed mouthparts and stout legs. They live in a variety of habitats, including burrowing in mud, crawling amongst decaying leaves, and scurrying over stones in fast flowing water.

True flies



Most fly larvae have a fairly indistinct head but elaborate tail ends. They often have small, soft legs (prolegs), segmented bodies and have the appearance of maggots. Some have bristles/spines and antennae. True flies live in a variety of habitats including sand, mud and stones in fast flowing water. They can either be carnivorous or filter feeders.

Images not to scale


DICHOTOMOUS KEY
START!
Shell
Snails/Clams/Mussels
No shell
No legs
Unsegmented body
Flatworms
Segmented body
Suckers on both ends
Leeches
Long, thin body
Worms
Legs
Clearly defined legs
Short, stubby legs (prolegs)
True flies
4 or more pairs of legs
Pincer-like front legs
Yes
Crabs
No
Shrimp
3 pairs of legs
Wings
Bugs & beetles
Beetle larvae
Hard, leathery front wings (NB: Wings may be folded)
No wings
No Tail
Portable shelter/ covering (made of sand, leaves, sticks)
Cased caddisflies
Bulging eyes
Dragonflies
Tail
Tufted tail
Uncased caddisflies
Elongated tail
2 tails
Stoneflies
Generally 3 tails
Feathery-like gills on abdomen
Other mayflies
Side view
Plate-like gills on abdomen
Minnow mayflies
Side view
Humped back, fish-like way of swimming
No feathery gills on abdomen; long body
Damselflies

Rivers where miniSASS has been conducted and recorded on the miniSASS website

South Africa					
Amanzimtoti	Golokodo	Kromvlei Spruit	Mkuze	Nguku	Thaka River
Anna Stream	Groot Marico	Kwadoda River	Modder River	Nkawana	Thina River
Apies River	Gwenspruit	KwaPata	Modderfontein	nkobongo	Thokoza Park
Assegaai	Gxulu river	Latonyanda	Mokopu	Nkoeliararo	Tholeni
Baakens	Hartbeesspruit	Lebele	Molweni	Nkutu	Town Bush
Baviaans	Harts	Leermansdrif	Mooi	Nyl Rivier	Tshikali
Baynespruit	Hex	Liesbeek	Moopetsi	Nyoka Ridge	Tshiombedi
Berg River	Highmoor	Lions	Moreletaspruit	Olifants	Tsomo
Bietourivier	Hike crossing	Little Bushman	Mossel River	Pabatlong	Tyume River
Bilanhlolo	hlambitwa	Little Pot	Mountain Home	Palmiet	Umbilo
Blesbokspruit	homestead lake	Lotheni	Mpanyeni	Palmiet River	Umdoni
Bloubos	Howison Poort	Lourens River	Mperu	Pearl Valley 4	Umgeni River
Bloukrans	Hurlyvale	Lutanyanda	Mpofana	Pholela	Umhlangeni
Blyde River	Inhlanza	Maalgate	Mpophoma	Phuza Moya	uMlaas
Bosfontein	Inkobongo	Mabane	Mpuluzi	Pongola	uMlazi
Bot Gardens	Jordan	Magalies	Mpuzama	Rademeyer	uMngeni
Braamfontein	Jubilee Creek	Magwazela	Mshwati	Reserve	uMnsunduze
Buffelsrivier	Jukskei	Malgalies	Mthunzima	Rietspruit	uMthunzima
Bulk River	Karkloof	Manyane River	Mukhase	Ronalds Kloof	Umzinti
Cannon	Keiskammahoek	Maphophomana_Tr	MuldersdrifSeLo	Salt	Uve Stream
Cata	kenmare spruit	Matatiele River	Mutale	Sandspruit	Vaal River
Crocodile	Keurbos	Mbokodweni	Mutshundudi	Shelter	Waboomsrivier
Dargle	Keyser's	Mbongokazi	Mvenyane	Shuttlewo	Waterkloofsprt
Diep	Khusane	Mbongozi	Mzimkulu	Siyayi	Westlake
Dorpspruit	Khusane stream	Mdlotane	Mzimvubu	Skeerpoort	White Mhlasini
Dorpsriver	KinnoulRd	Meerhof 1	Nahoon	Skoonspruit	Willowfontain
Dzindi	Klapmuts	Mfule	natalspruit	Slang Spruit	Xhologha river
Edenvale	Klein Boesmans	Mhlatuzana	Natural Stream	Sterkspruit	Xolora
Elands	Klein Jukskei	Mkabela	Ncandu	Sterkstroom	
Foxhill Spruit	Klein-Mooi	Mkhobosa Stream	Ndiza	Sungubala	
Fudge stream	Klein-Xspruit	Mkhomazi	Neshe	Swartspruit	
Garsfontein	krom river	Mkhumbane	Ngotwane	Symmons	

Argentina	Australia	Canada	India	Italy	Kenya
Sao Joao River	Sturt River	Cataraqui River	Sturt River	Santerno River	Amala River
		MacVicar River			Gogo River
					Isherero River
					Kisaina River
					Mandera River
					Mara River
					Nairobi River
					Nyangores River
					Purungat Trib
					Talek River

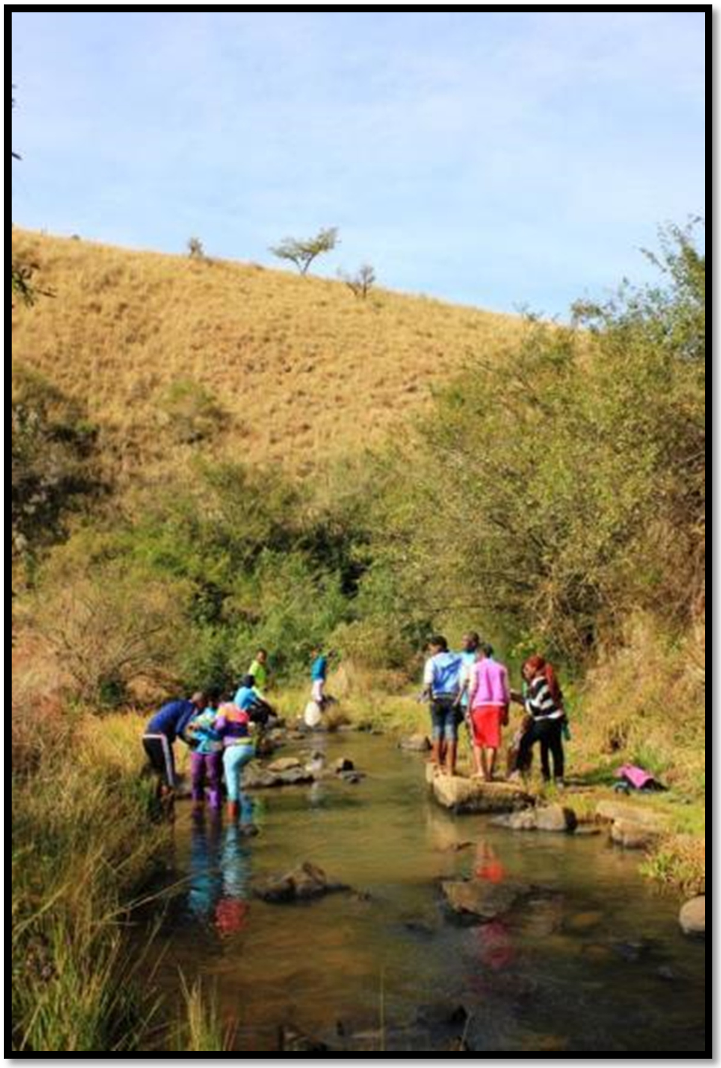
Korea	Malawi	Myanmar	Namibia	Poland	Spain
Bomun River	Fua River	Ayeyarwady River	Orange River	Straw Gurney	Cubillas River

	Kande River	Chaungmagyi River			
	Lichizi River	Maikha River			
	Luangwa River	Malikha River			
	Nkhata River	Myintnge River			
	Montealto UAE	Red River			

Sudan	**Tanzania**	**Turkey**	**United Kingdom**		
Dinder River	Dodwe River	Ballikayalar	Gleno River		
	Kinchwa Kubwa	G÷ktⁿrk G÷leti	Gulugji River		
	Muzi River				

APPENDIX I: THE RIPARIAN HEALTH AUDIT (RHA)

Riparian Health Audit



This is a product of The Water Research Commission: Project No. K5/2350

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

WESSA
PEOPLE CARING FOR THE EARTH

Contents

List of Figures

List of Tables

Introduction and Background

Introduction

This document serves as a manual for the assessment of the ecological health of riparian ecosystems using the Riparian Health Audit.

The key users of the assessment tool include:

- Citizen scientists
- Communities
- NGOs
- Local environmental authorities
- Landowners

It is recommended that prior to utilising the tool; assessors should review basic literature on riparian ecosystems and attend various training courses related to the subject. Though this may not be necessary, it will aid assessors in the identification of impacts and thereby, improve confidence in the data.

The application of the tool includes:

- Determining the current ecological health of the riparian system of interest and identifying the key impacts that should be addressed to maintain or restore its health
- Monitoring potential impacts to the riparian system from any development and industrial activities
- Monitoring for auditing of rehabilitation strategies

The fields of application include:

- Benchmarking studies (studies that confirm status compared to other riparian areas)
- Scientific research of citizen science studies
- Integrated catchment management programmes

Please note: This tool is intended to be a simple but effective tool that will allow the user to identify, rate and report on the impacts to local rivers and streams on a basic level.

To assess a river on an intermediate level particularly within an urban area the following document should be read:

Braid, S. 2014. Tools to Determine Enforcement Driven Rehabilitation Objectives on Urban River Reaches-Guideline Document, Water Research Commission, South Africa. Report No: TT594/14.

This guideline was aimed at Compliance and Enforcement Officials within Governmental bodies and contains South African legislation regarding river ecosystems.

Citizen scientists are therefore encouraged to first use the Riparian Health Audit given the intermediate level of knowledge and skill required.

Background

The National Water Act defines riparian areas as "*The physical structure and associated vegetation of areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas*." In simpler terms riparian ecosystems are defined as the interface between aquatic (water) and terrestrial (land) ecosystems; Figure 1.1 and Figure 1.2 provides an example.

It is important to note that wetlands are defined as transitional between aquatic and terrestrial systems. Therefore, riparian areas that are saturated or flooded for prolonged periods could be described as riparian wetlands. However, not all riparian areas are wetlands especially in areas that are well-drained.

Riparian areas form corridors through the catchment and are primarily structured through hydrological and geological activities. Due to their location and the associated environmental phenomena that influence their structure, they possess substantially different properties from the surrounding landscape.

The importance of riparian zones in maintaining catchment health exceeds their area of occupancy within the catchment by virtue of the ecosystem processes that occur within them. Furthermore, riparian ecosystems provide people with a diversity of natural resources. Collectively, these are referred to as Ecosystem Goods and Services.

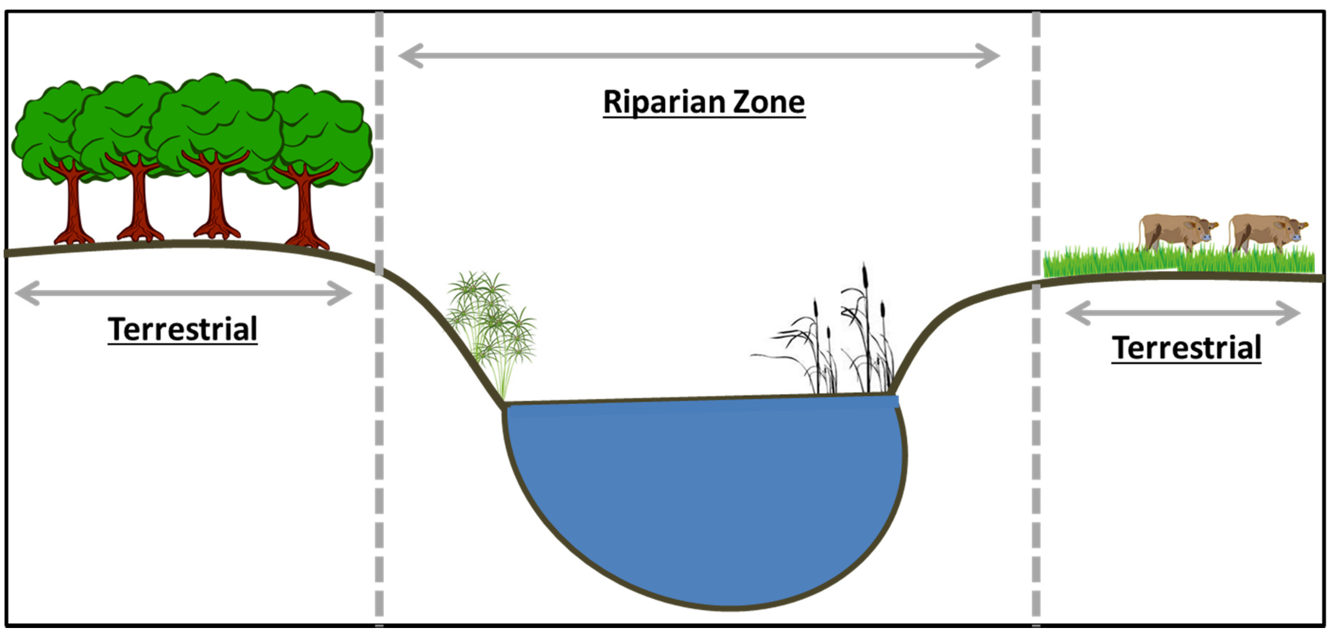


Figure 0.1 The riparian zone

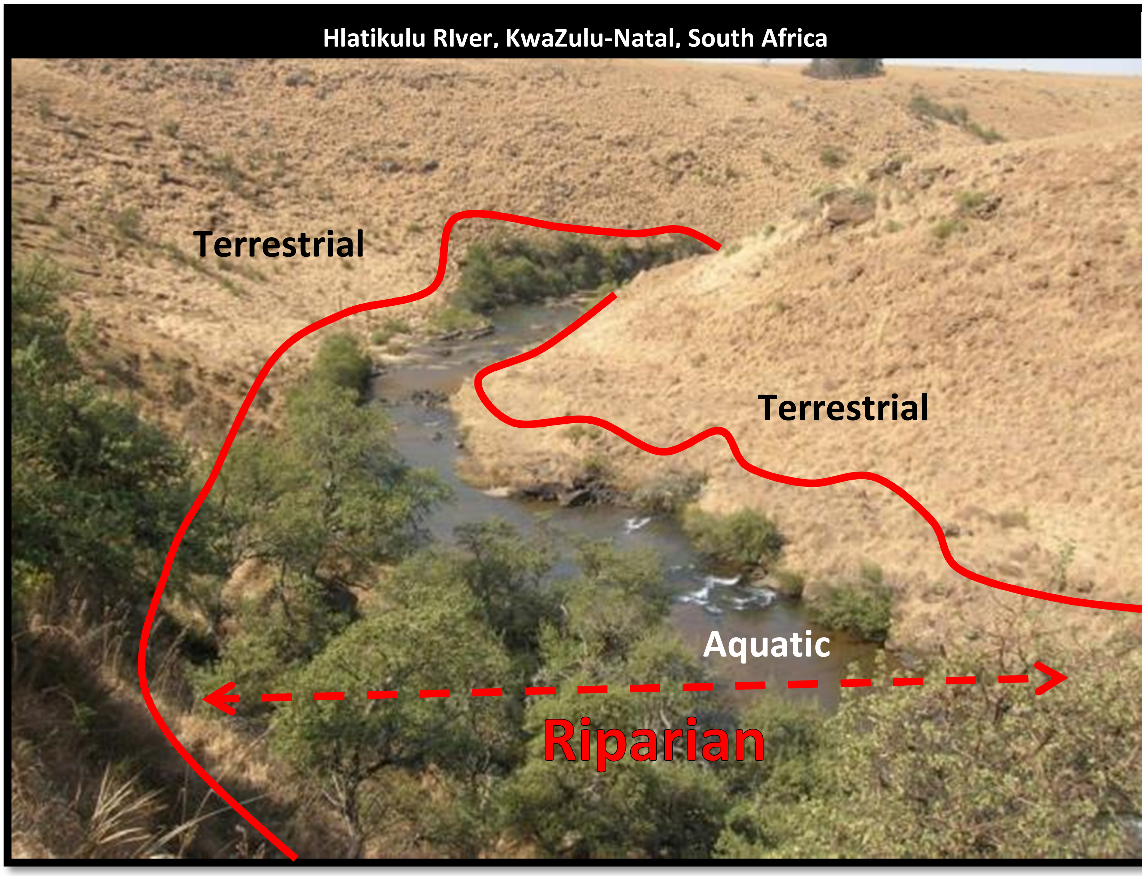


Figure 0.2 Riparian ecosystems (indicated by the red outline) are at the boundary between terrestrial and aquatic ecosystems

Rivers can be viewed as transport routes, carrying sediments and chemical compounds from one location to another. Riparian ecosystems effectively trap sediment from surface runoff decreasing sediment load. Moreover, due to the vegetation present within the riparian zone, bank erosion is generally impeded.

Riparian systems accumulate and remove nutrient and contaminant loads, such as Nitrogen, Phosphorous and pesticides by virtue of the ecological processes that occur within them. Therefore, riparian ecosystems are critical in maintaining water quality.

The alluvial soil (soil deposited by water flows) tends to form a relatively deep layer and is able to store quantities of water from run-off or rainfall. Therefore, riparian habitats support base flows when groundwater from the riparian zone seeps into the channel. (Base flow is the portion of stream flow that results from seepage of water from the ground into a channel slowly over time.)

Riparian ecosystems provide habitat and corridors for movement for many living organisms (biota), including amphibious and terrestrial organisms. These organisms themselves provide many ecosystem goods and services to people. They provide pest control, medicinal compounds and a pollination function. In addition, riparian systems are important for maintaining optimal habitat conditions for aquatic organisms by: a) providing physical structure in the form of woody debris; b) moderating water temperature through shading and evapotranspiration and c) providing energy resources. Furthermore, they aid in attenuating floods (attenuation is the process of water retention on site and slowly releasing it in a controlled discharge) thus preventing damage to downstream ecological and built infrastructure. Figure 1.3 provides an example of some of the ecosystem goods and services provided by riparian ecosystems.

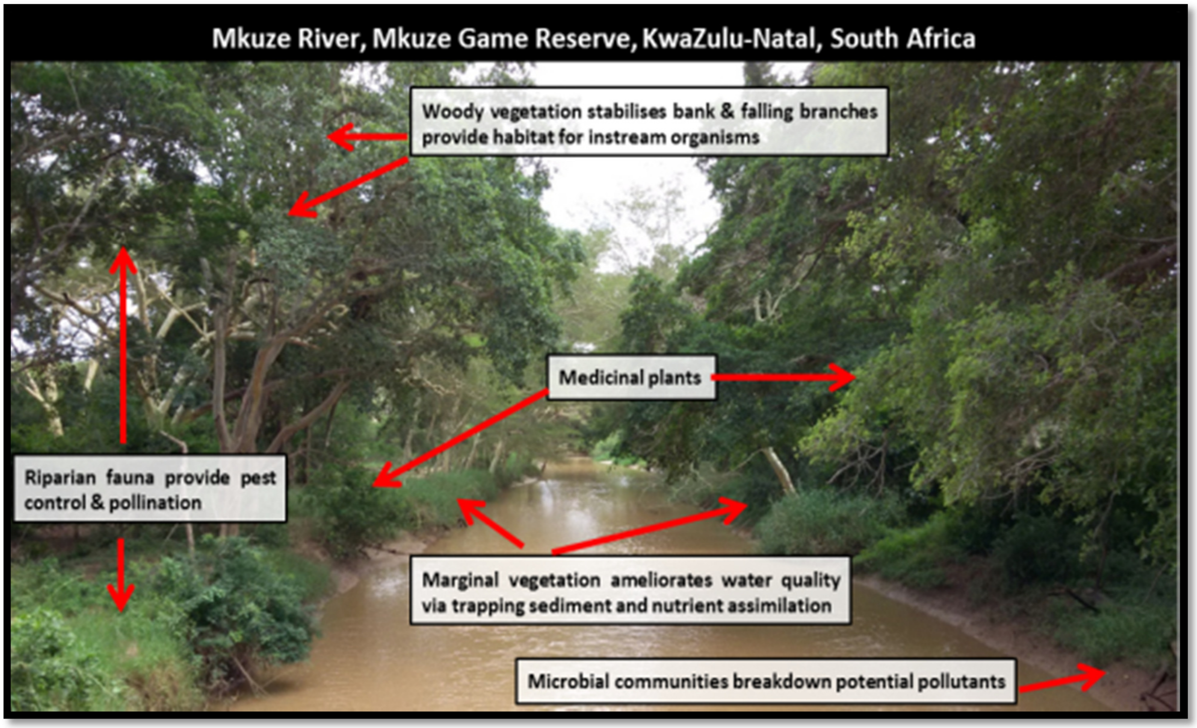


Figure 0.3 an example of the array of ecosystem goods and services that a naturally functioning riparian system can supply

Riparian systems can be referred to as 'Critical Transition Zones' as they serve as a pathway of a relatively vast amount of energy and matter from one clearly defined ecosystem to another. Due to their nature, these systems are usually subjected to intensive pressure by human activity. Therefore, riparian ecosystems are often impacted and transformed by these human activities on a local and global scale.

In order to manage these vital ecosystems it is important that their ecological condition can be assessed. Remember: *"You can't manage what you don't measure"*. The Riparian Health Audit (RHA) was developed to provide a simple and easy-to-use tool that will enable the assessment of riparian ecosystem condition by a wider range of users for various applications.

Structure of the riparian health audit

Background to the Structure of the Riparian Health Audit

The RHA method demonstrates to a user how to:

- Prepare for and undertake fieldwork
- Identify the riparian zone
- Identify key impacts within the riparian zone;
- Determine the extent to which these impacts are compromising the ability of the riparian zone to function naturally

Each impact is rated according to the intensity and extensiveness of that negative impact. The recorded scores are entered into the RHA Model on an Excel spreadsheet that produces a score, rating the ecological condition of the riparian zone. The score is based on the extent to which the riparian zone being assessed is degraded compared to that of natural conditions.

This guide is designed to aid prospective RHA users, and enables and assists in the:

- Identification of the lateral extent of riparian habitat
- Identification of human influences and negative impacts to the assessed riparian habitat
- Rating the intensity of these negative impacts

Through literature reviews and research, 8 impacts were identified as the principle negative influencers to the functioning and integrity of riparian ecosystems. The impacts identified are as follows:

- Exotic Vegetation
- Rubbish Dumping
- Bank Erosion
- Inundation
- Flow Modification
- Evidence of Decreased Water Quality
- Vegetation Removal
- Channel Modification

Glossary and Description of Impacts Observed and Recorded for the Riparian Health Audit

1.1.1 Exotic Vegetation

Exotic plants are species that are not indigenous to the specific geographic region being assessed. In this context, we include alien plants, alien invasive plants, commercial crops, gardens and hedgerows as exotic. Due to a lack of natural predators (as well as a number of other factors), exotic plants are able to outcompete indigenous plant species and therefore are able to spread. Some exotic species are so successful in their new environments that they become invasive and dominate the landscape. These invasive alien species (IAP's) out-compete the indigenous vegetation for resources. Exotic plants alter the natural functioning of riparian areas by exacerbating erosion and reducing biodiversity. They also negatively influence the instream habitat as they use more water than indigenous plants and change natural temperature cycles through excessive shading of the channel.

Ideally, the assessor should be able to identify exotic plants, particularly locally important species. There are several field guides available that will aid in identification.
Some possible references to aid the identification process:

- Bromilow C, 2010. *Problem plants and alien weeds of South Africa,* Third edition, Briza, Pretoria.
- www.ispotnature.org
- www.invasives.org.za

1.1.2 Rubbish Dumping

Rubbish dumping can be defined as the presence of solid waste within riparian ecosystems as a result of direct disposal into the riparian system or transported by the river or stream from upstream sources. Dumped rubbish changes habitat characteristics and negatively impacts ecosystem functioning. Furthermore, rubbish dumps drive health and safety issues, both locally and downstream and become breeding grounds for pest species including disease hosts and vectors.

1.1.3 Bank Erosion

The bank of a river or stream is the relatively steep part of the channel above the water level; this makes it susceptible to bank erosion. Bank erosion is a type of water erosion whereby the bank of a stream is eroded due to runoff. Although bank erosion (i.e. weathering) is a natural geological process (without bank erosion we would have no meandering streams); it may be accelerated by the impacts to the river system. Therefore, it is critical for an assessor to consider the environmental setting where the assessment is undertaken. The assessor should look to see if erosion is driven by vegetation removal, cattle access paths, an increase in water flow due to wastewater and storm water discharge, or the presence of exotic plants. If the user is not confident in distinguishing between natural or accelerated erosion, a riparian expert should be consulted.

1.1.4 Inundation

Inundation is the flooding of the riparian zone through the construction of impoundments or dams to slow down or stop water flow. Inundation typically results in an alteration of habitat characteristics. The riparian system is transformed into an aquatic system with a resultant change in ecosystem processes and biota.

1.1.5 Flow Modification

Flow modification refers to a change in the natural flow regime of a river. This could be either an increase in flow or a decrease in flow. This change in flow will affect the riparian zone, although the impact might not be that obvious initially or after a long time, as it is difficult to judge changes in riparian vegetation on a once-off visit. For this reason, it is necessary to investigate changes in flow above and below the reach that you are investigating. You will need to look for indications that the flow is being changed. Look for pipes and waterworks that are either pumping water into or out of the stream. It is also sometimes possible to assess change using the google earth timeline function. Floods that occur according to a natural cycle are required to prevent any one particular vegetation type from dominating the riparian zone. Naturally occurring high flows also aid in dispersing vegetation seeds or spores, transporting nutrients into the riparian zone and recharging groundwater. Therefore, modification of flows may reduce groundwater recharge, impede propagule dispersion and support the growth of plant species that will favour the new conditions.

Additionally, artificially sustained flows during the dry season, through the release of wastewater for example, may influence the reproductive and growth cycle of riparian vegetation. On the other hand, systems that normally have naturally sustained flows during the dry season may be impacted through diminished flows through water abstraction.

IMPORTANT NOTE: Where flow modification from wastewater and storm water exacerbates erosion and alters the water quality, these should be rated under their relevant sections to avoid duplication of impact ratings.

1.1.6 Channel Modification

Channel modification to the riparian zone is the alteration of the natural physical shape of the banks making up the riparian area. These can be caused by the construction of physical, man-made structures such as causeways, road-alignments, culverts, gabions and canals.

An important phenomenon to look out for, particularly in urban locations, is the re-shaping of the channel through increased discharges into the channel. In this scenario, increased discharges particularly through storm water erode the banks until the system eventually settles and lead to alterations of the channel dimensions. However, this may be difficult to identify in-field and may require historical knowledge of the area (again, try the timeline function on google earth).

IMPORTANT NOTE: Please take note and be clear of the difference between flow modification and channel modification before going into the field.

1.1.7 Evidence of Decreased Water Quality

This includes; Physico-chemical modifications which are changes to the riparian zone due to the alteration of water quality in the channel. Sources of pollution that change water quality may arise from a point (municipal and industrial wastewater effluent or storm water discharge points), or diffuse sources (run-off from surrounding landscape). Nutrient inputs may intensify exotic vegetation growth and may lead to root fanning towards the channel, and excessive shading. Excess sediment may be deposited within the riparian zone leading to an alteration in habitat characteristics and ultimately ecosystem functioning. Toxins present may cause acute and chronic affects to riparian biota through direct and indirect exposure.

1.1.8 Vegetation Removal

This is the removal of indigenous vegetation through livestock trampling (when livestock are gaining access to the channel for water), excessive harvesting by people, construction (including the construction of sports fields), agricultural and mining activities. It may be helpful at this stage to have a look at the site with the google earth timeline function.

Method to undertake the riparian health audit

The purpose of this section is to provide the user with the necessary guidelines to collect field data to assess the riparian system/s of interest.

Good Practices when using the Method:

a) Thoroughly read and ensure you understand the manual

b) Understand basic riparian ecology and functioning by reading background information on riparian ecology

c) Attend basic ecological education and training courses

d) Walk throughout the area that you are interested in rather than observing from a single point

e) Regularly refer to the photographic and illustrative guide section of this manual when rating impacts

f) Obtain landowner permission when and where required

g) Engage with the local community and authority in order to promote sustainable management and/or rehabilitation options

h) Talk to locals about the condition of the area; try to find out some history about the site to assist you with your assessment

Step 1 – Preliminary Steps

Before you start your assessment of a riparian system of interest, certain steps are needed to facilitate the assessment and aid in data collection. Preliminary activities include:

- Reach Delineation
- Visualisation of Natural Conditions
- Creation of Field Work Maps
- Checklist of items that will assist in undertaking the Riparian Health Audit

In order to facilitate these preliminary steps, users of the RHA should learn and use Google™ Earth or Google™ Earth Pro and be familiar with its capabilities. Download Google™ Earth Pro at http://www.google.co.za/earth/download/gep/agree.html

1.1.9 Reach Delineation

A reach is a length or section of river or stream that is relatively similar in terms of the channel pattern that can be observed on a map, for example some reaches have a much more twisted (i.e. sinuous) pattern than other reaches. The division of the riparian system of interest into reaches is dependent on the scale of the project. Large-scale projects should divide the riparian systems into reaches to provide greater detail of riparian ecological health and to highlight key areas within the catchment. The division of riparian systems into reaches for small-scale projects is not necessary, as the length of the system of interest may be limited to a relatively small area such as a single property or river crossing. The division of the riparian zone into reaches could be based on the following:

- Land-cover/use
- Obvious changes in the pattern of the channel
- Property boundaries

- River confluences (where two or more rivers meet)

Therefore, the division of reaches by geographical features is left to the discrepancy of the assessor but the aim or question of their study must be considered.

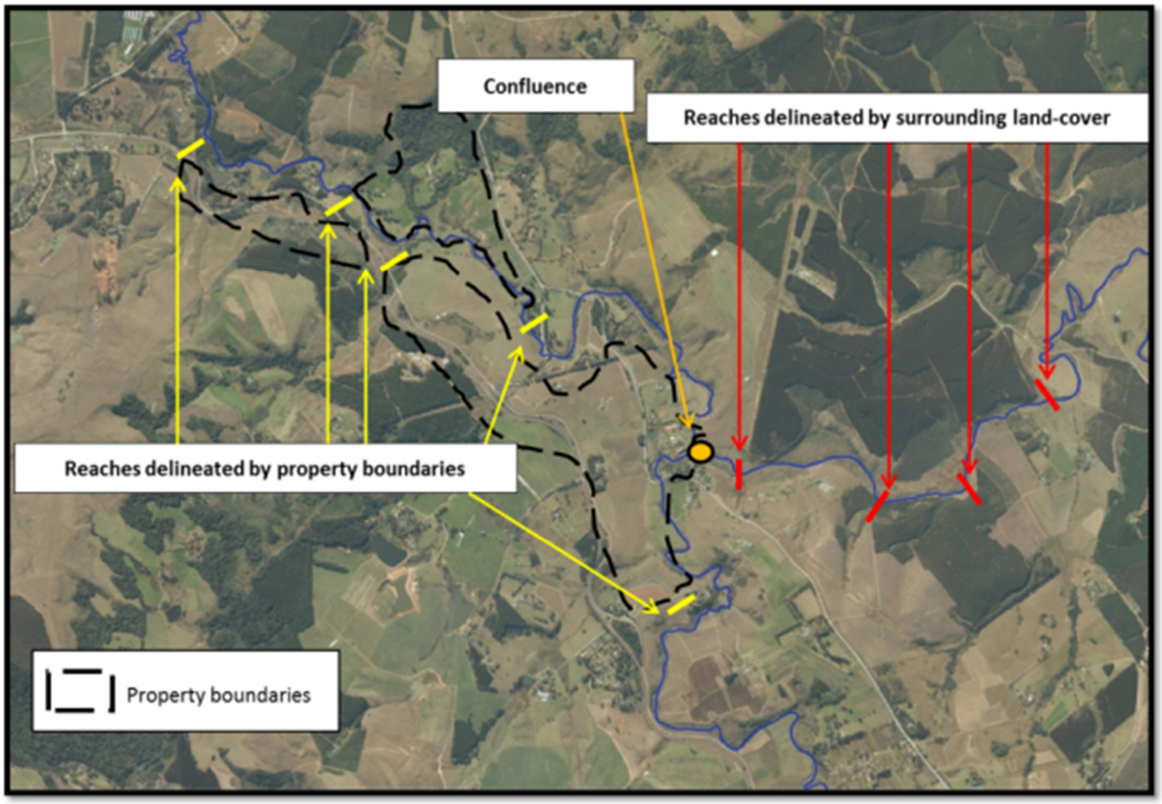


Figure 0.4 Example of reaches delineated by surrounding land-cover, property boundaries or at a confluence.

1.1.10 Visualisation of Natural Conditions

Prior to assessing the riparian system of interest, users should envision the reach as it would have been under natural conditions. While doing this it is also important to consider the landscape in which you are working. Are you in an arid or semi-arid part of the country, where rivers tend to be dry in the dry season, and prone to flash floods in the rainy season, or are you in a high rainfall area, where there rivers flow throughout the year?

Important features to note include the way it meanders (the channel sinuosity), the dominant vegetation growth form (grasses, reeds or woody vegetation) and the level of bank erosion. This can be determined through several means:

a) Review historical photographs or historical aerial imagery
b) Observe nearby systems that are in well-managed protected areas (such as nature reserves and national parks)
c) Speak to elderly members of the community. They have tremendous local knowledge and may be able to describe the past conditions of the system such as flood levels, vegetation types, etc.

1.1.11 Generation of Field Work Maps

To facilitate the assessment of riparian ecological health of a selected river system utilising the RHA, fieldwork maps should be made, if possible using Google™ Earth. These maps provide useful background conception to the current land-use and land-cover and annotations or notes can be added to the map once in the field. Therefore, it is preferable that these maps are in black and white. Figure 0.5 provides an example of a fieldwork map.

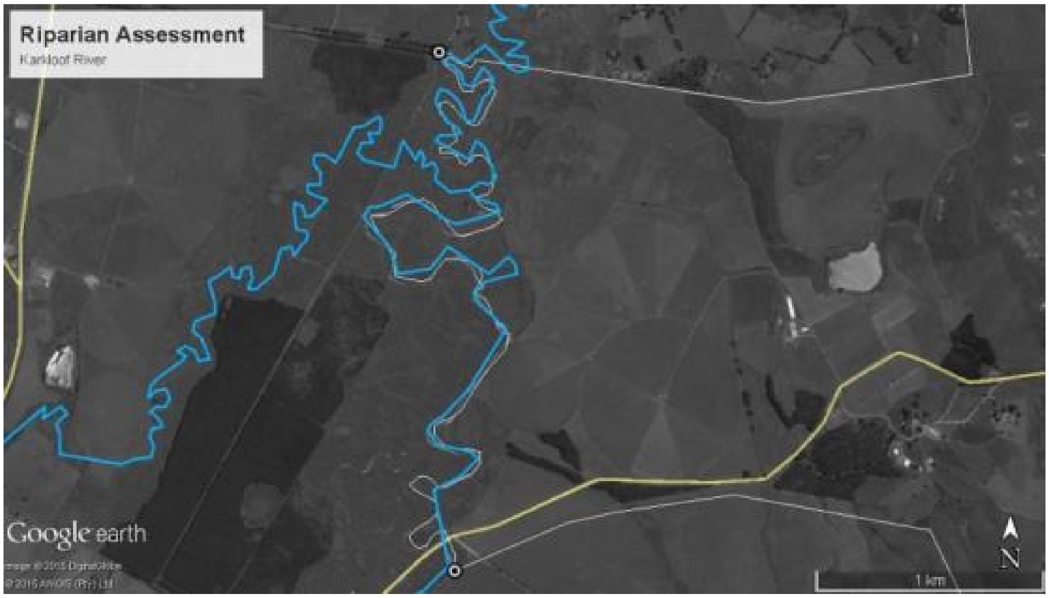


Figure 0.5 Example of a fieldwork map generated using Google™ Earth

1.1.12 Checklist of items that will assist in undertaking the Riparian Health Audit

Before undertaking fieldwork, the assessor/s should make a checklist of items that would be required or prove useful in the field (Table 0.1).

Table 0.1 Summary of essential and potentially useful fieldwork items for the Riparian Health Audit

Item	Essential	Potentially Useful
Field sheet	✓	
Suitable notebook[1], pencil and eraser	✓	
Clipboard (for field sheets)	✓	
Photographic & illustrative guide of the manual	✓	
Camera or camera phone	✓	
First aid kit	✓	
Field guides for identifying plants & animals	✓	
Global Positioning System / phone with GPS		✓
Gumboots		✓
Binoculars		✓
Spare batteries		✓
Machete		✓

Step 2 – Identification of Riparian Zone and Determination of Lateral Extent

To correctly undertake the RHA and provide an accurate assessment of the system's health, the lateral extent (or boundary) of the riparian zone needs to be identified.

Riparian habitats are influenced by the hydrological and geological dynamics of their associated river systems and consequently have vegetation which is distinguishable from the surrounding landscape. Therefore, users of the RHA are required to observe where transitions between different vegetation types occur. The lateral extent depends on the topography of the catchment. The riparian area may be narrow where the valley bottom is narrow with steep sides or wide where the valley bottom is wide with gentle slopes (Figure 0.6).

[1] Handy hint: make notes about anything relevant to the site in your notebook. This information might be very useful when you get back, especially if you are assessing a number of riparian areas on one day.

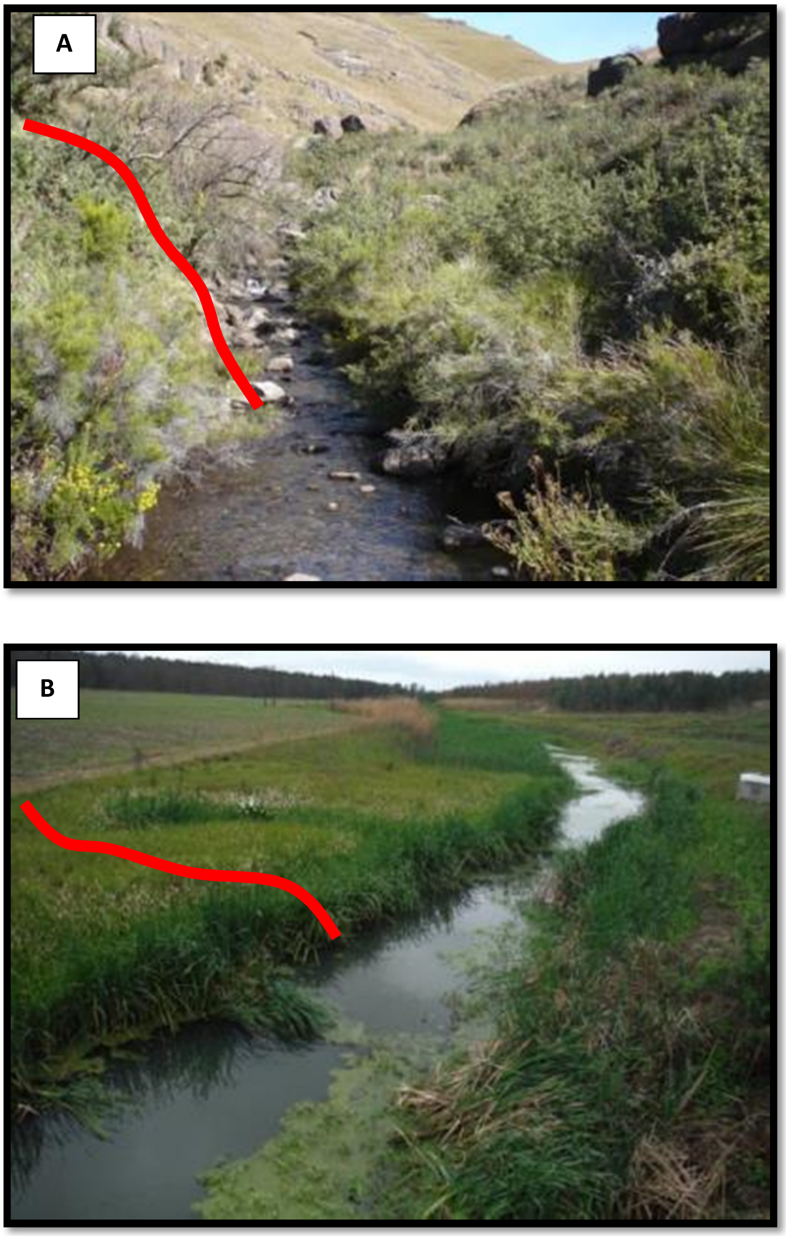


Figure 0.6 Examples of riparian zone extent indicated by the red line for a steep valley bottom (A) and a gently sloped valley bottom (B).

Step 3 – Rating Impacts

Subsequent to the identification of impacts, the rating of each impact must be undertaken. The rating system ranges from 0-5 and is dependent on the intensity and extensiveness of the impact. The impacts are rated as a percentage of change to the riparian system or coverage by the impacts. Table 0.2 provides a guideline to enable the rating of impacts.

IMPORTANT NOTE: Remember to consider the coverage or percentage change to both banks.

Table 0.2 A guideline to rating impacts in terms of the percentage of change caused by the impact or coverage of the impact to the riparian zone

Rating	Percentage Change or Coverage	Description
0.0	0	No Impact
0.5	1-10	Minor Impact
1.0	11-20	
1.5	21-30	Moderate impact
2.0	31-40	
2.5	41-50	Large impact
3.0	51-60	
3.5	61-70	Serious impact
4.0	71-80	
4.5	81-90	Critical impact
5.0	91-100	

To aid in data collection a field sheet where site information and impact ratings can be noted is provided (Table 3.3**Error! Reference source not found.**).

The accurate rating of impacts is very important. If the data recorded is inaccurate and is used in catchment management programs, the wrong decisions could be made by management, consequently, the incorrect allocations of resources will occur.

If assessors are unsure of a rating for a particular impact, it is useful to discuss the rating with colleagues. Ideally, although not essential, at least two assessors should undertake the assessment to ensure that all impacts are observed and a variety of perspectives considered.

Riparian Health Audit Field Sheet

Date:	Upstream boundary longitude (dd):	Downstream boundary longitude (dd):
River:	Upstream boundary latitude (dd):	Downstream boundary latitude (dd):
Project name/no:	General observations/comments:	

Rate each impact from 0-5 Please refer to the manual for rating guidelines

Site Name	Exotic Vegetation	Rubbish Dumping	Bank Erosion	Inundation	Flow Modification	Channel Modification	Evidence of decreased water quality	Vegetation Removal

Figure 0.7 Field sheet used for the Riparian Health Audit

Before leaving the assessment site always ensure the following:

- **All data have been entered onto the field data sheets**
- **Photograph numbers specific for each site have been recorded**
- **All equipment has been returned to the vehicle**
- **All gates were left as they were found if assessing an external party's property**

The impact ratings recorded are utilised to create a score that indicates the percentage of change that has occurred to the riparian system compared to the natural conditions. The score then translates to an Ecological Condition (EC) that describes the state of the system (Table 0.3).

Table 0.3 Summary of scores and percentage of change and their respective Ecological Condition for the Riparian Health Audit

Score	Percentage Change	Ecological Condition
0-4.5	0-10	**Natural**
5-11.5	11-29	**Good**
12-19.5	30-49	**Fair**
20-27.5	50-69	**Poor**
28-35.5	70-89	**Very Poor**
36-40	90-100	**Critical**

Step 4 – Data Entry into the Riparian Health Audit

The following section provides information on data entry into the RHA model and the calculation of the EC. It has two sub-sections for two different categories of assessors:

- Users that can use the digital model in the form of a Microsoft Excel spreadsheet (see sub-section 3.4.1)
- Manual Assessors - users that do not have access to the digital model and have to determine the EC manually (see sub-section 3.4.2)

1.1.13 Use of the automated RHA model to determine Ecological Condition

The data collected based on the in-field survey is entered into the RHA model to determine the EC. To enter data into the model go to the "IMPACT_RATING" tab in the associated RHA Excel file. Then, the site data and each impact must be rated according to the guideline in Table 0.2. The model will automatically generate a score, percentage of change and the respective EC. Table 0.4 provides an example of the data entered into the model and the generation of the EC.

Table 0.4 An example of data entry into the Riparian Health Audit model and the generation of the Ecological Condition[2]

Upstream Boundary - Latitude (decimal degrees)	Upstream Boundary - Longitude (decimal degrees)	Downstream Boundary - Latitude (decimal degrees)	Downstream Boundary - Longitude (decimal degrees)	Quaternary Catchment	River	Site Name	Exotic Vegetation (0-5)	Rubbish Dumping (0-5)	Bank Erosion (0-5)	Inundation (0-5)	Flow Modification (0-5)	Evidence of decrease water	Vegetation Removal (0-5)	Channel Modification (0-5)	Score	Percentage Transformed	Ecological Condition
-29.4736	29.8846	-29.4747	29.8849	U20A	uMngeni	Test 1	5	3	3	0	2	4.5	3	0	**21**	**51**	**Poor**
-29.4986	29.9272	29.5001	29.9288	U20A	uMngeni	Test 2	4	3.5	2	3	4	4	5	4	**30**	**74**	**Very Poor**
-29.5246	30.0297	29.5254	30.0292	U20A	uMngeni	Test 3	2.5	3.5	3	0	0	3.5	3.5	4	**20**	**50**	**Poor**
-29.5225	30.0874	29.5224	30.0882	U20A	uMngeni	Test 4	1.5	2	1	2	1.5	2	0	2	**12**	**30**	**Fair**
-29.4857	30.4877	29.4874	30.4882	U20G	uMngeni	Test 5	1	0	1	0	1	1	1	0	**5**	**13**	**Good**
-29.5564	30.5526	29.5559	30.5532	U20G	uMngeni	Test 6	0.5	0	1	0	0	1	1.5	0	**4**	**10**	**Natural**
-29.9635	30.9697	29.9645	30.9712	U60D	Mlaas	Test 7	5	5	5	5	5	5	5	5	**40**	**100**	**Critical**
-28.1907	31.7349	28.1911	31.7377	W20A	Mfolozi	Test 8	1	0	0	0	0	0	3	0	**4**	**10**	**Natural**

[2] N.B. this dataset is fictional and does not represent the actual EC of the reaches assessed

In addition, the spreadsheet enables users to develop a plot / graph to illustrate their ratings of impacts. Figure 3.5 below provides a plot of the impacts from the example data. From the example it can be seen when comparing pre- and post-development that although the rating for flow modification and flow channel modification decline, the rating for the other six impacts improve. The applications of this include the visual comparison of impacts between:

- Different assessment sites
- Pre- and post- development scenarios
- Pre- and post- riparian rehabilitation actions

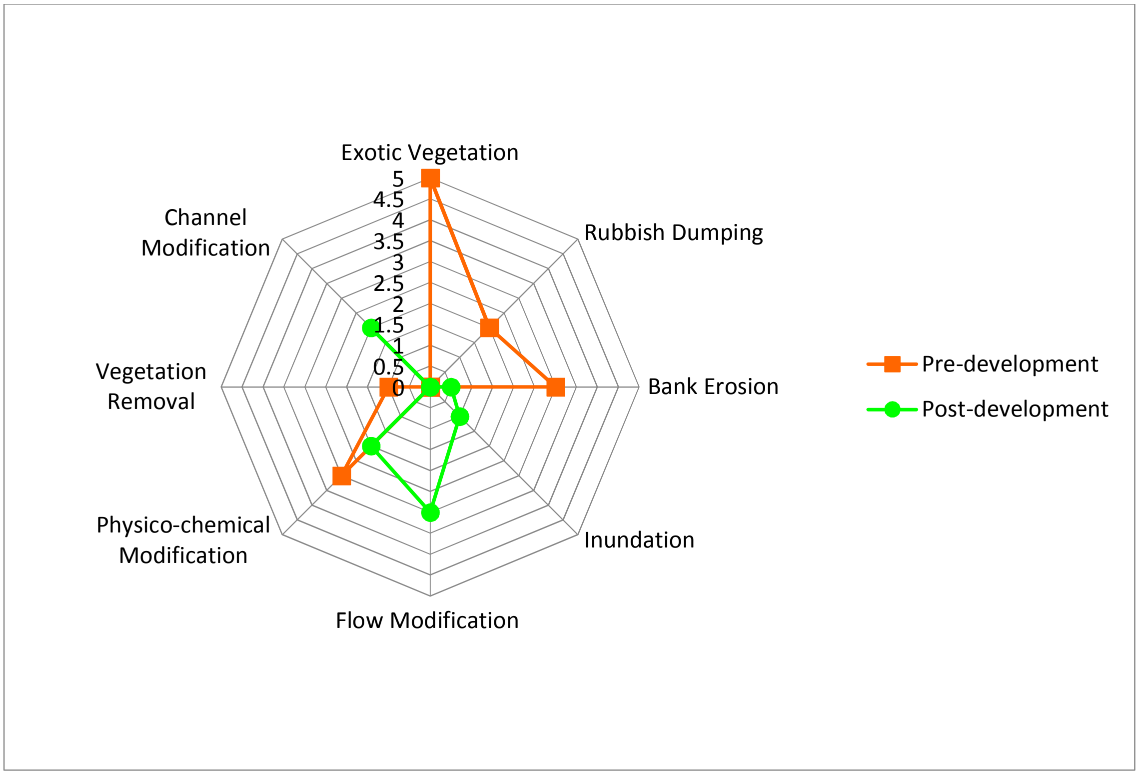


Figure 0.8 Example of a radar plot illustrating the ratings of impacts for the Riparian Health Audit from two example sites.

1.1.14 Manual calculation of Ecological Condition

Assessors that do not have the capability of utilising the digital model can calculate the EC manually. The various impact ratings are summed and then converted to a percentage of the maximum total impact rating. The maximum total impact rating is a product of the number of impacts and the maximum rating per impact: ***Number of impacts X Maximum rating = 8 X 5 = 40***

Table 0.3 of this document provides the EC for the percentage of change determined. An example of the manual calculation of riparian EC is demonstrated in Table 0.5 below.

Table 0.5 Example of the manual calculation of the Ecological Condition of a riparian system using the Riparian Health Audit

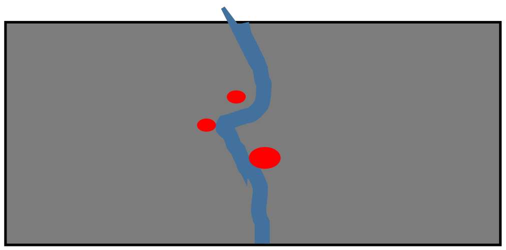
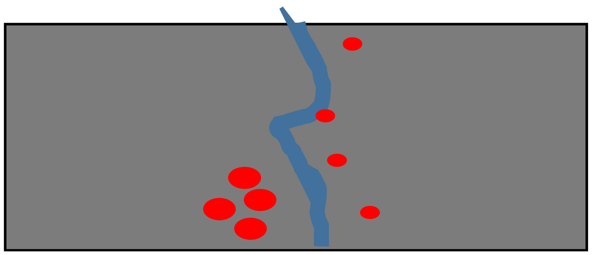
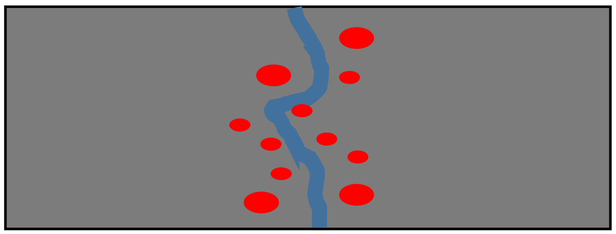
Impact	Rating
Exotic Vegetation	5
Rubbish Dumping	3
Bank Erosion	3
Inundation	0
Flow Modification	2
Evidence of decreased water quality	4,5
Vegetation Removal	3
Channel Modification	0
Score	**21**
Percentage Change (Score/40 X 100)	**51**
Ecological Condition	**Poor**

Photographic and illustrative Guide to Impacts

This section is a photographic and illustrative guide to aid prospective riparian assessors to identify and assist in rating the impacts considered in the RHA. The section is divided into subsections illustrating each impact.

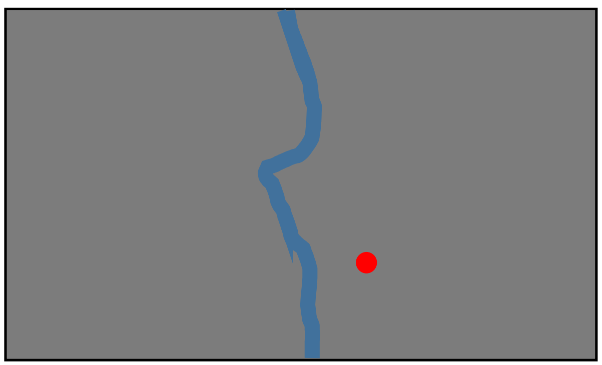
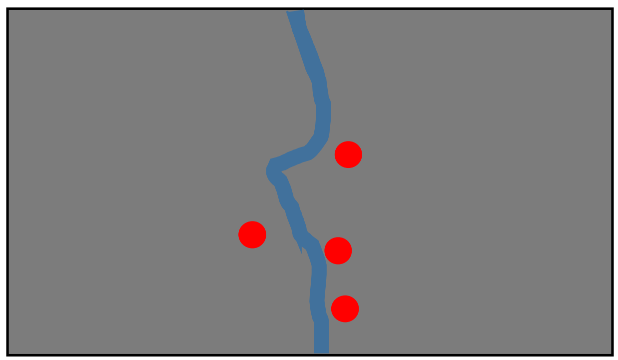
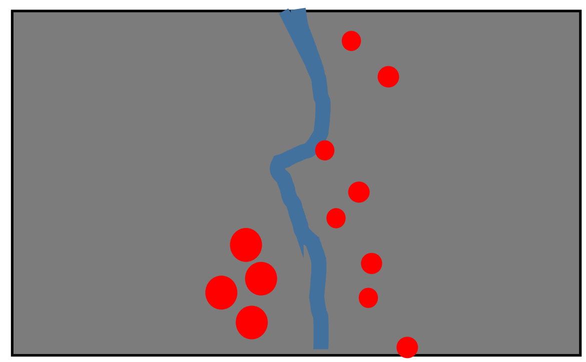
1.2 Exotic Vegetation

Exotic vegetation should be rated according to their abundance within the riparian zone. Remember, this includes IAP's, gardens, crops & hedgerows.

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
		
Hlatikulu River, KwaZulu-Natal		
		

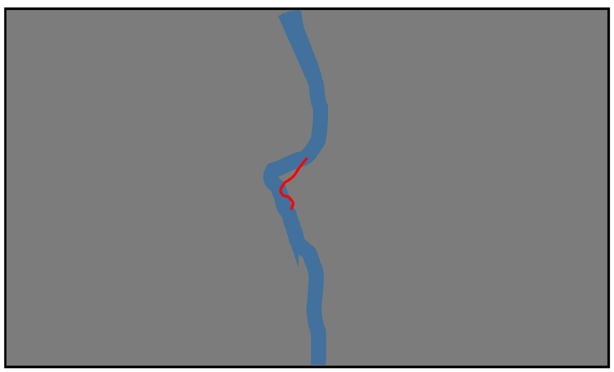
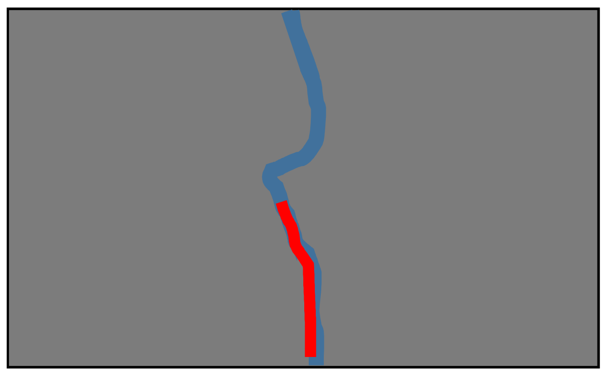
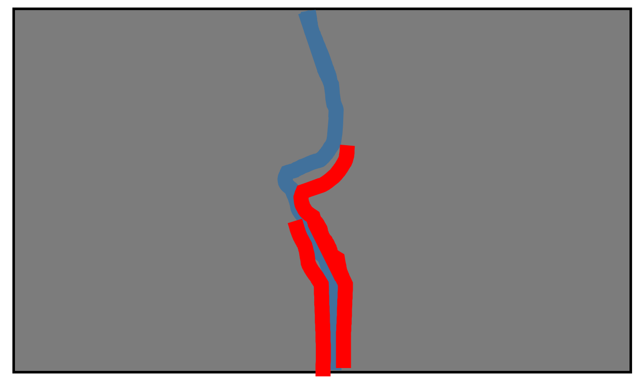
1.3 Rubbish Dumping

Rubbish dumping should be rated on the intensity and extent of coverage (percentage of cover) within the riparian zone and the local effects on ecological health.

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
		
Dorpspruit River, KwaZulu-Natal	Isipingo River, KwaZulu-Natal	Kwa Pata Stream, KwaZulu-Natal
		

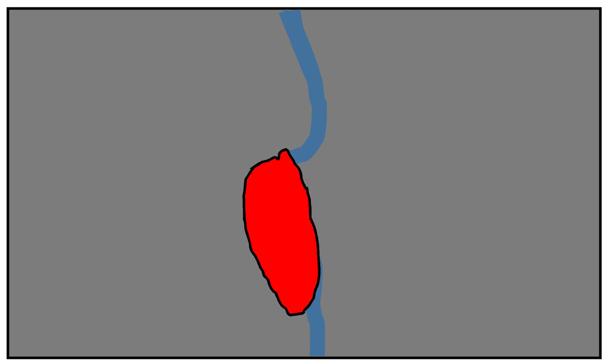
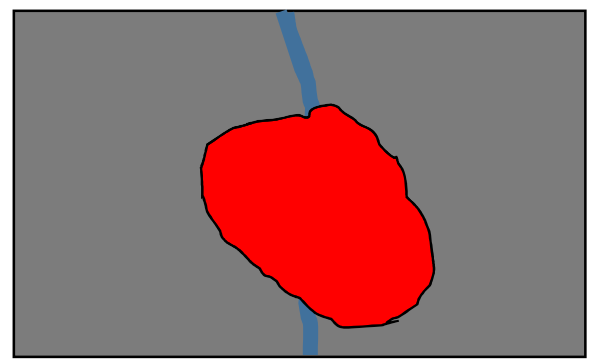
1.4 Bank Erosion

Bank erosion should be rated when it is caused by unnatural circumstances and should be based on the extent of coverage.

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
		
Lions River, KwaZulu-Natal	uMngeni River, KwaZulu-Natal	Lions River, KwaZulu-Natal
		

1.5 Inundation

Inundation is the flooding of the riparian zone through the construction of impoundments to impede water flow and typically results in an alteration of habitat characteristics. The riparian system is transformed into an aquatic system with a resultant change in geochemical processes and biota.

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
		
Thukela River, KwaZulu-Natal	Mkuze River, KwaZulu-Natal	Hlatikulu River, KwaZulu-Natal
		

1.6 Flow Modification

Flow modifications can be either an increase or decrease in flow, or a change in the natural seasonal flow.

Rating 0.5 - 1

Bush stream, KwaZulu-Natal

Rating 1.5 - 3

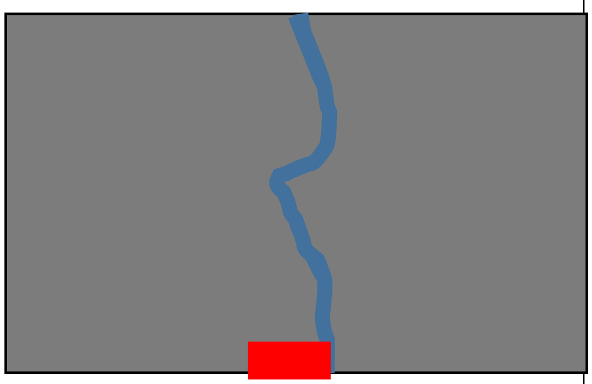
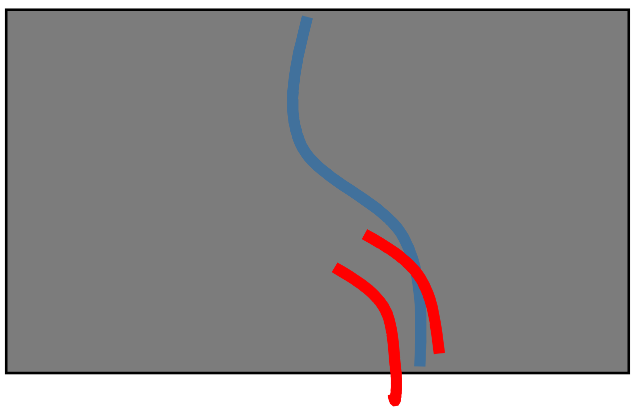
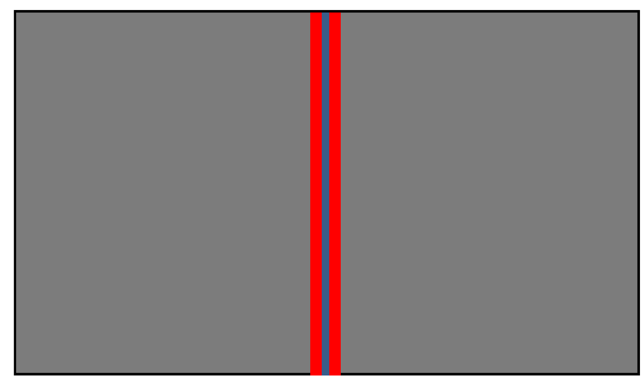
uMngeni River, KwaZulu-Natal

Rating 3.5 - 5

Mpushini River, KwaZulu-Natal

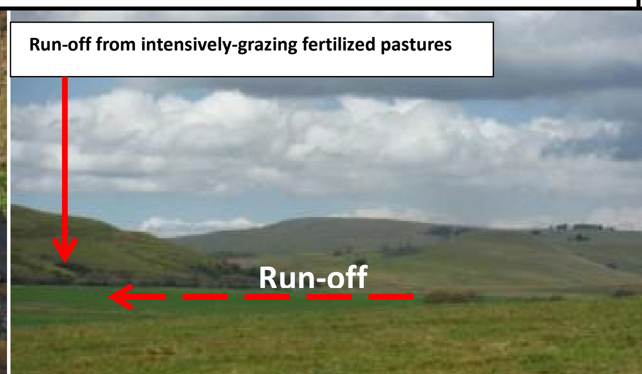
1.7 Channel Modification

The rating should be based on the longitudinal extensiveness (how far along the bank) of the modification within the reach being assessed.

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
		
Mooi River, KwaZulu-Natal	Mooi River, KwaZulu-Natal	Umlaas River, KwaZulu-Natal
		

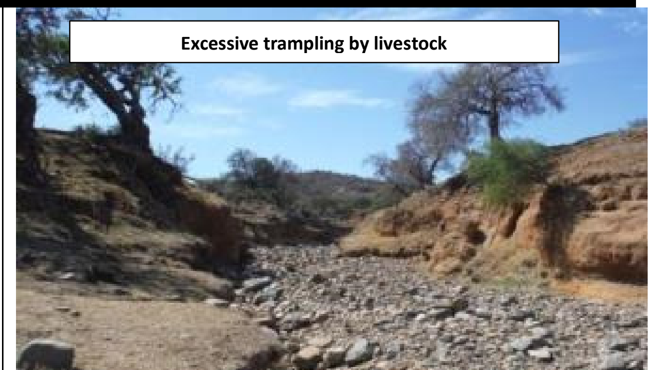
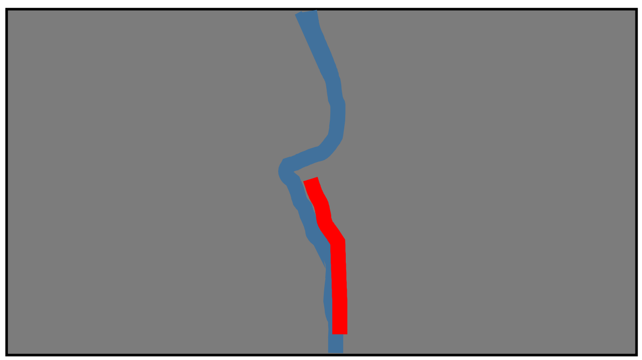
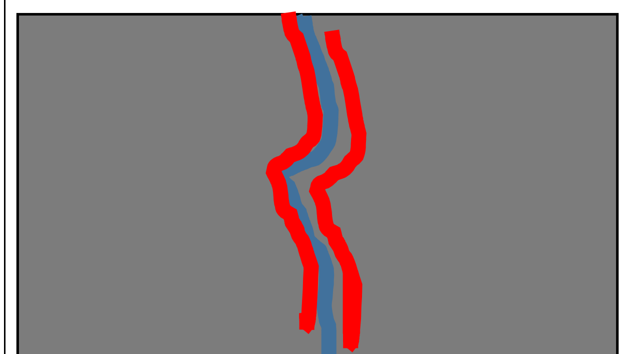
1.8 Evidence of Decreased Water Quality

The impact rating is based on the extent of the impact and the overall affect to riparian systems.

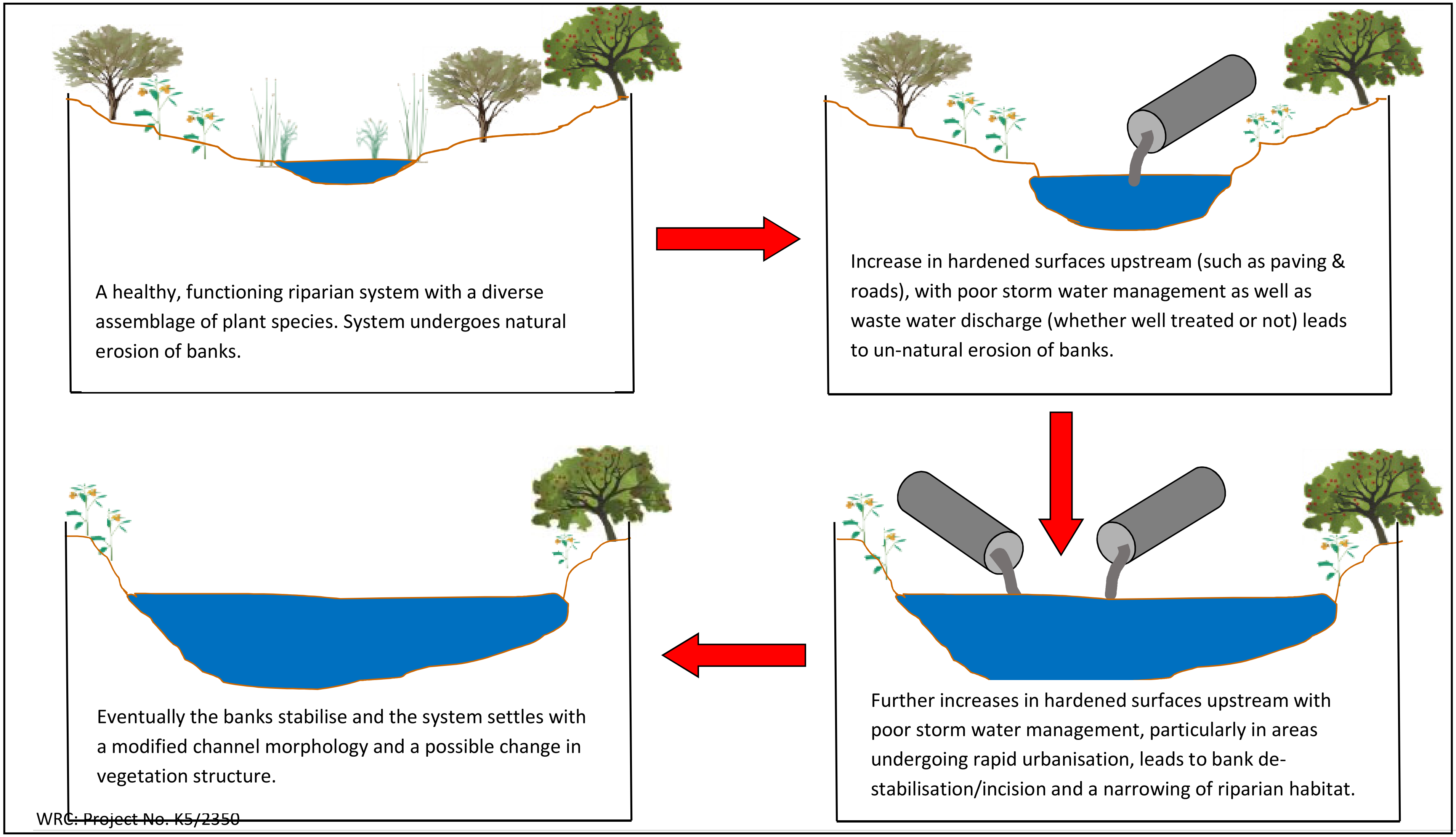
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
		
Mdloti River, KwaZulu-Natal	Mthinzima River, KwaZulu-Natal	Palmiet River, KwaZulu-Natal
		
Matigulu River, KwaZulu-Natal	Lions River, KwaZulu-Natal	Palmiet River, KwaZulu-Natal

1.9 Vegetation Removal

The impact rating should be based on the extent of removal.

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
		
Bush stream, KwaZulu-Natal	Lovu River, KwaZulu-Natal	Unnamed tributary of Thukela River, KwaZulu-Natal
		

As described, riparian ecosystems within urban areas are subject to major re-shaping as a result of poorly managed storm water runoff. The diagram below briefly describes the process. However, this is difficult to recognise and may require speaking to long-term residents of the area to obtain a better understanding of the channel shape and width.



Acknowledgements

Joint funding of the development of this tool by WWF-Mondi Wetlands Programme and the Water Research Commission is gratefully acknowledged. Donovan Kotze, Mark Graham, Kirsten Mahood and Bonani Madikizela are thanked for providing valuable comments on an earlier version of the tool.

Appendix A – DEVELOPMENT OF THE RIPARIAN HEALTH AUDIT

The Riparian Health Audit was derived from the Department of Water and Sanitation (previously known as the Department of Water Affairs) Index of Habitat Integrity[3] (IHI) Eco Classification tool. The IHI tool assesses the modification in riverine ecosystem habitat characteristics for both, the instream and riparian zones. The tool was aimed at specialist ecological consultants and professional scientists, to determine and understand the alteration of habitat characteristics by human drivers that have created a negative response in their biological unit (fish, macroinvertebrate, vegetation, etc.) of interest.

The IHI method is comprehensive and assesses eight (five for instream and three for riparian) primary metric groups, each based on several sub-metrics. In addition, metric ratings are integrated into each other where feasible and the calculation of the habitat integrity EcoClass complex. The tool, while valuable for experienced professionals, is complex for amateur or citizen scientists to use for assessing their systems of interest. Extensive data collection is required and the model is intimidating to use.

Therefore, the Riparian Health Audit was developed for citizen scientists by eliminating the sub-metric component, through the amalgamation of them into one metric that citizen scientists can rate. Furthermore, the calculation to determine the ecological category was simplified to allow users to calculate by hand if required. In addition, the model was developed to be user-friendly and allows for graphing outputs.

[3] Kleynhans CJ, Louw MD, Graham M, 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical manual) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 377-08

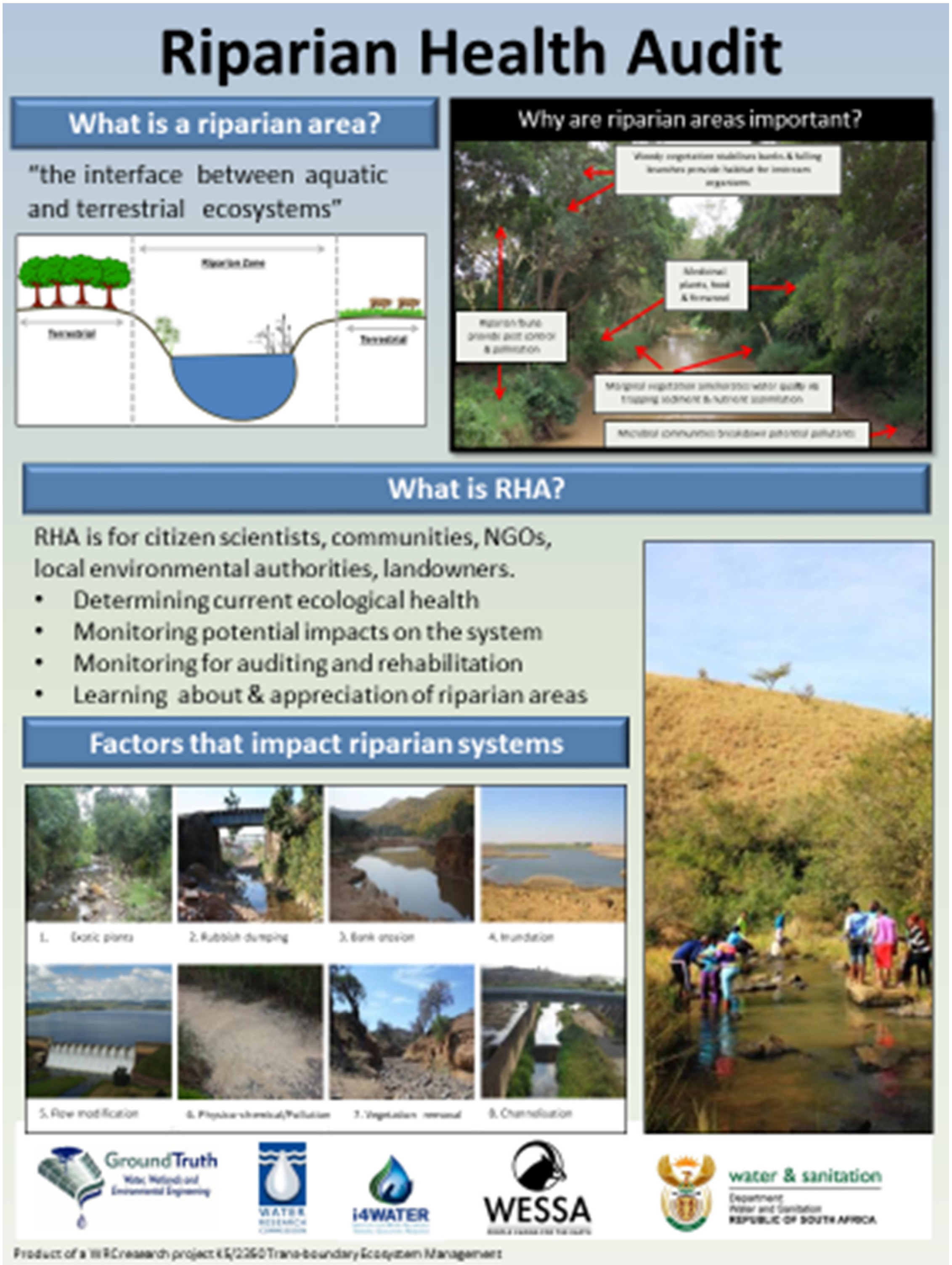
Field Sheet

Date:	Upstream boundary longitude (dd):	Downstream boundary longitude (dd):
River:	Upstream boundary latitude (dd):	Downstream boundary latitude (dd):
Project name/no:	General observations/comments:	

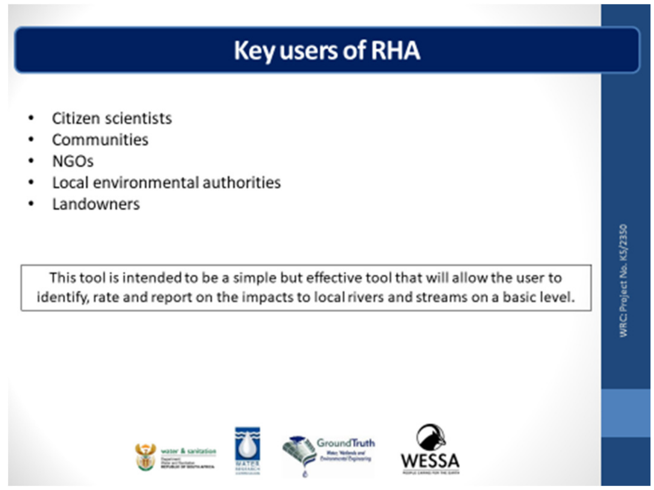
Rate each impact from 0-5 (0 = no impact; 5 = critical impact)
Please refer to the manual for rating guidelines

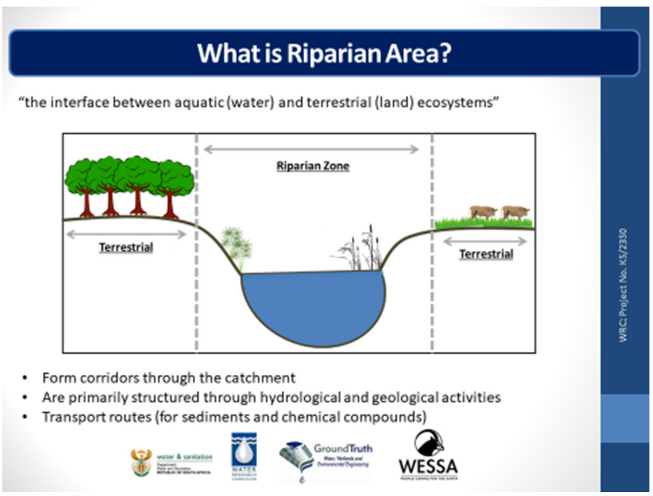
Site Name	Exotic Vegetation	Rubbish Dumping	Bank Erosion	Inundation	Flow Modification	Channel Modification	Evidence of decreased water quality	Vegetation Removal

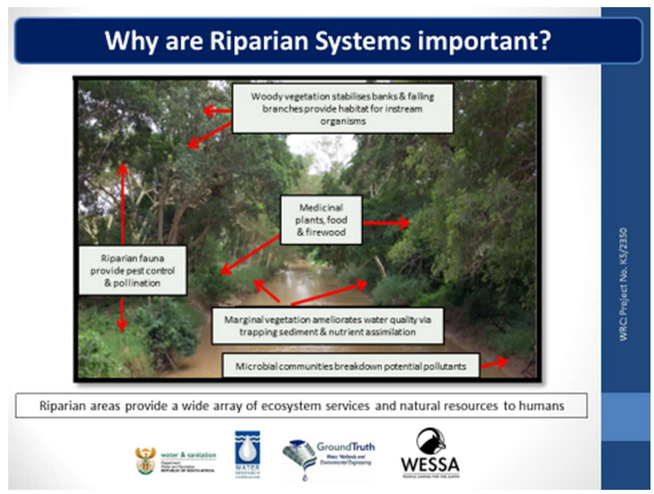
Poster

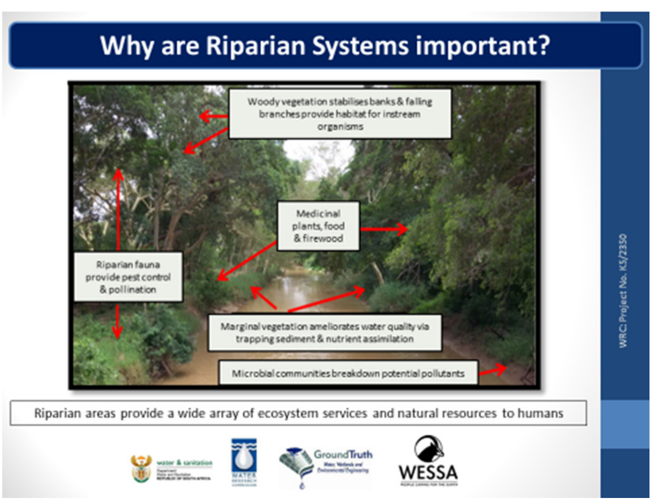

Riparian Health Audit
What is a riparian area?
"the interface between aquatic and terrestrial ecosystems"
Why are riparian areas important?
What is RHA?
RHA is for citizen scientists, communities, NGOs, local environmental authorities, landowners.
• Determining current ecological health
• Monitoring potential impacts on the system
• Monitoring for auditing and rehabilitation
• Learning about & appreciation of riparian areas
Factors that impact riparian systems
1. Exotic plants
2. Rubbish dumping
3. Bank erosion
4. Inundation
5. Flow modification
8. Channelisation
GroundTruth
WESSA
i4WATER
water & sanitation
Product of a WRC research project K5/2350 Trans-boundary Ecosystem Management

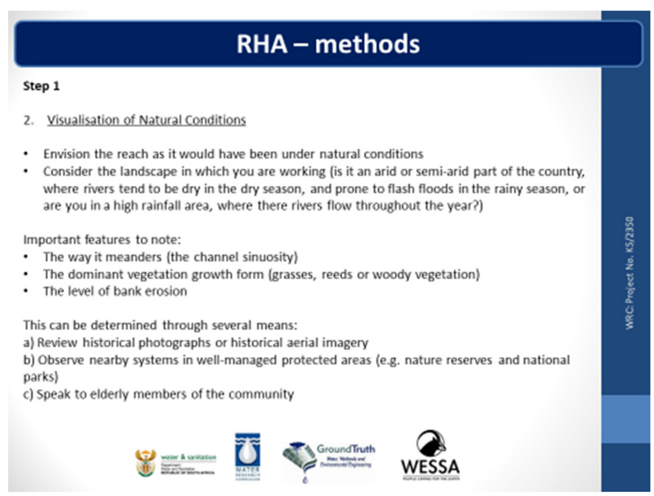
PowerPoint Presentation











RHA – methods

Step 1

2. Visualisation of Natural Conditions

- Envision the reach as it would have been under natural conditions
- Consider the landscape in which you are working (is it an arid or semi-arid part of the country, where rivers tend to be dry in the dry season, and prone to flash floods in the rainy season, or are you in a high rainfall area, where there rivers flow throughout the year?)

Important features to note:
- The way it meanders (the channel sinuosity)
- The dominant vegetation growth form (grasses, reeds or woody vegetation)
- The level of bank erosion

This can be determined through several means:
a) Review historical photographs or historical aerial imagery
b) Observe nearby systems in well-managed protected areas (e.g. nature reserves and national parks)
c) Speak to elderly members of the community

RHA – methods

Step 1

3. Generation of Field Work Maps

Figure 0.3 Example of a fieldwork map generated using Google™ Earth

RHA – methods

Step 1

4. Generation of Field Work Maps

Item	Essential	Potentially Useful
Field sheet	✓	
Suitable notebook, pencil and eraser	✓	
Clipboard (for field sheets)	✓	
Photographic & illustrative guide of the manual	✓	
Camera or camera phone	✓	
First aid kit	✓	
Field guides for identifying plants & animals	✓	
Global Positioning System / phone with GPS		✓
Gumboots		✓
Binoculars		✓
Spare batteries		✓
Machete		✓

RHA – methods

Step 2 - Identification of Riparian Zone and Determination of Lateral Extent

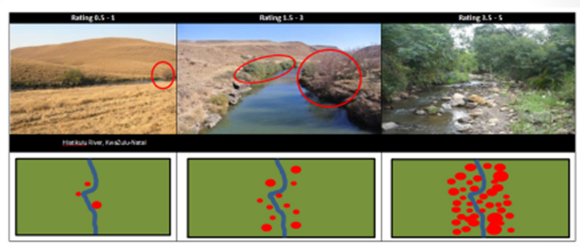
Figure 1.4 Examples of riparian zone extent indicated by the red line for a steep valley bottom (A) and a gently sloped valley bottom (B).

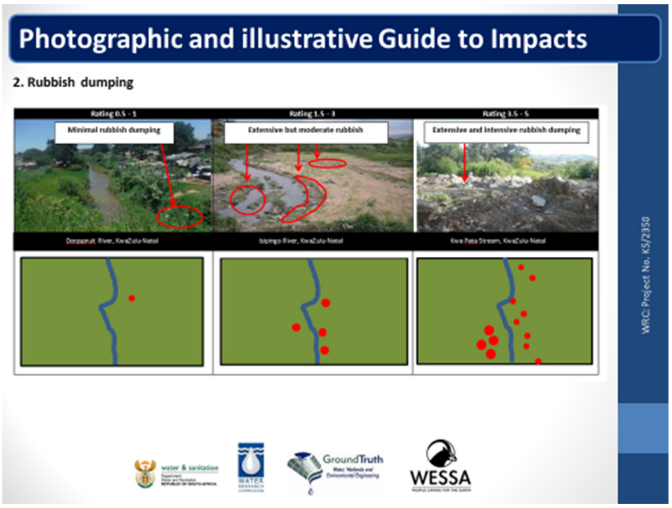
RHA – identifying impacts

Step 3 - Identify key impacts within the riparian zone

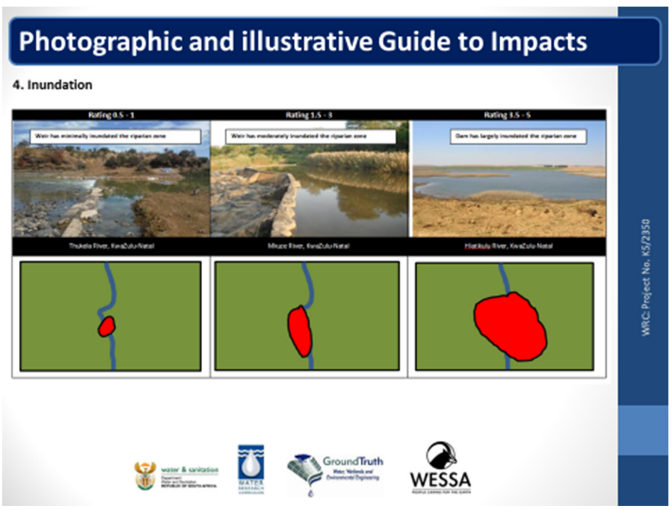
Photographic and illustrative Guide to Impacts

1. Exotic vegetation




Photographic and illustrative Guide to Impacts
2. Rubbish dumping
Minimal rubbish dumping
Extensive but moderate rubbish
Extensive and intensive rubbish dumping
WRC: Project No. K5/2350
GroundTruth
WESSA

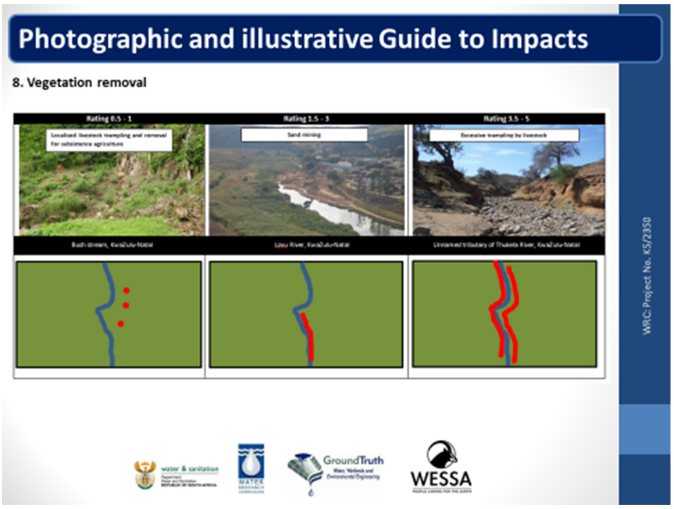

Photographic and illustrative Guide to Impacts
3. Bank erosion
Minimal erosion
Moderate erosion from cattle access paths
Extensive erosion
WRC: Project No. K5/2350
GroundTruth
WESSA

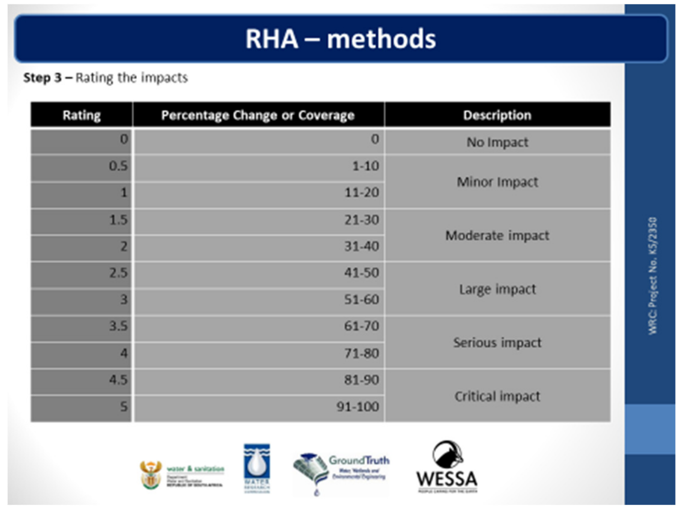

Photographic and illustrative Guide to Impacts
4. Inundation
WRC: Project No. K5/2350
GroundTruth
WESSA


Photographic and illustrative Guide to Impacts
5. Flow modification
WRC: Project No. K5/2350
GroundTruth
WESSA

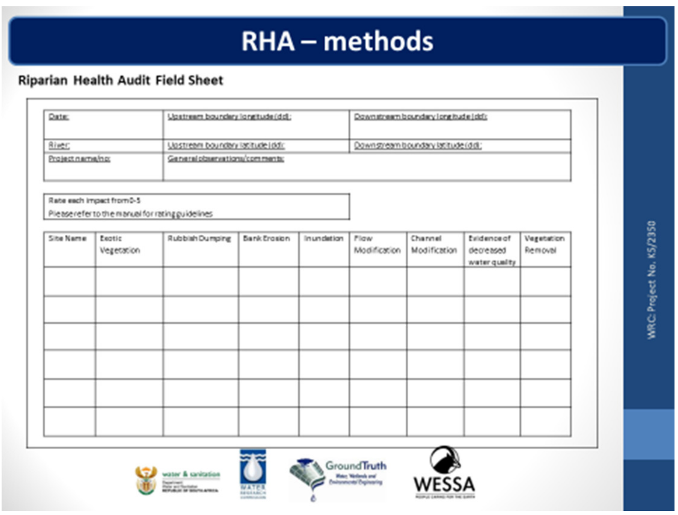

Photographic and illustrative Guide to Impacts
6. Channel modification
WRC: Project No. K5/2350
GroundTruth
WESSA

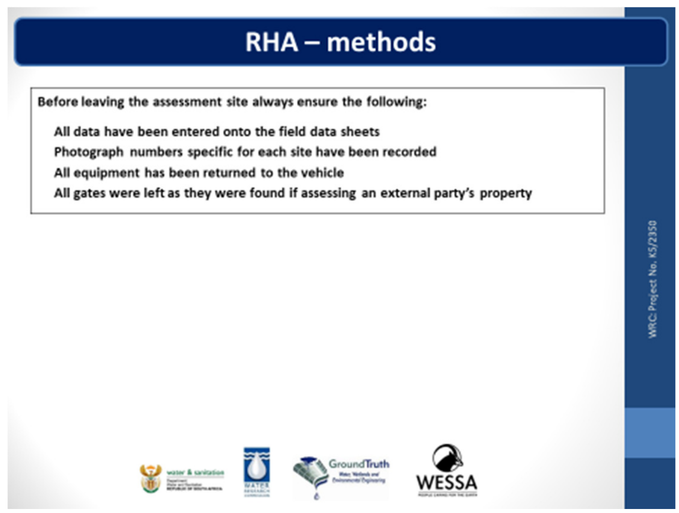

Photographic and illustrative Guide to Impacts
7. Evidence of decreased water quality
Run-off
WRC: Project No. K5/2350
GroundTruth
WESSA

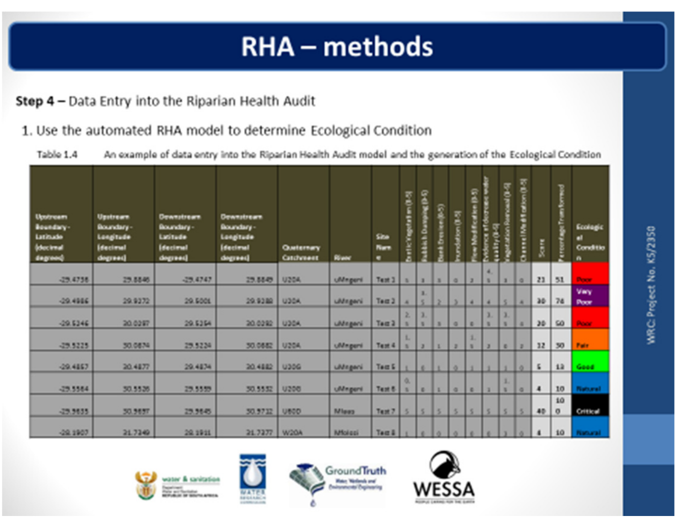


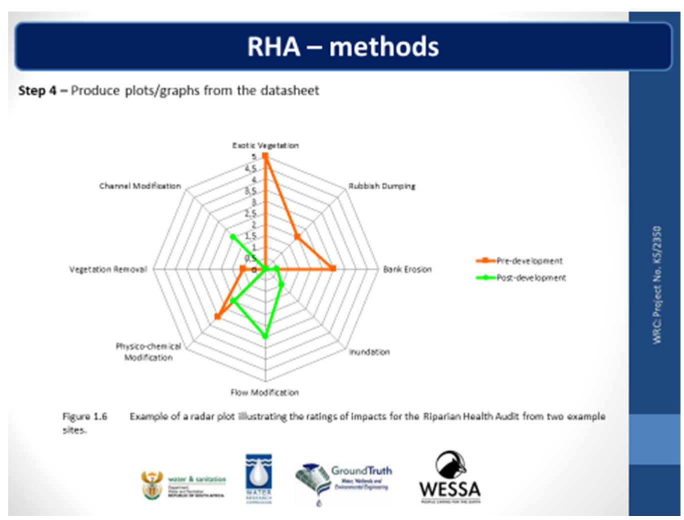


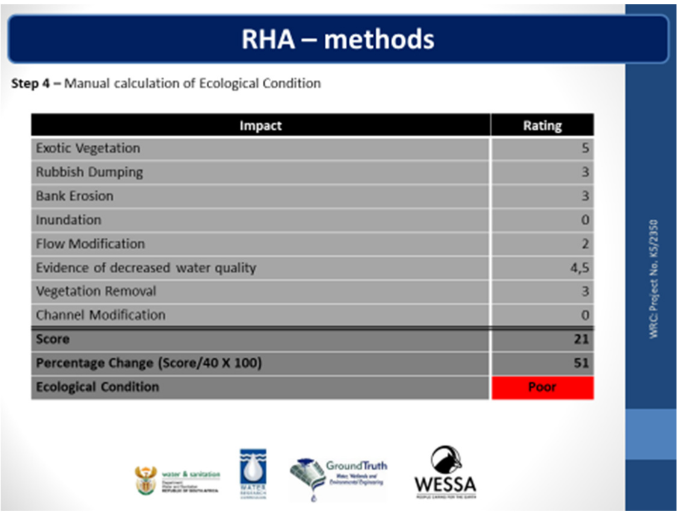
Rating	Percentage Change or Coverage	Description
0	0	No Impact
0.5	1-10	Minor Impact
1	11-20	
1.5	21-30	Moderate impact
2	31-40	
2.5	41-50	Large impact
3	51-60	
3.5	61-70	Serious impact
4	71-80	
4.5	81-90	Critical impact
5	91-100	










RHA – methods

Step 4 – Manual calculation of Ecological Condition

Impact	Rating
Exotic Vegetation	5
Rubbish Dumping	3
Bank Erosion	3
Inundation	0
Flow Modification	2
Evidence of decreased water quality	4,5
Vegetation Removal	3
Channel Modification	0
Score	**21**
Percentage Change (Score/40 X 100)	**51**
Ecological Condition	**Poor**

APPENDIX J: THE CLARITY TUBE

The Water Clarity Tube

This is a product of The Water Research Commission: Project No. K5/2350

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

WESSA
PEOPLE CARING FOR THE EARTH

Contents

List of Figures

Introduction and Background

What is a Clarity Tube?

There are several methods for testing water clarity; some of these methods are very accurate but very costly, often not practical options for projects that require multiple samples and less accuracy.

The clarity tube measures water clarity, which decreases with an increase in turbidity or suspended solids. The Water Clarity Tube can be used in rivers with a range of flow regimes, and can be used in shallow or deep areas, and where there are aquatic plants, making it a practical tool to use in a variety of aquatic environments.

Studies done in California on the use of the clarity tube in water quality measurements, found that the clarity tube measurements showed a strong relationship to turbidity and total suspended solids.

The clarity tube is easy to use. It is inexpensive, robust and easily transported tool. Several studies commend the reliability, ease and rapidity of using the tool. It can be use by farmers, school groups, citizen monitoring groups and local government agencies and more. The South African river health program has been utilising the water clarity tube as a tool for monitoring water clarity in the absence of expensive turbidity meters.

Water clarity tube design

The Water Clarity Tube is made of transparent Perspex. The tube is 100 cm long and has a diameter of 50 mm. A black stopper-cap seals the tube when it is full of water. The tube has a metered scale (in centimetres) on the side of the tube (Figures 1.1 and 1.2).

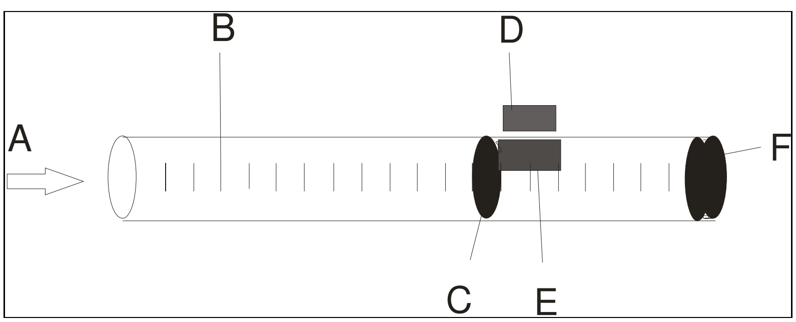


Figure1.1 Diagram of Clarity Tube components. A: Clear base for viewing the disk; B: Metered scale on the side of the tube; C: Black disk; D & E: Magnets for moving disk; and F: Black stopper-cap for sealing the tube

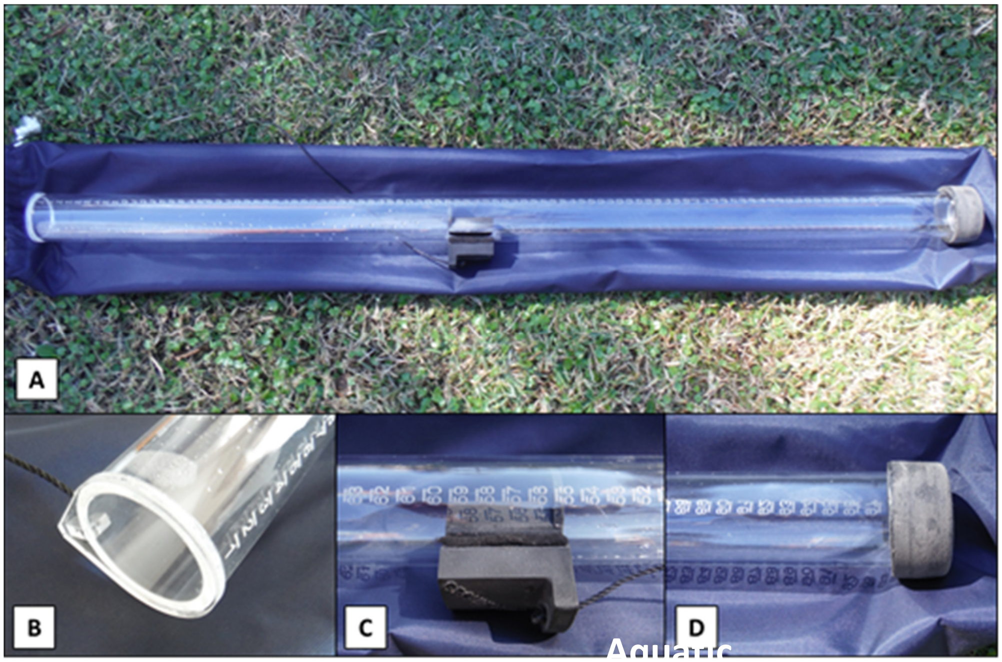


Figure 1.2 Photos of the components of a water clarity tube. A: The full length of the tube, with the protective cover; B: Clear base for viewing the disk; C: Magnets for moving disk; D: Black stopper-cap for sealing the tube

How to use the Clarity Tube

- Decide on a location where you will collect your sample. Make a note of the site, either with a GPS or on a map. Name your site so that you can find the site again in the future.
- The best way to collect a water sample is to place the water clarity tube, with the open end facing upstream. Dip the opening into the water and let the tube fill with water – make sure there are no bubbles!
- If you cannot put the clarity tube into the water, you can collect the water from the river or pond in a bucket. The clarity tube does not need to be placed in the water. The water must then be poured into the 1 m x 50 mm clear tube until it is full (i.e. no bubbles)
- Once the clarity tube is completely full, with no bubbles, seal the clarity tube with the black stopper-cap – make sure it is on completely.

IMPORTANT NOTE: Don't stir up sediment when you are collecting your sample. This will affect your readings!

- The tube is now full of water and you can start to take your water clarity measurement.
- Hold the tube horizontally, with the clear base facing toward you. If there are any bubbles in the tube; tilt the tube slightly so that they gather at the stopper-cap end - this will prevent bubbles from interfering with the reading you will take. Stand with your shoulder perpendicular to the sun, so that when you lift the clarity tube up to your eye, the sun is shining into the tube at 90 degrees.

Figure 2.1 Make sure that the clarity tube is 90^{o} to the sun

- Use the magnets to move the black disk inside the clarity tube to the 1 cm marker. Look through the clear base of the clarity tube and slowly move the black disk (using the magnet system) away from you. Make a note of the centimetre reading where the black disk is no longer visible.
- Now, push the disk all the way to the stopper-cap. Then looking through the clear base, slowly move the disk toward you. Make a note of the centimetre reading where the black disk becomes visible.
- To calculate the Water Clarity, calculate the average of the two readings you obtained and make a note of your reading.

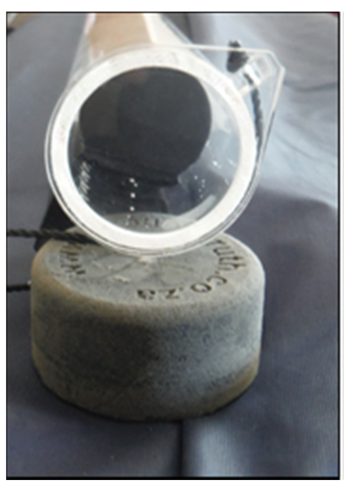


Figure 2.2 The black disk that you will move using the magnets

IMPORTANT NOTE: Readings do not change significantly if you are standing in shade or sun. However, DO NOT TAKE READINGS IN DAPPLED LIGHT; this will influence the reading. Make sure you are either standing in full sun or full shade!

CLARITY TIP: Get someone to help hold the clarity tube if it is too heavy. REMEMBER: do not cast any shadows onto the tube when shifting the black disk – this will affect your readings!

Monitoring protocol

Typically, information is gathered with the once-off collection of data from a particular site, however much more information becomes available with repeated sampling of the same sites. When repeated sampling is done, you can start to see trends (or patterns) developing from the information.

If you want to develop a monitoring protocol, it is important to first figure out what question you are trying to answer. For example, "Is the water flowing out of this wetland clearer than water flowing into the wetland?"

Once you have decided on a question and a site where you will work, decide on a monitoring routine that you will follow. Consider items such as season (rainy or dry), access to the site when you need it, landowner permission, and so on.

Routine monitoring should be conducted at a constant time interval on a designated day (e.g. the first Monday of the month). For all monitoring, make notes on the condition of the site, and if anything has changed since the previous data collection period. Remember to take measurements when there are significant environmental events, such as heavy rainfall, spills or other disturbances. Additionally, for event-driven measurements, make notes on what the event was and the duration for which it continued (e.g. 140 mm rainfall over 16hrs prior to sampling).

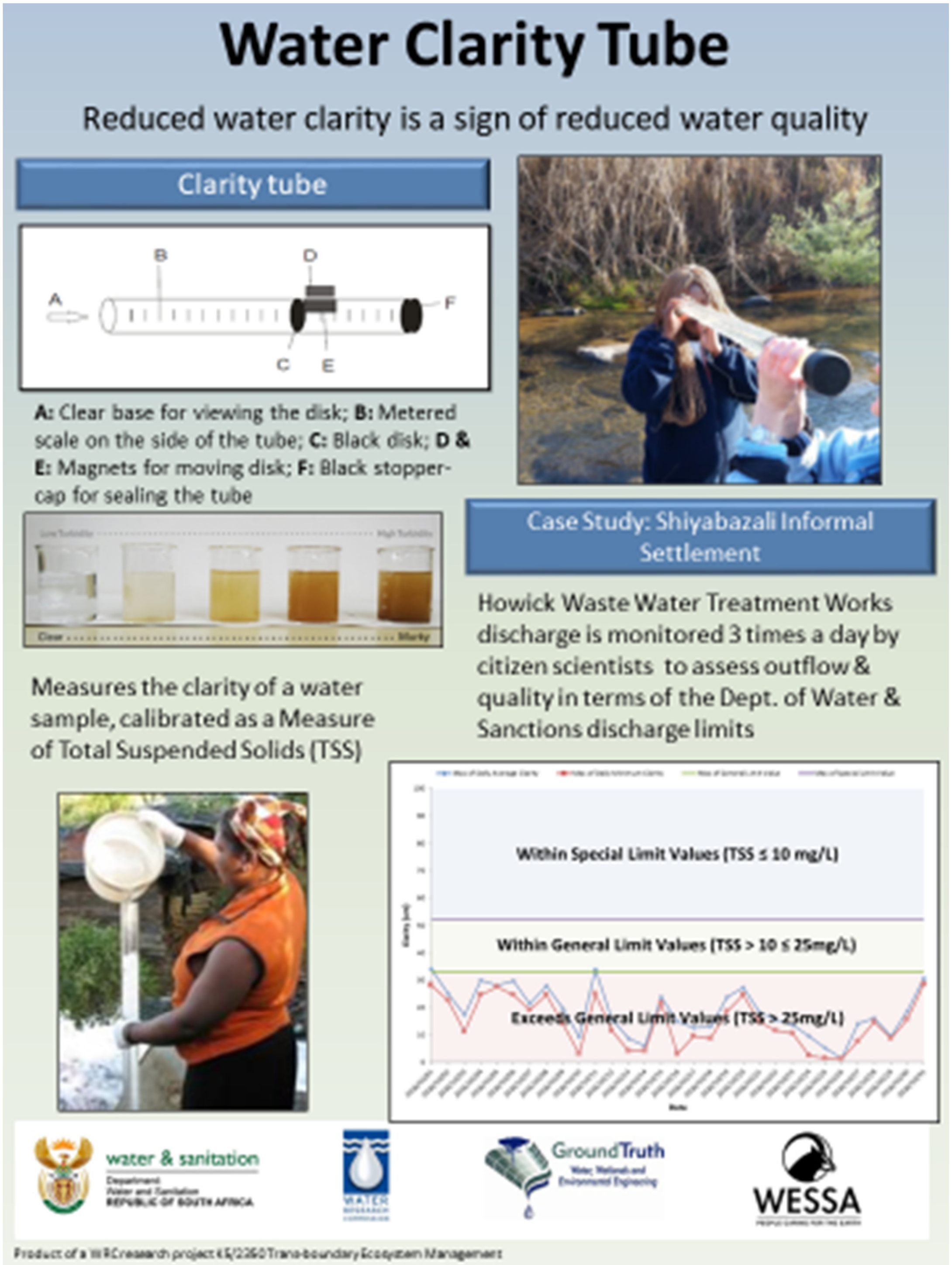
Care and maintenance

- To ensure sediment or debris do not contaminate samples from different sites, pour clean tap water into the clarity tube and use an elongated bottlebrush to scrub the sides of the clarity tube clean after each use. Residue from different water bodies may affect the water clarity readings. This is especially important if you are sampling multiple water bodies on the same day.
- If the clarity tube is going to be stored for more than a few days, place it upside down with the black stopper-cap off to allow the tube to dry before storage.
- Do not store in a warm, dark place if there is any moisture in the tube as this will cause algae to grow inside the tube interfering with future readings. If algae do begin to grow in the tube, mix 5 ml of bleach into 1 L of water and wash out the tube.
- Do not place the viewing disk on the ground; as this will scratch the disk and affect the water clarity reading.

Acknowledgements

Funding of the development of this tool by Water Research Commission research project K5/2350 is gratefully acknowledged.

Poster


Water Clarity Tube
Reduced water clarity is a sign of reduced water quality
Clarity tube
A
B
C
D
E
F
A: Clear base for viewing the disk; B: Metered scale on the side of the tube; C: Black disk; D & E: Magnets for moving disk; F: Black stopper-cap for sealing the tube
Measures the clarity of a water sample, calibrated as a Measure of Total Suspended Solids (TSS)
Case Study: Shiyabazali Informal Settlement
Howick Waste Water Treatment Works discharge is monitored 3 times a day by citizen scientists to assess outflow & quality in terms of the Dept. of Water & Sanctions discharge limits
Within Special Limit Values (TSS ≤ 10 mg/L)
Within General Limit Values (TSS > 10 ≤ 25mg/L)
Exceeds General Limit Values (TSS > 25mg/L)
water & sanitation
GroundTruth
WESSA

PowerPoint Presentation

The Water Clarity Tube

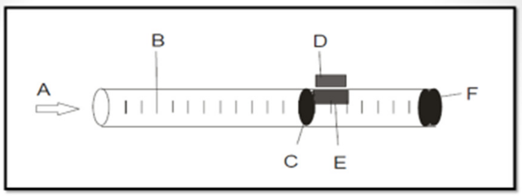
This is a product of The Water Research Commission: Project No. K5/2350

WRC Project No. K5/2350

What is a water clarity tube?

- It is a simple citizen science tool used to measure the clarity of water .
- Clarity gives information about water quality. Typically if there are lots of dissolved solids or suspended particles, the clarity is reduced.
- Reduced water clarity is a sign of reduced water quality.
- The tool can also be calibrated to assess discharge from Waste Water Treatment Works.

WRC Project No. K5/2350



A: Clear base for viewing the disc

B: Metered scale in cm on the side of the tube

C: Black disc - it moves inside the tube to indicate clarity

D: Magnet for moving the disc

E: Second magnet for moving the disc

F: Black stopper-cap for sealing the tube

WRC Project No. K5/2350

How do we use the clarity tube?

- Place the clarity tube into the water, with the open end facing upstream. Let the tube fill with water – make sure there are no bubbles in the clarity tube!
- If you can't put the clarity tube into the water, you can collect the water from the river or pond in a bucket. Once collected, pour the water into the clarity tube until it is full. **DO NOT** put the clear disk on the ground – it could scratch and affect the readings
- Once the clarity tube is full, seal it with the black stopper-cap. You are now ready to take your readings!

IMPORTANT: Make sure you don't stir up sediment when you are collecting your sample. This will affect your readings!

WRC Project No. K5/2350

- Hold the tube horizontally, clear base facing toward you. If there are bubbles in the tube tilt the tube slightly so that they gather at the stopper-cap end to prevent bubbles from affecting your reading.
- Use the magnets to move the black disk in the tube to the 1cm marker.
- Stand with your shoulder perpendicular to the sun, so that when you lift the clarity tube up to your eye, the sun is shining into the tube at 90°.

WRC Project No. K5/2350

- While looking through the clear base of the tube, slowly move the black disk away from yourself until you can't see it – stop moving the disc at this point and make a note of the centimetre reading on the side of the tube.
- Now, push the disk to the stopper-cap. Looking through the clear base, move the disk toward you. When the black disk becomes visible, stop moving it and make a note of the centimetre reading.
- The two readings should be quite similar, if not, retake the measurements.

TIP! Get someone to help move the black disk. Make sure the magnet is underneath the clarity tube & does not shadow the tube!

WRC Project No. K5/2350

So, what is the water clarity?

- You now have two readings for the sample. One when moving the disk away from you, and another moving the disk toward you.
- To calculate Water Clarity we need to determine the average for the two readings
- Add the two centimetre readings together and divide the sum by 2. This will give you the average – which is the Water Clarity for that sample. Make a note of the final Water Clarity.

WELL DONE! You have collected your first Water Clarity Reading!

WRC Project No. K5/2350

Care & Maintenance

- Ensure sediment or debris from different sites do not contaminate samples – clean The Clarity Tube properly between different sites.
- Pour clean tap water into the clarity tube and use an elongated bottlebrush to scrub the insides of the clarity tube.
- Clean the clarity tube between sampling at different water bodies, because residue may affect the water clarity readings (especially important if sampling different water bodies on the same day).

WRC Project No. K5/2350

Care & Maintenance Cont.

- If the clarity tube is going to be stored for more than a few days allow the tube to dry completely before storage.
- To store, place the tube upside down with the black stopper-cap off.
- Do not store in a warm, dark place, especially if there is any moisture in the tube, this will cause algae to grow inside the tube and this will interfere with future readings.
- If algae does begin to grow in the tube, mix 5ml of bleach into 1L of water and wash out the tube.
- Always store and transport the clarity tube in the supplied case or other protective covering to prevent scratching the tube. Scratches will impact on the readings.

WRC Project No. K5/2350

Where & when should the Water Clarity Tube be used?

- The Water Clarity Tube can be used in a variety of aquatic environments (rivers, ponds, wetlands etc.)
- The Clarity Tube can be used in sun or shade. When you are working on a particular site, always take measurements in the same way – either all in sun or all in shade.
- Do not take measurements in dappled light (mix of shade & sun).
- When collecting data, make a note of your location, either with a GPS or on a map, so that you can find the site again.
- Make a note of the weather conditions on the day – was it raining, sunny, misty etc.

WRC Project No. K5/2350

Develop a Monitoring Protocol

- When you collect data over time and space, the information gathered can be very powerful. One can see patterns developing and emerging from the information
- Do you have an interesting question that you want answered? For example: "***Is the wetland water outflow cleaner than the water inflow?***"
- If you have a question & site where you can collect data, decide on a monitoring routine to follow.
- Consider variables such as:
  - Season (rainy/high flow or dry/low flow)
  - Access to site
  - Landowner permission

WRC Project No. K5/2350

Standardizing Data Collection

- Routine monitoring should be done at least once a month on a designated day (e.g. the first Monday of the month).
- For all monitoring, make notes on the condition of the site, and if anything has changed since the previous data collection period.
- Remember to take extra measurements when there are significant events impacting on the study site, such as heavy rainfall, spills or other disturbances.
- For event-driven measurements, make additional notes on what the event was and the duration for which it continued (e.g. 140mm rainfall over 16hrs prior to sampling).

WRC Project No. K5/2350

Why is Standardizing Data Important?

In nature there is a lot of variation. We want to collect & compare data, but we don't want the natural variation of the system to influence our results. We also want to give others the opportunity to carry out the same process in a different place, so that their results can be compared with ours. For this to be possible, the data must be collected in exactly the same way, so that there is no chance that the data collection method influences the results, and that natural variation in the system is accounted for.

Making detailed notes about what you did is one way to make sure that others can do what you did (replicate) in the field

Always collect your data in exactly the same way every time you collect it. This is known as making your data collection repeatable.

THE END

APPENDIX K: THE TRANSPARENT VELOCITY HEAD ROD (TVHR)

The Transparent Velocity Head Rod

This is a product of The Water Research Commission: Project No. K5/2350

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WATER
RESEARCH
COMMISSION

GroundTruth
Water, Wetlands and
Environmental Engineering

WESSA
PEOPLE CARING FOR THE EARTH

Contents

List of Figures

List of Tables

Introduction and Background

What is Stream Flow and Why is it Important?

Stream velocity is the speed at which water in a stream is moving. Stream velocity is not consistent across a stream; it is generally fastest in the mid-channel and near the surface of the water. Stream velocity is slowest along the stream bed and along the banks. Stream velocity is usually measured in meters per second (m/s), which is similar to how we measure the speed a car is traveling at, which uses kilometres per hour (km/h). Note that these measurements are recorded in distance and time.

Discharge is the volume of water that moves past a given point in the stream in a given time. This means it is all the water that is transported over a particular width of stream in a specified amount of time. Note that where velocity is measured using distance and time (speed), discharge is measured as volume and time, usually in cubic meters per second (m^3/s).

How water flows (that is, how much water hand how fast it moves) is an important component of how streams work and flow affects many aspects of a stream, including the temperature of the water, how much oxygen is dissolved into the water and the concentration of various substances in the water. The flow will also impact what types of habitats and organisms would occur in various places throughout the stream. Low flow periods in summer allow the stream to heat up rapidly in warm weather, while in the autumn and winter stream temperatures may drop. Dissolved oxygen in the water is also very important in determining what organisms can live in the stream. If there is little oxygen, organisms that need high oxygen levels won't be found. High volumes of fast moving, churning water, especially "white water" created by rapids, riffles and falls, increases the amount of oxygen that becomes dissolved in the water. Additionally, the faster a stream flows the more debris and sediment it can transport. This debris and sediment settle-out in still or slow-flowing water.

Stream flow, acting together with slope and geology, determines the types of habitats present (pools, riffles, cascades, etc.), the shape of the channel, and the composition of the stream bottom. All these elements impact on the types of habitats available for organisms living in streams (http://www.waterontheweb.org accessed July 2017).

What is the Transparent Velocity Head Rod

The Transparent Velocity Head Rod (TVHR), or for short, the Velocity Plank is a very simple tool that allows us to measure the velocity of a stream. It was created in the 1940's (Wilm and Storey, 1944), and was originally made out of wood but it has since been modified to be transparent and lighter. The velocity plank is a simple construction of transparent plastic allowing for simultaneous measurement of upstream super elevated water level and the depressed downstream water level created when the rod is placed into flowing water. The difference between these water height measurements can be used to predict the depth-averaged flow velocity. The velocity plank is solid, lightweight, and simple enough to allow velocity measurements to be made effectively on site. It has a good accuracy; it is typically precise to within 5%.

Through the Water Research Commission project K5/2350 a South African citizen science TVHR was developed. This TVHR is made from PVC. It is 1.1 meters high and 10 cm wide, the thickness is 7 mm with a reinforcement bar at the back. The top of the tool has a handle to hold whilst taking measurements. A lanyard has been attached to the handle to prevent the user from losing the TVHR in the river.

Where to use it

- In any stream with a depth between 5 cm and 90 cm.
- In marked-off reaches of the chosen stream with a distance of 5 to 30 metres, depending on how fast the stream water is moving.
- At any point of the river where the stream bed is uniform and there are no large boulders.
- At any point in the river where water is less turbulent and the flow does not change rapidly.
- If possible, the TVHR should be used in a site located near a gauging station.

How to use the Transparent Velocity Head Rod to measure stream velocity

- Place the safety loop on one of your wrists.
- Place the TVHR perpendicularly to the stream flow and perpendicular to the water's surface, even in the case of a sloping streambed (Figure 2.1).
- Do not stand in front of the velocity plank, as this will alter stream flow, which will impact on the readings you take.

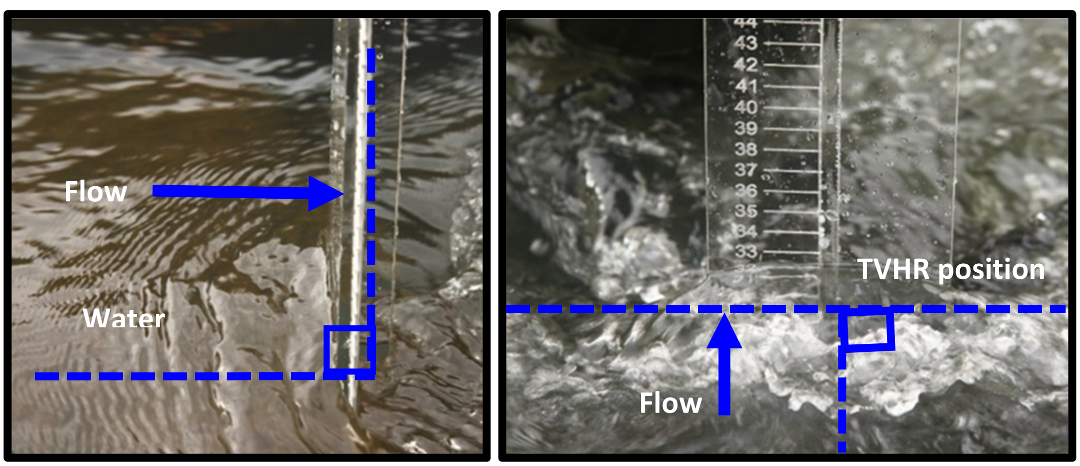


Figure 0.1 Measuring flow with the TVHR

- Get your head down, as close to the water surface as possible (Figure 2.2). Your head must be no more than 10 to 20 cm from the water level to provide eye level view of the values you want to read.

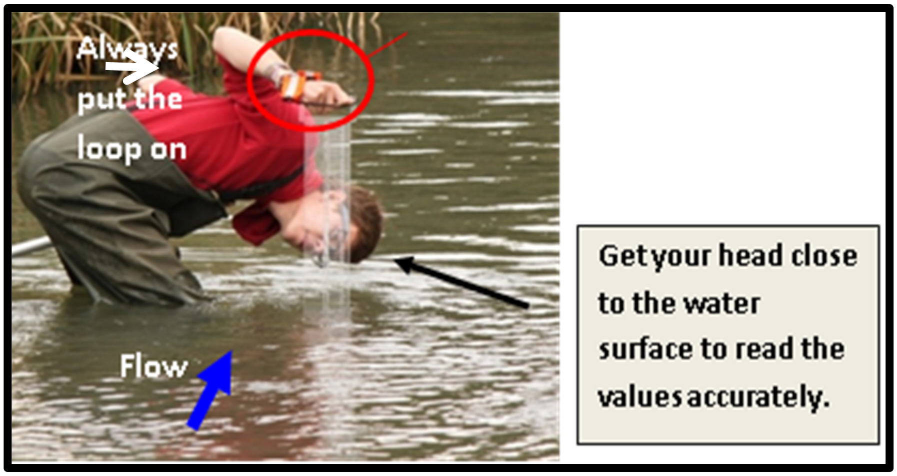


Figure 0.2 Observing maximum height of water on the TVHR

- Observe the maximum height reached by the water on the TVHR for 20 seconds. The highest point that the water reaches at least twice is recorded as the maximum height. Observe the lower point for 15 seconds.

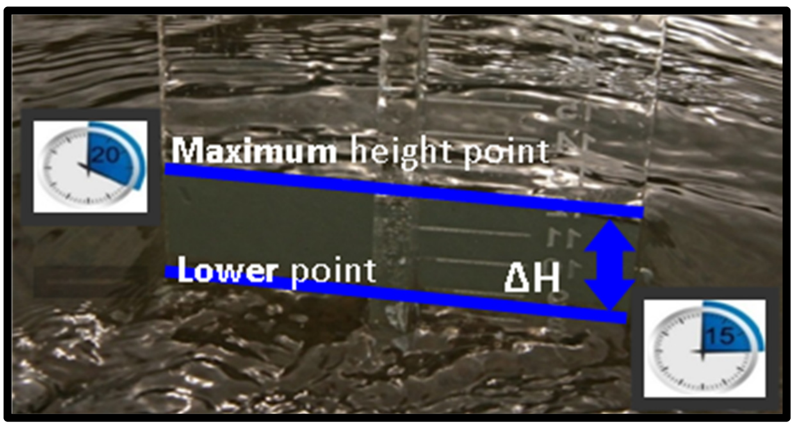


Figure 0.3 Detailed image observing maximum height of water on the TVHR

- The difference in height between the maximum point and the minimum point is called change in height (ΔH) and is measured in cm.
- Write down the ΔH.
- Find ΔH on the table of velocities and determine the corresponding velocity for that ΔH.
- At each measurement point in the stream, take two or three velocity measurements. Determine an average of those velocities to give the final velocity for the measuring point chosen.

How to use stream flow velocity to measure discharge

Measuring the width and depth of the stream

To measure discharge, you need to measure your stream velocity and multiply it by the area of your cross section. So, now you might be asking "what is a cross section?" Well, imagine a loop of piping, with no openings. Now, imagine we want to see what is happening inside that pipe. We would have to cut through the pipe to see what is inside. When we cut the pipe, we are making a "cross section". Now, imagine the stream you are interested in as the pipe – and that we want to see what is happening inside that stream, to calculate the discharge (see figure 3.1 and Figure 3.5, below).

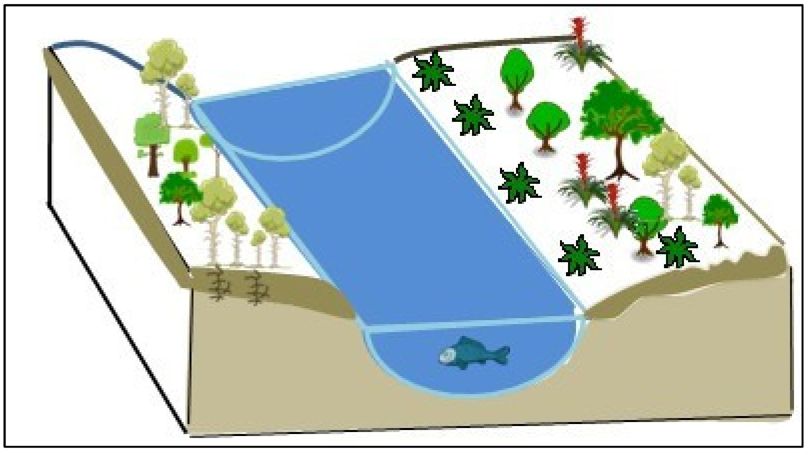


Figure 0.4 Diagram showing the cross section of a stream.

To get the area, the width and depth of the channel must be known. Measuring the width and depth are additional steps in the velocity plan measurement process.

- Use a measuring tape to determine the width of the stream.
- Measure the depth of the stream at each 50 cm along the cross section of the river using the TVHR for velocity. If the stream's width is more than 10 m take measurements at each meter.
- To measure stream depth, the TVHR, originally held perpendicularly to flow when measuring velocity, needs to be rotated 90 degrees in a clockwise direction to be parallel to the flow. If there is a rock/stone on the streambed preventing the TVHR from sitting flat on the streambed, move the TVHR to directly next to the stone and measure depth at this point.

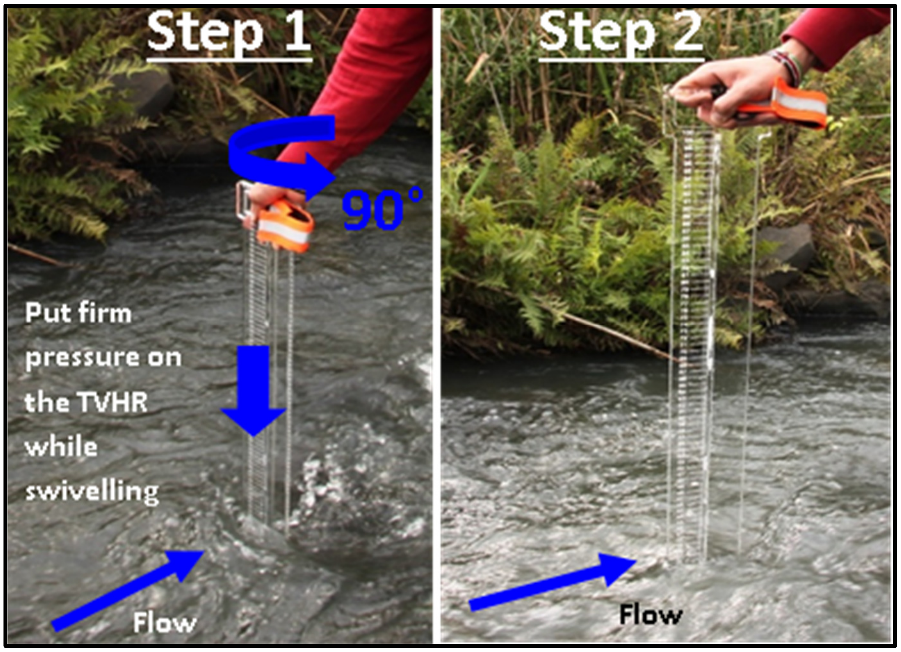


Figure 0.5 Measuring steam depth with the TVHR

- Hold the TVHR perpendicular to flow to measure depth. During this step, the TVHR needs to be pushed firmly against the stream bed to prevent any slipping.

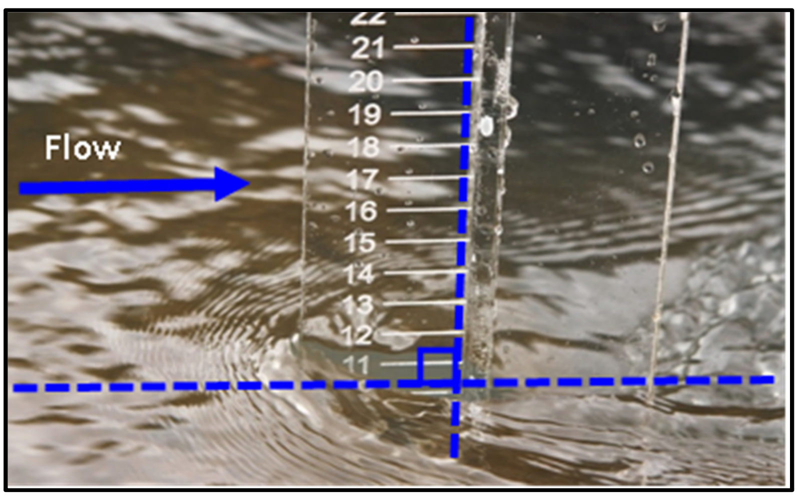


Figure 0.6 Measuring steam depth with the TVHR

- Record this as the depth at that point of measurement.
- Using the depth measured, you will now determine the area of the cross section and this is done as follows:

Calculating the area of the subsection

To determine the area of each subsection, you will use the formula used to determine the area of a trapezoid. The trapezoid shape is used to estimate the shape of each subsection in the cross section.

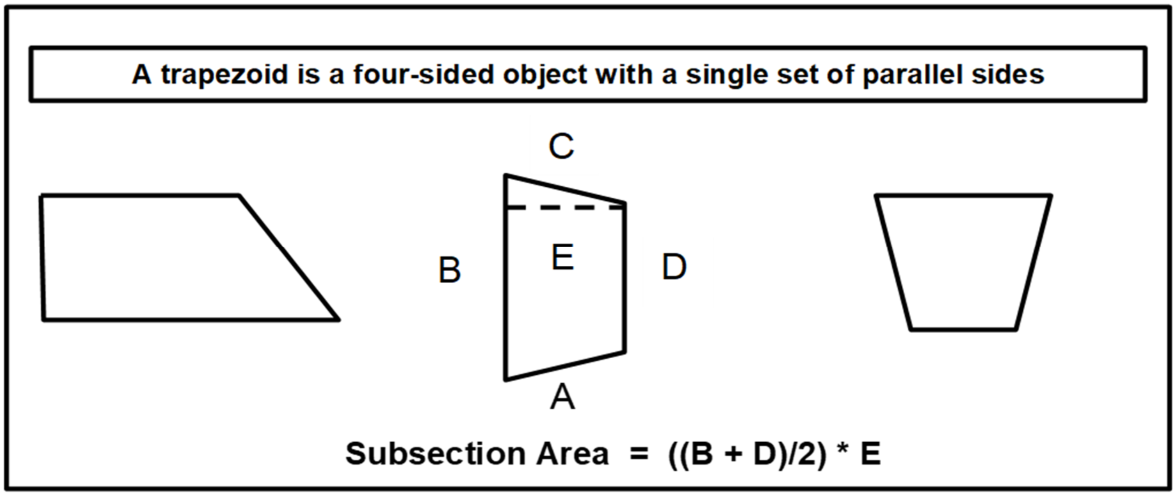
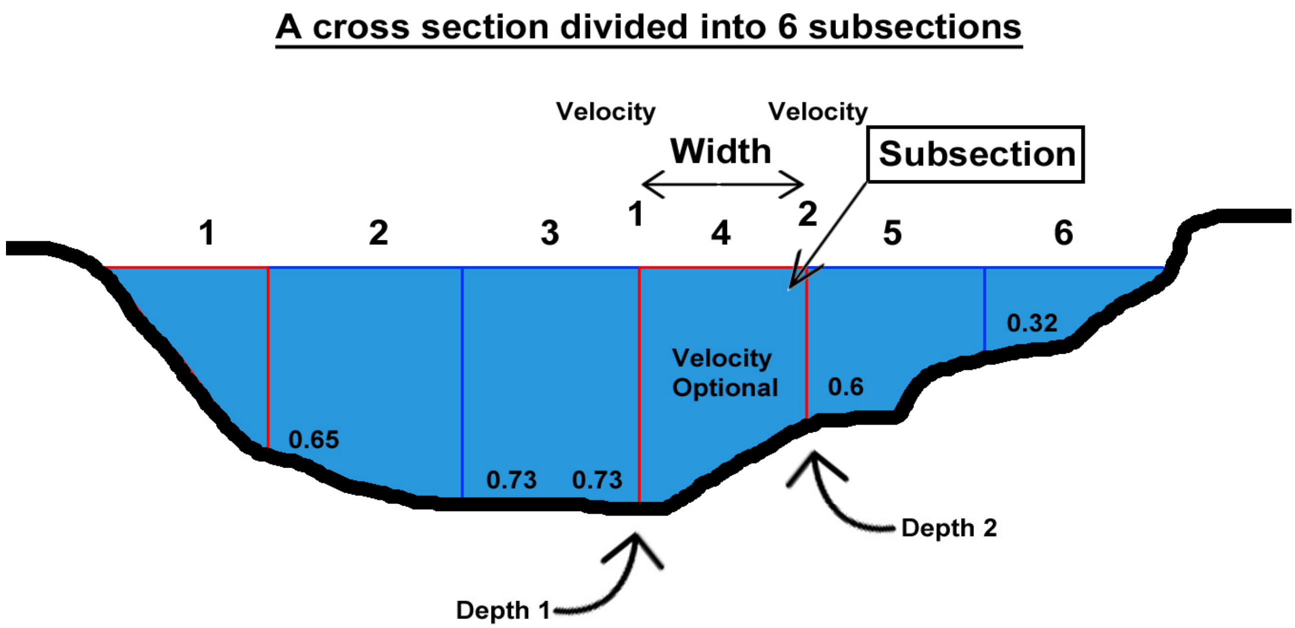


Figure 0.7 Determining the area of a subsection

- According to the trapezoid forumula the depths are represented by B and D, and the width is represented by the E in the trapezoid box above (Figure 3.4). To obtain the area of the subsections, the depths are added and divided by two then multiplied by the width of the subsection. The diagram below shows the summary of the formulas used and how the trapezoid shape (outlined in red) is used in a river cross section.



Discharge:

$$Q = \sum A_{subsection} \times V_{subsection} \Leftrightarrow Q = (A_1 \times V_1) + (A_2 \times V_2) + \cdots + (A_6 \times V_6)$$

$With\ A_1 = \left(\frac{depth_1 + depth_2}{2}\right) \times\ width\ \ and\ \ V_1 = \left(\frac{v_1 + v_2}{2}\right)$; In the case where three velocity measures were made to increase the accuracy, $V_1 = \left(\frac{v_1 + v_{2+} V_{optional}}{3}\right)$;

Figure 0.8 Summary of formulas used

- The subsections are marked from 1-6 on the above diagram, to obtain the total discharge of the entire cross section, you need to sum up the discharges of all the subsections (1-6). The number of subsections varies between cross sections.
- To obtain the discharge of the subsection write down the ΔH and record the velocity of each subsection using the table of velocities provided on the following page (Table 3.1). This is then multiplied by the area obtained for the subsection. The outcome value is the discharge.
- A third velocity measurement can be added by measuring the velocity in the middle of each subsection, these measurements can then be averaged to increase the accuracy of the velocity measurement.

Table 0.1 **The stream velocities in relation to the changes in height of the water level (ΔH) for ΔH values of 0.5 to 25 cm.**

ΔH (cm)	Velocity (m/s)	ΔH (cm)	Velocity (m/s)	ΔH (cm)	Velocity (m/s)	ΔH (cm)	Velocity (m/s)	ΔH (cm)	Velocity (m/s)
0.5	0.12	5.5	0.80	10.5	1.17	15.5	1.45	20.5	1.70
1.0	0.24	6.0	0.84	11.0	1.20	16.0	1.48	21.0	1.72
1.5	0.33	6.5	0.88	11.5	1.23	16.5	1.50	21.5	1.74
2.0	0.41	7.0	0.92	12.0	1.26	17.0	1.53	22.0	1.76
2.5	0.48	7.5	0.96	12.5	1.29	17.5	1.55	22.5	1.79
3.0	0.54	8.0	1.00	13.0	1.32	18.0	1.58	23.0	1.81
3.5	0.60	8.5	1.03	13.5	1.34	18.5	1.60	23.5	1.83
4.0	0.65	9.0	1.07	14.0	1.37	19.0	1.63	24.0	1.85
4.5	0.70	9.5	1.10	14.5	1.40	19.5	1.65	24.5	1.87
5.0	0.75	10.0	1.13	15.0	1.43	20.0	1.67	25.0	1.89

Acknowledgements

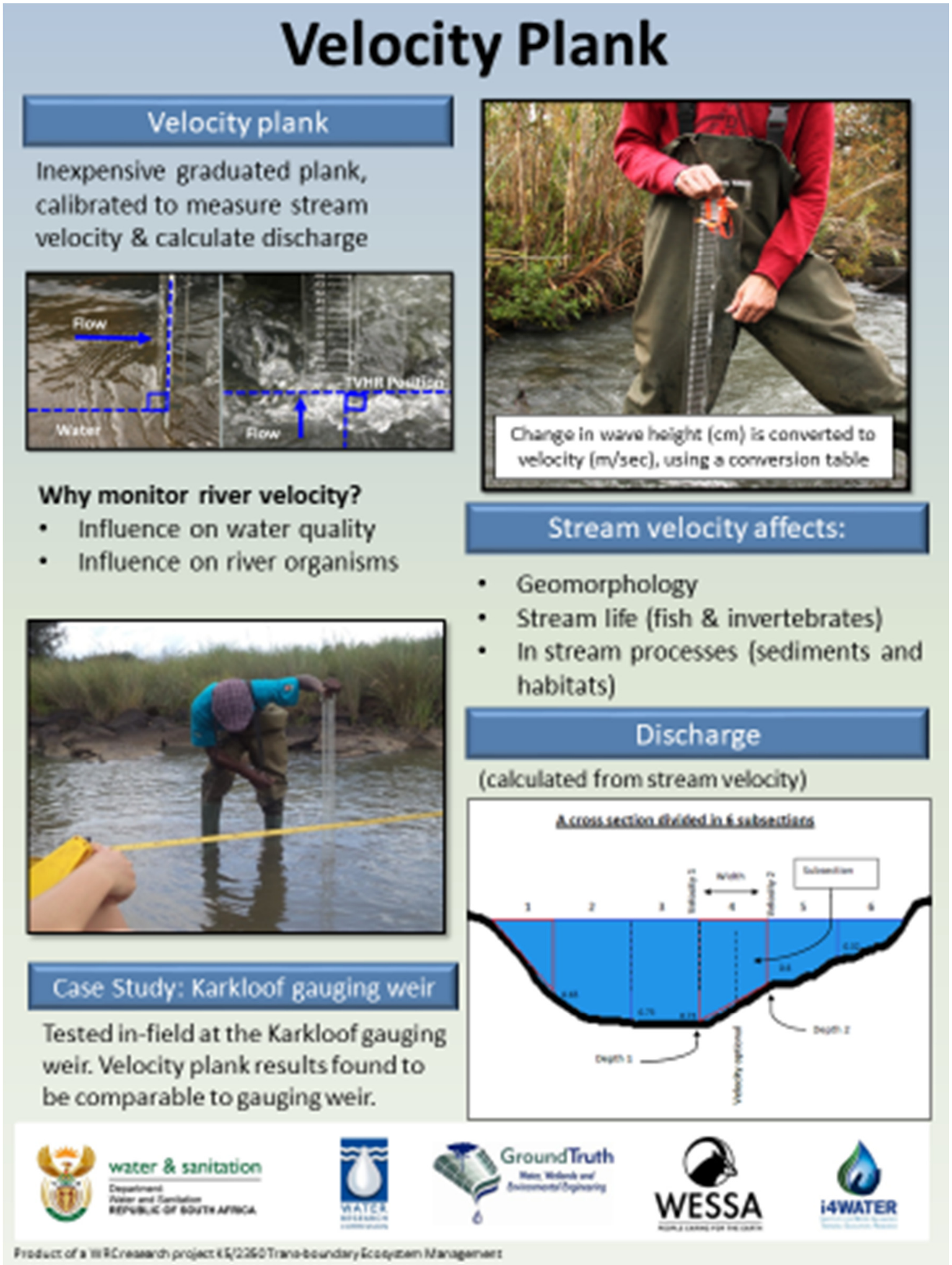
Funding from the Water Research Commission research project K5/2350 made the development of this citizen science tool possible.

References

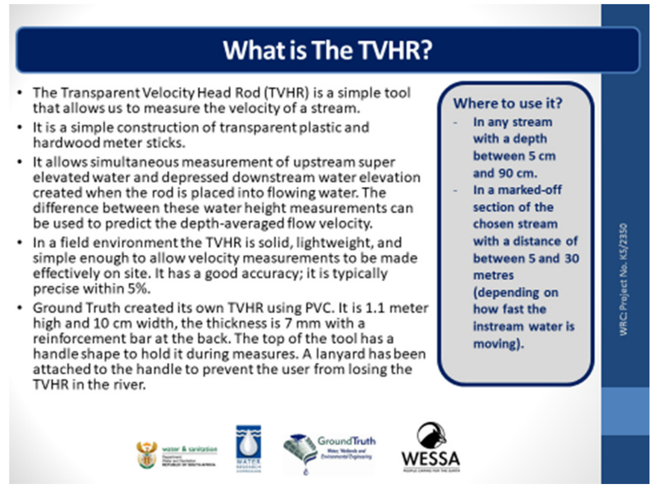
Wilm, H. G. & H. C. Storey, 1944. Velocity head rod calibrated for measuring stream flow. Civil Eng. (USA) 14: 475–476.

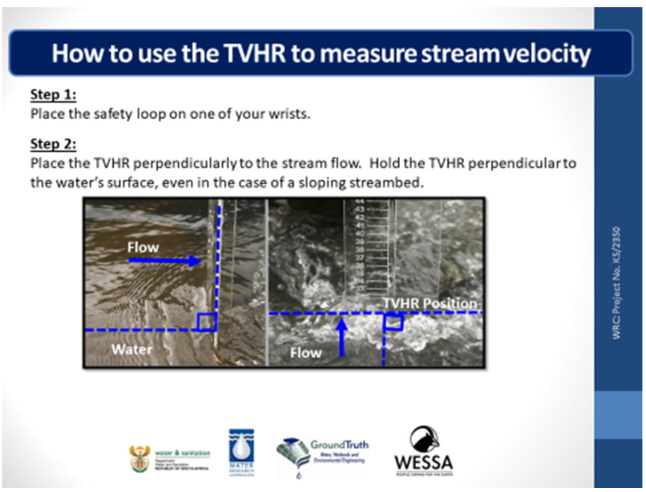
WOW. 2004. Water on the Web - Monitoring Minnesota Lakes on the Internet and Training Water Science Technicians for the Future - A National On-line Curriculum using Advanced Technologies and Real-Time Data. (www.waterontheweb.org). University of Minnesota-Duluth, Duluth, MN 55812.

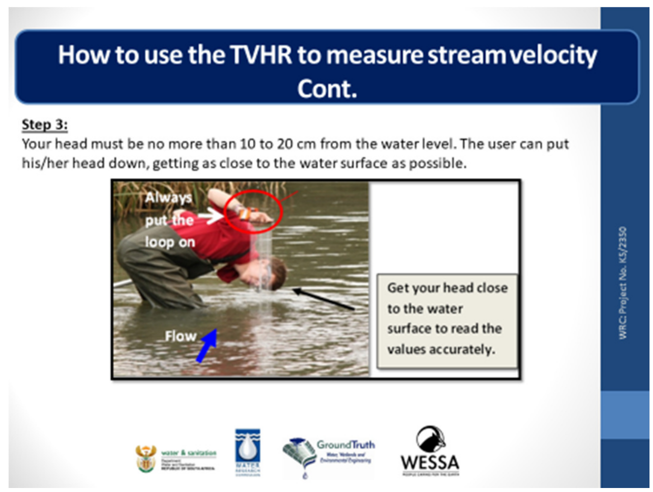
Poster

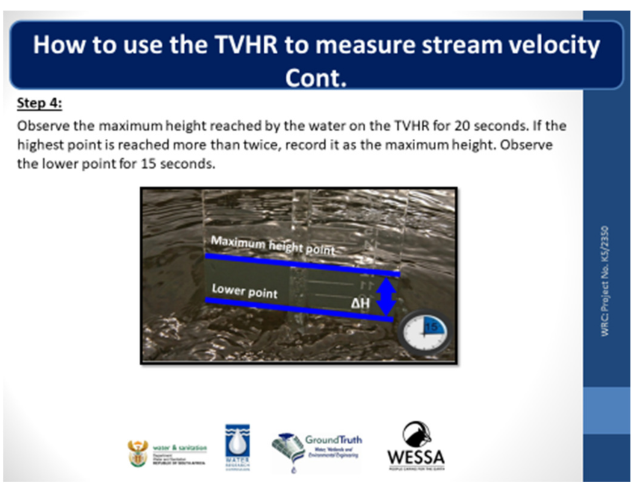

Velocity Plank
Velocity plank
Inexpensive graduated plank, calibrated to measure stream velocity & calculate discharge
Flow
TVHR Position
Water
Flow
Change in wave height (cm) is converted to velocity (m/sec), using a conversion table
Why monitor river velocity?
• Influence on water quality
• Influence on river organisms
Stream velocity affects:
• Geomorphology
• Stream life (fish & invertebrates)
• In stream processes (sediments and habitats)
Discharge
(calculated from stream velocity)
A cross section divided in 6 subsections
1 2 3 4 5 6
Case Study: Karkloof gauging weir
Tested in-field at the Karkloof gauging weir. Velocity plank results found to be comparable to gauging weir.
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA
GroundTruth
WESSA
i4WATER
Product of a WRC research project K5/2350 Trans-boundary Ecosystem Management

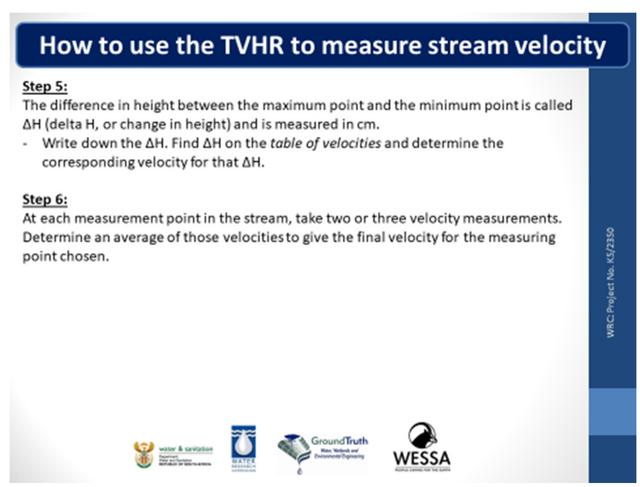
PowerPoint Presentation











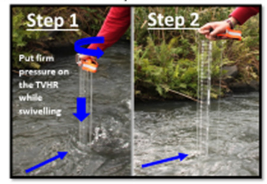
How to use stream flow velocity to measure discharge

To measure discharge, you need to measure your stream velocity and multiply it by the area of your cross section. To get the area, the depth of the channel must be known. Measuring the depth adds a step in the TVHR measurements.

Step 1:
Use a measuring tape to determine the width of the stream. Measure the depth of the stream at each 50 cm along the cross section of the river using the TVHR for velocity. If the stream's width is more than 10m take measurements at each meter.

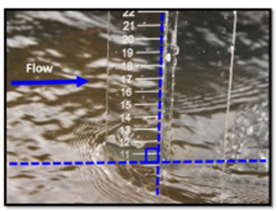
How to use stream flow velocity to measure discharge cont.

Step 2:
To measure stream depth, the TVHR, originally perpendicularly to flow when measuring velocity, needs to be rotated 90 degrees in a clockwise direction to be parallel to the flow. If there is a rock/stone on the streambed prevenient the TVHR from sitting flat on the streambed, move the TVHR to directly next to the stone and measure depth there.



How to use stream flow velocity to measure discharge cont.

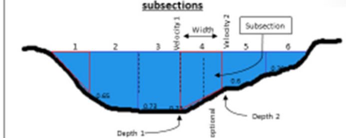
Step 3:
Hold the TVHR perpendicular to flow to measure depth. During this step, the TVHR needs to be pushed firmly against the stream bed to prevent any slipping.



How to use stream flow velocity to measure discharge cont.

Step 4:
Write down the ΔH and report the value to the *table of velocities* to know the velocity associated. Write down the depths along the cross section. Calculate the discharge by summing the area of each subsection multiplied by its average velocity. To get a better average velocity, the velocity can be measured in the middle of each subsection.

A cross section divided in 6 subsections



Discharge:

$$Q = \sum A_{subsection} \times V_{subsection} \Leftrightarrow Q = (A_1 \times V_1) + (A_2 \times V_2) + \cdots + (A_6 \times V_6)$$

With $A_1 = \left(\frac{depth_1 + depth_2}{2}\right) \times width$ and $V_1 = \left(\frac{v_1 + v_2}{2}\right)$; in the case where three velocity measures were made to increase the accuracy, $V_1 = \left(\frac{v_1 + v_2 + V_{optional}}{3}\right)$;

How to use stream flow velocity to measure discharge cont.

Step 6:
Calculate discharge by summing the area of each subsection multiplied by its average velocity. To get a better average velocity, the velocity can be measure in the middle of each subsection.

The Table of Velocities

Table of velocities

ΔH (cm)	Velocity (m/s)	ΔH (cm)	Velocity (m/s)	ΔH (cm)	Velocity (m/s)	ΔH (cm)	Velocity (m/s)	ΔH (cm)	Velocity (m/s)
0.5	0.12	5.5	0.80	10.5	1.17	15.5	1.45	20.5	1.70
1.0	0.24	6.0	0.84	11.0	1.20	16.0	1.48	21.0	1.72
1.5	0.33	6.5	0.88	11.5	1.23	16.5	1.50	21.5	1.74
2.0	0.41	7.0	0.92	12.0	1.26	17.0	1.53	22.0	1.76
2.5	0.48	7.5	0.96	12.5	1.29	17.5	1.55	22.5	1.79
3.0	0.54	8.0	1.00	13.0	1.32	18.0	1.58	23.0	1.81
3.5	0.60	8.5	1.03	13.5	1.34	18.5	1.60	23.5	1.83
4.0	0.65	9.0	1.07	14.0	1.37	19.0	1.63	24.0	1.85
4.5	0.70	9.5	1.10	14.5	1.40	19.5	1.65	24.5	1.87
5.0	0.75	10.0	1.13	15.0	1.43	20.0	1.67	25.0	1.89

A method to assess wetland ecological condition based on land-cover type

Part 2: Technical background

Donovan C. Kotze

A simple Citizen Science tool to assess the ecological condition of a wetland
Version 1.3, May 2016

This is a product of The Water Research Commission: Project No. K5/2350

Executive summary

A wide variety of different land-cover types occur within wetlands and their upslope catchments, e.g. commercial annual crops or open water of dams, and each land-cover type tends to have associated with it particular ecological impacts. For example, commercial annual crops involve the complete clearance of the indigenous vegetation, application of fertilizers, etc. If this land-cover was in the wetland then these impacts could considerably diminish the ecological condition of the wetland, depending on its extent in the wetland. If located in the wetland's upslope catchment, the impacts would be less direct, e.g. the vegetation in the wetland would not be directly removed, but the quality, quantity and seasonal pattern of water inflows to the wetland could potentially be significantly affected even if the land-cover was located some distance upstream, but again dependent on extent. Therefore, by rapidly identifying which land-cover types occur in a wetland and its catchment and how extensive these land-cover types are, inferences can be drawn about the magnitude of impact on the ecological condition of the wetland. This is the rationale underlying the method given in this report, which is being developed with funding from WWF and the Water Research Commission.

The scoring system of the method is based on that applied by WET-Health, which is a tool developed for assessing the ecological condition of South African wetlands. This involves estimating the spatial extent of individual land-cover types (each expressed as a proportion of the wetland and then of its upslope catchment). Proportional extent is then multiplied by the intensity of impact of each individual land-cover type, which ranges from 0 (no impact or deviation from natural) to 10 (critical impact or complete transformation from natural) to give a magnitude of impact score. The impact magnitude scores for all of the individual land-cover types present in the wetland are added together to derive a total ecological impact score for all land-covers in the wetland. In a similar way, a total ecological impact score for all land-covers in the wetland's upslope catchment is derived, accounting for the moderating effect that a buffer zone of natural vegetation around the wetland is likely to have, depending on its extent. Finally, the total score for impacts of land-covers in the wetland is combined with the total score for land-covers in the wetland's upslope catchment to arrive at an overall impact score for the wetland, which also ranges from 0 to 10.

The method builds on the approach of the WET-Health level 1 vegetation component, where default intensity scores have been assigned to each of a range of disturbance (land-cover) types. This approach is extended to the hydrology, geomorphology and water quality components to align them more closely with the vegetation component. The operator of the method is presented with a comprehensive list of land-cover types, to which typical impact intensity scores have been pre-assigned based on the scientific literature, expert judgement and peer-review. The land-cover types are represented in photos to aid in their identification. A list of land-cover types potentially occurring in a wetland's upslope catchment is also provided. The primary task of the operator who is applying the method is to identify the different land-cover types present in a wetland and its upslope catchment and then to identify the extent of these types. The

method does not require that the operator assign impact intensity scores, as required by WET-Health, thereby reducing the prominence that subjective judgments play on the part of the operator in the assessment, which is hoped will reduce the vulnerability of the method to inter-operator variability.

This method is divided into two parts: Part 1 (the user manual) is a detailed step-by-step description of the method; and Part 2 (this document) is a description of the technical background to the method, its scientific basis, and the specific rationale underlying the impact intensity scores assigned to different land-cover types.

Part 1 describes of two possible assessment options, both including steps to carry out in the office and steps for the field. The first option, a qualitative sketch-map option, is applicable if a brief scoping of the various factors impacting upon the wetland is needed but an overall score is not required. The second option, a semi-quantitative map-based option, is applicable if an overall ecological condition/health score is required and/or the condition of the wetland is being monitored and users of the tool have access to Google Earth Pro or other means of generating a land-cover map. In both options, there is provision for considering impacts not accounted for with land-cover, e.g. the point source release of wastewater into the wetland.

Users of the method should have reasonable field experience of wetlands in the region that they are assessing. However, they are not required to be wetland specialists, and might be field technicians or citizen scientists. The method is appropriate for situations where many wetlands need to be assessed across broad landscapes, particularly where good land-cover data are available. Some specific applications include: broad-scale catchment assessment and State of the Environment reporting. The method can also be applied where only one or two wetlands need to be assessed very rapidly or by citizen scientists lacking advanced technical training.

The method does, however, have several limitations which need to be recognized. In particular the method takes little account of the wetland's particular features, e.g. local climate and geology, the wetland's hydrogeomorphic type, the inherent erodibility of the soil in the wetland and the inherent infiltration potential of the soil in the wetland's upslope catchment. Although the method considers the extent to which a buffer zone of natural vegetation around the wetland moderates the impacts from the wetland's upslope catchment, this is done at a very coarse level. Given these limitations, it is important to recognize that the method is generally restricted to scoping-level assessments, and the results need to be seen as tentative, particularly with respect to the water quality component. Thus, a more detailed assessments of some of the assessed wetlands is likely to be required.

Contents

Background to the method

Wetlands may be impacted upon directly by land-uses located within the wetland or indirectly by land-uses located in the wetland's upslope catchment. The wetland's upslope catchment refers to that area upslope of the wetland from which water flows (above-ground and/or below-ground) into the wetland, including the slopes immediately adjacent to the wetland as well as including slopes further away which feed any streams ultimately supplying the wetland. A wide variety of different land-cover types occur within wetlands and their upslope catchments, e.g. commercial annual crops, open water of dams, and natural vegetation areas (Figure 1). Each land-cover type tends to have particular ecological impacts associated with it. For example, commercial annual crops involve the complete clearance of the indigenous vegetation, application of fertilizers, etc. If this land-cover was located directly in the wetland, it can be appreciated how these impacts could have a considerable effect on the ecological condition of the wetland, depending on its extent in the wetland. If located in the wetland's upslope catchment, the impacts would be less direct, e.g. the vegetation in the wetland would not be directly removed. Nonetheless, the quality, quantity and seasonal pattern of water inflows to the wetland could potentially be significantly affected even if the land-cover was located several kilometres upstream of the wetland, again depending on extent. Therefore, by rapidly identifying which land-cover types occur in a wetland and its upslope catchment and how extensive these land-cover types are, inferences can be drawn about the likely magnitude of impact on the ecological condition of the wetland.

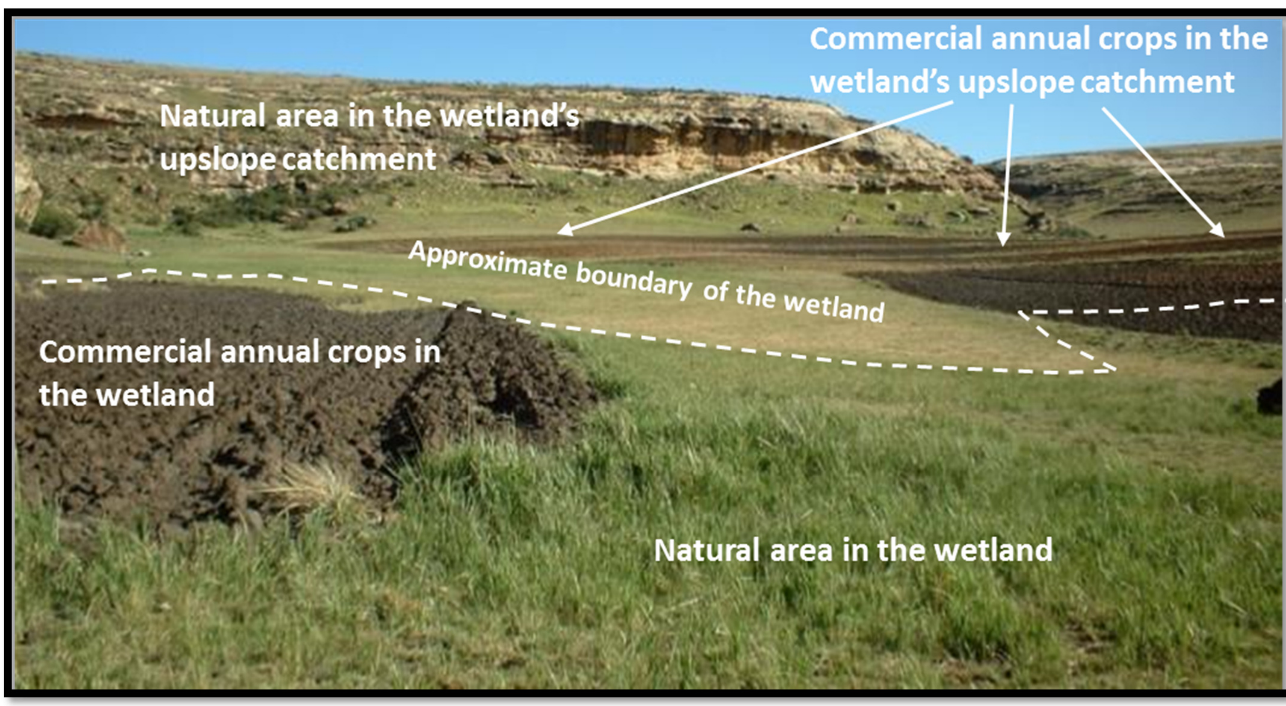


Figure 1: Different land-cover types in a wetland and the wetland's upslope catchment.

The ecological condition of a wetland (often referred to as "ecological health") refers to how close the system is to its natural (reference) condition – if it is close, then condition is taken as good but if far then condition is taken as poor. The natural condition is taken as that defined by Macfarlane et al. (2009), namely that condition in which natural inputs of resources or toxins have not been modified by recent human intervention, and which experiences levels of disturbance (e.g. from indigenous grazing animals) that are regarded as natural.

This report describes a method for assessing the ecological condition of a wetland based on identifying land-cover types in a wetland and its catchment and inferring impacts from the particular land-cover types present. The land-cover types used in method are based on those of Thompson (1996), expanded to account for specific land-covers associated with human use in wetlands. "Land-cover" refers to the physical cover on the earth's surface, including cultivated crops, buildings, natural grassland, etc. The term is distinct, but related to, "land use", which refers to how people use the land. It should be noted, however, that as with Thompson (1996) some of the land-cover types used in this method refer to land-use features, e.g. whether annual crops are irrigated or not.

Two methods, WET-Health (Macfarlane et al. 2009) and Wetland IHI (DWAF 2007), already exist for assessing the ecological condition of South African wetlands, prompting the question "why another method?" This new method is not being developed to replace WET-Health and Wetland IHI, but hopefully to fill some important gaps and limitations of these methods as described below.

Firstly, both of the existing methods require subjective scoring by the operators of the method. In a formal test of the robustness of WET-Health level 1 and Wetland IHI (DWAF 2007) Ollis *et al.* (2014) report that although independent operators scored relatively closely for wetlands which had been little transformed, some widely divergent scores were assigned to wetlands subject to high levels of transformation. In a robustness test of WET-Health Level 2 by Bodman (2011) independent operators scored closer than in the study of Ollis *et al.* (2014) but there was still some divergence. Therefore, Ollis *et al.* (2014) identified a need for trying different approaches for increasing assessment robustness, which this new method attempts to do. As explained further in the following section, the method presents (with example photographs) a broad range of land-cover types potentially occurring in wetlands and their upslope catchments, to which default impact scores have been assigned based on existing research and expert judgment. The new approach certainly does not eliminate the need for subjective judgments by the operator who is applying the method, but it reduces the prominence that such judgments play in the assessment, and makes it more appropriate as a tool to be used by non-scientists.

Secondly, WET-Health and Wetland IHI both give little coverage to impacts of land-uses in a wetland on water quality. While Malan *et al.* (2013) provides a very useful method for assessing the potential impacts of land-uses in a wetland's surrounding catchment on a wetland, it does not explicitly deal with the water quality impacts of different land-covers occurring within the wetland itself. This land-cover based assessment method explicitly attempts to do this. Nonetheless, it is important to emphasize that both this method and that of Malan et al. (2013) are designed merely as scoping tools for estimating water quality impacts to be used in situations where no actual water quality data are available.

Thirdly, WET-Health Level 1 and 2 and Wetland IHI (DWAF 2007) are primarily field-based techniques and are not designed for large-scale, coarse assessments undertaken primarily at a desktop level, e.g. across an entire sub-catchment. It is suggested that the land-cover based approach would assist greatly in undertaking these broad-scale assessments (with field verification) given that extensive land-cover data already exist both nationally and at a more detailed level for certain municipalities and catchments, and given the prohibitive expense and resources that are required for wetland assessment across a wide geographical expanse.

Suggestions have been made to revise and rationalize WET-Health and Wetland IHI, possibly through the development of a single "merged" method, which builds on the strengths of both methods (Ollis *et al.* 2014). The present new method has been designed so that its results will be as comparable as possible with these other two methods, and it is recognized that this new method, which has purposefully not been assigned a name, may get "absorbed" into this proposed "merged" method. However, in the meantime the new method needs to continue to be seen as exploratory and, as it is applied as widely as possible over the next year, it is hoped that valuable lessons will be learnt which help advance the science and practice of wetland assessment in South Africa.

The development of this method was jointly funded by WWF as part of a project to promote a Resilient Landscape Approach and by the Water Research Commission as part of a project (WRC/K5 2350) to develop innovative water resource monitoring tools for mainstreaming citizen science. In line with the goals of both initiatives, it is anticipated that the tool will make the assessment of wetland ecological condition more readily accessible to a wide range of role-players and production sectors and for a wide range of applications. It is hoped that this, in turn, will increase the active engagement of these different role-players and production sectors in monitoring and understanding wetlands, ultimately leading to better informed and more sustainable management of wetlands.

Overall structure of the method

The purpose of the method is to assess the ecological condition (health) of a wetland, as inferred from likely impacts associated with land-cover in the wetland and its upslope catchment. Ecological condition is assessed in terms of the following four components, which are combined to give an overall assessment score.

1. **Hydrology**, which in relation to wetlands refers to the movement of both surface and sub-surface water into, through and out of a wetland. Hydrology is the defining feature of wetlands and therefore forms a key component of assessing a wetland's ecological condition (Macfarlane *et al.* 2009).

2. **Geomorphology**, which refers to the origin and development of landforms on earth. It is recognized that wetlands are subject to both inputs and outputs of sediment, and under natural conditions input is generally equal to or greater than output (Macfarlane *et al.* 2009). Therefore wetlands are generally areas where sediment is accumulated. Two types of sediment are associated with wetlands, namely: mineral (clastic) sediment and organic material (Macfarlane *et al.* 2009).

3. **Water quality**, which refers to the physical, chemical and biological characteristics of water controlled or influenced by substances either dissolved or suspended in the water. Wetlands are naturally more variable in terms of water chemistry than rivers, both in space and time, and they also tend to be systems that function as sinks rather than sources of sediment and hence are accumulating systems, which in turn affects water quality (Malan and Day 2012). Nonetheless, it is possible at a coarse level to identify the extent to which different land-uses increase the input of substances (e.g. through adding fertilizers) or disrupt the storage/assimilation of these substances, thereby increasing the "leakage"/leaching of substances from the wetland.

4. **Vegetation**, which is specifically assessed in terms of vegetation composition, refers to the particular plant species that occur in a wetland under natural conditions. This vegetation not only provides habitat for a diversity of other species but also influences hydrological and geomorphological processes in the wetland and potentially provides important services such as forage for livestock grazing (MacFarlane *et al.* 2009).

The method uses the same scoring system applied in WET-Health (Macfarlane et al. 2009). This involves firstly assessing the spatial extent of individual land-uses (expressed as a proportion of the wetland or its catchment) and then separately identifying the intensity of impact of each individual land-use on each of the four components (hydrology, geomorphology, water quality and vegetation) on a scale ranging from 0 (no impact or deviation from natural) to 10 (critical impact or complete transformation from natural). The extent and intensity are then multiplied to give an overall magnitude of impact on a scale of 0 to 10. The method builds on the approach of the WET-Health (Macfarlane *et al.* 2009) level 1 vegetation component, where default intensity scores have been assigned by the method to each of a wide range of disturbance (land-cover) types. In the new method, this approach is extended to the hydrology, geomorphology and water quality components to align them more closely with the vegetation component.

The method, described in detail in Part 1, presents the user with a list of land-cover/disturbance types commonly occurring in wetlands, to which typical impact scores have been pre-assigned. These scores are based on the scientific literature and expert judgement, and were peer-reviewed in an attempt to make them as defensible as possible, and the rationale behind the scores is also provided. The land-cover types are also represented in photos in order to make then as easily identifiable as possible. This is similar in approach to the user-friendly photo guide developed by Graham and Louw (2009) for rivers (including riparian areas). The primary task of the operator who is applying the land-cover based method is to identify the different disturbance types present in a wetland and then to identify the extent of these land-cover types. The operator is provided with the following two options.

- The qualitative sketch-map option, which is applicable if a brief scoping of the various factors impacting upon the wetland is required but an overall score is not required, the information collected is not being used for monitoring or the users of the tool do not have access to Google Earth Pro or any other means of generating a land-cover map.

- The semi-quantitative map-based option, which is applicable if an overall ecological condition/health score is required and/or the condition of the wetland is being monitored over time and users of the tool have access to Google Earth Pro or other means of generating a land-cover map. Specific guidelines for mapping are given in Job *et al.* (in prep).

Part 1 (the user manual) provides a detailed, step-by-step description of the two options, including steps to carry out in the office and in the field. In both options, there is provision for considering impacts not accounted for with land-cover such as the point source release of wastewater into the wetland.

Land-cover impact scores and the rationale underlying these scores

As indicated in Section 1, impacts on wetlands which are related to land-cover may arise from within a wetland and from within the wetland's upslope catchment (Figure 2). Table 1, which deals with land-cover types potentially occurring in the wetland, and Table 2, which deals with land-cover types potentially occurring in the wetland's upslope catchment, represent the "engine" of the method. As can be seen from the respective tables, finer distinctions are made in terms of land-cover types within the wetland than for the wetland's upslope catchment given the more direct influence of land-cover in the wetland than upslope, as explained in Section 1.

As described in the detailed-map option in Part 1, the magnitude of impact for each land-cover present is determined by multiplying the relative extent of that impact by the pre-assigned intensity of impact score provided by the relevant table of the method. Then all of the impact magnitude scores for the individual land-covers present are summed to derive an overall ecological impact score for land-cover in the wetland and the wetland's upslope catchment respectively (a worked example is given in Part 1, Appendix A). The overall scores for land-cover both in the wetland itself and in the wetland's upslope catchment are finally combined using a 2:1 weighting ratio based on the assumption that a land-cover (e.g. commercial crops) in the wetland itself impacts more directly on the ecological condition of the wetland than if it is located in the wetland's upslope catchment.

A combined overall impact score is derived from the scores for Hydrology, Geomorphology, Water quality and Vegetation, weighted as 3:2:2:2, as recommended by Macfarlane et al. (2009). The overall score ranges from 0 to 10, and six Present Ecological State (PES) categories (A to F) are identified as follows: 0-0.9 =A; 1-1.9= B; 2-3.9= C; 4-5.9= D; 6-7.9 =E; and 8-10 =F (see Part 1, Table 5), where a category A means the wetland is in a totally natural state, and a category F means the wetland is highly degraded with virtually no wetland functioning remaining. These are the same categories used by DWAF (2007) and Macfarlane et al. (2009).

Figure 2: A wetland with extensive built up areas in its upslope catchment, and the considerable discharge of wastewater into the wetland. The wastewater treatment works are visible immediately adjacent to the wetland. The continuous wastewater inputs from this and other treatment works as well as from decanting mines have changed a naturally seasonal system into a continuously flooded system, which has greatly favoured the common reed (*Phragmites australis*).

Land-cover within the wetland

Impact intensity scores of different land-covers

Table 1 shows a list of land-cover types potentially occurring within a wetland. From Table 1 it can be seen that the intensity of impact varies widely amongst the different types, with mines and quarries having the highest impact intensity and natural land-cover the lowest impact intensity. The rationale following Table 1 attempts to explain the basis for these differences.

Table 1: Impact intensity scores for the hydrology, geomorphology, water quality and vegetation components of ecological condition for a range of different land-cover types potentially occurring **within a wetland**

Land-cover/disturbance types[1]		Intensity of impact[2] scores					
		Hyd-rology	Geomorphology[3] Mineral	Organic	Water quality	Vege-tation	Over all[2]
Annual crops, commercial, irrigated[5]	Conventional tillage, with severe artificial drainage[4]	7.5	4.0	7.0	7.0	10.0	7.5
	Conventional tillage, with moderate artificial drainage[4]	5.0	4.0	5.0	6.0	9.5	6.1
	Conventional tillage, with negligible/no artificial drainage[4]	3.5	3.0	3.0	5.0	9.0	4.9
	Minimum tillage, with severe artificial drainage[4]	7.0	2.5	5.0	5.0	10.0	6.5
	Minimum tillage, with moderate artificial drainage[4]	4.0	2.5	3.0	4.0	9.5	4.9
	Minimum tillage, with negligible/no artificial drainage[4]	2.5	2.0	2.0	3.0	9.0	3.9
Annual crops, commercial, not irrigated[5]	Conventional tillage, with severe artificial drainage[4]	7.0	4.0	7.0	6.0	10.0	7.1
	Conventional tillage, with moderate artificial drainage[4]	4.0	4.0	5.0	5.0	9.5	5.6
	Conventional tillage, with negligible/no artificial drainage[4]	2.5	3.0	3.0	4.5	9.0	4.5
	Minimum tillage, with severe artificial drainage[4]	6.5	2.5	5.0	5.0	10.0	6.3
	Minimum tillage, with moderate artificial drainage[4]	3.5	2.5	3.0	4.0	9.5	4.8
	Minimum tillage, with negligible/no artificial drainage[4]	2.0	2.0	2.0	3.0	9.0	3.8
Annual crops, subsistence[6]	With severe artificial drainage[4]	7.0	2.5	5.0	4.5	10.0	6.4
	With moderate artificial drainage[4]	3.5	2.5	3.0	3.5	9.5	4.7
	With negligible/no artificial drainage[4]	2.5	2.0	2.0	2.5	9.0	3.8
Sugarcane[7]	With severe artificial drainage[4]	8.0	3.5	6.5	5.0	10.0	7.1
	With moderate artificial drainage[4]	5.0	2.5	4.5	4.0	9.5	5.4
	With negligible/no artificial drainage[4]	3.5	2.0	2.5	3.0	9.5	4.4
Vineyards[7]	With severe artificial drainage[4]	7.0	2.0	5.0	4.0	10.0	6.2
	With moderate artificial drainage[4]	3.5	2.0	3.0	3.0	9.5	4.5
	With negligible/no artificial drainage[4]	2.5	1.5	2.0	2.0	9.0	3.7
Orchards[7]	With severe artificial drainage[4]	7.0	2.0	5.0	5.5	10.0	6.6
	With moderate artificial drainage[4]	4.0	2.0	3.0	4.5	9.5	5.0
	With negligible/no artificial drainage[4]	3.0	1.5	2.0	3.5	9.0	4.2
	With severe artificial drainage[4]	7.0	3.0	6.0	4.5	10.0	6.6
	With moderate artificial drainage[4]	3.5	2.5	4.0	3.5	9.5	4.8

Land-cover/disturbance types[1]		Intensity of impact[2] scores					
		Hyd-rology	Geomorphology[3] Mineral	Organic	Water quality	Vege-tation	Over all[2]
Planted pastures, annual[7,8]	With negligible/no artificial drainage[4]	2.5	2.0	2.0	3.0	9.5	4.1
Planted pastures, perennial[7,8]	With severe artificial drainage[4]	7.0	2.0	3.5	3.5	9.5	5.8
	With moderate artificial drainage[4]	3.0	1.5	2.5	3.0	9.0	4.1
	With negligible/no artificial drainage[4]	1.5	1.0	1.0	2.0	9.0	3.2
Unmaintained perennial pastures	With severe artificial drainage[4]	7.0	2.5	3.5	2.0	9.0	5.4
	With moderate artificial drainage[4]	3.0	1.5	2.5	1.5	8.5	3.7
	With negligible/no artificial drainage[4]	1.0	1.0	1.0	1.0	8.0	2.6
Recently abandoned lands[9]	With severe artificial drainage[4]	7.0	2.0	6.0	2.5	9.0	5.8
	With moderate artificial drainage[4]	3.0	2.0	3.0	2.0	8.5	3.9
	With negligible/no artificial drainage[4]	1.0	2.0	2.0	1.5	8.0	2.9
Old abandoned lands[9]/ semi-natural areas[10]	With severe artificial drainage[4]	7.0	3.0	5.5	2.0	8.0	5.5
	With moderate artificial drainage[4]	3.0	2.5	2.5	1.5	6.0	3.2
	With negligible/no artificial drainage[4]	1.0	1.5	1.5	1.0	4.0	1.8
Tree plantations	Plantations of eucalypt trees	8.0	4.0	4.0	3.0	10.0	6.4
	Plantations of pine, wattle or poplar trees	6.0	4.0	3.0	3.0	10.0	5.7
Dense infestations of invasive alien plants	Eucalypt trees	8.0	4.0	4.0	3.0	9.0	6.2
	Pine, wattle or poplar trees	6.0	4.0	3.0	3.0	9.0	5.4
	American brambles or other herbaceous invasive alien plants	2.0	4.0	3.0	3.0	8.5	4.0
Erosion gullies	Erosion gully with negligible vegetation colonization	7.0	10.0	10.0	5.0	9.0	7.7
	Erosion gully colonized with vegetation (mainly alien species)	6.0	7.0	7.0	3.0	9.0	6.2
	Erosion gully colonized with vegetation (mainly indigenous species)	6.0	7.0	7.0	2.0	7.0	5.6
Infrastructure (Urban and roads)	Formal residential	10.0	7.0	7.0	4.0	10.0	8.0
	Informal residential	8.0	6.0	6.0	7.0	10.0	7.8
	Commercial/industrial/agricultural (e.g. piggery)	10.0	7.0	8.0	7.0	10.0	8.8
	Roads[11]	10.0	8.0	7.0	6.0	10.0	8.6
Infilling without infrastructure	Natural sediment/soil used as infill	10.0	8.0	7.0	4.0	10.0	8.1
	Landfill material or solid waste (e.g. concrete rubble, plastic)	10.0	8.0	7.0	5.0	10.0	8.3

Land-cover/disturbance types[1]		Intensity of impact[2] scores					
		Hyd-rology	Geomorphology[3] Mineral	Organic	Water quality	Vege-tation	Over all[2]
	Mine dumps (spoil from the mining of underlying rock)	10.0	9.0	8.0	10.0	10.0	9.7
Mines and quarries	Mining of clay or sand	9.0	10.0	10.0	7.0	9.0	8.8
	Mining of underlying rock	10.0	10.0	10.0	10.0	10.0	10.0
Sports fields or gardens[12]	Sports fields or gardens on the original wetland ground surface	3.0	2.0	3.0	3.0	9.0	4.2
	Sports fields or gardens on wetland which has been infilled	10.0	6.0	5.0	3.0	10.0	7.4
Recent sediment deposits	Recent sediment deposition (deep, resulting in loss of wetland conditions).	10.0	6.0	3.0	3.0	10.0	7.2
	Recent sediment deposition (shallow, with wetland conditions persisting, although diminished).	4.0	3.0	2.0	2.0	5.0	3.4
Dams, ponds and areas where were water supply has been artificially sustained	Deep flooding by dams/ artificial ponds or upstream of embankments, not used for aquaculture	7.0	6.0	3.0	1.0	10.0	6.0
	Deep flooding by dams/ artificial ponds or upstream of embankments, used for aquaculture	7.0	6.0	3.0	5.0	10.0	6.7
	Shallow flooding by dams/ artificial ponds or upstream of embankments in the unit[8]	3.0	3.0	2.0	1.0	5.0	3.1
	Paddy fields	5.0	2.0	5.0	5.0	7.0	5.1
Natural, drained[13]	Natural vegetation with severe artificial drainage[4]	6.0	1.5	4.0	0.5	6.0	3.9
	Natural vegetation with moderate artificial drainage[4]	3.0	1.0	1.5	0.5	3.0	2.1
Natural, with wastewater flows[13]	Natural area of wetland into which the point-source release of untreated or poorly treated wastewater flows	4	3	3	8	6	5.1
	Natural area of wetland into which the point-source release of treated wastewater flows	4	3	3	2	5	3.6
Natural areas, very frequently burnt	Natural area of wetland which is burnt every year (e.g. as part of a firebreak)	2	1	3	2	3	2.2
Natural areas with small on-site impacts	Natural area of wetland affected by scattered invasive alien plants or other minor impacts	1	1	1	1	2	1.2
Natural	Natural vegetation with negligible/no artificial drainage or other impacts	0.0	0.0	0.0	0.0	0.0	0.0

[1]Intensive livestock grazing is not listed as a land-cover as such, but is assumed to be associated with planted pastures. If it occurs in any of the other land-covers listed in the table (e.g. old lands) it is suggested that the overall impact score be increased by 2 points. Intensive livestock grazing is taken as a stocking rate of higher than 2 ha per large stock unit.

[2]The “Mineral” component of Geomorphology refers to impacts on mineral sediments, while the “Organic” component refers to impacts on organic sediment.

[3]Intensity of impact is scored on a scale of 0 (nil/negligible) to 10 (critical) and Overall intensity is calculated as the average of Hydrology, Geomorphology, Water quality and Vegetation, weighted as 3:2:2:2.

[4]Artificial drainage generally comprises open artificial drainage furrows (canals) which are visible on the ground surface, as well as including the draining effect of erosion gullies and incised stream channels. However, it may also comprise buried perforated pipes, which are not visible on the ground surface. Severity of artificial drainage depends on spacing, depth and orientation of drainage furrows/pipes in relation to flows (including sub-surface) and tends to be most severe where drainage furrows/pipes are deep, dense and/or oriented to effectively intercept flows through the wetland. **For any cultivation type where the level of artificial drainage is not known then it should be assumed to be moderate** given that most wetland cultivation is associated with at least some level of drainage.

[5]For annual crops, commercial, if it is unknown whether there is irrigation or not then it should be **assumed that there is irrigation** because annual crops are usually irrigated. If it is unknown whether tillage is conventional or minimum tillage then **conventional tillage should be assumed** because this is still much more widespread than minimum tillage.

[6]It is assumed that for subsistence agriculture, tillage is by hand and that limited supplementary irrigation takes place.

[7]It is assumed that **annual planted pastures (usually ryegrass), vineyards and orchards are all irrigated** but perennial pastures and sugarcane are not irrigated.

[8]For **planted pastures, it is assumed that fertilizer is applied periodically and the pasture intensively grazed**. If it is unknown whether the planted pasture is annual or perennial then it should be assumed that it is annual, because in wetlands these are much more widespread than perennial pastures.

[9]Recently abandoned lands are taken as those which have been abandoned within the last year or two (following a period of being under cultivation, timber plantations or subject to some other form of physical disturbance which removed all of the natural vegetation, e.g. with a bulldozer) and are still strongly dominated by annual weedy plants. Old abandoned cultivated lands are taken as those which have been abandoned for long enough for perennial indigenous species to become reasonably well represented. If it is unknown when the lands were abandoned then it should be **assumed that they are old abandoned cultivated lands** (i.e. lands abandoned more than three years ago) unless it can be seen that the area is still dominated by annual weeds. Old abandoned lands are generally likely to be more widespread than recently abandoned lands.

[10]Semi-natural vegetation refers to vegetation in which the species composition has been significantly altered, but characteristic indigenous species are still reasonably well represented. **If the drying effect of the semi-natural areas by adjacent erosion gullies, etc. is not known then it should be assumed to be negligible**.

[11]The impact of a road is scored up to the edge of the road embankment, but does not include any damming effect of a road, which is dealt with under “Dams and ponds”.

[12]If it is unknown whether sports fields or gardens are infilled then **assume that they have been infilled** because this is probably the most widespread option.

Assumed practices associated with different agricultural land-covers

The scores assigned in Table 1 are based on the physical characteristics (mainly relating to vegetation cover) and practices commonly associated with the particular land-cover type, which vary widely amongst different agricultural land-covers, as follows:

Level of tillage is highest in commercial conventional annual crops, followed by subsistence annual crops, and annual planted pastures. Sugar cane (for which it is assumed that re-planting is after approximately 12 years) is intermediate with respect to level of tillage. Planted pastures, perennial, orchards and vineyards (which are generally replanted at an interval of >15 years) and annual crops grown under minimum till have the lowest level of tillage.

Periodic Removal of vegetative cover (thereby exposing the soil) is greatest in commercial conventional annual crops, followed by subsistence annual crops and annual planted pastures. Sugar is intermediate given the assumed 18 month harvesting rotation. In all of the remaining agricultural land-covers the periodic removal of vegetation is low.

Level of fertilizer application is highest in annual crops (conventional and minimum tillage) and sugar and intermediate for the remaining agricultural land-covers.

Level of biocide application is generally highest in orchards, followed closely by commercial annual crops (minimum till and conventional) and sugar, and intermediate in the remaining agricultural land-covers, except for subsistence crops, where it is generally moderately low.

Rationale relating to hydrological impacts

For the various forms of cultivation and abandoned lands included in Table 1, the primary physical characteristic impacting upon the hydrology of the wetland is the level of artificial drainage. Part 1 has several photographs showing different types of drains and levels of drainage and Job et al. (in prep) includes several satellite images of different wetland areas which have been artificially drained. The potentially profound impact of artificial drainage on wetlands has been widely demonstrated, e.g. by Scaggs (1980), Mitsch and Gosselink (1986) and Dunn and Mackay (1996) and is recognized in WET-Health. The hydrology impact scores in Table 1 also take into account whether the crop is irrigated, which is taken to increase the impact.

For tree plantations and invasive alien trees, the hydrology impact scores were informed by the extensive studies (e.g. Scott and Lesch, 1997; Scott *et al.*, 1998, Gush *et al.*, 2002; Scott, 2005) examining the water use of different tree types in relation to the natural vegetation, e.g. confirming that tree plantations and invasive alien trees generally use more water than the natural vegetation, and in addition eucalyptus trees are greater water users than wattle and pine trees.

Infilled areas and roads generally occur with a sufficient depth of fill to completely eliminate wetland conditions, resulting in major environmental impacts (Mitsch and Gosselink 1986). Therefore roads and infilling are scored very high in terms of hydrological impacts. Formal settlements in wetlands are taken to have similarly high hydrological impacts, resulting from infilling and/or a high level of artificial drainage and the hardened, impermeable surfaces associated with infrastructure. However, informal settlements are scored somewhat lower given that artificial drainage and/or infilling generally occurs to a much lesser extent, but hardened, impermeable surfaces are still extensive.

Mines and quarries represent extreme transformation of the landscape and often result in the complete removal of the wetland (Mitsch *et al.* 1983). Therefore, they are scored very high in terms of hydrological impacts.

Recent sediment deposits (e.g. as a result of sediment washing into the wetland from upslope eroding lands) vary in terms of their depth and level of impact. If the wetland is deeply buried and wetland conditions completely eliminated then a very high impact score is given, approaching that assigned to an infilled wetland. In contrast, if the deposit is relatively shallow and wetland conditions persists then a much lower impact score is given.

The majority of South African wetlands are very shallowly flooded, many of them for relatively short periods. Therefore deep flooding by dams represents a large departure from the natural condition and the impact score is thus relatively high.

The discharge of wastewater (whether treated or not) typically continues throughout the year, often altering the seasonal flow patterns in a wetland, and hence the hydrological condition of the wetland.

Rationale relating to geomorphological impacts

The greater the level of artificial drainage, the greater the impact on the geomorphology of the wetland. Artificial drainage acts directly to prevent the natural spreading of flow, thereby also affecting the natural trapping of sediment which characteristically occurs when flows are spread and therefore slowed down. Drainage also acts indirectly by reducing the level of wetness in the soil, which in turn increases the rate of breakdown of soil organic matter. The strong relationship that exists between level of wetness and soil organic matter has been well demonstrated (Tiner and Veneman 1988).

Similarly, cultivation practices, notably tillage and removal of vegetative cover, impact directly on the geomorphology of the wetland by increasing the susceptibility of the area to erosion and the loss of mineral and organic sediments (Kotze 2010). These practices also impact indirectly on organic sediments by reducing organic matter inputs and increasing the rate of break-down of soil organic matter. Thus, those cultivated land-cover types which have the highest levels of tillage and removal of vegetative cover (i.e. conventional tillage of annual crops), have the highest geomorphology impact scores. Macfarlane et al. (2010) provides further information on erosion in wetlands and Kotze (2010) provides further information dealing specifically with the effect of wetland cultivation on soil organic matter levels and erosion.

Infestations of invasive alien plants tend to be less effective than the indigenous vegetation in controlling erosion, one of the reasons being that they generally support more intense fires which are more damaging to the soil (Chamier *et al.* 2012).

Although the mineral sediment and some of the organic sediment in the wetland soils is preserved when it is buried beneath fill material, the wetland is no longer receiving active input of organic matter from vegetation growing in the area and the natural movement of sediment through the system is completely disrupted. Thus, the geomorphological impact score of infilling is relatively high.

Where wastewater entering a wetland may greatly increase discharge, which in turn greatly increases the capacity of flow to erode the channel banks and carry sediment, thereby promoting channel enlargement and impacting upon geomorphological condition (MacFarlane *et al.* 2009).

A marked increase in the frequency of fire in the wetland is likely to result in a somewhat higher exposure to erosion, also potentially reducing infiltration into the soil, with implications for hydrology, geomorphology and water quality (Kotze 2013).

Rationale relating to water quality impacts

The greater the level of artificial drainage of cultivated wetland areas, the greater will be the potential for leaching from these areas given that artificial drainage channels may act as a major conduit of nitrogen and phosphates from the soil of agricultural lands to receiving waters (Randall and Goss 2001; Nguyen and Sukias 2002). This, in turn, impacts negatively on the aquatic habitats within (and downstream of) the wetland.

Irrigation also contributes to the likelihood of leaching of nutrients from cultivated lands to receiving waters when compared with an equivalent non-irrigated crop (Görgens *et al.* 2012).

The greater the level of fertilizer or biocide application to cultivated areas, the greater the likelihood of their leaching from these areas (Thorburn *et al.* 2013). By virtue of the fact that certain crops generally receive more fertilizer and biocides it can be assumed that these crops have greater potential to impact on water quality.

In annual crops, the growth of plants (and therefore uptake of nutrients) is interrupted when one crop is harvested and the next has yet to develop (Randall and Goss, 2001). This provides greater opportunities for loss of nutrients from the soil than in perennial crops, where uptake of nutrients is sustained (Randall and Goss, 2001). This, in turn, impacts negatively on the aquatic habitats within (and downstream of) the wetland.

It has been well demonstrated that the greater the level of tillage, the greater the exposure of soil to erosion, and therefore the lower the potential of a wetland to store sediment, given that each time the soil is tilled its structure is disrupted and plant roots contributing to the strength of the soil are destroyed. The reduced storage of sediment in turn reduces the natural storage of phosphorus, given that phosphorus tends to be strongly bound to soil particles (Pierzynski *et al.* 2005).

Runoff from roads can have a major impact on the water chemistry of wetlands and aquatic systems, as a source of hydrocarbons, metals and other pollutants (Ellis *et al.* 1987; Mitsch and Gosselink 1993; Trombulak 2000). Several studies (e.g. Motha *et al.* 2004) have shown that unpaved (gravel) roads are a major source of sediment into aquatic and wetland receiving environments, often contributing disproportionately more on an area basis than cultivated lands.

Extensive evidence exists (e.g. that presented by Schoonover and Lockaby (2006) and Carey *et al.* (2011)) linking urban developments, and specifically impervious surfaces, with declining water quality from a range of different pollutants, including toxic heavy metals, faecal coliforms, hydrocarbons (e.g. from vehicle oil), elevated nutrients, etc.

As indicated in the previous section, invasive alien trees are generally less effective than indigenous vegetation in controlling erosion. The increased erosion has implications for water quality as a result of increased sediment loads in the water, which in turn increase turbidity as well as increasing the levels of nutrient and solutes, which were adsorbed on the sediment and become released into the water column (Chamier *et al.* 2012).

Several studies (e.g. Buck *et al.* 2004) have demonstrated the effect of high densities of livestock on water quality in receiving waters.

The very high impacts on water quality that are generally associated with mining are well documented (Mitsch *et al.* 1983; Heath *et al.* 2009; Barkley *et al.* 2011).

Wastewater, even where it has been ameliorated, typically increases the loading of nutrients and other solutes in a wetland. This has direct impacts on the ecological condition of the wetland in terms of water quality. The elevated nutrient levels, in turn, impact upon vegetation condition by generally favouring a few tall-growing competitive species at the expense of naturally growing, much more diverse vegetation (Hillebrand 2003).

Rationale relating to the impacts on vegetation composition

Land-covers where vegetation is replaced completely (e.g. by infrastructure or deep flooding by dams) resulting in there being no vegetation at all, have been assigned the highest possible vegetation impact score (i.e. 10).

Cultivation with moderate or negligible drainage often supports a few indigenous wetland species that are well adapted to high levels of disturbance (e.g. *Commelina africana*) but their abundance is generally very low and the overall composition of the vegetation is very different to the native vegetation. Thus, although not scoring the maximum in terms of vegetation impacts, these types are scored very close to the maximum score. Cultivation with severe drainage tends to entirely prevent the growth of indigenous wetland species and therefore scores the maximum impact.

Provided that the area is not severely drained, perennial crops generally provide slightly greater opportunities than annual crops for indigenous wetland species which are well adapted to high levels of disturbance (e.g. *Commelina africana*) to survive. However, the overall composition of the vegetation is very different to the native vegetation, and thus the score assigned is close to the maximum.

Unmaintained perennial pastures are not subject to any removal of non-crop plants, as occurs in actively cultivated areas (i.e. the first eight land-cover types in Table 1) and therefore indigenous wetland species are more abundant than in actively cultivated areas. However, the introduced pasture maintains a strong dominance (as shown in an example with *Paspalum dilatatum* by Cowden *et al.* (2014)), and the vegetation is therefore still quite different to the native vegetation and the impact score assigned is therefore not much less than the maximum.

The readiness with which the natural vegetation in a wetland recovers after removal of the vegetation, e.g. for cultivation, varies considerably. However, as a general rule, it appears that areas which are permanently wet and tending to naturally support a few tall-growing species recover far more readily than the temporary to seasonal wetland areas supporting shorter and more diverse vegetation (Walters *et al.* 2006).

The more sustained wetness during the dry season of wastewater discharge impacts on the vegetation by also generally favouring tall-growing competitive plants such as bulrushes (*Typha*) even in situations where nutrient levels are not elevated (Boers and Zelder 2008).

A marked increase in the frequency of fire in the wetland is likely to most obviously impact upon the vegetation species composition of the wetland, favouring species well adapted to a high fire frequency over those less well-adapted species (Kotze 2013).

Land-cover within the wetland's upslope catchment

Table 2 illustrates how the impacts on a wetland in terms of water inflow quantity and seasonal pattern and water quality vary greatly depending on the particular land-cover types located in the wetland's upslope catchment.

As indicated earlier, the overall method focuses in most detail on impacts from land-cover in the wetland (Table 1 and 2). As such, fewer distinctions are made in terms of land-cover types in the wetland's upstream catchment than in the wetland itself. Also fewer components related to wetland ecological condition are considered, i.e. scores are not presented separately for hydrology, geomorphology, vegetation and water quality as is done for land-cover in the wetland. In addition, although it is recognized that for a wetland's upslope catchment, the closer a specific land-cover impact is to the wetland, the less opportunity there is for the impact on the wetland to be buffered, the method does not consider distance of the land-cover to the wetland. However, the method does consider the level to which the wetland is surrounded by a buffer zone of natural vegetation, which is assumed to have a moderating influence over the overall impacts from the wetland's upslope catchment. In addition, in the Limitations of the method it is suggested how refinements could be made in order to better account for the moderating influence of the buffer, with reference to the buffer guidelines of Macfarlane et al. (2014).

Table 2: Impact intensity scores for a range of different land-cover types potentially occurring in a wetland's upslope catchment

Land-covers in the wetland's catchment	**Impact intensity[1]**		
	Water quantity & pattern[2]	**Water quality[3]**	**Overall[4]**
Tree plantations, eucalypt	8.0	3.0	5.5
Tree plantations, pine, wattle or poplar	6.0	3.0	4.5
Orchards	5.0	6.0	5.5
Vineyards	4.0	4.0	4.0
Annual commercial (row) crops, irrigated	5.0	6.0	5.5
Annual commercial (row) crops, not irrigated	4.0	5.0	4.5
Annual subsistence crops	4.0	4.0	4.0
Sugarcane	4.0	4.0	4.0
Mines and quarries	7.0	9.0	8.0
Built up dense settlements, roads, railway lines & airfields	7.0	5.0	6.0
Golf courses, sports fields & low density settlements	2.0	4.0	3.0
Old lands/ semi-natural vegetation	0.0	1.0	0.5

Land-covers in the wetland's catchment	Impact intensity[1]		
	Water quantity & pattern[2]	Water quality[3]	Overall[4]
Natural vegetation	0.0	0.0	0.0
Eroded areas	5.0	5.0	5.0
Dams	7.0	2.0	4.5

[1]Intensity of impact is scored on a scale of 0 (nil/negligible) to 10 (critical)

[2]For a more detailed assessment of the impacts on the quantity and seasonal pattern of water inputs from a wetland's upslope catchment see the hydrology component of MacFarlane *et al.* (2009).

[3]For a more detailed assessment of the impacts on the quality of water inputs from a wetland's upslope catchment see Malan and Day (2012) and Malan *et al.* (2013).

[4]The overall score is calculated as the average of the scores for (1) water quantity and pattern and (2) water quality.

Rationale behind the scores assigned to different land-cover types

The effect that different plantation trees (e.g. eucalypts vs. pines) have in reducing catchment yield is well demonstrated (see Rationale for Table 1). It is also important to add that tree plantations characteristically include a network of roads, which act to some extent as a drainage network increasing the collection and delivery of stormflows.

Orchards and vineyards, which characteristically occur in the winter rainfall area of South Africa, are subject to extended irrigation during the dry summer season, which generally results in increased dry season water inputs to downslope areas from irrigation return flows. Orchards tend to have relatively high levels of biocide application with vineyards having somewhat less, while levels of fertilizer application for both tend to be intermediate.

Commercial row-crops are generally subject to some of the highest levels of tillage, thereby exposing this land-cover to some of the highest levels of soil and nutrient loss, with important implications for water quality in downstream environments. Downstream impacts both in terms of water quantity and pattern and water quality (through increased leaching) tend to be further increased with irrigation.

Sugarcane is subject to less tillage and exposure of the soil than row-crops but nonetheless is subject to relatively high levels of agrochemical application and therefore the impacts on water quality are slightly lower than for row-crops, particularly those that are irrigated, but are still notable.

Mines and quarries represent an extreme form of hydrological disruption and; in the case of mines in particular are generally associated with severe impacts on water quality of downstream environments, e.g. through acid mine drainage.

Built-up dense settlements, roads railway lines and airfields all have a high extent of impermeable surfaces. The greater the extent of impermeable surfaces the lower the infiltration of storm-waters and therefore the greater the surface runoff and flood peaks (Macfarlane *et al.* 2009). Water quality is also affected by pollutants (e.g. hydrocarbons from motor vehicles) washed off the impermeable surfaces.

Golf courses, sports fields and low-density settlements have limited hardened surfaces, moderate levels of fertilizer application and maintenance of good ground cover. Therefore, these areas are generally not a major sources of sediment.

Old lands / semi-natural vegetation are not subject to tillage and fertilizer and biocide application and generally maintain good ground cover. However, very slightly higher levels of soil loss are generally anticipated compared with natural vegetation because of historical disturbance.

Eroded areas lack the protection of vegetation cover and generally result in significantly increased stormflows and sediment to downstream environments.

Dams have the potential to reduce both catchment yield and downstream flood-peaks (MacFarlane *et al.* 2009).

Once a total score has been determined of the impact on the wetland of land-covers in the wetland's upslope catchment then this score is automatically adjusted based on the extent to which the wetland is surrounded by a buffer zone of natural vegetation (see Part 1, Figure 4). The adjustment is based on following multiplier: Low to moderately low extent of buffer zone= 1 (i.e. the impact score remains the same); Intermediate = 0.9; moderately high to High = 0.7. Thus, it can be seen that as the buffer extent is increased, the impact score is reduced accordingly. It has been well demonstrated that particularly with respect to non-point source impacts on water quality, the greater the extent of the buffer of natural vegetation surrounding the wetland, the greater will be the moderating effect of the buffer on these impacts (Lovell and Sullivan 2006; Macfarlane et al. 2014). However, it is important to recognize that buffers generally have limited influence over certain impacts, notably point-source discharges and hydrological impacts caused by stream flow reduction activities (abstraction from an upstream dam) (Macfarlane et al. 2014) (Figure 3).

Figure 3: A valley bottom wetland with extensive dense infestations of the invasive alien plant American bramble. Extensive areas of the wetland's upslope catchment are occupied by tree plantations, although there is a buffer of natural vegetation approximately 20 m wide between the wetland and the adjacent tree plantations.

Combining the total score from within the wetland with that from the wetland's upslope catchment

The total impact score from within the wetland and that from the wetland's upslope catchment are combined into a single overall impact score in such a way that the higher score has the dominant effect but is adjusted by the lower score (see Appendix 1).

It is not necessary to weight the catchment lower than the within-wetland. This is because the scores in the original impact tables take into account the fact that the land-covers within the wetland's upslope impact less directly on the wetland than those arising from within the wetland. For example, a mine in the wetland's catchment scores 8 whereas a mine directly in a wetland scores 10. In addition, impacts from the catchment are further reduced based on the extent of a buffer around the wetland.

Limitations of the method & suggestions for addressing these limitations

Key limitations of the method

The following are probably some of the most important limitations of the method:

Site-specific features of the wetland not considered

The method generalizes broadly about the ecological impacts associated with particular land-covers, with little account taken of the wetland's particular features, notably its hydrogeomorphic type and ecoregion. Although studies such as Grundling (2014) are shedding valuable light on the hydrological characteristics of different HGM types, understanding of how the different hydrogeomorphic types influences land-use impacts has not been well developed. However, it is hoped that as this understanding improves, a consideration of the influence of hydrogeomorphic type will be able to be included in the method. Understanding of how the sensitivity of a wetland to human impacts might vary across different ecoregions is also limited, but with increased understanding, the method could potentially be tailored for specific ecoregions. The method also does not account for other site-specific features such as the erodibility of the soil, where for a given land-use/ land-cover, a site with a higher erodibility is likely to be subject to higher impacts. Such factors could potentially be accounted for in a refinement of the method, e.g. by including soil erodibility as a weighting factor.

Some land-cover types vary widely in terms of land-use practices

Although many different land-cover types were identified to try to limit the variability within each type, it is recognized that for certain types and for certain environmental impacts the impact intensity may vary quite widely from one site to the next. An important factor affecting this deviation will be the extent to which Best Management Practices are followed. For example, the water quality impact score for commercial/industrial infrastructure was assigned based on the assumption that the effectiveness of handling potential pollutants is moderate (i.e. there are occasional spillages of pollutants). However, in the wetland being assessed, handling of potential pollutants may be exceptionally good. If this information was available then the impact score could be adjusted down but in most cases such detail would not be available.

The influence of a buffer of intact vegetation around the wetland is considered at a coarse level

The method considers the degree to which the wetland is buffered (e.g. by a broad strip of intact natural vegetation around the wetland) from the overall land-cover impacts on the wetland from the wetland's upslope catchment. However, this consideration is at a course level. Thus, if a more refined assessment of impacts was required then the extent of individual land-cover types in the immediate buffer (e.g. of 100 m) surrounding the wetland could be quantified. In a further refinement, account could be taken of other influencing factors such as the gradient of the slope adjacent to the wetland. Macfarlane et al. (2014) provide comprehensive guidelines for determining adequate buffer widths taking into account factors such as the threats associated with the specific land-uses, gradient of the slope and the sensitivity of the downslope wetland, which provides useful guidance in conducting such refinements.

Defining the natural reference state of the wetland

The method largely avoids the issue of explicitly defining the natural reference state of the wetland being assessed. There is no quick fix for this challenging issue, which besets all of the methods. One of the resulting problems is that of deciding if the vegetation is natural. A possible future solution is to develop regional versions of the method with photos of typical natural wetland vegetation for each region together with typical examples of vegetation which has been compromised.

Additional limitations include the following:

- The method accounts only superficially for point source impacts, e.g. water abstraction from within the wetland and the discharge of untreated wastewater into the wetland. For guidance in carrying this out in more detail refer to Malan et al. (2013) and Macfarlane et al. (2009).
- The method assumes that the boundary of the wetland's upslope catchment can readily be seen based on the surface topography of the wetland. However, for depression wetlands on coastal plains in particular, this may not always apply, and a wetland may be fed by a much larger area than the wetland's local, topographically-defined catchment. However, as recommended by Malan and Day (2012) for the purposes of the assessment the wetland's local catchment could be used for these problematic wetlands, based on the fact that impacts arising from areas in close proximity to the wetland will have the most influence over inputs to the wetland.
- The method does not provide guidance for interpreting satellite imagery and mapping the land-cover units identified in a wetland. However, detailed interpretation and mapping guidance is provided by the national guideline for wetland mapping and inventory (Job et al. in prep)
- Although a comprehensive list of land-cover types is included in the method, this is not exhaustive, and inevitably users of the method will encounter land-covers which do not fit well any of those listed. If this takes place then it is recommend that the land-cover be recorded under the land-cover type which is closest match and a brief written description be given of the type. The pre-assigned impact scores can then be adjusted based on specific knowledge of the site provided that the basis for these adjustments is given.
- The method provides inadequate detail to be used in the context of Environmental Impact Assessments, which require that due consideration be given to the wetland's biotic and hydrogeomorphic features.

The level of confidence which can be placed in the method

Given all of the limitations described above, it is important to recognize that the method is generally restricted to scoping-level assessments, and is likely to require a more detailed assessments of a sub-set of the assessed wetlands. In the absence of such detailed site-specific assessments, it is important to recognize that the level of confidence which can be placed in the use of land-cover to infer the ecological condition of a wetland is likely to vary across the four respective components of ecological condition (Table 3). The score for that component with the lowest confidence, i.e. water quality, should be considered the most tentative. As a first step in better considering site-specific influences, a list of potential influencing factors is given in Table 4. Although this is not an exhaustive list, it attempts to capture a broad spectrum of potential influencing factors which could be potentially investigated in more detail in order to improve confidence in the assessment.

Table 3: level of confidence in the use of land-cover to infer wetland ecological condition according to the four respective components of condition

Components of ecological condition	**Level of confidence**	**Rationale**
Hydrology	Intermediate	The strong link between land-cover and hydrology has been well demonstrated, but is potentially influenced by several site-specific factors, e.g. the inherent infiltration potential of the soil in the wetland's upslope catchment. For further information on these factors see Macfarlane et al. (2009).
Geomorphology	Intermediate	Land-cover relates directly to geomorphology in as far as eroded areas are identified as a specific land-cover type. However, land-cover can also have several indirect effects, but, as is the case with hydrology, these effects may potentially be influenced by several site-specific factors, e.g. the longitudinal slope of the wetland, which affects surface water flow velocity (and therefore the potential to erode). For further information on these factors see Ellery et al. (2009) and Macfarlane et al. (2009).
Vegetation	Moderately high	Vegetation itself is a prominent feature of land-cover and therefore the link between land-cover and vegetation is very direct. Nonetheless, this link is still subject to the influence of site-specific factors. For example, the land-cover type "old cultivated lands" may represent varying levels of recovery of the native vegetation, subject to the influence of site-specific factors such as soil type or varying levels of competition from invasive alien species. For further information on these factors see Macfarlane et al. (2009) and Corry (2012).
Water quality	Intermediate/ Moderately low	While the link between land-cover and water quality has been very well demonstrated, it is probably the least direct and clear of all of the components, and therefore potentially most influenced by several site-specific factors. For further information on these factors see Malan and Day (2012).

Table 4: Some key site-specific factors influencing land-cover effects on the four respective components of ecological condition, hydrology (Hyd), Geomorphology (Geo), Water Quality (WQ) and Vegetation (Veg)

Some key site-specific factors	Components of condition				Some examples of site-specific effects and the potential need for adjusting the default scores given in Table 1
	Hyd	Geo	WQ	Veg	
Local climate and geology	**	**	**	**	Landscapes dominated by sandstone tend to yield soils and ecosystems (including wetlands) which are low in nutrients. Such wetlands are considered vulnerable to elevated nutrient inputs, potentially requiring that the default scores for water quality impacts be increased.
Endorheic (no surface or sub-surface outflow) vs. Exorheic (with surface and/or sub-surface outlfow)	*	*	**	*	If a wetland is endorheic then pollutants and nutrients tend to accumulate more readily then if exorheic, where much greater opportunities exist for “flushing” of the system. Thus, default scores for water quality impacts should potentially be increased for endorheic systems.
Infiltration potential of the soil in the wetland’s upslope/upslope catchment	**	**	*		If the inherent infiltration potential of the soil is high then the introduction of impermeable surfaces (e.g. through urban developments) will impact proportionally much more on a downslope wetland than if the inherent potential is low.
Vulnerability of the wetland to erosion, given its longitudinal slope and discharge/size	*	**			If the vulnerability of the wetland to erosion and/or the erodibility of the soil in the wetland were very high then the impact on geomorphology by land-covers involving physical disturbance in the wetland (e.g. through tillage) is potentially higher than the default impact scores given in Table 1. Conversely, if both the vulnerability of the wetland to erosion and the erodibility of the soil are low then the impact is potentially lower than the default impact scores.
Erodibility of the soil in the wetland	*	**			
Presence of soils with a naturally high organic content, including peat		**			If soils with a naturally high organic content are present in the wetland then the impact on geomorphology of land-covers involving artificial drainage and physical disturbance in the wetland (e.g. through tillage) is potentially higher than the default impact scores given in Table 1.
Invasive species in the species pool				**	In some wetlands there are many invasive alien plants already present or nearby to the wetland which can readily capitalize on human disturbance. In such wetlands the recovery of the natural vegetation in abandoned cultivated lands may be impaired much more than in wetlands where invasive alien plants pose much less of a threat, but recognizing the nowhere in South Africa are wetlands “out of reach” of invasive alien plants.

The direct deposition of nutrients into the wetland by fauna (e.g. as a result of a bird roosting site within a wetland).			**	*	The extent to which the default score for water quality impacts needs to be adjusted will depend on whether this deposition is natural or caused by human influence, e.g. the planting of trees, which in turn become used as a bird roosting site.

* =A direct influence is likely, although probably not a major influence
** =A direct influence is likely, and is potentially a major influence

References

Barclay S J, Trusler G, von Blottnitz H, Buckley C A, Kothuis B, and Janisch C, 2011. Cleaner Production: A Guidance Document for the Mining Industry in South Africa WRC Report No. TT 485/11. Water Research Commission, Pretoria.

Bodman L, 2011. An investigation on the variation of scores from users of the WET-Health tool. Honours thesis, University of KwaZulu-Natal, Pietermaritzburg.

Boers A M, Zedler J B, 2008. Stabilized water levels and Typha invasiveness. Wetlands 28: 676-685.

Brinson M M, 1993. Hydrogeomorphic classification of wetlands. Technical Report WRP-DE-4, U.S. Army of Engineer Waterways Experiment Station, Vicksburg, MS.

Bromilow C, 2010. Problem plants and alien weeds of South Africa. Third edition. Briza, Pretoria.

Buck O, Niyogi D K, and Townsend C R, 2004. Scale-dependence of land use effects on water quality of streams in agricultural catchments Environmental Pollution 130: 287-299.

Carey R O, Migliaccio K W, Li Y, Schaffer B, Kiker G A, and Brown M T, 2011. Land use disturbance indicators and water quality variability in the Biscayne Bay Watershed, Florida.

Chamier J, Schachtschneider K, le Maitre D C, Ashton PJ and van Wilgen B W, 2012. Impacts of invasive alien plants on water quality, with particular emphasis on South Africa. Water SA Vol. 38: 345-356.

Cockburn J, Dubazane N, Kotze D and Lindley D, 2014. WORKING CONCEPT PAPER: Defining the Resilient Landscapes Approach. WWF Mondi Wetlands Programme, Irene, Pretoria.

Corry F, 2012. Development of a tool for the assessment of the environmental condition of wetlands using macrophytes. WRC Report no. TT 436/12. Water Research Commission, Pretoria

Cowden C, Kotze D C, Ellery W N, and Sieben E J, 2014. Assessment of the long-term response to rehabilitation of two wetlands in KwaZulu-Natal, South Africa. African Journal of Aquatic Science 39: 237-247.

Day E and Malan H, 2010. Tools and metrics for assessment of wetland environmental condition and socioeconomic importance: handbook to the WHI research programme WRC Report No. TT 433/09, Water Research Commission, Pretoria

Dunn S M, and Mackay R, 1996. Modelling the hydrological impacts of open ditch drainage. Journal of Hydrology 179, 37–66.

Ellis JB, Revitt DM, Harrop DO, and Beckwith PR, 1987. The contribution of highway surfaces to urban stormwater sediments and metal loadings. Sci Total Environ 43:89 -102.

Görgens A H M, Lorentz S A, van der Laan M, Annandale J G, Jovanovic N Z, Matthews N, Grové B and le Roux JJ, 2012. Modelling Agricultural NPS Pollution and Economic-Environmental Trade-offs of Pollution Control Measures. A Project Overview. WRC Report No. TT 516/12.

Graham P M, Dickens C W S, and Taylor R J, 2004. miniSASS — A novel technique for community participation in river health monitoring and management. African Journal of Aquatic Science 29: 25-35.

Graham M, and Louw M D 2009. Module G: EcoClassification and EcoStatus Determination in River EcoClassification: Manual for Index of Habitat Integrity (Section 2, Model Photo Guide). Water Research Commission. WRC Report No TT 378/09, Water Research Commission, Pretoria.

Grundling A T, 2012. Remote sensing and biophysical monitoring of vegetation, terrain attributes and hydrology to map, characterise and classify wetlands of the Maputaland Coastal Plain, KwaZulu-Natal, South Africa, PhD thesis, Geography, University of Waterloo, Waterloo, Ontario, Canada

Gush M B, Scott D F, Jewitt G P W, Schulze R E, Lumsden T G, Hallowes L A, Görgens A H M, 2002. Estimation of streamflow reductions resulting from commercial afforestation in South Africa. WRC Report No. TT173/02. Water Research Commission, Pretoria.

Heath R G, van Zyl H D, Schutte C F, and Schoeman J, 2009. First order assessment of the quantity and quality of non-point sources of pollution associated with industrial, mining and power generation. WRC Report No. 1627/1/09. Water Research Commission, Pretoria.

Hillebrand H 2003. Opposing effects of grazing and nutrients on diversity. Oikos 100: 592-600

Job N, Ginsberg A, and Botts E, in prep. Guideline for Wetland Mapping and Inventory in South Africa. Report compiled for The South African National Biodiversity Institute, Pretoria.

Kotze D C, 2013. The effects of fire on wetland structure and functioning. African Journal of Aquatic Science 38: 237–247

Kotze D C, Marneweck G C, Batchelor A L, Lindley D S and Collins N B 2009. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. WRC Report No TT 339/09, Water Research Commission, Pretoria.

Lovell S T, Sullivan W C, 2006. Environmental benefits of conservation buffers in the United States: Evidence, promise, and open questions. Agriculture, Ecosystems and Environment 112 (2006) 249–260

Macfarlane DM, Bredin IP, Adams JB, Zungu MM, Bate GC and Dickens CWS, 2014. Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries: consolidated report. WRC Report No. TT 610/14, Water Research Commission, Pretoria.

MacFarlane D M, Kotze D C, Ellery W N, Walters D, Koopman V, Goodman P, and Goge M, 2009. WET-Health: A technique for rapidly assessing wetland health. WRC Report No. TT 340/09. Water Research Commission, Pretoria, South Africa.

Magee T K and Kantula M E, 2005. Response of wetland plant species to hydrologic conditions. Wetlands Ecol Manage 13: 163-181

Malan H L and Day J A, 2012. Water Quality and Wetlands: Defining Ecological Categories and Links with Land-Use. WRC Report No. 1921/1/12. Water Research Commission, Pretoria.

Malan H L, Batchelor A L, Scherman P, Taylor J, Koekemoer S, Rountree M W, 2013. Specialist Appendix A7: Water Quality Assessment, in: Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0). WRC Report No. 1788/1/13. Water Research Commission, Pretoria.

Malan HL, Day JA 2012. Water quality and wetlands: defining Ecological Categories and links with land-use. WRC Report No. WRC Report No. 1921/1/12. Water Research Commission, Pretoria.

Matry J T 2005. Effects of Cattle Grazing on Diversity in Ephemeral Wetlands. Conservation Biology 19: 1626-1632.

Mitsch W J, and Gosselink J G, 1986. Wetlands. Van Nostrand Reinhold, New York.

Mitsch W J, Taylor J R, Benson K B, Hill P L, 1983. Wetlands and coal surface mining in western Kentucky – a regional impact assessment. Wetlands 3: 161-179.

Motha J A, Wallbrink P J, Hairsine P B, Graysona R B, 2004. Unsealed roads as suspended sediment sources in an agricultural catchment in south-eastern Australia. Journal of Hydrology 286: 1–18.

Nguyen L, and Sukias J, 2002. Phosphorus fractions and retention in drainage ditch sediments receiving surface runoff and subsurface drainage from agricultural catchments in the North Island, New Zealand. Agriculture, Ecosystems and Environment 92: 49–69.

O Connor TG Kuyler P, 2009. Impact of land-use on the biodiversity integrity of the moist sub-biome of the grassland biome, South Africa. Journal of Environmental Management 9: 384-395.

Ollis DJ, and Malan H 2014. WRC project k5/2192 Draft final report (Volume 1) Review of available methods for the assessment of the ecological condition of wetlands in South Africa. Water Research Commission, Pretoria.

Ollis DJ, Snaddon CD, Job NM, and Mbona N, 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems No. 22, SANBI Biodiversity Series. South African National Biodiversity Institute, Pretoria. Draft final report to the Water Research Commission, Pretoria.

Pierzynski GM, McDowell RW and Sims JT. 2005. Chemistry, cycling and potential movement of inorganic phosphorus in soils. In: Sims J T and Sharpley A N (eds.) Phosphorus: Agriculture and the environment. Agronomy Monographs 46. ASA, CSSA and SSSA, Madison.

Randall G W, and Goss M J, 2001. Nitrate Losses to Surface Water through Subsurface, Tile Drainage. In: Follet RF and Hatfield JL (eds.) Nitrogen in the Environment: Sources, Problems, and Management. Elsevier, Amsterdam.

Scott D F, 2005. On the hydrology of industrial timber plantations. Hydrological Processes 19, 4203–4206.

Scott, D F, Le Maitre, D C, Fairbanks, D H K, 1998. Forestry and streamflow reductions in South Africa: a reference system for assessing extent and distribution. Water SA 24, 187–199.

Scott, D F, Lesch, W, 1997. Streamflow responses to afforestation with Eucalyptus grandis and Pinus patula and to felling in the Mokobulaan experimental catchments, Mpumalanga Province, South Africa. Journal of Hydrology 199, 360–377.

Schoonover J E, and Lockaby B G, 2006. Land cover impacts on stream nutrients and fecal coliform in the lower Piedmont of West Georgia. Journal of Hydrology 331: 371-382

Sieben, E J, Mtshali H, and Janks M. 2014. National Wetland Vegetation Database: Classification and analysis of wetland vegetation types for conservation planning and monitoring. Water Research Commission Report K5/1980.

Skaggs R W, 1980. A water management model for artificially drained soils. Technical Bulletin No. 267. North Carolina Agricultural Research Service, NC State University, Raleigh.

Thompson MW, 1996. A standard land-cover classification scheme for remote sensing applications In South Africa. South African Journal of Science 92: 34-43.

Thorburn P J, Wilkinson S N, Silburn D N, 2013. Water quality in agricultural lands draining to the Great Barrier Reef: A review of causes, management and priorities Agriculture, Ecosystems and Environment 180: 4-20

Tiner R W, Veneman, P L M, 1988. Hydric soils of New England. Revised bulleting C-183-R. University of Massachusetts Cooperative Extension, Amherst, MA.

Trombulak S C, 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14: 18–30.

Vidon P, Campbell M A, Gray M, 2008. Unrestricted cattle access to streams and water quality in till landscape of the Midwest. Agricultural Water Management 95: 322-330.

Walters D J, Kotze D C, and O’ Connor T G, 2006 Impact of land use on community organization and ecosystem functioning of wetlands in the southern Drakensberg mountains, South Africa. Wetlands Ecology and Management. 14: 329-348.

Appendix A: An explanation of the formula used for combining the total impact scores from the wetland's upslope catchment and from within the wetland

The impact score from within the wetland and that from the wetland's upslope catchment are combined in such a way that the higher score has the dominant effect but is adjusted by the lower score using the following formula.

If IWithin> ICatchment then	IOverall= IWithin + (10-IWithin)*ICatchment/10
But if IWithin< ICatchment then	IOverall= ICatchment + (10-ICatchment)*IWithin/10

Where:

IOverall is the combined overall impact score (from 0 [no impact] to 10[critical impact])

IWithin is the Total Impact score (0 to 10) from land uses within the wetland

ICatchment is the Total Impact score (0 to 10) from land uses in the wetland's upslope catchment

This above option is preferable to, and somewhat of a compromise between, the following three options:

- Taking the highest score alone, and therefore leaving the lower score without any influence over the overall score, which is of particular relevance should one of the scores be moderately high. For example, if IWithin =6.0 and ICatchment =4.5, it would be inappropriate to take IOverall as 6.0, without any regard for how the ICatchment impact of 4.5 was having on the remaining integrity of the wetland.
- Combining the two scores as an average, thereby overly "diluting" a high score if the other score was low. This option fails to recognize that if a wetland is critically impacted from land-uses within the wetland, for example, say IWithin scores 9.5, which effectively leaves almost "no remaining" integrity, it is of no "compensation" that impacts from its catchment are low, say ICatchment scores 1.5. Therefore, to represent the overall impact (IOverall) as 5.5 (the average of the two scores) is inappropriate.
- Adding the two scores together, which would potentially result in IOverall exceeding the maximum score, as would be the case for both of the above examples.

Let us now apply the formula, IWithin + (10-IWithin)*ICatchment/10, to the above two examples.

Example 1, IOverall: 6.0 + (10.0-6.0)*3.5/10 = 7.4

Example 2, IOverall: 9.5 + (10.0-9.5)*1.5/10 = 9.6

From the two examples it can be seen how the lesser impact adds to the greater, but as the greater tends towards 10 (the maximum impact) this additional contribution is proportionally less. This can be more clearly seen in Table A1, which shows how the combined score for Overall magnitude of impact changes across the range of impacts represented for within the wetland and from the wetland's upstream catchment.

Table A1: Scores for overall magnitude of impact on a wetland based on the joint consideration of total impacts arising from within the wetland and total impacts arising from with the wetland's upslope catchment

		Total impacts from within the wetland									
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Total impacts from the wetland's upstream catchment	*1*	**1.9**	**2.8**	**3.7**	**4.6**	**5.5**	**6.4**	**7.3**	**8.2**	**9.1**	**10.0**
	2	**2.8**	**3.6**	**4.4**	**5.2**	**6.0**	**6.8**	**7.6**	**8.4**	**9.2**	**10.0**
	3	**3.7**	**4.4**	**5.1**	**5.8**	**6.5**	**7.2**	**7.9**	**8.6**	**9.3**	**10.0**
	4	**4.6**	**5.2**	**5.8**	**6.4**	**7.0**	**7.6**	**8.2**	**8.8**	**9.4**	**10.0**
	5	**5.5**	**6.0**	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**
	6	**6.4**	**6.8**	**7.2**	**7.6**	**8.0**	**8.4**	**8.8**	**9.2**	**9.6**	**10.0**
	7	**7.3**	**7.6**	**7.9**	**8.2**	**8.5**	**8.8**	**9.1**	**9.4**	**9.7**	**10.0**
	8	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**	**9.8**	**10.0**
	9	**9.1**	**9.2**	**9.3**	**9.4**	**9.5**	**9.6**	**9.7**	**9.8**	**9.9**	**10.0**
	10	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**

Note: while it may be so under exceptional circumstances, impacts from a wetland's upslope catchment seldom exceed a total score of 8, and therefore the shaded cells fall beyond the maximum impact generally resulting from even the most extreme land-cover types in a wetland's upslope catchment.

It is not necessary to weight the catchment lower than the within-wetland. This is because the scores in the original impact tables take into account the fact that the land-covers within the wetland's upslope impact less directly on the wetland than those arising from within the wetland. For example, a mine in the wetland's catchment scores 8 whereas a mine directly in a wetland scores 10.

A method to assess wetland ecological condition based on land-cover type

Part 1: The user manual

Donovan C. Kotze

A simple Citizen Science tool to assess the ecological condition of a wetland

This is a product of The Water Research Commission: Project No.K5/2350

GroundTruth Water, Wetlands and Environmental Engineering

WATER RESEARCH COMMISSION

WESSA PEOPLE CARING FOR THE EARTH

Executive summary

A wide variety of different land-cover types occur within wetlands and their upslope catchments, e.g. commercial annual crops or open water of dams, and each land-cover type tends to have associated with it particular ecological impacts. For example, commercial annual crops involve the complete clearance of the indigenous vegetation, application of fertilizers, etc. If this land-cover was in the wetland then these impacts could considerably diminish the ecological condition of the wetland, depending on its extent in the wetland. If located in the wetland's upslope catchment, the impacts would be less direct, e.g. the vegetation in the wetland would not be directly removed, but the quality, quantity and seasonal pattern of water inflows to the wetland could potentially be significantly affected even if the land-cover was located some distance upstream, but again dependent on extent. Therefore, by rapidly identifying which land-cover types occur in a wetland and its catchment and how extensive these land-cover types are, inferences can be drawn about the magnitude of impact on the ecological condition of the wetland. This is the rationale underlying the method given in this report, which is being developed with funding from WWF and the Water Research Commission.

The scoring system of the method is based on that applied by WET-Health, which is a tool developed for assessing the ecological condition of South African wetlands. This involves estimating the spatial extent of individual land-cover types (each expressed as a proportion of the wetland and then of its upslope catchment). Proportional extent is then multiplied by the intensity of impact of each individual land-cover type, which ranges from 0 (no impact or deviation from natural) to 10 (critical impact or complete transformation from natural) to give a magnitude of impact score. The impact magnitude scores for all of the individual land-cover types present in the wetland are added together to derive a total ecological impact score for all land-covers in the wetland. In a similar way, a total ecological impact score for all land-covers in the wetland's upslope catchment is derived, accounting for the moderating effect that a buffer zone of natural vegetation around the wetland is likely to have, depending on its extent. Finally, the total score for impacts of land-covers in the wetland is combined with the total score for land-covers in the wetland's upslope catchment to arrive at an overall impact score for the wetland, which also ranges from 0 to 10.

The method builds on the approach of the WET-Health level 1 vegetation component, where default intensity scores have been assigned to each of a range of disturbance (land-cover) types. This approach is extended to the hydrology, geomorphology and water quality components to align them more closely with the vegetation component. The operator of the method is presented with a comprehensive list of land-cover types, to which typical impact intensity scores have been pre-assigned based on the scientific literature, expert judgement and peer-review. The land-cover types are represented in photos to aid in their identification. A list of land-cover types potentially occurring in a wetland's upslope catchment is also provided. The primary task of the operator who is applying the method is to identify the different land-cover types present in a wetland and its upslope catchment and then to identify the extent of these types. The method does not require that the operator assign impact intensity scores, as required by WET-Health, thereby reducing the prominence that subjective judgments play on the part of the operator in the assessment, which is hoped will reduce the vulnerability of the method to inter-operator variability.

This method is divided into two parts: Part 1 (the user manual) is a detailed step-by-step description of the method; and Part 2 (this document) is a description of the technical background to the method, its scientific basis, and the specific rationale underlying the impact intensity scores assigned to different land-cover types.

Part 1 describes of two possible assessment options, both including steps to carry out in the office and steps for the field. The first option, a qualitative sketch-map option, is applicable if a brief scoping of the various

factors impacting upon the wetland is needed but an overall score is not required. The second option, a semi-quantitative map-based option, is applicable if an overall ecological condition/health score is required and/or the condition of the wetland is being monitored and users of the tool have access to Google Earth Pro or other means of generating a land-cover map. In both options, there is provision for considering impacts not accounted for with land-cover, e.g. the point source release of wastewater into the wetland.

Users of the method should have reasonable field experience of wetlands in the region that they are assessing. However, they are not required to be wetland specialists, and might be field technicians or citizen scientists. The method is appropriate for situations where many wetlands need to be assessed across broad landscapes, particularly where good land-cover data are available. Some specific applications include: broad-scale catchment assessment and State of the Environment reporting. The method can also be applied where only one or two wetlands need to be assessed very rapidly or by citizen scientists lacking advanced technical training.

The method does, however, have several limitations which need to be recognized. In particular the method takes little account of the wetland's particular features, e.g. local climate and geology, the wetland's hydrogeomorphic type, the inherent erodibility of the soil in the wetland and the inherent infiltration potential of the soil in the wetland's upslope catchment. Although the method considers the extent to which a buffer zone of natural vegetation around the wetland moderates the impacts from the wetland's upslope catchment, this is done at a very coarse level. Given these limitations, it is important to recognize that the method is generally restricted to scoping-level assessments, and the results need to be seen as tentative, particularly with respect to the water quality component. Thus, a more detailed assessments of some of the assessed wetlands is likely to be required.

Contents

What are wetlands and why are they important?

What is a wetland?

The National Water Act, 1998 (Act No. 36 of 1998) defines wetlands as:

"*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils.*"

There is a wide variety of different types of wetlands, and this can make identifying a wetland tricky. For example, there are high altitude wetlands, mangrove forests, peatlands, and even arctic wetlands (http://www.wetlands.org/Whatarewetlands/tabid/202/AlbumID/11392-86/Default.aspx), and RAMSAR has a very broad definition of wetland, which can be found at http://www.ramsar.org/

However, for our purposes, we will use the definition provided by the National Water Act.

So, why are wetlands so important?

Throughout history, wetlands have provided a range of ecosystem goods and services to society. These include services such as reducing flood damage, reducing erosion, groundwater recharge & discharge, providing food, shelter and recreation & tourism http://www.grca.on.ca/stdprod_091596.pdf.

Ecologically, wetlands play a vital role in controlling water flow. In times of high rainfall and floods wetlands tend to slow the water flow, acting to reduce the impacts of flood events (Kotze, 1997). When water flow is slowed by a wetland, suspended matter settles out in the wetland and nutrients are absorbed by the wetland microbes and plants, which are adapted to thrive in these conditions. Thus, water quality is generally improved. (http://www.wetland.org.za/WetlandBasics.html)

Wetlands provide food, shelter, breeding and resting places for many plants, mammal, bird, reptile, amphibian, fish, and invertebrate species. Wetlands provide the critical habitat that many such organisms need to survive http://www.grca.on.ca/stdprod_091596.pdf.

Wetlands in South Africa, as in the rest of the world, are under serious threat, and it is estimated that up to 50% of wetlands in South Africa may have already been lost or degraded. Threats include activities such as channelization, crop production, effluent disposal and water abstraction.

How do our activities impact upon wetlands?

How we use wetlands and the scale on which we do so determines the extent of our impact. Land-use activities (e.g. growing crops or damming water) often affect how a wetland functions and what benefits it provides to society. In many cases, the effects are negative, such as when a wetland is disturbed in order to plant crops, the wetland's function of trapping sediment and holding the soil is reduced. This reduces the benefits that society receives from the wetland in purifying water and controlling erosion.

Impacts on wetlands result from both "on-site" activities in the wetland (e.g. drainage, cultivation disturbance, infilling, and flooding by dams) and from "off-site" activities (e.g. afforestation, mining and crop production) in the wetland's upslope catchment (Kotze, 1997). The wetland's upslope catchment refers to that area upslope of the wetland from which water flows (both above- or below-ground) into the wetland, including the slopes immediately alongside the wetland as well as including slopes further away which feed any streams ultimately supplying the wetland (Figure 1).

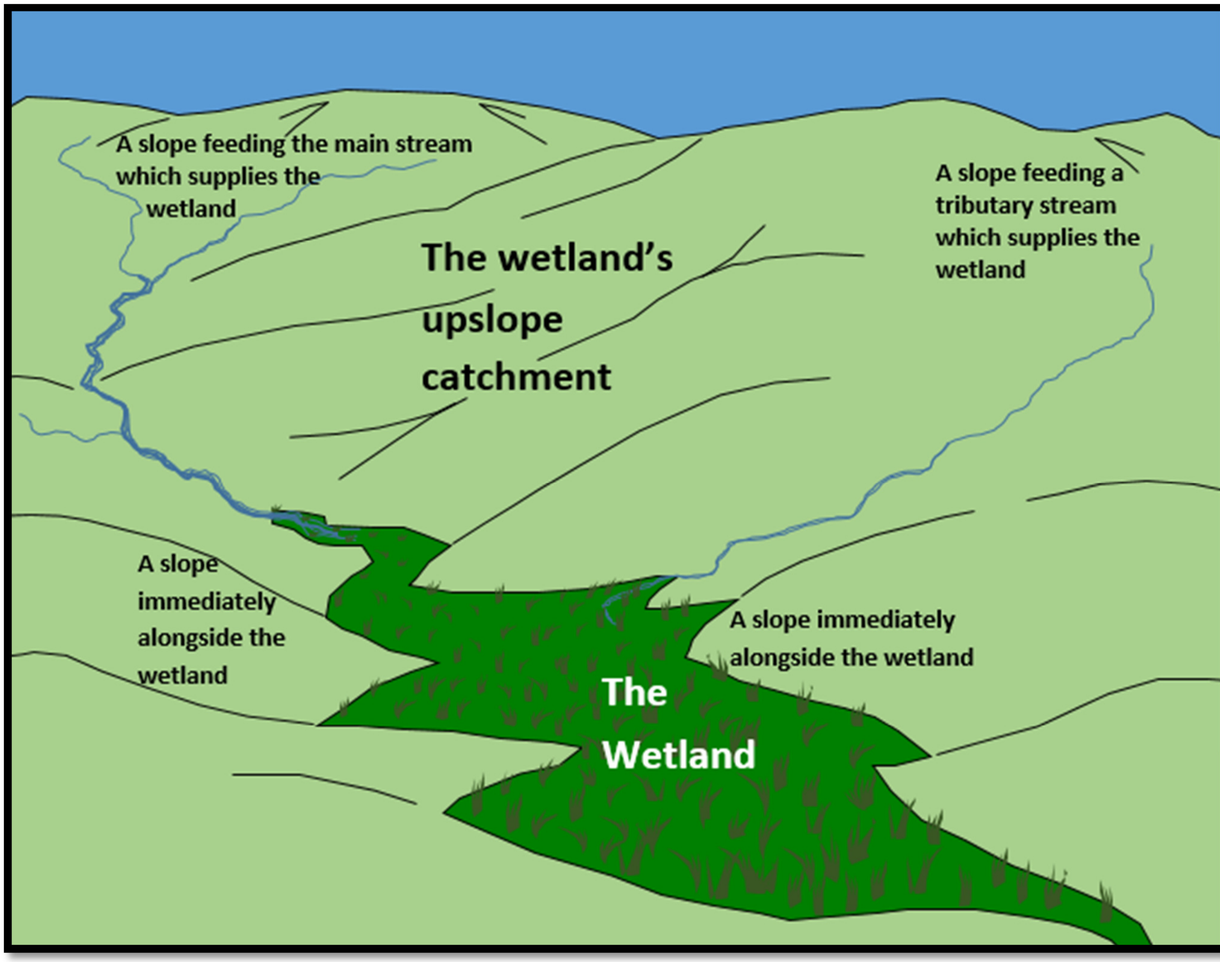


Figure 1: A wetland and its upslope catchment

Wetlands vary greatly in terms of the level to which they are impacted upon by human activities in the wetland and/or in the wetland's upslope catchment. In Figure 1 the wetland and the wetland's upslope catchment are under natural vegetation and no impacts are visible. In Figure 2 extensive areas of natural vegetation in the wetland and the wetland's upstream catchment have been transformed by human activities into various other land-cover types, resulting in large impacts arising from within the wetland and the wetland's upslope catchment.

Land-cover within the wetland has the potential to result in the greatest impacts to the wetland. This applies particularly to those land-cover types involving the complete removal of the natural vegetation. In Figure 2 it can be seen that infilling has resulted in the natural vegetation and wetland hydrological conditions being completely lost in two localized portions of the wetland. However, the overall impact of this infilling is limited by the limited extent of this land-cover in the wetland (about 2% of the wetland). Cultivation also involves the removal of the natural vegetation and the impacts of cultivation depend strongly on the level to which water retention in the wetland is reduced by artificial drains in the cultivated area. In Figure 2, although impacts on water retention is moderate as a result of shallow furrows and does not include major artificial drainage furrows, annual cultivation covers about 45% of the wetland, and therefore the overall impact on the wetland is relatively high.

Land-cover located in a wetland's upslope catchment has the potential to impact upon the quantity and seasonal pattern of water inflows to a catchment as well as the quality of the water entering the wetland. In Figure 2, it can be appreciated how the impermeable surfaces of the roads and built-up areas, which reduce the infiltration of water which falls during storm events, are likely to increase the intensity of surface water runoff into the wetland. The quality of water is affected by both non-point source water pollution which arises from diffuse sources, and may enter the water resource via both surface flow or subsurface flow (i.e. flow beneath the surface of the soil, moving slowly between the soil particles) and by point source pollution (Figure 3). However, it is important to recognize that the amount of non-point source pollutant reaching a wetland may be significantly reduced by a buffer of natural vegetation surrounding the wetland. Again, individual wetlands vary greatly in terms of the extent of this buffer zone (Figure 4).

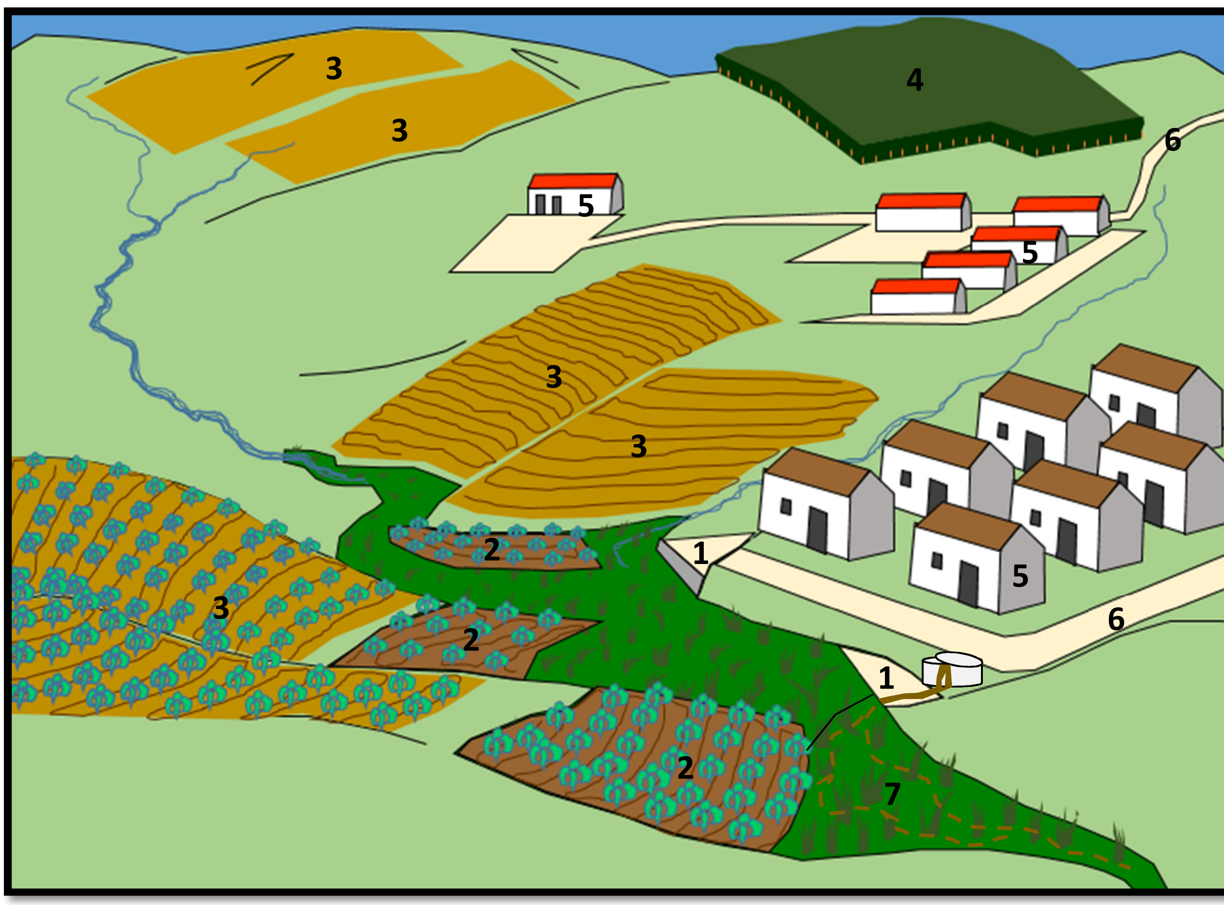


Figure 2: Extensive areas of natural vegetation have been transformed in both the wetland (1=infilling with concrete rubble, 2=commercial annual crops, not irrigated) and its upstream catchment (3=commercial annual crops not irrigated, 4= tree plantations, 5=built-up areas, 6=roads). In addition, an area of natural wetland is affected by the point-source release of untreated wastewater (7).

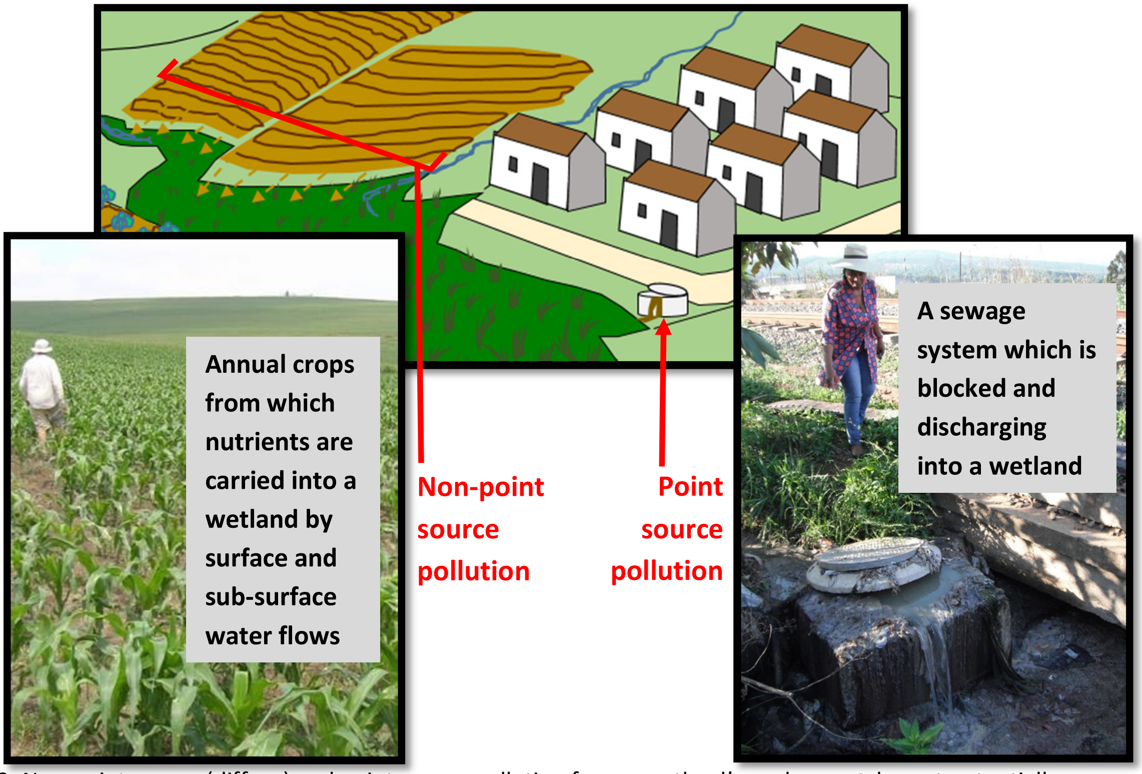


Figure 3: Non-point source (diffuse) and point source pollution from a wetland's upslope catchment potentially impacting upon the water quality of a wetland.

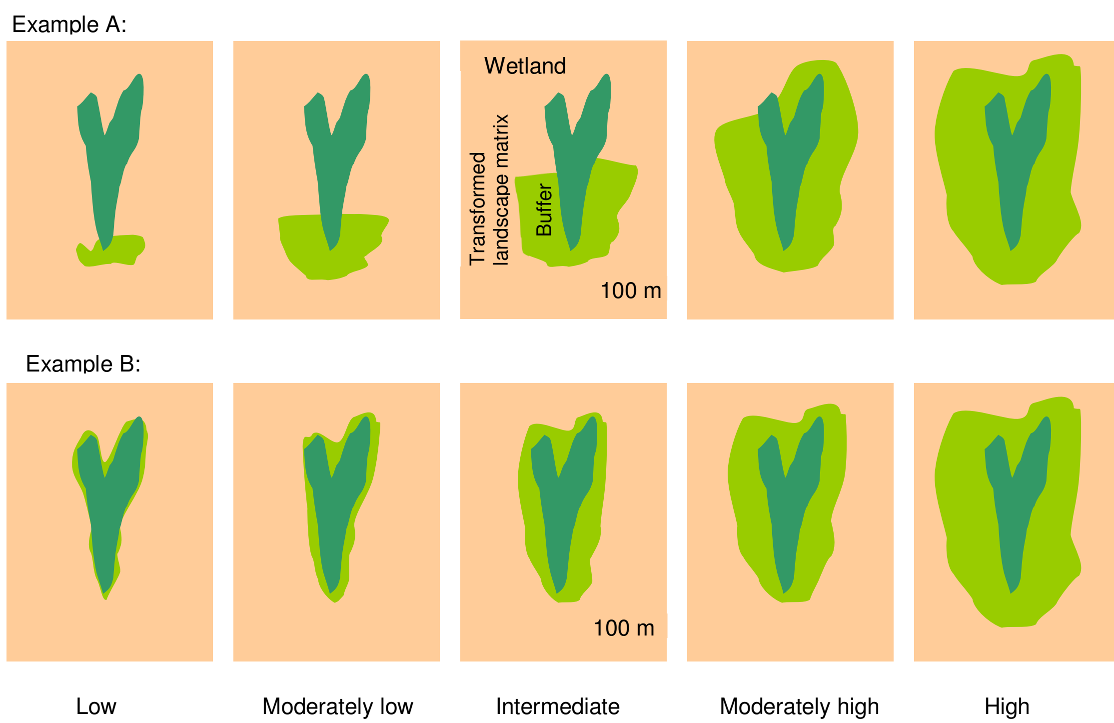


Figure 4: A guideline for scoring the extent of a buffer zone of natural vegetation around a wetland (adapted from Kotze et al. 2009).

Major impacts to wetlands (as can be seen in the example given in Figure 5) lead to a loss in biodiversity, as the plants and animals adapted to wetland habitats are often unable to adapt to new environmental conditions or to move to other habitats. Loss of water quality and flow regulation are other serious consequences of major impacts to wetlands, often resulting in loss of not only water provisioning but also the ability to use the water provided due to reduced water quality. There is also a loss of harvestable resources when wetlands are lost (e.g. reeds and grasses used in traditional construction).

Figure 5: A valley bottom wetland occupied by commercial annual crops, as well as by dense infestations of invasive alien trees. Only small fragments of natural/semi-natural vegetation remain. However, most of the wetland's upslope catchment is occupied by natural vegetation.

Overview of the method and its limitations

The method described in this document is designed to assess the ecological condition or health of a wetland. It is based on identifying the land-cover types (e.g. tree plantations, sugarcane, eroded areas and natural areas) present in the wetland and its upslope catchment and the extent of these types.

As explained further in Part 2, Section 3.1 and 3.2, each different land-cover type tends to have particular ecological impacts associated with it, e.g. in annual crops the complete clearance of the indigenous vegetation and the addition of fertilizers. If located in the wetland's upslope catchment, the impacts would be less direct than if in the wetland itself, e.g. the vegetation in the wetland would not be directly removed. Nonetheless, the quality, quantity and seasonal pattern of water inflows to the wetland could potentially be significantly affected. Therefore, by identifying which land-cover types occur in a wetland and its upslope catchment and how extensive these land-cover types are, inferences can be drawn about the likely magnitude of impact on the ecological condition of the wetland. This forms the central approach of the method.

This method consists of two parts. Part 1 is a step-by-step guide for applying the method. Part 2 is a description of the background to the method, its scientific basis, and the specific rationale underlying the impact intensity scores assigned to different land-cover types.

Part 1 provides two options for the user: (a) a sketch-map option and (b) a detailed-map option. Based upon your particular situation, you need to decide which option is most appropriate for you.

The sketch-map option (described in Section 4) generates a qualitative result and is generally appropriate in the following situations:

- A brief introduction of the various factors impacting upon the wetland is required but a score of ecological condition/health is not required.
- The information collected is not being used for monitoring.
- The users of the tool do not have access to Google Earth Pro or any other means of generating a land-cover map.

The detailed-map option (described in Section 5) is generally appropriate in the following situations:

- An overall ecological condition/health score is required to be as accurate as possible.
- The user already has a good background in wetland ecology.
- The condition of the wetland is being monitored based on repeated assessments over time.
- Users of the tool have access to Google Earth Pro or other means of generating a land-cover map.

Both options are based on Table 1 and 2 presented in Part 2, but in the sketch-map option, the tables have been condensed to a greater degree.

Even though the method is considered suitable for a wide range of users, applying it to a diversity of purposes, it is very important that due recognition be given to the limitations of the method, which are summarized below and given in more detail in Part 2, Section 4.

The method has been designed to be applicable to all types of inland wetlands, i.e. wetlands which do not have marine water inputs. However, as will be described in Part 2, Section 4, it has some particular limitations when applied to certain wetland types, notably depression wetlands on a coastal plain. The method takes little account of the wetland's particular features, e.g. local climate and geology, the wetland's hydrogeomorphic type, the inherent erodibility of the soil in the wetland and the inherent infiltration potential of the soil in the wetland's upslope catchment. In addition, it is recognized that even though a set impact intensity is assigned to all land-cover types (e.g. for eucalypt plantations in a wetland it is 6.4) for certain land-cover types the impact intensity may vary quite widely from one site to the next. Furthermore, although the method considers the extent to which a buffer zone of natural vegetation around the wetland moderates the impacts from the wetland's upslope catchment, this is done at a very coarse level.

Given the limitations of the method, it is very important to recognize that the method is generally restricted to scoping-level assessments, and the results need to be seen as tentative, particularly with respect to the water quality component. Thus, a more detailed assessments of some of the assessed wetlands is likely to be required.

For who is the method designed & for what purposes can it be used?

Users of the method described in this document should have reasonable field experience of the geographical area that they are assessing. However, they are not required to be a wetland specialist in order to apply the method. Specific users of the method might include:

- Field technicians
- Citizen scientists
- General environmental practitioners
- Wetland practitioners
- Landowners

The method is especially useful for situations where many wetlands need to be assessed across a broad landscape, particularly where good land-cover data are available. Some of the specific applications in this regard include:

- Broad-scale catchment assessment and monitoring programmes
- State of Environment Reporting
- Prioritizing at a landscape/sub-catchment level, e.g. for wetland rehabilitation
- Strategic Environmental Assessments

The method also has application as a learning tool for users whose primary purpose is to build their understanding of how land-use activities potentially affect wetlands.

The sketch-map option

This assessment option is mostly carried out in the field and, as can be seen below, it involves fewer steps than the detailed-map option.

Steps to carry out in the office before going into the field

Select a wetland that you would like to work in

Find a wetland that you are interested in studying. Make sure that you obtain permission from the landowner to work in the wetland. If you have access to the internet, you can use Google Earth or Google Maps (https://www.google.co.za/maps/) to view your wetland and types of infrastructure and land cover in and near to the wetland.

Familiarize yourself with land-cover types you may potentially find in the wetland

Refer to Table 1, which provides a list of land-cover types and the likely intensity of impact these might have on the wetland. Also, look at the photographs of the different land-cover types in Section 6.

Familiarize yourself with land-cover types you may potentially find in the wetland's upslope catchment

Refer to Table 2, which provides a list of land-cover types and the likely intensity of impact on the wetland commonly associated with each land-cover type.

Ensure that you have all of the necessary items before going to the field

Make sure you have Tables 1 and 2 and the photographs of the land-cover types (Section 6) with you to take to the field, they provide the primary prompts for collecting the information in the field. Remember to take a pen/pencil and a notebook. It is also valuable to have available a map of the general area (e.g. a Google Maps of Google Earth print-out of the area). If you have a GPS and a camera, take those along. Any field-guides that you have for the identification of alien plants, e.g. Bromilow (2010) would also be very useful.

Steps to carry out in the field

Observe the wetland and its catchment from a nearby vantage point and walk through the wetland

Take particular note of which of the land-cover types in Table 1 you can see within the wetland and which land-cover types in Table 2 you can see within the wetland's upslope catchment. Take note of features such as artificial drainage channels, erosion gullies and the presence of invasive alien plants. Try to find someone with a good historical knowledge of the wetland to obtain additional information on past and current use of the wetland, including activities such as discharge of wastewater and pumping of water out of the wetland.

Draw a sketch-map of the wetland and its catchment

The map should include the boundary of the wetland and its catchment and the approximate location of different land-cover types in the wetland and its upslope catchment. The wetland's upslope catchment refers to the area upslope of the wetland from where water feeds into the wetland, through both surface- and sub-surface flows (see Section 2).

Complete Table 1 and 2 (which appear in Section 4.3)

In Table 1, record which land-cover types are present in the wetland and if they occupying a small, moderate or extensive portion of the wetland. In Table 2, record which land-cover types are present in the wetland's upslope catchment and if they are occupying a small, moderate or extensive portion of the wetland's upslope catchment.

Determine which factors are having the greatest impact on wetland health

Review Table 1 dealing with land-cover in the wetland and Table 2 dealing with land-cover in the wetland's upslope catchment to see which factors are having the greatest impacts on the health of the wetland. The higher the intensity and the more extensive the land cover, the greater the magnitude of impact on the wetland. For example, if irrigated commercial annual crops with severe artificial drainage (which has a high impact intensity) occurred over a large area (extensively) in a wetland, then it would have a much greater impact than old abandoned lands with negligible artificial drainage, even if the old lands were equally as extensive in the wetland. If natural areas within the wetland were limited in extent it would be clear that the wetland overall was highly impacted. Conversely, if the natural areas of the wetland had no observable onsite impacts where land-cover types with large, serious or critical impacts are limited in extent in the wetland and its upslope catchment then impacts on the wetland are likely to be relatively low.

It is important to note that for the sketch-map option the information collected on the land-cover types in the wetland and its upslope catchment is used to flag key potential impacts on the wetland. It is not used to derive a health score for the wetland, as is carried out in the detailed-map option.

Identify future changes

Identify anticipated future changes to the health of the wetland based on observed trends. For example, do you expect observed erosion (see photos in Section 6) to continue advancing through the wetland in the future? If so, there would be a continuing increase in the impact. Make suggestions on what is anticipated to happen to the wetland in the future: a large improvement, a slight improvement, remain the same, a slight decline or a large decline in the health of the wetland.

Management actions

Identify and record management actions you think would be required to prevent any further deterioration in the ecological condition of the wetland and could hopefully improve the ecological condition of the wetland.

Tables to fill in for land-cover types in the wetland and the wetland's upslope catchment

For impacts arising from **within the wetland** record in Table 1 the extent of each the different land-cover type present in the wetland. For impacts arising from **within the wetland's upslope catchment**, record in Table 2 the extent of each of the different land-cover type present in the wetland's upslope catchment.

If you wish to see the basis on which the intensity of impact for each land-cover type given in Table 1 and 2 was determined then refer to Part 2, Section 3, where this is described in detail.

In order to show how the method might be applied, the example represented in Figure 2 is presented in Appendix A as Tables A1 and A2, which are abridged versions of Tables 1 and 2, showing only the land-cover types represented in the example.

Table 1: Impact intensities for a range of different land-cover types potentially occurring within a wetland

Land-cover/disturbance types		Intensity of impact[1]	Extent in the wetland		
			Present but small extent (<10% of the total area)	Moderately extensive (10-50%)	Extensive (>50%)
Annual crops, commercial, irrigated[2]	With moderate to severe artificial drainage[3]	Serious			
	With negligible artificial drainage[3]	Large			
Annual crops, commercial, not irrigated[4]	With moderate to severe artificial drainage[3]	Serious			
	With negligible artificial drainage[3]	Large			
Annual crops, subsistence[5]	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Moderate			
Sugarcane[6]	With moderate to severe artificial drainage[3]	Serious			
	With negligible artificial drainage[3]	Large			
Vineyards & Orchards	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Large			
Planted pastures	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Large			
Recently abandoned lands[8]	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Moderate			
Old abandoned lands[8]/ semi-natural areas[9]	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Small			
Tree plantations		Serious			
Dense infestations of invasive alien plants	Trees	Serious			
	Herbaceous invasive alien plants, e.g. American bramble.	Large			
Erosion gullies	Erosion gully with negligible vegetation colonization	Serious			
	Erosion gully colonized with vegetation	Serious			
Infilling and infrastructure, including roads and buildings		Critical			
Mines and quarries		Critical			
Sports fields or gardens[11]		Large			
Recent sediment deposits		Large			
Dams, ponds and areas where were water supply has been artificially sustained	Deep flooding by dams/ artificial ponds or upstream of embankments,	Serious			
	Shallow flooding by dams/ artificial ponds or upstream of embankments in the unit[8]	Moderate			
	Seepage downslope of dams or embankments or areas where water supply has become more sustained (e.g. from irrigation return flows)[12]	Moderate			
Natural areas of the unit with moderate on-site impacts (e.g. with moderate artificial drainage or discharge of wastewater)		Moderate			
Natural areas of the unit with small on-site impacts (e.g. scattered invasive alien plants)		Small			
Natural areas of the unit with no observable onsite impacts		None			

[1]Intensity of impact was determined in Part 2 based on considering impacts to hydrology, geomorphology, water quality and vegetation. See Part 2, Section 3, Table 1 and the rationale following the table. If you wish to see why mines and quarries, for example, have such a high intensity of impact then this is explained in Part 2, Section 3.

Table 2: Impact intensities for a range of different land-cover types potentially occurring in a wetland's upslope catchment

Land-cover types in the wetland's catchment	**Impact intensity[1]**	**Extent in the wetland's upslope catchment**		
		Present but limited in extent (<10% of the total area)	**Moderately extensive (10-50%)**	**Extensive (>50%)**
Tree plantations	Large			
Orchards & vineyards	Large			
Annual crops	Large			
Sugarcane	Large			
Mines and quarries	Critical			
Built up areas, roads, railway lines and airfields	Serious			
Golf courses, sports fields & low density settlements	Moderate			
Old lands/ semi-natural vegetation	None			
Natural vegetation	None			
Eroded areas	Large			
Dams	Large			

[1]The impact intensity is based on considering impacts on Water quantity and pattern and on Water quality, as shown in Part 2, Section 3, Table 2 and the rationale following the table.

Indicate the extent of the buffer zone around the wetland (see Figure 4)

Low □	Moderately low □	Intermediate □	Moderately high □	High □

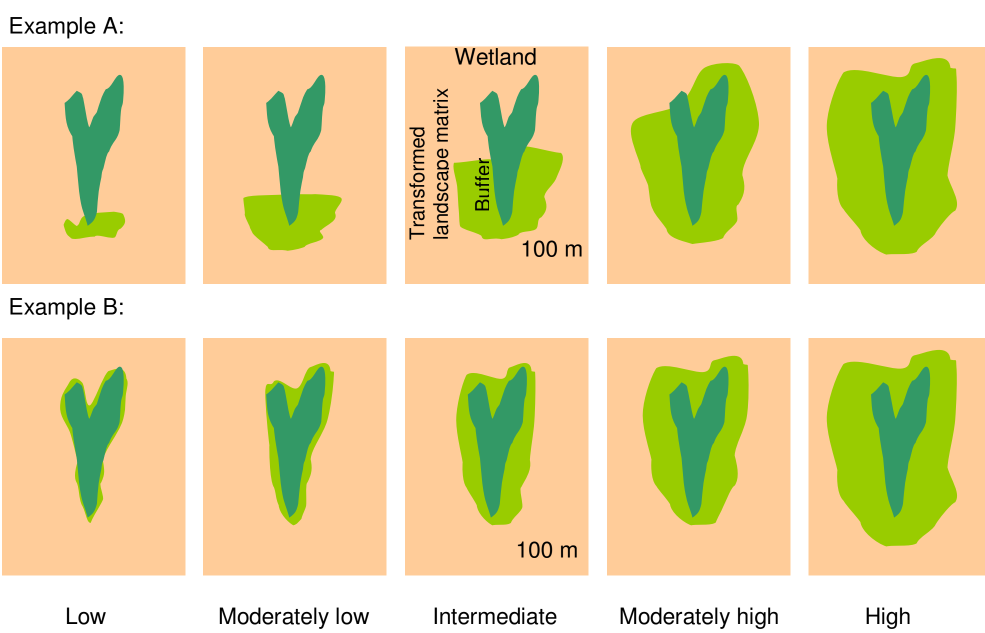


Figure 4: A guideline for scoring the extent of a buffer zone of natural vegetation around a wetland (adapted from Kotze et al. 2009).

Additional notes:

The detailed-map option

Steps to carry out in the office before going into the field

Secure experienced support for carrying out the assessment

If you do not have a good depth of experience in assessing wetlands generally and in the region in which you will be undertaking the assessment then it is advisable to contact someone who does have this experience to help guide you in carrying out the assessment and reviewing what you have done. In particular he/she can help you distinguish natural vegetation from semi-natural vegetation, which can be challenging without good local knowledge of the vegetation.

Identify the boundary of the wetland (i.e. delineate the wetland)

The mapping of a wetland boundary in the field is known as delineation. Delineation requires a high level of experience, especially in the interpretation of the appearance of the soil in the field and in the identification of wetland plant species. Many wetlands in the South Africa have already had their boundaries mapped. This may be for certain regions, as was undertaken for the Mpumalanga Highveld (Mbona et al. 2015) or undertaken coarsely at a national level as part of the National wetlands inventory (http://bgis.sanbi.org/nwi/project.asp). If you lack experience in the delineation of wetlands, you are encouraged to focus on wetlands which have already been mapped/delineated rather than trying to delineate the wetland yourself. Nevertheless, it may not always be possible to focus on a wetland which has already been mapped, in which case refer to the wetland delineation guidelines of DWAF (2006) (available from: http://www.dwa.gov.za/Documents/Other/EnvironRecreation/wetlands/WetlandZoneDelineationSep05Part2.pdf) and the mapping guidelines of Job et al. (in prep.) (which will be completed this year and become available on the Water Research Commission website, http://www.wrc.org.za/pages/KnowledgeHub.aspx) and seek assistance from someone who is experienced with delineation. You may also wish to carry out the delineation as a means of building your understanding about wetlands.

Map the boundary of the wetland's upslope catchment

The wetland's upslope catchment refers to the immediate area (the part of the catchment you are able to observe or physically access within reasonable time) up-slope of the wetland from which water (surface and sub-surface) flows into the wetland. A contour map of the area is useful to assist in mapping the catchment. Job et al. (in prep.) provide specific guidance on the use of a contour map to map the wetland's catchment. As described in Part 2, depression wetlands on coastal plains may be fed by a much larger area than the wetland's local, topographically-defined catchment, making them problematic to map. However, for the purposes of this assessment the wetland's local catchment could be used, based on the assumption that impacts arising from areas in close proximity to the wetland will have the most influence over inputs to the wetland (Malan and Day, 2012).

Identify the hydrogeomorphic type of the wetland

Hydrogeomorphic types refer to the shape of the landform as well as how the water flows through this landform. The landform and the water flow both impact on each other to influence the water flow and landform. Hydrogeomorphic types describe whether the wetland is a floodplain, channelled valley-bottom, unchannelled valley-bottom, depression, seep or flat. For a description of these types refer to Ollis et al. (2013) which is a classification system designed for use by both specialists and non-experts. It is user-friendly, with many illustrations and photographs. Although not absolutely necessary for carrying out the condition assessment, identification of the wetland's hydrogeomorphic type allows an improved assessment of ecological condition.

Familiarize yourself with land-cover types you may potentially find in the wetland

Refer to Table 3, including footnotes, which provides a list of land-cover types and the likely intensity of the impacts commonly associated with each land-cover type on the wetland.

Familiarize yourself with land-cover types you may potentially find in the wetland's catchment

Refer to Table 4, which provides a list of land-cover types and the likely intensity of impact on the wetland's catchment commonly associated with each land-cover type.

Undertake a preliminary map of land-cover

Make a preliminary map of the land-cover types in the wetland and the wetland's upslope catchment. Use Table 3 and 4 as a guide. Create the map using either a GIS (Geographic Information System) or Google Earth Pro (http://www.google.co.za/earth/download/gep/agree.html). Further information on land-use can be obtained from the 1:50 000 topographical maps (http://www.ngi.gov.za/index.php/what-we-do/maps-and-geospatial-information/35-map-products/51-1-50-000-topographical-maps), although remember that many of these maps are likely to be out of date.

Steps to carry out in the field

Ensure that you have all of the necessary equipment in the field

- Table 3 to 5 (central to the collection of information for the assessment), and the photographs of the land-cover types provided in Section 6.
- A pen/pencil and notepad, a GPS (Geographical Positioning System) and a camera
- A field-guide for the identification of alien plants, e.g. Bromilow (2010)

Observe the wetland

Observe the wetland from a nearby vantage point. If you are able to gain some height for this process it would be advantageous. Walk through the wetland to verify the land-cover types mapped in the office. Make sure you visit all of the different land-cover types mapped in the office. It is possible that some land-cover types have been misinterpreted on your preliminary map, e.g. without field verification old lands might easily be mistaken for planted pastures.

Observe the wetland's upslope catchment

Briefly drive or walk through the wetland's immediate upslope catchment (the part of the catchment you can visually observe or physically access within a reasonable amount of time) to verify the land-cover types mapped in the office. If the upslope catchment does not have roads, rather walk through the catchment. If you are not confident in your own ability to identify land use types in the catchment, talk to a local from the area or expert with good knowledge of history and upstream activities of that particular wetland

Revise the land-cover map

Revise the land-cover map for the wetland and its catchment based on field observations. It may also be necessary to revise the boundary of the wetland. Remember, what we see in the field is real, what we prepared in the office may not be a proper representation of real life.

Note the extent of a buffer of natural vegetation surrounding the wetland
With reference to the revised land-cover map and Figure 4, note the extent of a buffer of natural vegetation surrounding the wetland (Low to High). The higher the extent, the greater is the assumed moderating influence of the buffer on impacts from the upstream catchment.

Steps to carry out after the fieldwork

Spatial extent of land-cover types in the wetland

Identify the spatial extent of the different land-cover types present in the wetland (Table 3) based on the revised map, using Google Earth Pro or a GIS. Record the extent (as a percentage of the overall wetland area) in the Excel spreadsheet versions of Table 3. The Excel spreadsheet automatically calculates the magnitude of the impact for each land-cover type present by multiplying the intensity of impact score pre-assigned to that type by the proportional extent of that type in the wetland. For example, if sugarcane with severe artificial drainage (which has an impact intensity score of 7.1) covers 50% of the wetland then the impact magnitude will be 7.1*50/100 =3.6. Next, Table 1 automatically adds together all of the individual impact magnitude scores for the individual land-cover types present to derive an ecological impact score for land-cover in the whole wetland (see Appendix A for an example).

Spatial extent of land-cover types in the wetland upslope's catchment

Identify the spatial extent of different land-cover types present in the wetland's upslope catchment and record the extent (expressed as a percentage of the wetland's upslope catchment) in the Excel spreadsheet version of Table 4. The spreadsheet automatically calculates the magnitude of the impact for each land-cover type present by multiplying the intensity of impact score pre-assigned to that type by the proportional extent of that type in the wetland's upslope catchment. Next, the spreadsheet automatically adds together all of the individual impact magnitude scores for the individual land-cover types present in the upslope catchment to determine the total magnitude of impact. The extent of the buffer (Figure 4), recorded earlier, is then used by the spreadsheet to reduce the overall impact score of land-cover types upslope of the wetland based on the following multipliers: Low extent = 1 (i.e. the impact score remains the same); Moderately low extent= 0.9; Intermediate extent = 0.8; Moderately high= 0.7; High = 0.6). For example, if the combined magnitude of impact score from land-uses in the wetland's upslope catchment is 4.5 and the extent of buffer around the wetland is high then the adjusted score is 4.5*0.6 =2.7.

Review the combined score

Excel spreadsheet Table 4 automatically generates a combined overall score based on the total impact score from land-cover types in the wetland and the total impact score from the wetland's upslope catchment. This is done in such a way that the higher score has the dominant effect but is adjusted by the lower score (see Part 2, Appendix 1 which explains how this is done, using examples).

Based on the overall score, the spreadsheet indicates to which of the Present Ecological State (PES) categories shown in Table 5 the wetland belongs. If, for example, the overall impact score was 2.9, it can be seen from Table 5 that the wetland would fall into C category for the wetland's PES.

If there are any other impacts on the wetland that you think have been omitted, or if there are important influencing factors which have not been accounted for, the spreadsheet prompts for this information to be noted.

Identify anticipated future changes to the Overall Ecological Impact score

Identify potential or anticipated future changes to the Overall Ecological Impact score based on observed trends. For example, active erosion anticipated to continue advancing through the wetland in the future, thereby continuing to increase the impact score, and identify which of the following is anticipated: a large improvement, a slight improvement, remain the same, a slight decline or a large decline.

Identify and record management actions

Identify and record management actions you think will be required to prevent any further deterioration in the ecological condition of the wetland and hopefully will also improve the ecological condition.

Archive the assessment results

It is important that the assessment results be carefully archived, together with any photographs and additional information collected during the assessment. This is especially important if the assessment is to be repeated as part of a long-term monitoring programme.

Tables to fill-in for land-cover types in the wetland and the wetland's upslope catchment

For impacts arising from **within the wetland** record in Table 3 the extent of each the different land-cover types present in the wetland (as a percentage of the total extent of the wetland).

For impacts arising from **within the wetland's upslope catchment**, record in Table 4 the extent of each of the different land-cover types present in the wetland's upslope catchment (as a percentage of the total extent of the upslope catchment). In addition, with reference to Figure 4, identify the extent to which the wetland is surrounded by a buffer zone of natural vegetation.

If you wish to see the basis on which the intensity of impact scores for each land-cover type given in Table 3 and 4 was determined then refer to Part 2, Section 3, where this is described, including reference to supporting scientific literature.

In order to show how the method might be applied, the example represented in Figure 2 is presented in Appendix A as Tables A3 to A5, which are abridged versions of Tables 3 and 5, showing only the land-cover types represented in the example.

Table 3: Overall impact intensity scores, ranging from 0 (no impact) to 10 (critical impact), for different land-cover types potentially occurring **within a wetland**

Land-cover/disturbance types[1]		**Overall intensity of impact**[2]	**Extent (% of wetland)**
Annual crops, commercial, irrigated[2]	Conventional tillage, with severe artificial drainage[3]	7.5	
	Conventional tillage, with moderate artificial drainage[3]	6.1	
	Conventional tillage, with negligible artificial drainage[3]	4.9	
	Minimum tillage, with severe artificial drainage[3]	6.5	
	Minimum tillage, with moderate artificial drainage[3]	4.9	
	Minimum tillage, with negligible artificial drainage[3]	3.9	
Annual crops, commercial, not irrigated[4]	Conventional tillage, with severe artificial drainage[3]	7.1	
	Conventional tillage, with moderate artificial drainage[3]	5.6	
	Conventional tillage, with negligible artificial drainage[3]	4.5	
	Minimum tillage, with severe artificial drainage[3]	6.3	
	Minimum tillage, with moderate artificial drainage[3]	4.8	
	Minimum tillage, with negligible artificial drainage[3]	3.8	
Annual crops, subsistence[5]	With severe artificial drainage[3]	6.4	
	With moderate artificial drainage[3]	4.7	
	With negligible artificial drainage[3]	3.8	
Sugarcane[6]	With severe artificial drainage[3]	7.1	
	With moderate artificial drainage[3]	5.4	
	With negligible artificial drainage[3]	4.4	
Vineyards[6]	With severe artificial drainage[3]	6.2	
	With moderate artificial drainage[3]	4.5	
	With negligible artificial drainage[3]	3.7	
Orchards[6]	With severe artificial drainage[3]	6.6	
	With moderate artificial drainage[3]	5.0	
	With negligible artificial drainage[3]	4.2	
Planted pastures, annual[6,7]	With severe artificial drainage[3]	6.6	
	With moderate artificial drainage[3]	4.8	
	With negligible artificial drainage[3]	4.1	
Planted pastures, perennial[6,7]	With severe artificial drainage[3]	5.8	
	With moderate artificial drainage[3]	4.1	
	With negligible artificial drainage[3]	3.2	
Unmaintained perennial pastures	With severe artificial drainage[3]	5.4	
	With moderate artificial drainage[3]	3.7	
	With negligible artificial drainage[3]	2.6	
Recently abandoned lands[8]	With severe artificial drainage[3]	5.8	
	With moderate artificial drainage[3]	3.9	
	With negligible artificial drainage[3]	2.9	
Old abandoned lands[8]/ semi-natural areas[9]	With severe artificial drainage[3]	5.5	
	With moderate artificial drainage[3]	3.2	
	With negligible artificial drainage[3]	1.8	
Tree plantations	Plantations of eucalypt trees	6.4	
	Plantations of pine, wattle or poplar trees	5.7	
Dense invasive alien plant infestation	Eucalypt trees	6.2	
	Pine, wattle or poplar trees	5.4	
	American brambles or other herbaceous invasive alien plants	4.0	
Erosion gullies	Erosion gully with negligible vegetation colonization	7.7	
	Erosion gully colonized with vegetation (mainly alien species)	6.2	
	Erosion gully colonized with vegetation (mainly indigenous species)	5.6	
	Formal residential	8.0	

Land-cover/disturbance types[1]		Overall intensity of impact[2]	Extent (% of wetland)
Infrastructure (Urban and roads)	Informal residential	7.8	
	Commercial/industrial	8.8	
	Roads	8.2	
Infilling without infrastructure	Natural sediment/soil used as infill	8.1	
	Foreign material/ solid waste (e.g. concrete rubble, plastic) used as infill	8.3	
	Mine dumps (spoil from the mining of underlying rock)	9.7	
Mines and quarries	Mining of clay or sand	8.8	
	Mining of underlying rock	10.0	
Sports fields or gardens[11]	Sports fields or gardens on the original wetland ground surface	4.2	
	Sports fields or gardens on wetland which has been infilled	7.4	
Recent sediment deposits	Recent sediment deposition (deep, resulting in loss of wetland conditions).	7.2	
	Recent sediment deposition (shallow, with wetland conditions persisting, although diminished).	3.4	
Dams, ponds and areas where were water supply has been artificially sustained	Deep flooding by dams/ artificial ponds or upstream of embankments, not used for aquaculture	6.0	
	Deep flooding by dams/ artificial ponds or upstream of embankments, used for aquaculture	6.7	
	Shallow flooding by dams/ artificial ponds or upstream of embankments in the unit[8]	3.1	
	Paddy fields	5.1	
	Seepage downslope of dams or embankments or areas where water supply has become more sustained (e.g. from irrigation return flows)[12]	2.8	
Natural, drained[12]	Natural vegetation with severe artificial drainage[3]	4.1	
	Natural vegetation with moderate artificial drainage[3]	2.1	
Natural, with wastewater flows[13]	Natural area of wetland into which the point-source release of untreated or poorly treated wastewater flows (see Figure 2 and 3).	5.1	
	Natural area of wetland into which the point-source release of treated wastewater flows (see Figure 2 and 3)	3.6	
Natural areas, very frequently burnt	Natural area of wetland which are burnt every year (e.g. as part of a firebreak)	2.2	
Natural areas with small on-site impacts	Natural area of wetland affected by scattered invasive alien plants or other minor impacts	1.2	
Natural	Natural vegetation with negligible/no artificial drainage[3]	0.0	

Additional notes (including GPS coordinates of any point sources of pollution; erosion headcuts, etc.):

[1]Intensive livestock grazing is not listed as a land-cover as such, but is assumed to be associated with planted pastures. If it occurs in any of the other land-cover types listed in the table (e.g. old lands) then it is suggested that the impact intensity score be increased by 2 points. Intensive livestock grazing is taken as a stocking rate of higher than 2 ha per large stock unit.

Direct pumping of water out of the wetland is also not covered because of the difficulty of assessing the extent and intensity of the effect on wetland hydrology (see Macfarlane et al. 2009). However, if information is available for assessing this impact then note this under additional notes and include the impact as artificial drainage, because it has a potentially similar effect to artificial drainage in lowering the water level in the wetland.

[2]Intensity of impact has been scored on a scale of 0 (nil/negligible) to 10 (critical) and Overall Intensity was calculated in Part 2 Table 3 as the average of the Hydrology, Geomorphology, Water quality and Vegetation scores, weighted as 3:2:2:2, as recommended by Macfarlane et al. (2009).

[3]Artificial drainage generally comprises open artificial drainage furrows (canals) which are visible on the ground surface, as well as including the draining effect of erosion gullies and incised stream channels. However, it may also comprise buried perforated pipes that are not visible on the ground surface. Severity of artificial drainage depends on spacing, depth and orientation of drainage furrows/pipes in relation to flows (including sub-surface) and tends to be most severe where drainage furrows/pipes are deep, dense and/or oriented to effectively intercept flows through the wetland. For all cultivation types where the level of artificial drainage is not known, it should be assumed to be moderate, given that most wetland cultivation is associated with at least some level of drainage.

[4]For annual crops, commercial, if it is unknown whether there is irrigation or not then it should be assumed that there is irrigation because annual crops are usually irrigated. If it is unknown whether tillage is conventional or minimum tillage then conventional tillage should be assumed because this is more widespread than minimum tillage.

[5]It is assumed that for subsistence agriculture, tillage is by hand and that limited supplementary irrigation takes place.

[6]It is assumed that annual planted pastures (usually ryegrass), vineyards and orchards are irrigated but perennial pastures and sugarcane are not irrigated.

[7]For planted pastures, it is assumed that fertilizer is applied periodically and the pasture intensively grazed. If it is unknown whether the planted pasture is annual or perennial then it should be assumed that it is annual, because in wetlands these are much more widespread than perennial pastures.

[8]Recently abandoned lands are taken as those that have been abandoned within the last year or two (following a period of being under cultivation, timber plantations or subject to some other form of physical disturbance which removed all of the natural vegetation, e.g. with a bulldozer) and are still strongly dominated by annual weedy (ruderal) plants. Old abandoned cultivated lands are those that have been abandoned for long enough for perennial indigenous species to become well represented. If it is unknown when, approximately, the lands were abandoned, then assume that they are old abandoned cultivated lands (i.e. lands abandoned more than three years ago) unless it can be seen that the area is still dominated by annual weeds. Old abandoned lands are likely to be more widespread than recently abandoned lands.

[9]Semi-natural vegetation refers to vegetation where the species composition has been significantly altered, but characteristic indigenous species are still reasonably well represented, although weedy and/or alien species are also generally well represented. If artificial drainage of the semi-natural areas is not known then it should be assumed to be negligible.

[10]The impact of a road is scored up to the edge of the road embankment. This impact does not include the damming effect of a road which is dealt with under "Dams and ponds"

[11]For sports fields and gardens, if it is unknown whether the area is infilled, then assume that it has been infilled because this is probably the most widespread option.

[12]Drained natural areas often support dense stands of common reed (*Phragmites australis*) or bulrush (*Typha capensis*), which outcompete most of the indigenous plant species.

[13]In order to determine whether point-source discharge of water is flowing through an area of wetland will generally require fairly close observation on the ground

If some areas in the wetland could potentially be placed in more than one land-cover class given in Table 3 then select that class which has the highest impact intensity score. For example if an area of wetland is subject to the point-source release of untreated wastewater into the wetland (Intensity score 5.1) as well as having scattered invasive alien plants (Intensity score 1.3) then the impact intensity score for this area is taken as 5.1.

Table 4: Impact intensity scores for a range of different land-cover types potentially occurring in a wetland's upslope catchment

Land-cover types	**Overall intensity of impact on the downstream wetland**[1]	**Extent in the wetland's upslope catchment**
Tree plantations, eucalypt	5.5	
Tree plantations, pine, wattle or poplar	4.5	
Orchards	5.5	
Vineyards	4.0	
Annual commercial (row) crops, irrigated	5.5	
Annual commercial (row) crops, not irrigated	4.5	
Annual subsistence crops	4.0	
Sugarcane	4.0	
Mines and quarries	8.0	
Built up dense settlements, roads railway lines and airfields	6.0	
Golf courses, sports fields & low density settlements	3.0	
Old lands/ semi-natural vegetation	0.5	
Natural vegetation	0.0	
Eroded areas	5.0	
Dams	4.5	

[1]Intensity of impact is scored on a scale of 0 (nil/negligible) to 10 (critical). The impact intensity is based on considering impacts on Water quantity and pattern and on Water quality, as shown in Part 2, Table 4 and the rationale following the table.

Indicate the extent of the buffer zone around the wetland (see Figure 4)
Low □ = 1; Moderately low □ = 0.9; Intermediate □ = 0.8; Moderately high □ = 0.7; High □ = 0.6

Additional notes:

Table 5: Summary of the overall impacts on the wetland and trajectory of anticipated change

Total magnitude of impact from impacts within the wetland:			
Total magnitude of impact from impacts in the wetland's upslope catchment:			
Combined overall magnitude of impacts (see Part 2, Appendix A):			
Present Ecological State category (see Table 5):			
Any impacts on the ecological condition of the wetland which you consider to have been omitted or important influencing factors (see Part 2, Section 4, Table 4) which have not been accounted for:			
TRAJECTORY OF ANTICIPATED CHANGE IN THE WETLAND'S ECOLOGICAL CONDITION OVER THE NEXT 5 YEARS			
Large improvement	□	Supporting motivation:	
Slight improvement	□		
Remain the same	□		
Slight decline	□		
Large decline	□		

Table 5: Overall impact score categories and corresponding Present Ecological State (PES) categories (modified from MacFarlane 2009)

Overall impact score range	Impact category	Description	PES category
0.0-0.9	None	No discernible modification or the modification is such that it has no impact on wetland integrity.	A
1.0-1.9	Small	Although identifiable, the impact of this modification on wetland integrity is small.	B
2.0-3.9	Moderate	The impact of this modification on wetland integrity is clearly identifiable, but limited.	C
4.0-5.9	Large	The modification has a clearly detrimental impact on wetland integrity. Approximately 50% of wetland integrity has been lost.	D
6.0-7.9	Serious	The modification has a clearly adverse effect on this component of habitat integrity. Well in excess of 50% of the wetland integrity has been lost.	E
8.0-10	Critical	The modification is present in such a way that the ecosystem processes of this component of wetland health are totally / almost totally destroyed.	F

Photographs and further information on the land-cover types included in the method

Cultivation

Annual cultivation, commercial	**Annual cultivation, subsistence**
	
Commercial annual crops (e.g. maize, cabbages, potatoes and other vegetables) generally occur as extensive regularly shaped areas with uniform crop rows	Subsistence annual crops are distinguished from commercial annual crops by generally being more irregularly shaped areas, with less uniform crop rows. Many of the crops grown commercially (e.g. maize) are also widely grown for subsistence, but additional crops, notably madumbes, are also widely grown in wetlands.
	
A madumbe (*Colocasia esculenta*) crop	Most sugarcane in South Africa is grown on a large-scale commercial basis but in the former homeland areas it is also grown on a small scale, e.g. through out-growers schemes.

Planted Pastures

By far the most widely grown annual pasture in South Africa is annual ryegrass, mainly grown over the winter period.

Unmaintained Perennial Pastures

A variety of perennial pasture types may persist as strong dominants in wetlands without any maintenance, including the following:

		
Kikuyu (*Pennisetum clandestinum*)	*Paspalum dilitatum*	Nile grass (*Acroceras macrum*)

Sugarcane

Recently Abandoned Lands

Recently abandoned lands are characterized by the dominance of annual weedy plants.

<u>Old Abandoned Lands / Semi-Natural Areas</u>

	
Although annual weeds are clearly visible, they do not dominate the vegetation, and characteristic indigenous species are reasonably well represented.	An area of semi-natural vegetation in a wetland area from which tree plantations have been withdrawn, now characterized by a mix of weedy specie and characteristic indigenous wetland species.

<u>Different levels of artificial drainage potentially present in all crop types</u>

(Examples are given below for annual crops and sugarcane and abandoned/unmaintained lands in annual crops)

Severe	Moderate	None/ negligible
		

In Sugarcane

Severe	Moderate	None/ negligible
		

In addition to drainage furrows, a variety of other forms of artificial drainage may be employed in wetlands, including the following:

	
Ridge and furrow drainage	Raised beds, which is a common form of drainage in subsistence agriculture

Subsurface drainage, which comprises perforated pipes buried beneath the ground surface, are generally not possible to detect based on observation of the land surface alone.

Erosion Gullies

An erosion gully with negligible vegetation colonization	An erosion gully with vegetation colonization

Tree plantations

While the forestry industry has withdrawn considerable tree plantation areas from wetlands since the late 1990s, some tree plantation areas still remain in wetlands. In the photograph to the left, the plantation in the foreground is impinging slightly into the margin of a valley bottom wetland.

Dense infestations of alien invasive plants

Many different invasive alien plant species could be found within wetlands, including species which are well adapted to the prolonged saturated conditions of wetlands; as well as typical terrestrial species which are confined to the naturally drier margins of wetlands or to areas of wetland which have been dried out (e.g. by artificial drainage channels).

Severe

An infestation of American bramble (*Rubus cuneiformis*) within a wetland

For guidance in the identification of invasive alien plants, refer to a relevant guide such as Bromilow (2010)

Infrastructure, Residential

Photo: Dean Ollis

Residential infrastructure impinging into a wetland

Infrastructure, Roads passing through wetland areas

Infilling without Infrastructure

	
Infilling with foreign material (ash) in a wetland	A very small area of wetland infilled with plastic, rubble, etc.

Dams, ponds and areas where water supply had been artificially sustained

	
An area of wetland deeply flooded by a dam	An area of common reed (*P. australis*) sustained in the dry season by irrigation return-flows

Shallowly flooded margin of the dam supporting common reed (*Phragmites australis*)

Natural Areas

Natural vegetation in wetlands encompasses a considerable diversity of plant species, height and growth form. In the example on the left the vegetation consists of tall sedges, short sedges and the indigenous hydric fern *Thelypteris interrupta* and on the right mainly short sedges and indigenous grasses. In both examples, note the lack of weedy plants.

	
Vegetation consists of tall sedges, short sedges and the indigenous hydric fern *Thelypteris interrupta*	Vegetation consists mainly of short sedges and indigenous grasses

Using the method together with other tools

There may be situations where the use of the method can be complemented very well with the use of other inexpensive methods not requiring a high level of expertise, notably the Clarity tube, MiniSASS and the Riparian Health Audit.

The Clarity tube is a tool for measuring water clarity, and is much better suited for shallow or rapidly moving water than alternative methods such as the Secchi Disk method. Studies have shown that the clarity tube measurements showed a strong relationship to turbidity and total suspended solids, and could be used for water measurements at the inflows or outflows to/from the wetland, as well as within the wetland itself. For more information on the Clarity tube see http://www.groundtruth.co.za/equipment/clarity-tube.html.

MiniSASS a simplified version of SASS, which can be used by citizen scientists to monitor the health of a river or stream, and involves collecting a sample of macroinvertebrates (small animals) from the water. Macroinvertebrate groups vary greatly in terms of their tolerance to pollution, and based on which of the macroinvertebrates groups are found in the sample, the health class of the river is indicated. MiniSASS could be used for water measurements in any streams flowing into or out of the wetland, but like SASS is generally not appropriate for applying within the wetland itself. For more information on miniSASS see http://www.groundtruth.co.za/projects/minisass.html.

The Riparian Health Audit method (Desai in prep.) is as a manual for the rapid assessment of the ecological health of riparian ecosystems and identifying the key impacts that should be addressed to maintain or restore its health. Together with their associated rivers, riparian areas form corridors through the catchment and, often linking different wetlands in the overall landscape.

In addition, once the wetland method (and perhaps also some of the other rapid assessment tools mentioned above) has been applied, it may reveal specific issues that need to be investigated in more detail. For example, application of the wetland method may show a high impact on the water quality of the wetland. If that wetland has a particularly high priority (e.g. in terms of biodiversity conservation) it may be required that the impact(s) be validated through the collection of water samples and the analyses of these samples in the laboratory for important water quality parameters (e.g. soluble phosphate).

Acknowledgements

Joint funding of the development of this tool by WWF and the Water Research Commission is gratefully acknowledged. Heather Malan, Mark Graham, Kirsten Mahood, Bonani Madikizela and David Lindley are thanked for providing valuable comments on an earlier version of the tool, and Graham Jewitt, Damian Walters and Mahomed Desai are thanked for providing additional technical feedback. Nokwanda Ndebele, who applied an earlier draft of the method, is thanked for the useful insights this application provided for the revising the method. Heather Malan provided further useful suggestions for improving the document and Kirsten Mahood is thanked for assisting with layout of the document and making it more accessible to the intended users of the method.

References

Bromilow C, 2010. Problem plants and alien weeds of South Africa. Third edition. Briza, Pretoria.

Desai M, in prep. Riparian Health Audit. Water Research Commission, Pretoria.

DWAF, 2006. A practical field procedure for identification and delineation of wetlands and riparian areas. Department of Water Affairs and Forestry, Pretoria.

Job N, Ginsberg A, and Botts E, in prep. Guideline for Wetland Mapping and Inventory in South Africa. Report compiled for The South African National Biodiversity Institute, Pretoria.

Kotze D. C., 1997. Wetlands and people: what values do wetlands have for us and how are these values affected by our land-use activities? WETLAND-USE Booklet 1. SHARE-NET, Wildlife and Environment Society of South Africa, Howick. (Available on http://www.wetland.org.za/WetlandBasics.html)

Kotze D C, Marneweck G C, Batchelor A L, Lindley D S and Collins N B 2009. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. WRC Report No TT 339/09, Water Research Commission, Pretoria.

MacFarlane D M, Kotze D C, Ellery W N, Walters D, Koopman V, Goodman P, and Goge M, 2009. WET-Health: A technique for rapidly assessing wetland health. WRC Report No. TT 340/09. Water Research Commission, Pretoria, South Africa.

Mbona N, Job N, Smith J, Nel J, Holness S, Memani S and Dini J. 2015. Supporting better decision-making around coal mining in the Mpumalanga Highveld through the development of mapping tools and refinement of spatial data on wetlands Report

Ollis DJ, Snaddon CD, Job NM, and Mbona N, 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. No. 22, SANBI Biodiversity Series. South African National Biodiversity Institute, Pretoria. Draft final report to the Water Research Commission, Pretoria.

Glossary

This Glossary is adapted from Macfarlane et al (2009) and Day and Malan (2010).

Alien: Plant or animal species that does not occur naturally in the area

Alluvial fan: Gently sloping conical accumulation of coarse alluvium deposited by a stream upon emergence from an area of confined flow or due to a sudden loss of slope

Alluvium: Sedimentary materials deposited by flowing water as velocity slows

Anaerobic: Having no molecular oxygen (O2) present

Anthropogenic: Of, relating to, or resulting from the influence of human beings on natural objects

Assessment: The process of arranging into classes based on careful analytical evaluation

Bedload: Sediment that is transported by being rolled or bounced along the bed of a stream

Berm: A mound or bank of earth used as a barrier against flooding of land

Bioassessment: The use of living organisms to assess environmental condition (usually with reference to some aspect of conservation)

Biodiversity: Variety of living forms including the number of different species, the genetic variety within each species, and the variety of natural areas

Biophysical: The biological and physical components of the environment

Biotic: Living components of the environment

Buffer zone: a strip of vegetated land (composed in many cases of riparian habitat and upland plant communities) which separate development or adjacent land uses from aquatic resources (rivers, wetlands &
estuaries (Macfarlane et al. 2014)

Canalization: The creation of artificial drains or the incision caused by erosion gullies where no visible confined flow path existed previously

Capillary fringe: The zone of almost-saturated soil or sediment just above the water table

Catchment: All the land area from mountaintop to seashore which is drained by a single river and its tributaries. Each catchment in South Africa has been subdivided into secondary catchments, which in turn have been divided into tertiary. Finally, all tertiary catchments have been divided into interconnected quaternary catchments. A total of 1946 quaternary catchments have been identified for South Africa. These sub-divided catchments provide the main basis on which catchments are sub-divided for integrated catchment planning and management (consult DWAF [1994]).

Channel: The part of a river-bed containing its main current, naturally shaped by the force of water flowing within it.

Chroma: The quality of a colour; in classifying soils, the relative purity of the spectral colour of a soil, which decreases with increasing greyness. Measured with a Munsell colour chart.

Citizen scientist: A member of the general public who engages in scientific work, often relating to his/her natural environment, and usually leading to new learning skills and a deepening of his/her understanding of the environment. This increased understanding provides a sound basis on which to take action to address issues facing the environment. Citizen scientists generally work as networks of volunteers, often in collaboration with professional scientists.

Clarity tube: an inexpensive, robust and easily transported tool for measuring water clarity in the absence of an expensive turbidity meter. The clarity tube is much better suited for shallow or rapidly moving water than alternative methods such as the Secchi Disk method. Studies have shown that the clarity tube measurements showed a strong relationship to turbidity and total suspended solids.

Classification (of wetlands): The grouping into categories of systems with homogeneous natural attributes (such as aspects of hydrogeomorphology). NOTE: this is different from the 'classification' of water resources according to their departure from some reference condition as required by the National Water Act.

Clastic sediment: See Mineral sediment.

Co-management: where the responsibilities for allocating and using resources are shared amongst multiple parties, often including local communities and a relevant government agency.

Cut-off drain: An artificially created ditch that is intended to intercept runoff before or shortly after entering a wetland and promote its efficient flow downstream, in order to dry out he wetland in order to cultivate the land.

Depression wetland: A typically basin-shaped wetland that increases in depth from the perimeter to a central area of greatest depth (may be flat-bottomed or round-bottomed) typically associated with inward drainage of surface water.

Delineation (of a wetland): The identification of the outer edge of the zone that marks the boundary between the wetland and adjacent terrestrial areas (based on soil, vegetation and/or hydrological indicators (see definition of a wetland)).

Desiccation: The loss of moisture from material.

Discharge: The quantity of water flowing in a stream per unit time, typically in units of cubic meters per second ("cumecs").

Disturbance: Any activity (human or natural) that disrupts natural processes.

Disturbance unit: A vegetation unit of relatively similar disturbance history.

Drain: An artificially created ditch that is intended to promote the efficient flow of water from a region where flow is diffuse or non-existent.

Ecology: The science which deals with the relationship between plants and animals, and their environment.

Ecoregion: a region defined by similarity of climate, landform, soil, potential natural vegetation, hydrology and other ecologically relevant variables.

Ecosystem services: The direct and indirect benefits that people obtain from ecosystems. These benefits may derive from outputs that can be consumed directly; indirect uses which arise from the functions or attributes occurring within the ecosystem; or possible future direct outputs or indirect uses (Howe et al., 1991). Synonymous with ecosystem "goods and services".

Endorheic: Basin or area from which there is little or no outflow of water (either on the surface or underground by flow or diffusion through rock or permeable material).

Environmental conditions: Features of the environment that affect the distribution of plants or animals.

Erosion: Physical and chemical processes that remove and transport soil and weathered rock.

Eutrophication: the process whereby high levels of nutrients result in the excessive growth of plants.

Evaporation: The physical process of molecular transfer by which a liquid is changed into a gas.

Evapotranspiration: The loss of moisture from the terrain by direct evaporation plus transpiration from vegetation.

Exorheic: Area from which there is outflow of water (either on the surface and/or underground by flow or diffusion through rock or permeable material).

Extent of impact: The proportion of a site affected by a given activity.

Fauna: A collective term for the animal life characteristic of a particular region.

Flood attenuation: The holding or slowing of water flow such that it is slowly released to streams.

Floodpeaks: The highest discharges that occur in streams following a rainfall event.

Floodplain: Valley bottom areas with a well-defined stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.

Flora: A collective term for the plant life characteristic of a particular region or environment.

Fluvial: Related to running water (e.g. a river).

Geology: The study of the composition, structure and processes of the rock layers of the earth.

Geomorphology: The study of the origin and development of landforms of the earth.

Generalist: as used here; an organism that is able to thrive in a broad spectrum of environmental conditions.

GIS: "Geographical Information System;" a computer-based system that stores, manages and analyses data linked to locations of physical features on earth.

Governance: the socio-political structures and processes by which societies share power.

Groundwater: sub-surface water in the zone in which permeable rocks, and often the overlying soil, are saturated under pressure equal to or greater than atmospheric.

Gully: A well-defined channel created by running water eroding sharply into soil/sediment, typically on a hillslope or an unchanelled valley bottom.

Halophyte: a salt tolerant plant.

Head cut: The upper-most entrance into an erosion gully. The point where the headward extension of a gully is actively eroding into undisturbed soil.

Headward erosion: Extension of a stream, gully or canal up the regional slope of erosion.

Hillslope seepage wetland: Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is via a well-defined stream channel or via diffuse flow.

Hydraulic conductivity: A measure of the rate at which water can move through a permeable medium such as soil or rock.

Hydrogeomorphic unit: Recognizable physiographic wetland-unit based on geomorphic setting, water source and water flow patterns.

Hydric soil: a soil that is exposed to conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper layer(s).

Hydrology: The study of the properties, distribution, and circulation of water on the earth.

Indicator: Visible sign of human-induced impact.

Indicator species: A species whose presence in an ecosystem is indicative of particular conditions (such as saline soils or acidic waters).

Indigenous: Species that have originated naturally in a particular region or environment.

Infilling: Dumping of soil or solid waste onto the wetland surface.

Institutions: The formal rules, conventions and laws (e.g. marriage), as well as the informal codes of behaviour that constrain and direct societal activities and interactions.

Intensity of impact: The degree to which the component has been altered within the affected area.

Invasive species: A species that has the capacity to out-compete and dominate the naturally occurring species and that can adversely affect the habitats (economically, environmentally and/or ecologically) that they invade.

Inventory (of wetlands): A catalogue of their geographical position, number and characteristics.

Least impaired: Pertaining to wetlands; those which have incurred a minimal degree of human impairment, relative to other wetlands in a region.

Levee: Broad, low embankment built up along the banks of a channel during floods.

Lithology: Study of the nature and composition of stones and rocks.

Land-cover: the physical cover on the earth's surface, including cultivated crops, buildings, natural grassland, etc.

Land-use: how people use the land, e.g. if land is under crops, whether or not the land is irrigated.

Macro-invertebrate: Animals without backbones that are retained by a 500-1000 micron mesh (mesh size depending on definition used).

Magnitude of impact: The actual impact of a particular activity or suite of activities on the component of wetland health being evaluated. Often calculated as the intensity of impact multiplied by the extent of impact.

Manning's Roughness Coefficient: A measure of roughness that is used to determine flow velocity in streams for which dimensions and slope are known.

Management: The implementation of actions aimed at achieving a goal. It may encompass planning, organizing, staffing, directing and controlling.

Marsh: A wetland dominated by emergent herbaceous vegetation and usually permanently or semi-permanently flooded or saturated to the soil surface.

Mineral sediment: The particles of minerogenic material (clay, silt, sand, cobbles and boulders) that are moved by running water.

Minimum tillage: of "tillage": ploughing. Keeping disturbance of the soil to a minimum when cultivating crops.

MiniSASS: a simplified version of SASS, which can be used by citizen scientists to monitor the health of a river or stream, and involves collecting a sample of macroinvertebrates (small animals) from the water. Macroinvertebrate groups vary greatly in terms of their tolerance to pollution, and based on which of the macroinvertebrates groups are found in the sample, the health class of the river is indicated, ranging across five categories from natural to very poor.

Mitigate: to reduce the impact of.

Mottles: of soils, variegated colour patterns on a uniformly-coloured background.

Munsell colour chart: a standardized colour chart used to describe aspects of the colour and chroma of soil.

Natural reference condition: A system in which natural inputs of resources or toxins has not been modified by recent human intervention, and which experiences levels of disturbance that are regarded as natural.

Nick point: The point where the headward extension of a stream or gully is actively eroding headward into undisturbed soil or sediment.

Organic soil: See Peat.

Oxidation: Combining with oxygen, typically involving the breakdown of organic matter to produce CO_2 and H_2O.

Palustrine: of wetlands; those dominated by persistent emergent plants and commonly called marshes, floodplains, vleis and seeps.

Pan: Endorheic (i.e. inward draining; lacking an outlet) depressions typically circular, oval or kidney shaped, and usually intermittently to seasonally flooded and with a flat bottom.

Peat: Organic soil material with a particularly high organic matter content which, depending on the definition of peat, usually has at least 20% organic carbon by weight.

Perched water table: the upper limit of a zone of saturation in soil, separated from the main body of groundwater by a relatively impermeable unsaturated zone.

Perennial: permanent; persisting from year to year.

Poaching: (= "pugging") the disruption of soil structure as a result of the repeated penetration of the hooves of livestock into wet soil.

Precipitation: The deposition of moisture on the earth's surface from the atmosphere, including dew, hail, rain, sleet and snow.

Present state: The state of a system in which natural inputs of resources or toxins have been modified by recent human intervention, and which experiences levels of disturbance that are unnatural.

Quaternary Catchment: Each catchment in South Africa has been sub-divided into secondary catchments, which in turn have been divided into tertiary. Finally, all tertiary catchments have been divided into interconnected quaternary catchments. A total of 1946 quaternary catchments have been identified for South Africa. These sub-divided catchments provide the main basis on which catchments are sub-divided for integrated catchment planning and management (consult DWAF [1994]).

Ramsar Convention: The Convention on Wetlands that provides the framework for international cooperation for the conservation of wetlands.

Red Data species: All those species included in the categories of endangered, vulnerable or rare, as defined by the International Union for the Conservation of Nature and Natural Resources.

Reference sites: Those sites that are minimally impacted by human disturbance and that reflect the natural condition of a wetland type in a given region.

Rehabilitation (wetland): The process of assisting in the recovery of a wetland that has been degraded or of maintaining a wetland that is in the process of degrading so as to improve the wetland's capacity for providing services to society.

Resilience (of ecosystems): The ability to maintain functionality after being subject to perturbations

Riparian: The physical structure and associated vegetation of areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas." (National Water Act). Riparian areas that are saturated or flooded for prolonged periods would be considered wetlands and could be described as riparian wetlands. However, some riparian areas are not wetlands (e.g. where alluvium is periodically deposited by a stream during floods but which is well drained).

Ruderal plant: Short-lived, weedy plants (in this case) that typically invade disturbed ground.

Runoff: Total water yield from a catchment including surface and sub-surface flow.

SASS (South African Scoring System): a system for the rapid bioassessment of water quality of streams in South Africa using macro-invertebrates.

Saturation: of soil; that where the water table or *capillary fringe* reaches the surface.

Scroll bar: A mound of sediment that occurs on the convex bank of a meandering stream, resulting from deposition of sediment on the inner bank of the channel.

Sedges: grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses.

Sediments: Solid material transported by moving water, which typically comprises sand, silt and clay sized particles.

Solute: Dissolved substance.

Stakeholder: In the context of a wetland, any individual, group or community able to influence or be influenced by the management of the wetland.

State: The condition of a system with regard to its composition, structure or function.

Stocking rate: the number of animal units per unit of land for a specified period of time. An AU is taken as equivalent to a 450 kg animal that consumes 10 kg of dry matter per day.

Sustainable development: development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable use (of wetlands): use within the resource's capacity to renew itself.

Sustainable: that which can carry on indefinitely.

Threat: An indication of likely danger or harm.

Tillage: the preparation of soil for agricultural purposes, by ploughing, ripping, hoeing or otherwise disturbing it.

Toxicant: An agent or material capable of producing an adverse response in a biological system, seriously injuring structure and/or function of the system and its organisms or producing death.

Trajectory of change: The predicted nature of change in the state of a wetland from its present state given threats and vulnerability.

Transformed areas: Areas where natural habitat has been completely destroyed.

Valley-bottom wetland: Valley-bottom areas with or without a clearly defined stream channel, usually gently sloped and characterized by sediment deposition.

Water quality: The suitability of water for a user (human or environmental) determined by the combined effects of its physical attributes and its chemical constituents.

Wetland: "Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils." (National Water Act). Land where an excess of water is the dominant factor determining the nature of the soil development and the types of plants and animals living at the soil surface (Cowardin *et al*., 1979); lands that are sometimes or always covered by shallow water or have saturated soils long enough to support plants adapted for life in wet conditions.

Useful websites:

http://www.grca.on.ca/stdprod_091596.pdf (keep in mind this has a Northern hemisphere context)

http://www.ramsar.org/

http://www.wetlands.org/

Appendix A: Application of the method to the example in Figure 2

In order to show how the method might be applied, the example represented in Figure 2 is presented in this Appendix, firstly for the sketch-map option and secondly for the detailed-map option.

The sketch-map option

Tables A1 and A2, which are abridged versions of Tables 1 and 2, show only the land-cover types represented in the example in Figure 2.

Table A1: Impacts associated with the land-cover types occurring within the example wetland shown in Figure 2

Land-cover/disturbance types	**Intensity of impact[1]**	**Extent in the wetland**		
		Present but small extent (<10% of the total area)	**Moderately extensive (10-50%)**	**Extensive (>50%)**
Annual crops, commercial, not irrigated, with moderate to severe artificial drainage	Serious		X	
Infilling and infrastructure, including roads and buildings	Critical	X		
Natural areas of the unit with moderate on-site impacts (e.g. with moderate artificial drainage or discharge of wastewater)	Moderate		X	
Natural areas of the unit with scattered invasive alien plants	Small		X	

Table A2: Impacts associated with the land-cover types occurring within the upslope catchment of the example wetland shown in Figure 2

Land-cover types in the wetland's catchment	**Impact intensity[1]**	**Extent in the wetland's upslope catchment**		
		Present but limited in extent (<10% of the total area)	**Moderately extensive (10-50%)**	**Extensive (>50%)**
Tree plantations	Large		X	
Annual crops	Large		X	
Built up areas, roads, railway lines and airfields	Serious	X		
Natural vegetation	None		X	

[1]The impact intensity is based on considering impacts on Water inflow quantity and seasonal pattern and on Water quality, as shown in Part 2, Table 4 and the rationale following the table.

Additional notes: The impact of the built up areas is likely to be greater than suggested by Table A2 because they occupying slightly less than 10% of the upslope catchment (i.e. are very close to being moderately extensive) and furthermore much of the built up areas are located relatively close to the wetland.

Indicate the extent of the buffer zone around the wetland (see Figure 4)

Low □	Moderately low □	Intermediate □ X	Moderately high □	High □

As noted in the main document, the sketch-map option does not provide an impact score, but serves to flag those land-cover types in the wetland and its upslope catchment likely to be having the greatest contribution to impacts on the wetland.

The detailed-map option

Tables A3 and A5, which are abridged versions of Tables 3 and 5, show only the land-cover types represented in the example in Figure 2. In Table A6, the same example is compared under different land-cover scenarios (current vs. rehabilitated).

Table A3: Impact magnitude scores for the land-cover types occurring within the example wetland shown in Figure 2

Land-cover/disturbance types[1]		**Overall intensity of impact[2]**	**Extent (% of wetland)**	**Magnitude**
Annual crops, commercial, not irrigated	Conventional tillage, with moderate artificial drainage	5.6	45%	2.5
Infilling without infrastructure	Foreign material/ solid waste (e.g. concrete rubble, plastic) used as infill	8.3	2%	0.2
Natural, with wastewater flows[13]	Natural area of wetland into which the point-source release of untreated or poorly treated wastewater flows.	5.1	13%	0.7
Natural	Natural vegetation with scattered invasive alien plants	1.2	40%	0.5
			TOTAL MAGNITUDE OF IMPACT:	3.9

Table A4: Impact magnitude scores for the land-cover types occurring within the upslope catchment of the example wetland shown in Figure 2

Land-cover types	**Overall intensity of impact on the downstream wetland[1]**	**Extent in the wetland's upslope catchment**	**Magnitude of impact**
Tree plantations, pine, wattle or poplar	4.5	11%	0.50
Annual commercial (row) crops, not irrigated	4.5	30%	1.35
Built up dense settlements, roads railway lines and airfields	6.0	9%	0.54
Natural vegetation	0.0	50%	0.00
		TOTAL MAGNITUDE OF IMPACT:	2.4

[1]Intensity of impact is scored on a scale of 0 (nil/negligible) to 10 (critical). The impact intensity is based on considering impacts on Water inflow quantity and seasonal pattern and on Water quality, as shown in Part 2, Table 4 and the rationale following the table.

Indicate the extent of the buffer zone around the wetland (see Figure 4):
Low □ = 1; Moderately low □ = 0.9; Intermediate ☒ = 0.8; Moderately high □ = 0.7; High □ = 0.6

TOTAL MAGNITUDE OF IMPACT ADJUSTED FOR THE MODERATING INFLUENCE OF THE BUFFER:	1.9

Table A5: Summary of the overall impacts on the example wetland and trajectory of anticipated change

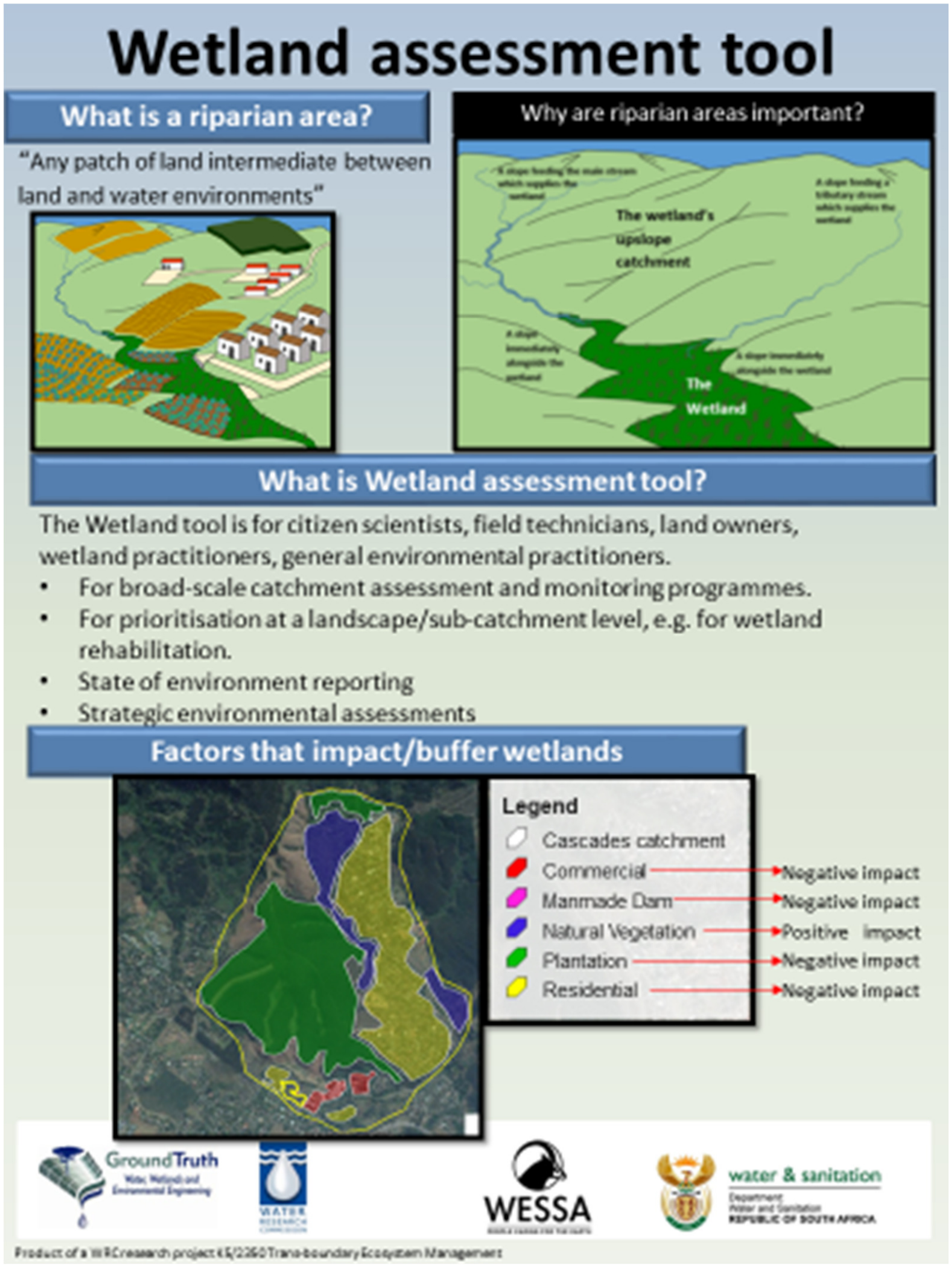
Total magnitude of impact from impacts within the wetland (WI):		3.9
Total magnitude of impact from impacts in the wetland's upslope catchment (WC):		1.9
Combined overall magnitude of impacts (see Part 2, Appendix A):		5.1
Present Ecological State category (see Table 5):		D
Any impacts on the ecological condition of the wetland which you consider to have been omitted or important influencing factors which have not been accounted for: For the purposes of this example, no further impacts are identified.		
TRAJECTORY OF ANTICIPATED CHANGE IN THE WETLAND'S ECOLOGICAL CONDITION OVER THE NEXT 5 YEARS		
Large improvement	□	Supporting motivation: The scattered invasive alien plants in the natural area of the wetland are anticipated to increase in extent within this area, particularly given that the wetland is subject to other impacts likely to favour these species.
Slight improvement	□	
Remain the same	□	
Slight decline	☒	
Large decline	□	

The method can be used for comparing the relative impacts of different land-cover scenarios. For example, let is compare the wetland above with the same wetland rehabilitated by halting the discharge of untreated wastewater (currently impacting upon 13% of the wetland) and withdrawing annual crops from the wetland and plugging artificial drains in these areas (45% of the wetland) and controlling invasive alien plants. From the total magnitude of impact in Table A6 it can be seen that this rehabilitation more than halves the total impacts on the wetland.

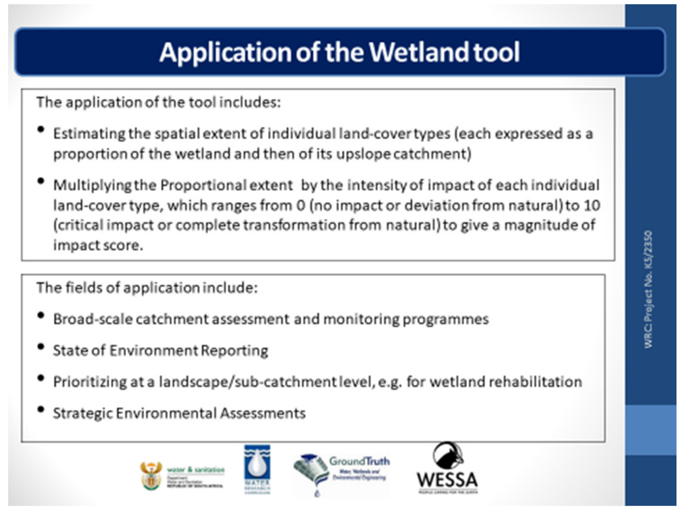
Table A6: Impact magnitude scores for the land-cover types occurring within the example wetland under the current scenario shown in Figure 2 and under a rehabilitated scenario.

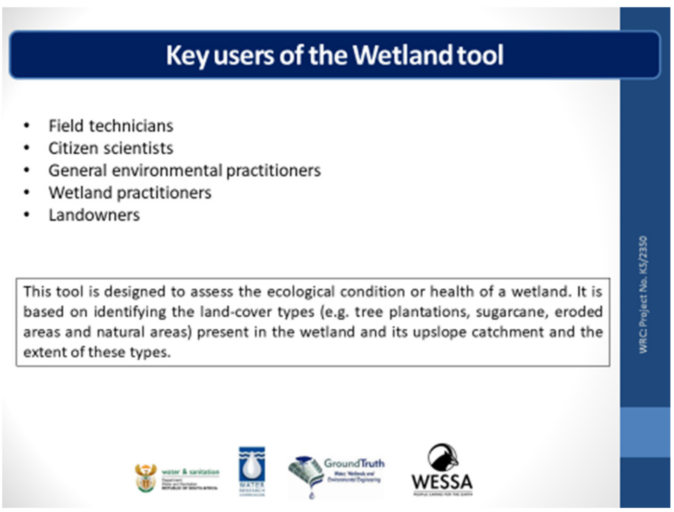
Land-cover/disturbance types[1]		**Overall intensity of impact**	**Current scenario**		**Rehabilitated scenario**	
			Extent	**Magnitude**	**Extent**	**Magnitude**
Annual crops, commercial, not irrigated	Conventional tillage, with moderate artificial drainage[3]	5.6	45%	2.5	0%	0.0
Old lands/semi-natural vegetation	With negligible artificial drainage	1.8	0%	0.0	45%	0.8
Infilling without infrastructure	Foreign material/ solid waste (e.g. concrete rubble, plastic) used as infill	8.3	2%	0.2	2%	0.2
Natural, with wastewater flows[13]	Natural area of wetland into which the point-source release of untreated or poorly treated wastewater flows.	5.1	13%	0.7	0%	0.0
Natural	Natural vegetation with minor impacts such as scattered invasive alien plants	1.2	40%	0.5	53%	0.6
TOTAL MAGNITUDE OF IMPACT:				**3.9**		**1.6**

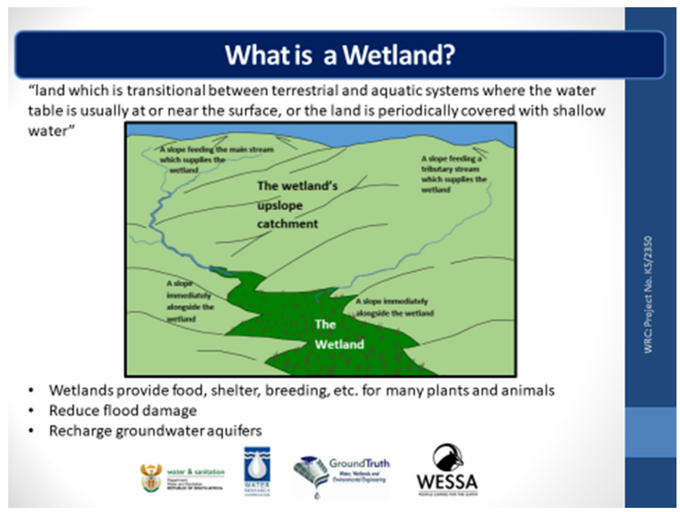
Poster

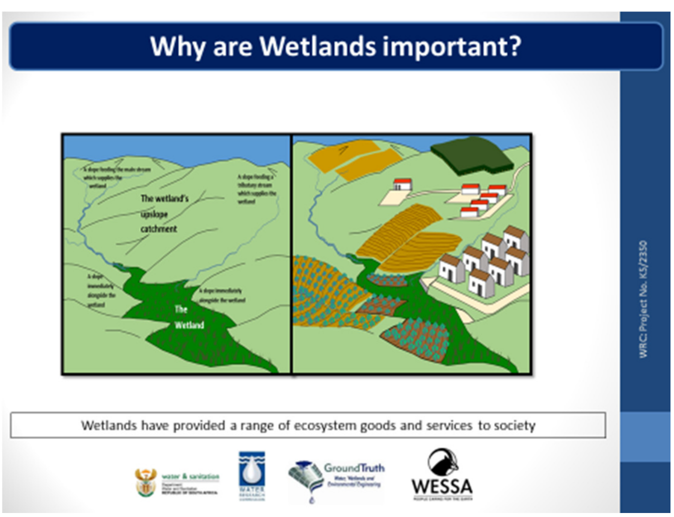

Wetland assessment tool
What is a riparian area?
"Any patch of land intermediate between land and water environments"
Why are riparian areas important?
The wetland's upslope catchment
The Wetland
What is Wetland assessment tool?
The Wetland tool is for citizen scientists, field technicians, land owners, wetland practitioners, general environmental practitioners.
• For broad-scale catchment assessment and monitoring programmes.
• For prioritisation at a landscape/sub-catchment level, e.g. for wetland rehabilitation.
• State of environment reporting
• Strategic environmental assessments
Factors that impact/buffer wetlands
Legend
Cascades catchment
Commercial
Manmade Dam
Natural Vegetation
Plantation
Residential
Negative impact
Negative impact
Positive impact
Negative impact
Negative impact
GroundTruth
WESSA
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA
Product of a WRC research project K5/2350 Trans-boundary Ecosystem Management

PowerPoint Presentation









Wetland tool methods

Material to use

Equipment needed:

- Preliminary land-cover map
- Pencil
- GPS
- Camera (optional)
- Tables
- Gumboots
- Binoculars (optional)

WRC: Project No. K5/2350

Wetland tool methods

Step 1

1. Familiarize yourself with land-cover types

Refer to Table 1, which provides a list of land-cover types and the likely intensity of impact these might have on the wetland

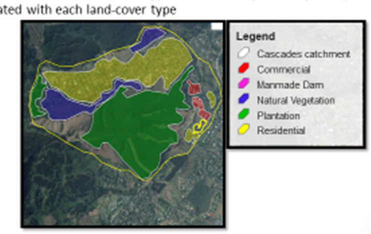
WRC: Project No. K5/2350

Wetland tool methods

Step 1

2. Familiarize yourself with land-cover types you may potentially find in the wetland's upslope catchment

Refer to Table 2, which provides a list of land-cover types and the likely intensity of impact on the wetland commonly associated with each land-cover type



WRC: Project No. K5/2350

Wetland tool methods

Step 2

Select a wetland

Find a wetland that you are interested in studying. Make sure that you obtain permission from the landowner to work in the wetland.

If you have access to the internet, you can use Google Earth or Google Maps (https://www.google.co.za/maps/) to view your wetland and types of infrastructure and land cover in and near to the wetland

WRC: Project No. K5/2350

Wetland tool methods

Step 3

Observe the wetland

Take particular note of which of the land-cover types in Table 1 you can see within the wetland and which land-cover types in Table 2 you can see within the wetland's upslope catchment.

Take note of features such as

- Artificial drainage channels
- Erosion gullies
- Presence of invasive alien plants.

Try to find someone with a good historical knowledge of the wetland to obtain additional information on past and current use of the wetland, including activities such as discharge of wastewater and pumping of water out of the wetland.

WRC: Project No. K5/2350

Wetland tool methods

Step 4

2. Draw a sketch-map of the wetland and its catchment

The map should include

- The boundary of the wetland and its catchment
- The approximate location of different land-cover types in the wetland and its upslope catchment.

The wetland's upslope catchment refers to the area upslope of the wetland from where water feeds into the wetland, through both surface- and sub-surface flows

WRC: Project No. K5/2350

Wetland tool methods

Step 5

Complete Table 1 (Impact extent in the wetland)

Land-cover/disturbance types		Intensity of impact[1]	Extent in the wetland		
			Present but small extent (<10% of the total area)	Moderately extensive (10-50%)	Extensive (>50%)
Annual crops, commercial, irrigated[2]	With moderate to severe artificial drainage[3]	Serious			
	With negligible artificial drainage[3]	Large			
Annual crops, commercial, not irrigated	With moderate to severe artificial drainage[3]	Serious			
	With negligible artificial drainage[3]	Large			
Annual crops, subsistence[3]	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Moderate			
Sugarcane[3]	With moderate to severe artificial drainage[3]	Serious			
	With negligible artificial drainage[3]	Large			
Vineyards & Orchards	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Large			
Planted pastures	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Large			
Recently abandoned lands[4]	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Moderate			
Old abandoned lands[5]/ semi-natural areas[5]	With moderate to severe artificial drainage[3]	Large			
	With negligible artificial drainage[3]	Small			
Tree plantations		Serious			
Dense infestations of invasive alien plants	Trees	Serious			
	Herbaceous invasive alien plants, e.g. American bramble	Large			
Erosion gullies	Erosion gully with negligible vegetation colonization	Serious			
	Erosion gully colonized with vegetation	Serious			
Infilling and infrastructure, including roads and buildings		Critical			
Mines and quarries		Critical			
Sports fields or gardens[11]		Large			
Recent sediment deposits		Large			
Dams, ponds and areas where were water supply has been artificially sustained	Deep flooding by dams/ artificial ponds or upstream of embankments,	Serious			
	Shallow flooding by dams/ artificial ponds or upstream of embankments in the unit[6]	Moderate			
	Seepage downslope of dams or embankments or areas where water supply has become more sustained (e.g. from irrigation return flows)[12]	Moderate			

Wetland tool methods

Step 5

Complete Table 2 (Wetland upslope catchment)

Land-cover types	Overall intensity of impact on the downstream wetland[1]	Extent in the wetland's upslope catchment
Tree plantations, eucalypt	5.5	
Tree plantations, pine, wattle or poplar	4.5	
Orchards	5.5	
Vineyards	4.0	
Annual commercial (row) crops, irrigated	5.5	
Annual commercial (row) crops, not irrigated	4.5	
Annual subsistence crops	4.0	
Sugarcane	4.0	
Mines and quarries	8.0	
Built up dense settlements, roads railway lines and airfields	6.0	
Golf courses, sports fields & low density settlements	3.0	
Old lands/ semi-natural vegetation	0.5	
Natural vegetation	0.0	
Eroded areas	5.0	
Dams	4.5	

Wetland tool methods

Step 6

Determine which factors are having the greatest impact on wetland health

Total magnitude of impact from impacts within the wetland (WI):	
Total magnitude of impact from impacts in the wetland's upslope catchment (WC):	
Combined overall magnitude of impacts (WI*2/3 + WC*1/3):	
Present Ecological State category (see Table 5):	
Any impacts on the ecological condition of the wetland which you consider to have been omitted or important influencing factors (see Part 2, Section 4, Table 4) which have not been accounted for:	
TRAJECTORY OF ANTICIPATED CHANGE IN THE WETLAND'S ECOLOGICAL CONDITION OVER THE NEXT 5 YEARS	

Large improvement	□	Supporting motivation:
Slight improvement	□	
Remain the same	□	
Slight decline	□	
Large decline	□	

Wetland tool methods

Step 6

Determine overall impact

Overall impact score range	Impact category	Description	PES category
0.0-0.9	None	No discernible modification or the modification is such that it has no impact on wetland integrity.	A
1.0-1.9	Small	Although identifiable, the impact of this modification on wetland integrity is small.	B
2.0-3.9	Moderate	The impact of this modification on wetland integrity is clearly identifiable, but limited.	C
4.0-5.9	Large	The modification has a clearly detrimental impact on wetland integrity. Approximately 50% of wetland integrity has been lost.	D
6.0-7.9	Serious	The modification has a clearly adverse effect on this component of habitat integrity. Well in excess of 50% of the wetland integrity has been lost.	E
8.0-10	Critical	The modification is present in such a way that the ecosystem processes of this component of wetland health are totally / almost totally destroyed.	F

Wetland tool methods

Before leaving the assessment site always ensure the following:

All data have been entered onto the field data sheets
Photograph numbers specific for each site have been recorded
All equipment has been returned to the vehicle
All gates were left as they were found if assessing an external party's property

The End

APPENDIX M: THE ESTUARY TOOL

Explore an Estuary

Guidelines for a one-day study of an estuary

Ricky Taylor

A citizen science tool to monitor water clarity, an indicator of turbidity and total suspended solids

A product of WRC Project number: K5/2350

WESSA
PEOPLE CARING FOR THE EARTH

WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

PURPOSE

This booklet is to provide the first steps for Citizen Scientists who would like to study how an estuary functions. It is aimed to lead an interested person or group of people who have the opportunity to spend one day exploring an estuary? And, hopefully, the interest generated during this day will spur the explorer(s) on to spend more time getting to know estuaries and then share the knowledge with others.

The objective is to undertake various activities to aid the learning about estuaries not just have a passive experience. This is why the visitor is a Citizen Scientist and not just a tourist. It is designed to be carried out in about 4 to 8 hours on site. Each estuary is unique. The design of these guidelines takes this into account by allowing the Citizen Scientists to focus in on what is most important for the particular estuary they will visit. For this reason our activity list contains more activities than can be done in a day, only the appropriate ones can be done at any one estuary.

Estuaries are changing all the time, largely in response to the tides, but also to river flows and mouth closures. There are also seasonal and weather impacts. The activities guide the user to recognise and measure the dynamics of estuaries and to think about the processes that drive them.

This is a guideline on what to look for and how to conduct some fieldwork that will enhance your experience, and at the same time make learning about estuaries fun.

This booklet is aimed at any person, or group of people, who wishes to spend a day (or more) engaged in a structured scientific exploration of an estuary. The group can be a school class, a youth group, adult study group, a society, etc.

BACKGROUND INFORMATION

WHAT IS AN ESTUARY?

What is an estuary? In short, it is the zone where a river enters the sea – and this zone forms a particularly productive and valuable ecosystem which has some of the characteristics of both the river and the sea. The formal definition is:

> ***An estuary is a semi-enclosed body of water which is affected by marine tides and in which there is a mixing of river water with sea water.***

Key features of an estuary:

- **It is tidal**
- **There is mixing of freshwater and seawater**

There are almost 300 estuaries in South Africa. Some are large some are small, some are large. We need to remember that each estuary is unique. For some there is no access, or severe constraints to easy access.

The parts of an estuary are shown in figure 1. These consist of the **estuarine basin** in the middle, the **estuary mouth** where it links with the sea and there is the **river interface** where there is the inflow of fresh water. The tidal inflow of seawater brings salt from the sea which mixes with freshwater from the river. In South Africa most of our estuaries close periodically. This closure occurs when sand from the beach blocks the estuary mouth.

On either side of the estuary is the **estuarine floodplain** – flooded when the river floods, or when there are particularly high tides or when the water backs up behind the closed mouth.

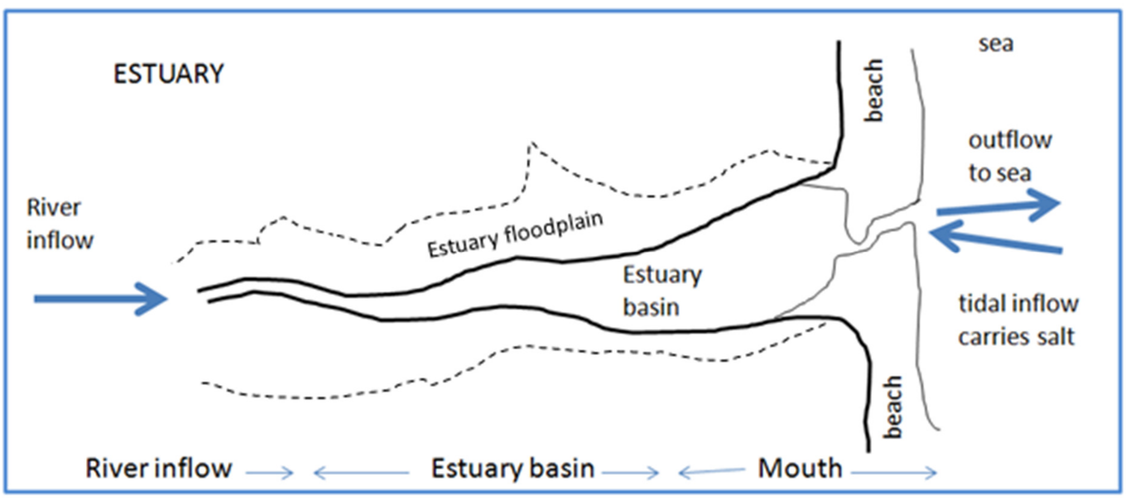


Figure 1: The parts of an estuary.

In an estuary its individual components are linked – to form an ecosystem where the hydrology, sediments, plants, animals and human users all interact.

Each plant or animal has a range of conditions it can tolerate. A range of salinity within which it can live happily. But salinity above or below this will result in death. The same applies for temperature. Some plants and animals have narrow ranges of tolerance and others wide ranges. Estuaries are changing continually.

This is in response to tides, changes in river inflows and mouth closures. Some animals move to stay within their preferred tolerated ranges – but this is not the case with plants which, once growing are fixed to a site and have to endure all the changes that occur at that site.

We have to be detectives. We have to look for evidence of how the estuary is changing and then we have to assemble a picture of how it functions. As much of what happens in an estuary happens underwater, we need tools to observe and study estuaries. This guidebook provides some of the basic tools and also gives some of the background knowledge you will require.

TIDAL PATTERNS

A feature of estuaries is that they are tidal. This is only the case if the mouth is open. The water level in an estuary rises and falls as the sea tides change. This happens twice a day and in South Africa the tidal range – the difference in water level between high and low tide - can be a little more than 2 metres. As tidal water enters the estuary this range is very much reduced. The tidal influence is less and less the further you are away from the mouth. When the mouth is closed water levels may rise as the water backs up behind the closed mouth.

The tidal range is also reduced if the estuary mouth is constricted or if it is neap tides.

Tides

In the sea the tide rises and falls twice a day, with the time of the tides shifting to be about an hour later each day. On a two-weekly cycle with spring tides changing to neap tides and back to spring tides. During spring tides the tidal range is at its greatest – which in South Africa is about a 2 m range from low tide to high tide. During neap tides this range is very much reduced, often only having a 50 cm range or even less between high and low tides. The timing is related to the phases of the moon – with spring tides associated with full and new moon periods and neap tides associated with half-moon periods. In South Africa the timing of the tides is such that spring low tides are early to mid-morning and neap low tides are in the mid-afternoon, and conversely spring high tides are mid-afternoon and neap high tides in the mid-morning.

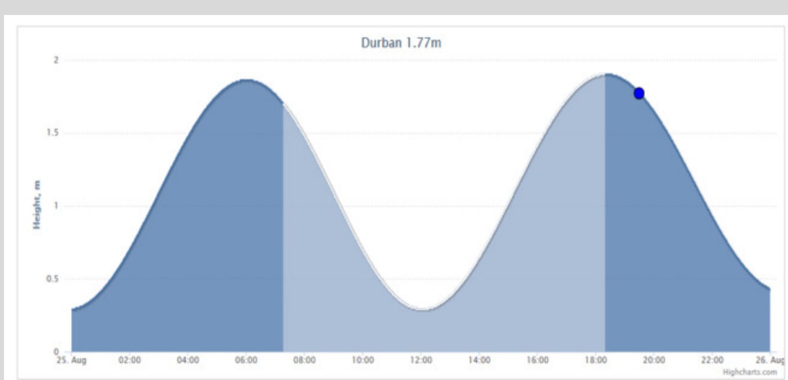


Figure ***. Daily tides. These are delayed by 52 minutes each day.

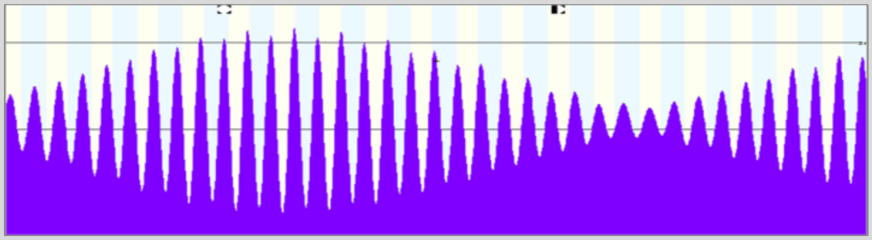
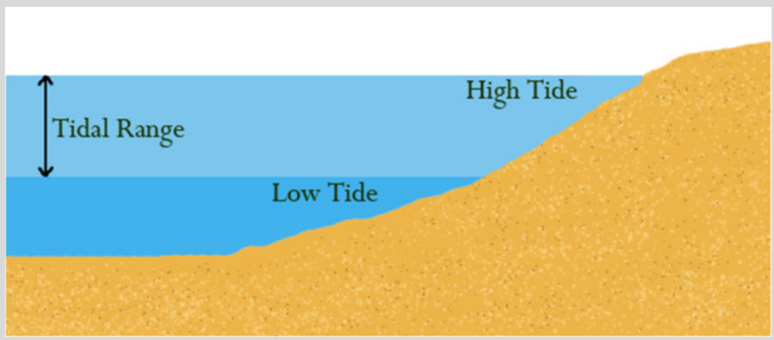


Figure ***: Neap/spring tides follow a 14 day cycle.



Tidal range ****: This is the difference of water level between the high tide and the low tide.

Tide tables are available that give the time and predicted heights of the tides. However, the predicted tidal height can be modified relative to the predicted tide by prevailing weather conditions. Winds, storms out at sea, frontal weather and cyclones all modify the tides. During equinox periods, tides are more extreme than during the solstices.

Use tide tables to see the predicted time and height of tides. The following web sites may be useful:

http://www.satides.co.za/

http://www.sanho.co.za/tides/tide_index.htm

http://www.tides4fishing.com/af/south-africa

When the estuary mouth is open, tidal water moves in and out of the estuary. As the tide rises, so water moves into the estuary. It moves up, but the tidal range reduces the further it moves up, and there can be a delay in the tidal response. At some point upstream the estuary is no longer tidal. Then once the tide changes the water flows out. The amount of water brought in and out is known and the 'tidal wedge' (figure ***)

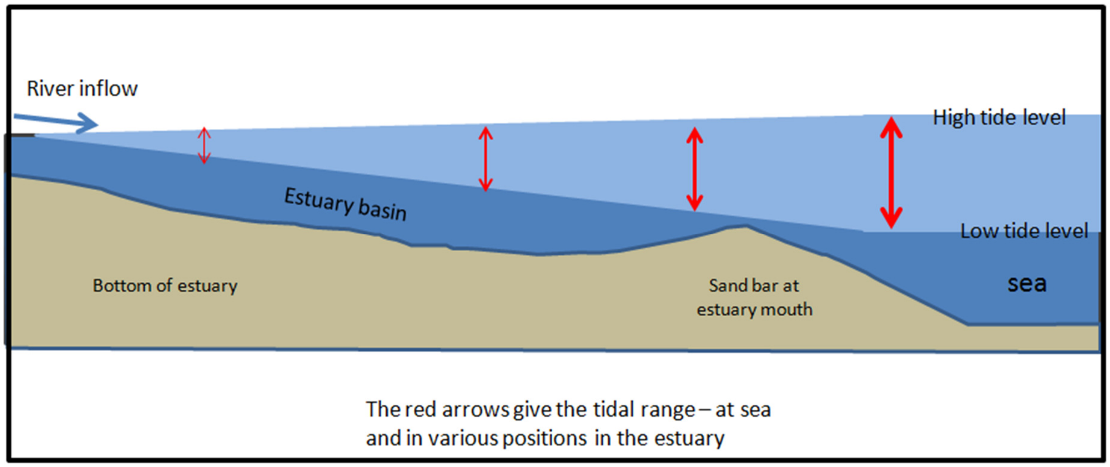


Figure ***: The 'Tidal Wedge' (light blue colour) is the water that flows in and out of the estuary as tides change from low to high and back to low. As indicated in this sketch it is a wedge-shaped volume of water. It is also sometimes known as the 'Tidal Prism'

The tidal exchange is the mechanism that 'pumps' salt water in and out of an estuary – and with it there is often migrations of fish, crabs and prawns between the estuary and the sea. The tidal pumping also affects the flushing of pollutants and sediments from an estuary.

The degree of the rising and falling in the different places in the estuary controls how much of the estuary shoreline is inundated with each tide. This affects plant growth and the intertidal area is a rich feeding site for wading birds.

Water levels in any of the rivers in South Africa are measured by the Department of Water and Sanitation. The data they measure is available to anyone on their web site https://www.dwa.gov.za/Hydrology/RTMain.aspx . However there is usually a delay of several weeks before the data are available as the loggers have to be downloaded (usually monthly), and then the data verified before being posted on the Internet.

SALINITY AND TEMPERATURE

Salinity is the amount of salt in estuary water. It is measured in grams per 1000 ml of water – giving a value expressed as a number with the units of ppt (parts per thousand).

In an estuary, water from the sea mixes with river water. There is fresh water at the estuary-river interface, sea water at the mouth and a gradient in salinity between. This is the **longitudinal gradient**.

A measurement of the salinity of the water within the estuary tells us how much fresh water has mixed with sea water. For instance, if the water has a salinity of 35 ppt, then it is likely to be undiluted sea water. If it is half this, i.e. 17.5 ppt, then there has been a half to half mixture of seawater and freshwater, and 10 ppt means that there is about one third seawater to two thirds freshwater.

However, there is an added complication. Saline water is heavier than freshwater, and often a **vertical gradient** in salinity can exist. This happens when there is not much stirring up of the water by wind and waves. Under these conditions the more saline water stays at the bottom of the estuary and the lighter freshwater floats on top of this. The interface layer in the water is called the **halocline**.

The salinity of the water does control to a large degree what plants and animals can live in different places within and estuary. Each plant or animal has a range of salinity conditions it can thrive in – and if salinity is above or below these limits, then the species cannot live there.

The result is that we can expect to find plants and animals with specific salinity requirements in discrete parts of an estuary. To understand the ecology of an estuary we first need to know the salinity patterns

MOUTH AND BEACH DYNAMICS

We have discussed the tidal nature of an estuary; how marine tides extend into the estuary and how this is the process that mixes the estuary and sea water. However, most of the estuaries in RSA are Temporary Open/Closed Estuaries (TOCEs). These close periodically – and sometimes remain closed for long periods.

The state of its mouth, whether open constricted or closed, controls how much sea water enters at high tides, and how much mixed water leaves. The state of the mouth dictates whether the water level in the estuary is raised (perched) or whether the water level is dammed up behind a closed berm and thus expands laterally to flood low-lying floodplains.

The impact of moth closure to an estuary is profound. With the mouth closed it is no longer tidal. The gradient of salinity in the water breaks down as the water mixes throughout the estuary. There cannot be migrations of fish and crustaceans between the sea and the estuary while the mouth is closed.

A closed estuary is isolated from the influences from the sea, but not of the rivers. Water flowing in from the catchment will cause water levels in the estuary to rise, and also dilutes the saltiness of the estuary. Once water levels are high enough they overtop the closed mouth causing it to breach. On breaching, especially if there is a head of water in the estuary, the estuary water flows rapidly into the sea – taking with it sediments scoured out of the estuary. This is an important process as it maintains the depth of the estuary. On breaching it also carries estuarine animals into the sea, and allows marine individuals to enter the estuary. There can be a considerable exchange of fish, crabs and prawns during a breaching event.

In the past mouth closure was considered to be a detrimental and estuary mouths were frequently breached. Nowadays we realise that mouth closure is part of the natural cycle of an estuary. Generally closed estuary mouths are left to open naturally and it is illegal to breach an estuary.

Estuary mouths are always changing – constricting as sand accumulates, widening in response to strong in and out flows, and at times closing. Typically an estuary mouth has the structure shown in figure ***.

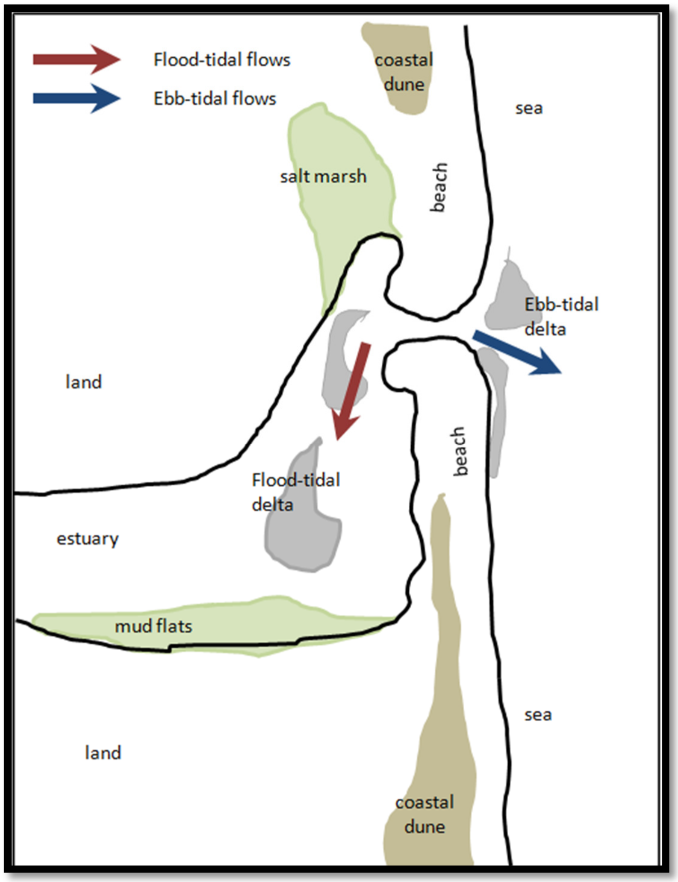


Figure ***: - structure of a typical estuary mouth.

The basic structure is a channel that passes through the beach berm – which may be quite narrow. Through this there are in and out flows driven by the tidal changes. As this water enters the estuary (the incoming water is called the flood tide) it carries sand into the estuary which is deposited where the channel widens to form the flood tidal delta. Then, when the tide turns, water is flows out of the system. It carries some sediment with it which is dropped where the flow enters the sea, forming the ebb-tidal delta.

Figure ***: The flood tidal delta formed in an estuary mouth by the incoming (flood) tide

Figure ***: The ebb tidal delta forming in the sea from sand carried from the estuary and deposited in the wave zone. The delta is not visible in this photo, but the effect it has on the waves is seen as it slows down an approaching wave

Also important in this process is the amount of sediment available in the nearshore zone of the sea adjacent to the estuary mouth. This supplies the sediment that is carried into the estuary. At any particular time the quantity of sediment is strongly dependant on whether the beaches are eroding (releasing sediments) or depositing (trapping sediments). For this reason the Citizen Scientist measures the slope of beaches near the mouth.

Along any particular stretch of coast there is wind-driven movement of the water – known as the long-shore drift. This movement is in the direction of the wind that is prevailing at the time. Thus in KZN it is mostly from the south. The estuary mouth is an inlet to the sea where the beaches on either side often extend as spits. (This may not be the case where there is a rock formation at the mouth). The spit from which the long-shore drift predominantly comes from is the larger one and set more seaward than the other one. The longshore drift carries sea sediments towards the estuary. As tidal water enters the estuary (on the incoming, or ebb, tide) it carries sea sediments in with it.

Severe wave action during an incoming tide period will stir up sediments and more sand will be brought into the estuary – promoting estuary mouth closure.

Beach erosion and deposition

ESTUARINE PLANTS, ANIMALS AND HABITATS

The Citizen Scientist is encouraged to learn the names of estuarine plants and animals. Once you can recognise a plant or animal it is easy to see where it is found and in what habitats it lives.

Also of importance are the life spans and life stages of the plants. Some, like the succulent salt marsh species, have short life spans – but produce large numbers of seeds which lie dormant in the mud until germination is initiated in response to freshwater flooding. They cash in on short-term conditions. Others such as mangroves are long lived and are able to survive the extremes of that locality.

Every species of plant has a range of conditions it can survive in – called its niche. The Citizen Scientist learns to study plant growth and to understand where we can expect to find the various species of plants.

As with plants, animals have also very specific environmental needs. But, the big difference is that most animals are mobile and can move to escape from adverse conditions. This is not the case with animals such as those buried in the mud (such as clams) or fixed to the substrate (such as barnacles).

Animals tend to be more sensitive to short-term fluctuations in temperature and oxygen levels than plants. Some species are very specific for the substratum they choose – whether it is sand or mud. As many of the animals have part of their life history in the sea, they are controlled by whether the mouth is open or closed at the time they are spawning or their larvae need to enter the estuary.

Estuaries have considerable value as natural areas. The most evident value is as nurseries for marine life. However, they are also important as bird sites as they offer a range of feeding opportunities for water birds. Wherever food is available and there are suitable nesting sites, we can expect the birds to breed. Many of the water birds breed in colonies. In addition there may be roosts where the birds congregate at night.

Toolbox and data sheets

For 'A Day at an Estuary'

Ricky Taylor

A citizen science tool to investigate and assess estuaries

A product of WRC Project number: K5/2350

PURPOSE

This booklet is to provide the first steps for Citizen Scientists who would like to study how an estuary functions. It is aimed to lead an interested person or group of people who have the opportunity to spend one day exploring an estuary? And, hopefully, the interest generated during this day will spur the explorer(s) on to spend more time getting to know estuaries and then share the knowledge with others.

The objective is to undertake various activities to aid the learning about estuaries not just have a passive experience. This is why the visitor is a Citizen Scientist and not just a tourist. It is designed to be carried out in about 4 to 8 hours on site. Each estuary is unique. The design of these guidelines takes this into account by allowing the Citizen Scientists to focus in on what is most important for the particular estuary they will visit. For this reason our activity list contains more activities than can be done in a day, only the appropriate ones can be done at any one estuary.

Estuaries are changing all the time, largely in response to the tides, but also to river flows and mouth closures. There are also seasonal and weather impacts. The activities guide the user to recognise and measure the dynamics of estuaries and to think about the processes that drive them.

This is a guideline on what to look for and how to conduct some fieldwork that will enhance your experience, and at the same time make learning about estuaries fun.

This booklet is aimed at any person, or group of people, who wishes to spend a day (or more) engaged in a structured scientific exploration of an estuary. The group can be a school class, a youth group, adult study group, a society, etc.

Refer to the background booklet for more information.

PREPARATION

Preparation before going into the field will make your visit to the estuary very much more fulfilling and more successful than going into the field without any preparation.

a. Choice of what to do:

What activities to do depends on accessibility to different regions of the estuary, whether the mouth is open or closed, the size of the estuary, availability of transport (if it is needed), whether a boat needed and if one available and what equipment is on hand. Not everything can be done in a day – so choose carefully and only to do some of the activities. Plan not to do too much and to do what you do well. Leave the rest for future excursions. The table below will guide what can be done and what cannot be done. Choose activities with smiley faces when you plan your day.

Activity	**Mouth (open)**	**Mouth (closed)**	**Estuary basin (if mouth is open)**	**Estuary basin (if mouth is closed)**	**River-estuary interface**
Preparation	☺	☺	☺	☺	☺
Tides	☺	☒	☺	☒	☒
Flows	☺	☒	☺	☒	☺
Salinity & temperature	☺	☺	☺	☺	☺
Mouth dynamics	☺	☒	☒	☒	☒
Beach dynamics	☺	☺	☒	☒	☒
Plants & animals	☺	☺	☺	☺	☺
Consolidation	☺	☺	☺	☺	☺

A last word before starting: do not skimp on the preparation before going to the estuary or the consolidation once you have returned from your field day. Make sure you make plenty of notes in the field as you might forget something when you get back. Take this toolkit with you in case you need to refer back to it in the field. Your day at the estuary will be considerably enhanced by what you do before and after going into the field.

b. Make your own map:

The purpose of this activity is to learn the 'lie of the land' before going into the field. Start by using Google Earth as the base. If this is not possible, then use a paper map – such as the Government 1:50 000 topo-cadastral map. If no map is available, ask someone who knows the area to sketch a map of the estuary for you.

Make your own base map onto which you mark place names, roads and tracks, buildings and jetties and landscape features (such as distinctive rocks). On this map, mark out the main component parts of the estuary – the mouth, the estuary basin, the river-estuary interface and the estuary floodplain. (See figure 1). This is the map that you will take into the field with you. It is the map onto which you can sketch additional features – such as intertidal salt marsh, mangroves, etc. once you are in the field.

Tip: the estuary floodplain is often defined as the area below the 5 m contour line

Figure 1: An example of a base map – a sketch of the Mpambanyoni Estuary based on a Google Earth image. While doing this map, roads and access points were noted as well as surrounding land uses. It is possible to see the floodplain (dotted line) and measure distances. We can see that this is a small estuary.

In the field you can add detail to your map. By doing so you can accumulate knowledge and so build a more comprehensive map for future visits. You can add seasonal details (e.g. record of a bird nest) and mark vegetation outlines and land uses.

Tip:
You can laminate your map and write details on it with a fine alcohol-based felt-tip pen. At a later stage, the data can be transferred to another map (scanned/photographed) and the laminated map cleaned with methylated spirits.

c. Prepare equipment:

Basic equipment includes:

- Camera/cell phone to take photos
- Ruler/tape measure
- Clipboard: To hold the data sheets and map, tide tables
- Pencil/pen

Once you have chosen the activities you will do, put aside all equipment needed for those activities.

d. Prepare data sheets:

The data sheets for each activity are described with the activity – but the data sheets do need to be prepared before going to the estuary – and copies made if required.

e. The logistics of the visit:

Some logistics planning is needed. This should include:

- Transport and the route you will take to get to the estuary. Who is going in which vehicle (if there are multiple vehicles)
- Once at the estuary, where do you start? What sample sites will you use?
- What tide is it – look at tide tables, is it neap or spring tide? Will the tide be high or low?
- Look at weather predictions so you know what to expect. The wind direction and speed are important to judge how waves in the sea may affect the estuary mouth.
- Remember to take a hat and suitable clothes for going into the mud and water. Also pack the necessary food and drink.

Prepare a schedule for the day. Give yourself enough time – do not choose to do too much. It is possibly best to choose three sites – the mouth area, somewhere in the estuary basin, and at the river-estuary interface. These will be the main sampling places. If the group is to be split up, choose more sites.

If the mouth is closed, some of the activities cannot be done – so spend more effort on those that can be done.

Now you should be ready to go into the field and do some of the activities

ACTIVITY

OBSERVING TIDAL PATTERNS

The purpose of this activity: is to estimate how large the tidal range is in different places within the estuary. This activity cannot be done if the estuary mouth is closed as the estuary is then no longer affected by tides.

The tidal range is the difference in water levels between high tide and low tide. If the mouth is open, the tidal range is greatest nearest the sea and it gradually diminishes inland.

Start by obtaining the tide tables for the estuary for that day. These can be obtained from:

http://www.satides.co.za/

http://www.sanho.co.za/tides/tide_index.htm

http://www.tides4fishing.com/af/south-africa

In the field, what to do is quite simple. It involves placing a stick in the water and then measuring water levels changes on the stick at intervals throughout the day. The equipment needed is a stick or lath that is reasonably straight (a branch of a tree will do). To prepare it you sharpen one end. Then make marks at 10 cm intervals with a waterproof felt-tip pen, with paint or by cutting grooves with a saw or knife. Hammer the stick in the estuary making sure that its base will still in the water at low tide. The stick should be long enough to measure the water levels at both high and low tides. This means that the stick should be about 2 m for near the mouth, and can be shorter in upstream localities that will have a smaller tidal range.

The first job when arriving at the estuary is to place measuring sticks in position at intervals from the mouth to the river-estuary interface. Mark the localities on your map (and record the coordinates by taking a waypoint if you have a GPS).

Measure the water level at the stick frequently during the day (not more frequently than 15 minute intervals); if possible at least once every few hours. A good trick is to record the level by taking a photo, but first make sure that the time-setting in your camera is correct. This is very important because later you can read the water level off the photo and correlate it with the time the photo was taken. Also realise that if the water is choppy you must take the reading at an average level. If photos are being taken it is best to take three or more photos at a time and use the average of these to give mean water level.

Even if you are taking photos, it is good practice to write down the water level measurement in the field and then later it can be recorded more accurately from the photographs. This allows one to track the tide during the day.

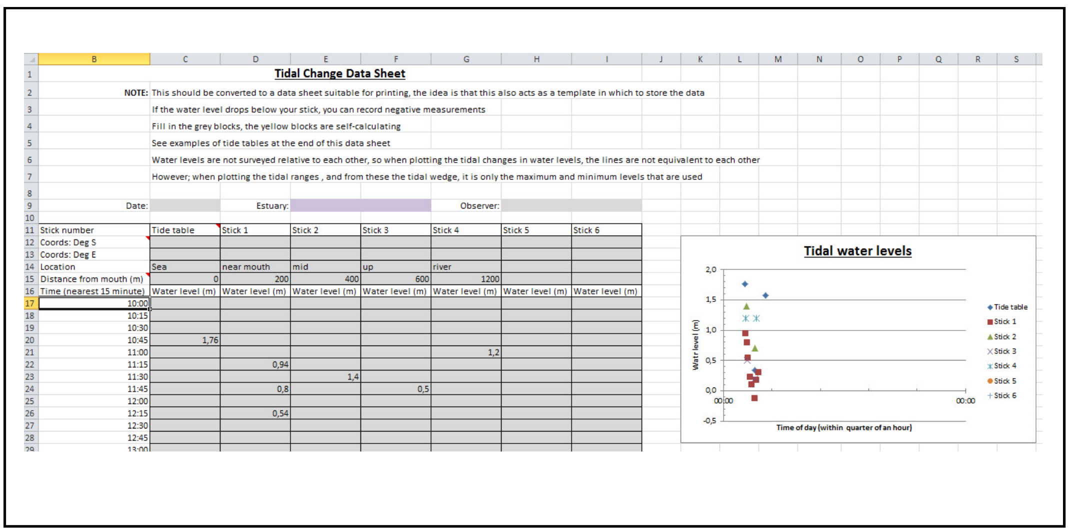
In the field you must note when the water is rising or falling, and also by how much. Compare this to the data from the tide tables.

Also, measure lateral spread as the water rises by putting in a stick at the edge of the water each time gauge is measured. This shows how the margins of the estuary are inundated and then how the water draws back.

There is a self-calculating graph on the data sheet that shows the tidal change represented by the variation of water levels over a period of time, measured at different points in an estuary. This information shows us the extent to which tides affect water levels in an estuary. There will be more readings at the estuary mouth/close to the mouth because this is where tidal change will be the most evident and water levels will vary the most.

Data sheet:

<<See spreadsheet for draft data sheet>>



Tidal Change Data Sheet

NOTE: This should be converted to a data sheet suitable for printing, the idea is that this also acts as a template in which to store the data
If the water level drops below your stick, you can record negative measurements
Fill in the grey blocks, the yellow blocks are self-calculating
See examples of tide tables at the end of this data sheet
Water levels are not surveyed relative to each other, so when plotting the tidal changes in water levels, the lines are not equivalent to each other
However; when plotting the tidal ranges , and from these the tidal wedge, it is only the maximum and minimum levels that are used

Date: Estuary: Observer:

Stick number	Tide table	Stick 1	Stick 2	Stick 3	Stick 4	Stick 5	Stick 6
Coords: Deg S							
Coords: Deg E							
Location	Sea	near mouth	mid	up	river		
Distance from mouth (m)	0	200	400	600	1200		
Time (nearest 15 minute)	Water level (m)	Water level (m)	Water level (m)	Water level (m)	Water level (m)	Water level (m)	Water level (m)
10:00							
10:15							
10:30							
10:45	1,76						
11:00					1,2		
11:15		0,94					
11:30			1,4				
11:45		0,8		0,5			
12:00							
12:15		0,54					
12:30							
12:45							
13:00							

At home processing:

Using Google Earth, measure the distances of the sticks from the mouth, not in a straight line, but along the curve of the channel to give the distance that the water actually flows.

<<<see spreadsheet for calculations to measure the tidal range (tidal wedge) at different points in the estuary>>>

In the lab plot time vs. height for all of the poles. Add the heights from the tide tables onto the same axis. Link the points by drawing in the lines in by hand.

Estimate the tidal range for different places in the estuary, and mark this range on your map.

If you are able to return to the estuary on another day, repeat this exercise to see how it responds to different tides, weather conditions and mouth state.

What to expect and why?

Expect a tidal rise and fall with duration of a little over 6 hours. The heights of the highest and lowest levels of the tide are given in tide tables for the sea at the mouth. This range gets less as one moves upstream from the mouth.

Note that the amount of tidal water exchanged is dependent on the range of the marine tide. This changes from neaps to springs and also is modified by storm conditions and rough seas.

Ask yourself how tidal rise and fall of water levels affects the functioning of an estuary. What will happen if the mouth closes and the estuary is no longer tidal? Tidal rise and fall means that the margins of the estuary are flooded and then dry out twice a day. This is the intertidal area of the estuary. It is in this intertidal area that some very special plants and animals live.

ACTIVITY

MEASURING WATER FLOWS

<u>The purpose of this activity:</u> is to measure flows in different places in the estuary at different times during the day. If the mouth is closed, then this activity can only be done in the in-flowing river as there will be no significant flows within the estuary.

Water movements within the estuary occur when the tide is rising or falling (if the mouth is open) and also a result of inflowing river water.

If your chosen estuary is less than 1 meter in depth across the entire cross section and it is safe to cross the estuary, you may use the Transparent Velocity Head Rod (TVHR). If this is not the case, there is an alternative method you may use to measure the water flow (below).

Choose suitable sites to measure flows. Preferably these should include some of the sites where the sticks were installed to measure the tidal rise and fall of the water. First measure off a length of shoreline of 5, 10 or 20 m (20 m where there are fast flows and 5 m for slow flows). Measure this with a tape measure and mark at each end with a stick or a rock. Then throw a floating object (a stick, a ball or an orange will do) into the middle of the estuary opposite the marker on the bank. (See figure 2). Time how long it takes to be carried by the water flow to be opposite the downstream marker. Use a cell phone stopwatch to time this. Repeat this several times so that an average rate of movement can be obtained.

Figure 2: This illustration shows Winnie the Pooh, Piglet and Christopher Robin throwing twigs into the stream from the upstream side of a bridge. They would then run to the downstream side to see how long it takes for the twig to travel the width of the bridge. This is the basis of the technique we use to measure the speed of water flow in the estuary. (Source of the picture: internet)

To obtain the volume of water moving it is necessary to also measure the cross-section area of the estuary. If it is possible, measure the channel width and depth at regular intervals to be able to calculate a cross sectional area.

Once you have the speed of flow and a cross-sectional area, then the volume of water flowing can be calculated.

Data sheet

<<< see draft spreadsheet>>>

	A	B	C	D	E	F
1			**Water Flow Data Sheet**			
2	NOTE:	Fill in the grey blocks, yellow blocks are self-calculating				
3		Record whether the measurements start on the left bank or the right bank (the 'left bank' is that on the left when one faces downstream)				
4		The cross-section area will change as the tide rises and falls				
5						
6	Date:		Estuary:			Observer:
7	**Water flow measurements**					
8	Stick number					
9	Coords: Deg S					
10	Coords: Deg E					
11	Location					
12	Distance from mouth (m)					
13						
14					**Speed of flow**	
15	Time of day		to relate to state of tide			
16	Distance along bank	10	m	Flow direction		in from sea or out towards sea
17	Time for stick to cover distance					
18	trial 1	4	sec			
19	trial 2	5	sec			
20	trial 3	3	sec			
21	trial 4	4	sec			
22	trial 5	4	sec			
23	trial 6	5	sec			
24	trial 7	3	sec			
25	trial 8	5	sec			
26	trial 9	5	sec			

At home processing

Note: At the point where the river enters the estuary the flow represents the inflow from the catchment. Elsewhere the flow is a combination of river flow plus the tidal flow as the tidal wedge rises and falls.

Graph – changes in flow vs time – same scale as tidal rise and fall

x-section gives area measurement

Why are we interested in flows? This is when there is a mixing of saline and freshwater. Can you do a water balance diagram?

Water balance: This describes the amount of water flowing into and out of a system.

Hint: Use arrows in your diagram.

What to expect, and why

We are interested in the flows to be able to learn about the water balance of the estuary (Figure 3). For most estuaries, groundwater, rainfall and evaporation are not particularly significant. The sea-estuary exchange is related to the tidal wedge which in turn is controlled by the mouth and whether it is open, constricted or closed. River inflows are controlled by rainfall events and the average rainfall over a season. All these affect the estuary basin. Its volume changes as the water level rises or falls, and depending on the proportions (ratio) of sea water: river water in the estuary, the salinity will change. The combination of volume and salinity will give you the salt load; the mass of salt held in the estuary.

Your measurements, once graphed, will give the speed and direction of flow related to tides. You will also have a measurement of cross-sectional area. With these measurements the volume of water moving can be calculated, i.e. speed of water in metres per second multiplied by section area. This gives the volume in units of cubic metres per second.

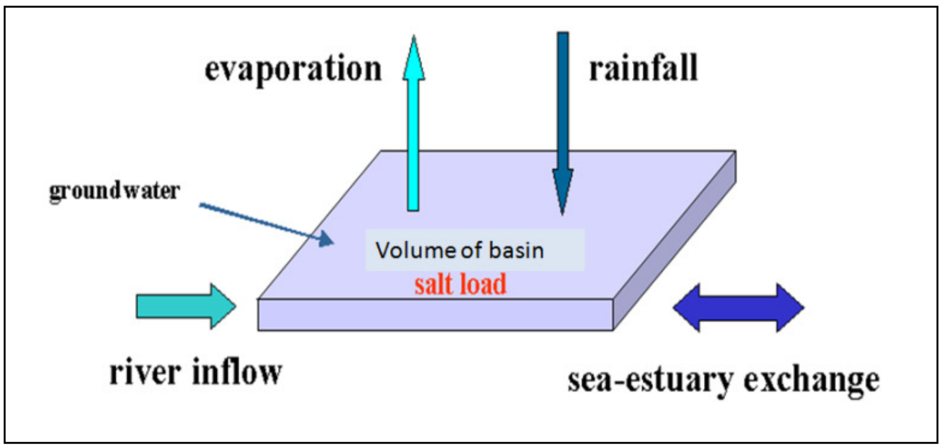


Figure 3: A schematic picture showing the water gains and losses within an estuary. Freshwater is gained from the catchment as river inflows and a tiny amount from groundwater seepage. It is also gained from rainfall that falls directly onto the surface of the estuary. For our purposes the water flowing in from the catchment is usually many times greater than that from direct rainfall and the groundwater so we ignore these latter inputs. Seawater enters the estuary during high tides via the mouth. At low tides water is lost from the estuary as it moves into the sea. This is water that is a mixture of river water and sea water. The measuring of salinity will tell us the proportion of seawater to river water. There is also a minimal amount of water lost via evaporation, which we usually ignore as it is a small amount relative to outflow. The other component of our water balance is to keep track of the volume of water held in the estuary by measuring the rise and fall of the water level.

What we should find is that the flows in the estuary can be in either direction (except at the point where the river meets the estuary). These flows are driven by the infilling of the estuary as tide rises, and the outflows as tide falls.

ACTIVITY

MEASUREMENT AND MAPPING OF SALINITY AND TEMPERATURE

The purpose of this activity: is to investigate salt and temperature patterns at different places and at different tides within the estuary.

In an estuary there is usually a salinity gradient from the sea to the river. But, as saline water is heavier than fresh water, often the salinity at the bottom of the estuary is higher than salinity on the surface. Both of these gradients affect the plants and animals of an estuary. In addition, there are temperature patterns in an estuary; both along the length of the estuary and vertically.

There are several methods to measure salinity, based on the properties of saline water. Measurements can be done to determine the density of the water, the refraction of light by the optically denser salty water, the electrical conductivity which changes as it is more salty, and chemical reactions. To measure salinity accurately requires specialised equipment which is expensive.

NOTE: it is not advisable to taste water to detect salinity as many of our estuaries are polluted.

The cheapest method is to use a hydrometer to measure the specific gravity of water. The principle of a hydrometer is: Salt water is denser than fresh water and hence has a greater specific gravity. The hydrometer is a float that is only slightly more buoyant than water. Above the float is a vertical scale that indicates the depth that the float sits in the water. In the dense saline water the hydrometer floats higher up than in the less dense fresh water. As it does this, so more of the measuring graduations are exposed (Figure 4).

One has to be careful when using a hydrometer as it is sensitive to temperature. Warm water is less dense than cold water and so temperature must be taken into account

For our purposes we can make a DIY hydrometer out of a drinking straw, a small piece of graph paper, some Prestick and some glue (Figure 4). This will not give a highly accurate reading of salinity but it is adequate for us to do comparisons that show if water from one site is more saline than that from another site.

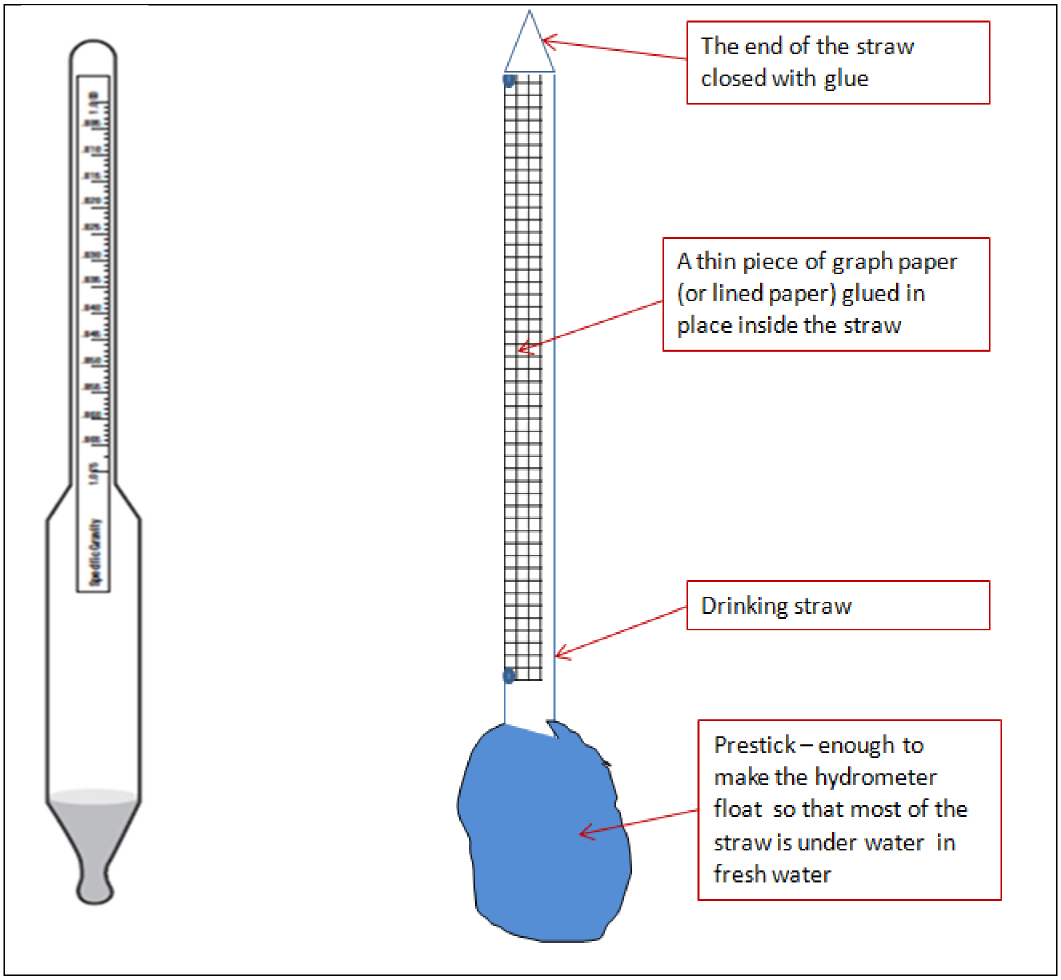


Figure 4: A commercial hydrometer (left) and a DIY one (right)

Add photographs here

As shown in figure 4, construction is simple. A slither of graph or lined paper is slipped into a clear straw and held in place with a small blob of glue. The top of the straw is sealed by pinching it and holding it in place with glue. Then a mass of Prestik is put on the lower end of the straw. The amount of Prestik to use is determined by trial and error by adding or removing some to make sure that the DIY hydrometer floats. Do this in fresh water as the hydrometer must float deep in the least dense water.

The DIY hydrometer can either be used just to compare samples, or it can be calibrated. To calibrate, first place it into seawater which we know has a salinity of 35 ppt (parts per thousand, i.e. grams of salt per 1000 ml of water). Then we put it into freshwater which we know has virtually no salt. By doing this we get the two extremes (i.e. 35 and 0 ppt), so we can then estimate salinity between these two extremes.

NOTE: Always ensure that the calibration and all salinity measurements are done at the same temperature. It is best to bring the samples back to the lab and allow them to stand for a few hours or overnight so that water temperatures are the same.

<<<< Check – is the floatation linear with density? – I have assumed so – is this correct? >>>>

Now that we have our DIY equipment to measure salinity, we can measure salinity in different places within the estuary and at different tides. To do this we collect samples in bottles. Any bottle will do. A sample of 500 ml or more is needed. In the lab the water is placed in a wide-mouthed jar and the hydrometer is floated in this. The graduation is measured to give relative salinity.

For temperature measurement we need a thermometer. Scientific thermometers are expensive; however, a modestly-priced one can be bought from a pet shop. They are used to measure temperature in aquaria. With one of these we can measure temperature in different places at different times. Temperature needs to be measured in situ.

In situ: is a Latin phrase used in scientific research that means on site, in other words the temperature must be measured at the original point where the sample is to be taken.

Data sheet

<<< see draft spreadsheet>>>

	A	B	C	D	E	F	G	H	I	J	K
1		Salinity & Temperature Data Sheet									
2	Date:			Estuary:			Observer:				
3											
4	Site location:										
5	Coordinates (S)										
6	Coordinates (E)										
7											
8			Tap	Sea							
9			Freshwater	Seawater							
10			4	23							
11											
12											
13			0	35							
14				19	graduations						
15				1,8	ppt						
16											
17		River interface	100m from river		Upper-mid estuary		Mid estuary		Lower-mid estuary		Mouth
18	Sample locality		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	
19											
20	Coordinates (S)										
21	Coordinates (E)										
22	Sample number	9	1	2	3	4	5	6	7	8	10
23	Depth	10	10	120	10	120	10	120	10	120	10
24	Hydrometer - measurement of stem above the water level	5	7	12	9	16	11	14	18	20	23
25	Thermometer - temp. at site (Deg C)										
26	Time (hours)										
27	Salinity										

At home processing

Measure the salinity of the samples that have been collected in the field but kept for some time so that all the samples are the same temperature. Map salinity and temperature at the different locations on your field map

What to expect and why?

If the mouth is open and the estuary is tidal, seawater comes into the estuary on a rising tide. This is 35 ppt. The further one is from the mouth the more mixing occurs with fresh water and so the salinity is lower. One should find a gradient of salinity ranging from freshwater at the river-estuary interface to sea water at the mouth. On the outgoing tide the water volume held in the tidal wedge moves out, so there is a shifting of the salinity gradient seawards as this occurs.

There is also a vertical gradient. If you are able to sample deep water it should be more saline than the surface water. But if it has been windy, then the water may be well mixed.

Water temperature should be similar to that of the sea near the mouth on an incoming tide. But in the estuary it may be warmer or cooler depending on air temperature relative to sea temperature. When there is little flow temperatures in shallow water may differ considerably from that in deeper water. When there is no wind on a warm day, the surface water in the estuary will be considerably warmer than the deeper water.

Should there be a fish die-off it is important to get measurements of water temperature and salinity where the fish are dying.

ACTIVITY

OBSERVING MOUTH AND BEACH DYNAMICS

The purpose of this activity: is to identify the main processes that shape the mouth.

This is done by looking for evidence showing which of these processes are operating and which are dominant. The best way to do this is to sketch the mouth and add annotations to the sketch to understand how the mouth functions. Plan to do this activity at low tide when most of the mouth features are exposed.

The mouth is the most dynamic part of an estuary. There are several discrete processes that interact to shape the mouth: Tidal water moves in and out, carrying sediments with it which are deposited in sandbanks. These sediments may accumulate to constrict or close the mouth. River floods expand the channel. Storm events out at sea create large waves and swells, which erode the mouth and adjacent beaches. Breaching occurs after the mouth has closed. All these processes operating at the same time lead to a rapidly changing configuration of the mouth.

The sketch map of mouth should show the main features (see figure 5). These include sand bars, the location of the channel and if there are rocks or any other guiding structures. Make many annotations to explain details.

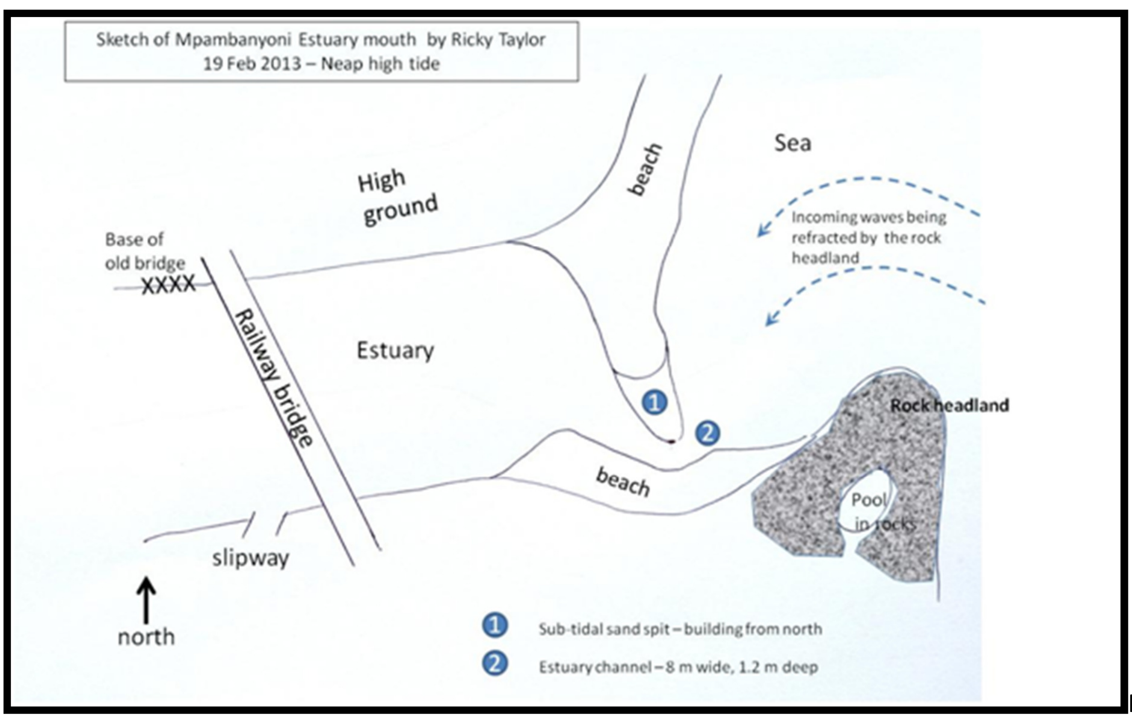


Figure 5: Sketch map of an estuary mouth. It shows the position of the rocky headland that 'holds' the estuary

mouth. It shows the angle of attack of waves and how they are affected by the rocks. It shows the width and depth of the outlet channel, and shows how the sandy spit is advancing from the north to constrict this channel. When the mouth closes it is this sand spit that closes the estuary channel. Include other features where necessary – such as the width of the beach, the presence of submerged sand bars in the estuary and any artificial structures made to control the estuary mouth.

The dimensions of the beach adjacent to the mouth can also give evidence of changes. Map the height of the sand berm (the sand bar in front of the mouth). Use the technique described in figure 14 to measure beach slopes and widths in different places.

Measurement of beach slope and width

Equipment: Two poles of one of 1 m and another of 2 m. For the 2 m pole, make a very distinct mark at 1 m which is called 0. Then mark at 10 cm intervals above and below this, where the marks above the 0 mark are -10, -20, -30 -40 up to -100 cm. The marks below are +10, +20, +3-0, +40 down to +100 cm.

Use a hand-held ruler to measure smaller distances between graduations. The bases of these poles should be linked by a string/rope that is exactly 5 m. (Note for very flat beaches it may be better to have a rope of 10 m).

Start at the top of the beach, preferably at a fixed point (such as a permanent pole, the base of a tree, a fence, a rock, etc.). Have two people, one on each pole. Stretch the string at the base of the poles taught so that they are exactly 5 m apart. The observer, with his eye on the top of the 1 m pole looks past the second pole to the sea horizon. The observer then looks at the scale on the pole to read how much the beach has sloped over this 5 m distance. Then place the 1 m pole where the 2 m pole had been and take another reading. Move all the way to the sea repeating this as you go.

There are negative numbers above zero and positive numbers below because the second pole is downslope of the observer

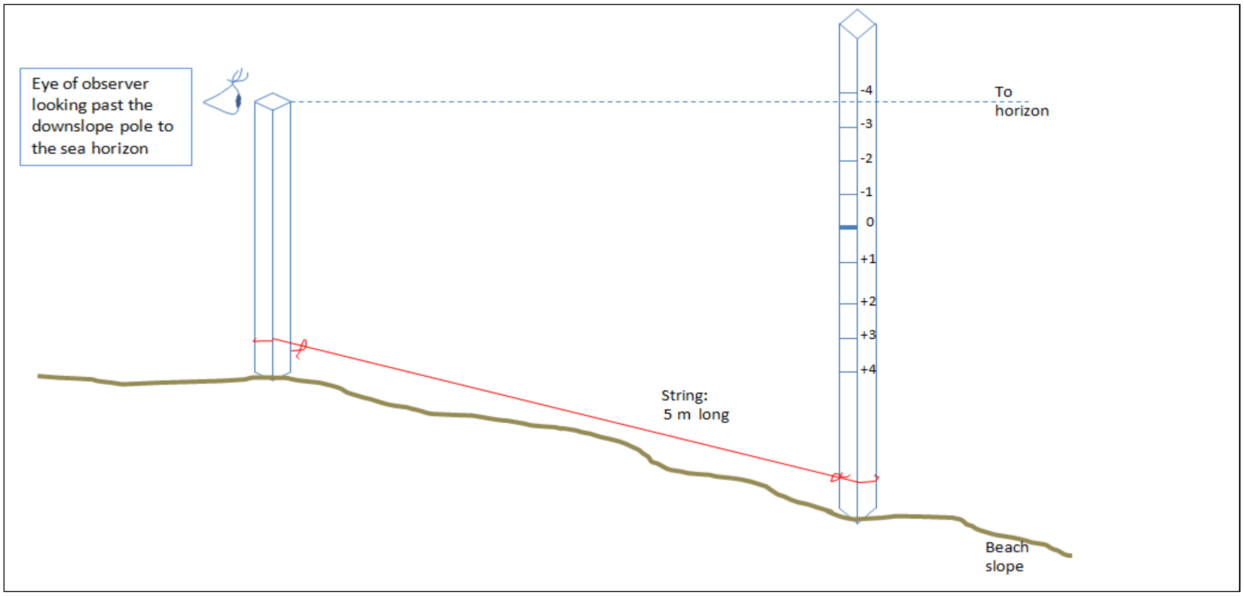


Figure 6: This illustrates the technique used to measure the slope of the beach. This method can also be used to map from the estuary to the sea if the mouth is open or closed. If open it gives the gradient of outflow. If closed it gives an estimate of how much the water has backed up in the estuary.

While measuring the slope of the beach, the identity and location of all the vegetation can be mapped, and also the locations of crab holes. This will show the patterns species change down the slope as one gets closer to the sea.

Tip:

If you have a GPS you can walk along one of the margins of the estuary mouth (or both margins if accessible) and take GPS waypoints all along the edge of the estuary at 5 m intervals. Once back in the lab, these points can be downloaded and transferred to a Google Earth image. This gives an accurate base map onto which your field sketch and annotations can be transferred by hand.

At home processing

Map the gradients of the beach to get beach profiles. What is the overall profile of the beach; convex indicating sediment deposition, concave indicating erosion, a steep scarp which is being actively eroded by waves, or an evenly sloped beach which is stable and is neither gaining nor loosing sediments?

Mark onto your field-map the locations of these profiles. Tidy up and further annotate your mouth map. You may wish to transfer the information onto a Google Earth image.

Identify the beach plants you have seen (and photographed). Use iSpot and plant identification books. (See the section on plants and animals).

Superimpose the patterns of the vegetation on the beach profiles. Is the vegetation in distinct zones?

What to expect, and why?

The mouth is possibly the most important controller of the estuary as it affects the tidal wedge, the salinity and the location of plants and animals. Thus a recognition and understanding of the processes affecting changes provides insights to how the whole estuary is functioning.

Is the beach eroding or depositing, i.e. concave or convex? This tells us about the sand supply for the mouth and whether there is sediment available to close the mouth. Look for tell-tale sand bars forming ebb-tidal or flood-tidal deltas, or causing sand-spits to extend.

Look for evidence of erosion in the mouth channel, usually on outer bends or where there is wave action. The evidence is a vertical bank that is being undercut by waves or water flows

There are likely to be distinct vegetation zones and plant successions on the beach. This gives some indication of how mobile the beach is; if there is a lot of sand loss, then the plants are unable to establish and the beach will be bare.

ACTIVITY

LEARNING ABOUT ESTUARINE PLANTS, ANIMALS AND THEIR HABITATS

The purpose of this activity: is to learn to identify estuarine plants and animals and to record where they occur, both along the length of the estuary and laterally where their distributions are related to tidal inundations.

The plants photosynthesise making estuaries amongst the most productive ecosystems on this

planet. The animals include the fish, crabs and birds which we value so highly for conservation, fisheries and for their beauty.

The first step is to be able to identify the plant and animal species. In the field take a photo of each species of plant and animal and if necessary give it a temporary name or code. For example a large crab with red nippers you may just call 'red crab' until you are able to get its common or scientific name. When you get back home use the iSpot website (http://www.ispotnature.org/communities/southern-africa) and reference books to work out the name the species. iSpot is particularly useful as it has a 'Species Finder' function, which guides the user to identify the species.

Once you have some species names, start a checklist of all the species of the estuary. This is something that may take many visits before it is comprehensive. New species are always found so one can never say that the checklist contains all plants and animals.

Start to look at habitats and what plants and animals live in them. The most common habitats are: mangroves, salt marsh, submerged water plants, emergent water plants, swamp forest,

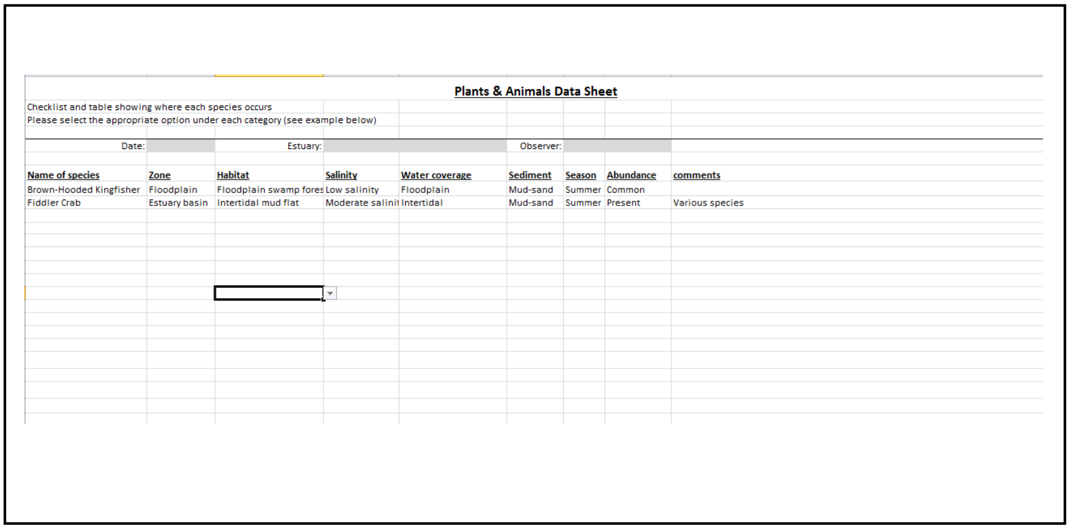
Where do these habitats occur?

Get to recognise habitats based mainly on the dominant plant species. Once this has been done, get to know what less common plants occur in these habitats and also what animals are present. Get a feeling for the abundance of each species. The distance from the river mouth where the species was found can also be recorded (this is an optional activity) and can be added to the salinity graph for interested users.

Abundance: Species abundance is an ecological concept that refers to the number of individuals of species that is represented in a particular ecosystem/habitat/zone.

Data sheet

You will notice in the plants and animals' data sheet that there are options for you to select under each category, below is a list of the possible options along with some explanations/examples:



Plants & Animals Data Sheet

Checklist and table showing where each species occurs

Please select the appropriate option under each category (see example below)

Date: Estuary: Observer:

Name of species	Zone	Habitat	Salinity	Water coverage	Sediment	Season	Abundance	comments
Brown-Hooded Kingfisher	Floodplain	Floodplain swamp fores	Low salinity	Floodplain	Mud-sand	Summer	Common	
Fiddler Crab	Estuary basin	Intertidal mud flat	Moderate salinit	Intertidal	Mud-sand	Summer	Present	Various species

<u>Zone</u>

Beach
Mouth
Estuary basin
River-estuary interface
Floodplain

<u>Habitat</u>

Floodplain swamp forest	Voacanga, Syzygium, Raufolvia, Ficus trichopoda, etc.
Floodplain reedbeds	Phragmites australis
Floodplain saline lawns	Paspalum vaginatum, Sporobolus vagincus
Supratidal salt marsh	Fairly dry salt marsh
Supratidal Juncus beds	Juncus kraussii (Ncema)
Supratidal succulent marsh	Plants such as Sarcocornia and Salicornia
Intertidal mangroves	Mangrove trees
Intertidal sand flat	Bare sand
Intertidal mud flat	Bare mud
Intertidal salt marsh	Spartina, Sporobolus, Vaginicus grasses, etc.

Intertidal rocks	May have barnacles on them
Submerged plants	Beds of plants such as; Zostera, Ruppia or Stuckenia
Submerged rocks	Never exposed
Submerged mud substratum	Muddy bottom of the estuary
Submerged sand substratum	Sandy bottom of the estuary
Submerged dynamic sand (mouth)	Mobile sand, moved by tides and currents
Supratidal beach	Zone in which plants may grow
Intertidal beach	No vegetation

Salinity

Fresh	0-4 ppt
Low salinity	4-15 ppt
Moderate salinity	15-25 ppt
High salinity	25-40 ppt
Hypersaline	Above 40 ppt

Water Coverage

Sediment

Mud

Mud-sand

Sand

Rocky

Season

Summer	December-February
Autumn	March-May
Winter	June-August
Spring	September-November

Submerged	Always covered in water
Intertidal	Exposed at low tide
Supratidal	Above normal high tide but flooded on exceptional tides
Floodplain	Flooded during river floods and when the estuary is closed and the water backs up

Abundance

Absent	This applies to users who have assessed an estuary previously and a species was recorded but is no longer present
Present	One or two individuals only
Common	Several individuals
Abundant	Lots of individuals
Very abundant	The individuals are seen everywhere

At home processing

Once back at base first identify the species so you have names for them.

Then list and describe the habitats you have used. Describe the key features of each habitat; what are its dominant plants that define it. Where in the estuary does it occur? Do you have any information about tidal range and salinity where that habitat occurs, and degree of exposure at low tides? From Google Earth, can you map where the habitats occur?

Then draft a checklist, plants first then animals. For each plant or animal record the habitat it was seen in and its abundance index within the habitat. Make it an annotated checklist by adding notes.

What to expect and why?

Some species are linked to specific places in an estuary and controlled by distance from mouth, salinity and tidal regime, sediment type, degree of exposure, wave action, etc. There may also be seasonal patterns. Other species are widespread. The ones that are able to cope with a wide range of salinities and other conditions are those which are most widespread.

Risks involved

Assessing an estuary is fun but there are precautions that need to be taken. You may potentially be in a wild area; there may be dangerous animals around such as crocodiles or hippos. Please take the necessary precautions in terms of permits, protection, etc. before beginning your assessment.

WARNING: DO NOT TAKE PLANT OR ANIMAL SAMPLES.

ACTIVITY

CONSOLIDATION; REVIEWING THE DAY SPENT AT THE ESTUARY

The purpose of this activity: is to obtain an overview of our understanding of the estuary.

After a day in the field it is necessary to review and consolidate what we have learnt. While doing so we need to store all our notes and measurements in a data base and synthesise the information in a form that can be communicated as a report, a poster or an Internet web-page.

Now is the time to have another look at the Google Earth image of the estuary. See where you have been and to add more detail to your map of the estuary from what you have learnt. As you work through your data, there are a number of features of estuaries you need to be aware of, and to discuss.

The map should show the estuary in the context of nearby roads and towns. It should show the different sections of the estuary; mouth, mid-section and upper section as well as the floodplain. It should show features such as rock outcrops, buildings, jetties, place names, sand banks and interesting features such as areas where fishing or plant harvesting takes place. Bird breeding or roosting colonies should be mapped. A really sophisticated map will also show the main vegetation habitats; salt marsh, bare sand, mangroves, swamp forest, reed beds, and beds of submerged plants

Use the tidal data to calculate the tidal ranges at different points along the estuary. This can be graphed (distance from the mouth on the x-axis and tidal range on the y-axis)

Is it possible to estimate how much water is exchanged on each tide? If we have the tidal ranges for various sections, and the width of the estuary at those sections we can get a 'first stab' at how much water is being exchanged when you measured it. Some points to remember:

1. The tidal range is what is happening in the upper layer of the water. It is the water that rises and falls irrespective of the depth of the estuary below the low-tide mark
2. If we use the width of the estuary when calculating water exchange, then we are assuming that there is not a significant lateral expansion and contraction of the water as the tide rises and falls. This is not the case where there are extensive intertidal salt marshes, so you will need to discuss this to see if your calculations are informative or not.

Water-flows in most estuaries are dominated by the tidal exchange of water. However, if the estuary is not very large and the river inflows are strong, this may not be the case. The river flow can be dominant. You will have measured river inflow and should be able to compare the magnitude of this with the amount of water that moves in and out with each tide. This is an important consideration when discussing mouth dynamics.

Salinity dictates where plants and animals occur within an estuary. It is not a straightforward horizontal gradient from freshwater to sea water. The fact that denser seawater sinks to the bottom of the estuary and then often has lighter low-salinity water floating on it means that there can be a vertical gradient in salinity as well. The gradient between the more salty and less salty water is the halocline. If there is a lot of wind to stir up and mix the water, then there will be no vertical salinity gradient.

Temperature can also change as one goes deeper. A thermocline, the gradient from warm water to cold water can be very sharp. There can be a temperature change of a few degrees c over 20 cm. You may have noticed this effect in a swimming pool that has not been stirred up on a hot day. A big difference between a halocline and a thermocline is that a thermocline will reform under calm conditions once it has been stirred up, but a halocline cannot reform unless more salty water is added.

The state of the mouth controls the estuary. In South Africa estuary mouths often close as they accumulate sand. They remain closed until they can breach. This usually occurs when there is a strong flushing of river water.

The sediment balance in an estuary mouth is complex. It starts with the amount of sand available in the wave zone of the sea. Then, if there is a large amount of water exchanged on each tide this tends to keep the mouth open. But if the flood-tidal delta (formed by the incoming tides) accumulates too much sand the mouth will close. This pattern can be modified by the river flows. As strong river flow will cause the flood-tidal delta to be eroded and the sand carried into the sea on the ebb tide (outflowing tide). After closure the waves build up the beach in front of the estuary. This estuary water level will back up and rise behind the closed mouth. When the water overtops, the fast-flowing outflow of water erodes a channel in the beach, opening the estuary.

The plants and animals of the estuary are affected by salinity. The ones that live along the margins of the estuary are also affected by the tidal regime; the amount of time they are flooded or exposed. The combination of salinity and exposure creates habitats for plants and animals. The plants are good indicators of the estuarine conditions at any particular site and some of the animals are closely linked to the plant habitats.

As part of the consolidation, make sure that your data is all neatly written up, or entered in a computer spreadsheet for storage. Store data, maps, etc. until the next visit and then build on this base. Record what you have seen and measured. When you return at some later state, add to the data already collected. This way you can build on and accumulate knowledge. That is what science is all about.

If the data is stored in spreadsheets it should be in a form which enables easy calculation and graphing. Use the attached formats where possible.

The maps and sketches can be photographed and inserted into Word documents. They can be part of the final report which would also incorporate any graphs that have been generated.

For plants and animals, identify the species from the photos taken. Once this has been done, the names can be inserted into a checklist that also shows localities. It is satisfying to post the pictures of species into iSpot and this has the advantage that other people can make comments and advise if the species are incorrectly identified. At the same time the posting becomes a record of the occurrence of the species in the estuary. As an example see the iSpot postings for the Mlalazi Estuary at http://www.ispotnature.org/projects/mlalazi-estuary--plants-and-animals/observations/gallery .

All the information can be displayed for others to see by progressively sticking each item of information, checklist, map or graph onto a wall using Prestik. Let this evolve as an informal poster. Have it on a wall where the participants can progressively add information. Once they have been completed they can all be stuck on a large piece of paper to create a more formal poster, or consolidated into a PowerPoint presentation. There is the possibility for all this to be put into a web page. If necessary these components can be the basis for an oral presentation or for a written report.

A good final product is a record for you or others to build on. It should be something to be proud of. Whenever you look at it, it will bring back happy memories of a day spent at an estuary.

REFERENCE BOOKS AND WEB SITES

Reference books

Fish, invertebrates and plants

The most comprehensive book is:

George Branch, C. L. Griffiths, M. L. Branch, L. E. Beckley. (2008). **Two Oceans: A Guide to the Marine Life of Southern Africa**. Struik Publishers.

Birds

There are many bird books on the market. A particularly useful one is:

Chittenden, Hugh. (2006). Roberts Bird Guide a Comprehensive Field Guide to Over 950 Bird Species in Southern Africa. Jacana Publishers.

Estuaries in general:

Patricia Berjak, G.K. Campbell, Barbara Huckett, N.W. Parmenter. (2011) In the Mangroves of southern Africa. WESSA.

Web sites

Plants and animals:

There are a number of web sites available. One of the best general sites, which is run by the South African National Biodiversity Institute (SANBI) is iSpot:

http://www.ispotnature.org/communities/southern-africa

Tides:

The following sites are useful for obtaining tide tables and to explain tides:

http://www.satides.co.za/

http://www.sanho.co.za/tides/tide_index.htm

http://www.tides4fishing.com/af/south-africa

River water levels and flows

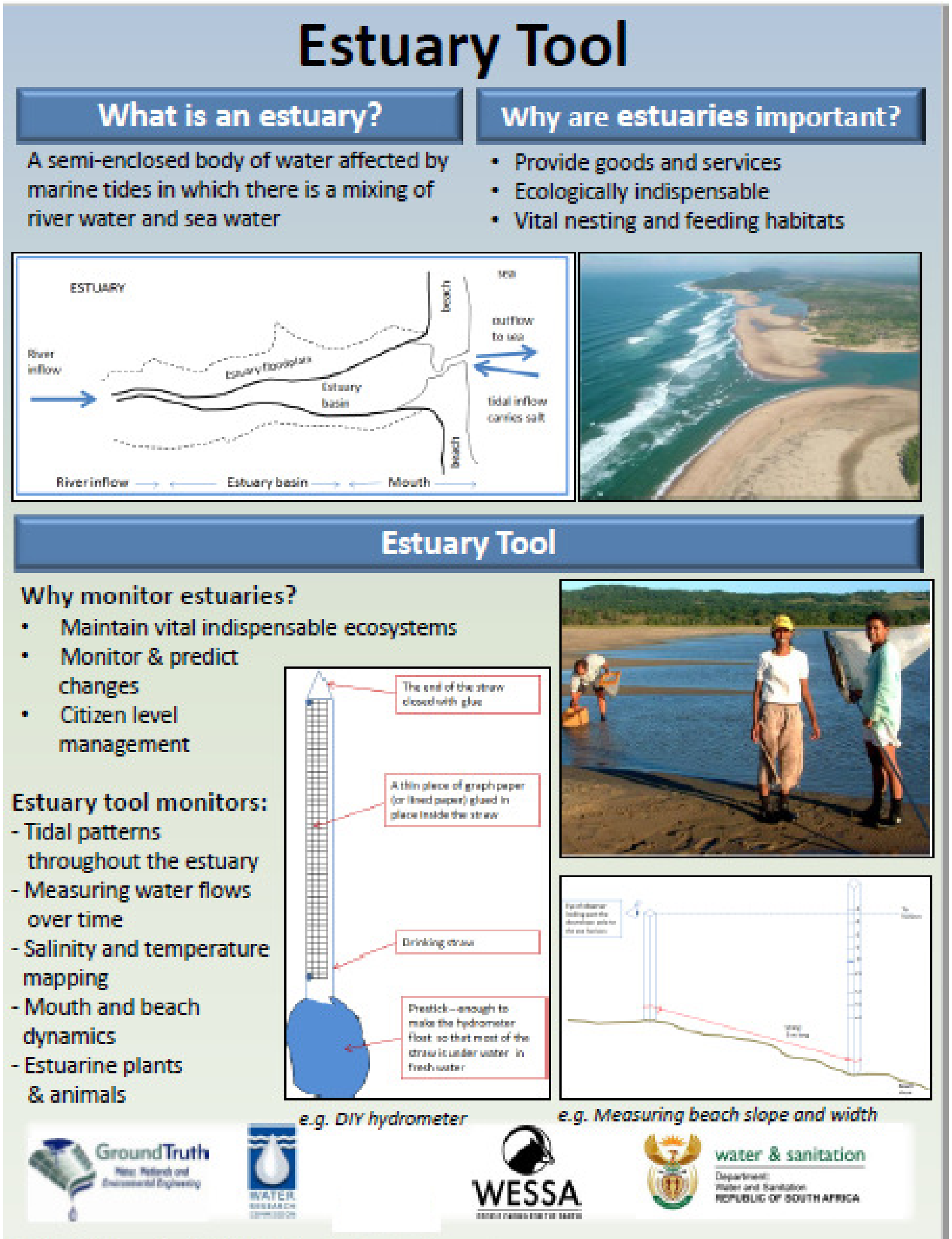
These are monitored by the Department of Water and Sanitation, and the data are available at:

https://www.dwa.gov.za/Hydrology/RTMain.aspx

Weather:

A good website for weather predictions in coastal areas is 'WindGuru': http://www.windguru.cz/int/

Poster


Estuary Tool
What is an estuary?
A semi-enclosed body of water affected by marine tides in which there is a mixing of river water and sea water
Why are estuaries important?
• Provide goods and services
• Ecologically indispensable
• Vital nesting and feeding habitats
ESTUARY
sea
beach
outflow to sea
River inflow
Estuary floodplain
Estuary basin
tidal inflow carries salt
beach
River inflow
Estuary basin
Mouth
Estuary Tool
Why monitor estuaries?
• Maintain vital indispensable ecosystems
• Monitor & predict changes
• Citizen level management
Estuary tool monitors:
- Tidal patterns throughout the estuary
- Measuring water flows over time
- Salinity and temperature mapping
- Mouth and beach dynamics
- Estuarine plants & animals
The end of the straw closed with glue
A thin piece of graph paper (or lined paper) glued in place inside the straw
Drinking straw
Prestick – enough to make the hydrometer float so that most of the straw is under water in fresh water
e.g. DIY hydrometer
e.g. Measuring beach slope and width
GroundTruth
WATER RESEARCH COMMISSION
WESSA
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

PowerPoint Presentation

Estuary Tool

This is a product of The Water Research Commission: Project No. K5/2350

WRC Project No. K5/2350

How do you prepare yourself?

1. Choice of what to do:

Activity	Mouth (open)	Mouth (closed)	Estuary basin (if mouth is open)	Estuary basin (if mouth is closed)	River-estuary interface
Preparation	☺	☺	☺	☺	☺
Tides	☺	☒	☺	☒	☒
Flows	☺	☒	☺	☒	☺
Salinity & temperature	☺	☺	☺	☺	☺
Mouth dynamics	☺	☒	☒	☒	☒
Beach dynamics	☺	☺	☒	☒	☒
Plants & animals	☺	☺	☺	☺	☺
Consolidation	☺	☺	☺	☺	☺

WRC Project No. K5/2350

IMPORTANT: Do not skimp on the preparation before going to the estuary or the consolidation once you have returned from your field day. Make sure you make plenty of notes in the field as you might forget something when you get back.

2. Make your own map:

- Make your own base map onto which you mark place names, roads and tracks, buildings and jetties and landscape features (such as distinctive rocks).
- On this map, mark out the main component parts of the estuary – the mouth, the estuary basin, the river-estuary interface and the estuary floodplain.
- This is the map that you will take into the field with you.
- It is the map onto which you can sketch additional features – such as intertidal salt marsh, mangroves etc. once you are in the field.

WRC Project No. K5/2350

3. Prepare equipment:

Basic equipment includes:

- Camera/cell phone to take photos
- Ruler/tape measure
- Clipboard: To hold the data sheets and map, tide tables
- Pencil/pen

Once you have chosen the activities you will do, put aside all equipment needed for those activities.

4. Prepare the data sheets

The data sheets for each activity are described with the activity – but the data sheets do need to be prepared before going to the estuary – and copies made if required.

WRC Project No. K5/2350

5. The logistics of the visit:

Some logistics planning is needed. This should include:

- Transport and the route you will take to get to the estuary. Who is going in which vehicle (if there are multiple vehicles)
- Once at the estuary, where do you start? What sample sites will you use?
- What tide is it – look at tide tables, is it neap or spring tide? Will the tide be high or low?
- Look at weather predictions so you know what to expect. The wind direction and speed are important to judge how waves in the sea may affect the estuary mouth.
- Remember to take a hat and suitable clothes for going into the mud and water. Also pack the necessary food and drink.
- Prepare a schedule for the day. Give yourself enough time – do not choose to do too much. It is possibly best to choose three sites – the mouth area, somewhere in the estuary basin, and at the river-estuary interface.

WRC Project No. K5/2350

Activity n° 1: Observing Tidal Patterns

- The tidal range is the difference in water levels between high tide and low tide. If the mouth is open, the tidal range is greatest nearest the sea and it gradually diminishes inland.
- The equipment needed is a stick or lath that is reasonably straight (a branch of a tree will do).
- Sharpen one end.
- Marks at 10 cm intervals with a waterproof felt-tip pen, with paint or by cutting grooves with a saw or knife
- Hammer the stick in the estuary making sure that its base will still in the water at low tide
- The stick should be long enough to measure the water levels at both high and low tides. This means that the stick should be about 2 m for near the mouth, and can be shorter in upstream localities that will have a smaller tidal range.

WRC Project No. K5/2350

Activity n° 1: Observing Tidal Patterns

- Place measuring sticks in position at intervals from the mouth to the river-estuary interface. Mark the localities on your map (and record the coordinates by taking a waypoint if you have a GPS).
- Measure the water level at the stick frequently during the day (not more frequently than 15 minute intervals); if possible at least once every few hours. A good trick is to record the level by taking a photo
- Note when the water is rising or falling, and also by how much. Compare this to the data from the tide tables.
- Measure lateral spread as the water rises by putting in a stick at the edge of the water reach time gauge is measured. This shows how the margins of the estuary are inundated and then how the water draws back.

WRC Project No. K5/2350

Activity n° 1: Observing Tidal Patterns

At home processing:

- Using Google Earth, measure the distances of the sticks from the mouth, not in a straight line, but along the curve of the channel to give the distance that the water actually flows.
- In the lab plot time vs. height for all of the poles. Add the heights from the tide tables onto the same axis. Link the points by drawing in the lines in by hand.
- Estimate the tidal range for different places in the estuary, and mark this range on your map.

WRC Project No. K5/2350

Activity n° 1: Observing Tidal Patterns

Data sheet:

Date:				Estuary:			Observer:	
Stick number		Tide table	Stick 1	Stick 2	Stick 3	Stick 4	Stick 5	Stick 6
Coords: Deg S								
Coords: Deg E								
Location		Sea	near mouth	mid	up	river		
Distance from mouth (m)		0	200	400	600	1200		
Time (nearest 15 minute)		Water level (m)	Water level (m)	Water level (m)	Water level (m)	Water level (m)	Water level (m)	Water level (m)
06,00	06:00							
06,25	06:15							
06,50	06:30							
06,75	06:45	1,76						
07,00	07:00							
07,25	07:15		0,94					
07,50	07:30			1,4				
07,75	07:45		0,8		0,5			
08,00	08:00							
08,25	08:15		0,54					
08,50	08:30							
08,75	08:45							
09,00	09:00							
09,25	09:15		0,23					
09,50	09:30							
09,75	09:45							
10,00	10:00							
10,25	10:15		0,1					

WRC Project No. K5/2350

Activity n° 1: Observing Tidal Patterns

What to expect and why?

- Expect a tidal rise and fall with duration of a little over 6 hours. The heights of the highest and lowest levels of the tide are given in tide tables for the sea at the mouth. This range gets less as one moves upstream from the mouth.
- Note that the amount of tidal water exchanged is dependent on the range of the marine tide. This changes from neaps to springs and also is modified by storm conditions and rough seas.
- Ask yourself how tidal rise and fall of water levels affects the functioning of an estuary. What will happen if the mouth closes and the estuary is no longer tidal? Tidal rise and fall means that the margins of the estuary are flooded and then dry out twice a day. This is the intertidal area of the estuary. It is in this intertidal area that some very special plants and animals live.

WRC Project No. K5/2350

Activity n° 2: Measuring Water Flows

- Choose suitable sites to measure flows. Preferably these should include some of the sites where the sticks were installed to measure the tidal rise and fall of the water.
- First measure off a length of shoreline of 5, 10 or 20 m.
- Measure this with a tape measure and mark at each end with a stick or a rock.
- Throw a floating object (a stick, a ball or an orange will do) into the middle of the estuary opposite the marker on the bank.

WRC Project No. K5/2350

Activity n° 2: Measuring Water Flows

- Time how long it takes to be carried by the water flow to be opposite the downstream marker. Use a cell phone stopwatch to time this.
- Repeat this several times so that an average rate of movement can be obtained.
- To obtain the volume of water moving it is necessary to also measure the cross-section area of the estuary. If it is possible, measure the channel width and depth at regular intervals to be able to calculate a cross sectional area.

WRC Project No. K5/2350

Activity n° 2: Measuring Water Flows

Data sheet:

Date:		Estuary:		Observer:
Water flow measurements				
Stick number				
Coords: Deg S				
Coords: Deg E				
Location				
Distance from mouth (m)				

			Speed of flow		
Time of day		to relate to state of tide			
Distance along bank	10	m	Flow direction		in from sea or out towards sea
Time for stick to cover distance					
trial 1	4	sec			
trial 2	5	sec			
trial 3	3	sec			
trial 4	4	sec			
trial 5	4	sec			
trial 6	5	sec			
trial 7	3	sec			
trial 8	5	sec			
trial 9	5	sec			

Activity n° 2: Measuring Water Flows

What to expect, and why

- Your measurements, once graphed, will give the speed and direction of flow related to tides.
- You will also have a measurement of cross-sectional area. With these measurements the volume of water moving can be calculated i.e. speed of water in metres per second multiplied by section area. This gives the volume in units of cubic metres per second.
- What we should find is that the flows in the estuary can be in either direction (except at the point where the river meets the estuary). These flows are driven by the infilling of the estuary as tide rises, and the outflows as tide falls.

Activity n° 4: Observing mouth and beach dynamics

Identify the main processes that shape the mouth

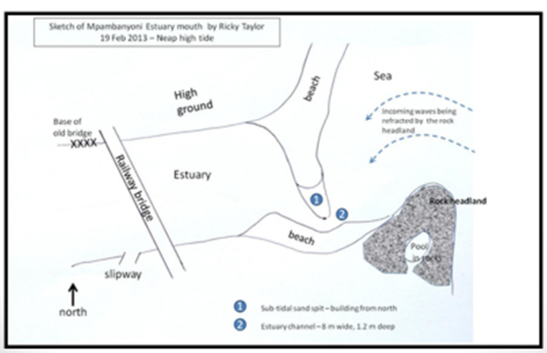
- The best way to do this is to sketch the mouth and add annotations to the sketch to understand how the mouth functions.
- Plan to do this activity at **low tide** when most of the mouth features are exposed.

The mouth is the most dynamic part of an estuary. There are several discrete processes that interact to shape the mouth:

- Tidal water moves in and out, carrying sediments with it which are deposited in sandbanks. These sediments may accumulate to constrict or close the mouth.
- River floods expand the channel.
- Storm events out at sea create large waves and swells, which erode the mouth and adjacent beaches.
- Breaching occurs after the mouth has closed.

All these processes operating at the same time lead to a rapidly changing configuration of the mouth.

The sketch map of mouth should show the main features. These include sand bars, the location of the channel and if there are rocks or any other guiding structures. Make many annotations to explain details:



Measurement of beach slope and width

Equipment: Two poles of one of **1 m** and another of **2 m**. For the 2 m pole, make a very distinct mark at 1 m which is called 0. Then mark at 10 cm intervals above and below this, where the marks above the 0 mark are -10, -20, -30 -40 up to -100 cm. The marks below are +10, +20, +3-0, +40 down to +100 cm.

Use a hand-held ruler to measure smaller distances between graduations. The bases of these poles should be linked by a string/rope that is exactly 5 m. (Note for very flat beaches it may be better to have a rope of 10 m).

At home processing

1. Map the gradients of the beach to get beach profiles.
2. Mark onto your field-map the locations of these profiles. Tidy up and further annotate your mouth map. You may wish to transfer the information onto a Google Earth image.
3. Identify the beach plants you have seen (and photographed). Use iSpot and plant identification books. (See the section on plants and animals).
4. Superimpose the patterns of the vegetation on the beach profiles.

Activity n° 5: Learning about estuarine plants, animals

The first step is to be able to identify the plant and animal species:

- ✓ In the field **take a photo of each species** of plant and animal and if necessary give it a temporary name or code. For example a large crab with red nippers you may just call 'red crab' until you are able to get its common or scientific name.
- ✓ When you get back home use the **iSpot website** (http://www.ispotnature.org/communities/southern-africa) and reference books to work out the name the species.

WRC Project No. K5/2350

base of the poles taught so that they are exactly 5 m apart.

looking past the downslope pole to the sea horizon

horizon

Once you have some species names: start a checklist of all the species of the estuary. This is something that may take many visits before it is comprehensive. New species are always found so one can never say that the checklist contains all plants and animals.

Start to look at habitats and what plants and animals live in them. The most common habitats are: mangroves, salt marsh, submerged water plants, emergent water plants, swamp forest.
Get to recognise habitats based mainly on the dominant plant species.

Get to know what less common plants occur in these habitats and also what animals are present. Get a feeling for the *abundance* of each species. The distance from the river mouth where the species was found can also be recorded (this is an optional activity) and can be added to the salinity graph for interested users.

Abundance: Species abundance is an ecological concept that refers to the number of individuals of species that is represented in a particular ecosystem/habitat/zone.

Data sheet

Plants & Animals Data Sheet

Checklist and table showing where each species occurs
Please select the appropriate option under each category (see example below)

Date: Estuary: Observer:

Name of species	Zone	Habitat	Salinity	Water coverage	Sediment	Season	Abundance	comments
Brown-Hooded Kingfisher	Floodplain	Floodplain swamp fores	Low salinity	Floodplain	Mud-sand	Summer	Common	
Fiddler Crab	Estuary basin	Intertidal mud flat	Moderate salini	Intertidal	Mud-sand	Summer	Present	Various species

Fill in the data sheet with the following data:

Zone, Habitat, Salinity, Water Coverage, Sediment, Season, Abundance

At home processing

Once back at base first identify the species so you have names for them.

Then **list** and **describe** the **habitats** you have used. Describe the key features of each habitat; what are its dominant plants that define it.
Where in the estuary does it occur? Do you have any information about tidal range and salinity where that habitat occurs, and degree of exposure at low tides? From Google Earth, can you map where the habitats occur?

Then **draft a checklist**, plants first then animals. For each plant or animal record the habitat it was seen in and its abundance index within the habitat. Make it an annotated checklist by adding notes.

Risks involved

Assessing an estuary is fun but there are precautions that need to be taken. You may potentially be in a wild area; there may be **dangerous animals** around such as crocodiles or hippos.

Please take the necessary precautions in terms of permits, protection etc. before beginning your assessment!

WARNING: DO NOT TAKE PLANT OR ANIMAL SAMPLES

Activity n°6: Consolidation; Reviewing the day spent at the estuary

The purpose of this activity: is to obtain an overview of our understanding of the estuary.

After a day in the field it is necessary to review and consolidate what we have learnt. While doing so we need to store all our notes and measurements in a data base and synthesise the information in a form that can be communicated as a report, a poster or an Internet web-page.

Now is the time to have another look at the Google Earth image of the estuary.

The map should show the estuary in the context of nearby roads and towns. It should show the different sections of the estuary; mouth, mid-section and upper section as well as the floodplain.

It should show features such as rock outcrops, buildings, jetties, place names, sand banks and interesting features such as areas where fishing or plant harvesting takes place. Bird breeding or roosting colonies should be mapped.

A really sophisticated map will also show the main vegetation habitats; salt marsh, bare sand, mangroves, swamp forest, reed beds, and beds of submerged plants

Use the tidal data to calculate the tidal ranges at different points along the estuary. This can be graphed (distance from the mouth on the x-axis and tidal range on the y-axis)

Is it possible to estimate how much water is exchanged on each tide? If we have the tidal ranges for various sections, and the width of the estuary at those sections we can get a 'first stab' at how much water is being exchanged when you measured it. Some points to remember:

1. The tidal range is what is happening in the upper layer of the water. It is the water that rises and falls irrespective of the depth of the estuary below the low-tide mark
2. If we use the width of the estuary when calculating water exchange, then we are assuming that there is not a significant lateral expansion and contraction of the water as the tide rises and falls. This is not the case where there are extensive intertidal salt marshes, so you will need to discuss this to see if your calculations are informative or not.

- Water-flows in most estuaries are dominated by the tidal exchange of water. However, if the estuary is not very large and the river inflows are strong, this may not be the case. The river flow can be dominant. You will have measured river inflow and should be able to compare the magnitude of this with the amount of water that moves in and out with each tide. This is an important consideration when discussing mouth dynamics.
- As part of the consolidation, make sure that your data is all neatly written up, or entered in a computer spreadsheet for storage. Store data, maps etc. until the next visit and then build on this base. Record what you have seen and measured. When you return at some later state, add to the data already collected. This way you can build on and accumulate knowledge.That is what science is all about.

A good final product is a record for you or others to build on!

THE END

APPENDIX N: THE SPRING TOOL

Spring Assessment Tool

A simple Citizen Science tool to assess natural springs

This is a product of The Water Research Commission: Project No. K5/2350

CONTENTS

List of Figures

List of Tables

1. INTRODUCTION AND BACKGROUND

1.1 Introduction

South Africa is a water-stressed country, security or management of both groundwater (includes wells, boreholes and springs) and surface water (rivers, streams, dams, etc.) supplies has become a key strategic issue as well as a driver for continued and sustained economic growth and service delivery to the people of South Africa (Parsons and Tredoux, 1995).

Currently, at least two thirds of South Africa's population depend on groundwater resources for domestic water needs (DWAF, 2000). Groundwater is water that exists in pore spaces and fractures in rock and sediment beneath the Earth's surface. It is naturally replenished by surface water from precipitation or snow, and then moves through the soil into the groundwater system where it recharges the water table.

In areas rural areas where rural infrastructure is minimal, communities rely more on informal groundwater source, such as springs as a water source. In addition, it has been mentioned that springs also continue to supply water to major cities in South Africa such as Pretoria. Todd and Mays (2005), defined a spring as a concentrated discharge of groundwater appearing at the ground surface as a current of flowing water. Not only are they known to be a direct source of water for communities but they are also known to have indirect benefits which include their contribution to base flows of streams and rivers. Different types of springs (see sub-section 3.2.2 below) behave differently, depending upon factors such as the characteristics of aquifers feeding the spring.

Although groundwater resources are usually significantly cheaper to develop and manage than surface water, in situations, where they are vulnerable to contamination the cost of treatment may be significant. With that said, there is a critical need for spring water monitoring, management and protection to reduce stress on groundwater resources to secure continued supply of water.

This document serves as a manual for the assessment of the ecological state of spring ecosystems using the Spring Assessment Tool. The key users of the assessment tool include:

- Citizen scientists;
- Communities;
- NGOs;
- Local environmental authorities; and
- Landowners

It is recommended that prior to utilising the tool assessors should review basic literature on spring ecosystems, and where possible, attend various training courses related to the subject. Though this may not be essential, it will aid assessors in the identification of impacts and thereby, improve confidence in the information collected.

The application of the tool includes:

- Determining the current ecological state of the spring system of interest and identifying key impacts to address to maintain or restore the spring's health;
- Monitoring potential impacts to the spring system from any human activities;
- Monitoring for auditing of rehabilitation strategies.

The fields of application include:

- Benchmarking studies (studies that confirm status compared to other springs);
- Scientific research of citizen science studies; and
- Integrated catchment management programmes.

1.2 Background

Currently, South Africa has no formal standardised method or tool for monitoring springs. Due to this gap, the research team has taken the first steps in identifying and drafting a list of the key parameters (factors) regarding springs that require monitoring. These parameters formed the foundation in developing a pilot "Spring Assessment Tool" for application in southern Africa. The objective in developing this index will be to capture relevant information relating to springs and filter this information through to the right institutions and to the relevant authorities.

As part of this process, the team set out to research and find relevant monitoring programmes already in practice in other parts of the world. It helps the team to identify some of the key characteristics and parameters other monitoring programmes use and to see whether these are relevant for springs in Southern Africa. We identified two relevant international organisations using citizen scientists for assessing, monitoring, managing and protecting springs. These included Black Rock National Conservation Area (BRNCA) (McKnight, 2014) and the Springs Stewardship institute (Stevens et al. 2011). Many of the parameters measured by these organisations were relevant for springs in Southern Africa and were integrated into this pilot Spring Assessment Tool (e.g. measuring physical characteristics, such as spring type, discharge and important plants and animals identified) (McKnight 2014).

The index involved different steps of assessment, with varying degrees of intensity. These steps are based on the objectives of the citizen scientists conducting the study. Step 1 purely measures the locality and records the basic features of a spring. This serves as a method which signals that a particular spring may require further assessment. Step 2 and 3 measure more detail, potentially flagging certain springs that require regular monitoring and possibly require some rehabilitation.

2 STRUCTURE OF THE SPRING Assessment Tool (SAT)

2.1 Background to the Structure of the Spring Assessment Tool

The Spring Assessment Tool demonstrates how to undertake fieldwork, identify a spring system and the key impacts within and around the spring zone. It can also be used to determine the extent to which these impacts are compromising the ability of the spring to function naturally.

Each impact is rated according to the intensity (concentration) and extent (coverage or size) of the negative impacts. The recorded scores are entered into the SAT model that produces a percentage of change which then determines the ecological condition of the spring. The score is based on the degree of change of the spring system exerted by human influences.

This guide was designed to aid prospective SAT users to:

- Identify the size & shape of the spring system habitat;
- Identify anthropogenic influences and negative impacts to the assessed spring; and
- Rate the intensity of negative impacts.

There are many studies done focused on the potential pollution to groundwater resources and very few done on distance of potential pollution to groundwater resources.

The minimum distance between spring outlet and any potential polluting activity upslope of a spring has to be at least 100 metres (DWAF, 2004). Banda (2013) reviewed that the minimum distance between a borehole and any potentially polluting activity has to be at least 30 metres.

Well/borehole water is mostly from confined aquifer whereas spring water is mostly from unconfined aquifer, which makes spring water more vulnerable to surface activities such as pollution. Therefore, the minimum distance between a spring and any potentially polluting activity has to be double the distance between a borehole and any potentially polluting activity, to be at least 60 metres.

Literature highlighted 10 impacts (within 60 m around the spring or 100 m if the pollution is upslope of a spring) as the principal negative influencers to the functioning and integrity of spring ecosystems:

- Livestock grazing
- Pollution near the spring
- Physic-chemical changes
- Surface water diversion & flow modification (change in the flow of water)
- Spring structure modification
- Vegetation removal
- Groundwater withdrawal
- Development and path ways
- Invasive Alien Species
- Soil erosion

2.2 Glossary and Description of Potential Impacts on Spring Health

2.2.1 Livestock grazing

Inappropriate or excessive livestock grazing affects springs by compacting or compressing wet soils, breaking down banks, increasing sediment and nutrients. This also reduces plant cover and the presence of desired riparian species.

2.2.2 Pollution near the spring

This refers to the disposal of solid waste around the spring. These solid wastes may infiltrate/percolate the groundwater with rain water and lead to a negative change in the quality of the water.

2.2.3 Physico-chemical modification

Physico-chemical modification may arise from point sources such as municipal and industrial wastewater effluent or storm water discharge points; or diffuse sources such as excessive run-off from surrounding landscape. Dungs from livestock grazing, pit latrines, sullage and waste disposal sites, agricultural and related activities are also included. These modifications lead to extra nutrients entering the spring system. These extra nutrient inputs may intensify aquatic animals and plants development, particularly invasive alien plants, and may lead to root fanning towards the channel, and shading. Nutrients can also lead to blue-algae in spring water.

2.2.4 Surface water diversion and flow modification (changes in the flow of water)

This term refers to the alteration of water flow from the ground to the surface area, either by changing water flow direction, or volume. This modification can be caused by factors such as the installation of pipes to harvest water directly from the spring. Some species such as spring-snails, like to live in a place that is not modified or impacted (McKnight, 2014). Altering a springs' discharge affects the productivity of aquatic and riparian habitats, in turn lowering the number of plants and animals of the site.

2.2.5 Spring structure modification

Spring modification is the alteration of the natural physical shape of the banks by physical man-made structures, such as building walls around the spring.

2.2.6 Vegetation removal

This is the removal of vegetation through activities such as livestock grazing, harvesting by people, excessive or non-naturally occurring fires, recreational activities and other activities that may cause the removal of vegetation near a spring.

2.2.7 Groundwater withdrawal

This is the extraction of groundwater through boreholes and wells. Extracted water would be used for things such as irrigation, industrial and domestic use. Its impact affects the spring discharge and can reduce spring source discharge.

2.2.8 Development and pathways

This is a broad category, including all infrastructures and buildings around the spring, and also included in this are tracks created by livestock migration.

2.2.9 Invasive Alien Species (IASs)

Invasive alien species are plants, animals, pathogens and other organisms that are non-native to an ecosystem and which may cause economic or environmental harm or adversely affect human health. In particular, they impact adversely upon biodiversity, including decline or elimination of native species through competition, predation, or transmission of pathogen and the disruption of local ecosystems and ecosystem functions (CBD, 2006).

Invasive Alien Species also negatively influence the spring habitat as some invasive alien plants tend to utilise more water than indigenous plants and change natural temperature cycles through excessive shading of the channel.

2.2.10 Soil erosion

Soil erosion is the washing away of the earth's topsoil by wind or water. Although, it is a natural process, it can be accelerated by excessive human and animal activity. This accelerated soil erosion can change the outlook of the spring and can also remove the indigenous plants needed for maintaining integrity of the natural ecosystem.

3. METHOD TO UNDERTAKE THE SPRING ASSESSMENT TOOL ASSESSMENT

The purpose of this section is to provide the user with the necessary guidelines to collect field data to assess and monitor the ecological condition of a spring.

Good practices when using the tool:

- **a) Obtain landowner permission when and where required;**
- **b) Thoroughly read and ensure you understand the method and manual;**
- **c) Understand basic spring ecology and functioning by reading background information on springs;**
- **d) Attend basic ecological education and training courses (if available);**
- **e) Do a full investigation on the spring system you are interested in; and**
- **f) Regularly refer to the photographic and illustrative guide section of this manual when rating impacts.**

3.1 Checklist of Items Needed to Determine Spring Condition

Before undertaking fieldwork, the assessor should make sure they have all the items required to undertake the assessment, or that might prove useful in the field (Table 3.1).

Table 0.1 Summary of essential and potentially useful fieldwork items for the Riparian Health Audit

Item	Essential	Potentially Useful
Field sheet	✓	
Suitable pencil and eraser	✓	
Notebook	✓	
Clipboard	✓	
Photographic and illustrative guide for the manual	✓	
Camera or camera phone	✓	
Notebook	✓	
Global Positioning System (NB: this could be in your phone)	✓	
First aid kit	✓	
miniSASS Net (including hand net)	✓	
Measuring tape (100 m long)	✓	
Gumboots		✓
Binoculars		✓
Spare batteries		✓
Machete		✓

3.2 STEP 1 – Site Overview

There is certain information that needs to be collected before you begin your spring condition assessment. These steps facilitate the assessment and provide a base of data to work from. These preliminary activities include:

- Determine the spring location
- Determine the type of spring
- Determine surrounding land cover/use
- Geomorphology of the area

3.2.1 Name and location of the spring

The location is the place (or site) where the spring is situated. The site name and Geographic Positioning System (GPS) coordinates must be recorded on the data fieldwork sheet. If you don't have a dedicated GPS, the GPS on a smart phone can be used. If your phone has the geo-tag function, consider taking a geo-tag photo of the spring. You could add this photo in to your report later. If you have access to aerial or ortho-photo maps of the area these can be very useful to gain an overview of the area when you are not in the field. If you have access to a computer and the internet; try to get a satellite image of the site from Google Earth (you can download the program for free: https://www.google.com/earth/).

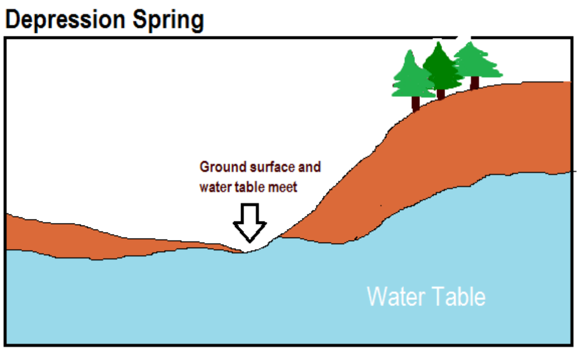
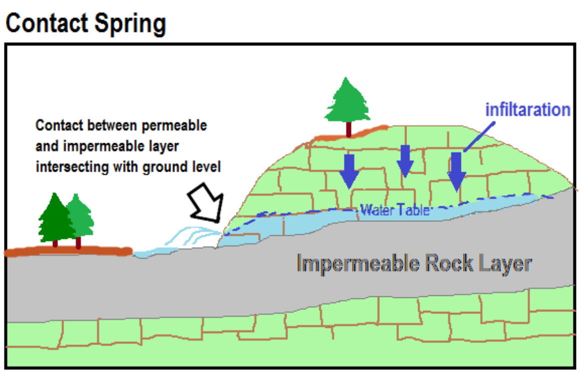
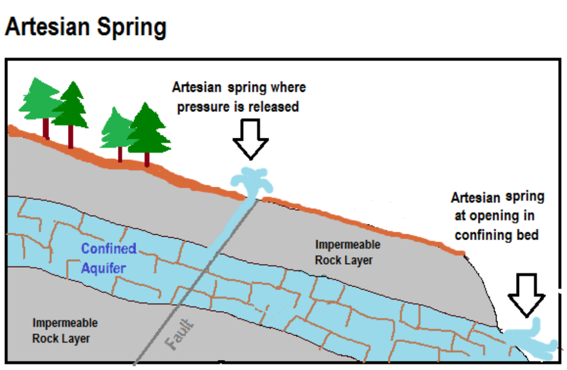
HINT: Google Earth can also give you "time-lapse" images (images of the same place taken in different years) of the site, so you can investigate what the site looked like a few years ago.

3.2.2 Type of spring

A spring is defined by the rate (how fast) and behaviour of the discharge. Discharge is the water flowing out of the spring. (In other words, the spring can be described by how fast the water is flowing out of the spring, as well as how the water flows out of the spring.) Discharge depends on a number of things, such as the type of aquifer (underground water) feeding the spring. Spring "types" are based on their characters and can be classified into the following types (Mahamuni et al., 2012):

Table 0.2 Summary of different types of springs

Type of Spring	**Description**
Depression Springs	formed where the ground surface intersects the water table
Contact Springs	created by permeable water bearing formation overlaying a less permeable formation that intersects the ground surface
Artesian Springs	resulting from releases of water under pressure from confined aquifers either at an outcrop of the aquifer or through an opening in the confining bed
Fracture Springs	issuing out of the ground where fractures lead water to the surface out of impervious aquifers
Tubular Springs	issuing from confined channels, such as lava tubes or solution channels, connecting with groundwater

<table>
<tr>
<td>
</td>
<td>Formed where the ground surface intersects the water table</td>
</tr>
<tr>
<td>
</td>
<td>Created by permeable water bearing formation overlaying a less permeable formation that intersects the ground surface</td>
</tr>
<tr>
<td>
</td>
<td>Resulting from releases of water under pressure from confined aquifers either at an outcrop of the aquifer or through an opening in the confining bed</td>
</tr>
</table>

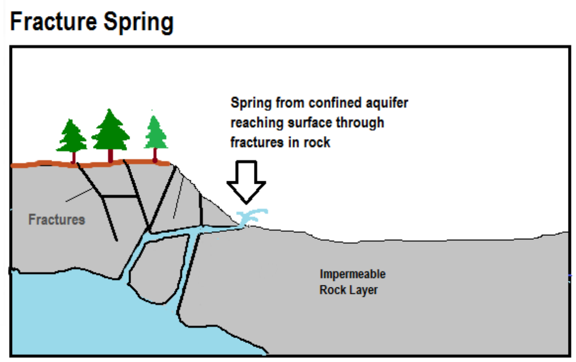
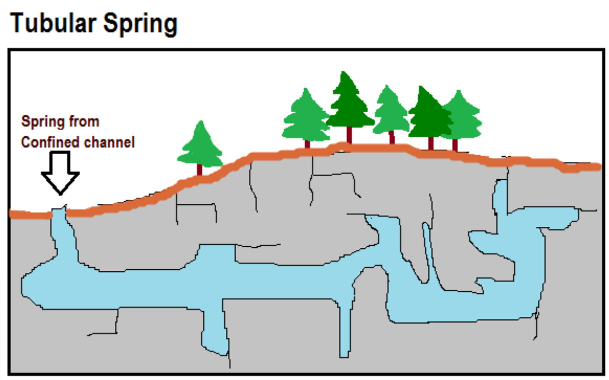
	Water issuing out of the ground where fractures lead water to the surface out of impervious aquifers
	Water issuing from confined channels, such as lava tubes or solution channels (where the rock has dissolved away), connecting with groundwater

Figure 3.1 *illustrative guide to various types of springs*

3.2.3 Land cover/use

Land cover or land use refers to activities practiced on the earth's surface surrounding the spring. These could include activities such as residential, business, industrial, agricultural, and forestry. There are two potential ways to determine land use/cover. If you have access to a computer & the internet, you could use Google Earth to see what the current land use is. However if you don't have these tools, you can determine the land use when you visit the site.

To facilitate the assessment of a spring's condition it is recommended that a fieldwork map is generated. These maps provide a useful background study & understanding of the current land-use and potential impacts at the site. Additional notes can be added to the map to provide more information on the site.

> Handy hint: make notes about anything relevant to the site, either on the map or in a notebook. The Information might be useful when you get back to the classroom or office, especially if you are assessing a number of springs.

3.2.4 Geomorphology of the area

Geomorphology is the branch of geology that studies the form of earth's surface. In this section, the main focus is the rock and soil types of the area around the spring. To facilitate the assessment of a spring's condition it is recommended that research or knowledge about geomorphology of the area where spring located is well known. These include information such as overlaying formation of the area; parent rock and soil types:

- **Parent rock types**: Igneous (andersite, basalt, dacite, diorite, gabbro, granite, peridotite, rhyolite); Metamorphic (gneiss, marble, marble, quartzite, slate, schist); and Sedimentary (coal, conglomerate, dolomite, evaporates, limestone, mudstone, sandstone, siltstone).
- **Soil types**: Sand - soils with particle sizes ranging from 2.0 to .05 mm; Silt/Loam - soils with particle sizes ranging from .05 to .002 mm; and Clay - soils with particles sizes smaller than .002 mm.

The major factors affecting the groundwater availability are permeability and porosity. Permeability refers to the ease with which water flows within a rock formation or soil to transmit water while porosity is the ratio of the voids to the total volume of material.

Groundwater moves very slowly through sediments with low permeability, such as clay. This allows more time for minerals to dissolve. In contrast, sediments with high permeability, such as sand, allow groundwater to move more quickly. There is less time for minerals to dissolve and thus the groundwater usually contains lower levels of dissolved minerals (Todd and Mays, 2005).

3.3 STEP 2 – Rating Impacts

Once the impacts have been identified according to the information given in section 2.2, each impact must be rated. The rating system varies from 0 (No impact) – 25 (Critical impact) and it is dependent on the intensity (concentration) and extent (coverage or size) of the impact. In other words, how much has the spring changed, compared to what it would look like naturally, or before the impacts. Table 3.2 provides a guideline to enable the rating of impacts.

Table 0.3 A guideline to rating impacts in terms of the change caused by the possible impacts or coverage of the impact to the spring health.

Rating	Percentage Change or Coverage	Description
0.0	0	No Impact
0.5	1-10	Minor Impact
1.0	11-20	
1.5	21-30	Moderate impact
2.0	31-40	
2.5	41-50	Large impact
3.0	51-60	
3.5	61-70	Serious impact
4.0	71-80	
4.5	81-90	Critical impact
5.0	91-100	

To aid in data collection a field sheet is provided where site information and impact ratings can be noted (Figure 3.1).

The accurate rating of impacts is of great importance. If the data recorded is inaccurate and is used in catchment management programs, the wrong decisions may be made by management.

If assessors are unsure of a rating for a particular impact it would be useful to discuss with colleagues on the rating that should be given. Ideally, although not essential, a team could undertake the assessment to ensure that all impacts are observed and a variety of perspectives considered.

The details of the site need to be filled in on the field sheet used before the sheet is completed. In the absence of a GPS for determining the coordinates, detailed information about the location of the spring should be filled in accordingly.

Date:	Project name:
Area name:	GPS cords; Lat: Long:
Spring name:	
Spring type:	Land cover/use
Comments/notes	

NB: Rate each impact from 0-25; Please refer to manual for rating guidelines

	Impacts												
	Livestock grazing	Pollution	Physic-chemical modification	Surface water diversion	Spring Modification	Vegetation Removal	Groundwater withdrawal	Development and Path ways	Invasive Alien species	Water Erosion	TOTAL SCORE	PERCENTAGE OF CHANGE	ECOLOGICAL CONDITION
Score													
total	25	25	25	25	25	25	25	25	25	25	250		

Figure 0.2 **Field sheet used for Spring Assessment Tool**

The impact ratings recorded are used to create a score that indicates the percentage of change that has occurred to the spring system from its natural (original) condition. The score then gives us an Ecological Condition (EC) that describes the condition of the system (**Table 0.3**).

Table 0.4 Summary of scores and percentage of change and their respective Ecological Condition for the Spring Assessment Tool

Calculated percentage change	Ecological Condition
0-20	Natural
21-40	Good
41-60	Fair
61-80	Poor
81-100	Very Poor (Critical)

3.4 STEP 3 - Data Entry into the Spring Assessment Tool

The following section provides information on data entry into the SAT model and the calculation of the Ecological Condition. It is divided into three sub-sections for two different categories of assessors:

- Use of rating impacts
- Use of miniSASS for aquatic biota (only on flowing water)
- Comparison of the rating impacts and miniSASS results

3.4.1 Use of rating impacts

The various impact ratings are summed and converted to a percentage of the maximum total impact rating. An example of the calculation of the Spring Ecological Condition is provided below (Figure 3.2). Following the calculation of the percentage of change, the ecological condition is determined to provide information on the health of the stream (Table 3.3).

	IMPACTS												
	Livestock Grazing (0-5)	Pollution (0-5)	Physico-chemical modification (0-5)	Surface water diversion (0-5)	Spring modification (0-5)	Vegetation removal (0-5)	Groundwater withdrawal (0-5)	Development and pathways (0-5)	Invasive alien species (0-5)	Soil erosion (0-5)	Total Score	Percentage Changed (score/potential total)*100	Ecological Condition
Score	1	1	2	3	1	3	2	1	1	1	16	32	GOOD
Potential Total	5	5	5	5	5	5	5	5	5	5	50		

Figure 0.3 Example showing the calculation of the Spring Ecological condition using the impacts ratings.

3.4.2 Use of miniSASS for aquatic biota

The miniSASS tool should be used to assess the health of a spring by determining the composition of macro-invertebrates living in the spring or those found in the water that outflows from the spring. More information about miniSASS can be assessed from the following website (http://www.minisass.org/en/) and interpretation of miniSASS score is shown in Table 3.5 below:

Table 0.5 Interpretation of miniSASS score

ECOLOGICAL CATEGORY (CONDITION)	RIVER CATEGORY	
	SANDY TYPE	ROCKY TYPE
Unmodified (NATURAL condition)	> 6.9	> 7.2
Largely natural/few modifications (GOOD condition)	5.9 to 6.8	6.2 to 7.2
Moderately modified (FAIR condition)	5.4 to 5.8	5.7 to 6.1
Largely modified (POOR condition)	4.8 to 5.3	5.3 to 5.6
Seriously/critically modified (VERY POOR condition)	< 4.8	< 5.3

3.4.3 Comparison of the results

MiniSASS helps to give information about the quality of the water after it moves way from the source. However, as previously mentioned the MiniSASS method may only be used if the spring flows out, if this is indeed the case then the results from the miniSASS can be integrated into the results from the spring ecological condition to thus produce better conclusions of the health of the spring studied.

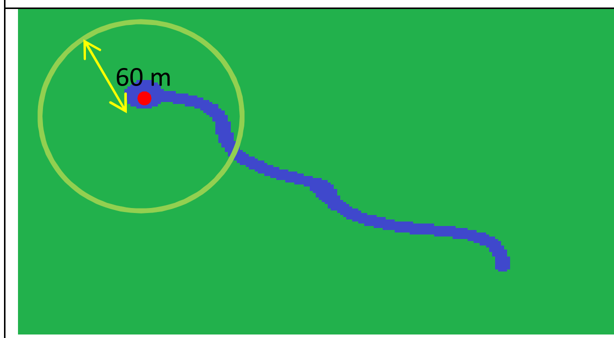
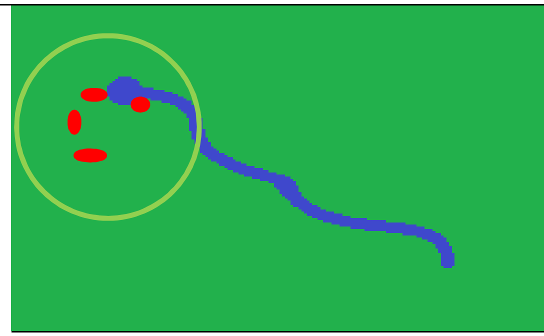
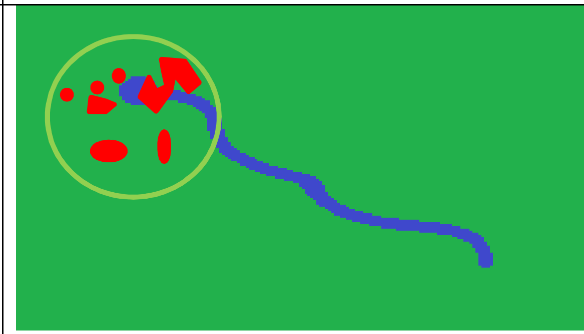
Table 3.5. Example of a site overview sheet, this sheet is to be completed before the spring health assessment is conducted.

Name of Spring	Location	Type of spring	Is this a got or a cold spring	Land-uses around the spring	Is the spring being used	Notes on the geomorphology of the spring	Is the spring in an easy accessible area	Does the spring dry up at any time of the year	Is the spring protected from any outside influences

4 PHOTOGRAPHIC AND ILLUSTRATIVE GUIDE TO IMPACTS

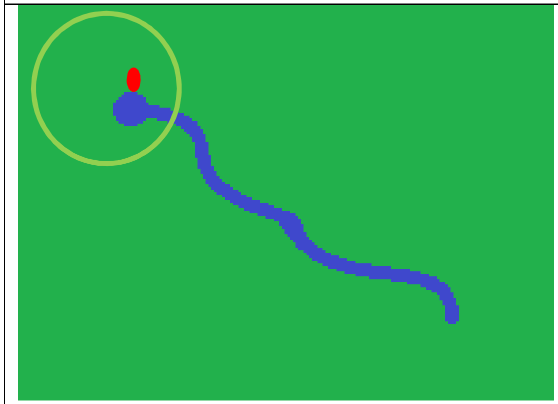
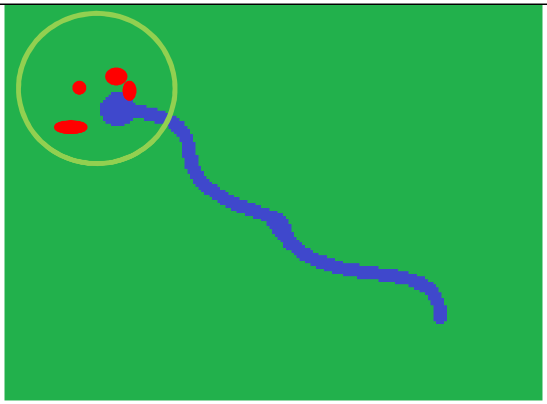
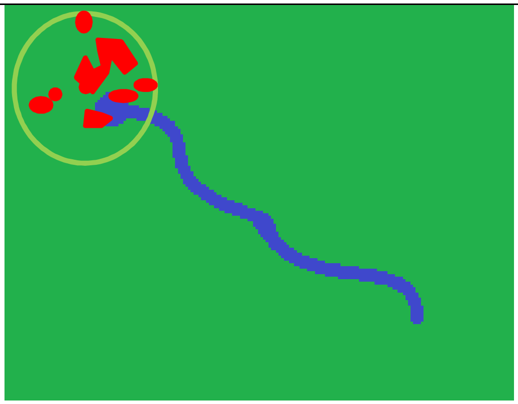
Below is a photographic and illustrative guide to aid in identifying and rating the potential impacts considered in the Spring Assessment Tool. Remember: we are looking at impacts within 60 meters around the spring.

4.1 Livestock grazing

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal livestock grazing	Moderate and extensive livestock grazing	Intensive and extensive livestock grazing
		
		

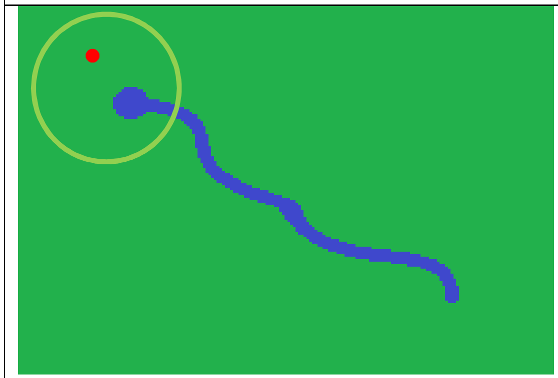
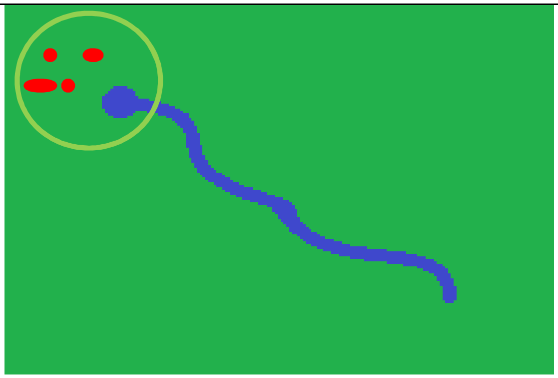
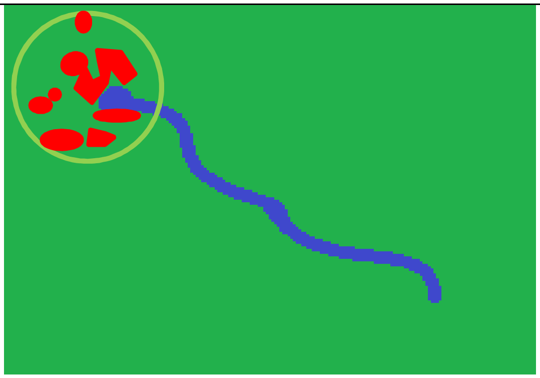
4.2 Pollution

The impacts should be rated on the intensity and extent of coverage around the spring area

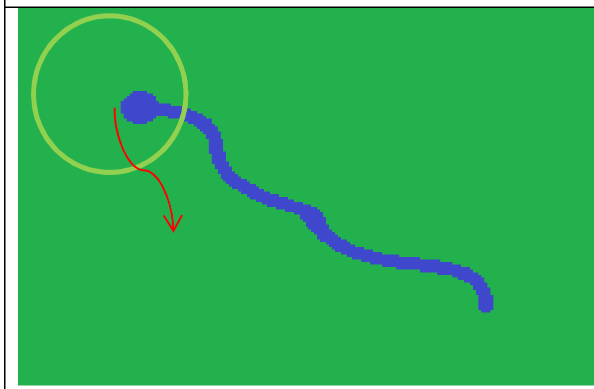
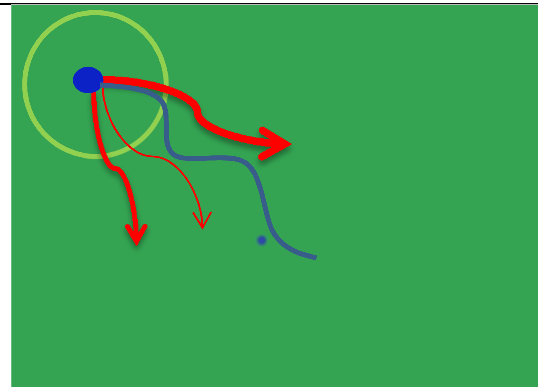
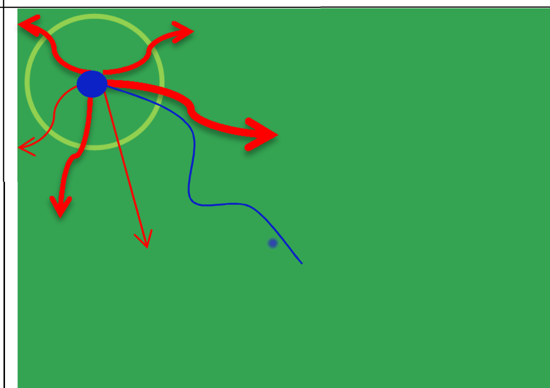
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal pollution	Moderate and extensive pollution	Intensive and extensive pollution
		

4.3 Physic-chemical modification

The impact rating is based on the extent of the impact or discharge rate of chemicals to the surrounding

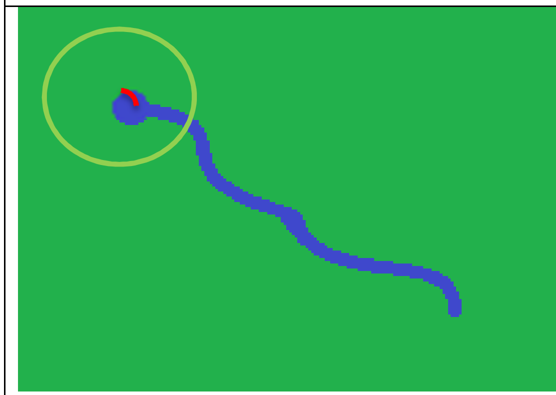
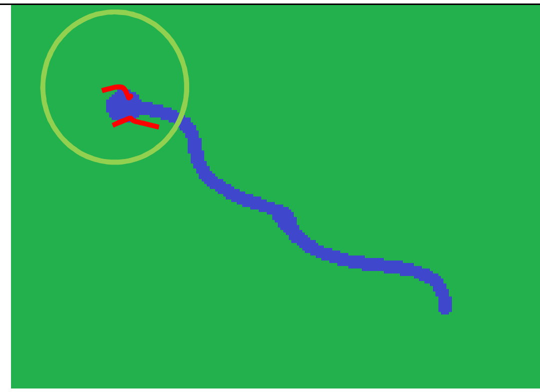
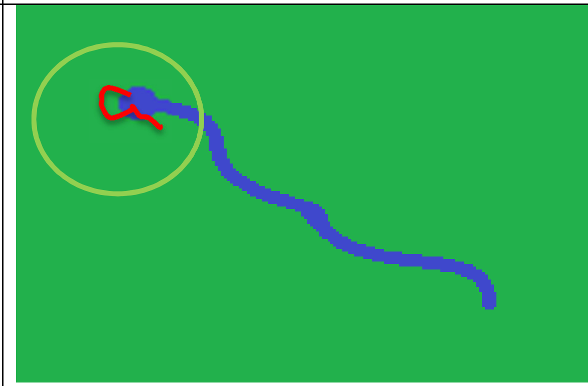
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal chemical spillage	Moderate and extensive chemical spillage	Intensive and extensive chemical spillage
		
		

4.4 Surface water diversion

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal Surface water diversion	Moderate and extensive Surface water diversion	Intensive and extensive Surface water diversion
		
		

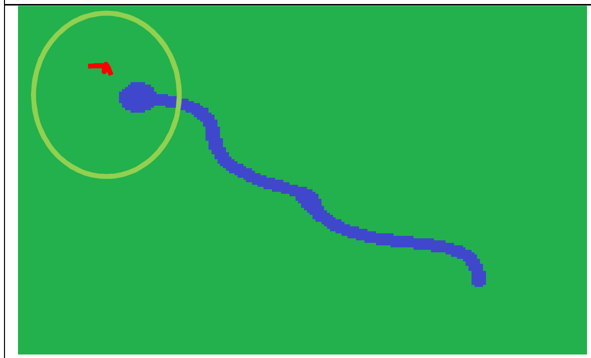
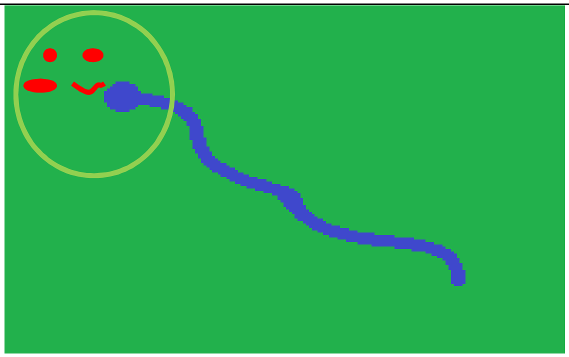
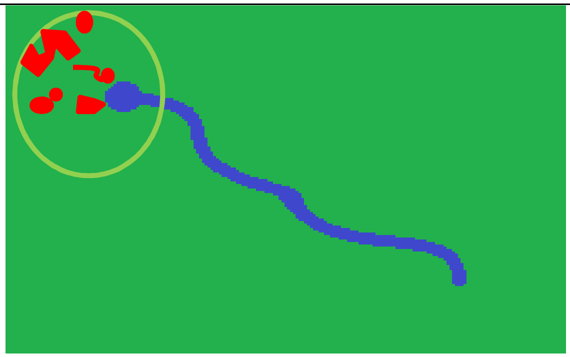
4.5 Spring modification

The rating should be based on the longitudinal extensiveness of the modification around the spring

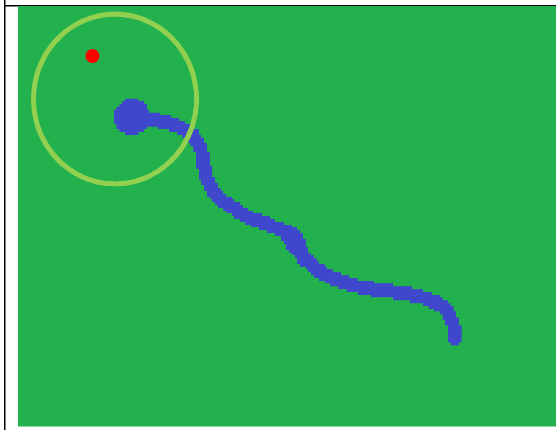
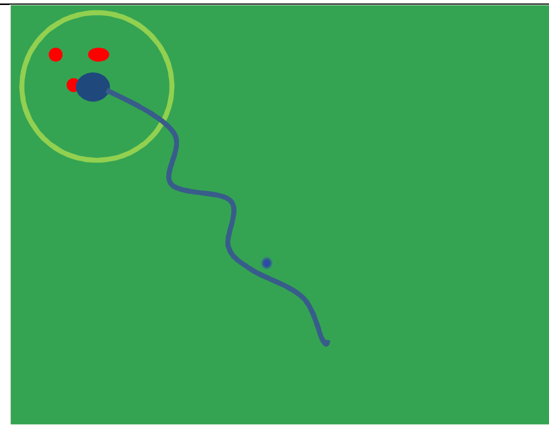
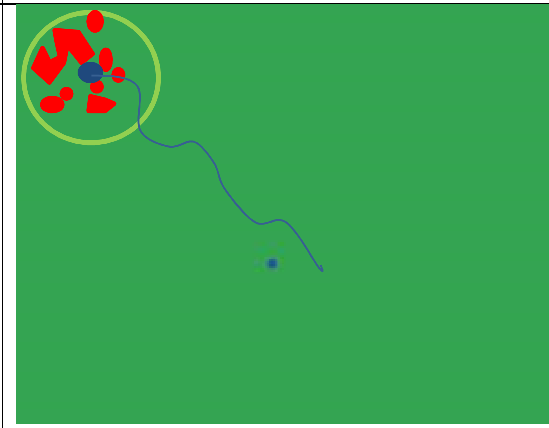
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal Spring modification	Moderate and extensive Spring modification	Intensive and extensive Spring modification
		
		

4.6 Vegetation removal

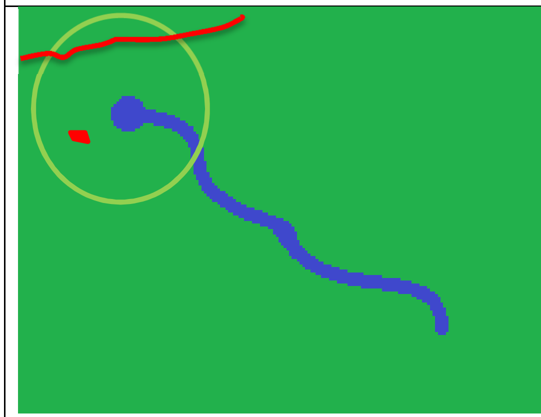
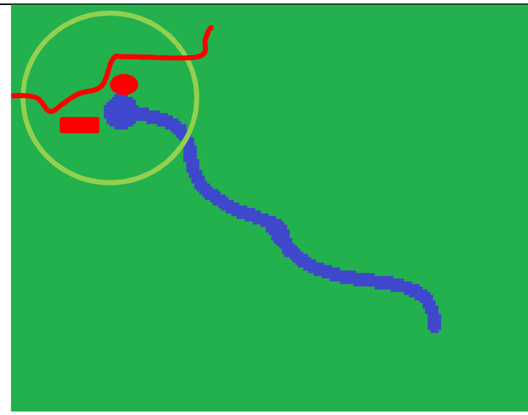
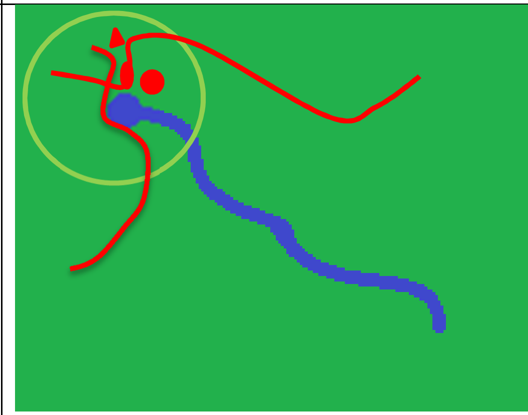
The impact rating should be based on the extent of vegetation removal

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal vegetation removal	Moderate and extensive vegetation removal	Intensive and extensive vegetation removal
		
		

4.7 Groundwater withdrawal

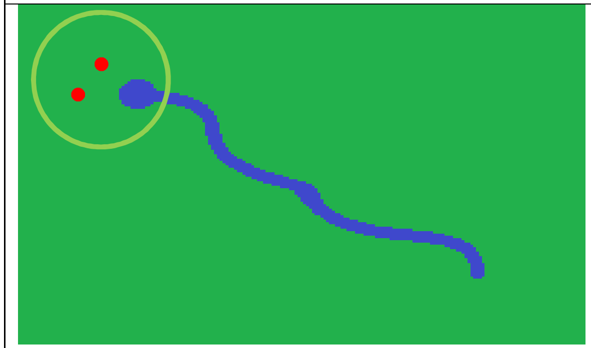
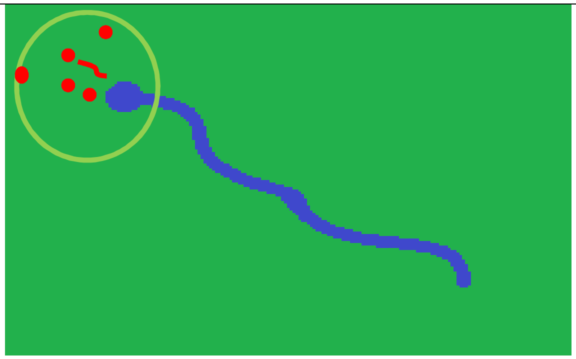
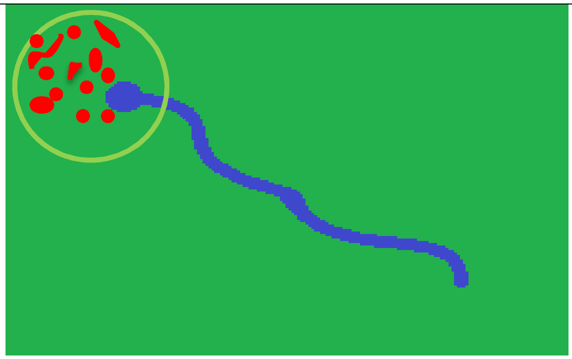
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal water extraction	Moderate and extensive water extraction	Intensive and extensive water extraction
		

4.8 Developments and path ways

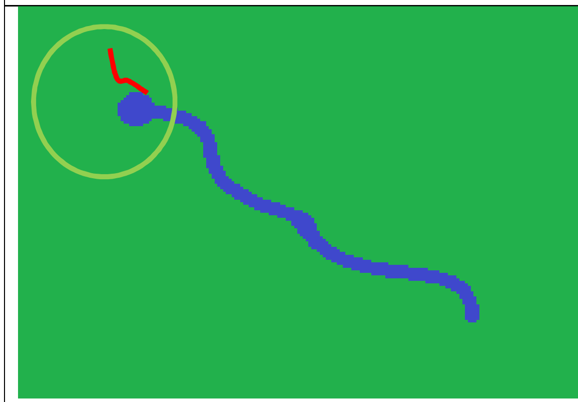
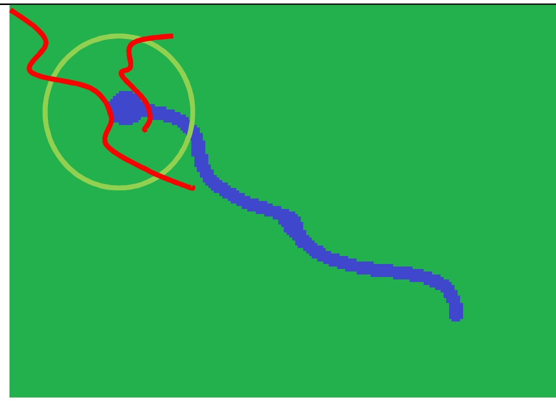
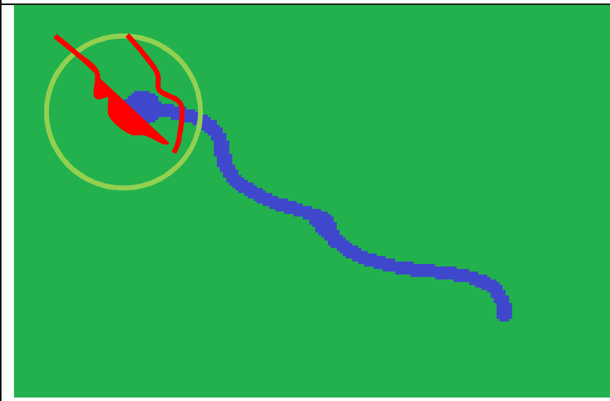
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal livestock of developments and path ways	Moderate and extensive of developments and path ways	Intensive and extensive of developments and path ways
		
		

4.9 Invasive Alien Species

Impacts should be rated according to their abundance and intensity within the spring area.

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal Invasive Alien Species	Moderate and extensive Invasive Alien Species	Intensive and extensive Invasive Alien Species
		
		

4.10 Erosion

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal erosion	Moderate and extensive erosion	Intensive and extensive erosion
		
		

5. COMMENTS AND CONCLUSION

Comments and conclusion part must be done by experts on the field of Spring Assessment Tool such as hydrologist, hydrogeologist or experienced person in the field of spring groundwater.

The assessors must have thorough knowledge on possible impacts on groundwater recharge, regardless the issue of distance from the spring source; and thorough knowledge on potential contamination sources include livestock gathering points, pit latrines and waste disposal sites located upslope from the spring outlet.

6. REFERENCES

Banda, L. J. (2013). Effect of siting boreholes and septic tanks on groundwater quality in Saint Bona Venture Township of Lusaka District. A dissertation submitted to the Department of Public Health, School of Medicine, University of Zambia, in partial fulfilments of the requirements for the Degree of Masters of Public Health (Environmental Health).

CBD, 2006. Global Biodiversity Outlook 2 Secretariat of the Convention on Biological Diversity, Montreal, 81 + vii pages.

DWAF (2000). Policy and Strategy for Groundwater Quality Management in South Africa. Number W1.0, First Edition. Department of Water Affairs and Forestry, Pretoria.

DWAF (2004). Groundwater Protection: Guideline for Protecting Springs. Toolkit for Water Services: Number 3.2. Department of Water Affairs and Forestry, Pretoria.

http://www.minisass.org/.

Mahamuni, Kaustubh, and Himanshu Kulkarni (2012). Groundwater Resources and Spring Hydrogeology in South Sikkim, With Special Reference to Climate Change. Climate Change in Sikkim Patterns, Impacts and Initiatives. Information and Public Relations Department, Government of Sikkim, Gangtok, India.

Mcknight, S. 2014. Black Rock-High Rock National Conservation Area: Citizen Spring Inventory Protocol. Friends of Black Rock High Rock Gerlach, NV

Parsons, R. and Tredoux, G. (1995). Monitoring groundwater quality in South Africa: Development of a national strategy, Journal of Applied Hydrogeology, Pp 113

Springer, A.E., L.E. Stevens, and R. Harms. 2006. Inventory and classification of selected National Park Service springs on the Colorado Plateau: NPS Cooperative Agreement Number CA 1200-99-009. National Park Service, Flagstaff.

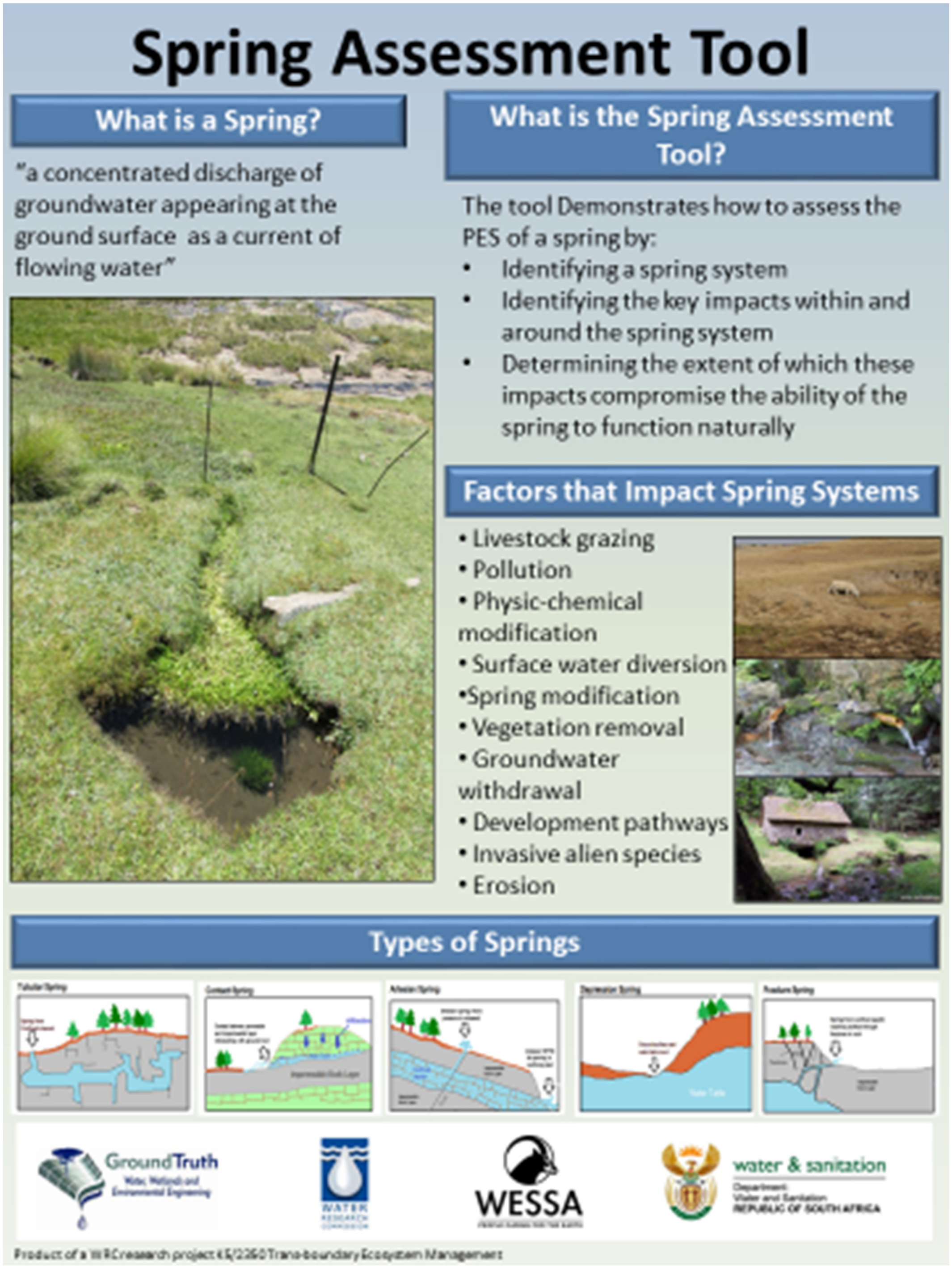
Springer, A.E., L.E. Stevens, D. Anderson, R.A. Parnell, D. Kreamer, and S. Flora. 2008. A comprehensive springs classification system: integrating geomorphic, hydrogeochemical, and ecological criteria. Pp. 49-75 in Stevens, L.E. and V. J. Meretsky, editors. Arid land Springs in North America: Ecology and Conservation. University of Arizona Press, Tucson.

Stevens, E. L., Springer, E.A. and Ledbetter, D.J. 2011. Inventory and Monitoring Protocols for Springs Ecosystems: Version 1.

Todd, K.D. and Mays, W.L. (2005). Groundwater Hydrology: Third Edition. John Wiley and Sons. United State of America.

UNHCR (2006), Practical Guide to the Systematic Use of Standards and Indicators in UNHCR Operations. www.unhcr.org/statistics/STATISTICS/40eaa9804.pdf.

Poster



Spring Assessment Tool
What is a Spring?
"a concentrated discharge of groundwater appearing at the ground surface as a current of flowing water"
What is the Spring Assessment Tool?
The tool Demonstrates how to assess the PES of a spring by:
• Identifying a spring system
• Identifying the key impacts within and around the spring system
• Determining the extent of which these impacts compromise the ability of the spring to function naturally
Factors that Impact Spring Systems
• Livestock grazing
• Pollution
• Physic-chemical modification
• Surface water diversion
•Spring modification
• Vegetation removal
• Groundwater withdrawal
• Development pathways
• Invasive alien species
• Erosion
Types of Springs
GroundTruth
WESSA
water & sanitation
Department: Water and Sanitation REPUBLIC OF SOUTH AFRICA
Product of a WRC research project K5/2350 Trans-boundary Ecosystem Management

PowerPoint Presentation

Spring Assessment Tool

This is a product of The Water Research Commission: Project No. K5/2350

Application of the Spring Assessment Tool

The application of the tool includes:

- Determining the current ecological state of the spring system of interest and identifying the key impacts that should be addressed to maintain or restore its health
- Monitoring potential impacts to the spring system from any human activities
- Monitoring for auditing of rehabilitation strategies

The fields of application include:

- Benchmarking studies (studies that confirm status compared to other springs)
- Scientific research of citizen science studies
- Integrated catchment management programmes

Checklist of Items Needed to Determine Spring Condition

Item	Essential	Potentially Useful
Field sheet	✓	
Suitable pencil and eraser	✓	
Notebook	✓	
Clipboard	✓	
Photographic and illustrative guide for the manual	✓	
Camera or camera phone	✓	
Notebook	✓	
Global Positioning System (NB: this could be in your phone)	✓	
First aid kit	✓	
miniSASS Net (including hand net)	✓	
Measuring tape (100 m long)	✓	
Gumboots		✓
Binoculars		✓
Spare batteries		✓
Machete		✓

Spring Assessment Tool – Methods

Step 1 (Site Overview)

1. **Name and Location of the Spring**

The location is the place (or site) where the spring is situated. The site name and Geographic Positioning System (GPS) coordinates must be recorded on the data fieldwork sheet. If you don't have a dedicated GPS, the GPS on a smart phone can be used. If you have access to aerial or ortho-photo maps of the area these can be very useful to gain an overview of the area when you are not in the field. If you have access to a computer and the internet; try to get a satellite image of the site from Google Earth (you can download the program for free: https://www.google.com/earth/).

HINT: Google Earth can also give you "time-lapse" images (images of the same place taken in different years) of the site, so you can investigate what the site looked like a few years ago.

Spring Assessment Tool – Methods

Step 1 (Site Overview)

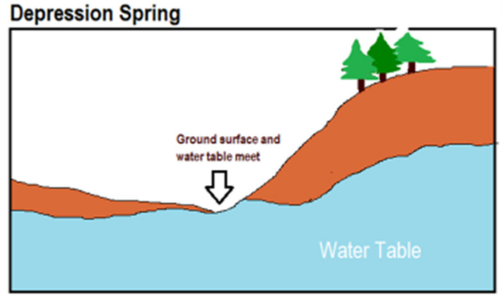
2. **Type of Spring**

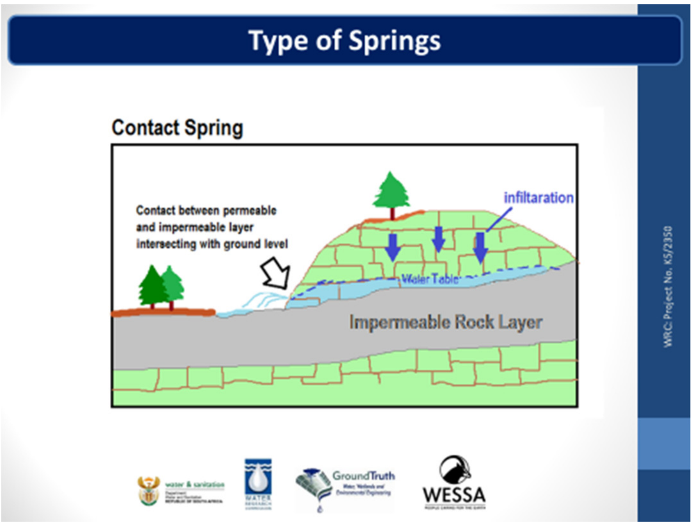
A spring is defined by the rate (how fast) and behaviour of the discharge. Discharge is the water flowing out of the spring. (In other words, the spring can be described by how fast the water is flowing out of the spring, as well as how the water flows out of the spring.) Spring "types" are based on their characters and can be classified into the following types (Mahamuni et al., 2012):

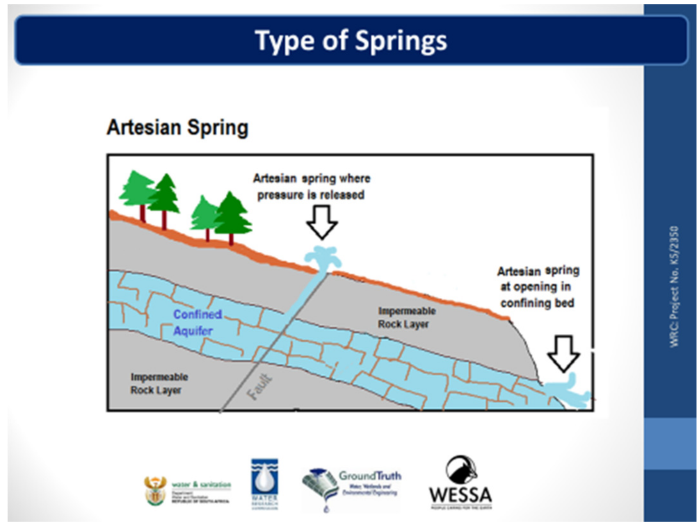
Types of Spring	Description
Depression Springs	Formed where the ground surface intersects the water table
Contact springs	Created by permeable water bearing formation overlaying a less permeable formation that intersects the ground surface
Artesian Springs	Resulting from releases of water under pressure from confined aquifers either at an outcrop of the aquifer or through an opening in the confining bed
Fracture Springs	Issuing out of the ground where fractures lead water to the surface out of impervious aquifers
Tubular Springs	Issuing from confined channels, such as lava tubes or solution channels, connecting with groundwater

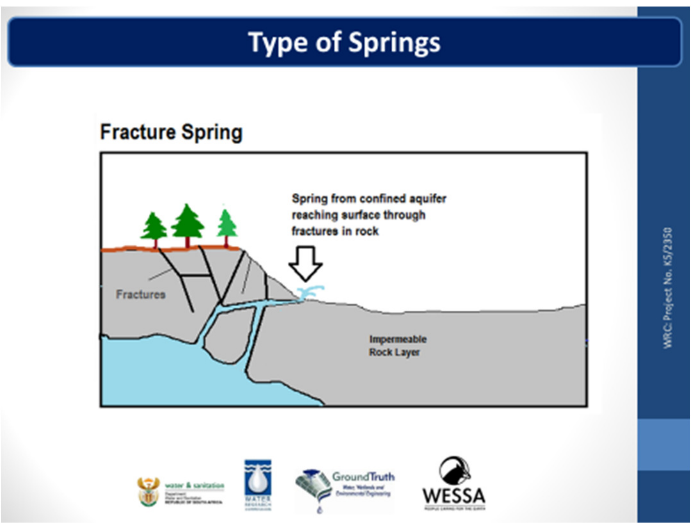
Type of Springs

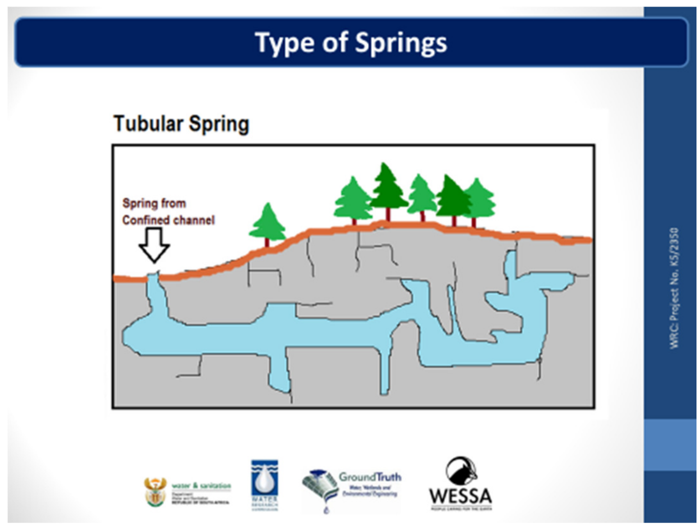
Depression Spring

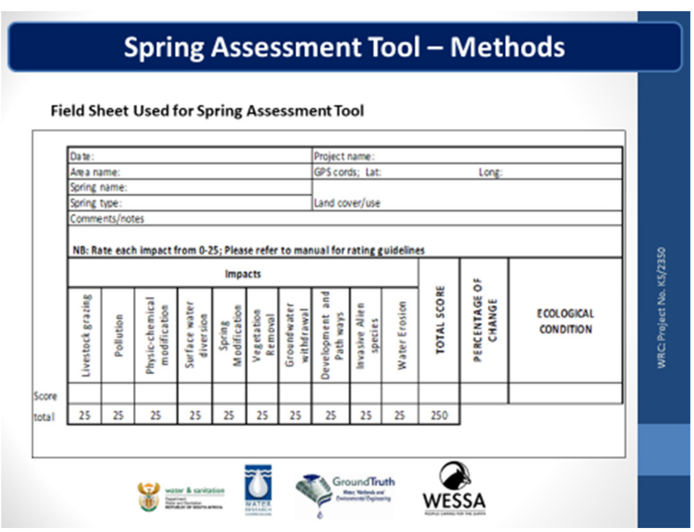


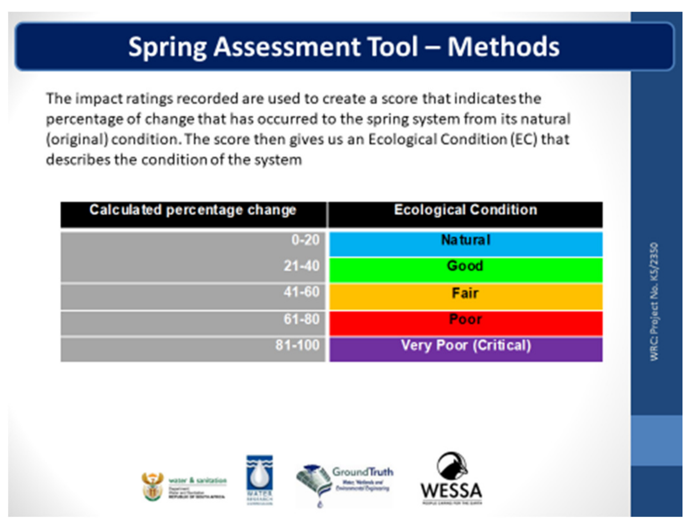

Type of Springs
Contact Spring
Contact between permeable and impermeable layer intersecting with ground level
infiltaration
Water Table
Impermeable Rock Layer
WRC Project No. K5/2350
GroundTruth
WESSA

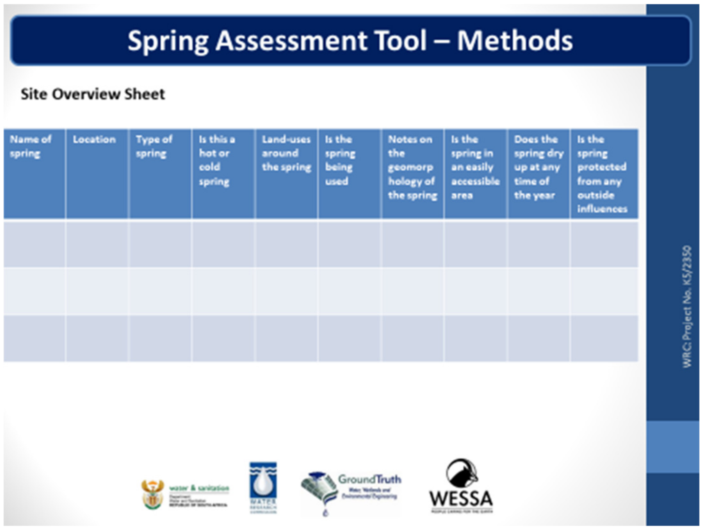

Type of Springs
Artesian Spring
Artesian spring where pressure is released
Artesian spring at opening in confining bed
Confined Aquifer
Impermeable Rock Layer
Impermeable Rock Layer
Fault
WRC Project No. K5/2350
GroundTruth
WESSA


Type of Springs
Fracture Spring
Spring from confined aquifer reaching surface through fractures in rock
Fractures
Impermeable Rock Layer
WRC Project No. K5/2350
GroundTruth
WESSA


Type of Springs
Tubular Spring
Spring from Confined channel
WRC Project No. K5/2350
GroundTruth
WESSA


Spring Assessment Tool – Methods
Field Sheet Used for Spring Assessment Tool
Date:
Project name:
Area name:
GPS cords; Lat:
Long:
Spring name:
Spring type:
Land cover/use
Comments/notes
NB: Rate each impact from 0-25; Please refer to manual for rating guidelines
Impacts
Livestock grazing
Pollution
Physic-chemical modification
Surface water diversion
Spring Modification
Vegetation Removal
Groundwater withdrawal
Development and Path ways
Invasive Alien species
Water Erosion
TOTAL SCORE
PERCENTAGE OF CHANGE
ECOLOGICAL CONDITION
Score
total
25 25 25 25 25 25 25 25 25 25 250
WRC Project No. K5/2350
GroundTruth
WESSA

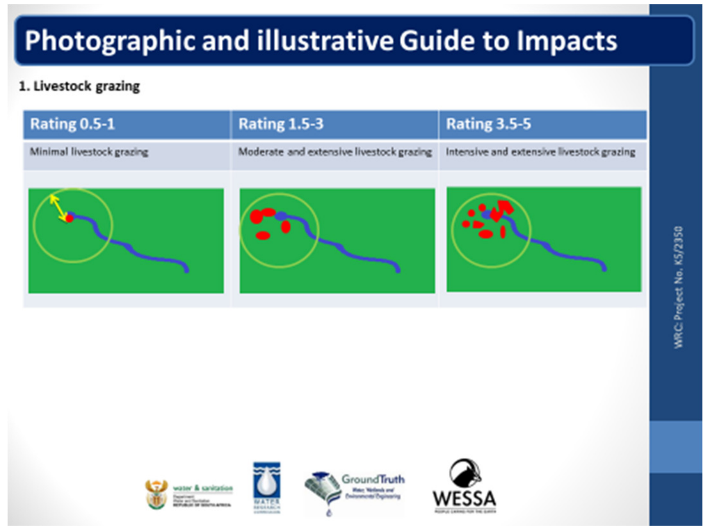

Spring Assessment Tool – Methods
The impact ratings recorded are used to create a score that indicates the percentage of change that has occurred to the spring system from its natural (original) condition. The score then gives us an Ecological Condition (EC) that describes the condition of the system
Calculated percentage change
Ecological Condition
0-20
Natural
21-40
Good
41-60
Fair
61-80
Poor
81-100
Very Poor (Critical)
WRC Project No. K5/2350
GroundTruth
WESSA

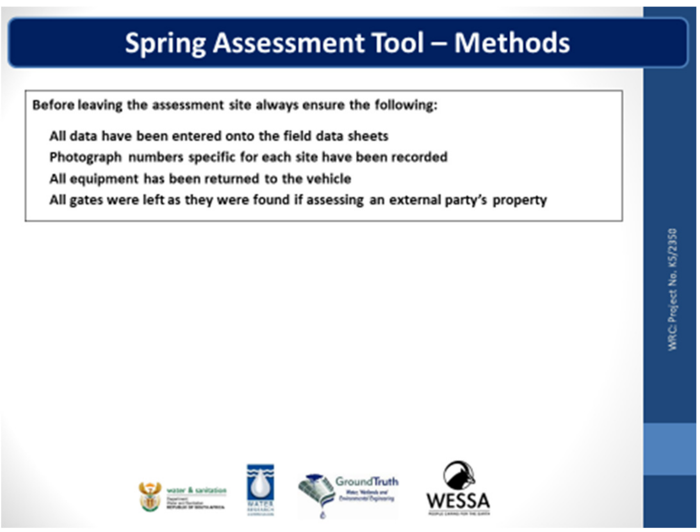


Spring Assessment Tool – Methods

Site Overview Sheet

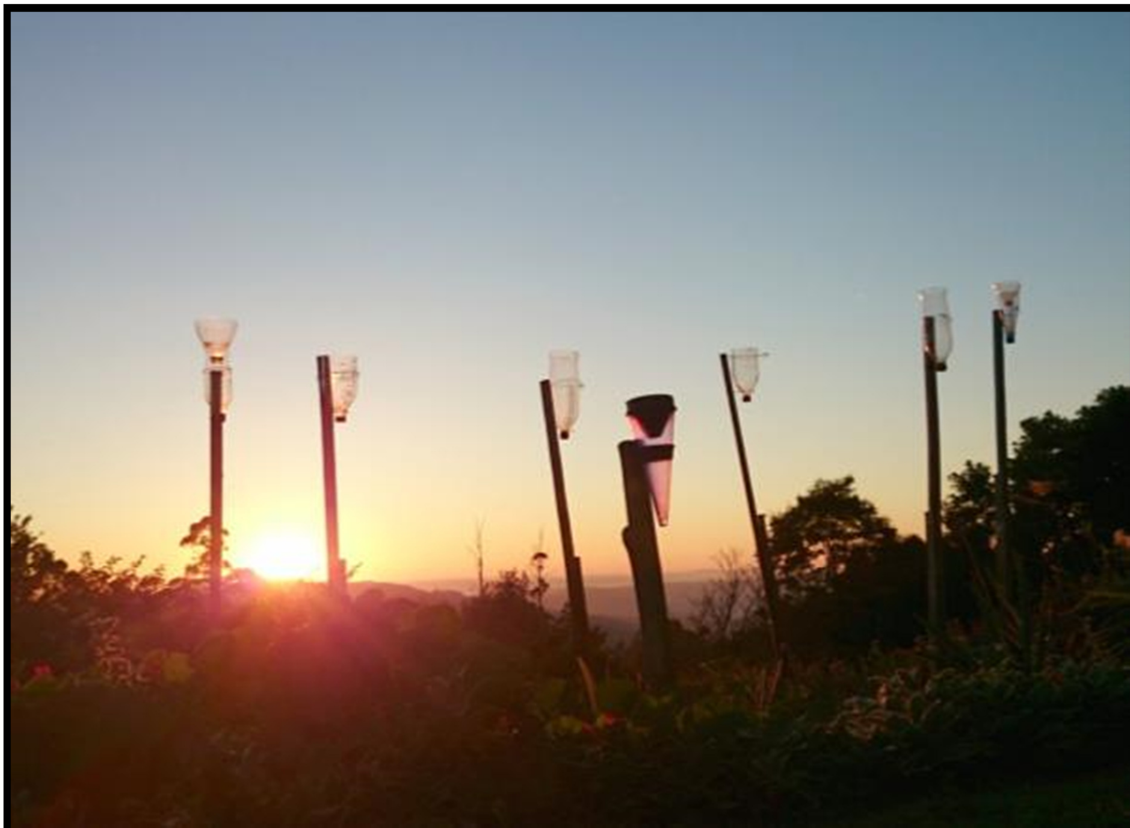
Name of spring	Location	Type of spring	Is this a hot or cold spring	Land-uses around the spring	Is the spring being used	Notes on the geomorphology of the spring	Is the spring in an easily accessible area	Does the spring dry up at any time of the year	Is the spring protected from any outside influences





APPENDIX O: HOME MADE RAIN GAUGE

Rain Gauge Tool



WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

WESSA
PEOPLE CARING FOR THE EARTH

A simple Citizen Science tool to measure rainfall

This is a product of The Water Research Commission: Project No. K5/2350

Contents

Section A

Introduction

Citizen science rainfall networks are not a new concept, as they have been investigated and tried in Europe and North America (Cifelli *et al*., 2005; Micheal *et al*., 2014), where they proved to work in gathering accurate information over large spatial areas with limited resources. There is also an overabundance of information available to the layperson on the internet regarding the construction and use of homemade rain gauges, although not all of these methods are accurate.

The aim of this document is to introduce users to the water (Hydrological) cycle, and to provide a method to make and use a homemade rain gauge constructed from household items, so that the rain gauge is low cost but scientifically robust.

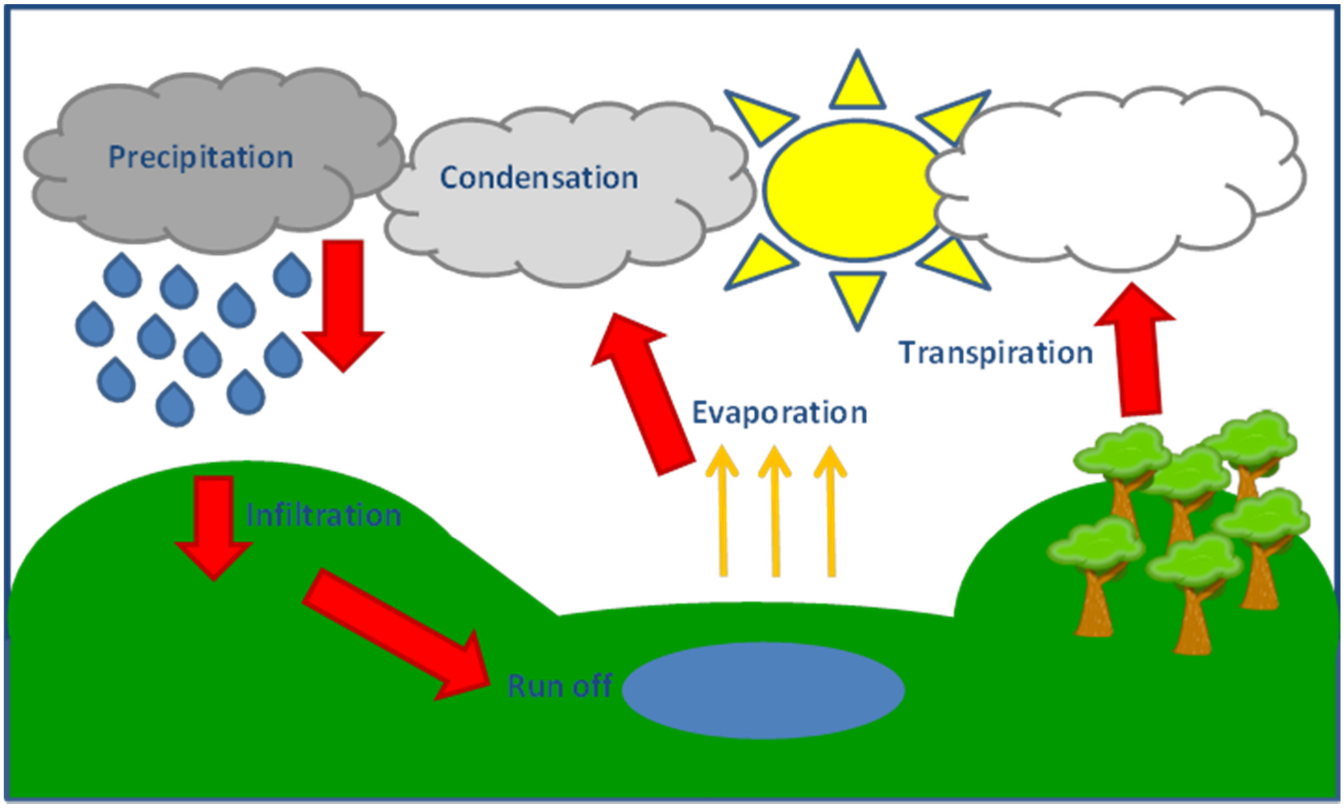
Why is Rainfall Information Important?

Rainfall is important in South Africa because it is our primary source of water, especially in terms of agriculture which is so vital to rural communities. The question now is: Why is it necessary to record rainfall data? This is most important in rural areas because by collecting rainfall information using a rain gauge the information can help us better understand rainfall patterns and predict future events. The data collected may also assist in planning a response to extreme rainfall events such as floods, droughts and storm frequencies. Flood warnings may be more accurate when there is evidence of rainfall patterns. The data recorded from the rain gauge can be used for analysing water supply and drainage systems as well as water resource planning. Comparing rainfall levels to the success of crops at that time is useful because understanding how rainfall affects crops may help in terms of planning when to plant crops in the future in order to obtain maximum productivity. If possible, long term data should also be recorded (year -to-year) because these records are extremely important in understanding rainfall fluctuations, seasonality and possible future patterns.

Where to use the Rain Gauge Tool:

- In schools for research and learning purposes
- In rural areas where rainfall information is sometimes limited

The Hydrological Cycle

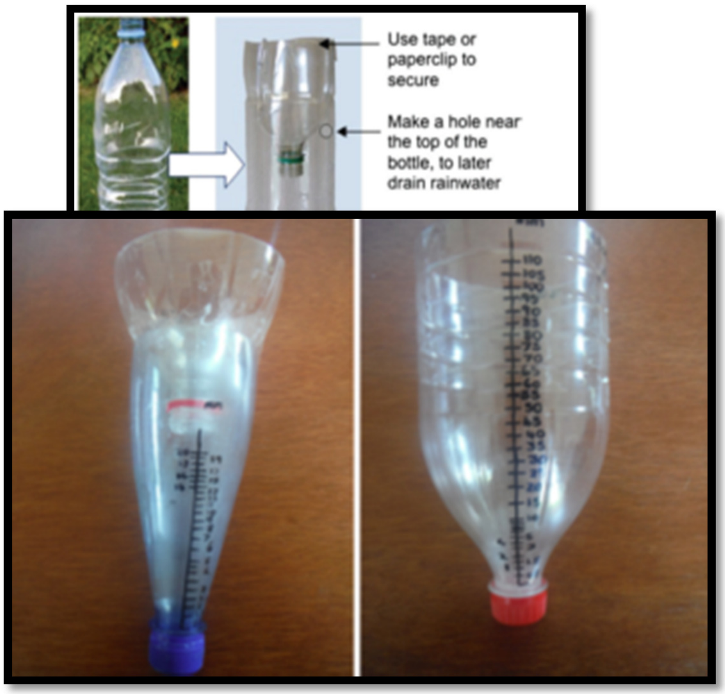


- **Evaporation:** Is the process of water changing to a water vapour due to an increase in temperature. This occurs gradually and is dependent on the rate of temperature increase and the amount of water.
- **Condensation:** Is the opposite of evaporation, it is the process where water vapour is transformed back to water due to a change in temperature/pressure. This is a crucial stage in the hydrological cycle because it is responsible for the formation of clouds.
- **Precipitation:** Is the stage where water falls from the sky in the form of rain, sleet, hail or snow.
- **Infiltration:** Is the stage where a portion of the water that has fallen is absorbed by soil of is infiltrated into rocks through cracks and pores.
- **Run off:** Is simply the water that has not been infiltrated by the soil, this water is transported down a gradient and so it is often a cause of soil erosion.
- **Transpiration:** Is the discharge of water vapour from plants and trees (leaves) into the atmosphere. This is one of the many reasons why trees are so important to our environment.

Rain Gauge Design

The most commonly used design used to create a recycled rain gauge uses a standard 2 L plastic bottle which in South Africa, is the *Coca-Cola* bottle. The *Coca-Cola* bottle has an irregularly shaped bottom, similar to that of the bottles used in the studies of Wrage *et al*. (1994) and Micheal *et al*. (2014). They overcame this disadvantage by filling the bottom to the bottle with immiscible liquids such as cooking and motor oil and jelly.

Alternatively, a slightly different design can be used that uses a bottle with the sprout at the bottom and the base at



the top, which is similar to the shape of a standard rain gauge (*Woolworths* 500 ml sparkling water bottle). This eliminates the problem of calibrating the amount of rainfall with an irregular shape.

Section B

How to Build a Rain Gauge

Aim: The purpose of this guide is to give step-by-step instructions on how to build a rain gauge, including the list of materials needed and factors to consider for placement of the rain gauge. This guide shows you how to use ordinary everyday items to make a rain gauge.

Why do we use mm to measure rainfall?

Typically rainfall is measured in mm (or inches). But how can this be? Rainfall is a liquid, which is usually measured in mL or L. How is it that we measure rainfall in mm, which is a measure of length, not a volume scale?

We can do this by simply understanding the information we receive from the equation of calculating volume, this equation is given as;

- Volume = length x width x height

Still confused? Well consider this…

Let's imagine a water tank and next to that, an imaginary bucket. Let's say that both are empty, and then an imaginary thundershower happens. During the same storm, the water tank will collect a much larger volume of rainwater – but what about the height? Does the collected water rise by the same amount in the tank as in the bucket?

The answer is yes! But because the tank is bigger than the bucket, the volume that the tank collects is more than the bucket. That is why we use mm to measure rainfall.

Materials

A rain gauge can be made easily and cheaply out of plastic cool-drink bottles such as Coke or Sprite, etc. To begin making the rain gauge the following items will be needed:

- Plastic 2 L *Coca-Cola* bottle.
- Craft knife or pair of sharp scissors
- Silicone or wax
- 2 wire coat hangers.
- Wooden pole 1.8 m tall.
- Spade.
- Axe or saw.
- Wire
- 10 ml and 5 ml syringe

Procedure

Step 1: Use the craft knife to cut off the base of the bottle along the bottom ridge. Try to do this as neatly as possible as the top of the rain gauge must be level. Sand paper can be used if necessary to smooth off the edges. Highlight the central line (present in every soft-drink bottle). This will be used as a measurement line.

Step 2: With the cap tightly screwed on, fill the inside area of the cap with candle wax or silicone

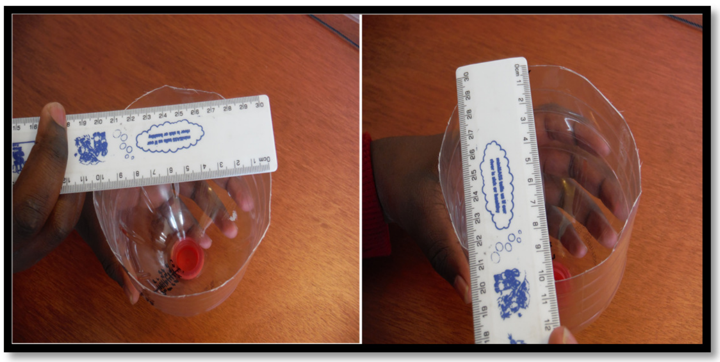
Allow to dry.

<u>Step 3:</u> **Calibrating the Rain Gauge**

3.1. Calculating the radius of the rain gauge

You will notice that the circumference of the soft drink bottle may not be even. To compensate for this you can measure the diameter of the bottle 3 times, and then calculate the average diameter. This is necessary to do as soft drink bottles can be skewed on other sides as can be seen on the figure below. To obtain the radius of the gauge from the diameter we divide it by 2.

- Example: our diameter readings were: 10.2; 10.5 and 10.8. To get the average we first add these three numbers together. The answer is 31.5. We now divide this answer by 3 (the total number of measurements), to get the



average. The average is: 10.5 – this is the average diameter for the gauge. The radius (r) of the bottle is ½ the diameter, so we divide the diameter (10.5) by 2. The radius is 5.25.

- Now that we know the radius of the rain gauge, we can get the surface area of the bottle.

3.2. Calculating the surface area of the bottle

To calculate the surface area of the bottle we use the equation;

Example 1: Bottle surface area = π x (radius) ^{2}; we now know the radius and the Pi (π) is a constant given as 3.14159265359. Thus;

Example 2: Bottle surface area = 3.14159265359 x $(5.25)^2$

Area = 86.590148 cm^2

- Done! We now know the surface area of the bottle, but we're not really done with our calculations since our objective was to move from mL (volume) to mm (depth).

3.3. Conversion of water mL to mm

The equation for the calculation is given as:

Example 1: $$Precipitation\ (mm) = \frac{Volume\ of\ water\ (ml)}{area\ of\ funnel\ (cm^2)}\ x\ 10$$

Now, if we look at this equation we can see that $Precipitation\ (mm)$ is the subject of the equation however we want $Volume\ of\ water\ (ml)$ to be the subject because that is what we want to calculate. So this means that we need to manipulate the above equation. After manipulation of the equation we end up with an equation that looks like this:

$$Volume\ of\ water\ (ml) = \frac{Precipitation\ (mm)\ x\ area\ of\ funnel\ (cm^2)}{10}$$

Using the above equation for volume of water represented by depth of water (mm) over the surface area of the gauge we found that 1 mm depth of water is equivalent to 8.5 mL of water added, so is 7.5 mm, 15 mm and 130 mm equivalent to 63.7 mL, 127.4 mL and 1104.3 mL, respectively. This is shown in the table below:

Rain (mm)	Water (mL)	Difference (mL)	Diameter	Radius (Diameter/2)	Area = pi x rad ^2
1	8.7	4.3	10.5	5.25	86.5901
1.5	13.0	4.3			
2	17.3	4.3			
2.5	21.6	4.3			
3	26.0	4.3			
3.5	30.3	4.3			
4	34.6	4.3			
4.5	39.0	4.3			
5	43.3	4.3			
5.5	47.6	4.3			
6	52.0	4.3			
6.5	56.3	4.3			
7	60.6	4.3			
7.5	64.9	4.3			
8	69.3	4.3			
8.5	73.6	4.3			
9	77.9	4.3			
9.5	82.3	4.3			
10	86.6	4.3			

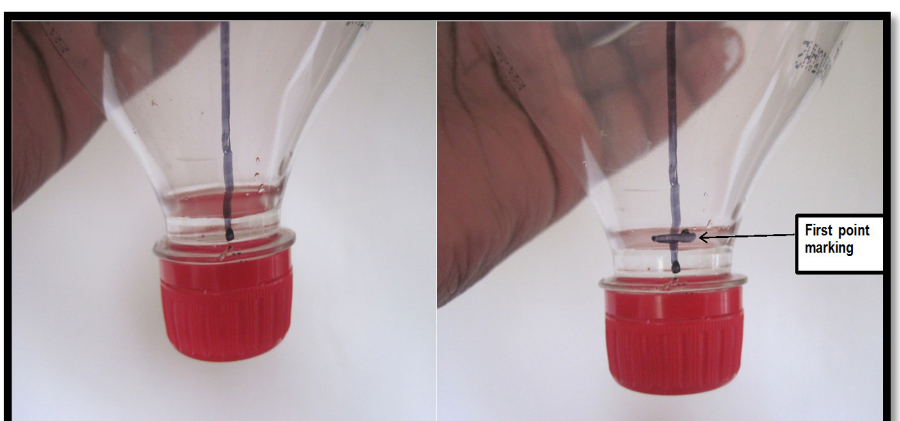
The column (A) on the left is the theoretical rainfall amount (mm), column (D) is the average diameter measured in 3.1, Column (E) is the radius obtained from the diameter measurement and column (F) is the area of the bottle calculated using the equation (1). Column (B) gives the water volume (mm) that obtained using equation (2). Lastly column (C) gives the differences in measurements from column (B).

3.4. After all the calculations have been done we can use the measuring tools such as a volumetric flask and syringe (as shown below); one can add the volume of water to represent the equivalent depth in mm.

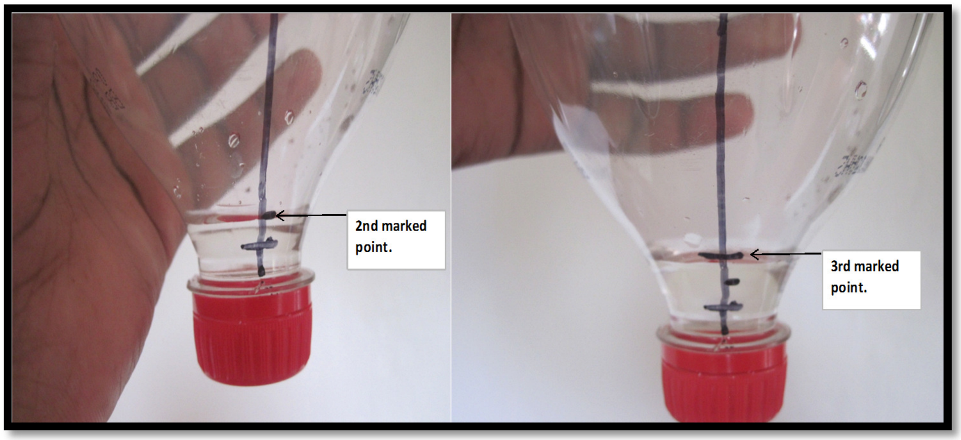
- Now that we know exactly how much water (mL) can be represented by certain length measurement (mm) we can then begin to construct and install our rain using the materials outlined in the beginning of the guide.

<u>Step 4:</u> Remember the excel spread sheet before? Now we are going to use it to guide us as to how much water in mL to add using the volumetric flask and syringe to give us the rainfall depth in mm. In the example given above, the addition of 8.7 mL of water is equivalent to 1 mm depth in a rain gauge. Mark that as your first point on the rain gauge as shown below.

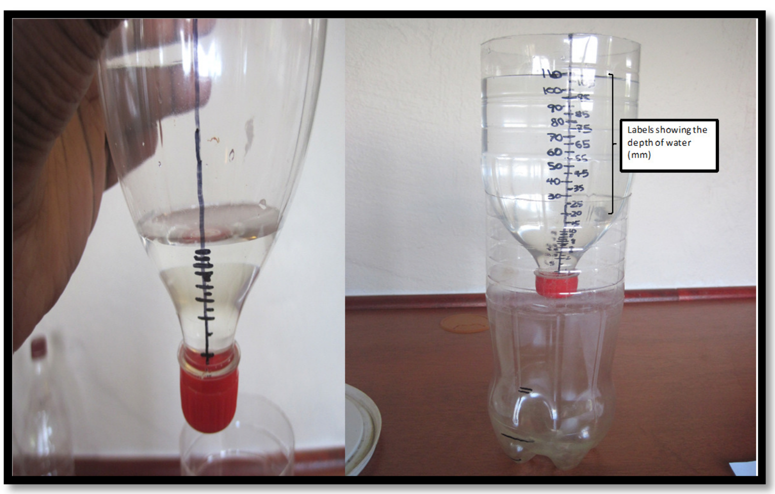
So, how do we get the second point? Easy, we use the difference column in our table (Column C) to guide us on how much water to add next. In the example we are to add 4.3 mL of water to add 0.5 mm equivalent depth, and 43 mL for an equivalent of 5 mm. See the images below for a demonstration.



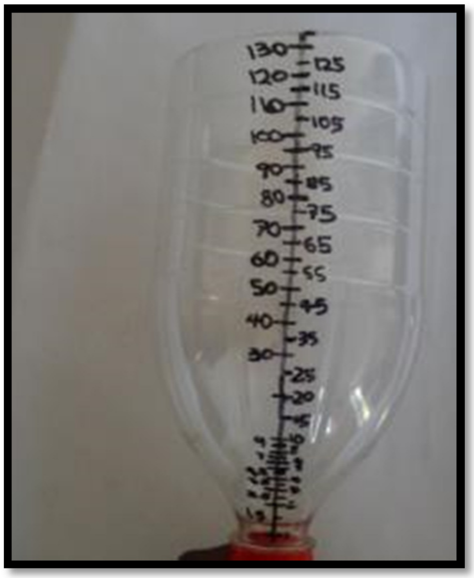
From here we can then easily add the cumulative depth of water, which is equivalent to its respective water volume (Table 1).



After marking all the points on the gauge, the depth represented by the lines can then be labeled.



- After labeling the rain gauge, it is then complete and ready for installation. However, before the gauge is installed it is important that the protocols guiding the installation of rain gauges are read.

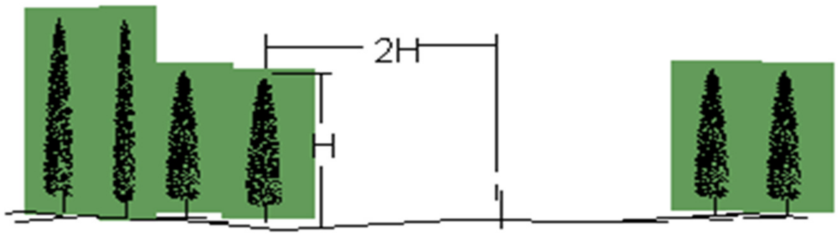


The desired rain gauge ready for installation

<u>Step 5:</u> **Placement (factors to consider for placement of the rain gauge)**:

The placement of the rain gauge is critical. There are two main criteria to consider for selecting a site for the rain gage namely:

- **The exposure of the gauge to rainfall**
    - The general rule is that the rain gauge must be located at a distance no lesser than 2 x height of nearest tree, i.e. $D_{gauge} = 2 \times h_{tree}$ (see image below)



- The gauge must also be protected from the wind in all directions as the greater the disturbance from wind, the greater the measurement error. Thus, gauges should not be placed in wide-open spaces or on top of buildings, because of wind and turbulence.
- Gauges should also not be placed close to ever-present obstructions such as trees and buildings, as these may rebound precipitation under turbulent conditions.
- The gauge should stand at least 1.2 m above the ground as per South African standard requirements. This is to prevent creeping in of droplets from splash erosion and tall vegetation. It is up to the individual to decide how far below the ground the rod supporting the gauge should penetrate, but as long as the gauge will be anchored strong enough so it will not be affected during turbulent conditions.

- **The suitability of the gauge for the reader while minimizing access to trespassers.**
  - The gauge should be placed in a suitable location for the observer, i.e. in a place where it can be readily accessible so to encourage daily observations. However, the gauge should not be in a conspicuous location that will attract defacement from trespassers.

➢ Now that we are aware of the protocols around the placement of the rain gauge we can then proceed to the installation phase.

<u>Step 6:</u> **Installing the rain gauge**

For this step you will need the resources below:

NOTE: As has been mentioned above, the gauge should stand at least 1.2 m above the ground as per South African standard requirements. It is advisable to use a log or rod of at least 1.5 m long to allow for at least 0.3 m below the ground penetration of anchoring. If however you are not able to get that length of material, you can join together two logs to make that height (as shown below in a red rectangle). You can use any material (woody or metal), as long as the gauge can stand at least 1.2 m above the ground and 0.3 m above ground if possible.

If you look again at the image below (circled in light green), you can see that wire strings are attached in such a way as to hold a rain gauge. Soft wire was used as it can be adjusted easily by any age group. A subsequent image shows the gauge being attached around a wire and ready to operate.

Step 7: Place your bottle at the top of the wooden stake where it will be secured and mark off where the neck and the middle of the gauge are. Once these have been marked, use a saw or knife to carve ridges into the wood along your markings to make sure your gauge does not slide down the pole once it has been attached.

Step 8: Straighten out the coat hangers that will be used to attach the gauge to the wooden stakes. Twist the wire tightly around the pole in the ridges and then into a small loop lower down for the cap of the bottle to fit into, and a larger loop higher up for the opening of the bottle.

- Make sure the wire loops can hold the bottle, and that the bottle can be removed.
- Test whether the wire is able to hold the bottle upright on the pole. It should also be strong enough to hold the bottle with water in and this should be tested.

Step 9: Height and location of the rain gauge is important: In **open areas** the rain gauge should sit approximately 2 feet (60 cm) above the ground and be placed twice as far from the nearest obstacles as the height of those obstacles. In **developed areas** the rain gauge should sit approximately 5 feet (1.5 m) above the ground and be placed as far from the nearest obstacles as the height of those obstacles.

- This is to ensure that nearby obstacles do not affect the catch of the rain gauge.

Step 10: The hole can be dug, using the spade, which should be at least 25-30 cm deep to ensure the pole remains sturdy.

Step 11: Make sure the pole is standing vertical before refilling the hole with soil and compacting it so that the gauge remains level.

How to use The Rain Gauge

- Gauges need to be placed in areas that are protected from strong wind, but at the same time, not near any obstructions such as vegetation or buildings (obstructions may affect the amount of rainfall that is falling into the gauge therefore the gauges need to be placed at a distance that is further than twice the height of the surrounding obstructions).
- Take note that rain that is less than 1 mm cannot be measured as this fills the area of the cap.
- Different substances that have been considered and used in previous studies to fill the caps of the rain gauges include; silicone, gelatin, wax and oils – Silicone and wax are optimal because they are not as affected by the elements (oil can work but would have to constantly be refilled).
- The gauges with filled caps tend to perform slightly better than those that do not have filled caps.
- Smaller bottles that have a filled cap and a sprout taped on require a small hole near the top of the bottle to allow water to be emptied out.
- Continued monitoring and statistical analyses are required to determine if there is a statistical difference between the precipitations measured in the standard rain gauge and homemade gauges.

Measuring Rainfall

- Measure the widest diameter of the opening in centimeters and divide by 2 to get the radius.
- Square this number (multiply by itself) and then multiply by 3.142 (π) to get the area of the top of the funnel in cm^2. This formula is area = πr^2which gives us the area of a circle.
- Use the formula: rainfall (mm) = area x (interval/10) to mark off your intervals or precipitation of rain.

For example:

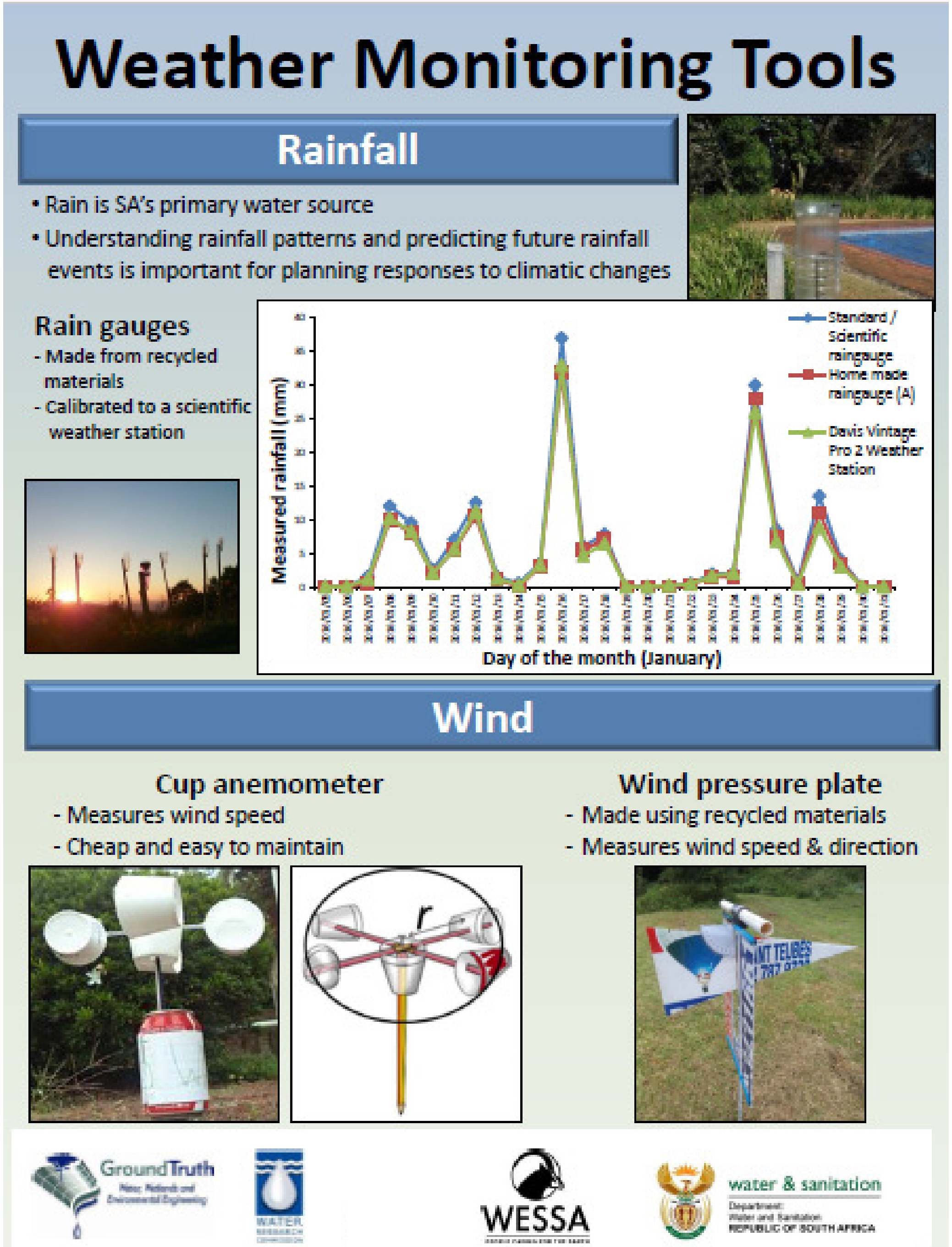
If the diameter of the opening is 10 cm: 10/2 = 5 cm.
$5^2 \times \pi = 78.55\ cm^2$
To mark off 1 mm of rain: 78.55 x 1/10 = 7.855 ml
Measure 7.855 ml into your gauge and make a mark at the bottom of the meniscus
To mark off 2 mm of rain: 78.55 x 2/10 = 15.71 ml
Empty the gauge and measure 15.71 ml into the gauge and mark the bottom of the meniscus
To mark off 50 mm of rain: 78.55 x 50/10 = 392.75 ml
Empty the gauge and measure 392.75 ml into the gauge and mark the bottom of the meniscus

And so on.

Factors that could affect accuracy of citizen science gauges are:

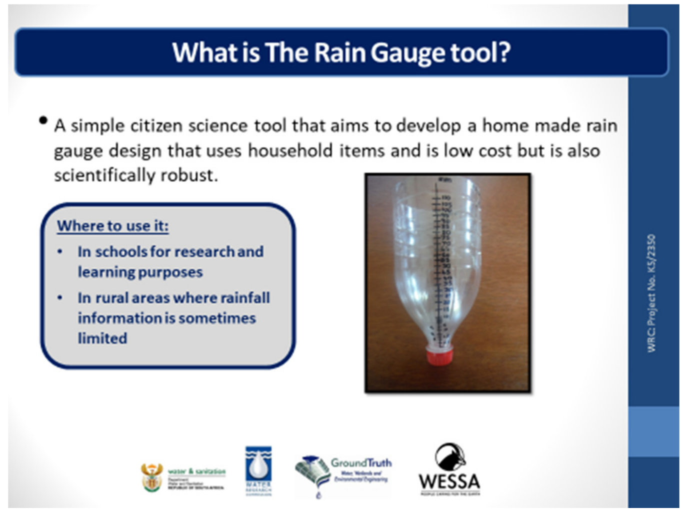
- Human error whilst marking
- Error whilst reading (if bottle is tilted and not level whilst marking or reading measurements)
- Incorrect measurement is recorded
- Calculation errors while calculating the area of funnel.

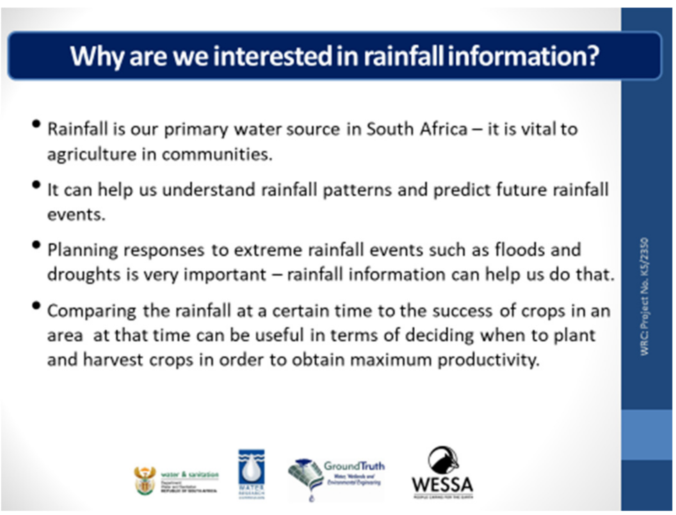
Poster

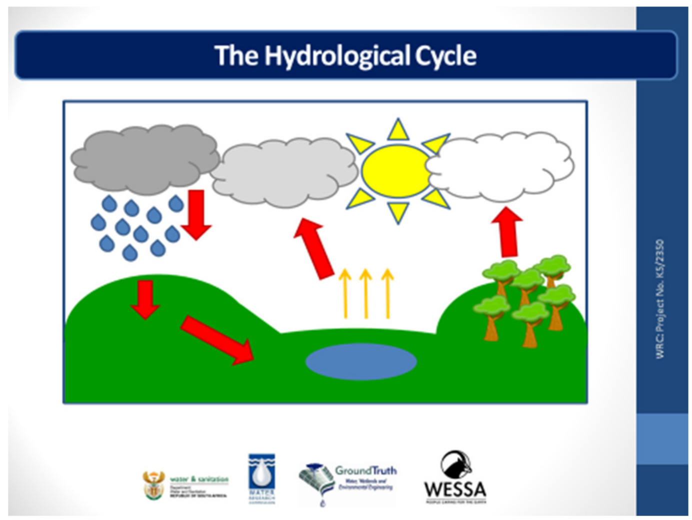


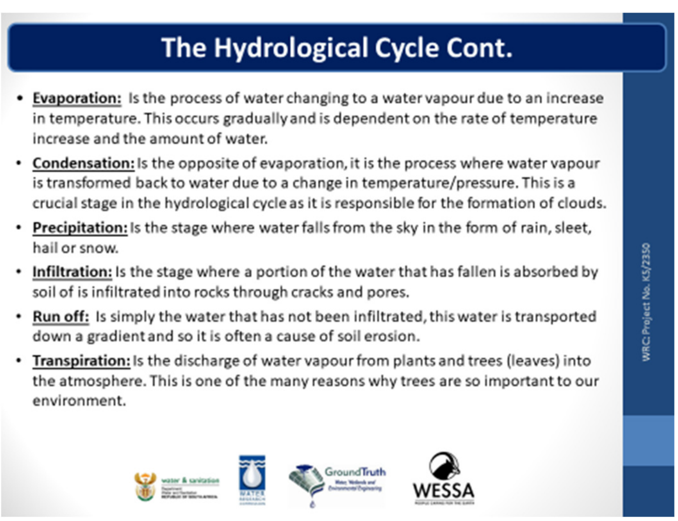
Weather Monitoring Tools
Rainfall
• Rain is SA's primary water source
• Understanding rainfall patterns and predicting future rainfall events is important for planning responses to climatic changes
Rain gauges
- Made from recycled materials
- Calibrated to a scientific weather station
Standard / Scientific raingauge
Home made raingauge (A)
Davis Vintage Pro 2 Weather Station
Measured rainfall (mm)
Day of the month (January)
Wind
Cup anemometer
- Measures wind speed
- Cheap and easy to maintain
Wind pressure plate
- Made using recycled materials
- Measures wind speed & direction
GroundTruth
WESSA
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

PowerPoint Presentation









How To Build A Rain Gauge Cont.

Step 1:
Use the craft knife to cut off the base of the bottle along the bottom ridge. Try to do this as neatly as possible as the top of the rain gauge must be level. Sand paper can be used if necessary to smooth off the edges. Highlight the central line (present in every soft-drink bottle). This will be used as a measurement line.

Step 2:
With the cap tightly screwed on, fill the inside area of the cap with candle wax or silicone Allow to dry.

Step 3: *Calibrating the Rain Gauge*
3.1. Calculating the radius of the rain gauge
You will notice that the circumference of the soft drink bottle may not be even. To compensate for this you can measure the diameter of the bottle 3 times, and then calculate the average diameter. This is necessary to do as soft drink bottles can be skewed on other sides as can be seen on the figure below. To obtain the radius of the gauge from the diameter we divide it by 2.

How To Build A Rain Gauge Cont.

3.2. To calculate the surface area of the bottle we use the equation:
Bottle surface area = π x (radius) ²
- we know the radius and the Pi (π) is a constant given as 3.14159265359.

3.3. Conversion of water mL to mm
The equation for the calculation is given as:

Example: $Precipitation\ (mm) = \frac{Volume\ of\ water\ (ml)}{area\ of\ funnel\ (cm^2)}\ x\ 10$

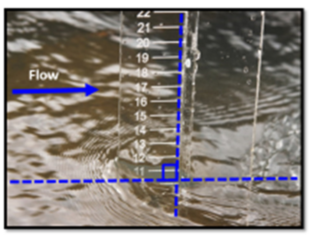
- if we look at this equation we can see that $Precipitation\ (mm)$ is the subject of the equation however we want $Volume\ of\ water\ (ml)$ to be the subject because that is what we want to calculate. So we need to manipulate the above equation. After manipulating the equation we end up with an equation that looks like this:

$$Volume\ of\ water\ (ml) = \frac{Precipitation\ (mm)\ x\ area\ of\ funnel\ (cm^2)}{10}$$

- This equation shows the volume of water (ml) represented by depth of water (mm) over the surface area of the gauge. We found that 1 mm depth of water is equivalent to 8.5 mL of water added, so is 7.5 mm, 15 mm and 130 mm equivalent to 63.7 mL, 127.4 mL and 1104.3 mL, respectively. This is shown in the table on the next slide.

How to use stream flow velocity to measure discharge cont.

Step 3:
Hold the TVHR perpendicular to flow to measure depth. During this step, the TVHR needs to be pushed firmly against the stream bed to prevent any slipping.



How To Build A Rain Gauge Cont.

	A	B	C	D	E	F
1	Rain (mm)	Water (mL)	Difference (mL)	Diameter	Radius (Diameter/2)	Area = pi x rad ^2
2	1	8.7	4.3	10.5	5.25	86.5901
3	1.5	13.0	4.3			
4	2	17.3	4.3			
5	2.5	21.6	4.3			
6	3	26.0	4.3			
7	3.5	30.3	4.3			
8	4	34.6	4.3			
9	4.5	39.0	4.3			
10	5	43.3	4.3			
11	5.5	47.6	4.3			
12	6	52.0	4.3			
13	6.5	56.3	4.3			
14	7	60.6	4.3			
15	7.5	64.9	4.3			
16	8	69.3	4.3			
17	8.5	73.6	4.3			
18	9	77.9	4.3			
19	9.5	82.3	4.3			
20	10	86.6	4.3			
21						

The column (A) is the theoretical rainfall amount (mm), column (D) is the average diameter measured in 3.1, Column (E) is the radius obtained from the diameter measurement and column (F) is the area of the bottle calculated using the equation (1). Column (B) gives the water volume (mm) that obtained using equation (2). Lastly column (C) gives the differences in measurements from column (B).

How To Build A Rain Gauge Cont.

3.4. After all the calculations have been done we can use the measuring tools such as a volumetric flask and a syringe; one can add the volume of water to represent the equivalent depth in mm.
- Now that we know exactly how much water (mL) can be represented by certain length measurement (mm) we can begin to construct and install our rain using the materials outlined in the beginning of the guide

Step 4: ***Marking the Rain Gauge***
4.1 . We are going to use the table to guide us as to how much water in mL to add using the volumetric flask and syringe to give us the rainfall depth in mm. In the example given above, the addition of 8.7 mL of water is equivalent to 1 mm depth in a rain gauge. Mark that as your first point on the rain gauge as shown below. To get the second point we use the difference column in the table (Column C) to guide us on how much water to add next. In the example we are to add 4.3 mL of water to add 0.5 mm equivalent depth, and 43 mL for an equivalent of 5 mm. See the images below for a demonstration.

How To Build A Rain Gauge Cont.

4.2. From here we can add the cumulative depth of water, which is equivalent to its respective water volume (Table 1).

4.3. After marking all the points on the gauge, the depth represented by the lines can then be labeled.

After labeling the rain gauge is then complete and ready for installation. However, before the gauge is installed it is important that the protocols guiding the installation of rain gauges are read.

How To Build A Rain Gauge Cont.

Step 5: ***Placement of the Rain Gauge***

There are two main criteria to consider for selecting a site for the rain gage namely:

- Exposure of the gauge to rainfall
  - The general rule is that the rain gauge must be located at a distance no less than 2 x height of nearest tree, i.e. $D_{gauge} = 2 \times h_{tree}$

  - The gauge must also be protected from the wind in all directions as the greater the disturbance from wind, the greater the measurement error. Thus, gauges should not be placed in wide-open spaces or on top of buildings.
  - Gauges should also not be placed obstructions such as trees and buildings, as these may rebound precipitation under turbulent conditions.

How To Build A Rain Gauge Cont.

- The gauge should stand at least 1.2m above the ground as per South African standard requirements. This is to prevent creeping in of droplets from splash erosion and tall vegetation. It is up to the individual to decide how far below the ground the rod supporting the gauge should penetrate, but as long as the gauge will be anchored strong enough so as not to be affected during turbulent conditions.

- The suitability of the gauge for the reader while minimizing access to trespassers.
  - The gauge should be placed in a suitable location for the observer (in a place where it can be readily accessible so to encourage daily observations). However, the gauge should not be in a conspicuous location that will attract defacement trespassers.

Now that we are aware of the protocols around the placement of the rain gauge we can then proceed to the installation phase.

How To Build A Rain Gauge Cont.

Step 6: ***Installing The Rain Gauge***

For this step you will need theses resources

If you look at the image below (circled in light green), you can see that wire strings are attached in such a way as to hold a rain gauge. Soft wire was used as it can be adjusted easily by any age group. A subsequent image shows the gauge being attached around a wire and ready to operate.

How To Build A Rain Gauge Cont.

Step 7:
Place your bottle at the top of the wooden stake where it will be secured and mark off where the neck and the middle of the gauge are. Once these have been marked, use a saw or knife to carve ridges into the wood along your markings to make sure your gauge does not slide down the pole once it has been attached.

Step 8:
Straighten out the coat hangers that will be used to attach the gauge to the wooden stakes. Twist the wire tightly around the pole in the ridges and then into a small loop lower down for the cap of the bottle to fit into, and a larger loop higher up for the opening of the bottle.

- Make sure the wire loops can hold the bottle, and that the battle can be removed.
- Test whether the wire is able to hold the bottle upright on the pole. It should also be strong enough to hold the bottle with water in and this should be tested.

How To Build A Rain Gauge Cont.

Step 9:
Height and location of the rain gauge is important:

- In open areas the rain gauge should sit approximately 2 feet (60cm) above the ground and be placed twice as far from the nearest obstacles as the height of those obstacles.
- In developed areas the rain gauge should sit approximately 5 feet (1.5m) above the ground and be placed as far from the nearest obstacles as the height of those obstacles (this is to ensure the nearby obstacles do not affect the catch of the rain gauge).

Step 10:
The hole can be dug, using the spade, which should be at least 25-30cm deep to ensure the pole remains sturdy.

Step 11:
Make sure the pole is standing vertical before refilling the hole with soil and compacting it so that the gauge remains level.

How to use The Rain Gauge

- Gauges need to be placed in areas that are protected from strong wind, but at the same time, not near any obstructions such as vegetation or buildings.
- Take note that rain that is less than 1mm cannot be measured as this fills the area of the cap.
- Different substances that have been considered and used in previous studies to fill the caps of the rain gauges include; silicone, gelatin, wax and oils – Silicone and wax are optimal because they are not as affected by the elements (oil can work but would have to constantly be refilled).
- The gauges with filled caps tend to perform slightly better than those that do not have filled caps.
- Smaller bottles that have a filled cap and a sprout taped on require a small hole near the top of the bottle to allow water to be emptied out.
- Continued monitoring and statistical analyses are required to determine if there is a statistical difference between the precipitations measured in the standard rain gauge and homemade gauges.

Measuring Rainfall

- Measure the widest diameter of the opening in cm and divide by 2 to get the radius.
- Square this number and then multiply by π (3.142) to get the area of the top of the funnel in cm^2. This formula is area = πr^2 which gives us the area of a circle.
- Use the formula: rainfall (mm) = area x (interval/10) to mark off your intervals or precipitation of rain.

For example:

If the diameter of the opening is 10cm: 10/2 = 5cm and $5^2 \times \pi = 78.55cm^2$

To mark off 1mm of rain: 78.55 x 1/10 = 7.855ml

Measure 7.855ml into your gauge and make a mark at the bottom of the meniscus

To mark off 2mm of rain: 78.55 x 2/10 = 15.71ml

Empty the gauge and measure 15.71ml into the gauge and mark the bottom of the meniscus

To mark off 50mm of rain: 78.55 x 50/10 = 392.75ml

Empty the gauge and measure 392.75ml into the gauge and mark the bottom of the meniscus

And so on.

The End

APPENDIX P: HOME MADE WIND PRESSURE PLATE

Wind Pressure Plate

This is a product of The Water Research Commission: Project No. K5/2350

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

WESSA
PEOPLE CARING FOR THE EARTH

Contents

List of Figures

Introduction and Background

Wind speed describes how fast the air is moving past a certain point. This may be an averaged over a given unit of time, such as miles per hour, or an instantaneous speed, which is reported as a peak wind speed, wind gust or squall. Wind direction describes the direction on a compass from which the wind is coming from, for instance, from the North or from the West (Fondriest Staff, 2010).

Why is Wind Speed and Direction Important?

Wind speed and direction are important for monitoring and predicting weather patterns and global climate. Wind speed and direction have numerous impacts on surface water. These parameters affect rates of evaporation, mixing of surface waters, and the development of seiches and storm surges. Each of these processes has dramatic effects on water quality and water level. Wind speed is typically reported in knots, or meters per second (Fondriest Staff, 2010).

Wind direction is typically reported in degrees, and describes the direction from which the wind emanates. A direction of 0 degrees is due North on a compass, and 180 degrees is due South. A direction of 270 degrees would indicate a wind blowing in from the west (Fondriest Staff, 2010).

Wind Speed and Direction Technology

The measurement of wind speed is usually done using a cup or propeller anemometer, which is an instrument with three cups or propellers on a vertical axis. The force of the wind causes the cups or propellers to spin. The spinning rate is proportional to the wind speed. Wind direction is measured by a wind vane that aligns itself with the direction of the wind (Fondriest Staff, 2010).

How to make the wind pressure plate

Materials needed

Corrugated cardboard or 2 property rental signs (most estate agencies are willing to donate old ones)
2 pieces scrap PVC piping about 25 mm wide- 35 cm and 20 cm long
2-3 Plastic book binders
Duct tape/ clear tape
Wire
Plumbing T-junction to fit pipe (if available)
Compass (or you can print the template provided)
Metal rod or a long straight stick/pole
Tape
Scissors/ craft knife
Saw to cut pipe
Cable Ties

Method

1. Cut the board into two shapes similar to the shapes below

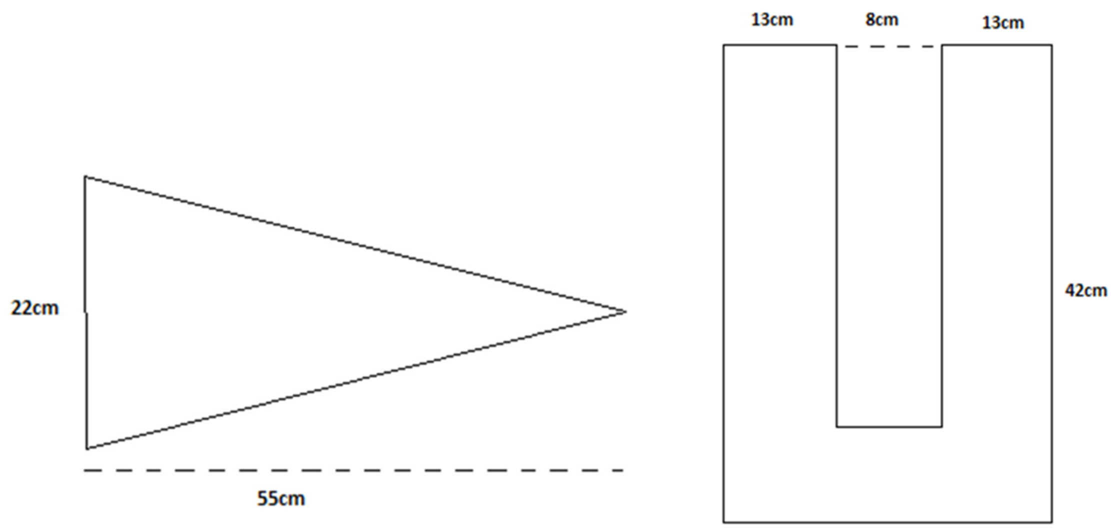


Figure 0.1 Shapes and dimensions of board

Figure 0.2 Photo showing the different pieces of board required

2. Now you are going to attach the triangular board to the smaller piece of pipe to act as a wind vane. Cut a vertical slit through the shorter pipe using a saw DO NOT CUT THE PIPE IN HALF! Stop the cut about 3 cm from the base. Slot the triangular board into the pipe so it sits about half way across the triangle. Re-close the split end of pipe with a cable tie. The triangle should be held firmly in place.

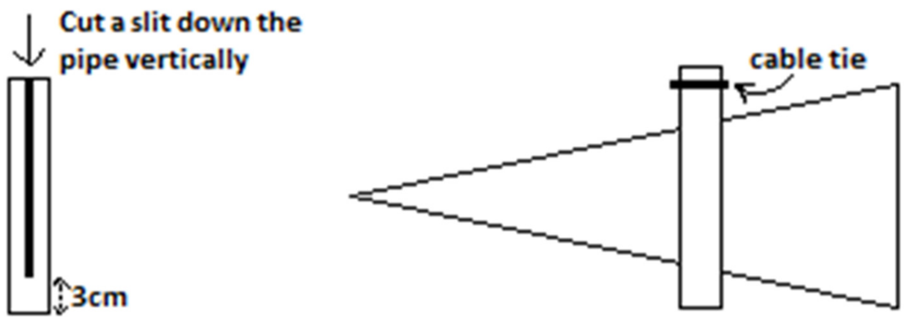


Figure 0.3 Construction of the plate

3. **If you have a T-junction for the pipe:** cut the 35 cm pipe in calf and insert into the top ends of the T-junction joint. Insert the pipe with the triangle (the end without the cable tie) into the bottom opening of the joint.

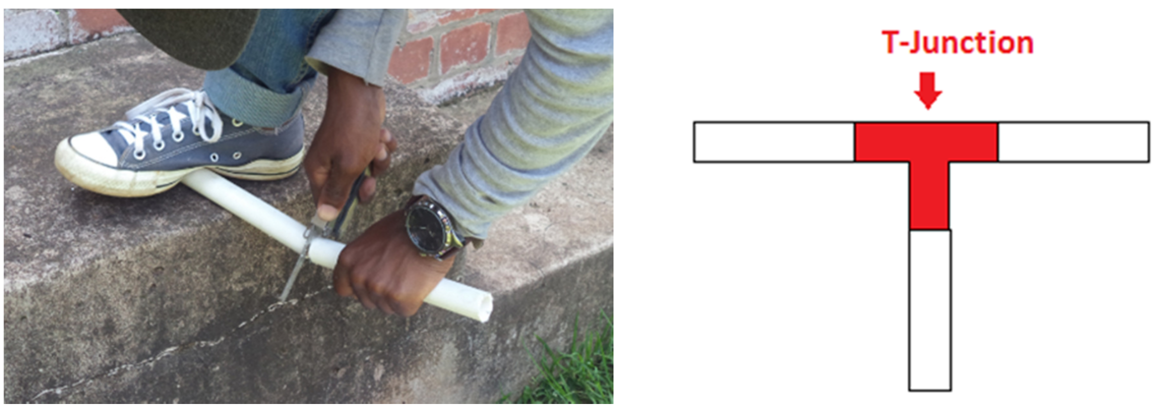


Figure 0.4 Use of a T-junction joint

4. If you do-not have a T-junction joint: Take the longer piece of the pipe and place it perpendicular to the shorter piece with the triangle. Secure with tape and cable ties as needed.

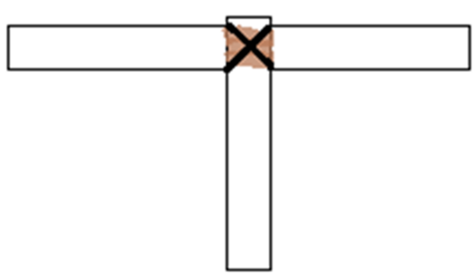
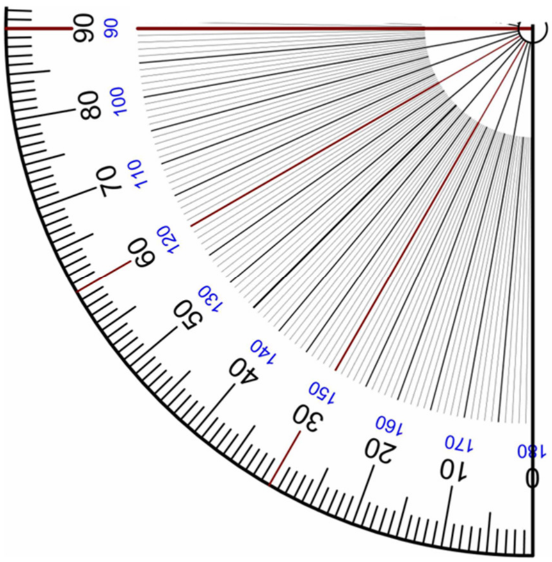


Figure 0.5 Construction of a T-junction without a T-junction joint

5. Use the saw or other cutting tool to cut two 13 cm pieces from one of the book binders, slide these onto the ends matching in size of the rectangular piece of board. Use tape to secure them on extra firmly if necessary.

6. Thread a piece of wire through the top part of the 'T' pipe shape. On each end of the T, attach the rectangular board by threading the wire (that is already through the pipe) through the pieces of book binder secured to the board. When the wire has been threaded through, attaching the rectangular shape at both sides, you can join the loose ends of wire together (if the wire is tough you may need extra tape and cable ties to help do this). This part will form the pressure plate of the instrument.
7. Print and cut out the compass provided below, if possible laminate it or cover it with a piece of plastic. Use clear tape to attach it to the triangular part of the instrument (shown in pictures). Alternatively you could use a compass from a maths set to mark the angles on the vane.



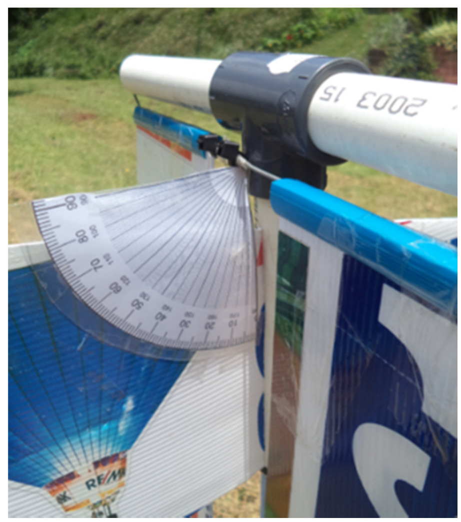


Figure 0.6 Using a compass to set the angles of the vane

8. The tool can now be mounted on the rod/pole or stick (through the shorter pipe) and set up outside in an open area (where the wind can reach

Acknowledgements

Funding of the development of this tool by Water Research Commission research project K5/2350 is gratefully acknowledged.

REFRENCES

Fondriest Staff, 2010. Wind Speed and Direction. Environmental Monitor. www.fondriest.com/news/wind-speed-and-direction.htm (site accessed June 2017)

PowerPoint Presentation

The Wind Pressure Plate

This is a product of The Water Research Commission: Project No. K5/2350

WRC Project No. K5/2350

Why is wind speed and direction important?

- For monitoring and predicting weather patterns and global climate.
- Wind speed and direction have numerous impacts on surface water which affect evaporation, mixing of surface waters, and the development of seiches and storm surges. Each of these processes has dramatic effects on water quality and water level.
- Wind speed is typically reported in knots or meters per second
- Wind direction is typically reported in degrees. A direction of 0 degrees is due North on a compass, and 180 degrees is due South. A direction of 270 degrees would indicate a wind blowing in from the west.

WRC Project No. K5/2350

Wind Speed and Direction Technology

- The measurement of wind speed is usually done using a cup or propeller anemometer, which is an instrument with three cups or propellers on a vertical axis.
- The force of the wind causes the cups or propellers to spin. The spinning rate is proportional to the wind speed.
- Wind direction is measured by a wind vane that aligns itself with the direction of the wind.

WRC Project No. K5/2350

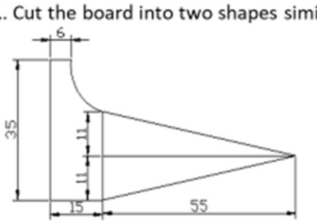
What materials do you need to make the wind pressure plate?

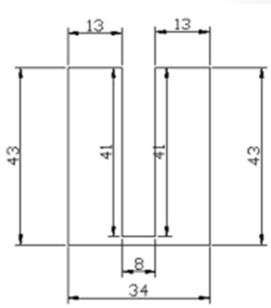
- Corrugated cardboard or 2 property rental signs (most estate agencies are willing to donate old ones)
- 2 pieces scrap PVC piping about 25mm wide- 34cm and 20cm long
- 2-3 Plastic book binders
- Duct tape/ clear tape
- Wire
- Plumbing T-junction to fit pipe (if available)
- Compass (or you can print the template provided)
- Metal rod or a long straight stick/pole
- Tape
- Scissors/ craft knife
- Saw to cut pipe
- Cable Ties
- 2 Toothpicks

WRC Project No. K5/2350

How to make the wind pressure plate?

1. Cut the board into two shapes similar to the shapes below

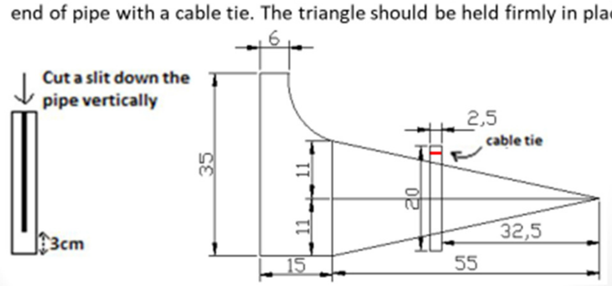




WRC Project No. K5/2350

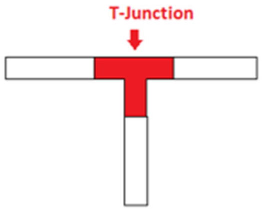
2. Now you are going to attach the triangular board to the smaller piece of pipe to act as a wind vane. Cut a vertical slit through the shorter pipe using a saw **DO NOT CUT THE PIPE IN HALF**!

Stop the cut about 3 cm from the base. Slot the triangular board into the pipe so it sits about half way across the triangle. Re-close the split end of pipe with a cable tie. The triangle should be held firmly in place.

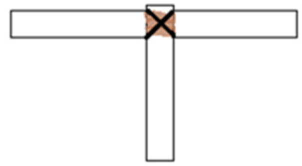


WRC Project No. K5/2350

3. If you have a t-junction for the pipe: cut the 34cm pipe in calf and insert into the top ends of the t-junction joint. Insert the pipe with the triangle (the end without the cable tie) into the bottom opening of the joint.



4. If you do-not have a t-junction joint: Take the longer piece of the pipe and place it perpendicular to the shorter piece with the triangle. Secure with tape and cable ties as needed.

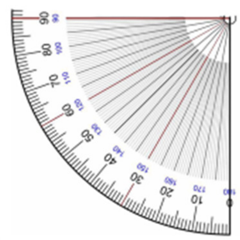


5. Use the saw or other cutting tool to cut two 13cm pieces from one of the book binders, slide these onto the ends matching in size of the rectangular piece of board. Use tape to secure them on extra firmly if necessary.

6. Thread a piece of wire through the top part of the 'T' pipe shape. On each end of the T, attach the rectangular board by threading the wire (that is already through the pipe) through the pieces of book binder secured to the board. When the wire has been threaded through, attaching the rectangular shape at both sides, you can join the loose ends of wire together (if the wire is tough you may need extra tape and cable ties to help do this).

This part will form the pressure plate of the instrument!

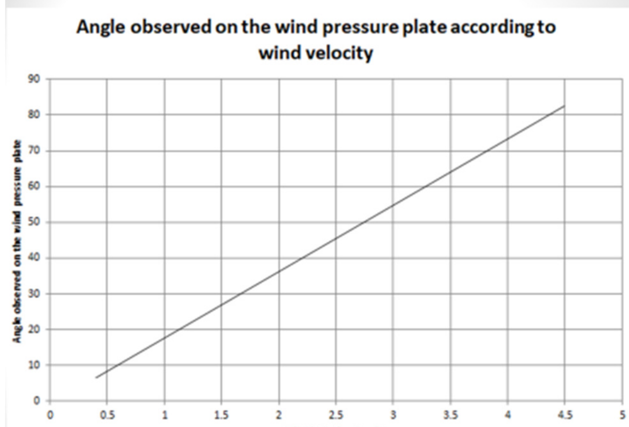
7. Print and cut out the compass provided below (15cm height and width), if possible laminate it or cover it with a piece of plastic. Use clear tape to attach it to the triangular part of the instrument (shown in pictures). Make sure that the compass angle touches the wire. Alternatively you could use a compass from a maths set to mark the angles on the vane.



8. Add a toothpick or a similar object on each side of the plate so you can read more easily the graduation on the compass.

9.The tool can now be mounted on the rod/pole or stick (through the shorter pipe) and set up outside in an open area (where the wind can reach)

IMPORTANT: Make sure the plate is in front of the zero when there is no wind!



THE END

WRC Project No. K5/2350

water & sanitation

GroundTruth

WESSA

APPENDIX Q: HOME MADE ANEMOMETER

How to make and calibrate a cup

This is a product of The Water Research Commission: Project No. K5/2350

Contents

List of Figures

List of Tables

Introduction and Background

An anemometer is a tool that is used to measure wind speed, and is a common weather station tool. There are several types of anemometers that can measure wind speed, and most of them are accurate but very costly and difficult to maintain. In a changing world where weather patterns are slowly becoming unpredictable, more weather data is needed to make reliable predictions especially in areas where data is limited.

A homemade “cup” anemometer is a simple type of an anemometer. It looks similar to a weather vane, but instead of measuring which direction the wind is blowing with pointers, it has four paper cups that are used to measure wind speed. Each cup is attached to the end of a horizontal arm, each of which is mounted on a central point (a central axis). When wind blows the cups they on the axis. If one were to count the number of times the cups turn (rotate) over a set time period will help us to determine how fast the wind is blowing. If the cups move very fast and complete many rotations in the set time, it indicates that the wind is blowing hard. If the cups do not move fast, and only a few rotations are completed in the same set time, it indicates that the wind is not that strong. The faster the wind, the faster the cups spin the axis.

Figure1.1 An example of a home-made cup anemometer, using a cool drink can, a pencil and some Styrofoam cups.

Method

2.1 Materials

- Ball point pen
- 4x polystyrene cups
- Pencil sharpener
- 2x dowel sticks (30 cm in length and 5 mm in diameter)
- 1x cork
- Glue
- Paint
- 1x base board (1 m^2)

2.2 How to build a homemade cup anemometer

1. Measure 3 cm up from the base of the paper cups and cut and remove the top section of the cup.
2. Sharpen the pencil and glue the bottom end of it onto the board.
3. Push and fit the cap of the ball point pen into the cork.
4. Push the 2 dowel sticks through the cork so that they form a cross and attach the 4 cups to the ends of each dowel.
5. Place the cork over the pencil so that the ball point pen cap rests on the tip of the pencil.
6. When the wind blows the cups will spin
7. Colour 1 of the cups and count how many turns it makes in 30 seconds at different speeds
8. This may be done by using an electric fan or holding your anemometer out of the window of a moving vehicle that is driven at different speeds.
9. Once you know how many times it turns for each speed, you will be able to determine wind speed on a windy day.
10. Record the wind speed daily.

2.3 The use of a wind tunnel

The wind speed is very variable and this makes it difficult to calibrate this type of an instrument. Challenges of adequate wind have also been a factor hindering the progress of the tool calibration. To compensate for this, windy conditions were simulated using a wind tunnel. The wind tunnel was therefore constructed using large cardboard boxes. The lids were cut off and the 2 boxes were taped together to make a tunnel. A fan was then placed in the one end and the sensors just inside the tunnel at the other end.

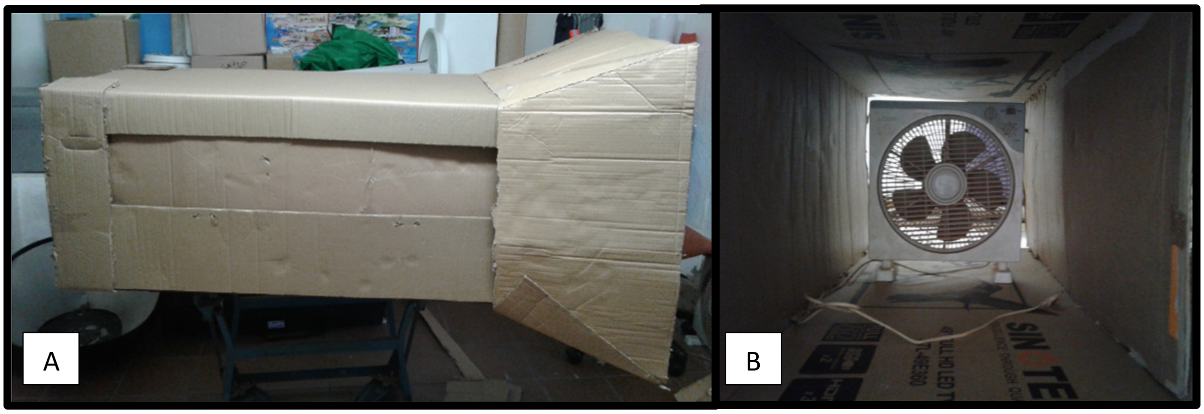


Figure 2.1 A: Side view of a homemade wind tunnel; B: Fan inside the wind tunnel

2.3 Manual calculation

The circumference of the circle made by the rotating cups was calculated by measuring the distance around the circle that they make (using a piece of string that was measured with a ruler in centimetres. This was then converted to meters by dividing the number of centimetres by 100. Multiply this number by rpm. Finally, divide your product by 60 (to convert minutes to hours) and you will have an approximation of the velocity at which the anemometer is spinning (in mph), although this does not take friction in to account The formula of the circumference is given by:

$$C=2\pi r$$

Where C = Circumference

π = 3.142 (Constant)

r = radius

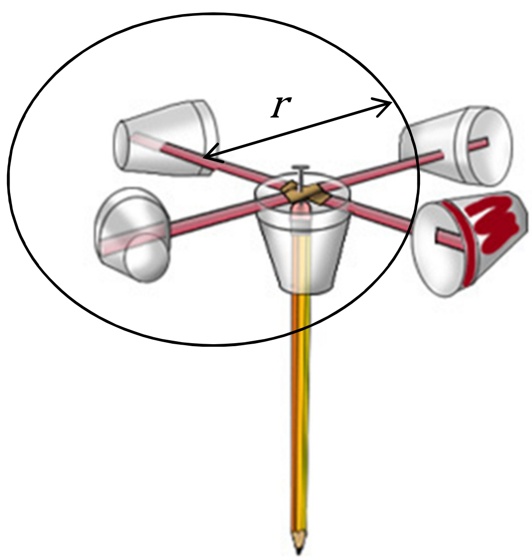


Figure 2.2 Measurement of circumference

After measuring the radius of our anemometer, we found that it was 11.3 cm
Now that we know the radius we can calculate the circumference

$C = 2\pi r$
$= 2 \times \pi \times 11.3$ cm
$= 71$ cm

Assumption: The cups rotated four times in 10 seconds

Results

Table 2.1 Comparison of the Davis and homemade anemometer

Intervals (sec)	Davis (m/s)	Homemade (revolutions)
10	2.5	7
10	1.1	7
10	1.1	3
10	1.9	6
10	1.9	10
10	2.1	8
10	0.8	2
10	2.2	10
10	2.0	4
10	4.1	10
10	2.9	11
10	3.0	7
10	2.5	9
10	3.6	8

Acknowledgements

Joint funding of the development of this tool by WWF-Mondi Wetlands Programme and the Water Research Commission is gratefully acknowledged. Donovan Kotze, Mark Graham, Kirsten Mahood and Bonani Madikizela are thanked for providing valuable comments on an earlier version of the tool.

PowerPoint Presentation

Cup Anemometer

This is a product of The Water Research Commission: Project No. K5/2350

WRC Project No. K5/2350

What is an anemometer?

A tool that is used to measure wind speed, and is a common weather station tool.

There are several types of anemometers that can measure wind speed, and most of them are accurate but very costly and difficult to maintain.

A homemade "cup" anemometer is a simple type of an anemometer.

No. of times the cups turn (rotate) over a set time period → helps determine how fast the wind is blowing.

How to build a homemade cup anemometer

Materials

- Ball point pen
- 4x polystyrene cups
- Pencil sharpener
- 2x dowel sticks (30cm in length and 5mm in diameter)
- 1x cork
- Glue
- Paint
- 1x base board (1m2)

How to build a homemade cup anemometer

1. Measure 3cm up from the base of the paper cups and cut and remove the top section of the cup.
2. Sharpen the pencil and glue the bottom end of it onto the board.
3. Push and fit the cap of the ball point pen into the cork.
4. Push the 2 dowel sticks through the cork so that they form a cross and attach the 4 cups to the ends of each dowel.
5. Place the cork over the pencil so that the ball point pen cap rests on the tip of the pencil.
6. When the wind blows the cups will spin
7. Colour 1 of the cups and count how many turns it makes in 30 seconds at different speeds
8. This may be done by using an electric fan or holding your anemometer out of the window of a moving vehicle that is driven at different speeds.
9. Once you know how many times it turns for each speed, you will be able to determine wind speed on a windy day.
10. Record the wind speed daily.

The use of a wind tunnel

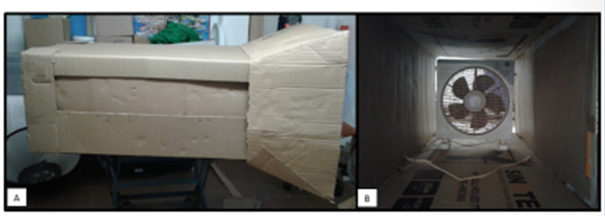


Figure 2.1 A: Side view of a homemade wind tunnel; B: Fan inside the wind tunnel

Variable wind speed makes it difficult to calibrate this type of an instrument. To compensate for this, windy conditions were simulated using a wind tunnel.

Manual calculation

$C = 2\pi r$

Where C = Circumference

π = 3.142 (Constant)

r = radius

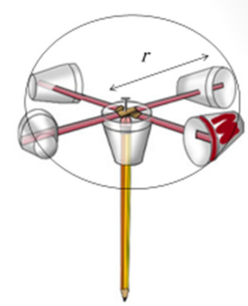


Figure 2.2 Measurement of circumference

Manual calculation - example

After measuring the radius of our anemometer, we found that it was 11.3 cm
Now that we know the radius we can calculate the circumference

C = 2πr
= 2 x π x 11.3cm
= 71 cm

Assumption: The cups rotated four times in 10 seconds

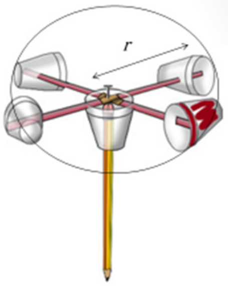


Figure 2.2 Measurement of circumference

Results

Table 3.1 Comparison of the Davis and homemade anemometer

Intervals (sec)	Davis (m/s)	Homemade (revolutions)
10	2.5	7
10	1.1	7
10	1.1	3
10	1.9	6
10	1.9	10
10	2.1	8
10	0.8	2
10	2.2	10
10	2.0	4
10	4.1	10
10	2.9	11
10	3.0	7
10	2.5	9
10	3.6	8

THE END

APPENDIX R: THE EXPOSE *E.COLI* SWAB

The Expose *E. coli* Swab

*The **Expose** **E. coli** **swab** is a product of Micro Food Lab. This user manual was produced as part of WRC research project K5/2350.*

Contents

List of Figures

Introduction and Background

1.1 What is *E. coli*?

Escherichia coli (which is part of the coliform group of bacteria) is normally found in the intestines of warm blooded animals (including humans), as well as in animal waste material. Most *E. coli* are harmless and are important in the intestinal system. However, some *E. coli* are pathogenic and can cause illness, such as diarrhoea. These types of *E. coli* can be spread through contaminated water or food, or through contact with animals or people. In water, *E. coli* have no taste, smell, or colour. Traditionally, they can only be detected through a laboratory test.

1.2 Why should we monitor *E. coli*?

The occurrence of *E. coli*, particularly in large quantities, is an indicator of sewage or faecal contamination in water. *E. coli* indicates the likely presence of other disease-causing pathogens (e.g. certain bacteria, viruses and parasites). The presence of *E.coli* in a water body may also have direct negative impacts, as certain strains of *E. coli* can cause illness to humans, with symptoms such as diarrhoea, vomiting, stomach cramps and fever. Scientific monitoring of *E. coli* in water bodies used for drinking water or recreation, especially when considering that coliform bacteria are colourless, odourless and tasteless and thus cannot be detected without specialised equipment, is vital.

1.3 What causes *E. coli* contamination of water?

Pathogens in water are generally introduced through contamination from human or animal faecal waste. This can be brought about by various circumstances such as septic tank and sewage discharges which are improperly managed, leaching of animal manure, run-off from storm water, and the presence of domestic and wild animals near to water bodies.

The *E. coli* swab and how to use it

The *E. coli* swab was developed by Micro Food Labs as a rapid assessment to detect the presence or absence of *E. coli* bacteria. The swab provides an indication for the user to determine if further testing is required, based on the outcome of the test.

The swab works on the principal that a sample is collected, and incubated for a period of between 18-24 hours, to allow any *E. coli* present to reproduce to determine if there is *E. coli* present or not.

2.1 How to use the E. coli swabs

1. Remove the swab from the sheath, twisting the swab whilst removing it.
2. When testing the water, ensure that the swab moved around so as to 'saturate' the swab with liquid.
3. The swab should not be allowed to touch anything other than the liquid which is being tested (i.e. it must not touch rocks or plants).
4. The sample should be taken from an area where the water is still (e.g. behind a rock or in a place where an eddy has formed) rather than an area of flowing water (Figure 2.1).
5. Return the swab to the sheath (Figure 2.1), ensuring that it makes adequate contact with the media/gel at the bottom of the swab container (it may be necessary to move the swab up and down a few times in the media to achieve this).
6. It is vital that the swab is NOT REMOVED from the sheath once it has been placed back in it.

Figure 0.1 Collecting the sample from an area of still water and replacing the swab in the test tube

7. Number and date the samples that are collected, so that you can identify them after incubation.
8. The swab must now be incubated, which is a process of maintaining the swab at a controlled temperature in order to provide the best growing conditions for *E. coli* growth. Place the swab into the incubator, which must be plugged into a power source, and switched on.
9. 18-24 hours after placing the swab into the incubator the swab can be "read". If a negative result (no *E. coli* present) is achieved after this time, re-incubate the swab for another 18-24 hours (giving a 48-hour result) to ensure that the result really is negative (that means no *E. coli* present).

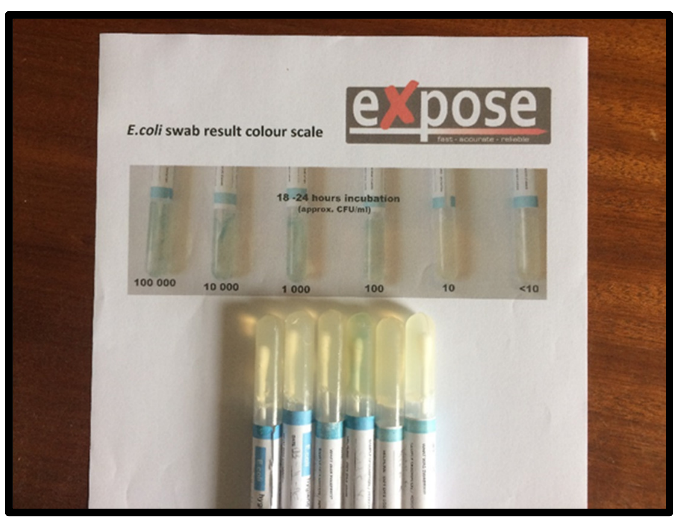


Figure 0.2 Judging the swabs according to the expose *E. coli* swab result colour scale

10. The middle hole of the incubator (the 'control' hole) should be left open, allowing excess heat to escape in order to keep the temperature within the correct range.
11. Once the result has been recorded, dispose of the swab in the disposal box provided (once this box is full, contact the provider of the swabs in order to safely dispose of them).

A swab can only be used once, and has a shelf life (from date of manufacture) of 2 months, provided that it is kept at 2-8°C

What does a positive result mean?

A positive result means that there is *E.coli* bacteria present in the water, and the water is thus not safe to drink. The chart below (Figure 3.1) gives a rough indication of the level of contamination, based on the blue colouration that appears in the swab after incubation. Contaminated water can only be consumed if it is boiled or treated with chlorine to destroy the pathogens in the water. In addition to this, ensure that un-boiled/un-treated water used for household purposes is not consumed (e.g. while bathing). Swimming in contaminated waters is also dangerous as chances of acquiring illnesses are high. Secondary effects should also be kept in mind, such as build-up of bacteria in plumbing systems and wells.

The presence of *E. coli* also suggests that there may be other pathogens in the water. In order to deal with possible threats, the source of the bacteria should be investigated and corrective measures taken.

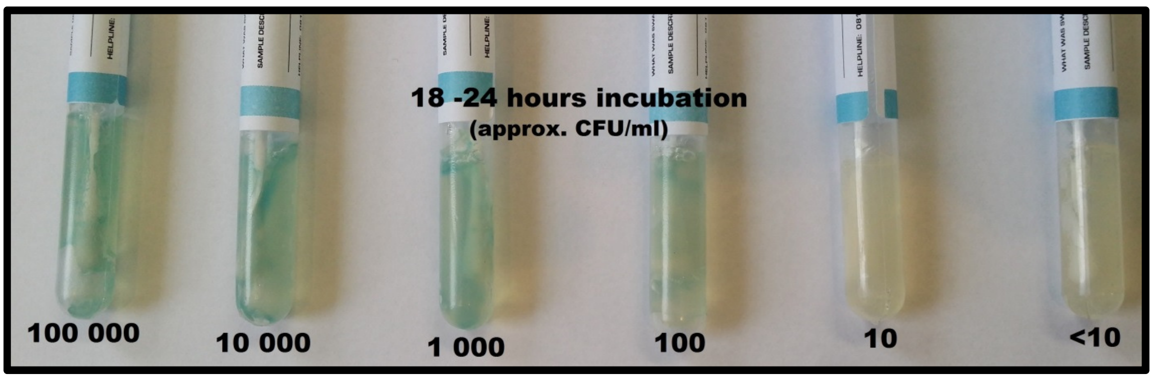


Figure 0.3 Results of *E. coli* swabs – Blue colouration showing *E.coli* bacteria. Please note that the colours are a rough guide to the extent of (CFU refers to the measure of "*colony forming units*")

Acknowledgements

The ***Expose E. coli swab*** was developed and rights are still wholly owned by Micro Food Lab. This user manual was developed by Ground Truth through funding from WRC project K5/2350.

Poster

eXpose

E. coli swabs

What is *Escherichia coli* (*E. coli*)?

- Bacteria found in the intestines of warm-blooded animals
- Most *E. coli* are harmless & needed in the intestinal system
- But, some *E. coli* cause illness (e.g. diarrhoea)
- Transferred through water, food, and animal/human contact

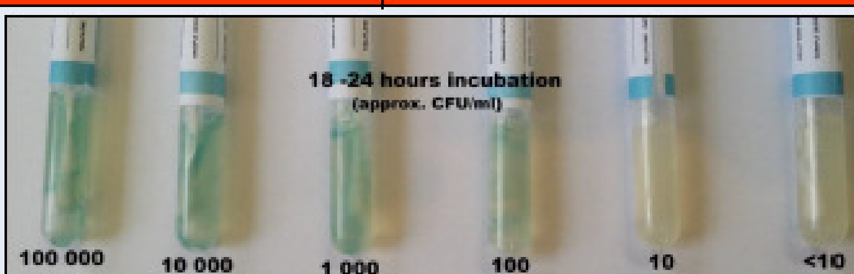
Why monitor *E. coli*?

High faecal coliform bacteria in water indicates sewage contamination (& presence of disease carrying organisms)

& possibility to cause illness such as nausea, diarrhoea, stomach cramps, fever)

What are the limits for drinking water in South Africa?

Faecal Coliform Range (count / 100mL water)	Effects
0 (Target Water Quality Range)	Negligible risk of microbial infection
1 – 10	Slight risk of microbial infection with continuous exposure
11 - 20	Risk of infectious disease with continuous exposure
> 21	Significant and increasing risk of infectious disease transmission



GroundTruth Water, Wetlands and Environmental Engineering · WESSA · water & sanitation, Department: Water and Sanitation, REPUBLIC OF SOUTH AFRICA

Product of a WRC research project K5/2350 Trans-boundary Ecosystem Management

PowerPoint Presentation

E. coli dipstick

WRC Project No. K5/2350

This is a product of The Water Research Commission: Project No. K5/2350

What is E. coli dipstick?

- It is a simple citizen science tool used to detect the presence or absence of E. coli bacteria.
- The presence of E. coli bacteria is a sign of reduced water quality.
- The swab provides an indication for the user to determine if further testing is required, based on the outcome of the test.
- A sample is collected, and incubated for a period of between 18 – 24 hours, to allow any E. coli present to reproduce to determine if there is E. coli present or not.

WRC Project No. K5/2350

How do we use the E. coli dipstick?

- Remove the swab from the sheath, twisting the swab whilst removing it.
- When testing the water, ensure that the swab moved around so as to '**saturate**' the swab with liquid.
- The swab **SHOULD NOT** be allowed to touch anything other than the liquid which is being tested (i.e. it must not touch rocks or plants)!
- The sample should be taken from an area where the **water is still** rather than an area of flowing water.

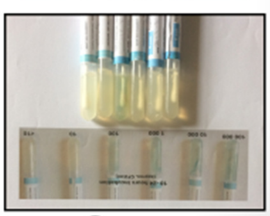
IMPORTANT: Make sure the swab should not touch anything other than the liquid which is being testing!

WRC Project No. K5/2350

Collecting the sample from an area of still water and replacing the swab in the test tube

- Number and date the samples that are collected, so that you can identify them after incubation.

- The swab must now be incubated, which is a process of maintaining the swab at a controlled temperature in order to provide the best growing conditions for E. coli growth. Place the swab into the incubator, which must be plugged into a power source, and switched on.
- 18-24 hours after placing the swab into the incubator the swab can be "read". If a negative result (no E. coli present) is achieved after this time, re-incubate the swab for another 18-24 hours (giving a 48hour result) to ensure that the result really is negative.



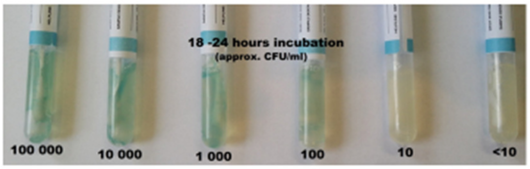
WRC Project No. K5/2350

- The middle hole of the incubator (the '*control*' hole) should be left **open**, allowing excess heat to escape in order to keep the temperature within the correct range.
- Once the result has been recorded, dispose of the swab in the disposal box provided (once this box is full, contact the provider of the dipstick in order to safely dispose of them).

A swab can only be used once, and has a shelf life (from date of manufacture) of 2 months, provided that it is kept at 2-8°C

So, what does a positive result mean?

- A positive result means that there is E.coli bacteria present in the water, and the water is thus not safe to drink.



The chart gives a rough indication of the level of contamination, based on the blue colouration that appears in the swab after incubation

- Contaminated water can only be consumed if it is boiled or treated with chlorine to destroy the pathogens in the water.
- Ensure that unboiled/un-treated water used for household purposes is not consumed.
- Swimming in **contaminated waters** is also **dangerous** as chances of acquiring illnesses are high. Secondary effects should also be kept in mind, such as build-up of bacteria in plumbing systems and wells.

What are the limits for drinking water in South Africa?

Faecal Coliform Range (count / 100mL water)	Effects
0 (Target Water Quality Range)	Negligible risk of microbial infection
1 – 10	Slight risk of microbial infection with continuous exposure
11 - 20	Risk of infectious disease with continuous exposure
> 21	Significant and increasing risk of infectious disease transmission

Where & when should the E.Coli dipstick be used?

- The occurrence of E. coli, particularly in large quantities, is an **indicator of sewage or faecal contamination** in water. E. coli indicates the likely presence of other disease-causing pathogens.
- The E. Coli dipstick can be used in a variety of aquatic environments (rivers, ponds, wetlands etc.)
- The sample should be taken from an area where the water is still rather than an area of flowing water.
- When collecting data, make a note of your location, either with a GPS or on a map, so that you can find the site again.

Develop a Monitoring Protocol

- When you collect data over time and space, the information gathered can be very powerful. One can see patterns developing and emerging from the information
- Do you have an interesting question that you want answered? For example: ***"Is the wetland water outflow cleaner than the water inflow?"***
- If you have a question & site where you can collect data, decide on a monitoring routine to follow.
- Consider variables such as:
  - Season (rainy/high flow or dry/low flow)
  - Access to site
  - Landowner permission

Standardizing Data Collection

- Routine monitoring should be done at least once a month on a designated day (e.g. the first Monday of the month).
- For all monitoring, make notes on the condition of the site, and if anything has changed since the previous data collection period.
- Remember to take extra measurements when there are significant events impacting on the study site, such as heavy rainfall, spills or other disturbances.
- For event-driven measurements, make additional notes on what the event was and the duration for which it continued (e.g. 140mm rainfall over 16hrs prior to sampling).

Why is Standardizing Data Important?

In nature there is a lot of variation. We want to collect & compare data, but we don't want the natural variation of the system to influence our results. We also want to give others the opportunity to carry out the same process in a different place, so that their results can be compared with ours. For this to be possible, the data must be collected in exactly the same way, so that there is no chance that the data collection method influences the results, and that natural variation in the system is accounted for.

Making detailed notes about what you did is one way to make sure that others can do what you did (replicate) in the field
Always collect your data in exactly the same way every time you collect it. This is known as making your data collection repeatable.

WRC Project No. K5/2350

THE END

WRC Project No. K5/2350

Edition - October 2015

APPENDIX S: SCHOOL LESSON PLANS

Section A - Introduction and Templates

A Fieldwork Toolkit for Intermediate Primary Phase, Senior Primary Phase and Further Education & Training Phase

This is a product of the Water Research Commission: Project No. K5/2350

WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

WESSA
PEOPLE CARING FOR THE EARTH

Fieldwork Toolkit (First Edition)

(Focusing on Rivers and their Catchments)

Teachers: This is for you!

This toolkit contains a set of resources for teachers who are planning and conducting CAPS aligned fieldwork activities either in the school grounds or within walking distance of the school:

Natural Sciences - Intermediate Phase & Senior Primary Phase and Geography FET Phase.

Dear educator: since your purpose is to encourage a sharing of ideas, why not get-together with others to discuss how they can be further developed to suit your circumstances?

- *Enabling transformative environmental learning through effective knowledge-informed field-work aligned with the CAPS assessment.*

Fieldwork Toolkit
(First Edition October 2015)

(Focusing on Rivers and their Catchments)

CONTENTS Page Number

THE VALUE OF FIELDWORK IN TEACHING & LEARNING

Teachers (and parents of school-going children)

Consider these thoughts on learning and education:

- *"Education is the most powerful weapon you can use to change the world"* - Nelson Mandela.
- *"Education is not preparation for life. It is life itself."* - John Dewey (American philosopher & educational reformer).
- *"We learn through our interactions and communications with others. Learning takes place when meaning ascends from the abstract to the concrete as knowledge comes to us from others and we make it our own."* - Lev Vygotsky (Russian teacher & psychologist).
- *"The purpose of school learning is not to learn, but to learn how to think"* Anon

  - *What is your personal view on these statements?*
  - *How do they match your own view of education?*
  - *Would you add to or change any of these messages?*

The role of Fieldwork in the construction of knowledge

An increasing number of researchers are pointing to the critical role of fieldwork in the construction of knowledge. Referring to its value enables learners to learn together in a process known as 'co-production'.

This involves:

1. Covering experiences (ways of doing things)

2. Gaining facts (the acquisition of new information)

3. Social learning (ways of sharing information that benefits all who share in the process)

The school curricula for Natural Sciences, Life Sciences and Geography all include fieldwork. Fieldwork experiences can be small or large, within the school grounds or outside of them. These experiences encourage learners to cooperate together and make contributions to the planning and execution of the work and to grow as independent thinkers.

Citizen Science and Indigenous Knowledge

Environmental educators have for years been advocating citizen involvement as a 'game changer' for encouraging/pressurizing municipal managers and local authorities to take action to improve.

- **Citizen science:** is scientific research conducted, in whole or in part, by amateur or nonprofessional scientists. In past times this usually referred to adult members of society, but today it is acknowledged as a science that may involve 'citizens' of any age – from very young to very old.

- **Indigenous knowledge:** is knowledge acquired by our forebears. It often shows unique understandings of the natural environment and should be included, where appropriate, in our lesson plans.

Measuring the health of our rivers - The example of the miniSASS Toolkit

GroundTruth, WESSA (the Wildlife & Environment Society of South Africa), and Umgeni Water worked together to develop a simple macroinvertebrate scoring system whereby non-technical, private persons (including learners) can assess the health of local rivers by using a miniSASS (Mini Stream Assessment Scoring System). This scoring system uses a technique known as bio-monitoring – the monitoring of life. Users observe the evidence (the existence/absence of macro-invertebrates in particular) to determine the condition or 'health' of the river they are working in. By learning to use simple identification keys, people of all ages (even children as young as 10) can easily identify thirteen taxa that live in local streams and rivers and to use this information to calculate a River Health Index that will tell them how polluted the river is.

Hilton-based company, GroundTruth, in partnership with WESSA, the Water Research Commission; and the Departments of Science and Technology, and Water and Sanitation have developed a miniSASS website (http://www.minisass.org/en/). This website provides information on how to do miniSASS, you can download all necessary information and you can upload your results to contribute to the growing picture of river health for South Africa. Why not go to this website for useful information that will help you with your field-work?

The latest addition to the set of miniSASS tools is the miniSASS phone App (for Android). With the App you can upload information, see other sites on the river you are working on and find new places to sample. The App can be downloaded from the Google Play store.

GET IT ON Google play

Edition - October 2015

SECTION A

FIELDWORK TEMPLATES®

FOCUS:

RIVERS & THEIR CATCHMENTS

For

Intermediate Primary Phase

Senior Primary Phase

Further Education and Training (Grade 10)

A template is a document with a format that can be used as the basis for planning. The templates in this section will provide guidelines for you, the teacher, to use when planning a fieldwork experience. Why not discuss each template with your colleagues so that you can make changes or improvements to suit your own school's situation?

Natural Science: CAPS Intermediate Phase

Template for Fieldwork: Focus on rivers and their catchments

Rivers of life

With increasing awareness of the issues facing water security in South Africa the templates below contains ideas for you and your colleagues to consider when planning fieldwork based on rivers and their catchments. It is a guide that will help you, the Intermediate Phase teacher to plan out-of-the-classroom fieldwork experiences that will not only bring the work to life for the learners but will also meet the requirements of the CAPS Curriculum.

The template and the Model Lesson Plans in Section B have been based on the CAPS curriculum. (For details of the extracts please refer to Appendix 2: Curriculum Contexts- Primary Phases)

The notes in this Lesson Plan will serve as a guide to you in the design and implementation of your own fieldwork. They may be used "as they are" or they may be adapted to suit your local environment. If you make any changes you will have to adapt the Fieldwork Record Sheet at the end of the notes to accommodate the changes.

- Below is an example of planning that could be used when designing your own Lesson Plans. Why not sit with a colleague and go through each part carefully – adding your own thoughts on each? Since every school locality is different to the next why not consider ways in which the template may be adjusted to suit what's best for your school?

Natural Science: CAPS Intermediate Phase

Template for Fieldwork: Focus on rivers and their catchments

STARTING WITH THE END IN SIGHT		
Duration: This is where you enter the time frame (e.g. 2 hrs.) Curriculum allocations of instructional times available: Intermediate Phase – 3, 5 hr/week. Senior Phase: 3 hrs/ week.	**Term/Week**: In which term and in which week will the fieldwork be done? (e.g. 'Term 2 week 6). **Grade**: This is where you enter the Grade level (e.g. Grade 6).	
Specific Aims	**Concepts & Content**	**Integration:**
Enter the Specific Aims from the chosen Learning Area <u>For Example: (Intermediate phase):</u> **Specific Aim 1**: *Doing science.* Learners should be able to complete investigations, analyse problems and use practical processes and skills in evaluating solutions.	This means that learners plan and do simple investigations and solve problems that require some practical ability. There are attitudes and values that underpin this ability. Respect and compassion for living things is an example of this – learners should not strip leaves off bushes just to compare them; if they examine small animals they should care for them and release them unharmed in the place where they originally found them.	How does this Natural Science work integrate with other curricula? For example: ***<u>Integration with Technology</u>*** An appreciation of the history of scientific discoveries and technological solutions, as well as their relationship to indigenous knowledge and different world views. This enriches our understanding of the connections between Science, Technology and Society.

<table>
<tr>
<td>Specific Aim 2: Understanding and connecting ideas.

Learners should have a grasp of scientific, technological and environmental knowledge and be able to apply it in all contexts.</td>
<td>The main task of teaching is to build a framework of knowledge for learners and to help them make connections between the ideas and concepts in their minds. This is different to learners simply retaining facts. When learners do an activity, questions and discussion must follow and relate to the previously acquired knowledge and experience; connections must be made.</td>
<td rowspan="2"><u>Integration with Social Science</u>

SA 1: Are curious about the world they live in.

SA 3: Understand the interaction between society and the natural environment.

<u>Integration with Languages (Skills)</u>

Skill 1: Listening and speaking

Skill 2: Reading and viewing

Skill 3: Writing and presenting

<u>Integration with Mathematics</u>

Mathematics in this Phase focuses on the measurement and the recording of data.

<u>Indigenous knowledge</u>

Finding examples of Indigenous knowledge that is appropriate to the content being investigated.</td>
</tr>
<tr>
<td>Specific Aim 3: Science, Technology and Society.

Learners should understand the practical uses of Natural Sciences and Technology in society and the environment. They should obtain values that make them caring and creative citizens.

(This is an aspect of Citizen Science whereby learners start to think and act as citizens in their community).</td>
<td>Science and Technology learnt at school should produce learners who understand that school science can be relevant to aspects of their lives outside of school. Issues such as improving water quality, growing food without damaging the land, and building energy-efficient houses are examples of everyday applications. Similarly, Science and Technology can lead learners to a range of future career and job possibilities.</td>
</tr>
</table>

<table>
<tr><th colspan="2">WHAT WILL WE NEED TO HELP US FIND ANSWERS?</th></tr>
<tr>
<td>Prior knowledge:

Work covered in the previous Grade(s) on this topic. Time spent with learners assessing their levels of understanding of related work covered in previous grades.</td>
<td>Looking forward to:

For this Grade: Exciting the learners with regard to the investigation. Taking what the learners know to a new level. Discovering more about the topic.</td>
</tr>
<tr><td colspan="2"><u>The investigation:</u> (This is the HOW, WHY, WHAT and WHERE of the fieldwork investigation).</td></tr>
</table>

HOW: How will the investigation be done? Group-work (Size of groups?) Individual work? (Combination of both?)

WHY: There may be a number of reasons why you are doing the investigation.

For example: Giving learners without access to a wetland (and even those who do have access to a wetland) an idea on how a wetland actually works. Raising awareness in terms of the need to conserve wetlands is the primary aim of World Wetlands Day.

WHAT: What the learners will have to do to gain the experience and knowledge that the Assessment will measure. Here the design of the fieldwork is important. Where will the fieldwork take place? How will the instructions be given? What resources will be used? (e.g. identification keys) What resources have to be prepared? (e.g. outline maps) How will the work be assessed?, etc.

WHERE: Large class sizes may present challenges to teachers with regard to fieldwork management. The model lesson plans have examples of fieldwork that are closely integrated with work done in the classroom. This integration should enable the learners to see the linkages between all the elements of the study.

In discussion with others why not write down other ideas on a separate sheet of paper?

Support resources for river health fieldwork

The *miniSASS project*, a joint initiative of the Hilton based GroundTruth organization, WESSA (the Wildlife and Environment Society of South Africa) and the Water Research Commission, has produced a number of easy-to-use bio-monitoring resources for assessing the health of rivers.

Examples of these appear in Appendix One - Identification Keys.

For teachers with access to the Internet the miniSASS Project has developed the miniSASS website and data base (google “miniSASS” or visit www.miniSASS.org). The website allows miniSASS users of all ages to explore their catchments and find and sample their own rivers; then upload their miniSASS results to the website. In this way schools can participate in a regional program of record-keeping with the results constantly being uploaded on an interactive google map of river health right across Southern Africa.

As ‘citizen scientists’ learners and teachers can compare and contrast their own observations with other results across catchments while connecting with others who are sampling rivers in their own communities.

Why not connect with miniSASS and start participating in looking after the health of your own river?

ASSESSMENT: MEASURING SUCCESS

Learner organization:	**Rubrics**	**Examples of the activities for which the learners will be assessed.**

<table>
<tr>
<td>Learners will work in small groups.

For example: In groups of four to six.

Each group will use the information supplied by the teacher to draw up a plan (consulting with the teacher where necessary) and to allocate tasks to individuals (or pairs)

NB: The effectiveness of the group work will depend on the preparation that goes into the fieldwork.</td>
<td>Learner activities may be assessed using rubrics according to criteria that you establish.

Four levels of achievement for each of the outcomes are usually used in the assessment.

<u>For example:</u>

Level 4: Learner's performance has exceeded the requirements for the Learning Outcome.

Level 3: Learner's performance has satisfied the Learning Outcome for the grade.

Level 2: Learner's performance has partially satisfied the Learning Outcome for the grade.

Level 1: Learner's performance has not satisfied the Learning Outcome for the grade.

(Each of the Model Lesson Plans has an example of an assessment rubric.)</td>
<td>1. Unpacks the instructions and study any resources that are provided.

2. Gathers together the equipment listed.

3. Completes the tasks that have been set.

5. Writes up the results of the tasks.

6. Draws conclusions from the results.

7. Communicates the findings to the rest of the class.

(You may wish to alter this list to suit your requirements.)</td>
</tr>
<tr>
<td>Type of assessment: formative and summative

Form of assessment: Investigation (performance task); using a rubric (Discussed above).</td>
<td colspan="2">Resources: Decide on and prepare any resource sheets that will be required. (e.g. outline maps, tables or diagrams to be completed) as well as clear instructions as to how the learners will work.</td>
</tr>
<tr>
<td colspan="3">Examples of assessment rubrics for Intermediate & Senior phase fieldwork may be found in Section B</td>
</tr>
</table>

Geography: CAPS Further Education & Training Phase
Template for Grade 10 Fieldwork
Focus on rivers and their catchments

Rivers of life

This template contains Ideas for you and your colleagues to consider when planning your fieldwork.
It is a Guide that will help you, the Grade 10 Geography teacher to conduct out-of-the-classroom fieldwork experiences that will not only bring the work to life for the learners but will also meet the requirements of the CAPS Curriculum.
In Grade 10 fieldwork is compulsory and this template and the examples that follow will give you some ideas regarding the planning and execution of this fieldwork.
Remember that the template provides the outline for a lesson plan. The Model Fieldwork Lesson Plans (Section D) provide examples of how you might use the template for designing, implementing and evaluating your own fieldwork.

- *Why not get-together as a team of fieldwork teachers to plan what's best for your school?*

LESSON PLAN TEMPLATE FIELDWORK IN THE CAPS CURRICULUM – FURTHER EDUCATION AND TRAINING A cross-curricula approach with a focus on **Grade 10 Geography**[4]	
<u>LESSON PLAN TOPIC:</u> This is where you enter the topic for the Lesson Plan. The topic is chosen from the Curriculum document. For example "***Water resources***" (Term 4: ***Sustainable use of water in South Africa****.)*	
Learning Area: Geography	Grade: 10
Duration: This is where you enter the time frame (e.g. 2 hrs) The Geography Curriculum allocation of instructional times available for Grade 10 Geography is 4 hrs per week.	Term / Week: In which term and in which week will the fieldwork be done? The Geography Curriculum stipulates that there should be 4 hrs of fieldwork and practical work in Term One.
THE GEOGRAPHICAL APPROACH: STARTING WITH THE END IN SIGHT	

Outcomes and Assessment Standards for other subject, e.g. *English* and *Arts and Culture,* are included with the Model Fieldwork Lessons

Geography as the study of place

Geography is a field of study that looks at all the elements that give a place its unique character. Every place has a unique combination of ecological, social and political elements that give it its character.

Geography as an Environmental Science – Patterns and interactions

In order to understand the Geography of different places we study the **environmental** elements that give different places their character, their patterns of distribution and the interactions between them. For example the climate, relief and human activities affect the character of places.

Geography's role in environmental management (For details see Appendix Two of this document)

Geography has an invaluable role in enabling citizens make sensible decisions affecting the health of their environments. Work with the learners to reflect on these aims. What is the value of each for community-based learning? (Focus on making Geography more relevant to the individual circumstance of each learner.)

This is an aspect of Citizen Science whereby learners start to think and act as citizens in their community.

Noting the skills to be developed: (For details see Appendix Two of this document)

An essential part of any Geography lesson is the skills that may be required to complete any tasks. These include mastery of Mapwork (Topographical maps, Aerial photographs & orthophoto maps), Geographical information systems, Fieldwork, Reporting and Sharing. None of these skills can be taken for granted and time should be taken to ensure that the learners have the skills to participate in the fieldwork.

Indigenous knowledge: Finding examples of Indigenous knowledge that is appropriate to the content being investigated.

Why not discuss the approach to Geography teaching and learning with a colleague? Is there anything that you could add to this discussion?

THE CHALLENGE OF LARGE NUMBERS OF LEARNERS

Many schools with large numbers face challenges when it comes to conducting fieldwork. In addition to equipment costs, the cost of transporting learners to suitable fieldwork venues is often a major stumbling block.

The Model Lesson Plans in Section C have some suggestions in this regard. Examples of inexpensive low-tech equipment and learner-supported learning are provided.

Why not use these to develop your own with special relevance to your own school environment?

THE AIMS OF GEOGRAPHY

During Grades 10, 11 and 12 learners are guided towards developing the knowledge, skills and attitudes listed below. FET Geography seeks to:

1. explain and interpret both physical and human geographical processes
2. describe and explain the dynamic interrelationship between the physical and human worlds
3. develop knowledge about where places are, and the nature of a range of different places at different scales
4. practice essential transferable skills – literacy, numeracy, oracy and graphicacy
5. promote the use of new technologies, such as Information Communication Technology (ICT) and geographical Information Systems (GIS)
6. develop a commitment towards sustainable development
7. create awareness and sensitivity to inequality in the world
8. foster empathy, tolerance and fairness
9. make and justify informed decisions and judgments about social and environmental issues.

Your lesson plans should reflect an understanding of these. When you are preparing your fieldwork notes why not create a boxed 'tick-list' so that you can keep an eye on this?

When designing a fieldwork experience you should provide opportunities for each and every learner in your class to achieve a level of competency for each aim.

Section C has examples of fieldwork. Why not study these with a colleague and make suggestions as to how they may suit your local environment?

The *miniSASS project*, a joint initiative of the Hilton based GroundTruth organization, WESSA (the Wildlife and Environment Society of South Africa) and the Water Research Commission, has produced a number of easy-to-use bio-monitoring resources for assessing the health of rivers.

Examples of these appear in Appendix One - Identification Keys.

For teachers with access to the Internet the miniSASS Project has developed the miniSASS website and data base (google "miniSASS" or visit www.miniSASS.org). The website allows miniSASS users of all ages to explore their catchments and find and sample their own rivers; then upload their miniSASS results to the website. In this way schools can participate in a regional program of record-keeping with the results constantly being uploaded on an interactive google map of river health right across Southern Africa.

As 'citizen scientists' learners and teachers can compare and contrast their own observations with other results across catchments while connecting with others who are sampling rivers in their own communities.

Why not connect with miniSASS and start participating in looking after the health of your own river?

DESIGNING THE FIELDWORK EXPERIENCE

Prior knowledge	**Looking forward to:**
Work covered in the previous Grade(s) on this topic. Spend time with the learners assessing their levels of understanding of related work covered in previous grades.	For this Grade: Exciting the learners with regard to the investigation. Taking what the learners know to a new level. Discovering more about the topic

The investigation: (This is the HOW, WHY, WHAT and WHERE of the fieldwork investigation.)

HOW: How will the investigation be managed? Group-work (Size of groups?) Individual work? (Combination of both?)

WHY: There may be a number of reasons why you are doing the investigation. For example: 1) Giving learners without access to a wetland (and even those who do have access to a wetland) an idea on how a wetland actually works. Raising awareness of the need to conserve wetlands is the primary aim of World Wetlands Day.

WHAT: What the learners will do to gain the experience and knowledge that the Assessment will measure. Here the design of the fieldwork is important. Where will the fieldwork take place? How will the instructions be given? What resources will be used? (e.g. identification keys) What resources have to be prepared? (e.g. outline maps) How will the work be assessed?, etc.

WHERE: Large class sizes may present challenges to teachers with regard to fieldwork management. The model lesson plans have examples of fieldwork that is closely integrated with work done in the classroom. This integration should enable the learners to see the linkages between all the elements of the study.

In discussion with others why not write down other ideas on a separate sheet of paper? Asking the right questions (See *Section 2.2.4 of the CAPS FET Geography curriculum).*

CLASS PREPARATION

The amount of time that you spend preparing the learners for the fieldwork will help to determine the value of the fieldwork for them. The quotes below emphasize this:

- "Success is where preparation and opportunity meet "
- "By failing to prepare you are preparing to fail."

Why not prepare a bullet list of important points that you can go over with the learners? For examples of these please refer to Lesson Plans in Sections B and C.

ASSESSMENT – MEASURING SUCCESS

Assessment Standards *(Starting with the end in sight):*

Section 4.3.2 of the CAPS curriculum has the full details of assessment standards for Grade 10 fieldwork. Section (A) on Page 51 lists the assessment tasks that are applicable to Fieldwork in Geography. The learner should be competent in the following:

- conducting fieldwork, recording and interpreting findings
- working with concepts, data, procedures related to GIS
- conducting and writing up research
- writing paragraphs and essays
- evaluating arguments and expressing and supporting a point of view.

Points to consider when designing assessment tasks:

- The purpose of the assessment tasks is to assess the learner's ability to apply in an integrated way, knowledge, skills and a range of competencies.
- It is helpful to design assessment tasks around specific issues in familiar or unfamiliar contexts to enhance the interest and enthusiasm of learners.

The rubric for assessing each part of the fieldwork project should be discussed and negotiated with the learners before they start the task. This will enable learners to have a clear vision of what is expected of them.

ASSESSMENT	
Type of assessment: formative and summative **Form of assessment:** Investigation (performance task); using a rubric. (Discussed above. For examples please see Model Lesson Plans))	**Resources:** Decide on and prepare any resource sheets that will be required. (e.g. Outline maps, tables or diagrams to be completed) as well as clear instructions as to how the learners will work.
Examples of assessment rubrics for Grade 10 fieldwork may be found in Section D	

This edition – October 2015

Section B - Lesson Plans

- Science and Technology
- Intermediate Phase

Rivers and their catchments: Examples of fieldwork lesson plans for Intermediate Phase

WATER RESEARCH COMMISSION

GroundTruth Water, Wetlands and Environmental Engineering

WESSA PEOPLE CARING FOR THE EARTH

This is a product of The Water Research Commission: Project No. K5/2350

WRC: Project No. K5/2350

This edition – October 2015

SECTION B

RIVERS & THEIR CATCHMENTS

Some examples of Fieldwork Lesson Plans

For CAPS

INTERMEDIATE PHASE

Dear Educator: The model Lesson Plans in this section have been developed in compliance with the CAPS curriculum documents. They are simply examples of what is possible. Why not work with a colleague to see how they suit your local situation and make any changes that might be necessary?

WRC: Project No. K5/2350

This edition – October 2015

CONTENTS

Page Number

CONTENTS

Page Number

Natural Sciences & Technology: CAPS Intermediate Phase

Model Fieldwork Lesson Plan: *A walk in a wetland*

(Learning through the senses)

Natural Science	**Grade 4 :** Living and non-Living things
Duration: 1 ½ hours	**Term 1:** Week 1 Living things and non-living things

STARTING WITH THE END IN SIGHT

From the CAPS Curriculum: *Science and Technology are activities that promote and sustain enjoyment and curiosity about the world and natural phenomena.*

This Lesson Plan combines a walk in a wetland with classroom picture-building that will encourage Grade 4 and 5 learners to use their senses of sight, scent, touch and hearing to find out more about a local wetland.

If your school is not within walking distance of a wetland why not create a chalkboard/large poster picture of one and use story-telling to unpack the elements that give it its character? (See examples below.)

CAPS Specific Aims	**Concepts & Content**	**Integration**
Specific Aim 1: *Doing science* Using a combination of fieldwork (for example a walk in a wetland area) and classroom activities (picture-building based on the fieldwork experience) the learners will be working with 4 important approaches to scientific investigations: 1. Looking 2. Observing (noting what you are seeing) 3. Recording (in words or pictures) 4. Discussing (explaining what you have experienced) This means that learners plan and do simple investigations that need some practical ability. There are	The learners will be able to do simple investigations that require some practical ability. Learning what a wetland constitutes (Distinctive soil, plants and animals) and why they are important. The learners should be able to talk about the elements of the wetland.	**CAPS Connections** **Aims of Social Science** 1. Learners are curious about the world they live in 2. They understand the interaction between society and the natural environment 3. They think independently and support their ideas with sound knowledge 4. They care about their planet and the well-being of what lives on it **Languages Skills** Skill 1: Listening and speaking Skill 2: Reading and viewing Skill 3: Writing and presenting

<table>
<tr>
<td>attitudes and values that underpin this ability. Respect and compassion for living things is an example of this.</td>
<td></td>
<td rowspan="2"><u>Visual Arts</u>

Learners in the Intermediate phase observe photographs and pictures that are related to the natural world.

They explore colours, shapes and textures that can be observed in nature.

<u>Mathematics</u>

Mathematics in this phase focuses on measurement and the recording of data.</td>
</tr>
<tr>
<td>Specific Aim 2: Understanding and connecting ideas

The classroom activity will bring together the experiences of the walk in the wetland area in the form of a chalk-board picture.

Using coloured chalks the teacher will show the main elements of the wetland environment. The teacher will then use an activity to encourage responses from the learners.

This is an aspect of Citizen Science whereby learners start to think and act as citizens in their community.

The main task of teaching is to build a framework of knowledge for learners and to help them make connections between the ideas and concepts in their minds.

This is different to learners just retaining facts. Discussion must relate to previously acquired knowledge and experience and connections must be made.</td>
<td>They should be able to draw a picture of the wetland and:

- Write sentences about each part of the wetland
- Write a sentence to say why wetlands are important for both people and the environment.
- Write a sentence to say how we can look after our local wetlands.</td>
</tr>
<tr>
<td colspan="3">THE WETLAND CONTEXT</td>
</tr>
<tr>
<td colspan="3">A wetland is a place where the ground is wet throughout the year. It is characterized by soil with a high clay content. It also inhabits plants that are adapted to growing in mud or water and animals that use wetlands for food, shelter and a place to breed. Wetlands are the places where streams rise. The small streams from many wetlands join together to form the rivers of South Africa. A good reason for learners to start to know more about them and why they are important.</td>
</tr>
</table>

WHAT WILL WE NEED TO HELP US FIND ANSWERS? (Planning the work. Working the plan)		
Prior knowledge: Since this fieldwork involves the 5 senses start by discussing these senses and how they help us to connect with our surroundings. **Indigenous knowledge**: During the walk and classroom discussion encourage the learners to share their own stories about the wetland.	**Looking forward:** Managing a fieldwork experience that will enable the learners to use their senses to find out for themselves about a local wetland.	**Prior planning:** To plan the learning program it is essential that you visit the study area beforehand. **NB**: For each stopping point you will need to locate a site where the class can gather and participate.

Equipment required

This edition – October 2015

Before the fieldwork: In the classroom

In the classroom before the field work it is important that the teacher explains what is expected from the field work. Give the learners a brief overview of the field work and the reasons why wetlands are important, tell them that you will be helping them to explore the wetland.

In the field

The teacher will walk with the learners along the edge of the wetland, together with you they will find out more about wetlands:

- At the first convenient spot on the edge of the wetland. Stop and ask the learners to gather around you. Ask them to tell you what they **SEE?** As the learners respond guide them by asking questions with regard to the three most obvious elements:
  - Plants
  - Animals (e.g. birds, crabs, fish)
  - Soil (mud)

  Telling the story: Habitats make happy homes: Just as each learner has a home – the wetland is a home to all the plants and animals. Here the plants can grow in places that they like to grow and the animals have a place where they can find food and are safe from enemies and raise their families.
- Walk on a little further. Stop and ask the learners to close their eyes and listen carefully to what they **HEAR?**. As the learners respond guide them with questions (e.g. the sound of wind blowing, water running, birds calling, and frogs calling).

  Telling the story: Birds have ears behind and below their eyes that are covered by soft feathers. Some birds (e.g. owls) have feathers that look like human ears; they use sound to find their prey.

  Mammals have ears just like people, they need good hearing to detect enemies and find their prey.
- Walk on a little further. Stop and ask the learners to sniff the air. What can they **SMELL?** As the learners respond guide them with questions.

  Telling the story: Mammals use their noses to find food and to detect enemies.
- Lastly gather the learners around a spot where there is damp soil or mud. Ask the learners to squish the soil/mud between thumb and forefinger. How does it **FEEL?** What does it smell like? What colour is the soil / mud?

  Telling the story: The soil/mud provides a place where plants can grow and gives them plant-food. Just like we need to eat every day - plants get the food that they need from the soil/mud in which they are growing. The dark colour of the mud shows that there is organic matter (similar to compost) in the soil/mud.

Rounding off the wetland walk

Before going back to the classroom remind the learners that the river walk was just the first part of finding out about wetlands and that the rest of the story will be explored back in the classroom.

After the Fieldwork: Back in the classroom:

When next you have a Natural Science lesson with the same class use a chalk-board sketch similar in style to the one below to re-live their experiences.

Resources: Decide on and prepare any resource sheets that are required for the lesson. (e.g. Wetland reference map, pictures of wetland plants and animals). Have clear instructions as to how the learners will work.

- Activity One: If you have access to photocopying machine, copy the sketch and give a copy to each learner. If not give each learner a clean sheet of paper (preferably without lines) and ask them to copy the sketch that you have on the board.
- Activity Two: Refer to the example of a chalkboard picture below. Talk about each of the bubbles in the example. As you go ask the class to share what they saw or experienced for each. Each learner should write a sentence on what they saw or experienced at each of the four stopping points.
- Activity Three: Explain to the learners why wetlands are important to both people and animals.
  - People: Wetlands are the places where all our rivers start. They help to give us all the water that we need
  - Animals: Wetlands provide habitats (homes) where animals can live safely.

⚠ *Ask the learners to write down two reasons why wetlands are important from what they have learned.*

Figure 1: An example of what your chalkboard picture might look like. Keep the drawing simple and use different chalk colours

Support resources for river health fieldwork

Appendix One has examples of information sheets on some of the animals that might occur in the wetland near you (The *Water Creatures Information Sheet, River Animals Information Sheet* and the *River animals identification Key*). You may find these useful if the learners see any wetland animals while on their walk.

If you have access to the Internet, the miniSASS Project has developed the miniSASS website and data base (Google miniSASS or visit www.miniSASS.org). The website allows miniSASS users of all ages to explore their catchments and find and sample their own rivers, then upload their miniSASS results to the website. In this way schools can participate in a regional program of record-keeping with the results constantly being uploaded on an interactive google map of river health right across Southern Africa.

As ‘citizen scientists’ learners and teachers can compare and contrast their own observations with other results across catchments while connecting with others who are sampling rivers in their own communities.

⚠ *Why not connect with miniSASS and start your school participating in looking after the health of your own river?*

ASSESSMENT: MEASURING SUCCESS

Rubrics

At this level of the Primary Phase assessment Learner activities may be assessed using rubrics according to criteria that you establish for each activity.

An example of an Assessment rubric for this fieldwork is attached. You will see that there are **FIVE** sets of activities, each with its own marking rubric.

Specific Aim 1: *Doing science*

Activity One: The learner must draw a picture depicting a wetland.

Activity Two: Each learner must write a sentence on the ANIMALS they saw or heard in or close to the wetland (Birds, crabs, mammals, etc.).

Activity Three: Each learner must write a sentence describing ONE PLANT that they saw growing in the water.

Activity Four: Each learner must write a sentence on the mud that they saw in the wetland (Colour, characteristics, etc.).

Specific Aim 2: *Understanding and connecting ideas*

Activity Five: Each learner must write a sentence on the importance of wetlands for people and for plants and animals.

- For people: Wetlands are the places where all our rivers start. They help to give us all the water that we need.
- For animals: Wetlands provide habitats (homes) where animals can live safely.

Details of the suggested marking rubrics for this fieldwork appear below, check for yourself how suited they are to your own situation.

Example of a Rubric for assessing the learner's performance

Natural Science (Grade 4)

A walk in a wetland **(*Learning through the senses*)**

Learner's Name ………………………………………………Class:………………………………….

RUBRICS (Place the mark in the appropriate box)				
Learning Outcome used in the lesson	**4 Marks:** **Learner's performance** **has exceeded the assessment expectations for the grade.**	**3 Marks:** **Learner's performance** **has satisfied the assessment expectations for the grade.**	**2 Marks:** **Learner's performance** **has partially** **satisfied the assessment expectations for the grade.**	**1 Mark:** **Learner's performance** **has not satisfied** **the assessment expectations for the grade.**
Activity One: Copying the sketch of the wetland. Each learner must reproduce a picture of the wetland environment				
Activity Two: Each learner must write a sentence on the ANIMALS they saw or heard in or close to the wetland (Birds, crabs, mammals, etc.).				
Activity Three: Each learner must write a sentence describing ONE PLANT that they saw growing in the water.				
Activity Four: Each learner must write a sentence on the mud in a wetland (Colour, characteristics, etc.).				

Activity Five: Each learner must write a sentence on the importance of wetlands for people, plants and animals. ❖ For people: Wetlands are the places where all our rivers start. They help to give us all the water that we need. ❖ For animals: Wetlands provide habitats (homes) where animals can live.				
TOTAL OF MARKS (OUT OF 20)				

Natural Science: CAPS Intermediate Phase

Model Fieldwork Lesson Plan: *Ecosystems and Food Webs*

(Investigating a Wetland Ecosystem)

<table>
<tr><td>Natural Science</td><td colspan="2">Grade 6</td></tr>
<tr><td>Duration: 2 hours</td><td colspan="2">Term 1: Weeks 9 and 10</td></tr>
<tr><td colspan="3">STARTING WITH THE END IN SIGHT</td></tr>
<tr><td>CAPS Specific Aims</td><td>Concepts & Content</td><td>Integration</td></tr>
<tr>
<td>Specific Aim 1: Doing science

Learners should be able to complete investigations, analyse problems and use practical processes and skills in evaluating solutions.

Using a combination of fieldwork and classroom activities, the learners will be working with 4 important approaches to scientific investigations
1. Looking
2. Observing (noting what you are seeing)
3. Recording (in words or pictures)
4. Discussing (explaining what you have experienced)

The ecosystem investigation will provide an opportunity for learners; to work together in small groups, to work in a sample space and to apply a scientific sampling approach to an ecological study.</td>
<td>Ecosystems and Food Webs (in a wetland ecosystem)

From the CAPS Curriculum
Grade 6 Term 1: Investigating a local ecosystem
Select a wetland ecosystem on/near the school grounds.
• Roughly measure an area of 5x5 m square (See Fieldwork notes below).
• Draw and write about three plants and three animals that are found there. Describe:
- Food, water, amount of sunlight and shelter available for each species.
- The feeding relationships (food webs) for each.</td>
<td>CAPS Connections
Natural Sciences
Link with the Term 2 section on “Mixtures & Water Resources”
<u>Aims of Social Science</u>
1. Learners are curious about the world they live in
2. They understand the interaction between society and the natural environment
3. They think independently and support their ideas with sound knowledge
4. They care about their planet and the well-being of all who live on it

<u>Languages (Skills)</u>
Skill 1: Listening and speaking
Skill 2: Reading and viewing</td>
</tr>
</table>

Specific Aim 2: *Understanding and connecting ideas* Learners should have a grasp of scientific, technological and environmental knowledge and be able to apply it in various contexts.	The ecosystem investigation will provide an opportunity for learners to work together in small groups to find out for themselves how animals and plants in the wetland ecosystem relate to each other.	Skill 3: Writing and presenting ***Visual Arts*** Learners in the Intermediate phase observe photographs and pictures related to the natural world. They explore colours, shapes and textures that can be observed in nature. ***Mathematics*** Mathematics in this Phase focuses on measurement and the recording of data
Specific Aim 3: *Science, Technology and Society* Learners should understand the practical uses of Natural Sciences and Technology in society and the environment. They should have values that make them caring and creative citizens. **This is an aspect of Citizen Science whereby learners start to think and act as citizens in their community**.	The learners will be able to describe ways in which society has changed wetland environments. The learners will identify any possible threats to the wetland ecosystem being studied and suggest possible ways to overcome them.	

- ***Did you know***

  For the teacher: The word 'ecology' comes from two Greek words 'oikos' which simply means home and 'logos' which means 'the study of'. Ecology is simply the study of a place that is 'home' to all that live there (Plants, animals, fungi, microbes, and all!).

Support resources for river health fieldwork

The *miniSASS project*, a joint initiative of the Hilton based GroundTruth organization, WESSA (the Wildlife and Environment Society of South Africa) and the Water Research Commission, has produced a number of easy-to-use bio-monitoring resources for assessing the health of rivers.

Examples of these appear in Appendix One - Identification Keys.

For teachers with access to the Internet the miniSASS Project has developed the miniSASS website and data base (google "miniSASS" or visit www.miniSASS.org). The website allows miniSASS users of all ages to explore their catchments and find and sample their own rivers; then upload their miniSASS results to the website. In this way schools can participate in a regional program of record-keeping with the results constantly being uploaded on an interactive google map of river health right across Southern Africa.

As 'citizen scientists' learners and teachers can compare and contrast their own observations with other results across catchments while connecting with others who are sampling rivers in their own communities.

Why not connect with miniSASS and start your school participating in looking after the health of your own river?

THE WETLAND CONTEXT

A wetland is a place where the ground is wet throughout the year. It is characterized by soil with a high clay content. As well as plants that are adapted to growing in mud or water and animals that use wetlands as habitats (for food, shelter and a place to breed). Wetlands are also the places where streams rise. The small streams from many wetlands join together to form the rivers of South Africa. A good reason for learners to learn more about them and why they are important.

WHAT WILL WE NEED TO HELP US FIND ANSWERS?

Prior knowledge	Looking forward to:	Prior planning:
In Grade 4 the learners will have learned about: *Living and non-living things, What plants need to grow* and the *Habitats of animals*. In Grade 5 the learners will have learned about: *Plants and animals on Earth, Inter-dependence, Food-Chains,* and *Rocks & Soil.* Using a board picture/diagram of a wetland, revise what the learners should already know.	Exciting the learners with regard to the investigation. Taking what the learners know to a new level. Discovering more about the topic but this time focusing on a local wetland ecosystem.	To plan the learning program it is essential that you visit the study area before hand and to locate and consider the best site for the fieldwork to take place. **NB:** You will need to locate a site that will accommodate the whole class, presuming that each quadrate will involve 4-6 learners.

Resources and Equipment per learner:

- Hand lens: Funds permitting provide a small (plastic) hand lens (1 per group). Plastic hand lenses generally cost between R10 and R15 and are available from most toy shops
- Note pad or small note book (Each learner)
- Recording sheets where observations can be recorded, a set for each learner (See example below).
- Four 'pegs' (short lengths of stick) that each group of the learners can use to mark off the four corners of the study quadrant. A 'quadrant' is a square marked off on the ground, it defines the area of the research).
- A length of string 5 m long, tie two knots 5 m apart at each end of the string. This will make measuring easy and accurate.
- A choice of one or more of the resources mentioned under "Support Resources" (above). One page/set pert group.

The Fieldwork: Investigating a local ecosystem in the classroom

- Revise what the learners have experienced in previous grades and prepare them for what's to come (See section above).
- Divide the class into groups of 4 or 6 (depending on class size). We suggest that you do NOT appoint a leader for each group, rather let them work out the management for themselves.
- For each group handout, there needs to be a hand lenses and the 5 meter length of string.

At the wetland on the edge of the water.

- Each group should mark of a quadrate, using the 5 m length of string to place the pegs as accurately as possible (teacher to demonstrate how this might be done).
- In their quadrate each group will identify **3 different species kinds of plants and 3 different species of animals** by describing each and giving each a name.
  For example:
  Plants:
  - Grass plant – Creepy Grass (the name they might choose), Description: Short and bright green
  - Reeds – Description: Tall reeds with feathery flowers
  - Algae: Green water weed

  The animals:

  - A weaver bird
  - A crab
  - A black ant
- Each group will write what they have observed in terms of the characteristics of each plant and animal according to the template provided (below).

EXAMPLE OF A BLANK RECORDING TABLE follows on the next page

EXAMPLE OF A BLANK RECORDING TABLE (HAND-OUT PER LEARNER)

My Name: ……………………………………………… Class: ………………………………

A WETLAND ECOSYSTEM				
Finding out about the plants and animals in a sampling square 5 m X 5 m				
Plants we have found	**What did the plant look like?**	**Where was the plant growing?**	**An interesting fact about the plant.**	
• (Plant One)				
• (Plant Two)				
• (Plant Three)				
Animals we have seen	**Where was the animal in my study area?**	**What did the animal look like?**	**What was the animal doing?**	**An interesting fact about the animal**
• (Animal One)				
• (Animal Two)				
• (Animal Three)				

THIS IS AN EXAMPLE OF WHAT A COMPLETED RECORD SHEET MIGHT LOOK LIKE:

A WETLAND ECOSYSTEM			
Finding out about the plants and animals in a sampling square 5 m X 5 m			
Plants we have found	**What did the plant look like?**	**Where was the plant growing?**	**An interesting fact about the plant.**
• (Grass)	A grass plant creeping along the ground. With thin leaves, each shaped like a spear.	This grass was growing on a sunny patch of open ground.	This grass covered most of our study area.
• (Algae)	It looks like seaweed growing in the wetland water	Where there are small pools of water.	A slippery plant that feels slimy
• (Reeds)	Reeds	Most reeds were growing in water. Some were at the water's edge	Weaver birds have made nests in the reeds

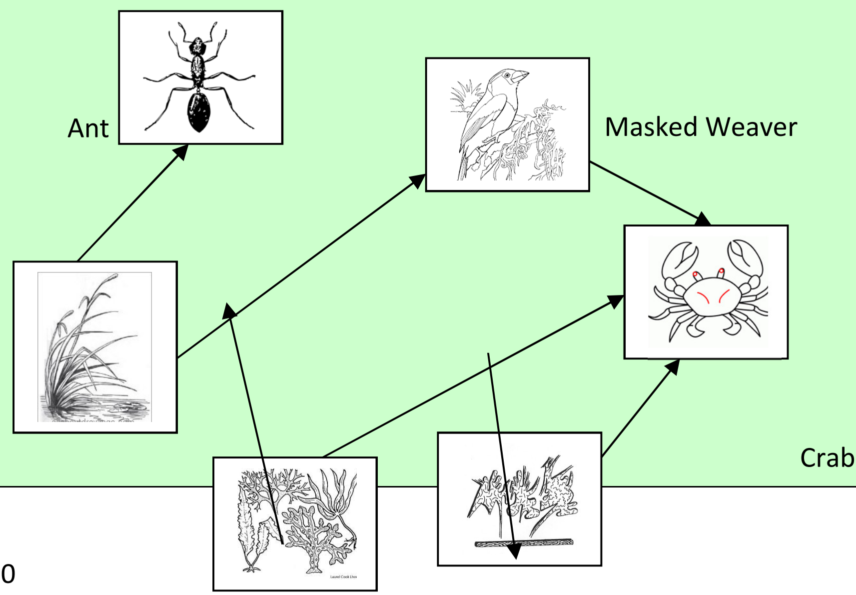
ANIMALS THAT WE SAW				
Animals we have seen	**Where was the animal in my study area?**	**What did the animal look like?**	**What was the animal doing?**	**An interesting fact about the animal**
• (Weaver bird)	The weaver bird was flying from reed to reed.	It was bright yellow with a black face	It was flying from nest to nest making a sizzling noise.	The female birds were also seen. They were brown in colour.
• (Crab)	The crab was close to the water's edge	It was brown in colour, it had two large claws and	It was putting small balls of mud in its mouth.	There were crabs of different sizes

		eyes that were on the end of little stalks.		
• (Black ant)	There were many ants running about in the study area.	Small black ants with shiny bodies.	Running around looking for food.	When two ants met they stopped to touch noses together.

PLANTS THAT WE SAW		
1 (Name)	2 (Name)	3 (Name)

ANIMALS THAT WE SAW		
1 (Name) (In the primary phase, encourage creative drawings. Keep them as simple as possible.). *We found a crab in our square. It had a brown body and white claws.*	2 (Name)	3 (Name)

THE FOOD WEB FROM MY STUDY AREA



The arrow shows the flow of food

For example: The crab eats organic material, Green Algae and dead birds

The ant eats leaves from Reeds and Green Algae

The Masked Weaver eats the seeds of reeds and grasses

Reeds

Green algae

Organic material

Figure 2: An example of a wetland food web

Rounding off the wetland lesson

Before going back to the classroom, remind the learners that the fieldwork investigation was just the first part of finding out about wetlands and that the rest of the story will be explored back in the classroom.

The Wetland investigation – Back in the classroom:

When next you have a Natural Science lesson with the same class use a chalk-board sketch of the study area to focus on examples of plants that occur in the area.

Feedback: Starting with the findings of one group, add to your chalk-board sketch the details of their investigation. Draw the parts of the food-web that the learners have identified. Ask members of that group to say what they have written for each part.

Go on to the next group and repeat the process – adding to the chalk-board diagram as you get more information from the class.

Once you have had a report-back from all of the groups, get the class to copy both the pictures and to complete the record sheets.

Citizen Science: Once the class has completed the tasks in the feedback session - discuss with them their responsibilities with regard to the wetland eco-environment. Allow each group to work together to list at least TWO threats to the wetland and what suggestions they may have to overcome these threats.

Each learner should then record their answers.

EXAMPLE OF A CHALK-BOARD SKETCH

SKETCH-MAP OF THE WETLAND STUDY

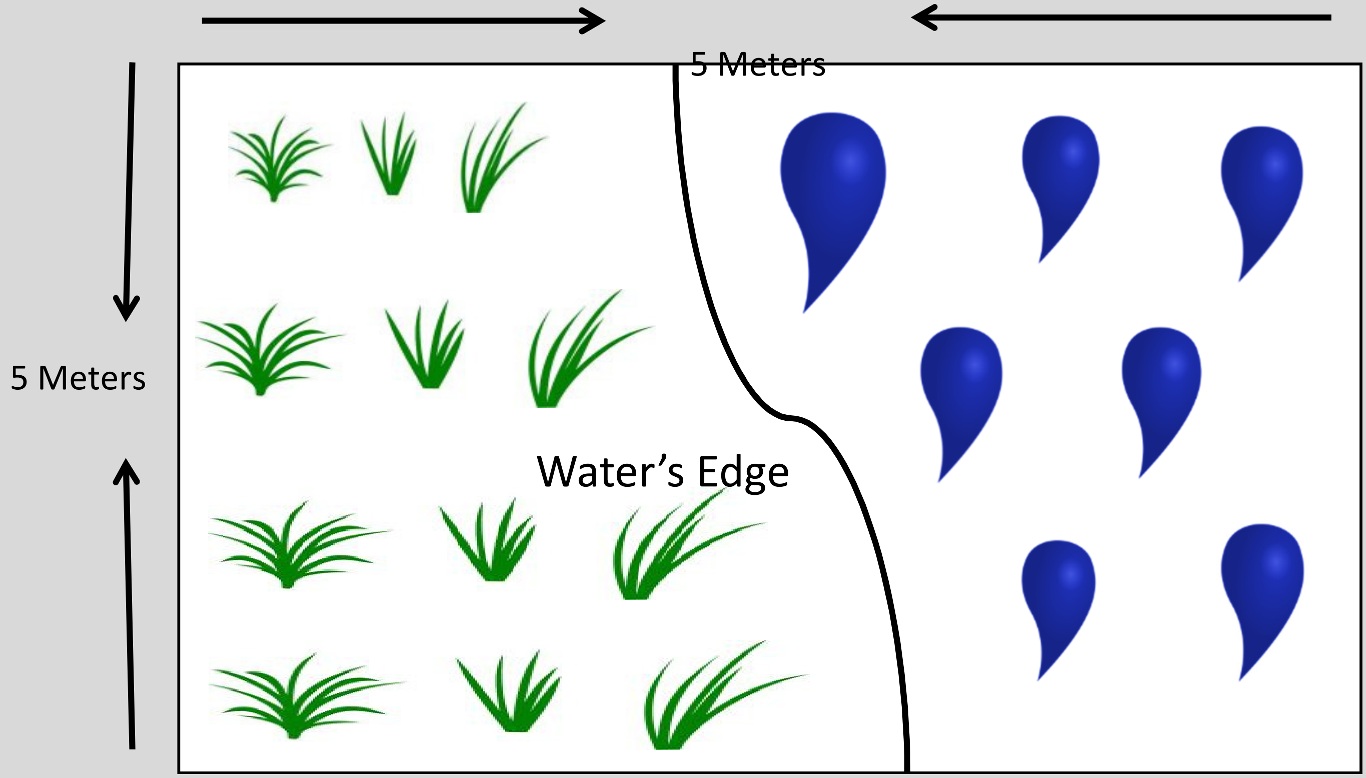


Figure 3: Basic wetland sketch map

ASSESSMENT: MEASURING SUCCESS

This edition – October 2015

Rubrics

At this level of the Primary Phase assessment, learner activities may be assessed using rubrics according to criteria that you establish for each activity.

An example of an assessment rubric for this fieldwork is attached. You will see that there are **FIVE** sets of activities, each with its own marking rubric.

Specific Aim 1: *Doing science*

- **Activity One:** Each learner will participate in the group by writing full sentences on the ecology of the three plant species – by completing the sections in the record sheet
- **Activity Two :** In their quadrant each learner will participate in the group by observing and identifying three different species of wetland animals
- **Activity Three:** Each learner will participate in the group by writing full sentences on the ecology of the three animal species – by completing the sections in the record sheet.
- **Activity Four:** Each learner will complete the drawings of plants and animals in the spaces provided.

Specific Aim 2: *Understanding and connecting ideas*

The activities under Specific Aim 1 will provide opportunities for learners to make the connections between different parts of the ecosystem.

Specific Aim 3: *Science, Technology and Society*

- **Activity Five:** Each learner will participate in the group to describe some ways in which society has changed the environment.
- The learners will identify TWO possible threats to this wetland ecosystem and will suggest possible ways to overcome them.

This is an aspect of Citizen Science whereby learners start to think and act as citizens in their community.

Example of a Rubric for assessing the learner's performance
Natural Science (Grade 6)
Ecosystems and Food Webs (Investigating a Wetland Ecosystem)

WRC: Project No. K5/2350

This edition – October 2015

Learner's Name ………………………………………………………. Class: ………………………..

RUBRICS (Place the mark in the appropriate box)				
Learning Outcome used in the lesson	**4 Marks:** **Learner's performance** **has exceeded the Assessment expectations for the grade.**	**3 Marks:** **Learner's performance** **has satisfied the Assessment expectations for the grade.**	**2 Marks:** **Learner's performance** **has partially** **satisfied the Assessment expectations for the grade.**	**1 Mark:** **Learner's performance** **has not satisfied** **the Assessment expectations for the grade.**
Activity One: Each learner will write full sentences on the ecology of the 3 plant species – by completing the sections in the record sheet				
Activity Two: In their quadrant each learner will observe and identify 3 different species of wetland animals				
Activity Three : Each learner will write full sentences on the ecology of the 3 animal species – by completing the sections in the record sheet				
Activity Four: Each learner will draw the animals and plants in the spaces provided.				
Activity Five: Each learner will identify TWO possible threats to this wetland ecosystem and will suggest possible ways to overcome them.				
TOTAL OF MARKS (OUT OF 20)				

Section C - Lesson Plans

- Natural Science
- Senior Primary Phase

Rivers and their catchments: Examples of fieldwork lesson plans for Senior Primary Phase

WATER RESEARCH COMMISSION

GroundTruth Water, Wetlands and Environmental Engineering

WESSA PEOPLE CARING FOR THE EARTH

This is a product of The Water Research Commission: Project No. K5/2350

fundisa for change

SECTION C

RIVERS & THEIR CATCHMENTS

Some examples of Fieldwork Lesson Plans for the CAPS

SENIOR PRIMARY PHASE

GRADE 7: NATURAL SCIENCE

CONTENTS

Dear Educator: The model Fieldwork Lesson Plans in this section have been developed in compliance with the CAPS curriculum documents. They are simply examples of what is possible. Why not work with a colleague to see how they suit your local situation and make any changes that might be necessary?

Natural Science: CAPS Senior Phase

Model Fieldwork Lesson Plan: *The Wetland Biosphere*

Aim: Exploring the ecology of a local wetland

Natural Science	**Grade 7 :** The (Wetland) Biosphere
Duration: 4 hours (Sessions of Fieldwork)	**Term 1:** Week 4 Requirements for sustaining life in a (Wetland) Biosphere

THE CURRICULUM CONTEXT

From the CAPS Curriculum for Natural Science**:**

Activities in the Science curriculum should promote and sustain enjoyment and curiosity about the world and its natural phenomena.

BIODIVERSITY

From the Grade 7 Natural Science curriculum:

- **The Concept of the Biosphere**:

  Learners should develop an understanding of the biosphere as the space where life exists.

  - The lithosphere (soil and rocks)
  - Hydrosphere (water)
  - Atmosphere (gases)
  - All living organisms including plants, animals and, microorganisms
  - Dead organic matter
- **Biodiversity**
  - Classification of living things
  - Diversity of animals
  - Diversity of plants

This fieldwork study uses wetlands as an opportunity for learners to personally experience the fullness of the biodiversity of a wetland ecosystem. By participating in this fieldwork, the learners will be given the opportunity to encounter biodiversity in their own environment and to use personal observations and experiences to develop concepts regarding the ecology of species.

- **To meet the requirements of the curriculum more than one session of fieldwork will be necessary. The teacher will have to adapt to their local situation to ensure the time needed to complete the activities.**

WHAT IS A WETLAND?
A wetland is a place where the ground is wet throughout the year. It is characterized by soil with a high clay content. It inhabits plants that are adapted to growing in mud or water and animals that use wetlands as habitats for food, shelter and a place to breed. Wetlands are the places where streams rise. The small streams from many wetlands join together to form the rivers of South Africa. A good reason for learners to start to know more about them and why they are important.
INDICATOR SPECIES
Environmental Scientists use the term ‘Indicator Species’ for animal and plant species whose presence, absence or relative well-being in a particular ecological environment is an ‘indicator’ (sign) of the overall health of the ecosystem

<table>
<tr><th colspan="3">STARTING WITH THE END IN SIGHT</th></tr>
<tr><th>Specific Aims</th><th>Concepts & Content</th><th>Integration</th></tr>
<tr>
<td>Specific Aim 1: Doing Science

Learners should be able to complete investigations, analyse problems and use practical processes and skills in evaluating solutions.

Using a combination of fieldwork and classroom activities the learners will be working with 4 important approaches to scientific investigations
1. Looking
2. Observing (noting what you are seeing)
3. Recording (in words or pictures)
4. Discussing (explaining what you have experienced)

The learners should be able to do simple investigations that require some practical ability.</td>
<td>The learners will demonstrate an understanding of what constitutes a wetland (distinctive soil, plants and animals) and the role that each of these plays in the wetland ecosystem.

• <u>Describing</u> conditions that sustain life in a wetland ecosystem
• <u>Investigating</u> the components of their wetland ecosystem.
• <u>Using different techniques</u>, e.g. miniSASS can be used to assess the water quality of rivers/streams leading into or out of the wetland.</td>
<td rowspan="3">Extracts from the curricula of other Senior Phase learning areas that provide links with Natural Science:

<u>Aims of Social Science</u>

1. Learners are curious about the world they live in
2. They understand the interaction between society and the natural environment
3. They think independently and support their ideas with sound knowledge
4. They care about their planet and the well-being of all who live on it

<u>Languages Skills</u>

Skill 1: Listening and speaking

Skill 2: Reading and viewing

Skill 3: Writing and presenting

<u>Visual Arts</u>

Senior Primary phase learners are encouraged to:

• Use creative art as a tool to develop research skills.
• Reflect through looking, talking, listening and writing about the visual world through the language of art elements and design principles</td>
</tr>
<tr>
<td>Specific Aim 2: Knowing the subject content and making connections

Learners should have a grasp of scientific, technological and environmental knowledge and be able to apply it in new contexts.</td>
<td>Through fieldwork the learners will experience and begin to understand the connections between the different parts of the wetland ecosystem.

Fieldwork creates opportunities for educators and learners to share stories that they may have about the animals and plants found in wetlands.</td>
</tr>
<tr>
<td>Specific Aim 3: Understanding the uses of Science

Learners should understand the uses of the Natural Sciences and indigenous knowledge in society as well as in the environment.</td>
<td>The learners will use their observations as the basis for identifying any possible threats to the wetland water and suggest ways</td>
</tr>
</table>

Natural Science as a subject at school should produce learners who understand that science in school can be relevant to everyday life. Indigenous knowledge and different world views enrich our understanding of the connections between Science and Society.	in which the local community can look after their wetland.	Mathematics Aims to develop the following in the learner: • Critical awareness of how mathematical relationships are used in social and environmental relations • Confidence and competence to deal with any mathematical situation.

PROCESS SKILLS FOR FIELDWORK		
<u>Process Skills (Section 2.7 of the Natural Sciences Curriculum)</u> The teaching and learning of Natural Science involves the development of a range of process skills that may be used in everyday life, in the community and in the workplace. Learners should also develop the ability to think objectively and use a variety of forms of reasoning while they use these skills. Learners can gain these skills in an environment that taps into their curiosity about the world that supports creativity, responsibility and growing confidence. The Curriculum lists 15 Process skills and each is important to consider when planning a fieldwork experience.		
WHAT WILL WE NEED TO HELP US FIND ANSWERS? **(Planning the work. Working the plan)**		
Prior knowledge: At the start of Term One the learners will have learned about the biosphere and biodiversity and will know about the classification of living things. Use a chalkboard summary diagram of part of a wetland ecosystem showing: - The sun - The air - The substrate (soil, mud) - Plants and animals (See chalk-board sketch below)	**Looking forward:** The learners can look forward to finding out for themselves about each part of a wetland ecosystem. The teacher will be referring back to this sketch once the fieldwork has been completed.	**Prior planning:** To plan the learning program it is essential that you visit the study area beforehand.

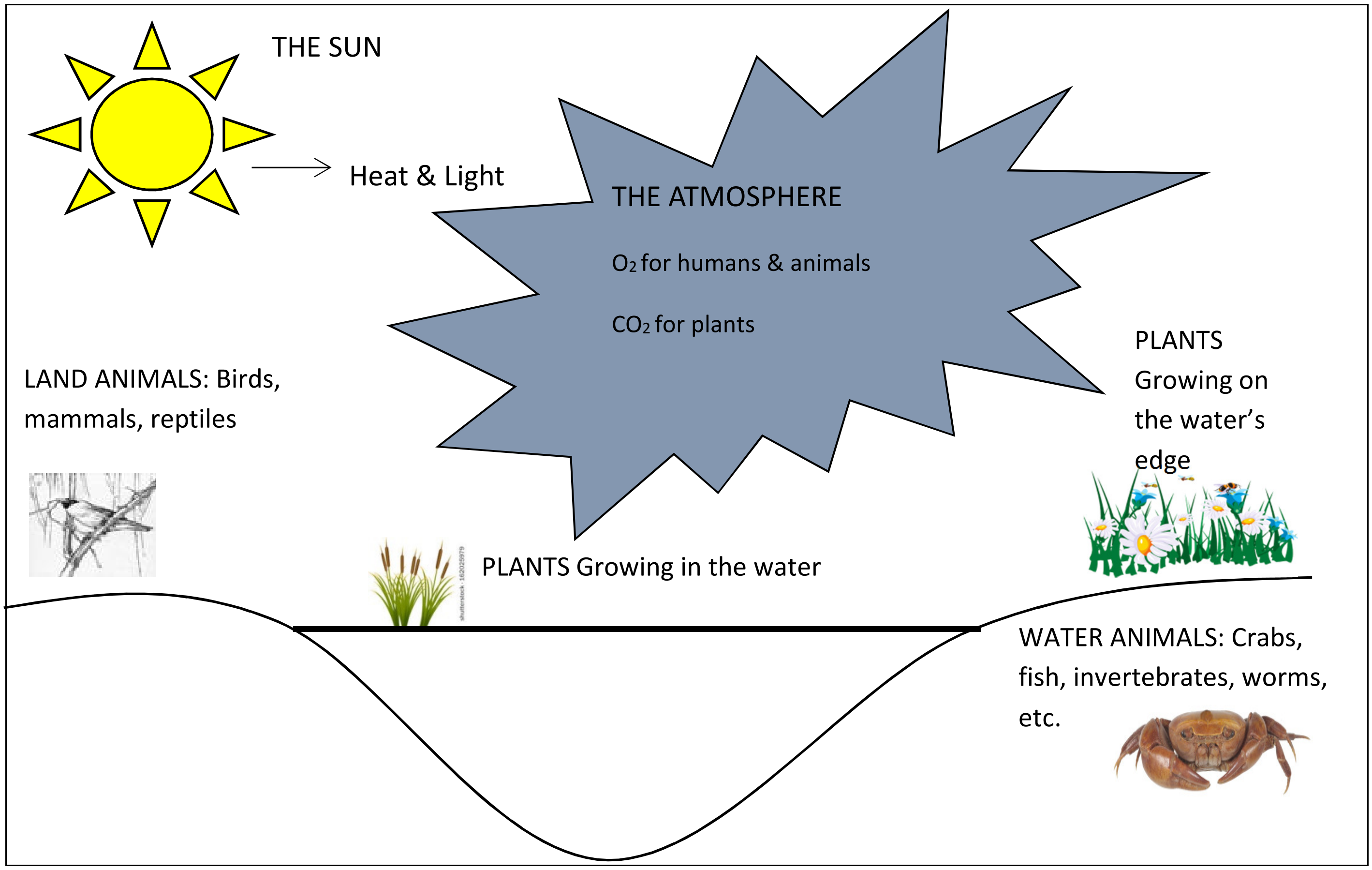


Figure 1: Diagram showing the components of a wetland

PREPARING FOR THE FIELDWORK

In the classroom divide the class into groups of four:

- Give each group one clear plastic/glass bottle (e.g. jam-jar) with a lid.
- Give each learner *Ecology Fieldwork Recording Sheet* (Example attached) and cardboard 'clipboard'.
- Give each group the appropriate identification key(s) - See previous section.
- Give each group a small plastic hand lens (funds permitting). Plastic hand lenses generally cost between R10 and R15 and are available from most toy shops.

AT THE WETLAND

Activity One: The air around the wetland

With the learners seated in a circle around you ask them to close their eyes and to think about their breathing. Ask the learners:

- What important gas is the air providing?
- What happens when you hold your breath?
- What animals are in the wetland – all breathing oxygen to stay alive?
- Confirm the process of animal respiration. (Oxygen is taken in and carbon dioxide is expelled.)

With open eyes:

- What about the plants? What gas do they need to stay alive?
- Confirm the process of plant respiration. The process of consuming carbon dioxide and expelling oxygen as a waste gas.

Activity Two: The soil and mud in the wetland

Get a bucket of clean water handy so that the learners can rinse their hands from time to time.

This simple experiment will help you compare the sand, silt and clay content of TWO soil samples – one from at the wetland and the other a distance from it.

What you will need:

- Two plastic or glass jars / bottles with screw tops with the labels removed, e.g. peanut butter jar (two jars per group).
- Plastic rulers (one ruler per group).

The Soil Shake Investigation (See diagram below)

- Divide the class into convenient chat-groups (e.g. 4)
- Give each group TWO jars – marked A and B (use a label or mark with a Koki)
- Each group is to sample two lots of soil:
    - One as close to the water's edge as possible (Sample A)
    - The second away from the wetland's edge. (Sample B)
- Each sample is placed it in the jar to a depth of about 1/3 of the jar.
- Each jar is then topped up with water and the lid firmly replaced.
- The water in each jar must be shaken well for a few seconds until the contents are well mixed.
- The jars are then placed on a log or stone where they can be easily viewed.
- While the class waits for the mixtures to settle they can go on to the next activity (Mud puddling)

<u>Activity Three – Puddling (Soil or mud)</u>

Farmers and other people interested in the soil sometimes use a simple puddling test to sample the wetland soil/mud.

In this activity:

- Each learner takes a small handful of soil/mud
- If the material is dry the learner closes her fist over the sample and plunges her hand into a bucket of water to wet the sample. She removes her fist and squeezes excess moisture out of the sample.

Puddling the sample

To get an idea of the sand, silt and clay content gently rub the sample between thumb and forefinger.

- If the sample is sticky this tells you that there is clay.
- If you can feel slippery parts this shows the presence of silt.
- The gritty parts of the sample show the presence of sand.

Following up on Activity Two

It is important that the learners do not disturb the soil-shake sample. They must study it at rest where they first placed it.

Each group must be close to their soil-shake sample so that they can interact with the teacher.

<u>Discussion</u>

With the whole class gathered the teacher should guide the learners with regard to their findings and discuss the importance of each part of the mud / soil sample:

- What can they see floating on the surface in terms of the sand, silt and clay parts?

What do our findings tell us?

- The organic material (pieces of leaves, sticks) floating on the top tells us that soil/mud has organic matter in it
- Soil/Mud Sand is important because it provides air spaces (oxygen) for soil animals
- Silt is important because it helps to support the plant
- Clay is important because it holds the nutrients that the plant needs (Nitrogen, Potassium, Phosphate and other plant foods)

Discussion of the wetland ecosystem

- Decaying organic material from plants and animals breaks down to provide some of the plant food
- The substrate in the wetland (mud/sand) is very different to the soil of the surrounding area
- The plants have adapted to the wetland conditions (mud or sand)
- The next part of the fieldwork will look at the plants and animals in a wetland

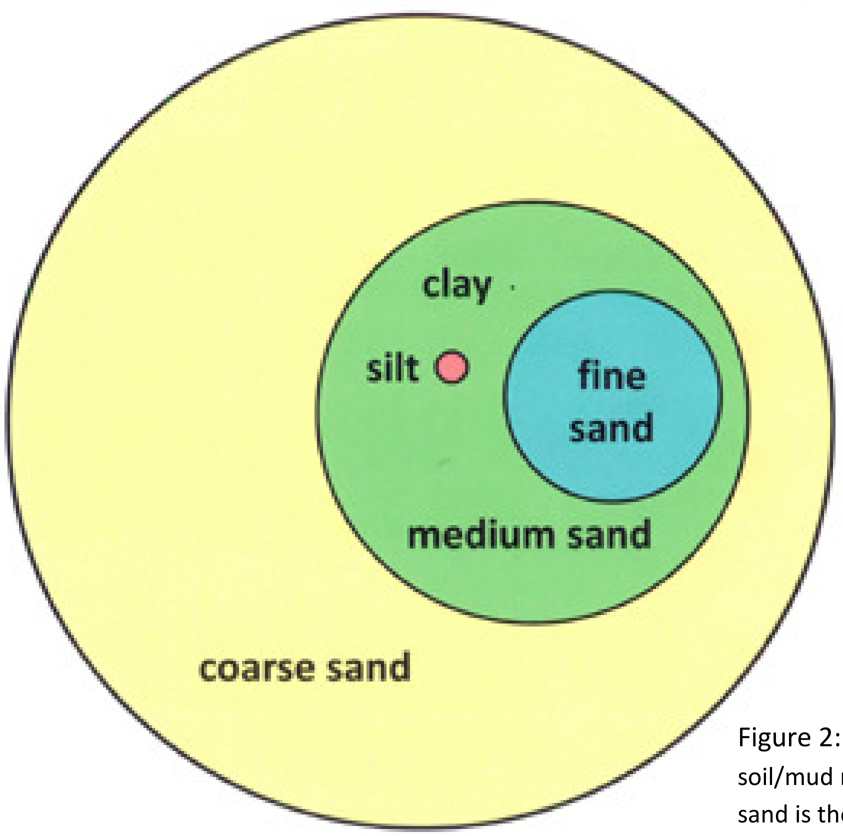
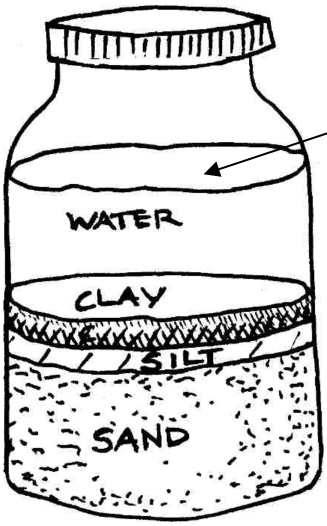


Figure 2: Diagram showing the comparative sizes of soil/mud material. One sugar-crystal sized grain of coarse sand is the largest and one grain of clay is by far the smallest (just a dot in the diagram).

THE SOIL / MUD SHAKE INVESTIGATION



Organic matter floating on the surface (e.g. Leaves, sticks, etc.)

Muddy water shows the presence of clay suspended in the water. The smallest particles may take weeks to settle.

The sample from the wetland will probably not have much silt or sand in it.

The sample from a distance from the wetland's edge will probably have more sand and less clay.

Figure 3: Diagram showing the soil/mud shake investigation.

<u>Activity Four: Ecological diversity in a wetland - The plants and animals</u>

There are at least two reasons for surveying the diversity of the wetland:

1. To consider wetlands as habitats for plants and animals
2. To consider the variety(diversity) of animals and plants in a wetland

Recording observations:

Working in their groups the learners record their observations in the '*My Wetland Biosphere'* recording sheet - See attached example at the end of this document.

Habitats make happy homes:

Discuss with the learners the concept of 'habitat' (get their memories of it before assisting).

- *A habitat is the natural home of an animal, plant or other organism. It is a place in the environment where a species can live.*

Adaptation:

The living things that find habitats in wetlands are all adapted to the environment. By observing and recording their observations the learners should be guided to an understanding of adaptation. Discuss with the learners the concept of adaptation saying that once they have identified a plant or animal they will be discussing how it is adapted to the place where it was observed.

The plants:

In preparing for the fieldwork the teacher should identify as many different plant species as possible beforehand. Scientific names are not necessary, but wherever possible commonly used names should be applied (English as well as vernacular). For example: In the water there will be reeds, water lilies, green algae, bulrush, and at the water's edge the will be Sedge, bulrush, arum lilies.

- The learners should choose at least three plants growing in the water and three plants growing at the water's edge
- If the English names are not known to the group then an appropriate English name should be chosen.
- If a vernacular name is know it should be recorded.
- For each plant the learners should consult together to provide a way in which the plant is adapted to its habitat.

The animals:

The teachers' site visit before the fieldtrip will provide evidence that can be used in guiding the learners.

Sightings or evidence (e.g. droppings, bird nests) of amphibians (frogs), crabs, leguaans, weaver birds and other animals.

In the "*My Wetland Biosphere*" recording sheet each learner must record the names of the animals and discuss as a group. They should also write a note about each species adaptation to the habitat it was recorded in.

Working in their groups the learners should look for sightings or evidence of not more then:

- Three bird species
- Two mammals species

The learners will use the identification key(s) chosen by the teacher to identify three animals living in the water. To do this each group should:

- Collect a full container of stream water from the wetland.
- Carefully lift up rocks and branches and inspect them for 'creep-crawly' animals.
- Any animal that is found should be gently removed with the end of a pencil or stick and placed in the container of water.

IDENTIFYING THE SPECIES & RECORDING THE RESULTS

When the groups have completed the sampling each group should find a dry spot to sit and identify the animals that they have found.

- The teacher then gives:
  - Each group of learners a copy of the river animal identification sheet – chosen from the three examples in Appendix One (*Water creatures identification sheet, River animals identification key* and *Water creatures information sheet).* If possible it is suggested that the teacher laminates these pages (this will protect them from wet fingers). The teacher should choose the most suitable key for the class and for the local wetland.
  - Each learner a cardboard 'clipboard' with its recording sheet: "*My wetland biosphere"* (A suggested copy of this page is included at the end of this Lesson Plan).
- Once they have found their animals the learners must use the information sheet(s) to identify them and then they should record the information on the *My Wetland Biosphere* recording sheet.
- When they have identified their sample of animals they should carefully return them to the place where they were found.

Action Steps

Back in the classroom

Note-making

- Discuss the findings with the learners by referring back to your original chalkboard diagram and asking the learners to help you place examples of THEIR findings on the diagram
- Discuss with the learners examples of adaptation to specific niches in the wetland. Use examples from both the learners' observations as well as your own research
- Discuss the role of wetlands in providing water for streams and rivers below the wetland
- Once done allow time for each learner to complete the '*My Wetland Biosphere'* record sheet

Taking action

- Ask the learners for their ideas regarding improving community awareness in terms of the importance of wetland conservation (sources of water, conservation of species, soil conservation, places for school fieldwork, etc.)
- Ask the learners to design a poster that will encourage their community to protect the local wetland. The poster should show the diversity of life in a wetland and indicate what ecological services the wetland provides (they can work individually or in their groups).

FIELDWORK RECORD KEEPING: *Exploring the ecology of a local wetland* (one per learner)

Example of a FIELDWORK RECORD KEEPING sheet follows:

FIELDWORK RECORD KEEPING: *Exploring the ecology of a local wetland* (one per learner)

	MY NOTES: WHAT I LEARNED TODAY	
The sun		
The air around the wetland		
The sand/mud		
	Species (Seen or found signs of)	Adaptation to the wetland habitat
Plants (In or above the water)		
Plants (At the water's edge)		
Birds in the wetland		
Mammals		
Frogs (or tadpoles)		
The insects (Any number)		
Other animals (e.g. reptiles)		

In addition to the English name of the plant or animal if you know the local name you should write in here. If finding species is difficult the teacher should assist in identifying possible species.

On the reverse side of this page design a poster picture that encourages people to respect wetlands (It should give reasons)

The Wetland Biosphere

(Exploring the ecology of a local wetland)

Example of a Rubric for assessing the learner's performance

Natural Science (Grade 7)

The Assessment will be based on observations of learner participation in the field as well as on an assessment of the "*My Wetland Biosphere*" individual recording sheets.

Learner's Name ………………………………………………………. Class: ……………………………….

RUBRICS (Place the mark in the appropriate box)				
Learning Outcome used in the lesson In the table the use of his/her gender descriptions are inter-changeable.	**4 Marks:** **Learner's performance** **has exceeded the Assessment expectations for the grade.**	**3 Marks:** **Learner's performance** **has satisfied the Assessment expectations for the grade.**	**2 Marks:** **Learner's performance** **has partially** **satisfied the Assessment expectations for the grade.**	**1 Mark:** **Learner's performance** **has not satisfied** **the Assessment expectations for the grade.**
1. The learner demonstrates through the poster picture an understanding of the importance of the wetland biosphere.				
2. The learner participates well in the experiments leading to a recognition of the four soil components of humus (organic matter), clay, silt and sand.				
3. The learner chooses names and describes at least three wetland plants.				
4. The learner is able to use simple identification keys to identify and record three wetland animal species				
5. In the table "My Wetland Biosphere" the learner shows an understanding of the concept of adaptation.				
TOTAL OF MARKS (OUT OF 20)				

Natural Science: CAPS Senior Phase

Model Fieldwork Lesson Plan: *The Wetland Biosphere*

(How healthy is my wetland stream)

Natural Science	**Grade 7 : The (Wetland) Biosphere**
Duration: 2 hours	**Term 1: Week 4 (Wetland) Biodiversity**

THE CURRICULUM CONTEXT

From the CAPS Curriculum for Natural Science:

Activities in the Science curriculum should promote and sustain enjoyment and curiosity about the world and its natural phenomena.

Following on the previous fieldwork whereby the learners explored the living and non-living parts of a wetland ecosystem – this fieldwork study now focuses on an investigation of the health of a wetland stream - the aquatic part of the ecosystem.

The study consolidates the learners' knowledge of ecosystem functions and reinforces the need for learners to 'think citizen science' when in a natural environment.

<u>BIODIVERSITY</u>

The Grade 7 Natural Science curriculum has two sections in the strand "Life and Living": *The Biosphere* and *Requirements for Sustaining life.* Within the section on the Biosphere the suggested activities include:

1. **Identifying:** living organisms found in each sphere
2. **Classifying:** living things
3. **Describing:** conditions that sustain life.

As part of the requirements for sustaining life learners will research how living things are suited (adapted) to the environment in which they live.

This fieldwork study has four purposes:

1. It provides learners with fieldwork experiences that brings them into direct contact with the biodiversity in a local wetland environment
2. It enables learners to use identification keys to identify aquatic animal species
3. As part of the requirements for sustaining life learners will research how living things are suited (adapted) to the environment in which they live
4. It enables learners to use personal observations and experiences to investigate a local environmental issue – that of water quality in the local wetland

WHAT IS A WETLAND?

A wetland is a place where the ground is wet throughout the year. It is characterized by soil with a high clay content as well as plants that are adapted to growing in mud or water and animals that use wetlands as habitats for food, shelter and a place to breed. Wetlands are often places where streams rise. The small streams from many wetlands join together to form the rivers of South Africa. A good reason for learners to start to know more about them and why they are important.

INDICATOR SPECIES

Environmental Scientists use the term 'Indicator Species' for animal and plant species whose presence, absence or relative well-being in a particular ecological environment is an 'indicator' (sign) of the overall health of the ecosystem.

For example: Aquatic invertebrates and fish have commonly been surveyed as indicators of water quality of streams and rivers (the health of aquatic ecosystems). If a site has populations of so-called "sludge worms" or tubificids for example, this usually suggests that water quality has been degraded by inputs of sewage or other oxygen-consuming organic matter. Sludge worms can tolerate virtually anoxic water (water with almost no oxygen), in contrast with most of the animals of unpolluted environments, such as mayflies and stoneflies which require well-oxygenated conditions.

MiniSASS is a tool developed by environmental scientists to monitor the health of a river/stream and measure the general quality of the water in that river/stream. It uses the composition of invertebrates (small animals) living in rivers and is based on the sensitivity of the various animals to water quality.

In this fieldwork learners can get the chance to look for indicator species in a river/stream and can use the miniSASS scoring system to decide how healthy that river/stream is.

<table>
<tr><th colspan="3">STARTING WITH THE END IN SIGHT</th></tr>
<tr><th>Specific Aims</th><th>Concepts & Content</th><th>Integration</th></tr>
<tr>
<td>Specific Aim 1: Doing Science

Learners should be able to complete investigations, analyse problems and use practical processes and skills in evaluating solutions.

Using a combination of fieldwork and classroom activities the learners will be working with 4 important approaches to scientific investigations
1. Looking
2. Observing (noting what you are seeing)
3. Recording (in words or pictures)
4. Discussing (explaining what you have experienced)

The learners should be able to do simple investigations that require some practical ability.</td>
<td>The learners will demonstrate an understanding of what constitutes a wetland (distinctive soil, plants and animals) and the role that each of these plays in the wetland ecosystem.

• Describing: conditions that sustain life in a wetland ecosystem
• Describing: the components of the wetland ecosystem.
• Sampling: the animal life in the water and using the miniSASS sampling technique to identify aquatic organisms found in rivers/streams around the wetland (to analyse the quality of water that may be flowing into the wetland) .

Using this data to assess the health of the rivers/streams in the surrounding areas and the impact that this may have on the wetland.</td>
<td rowspan="2">Extracts from the curricula of other Senior Phase learning areas that provide links with Natural Science:

<u>Aims of Social Science</u>

1. Learners are curious about the world they live in
2. They Understand the interaction between society and the natural environment
3. They think independently and support their ideas with sound knowledge
4. They care about their planet and the well-being of all who live on it

<u>Languages Skills</u>

Skill 1: Listening and speaking

Skill 2: Reading and viewing

Skill 3: Writing and presenting

<u>Visual Arts</u>

Senior Primary phase learners are encouraged to:

• Use creative art as a tool to develop research skills</td>
</tr>
<tr><td></td><td>Through fieldwork the learners will experience and</td></tr>
</table>

<table>
<tr><td>Specific Aim 2: Knowing the subject content and making connections

Learners should have a grasp of scientific, technological and environmental knowledge and be able to apply it in new contexts.</td><td>begin to understand the connections between the different parts of the wetland ecosystem.

Fieldwork creates opportunities for educators and learners to share stories that they may have about the animals and plants found in wetlands.</td><td>• Reflect through looking, talking, listening and writing about the visual world through the language of art elements and design principles

<u>Mathematics</u></td></tr>
<tr><td>Specific Aim 3: Understanding the uses of Science

Learners should understand the uses of Natural Sciences and indigenous knowledge in society and the environment.

Science learnt at school should produce learners who understand that school science can be relevant to everyday life, indigenous knowledge and different world view. This should enrich their understanding of the connections between Science and Society.

This is an aspect of Citizen Science whereby learners start to think and act as citizens in their community.</td><td>The learners will use their observations as the basis for identifying any possible threats to the wetland water and suggest ways in which the local community look after their wetland.</td><td>Aims to develop the following in the learner:

• Critical awareness of how mathematical relationships are used in social and environmental relations
• Confidence and competence to deal with any mathematical situation</td></tr>
<tr><td colspan="3">PROCESS SKILLS FOR FIELDWORK: HEALTH OF THE LOCAL STREAM</td></tr>
<tr><td colspan="3"><u>Process Skills (Section 2.7 of the Natural Sciences Curriculum)</u>

The teaching and learning of the Natural Sciences involves the development of a range of process skills that may be used in everyday life, in the community and in the workplace. Learners also develop the ability to think objectively and use a variety</td></tr>
</table>

of forms of reasoning while they use these skills. Learners can gain these skills in an environment that taps into their curiosity about the world, and that supports creativity, responsibility and growing confidence.

The Curriculum lists 15 Process skills and each is important to consider when planning a fieldwork experience.

The Scientific Process (Process Skill 15): is a skill that is needed to investigate things about the world. Using steps in the process skill learners can act scientifically to find out about the world and solve problems.

The process skills from the Curriculum that are relevant to this wetland field-study are listed below. This list is adapted for use in the Marking Rubric for this Fieldwork.

Process	Response
Step 1: Identify and describe the issue under investigation. What is it you want to find out?	Is the stream healthy? Is the stream a suitable habitat for water organisms?
Step 2: Form a hypothesis (scientific theory). A hypothesis is an idea, answer, or prediction about what will happen and why.	Hypothesis: The stream is in a healthy state and provides a suitable habitat for a range of water organisms.
Step 3: Design an activity or experiment to test your idea or prediction to see if you were right.	Conduct a miniSASS investigation to discover the range of organisms present in the stream.
Step 4: Observe and record your observations in a table. What were the results of your activity?	Record your findings in a table. Use the miniSASS scoring system to measure the health of the stream.

Step 5: Make inferences about the observations recorded and then make some conclusions. What did you find out? Do your results support your hypothesis? What did you learn from this investigation?

WHAT WILL WE NEED TO HELP US FIND ANSWERS?

(Planning the work. Working the plan)

Prior knowledge: At the start of Term One the learners will have learned about the biosphere and biodiversity and will know about the classification of living things. Use a chalkboard diagram to revise with examples of bio-diversity: the variety of plant and animal life in the world or in a particular habitat.	**Looking forward:** The learners can look forward to finding out for themselves about the biodiversity of their local wetland by using a simple sampling technique of the organisms in the water.	**Prior planning:** To plan the learning program it is essential that you visit the study area beforehand.

PREPARING FOR THE FIELDWORK: ECOLOGICAL INVESTIGATION

<u>Resources and fieldwork equipment</u>

Teachers can provide each group of learners with a 'clip-board' made by placing a bulldog clip on an A4 size cut up cardboard box (obtainable from any grocery store).

- The learners will go bare-footed into the stream water. To protect them from possible pollution use strong plastic bags held up with elastic bands.
- Take fresh water and liquid soap into the field so that the learners can wash their hands after they have collected their specimens.

IN THE CLASSROOM:

Use a chalk-board to outline the purpose of the field-work

- To find out whether or not the local stream is polluted.
- To look for water animals that will help us to decide.

Organising the work

- Divide the class into chat-groups. (e.g. 4 learners per group)
- To add fun to the work each group can decide on a name for themselves. (e.g. Mayflies, Dragon Flies, Mosquitoes, etc.)
- Give each group one container (e.g. a plastic ice-cream container), a small plastic cup and a pencil
- Provide a small plastic hand lens (Funds Permitting) -1 per group. Plastic hand lenses generally cost between R10 and R15 and are available from most toy shops.

AT THE STREAM

Instructions:

- Each group must collect a full container of stream water from the wetland
- Learners in the group must carefully lift up rocks and branches and inspect them for ‘creep-crawly’ animals
- Any animal that is found should be gently removed with the end of a pencil or stick and placed in the container of water
- Learners can explore the stream and collect as many creepy-crawlies as they can in 15 minutes
- If they see animals (such as tadpoles) which they are unable to catch they must make a note of this on their recording sheet

After 15 minutes of sampling each group must find a comfortable spot to identify the animals that they have found. The teacher gives each group the two information sheets for identifying their animals: ***River animals identification key*** and ***River animals information sheet*****.** If possible it is suggested that you laminate these pages. This will protect them from wet fingers.

Two additional sampling activities for those with an opportunity to do more:

1) Using a home-made sampling net: If you have a small class or if you would like one or two groups of learners to use this sampling technique you can use a home-made sampling net (See diagram below). The net is pulled gently through the water to catch any swimming animals. They will be caught in the small plastic bottle from where they can be placed into the container full of water.

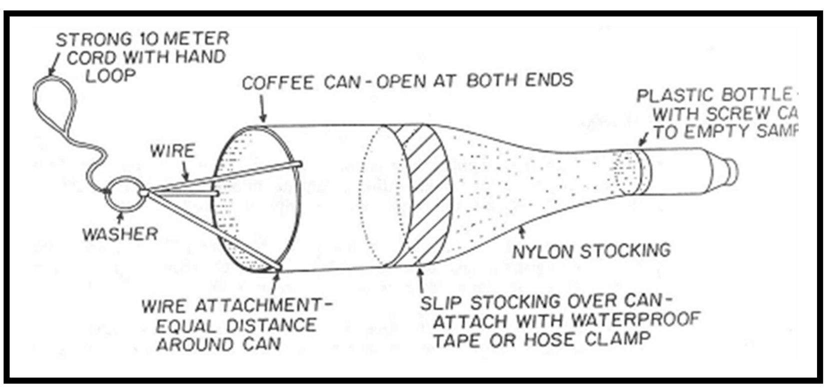


Figure 4: Home-made sampling net created by using a small plastic bottle with a screw top, a tin can and 10 m of rope. Cut out the bottom and fasten the stocking on with tape. To empty the bottle simply unscrew the top.

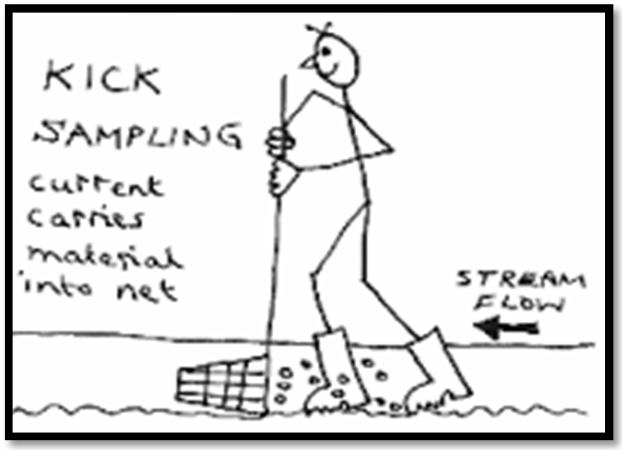


Figure 5: The kick sampling method, the stream current carries material into the net once it has been disturbed by your feet.

Alternatively you can use a homemade net in a flowing stream and, while you shuffle your feet to disturb the sand and mud on the bottom of the stream, allow the water to carry disturbed water animals into the net.

WHAT WAS LEARNED FROM THE INVESTIGATION?

(Recording the Results)

RECORDING THE RESULTS

When the groups have completed the sampling each group should find a dry spot to sit and identify the animals that they have found. The teacher then gives each learner a cardboard 'clipboard' with its recording sheet: "*How Healthy is my stream?"* – printed back-to-back (See Section F).

Other hand-outs:

- The two information sheets (attached to this document): ***River animals identification key*** and ***River animals information sheet*.** If possible it is suggested that you laminate these pages. This will protect them from wet fingers.

- **The sensitivity scoring information sheet (below):** This scoring sheet shows 13 examples of water invertebrates most likely to be found in the wetland. The animals are listed in terms of their ability to tolerate polluted water – from the larvae of true flies (most tolerant) to the larvae of stoneflies (least tolerant).

The learners will work together to allocate sensitivity scores to each GROUP of animals found and each learner will fill in their results on the recording sheet.

Deciding on the stream-water quality

Once the group has completed the table "*How healthy is my stream*" they can use the sensitivity scores to measure the health of the stream. Each group pf learners must:

1. Add up all of the sensitivity scores in Table A
2. Divide the total of the sensitivity score by the number of groups identified
3. Check the score against the information in Table B

The result is the average score for the stream and the learners can then discuss the health of the stream.

ACTION STEPS

Back in the classroom

Discuss the findings with the learners.

- If the stream water is relatively clean then ask the learners, working in their groups, to design a poster that will encourage the community to conserve the wetland environment.
- If the wetland is showing signs of pollution then ask the learners to design a poster telling the community about the pollution and encouraging households to combat the pollution at a personal level.

MAKE A CONTRIBUTION AT A NATIONAL LEVEL

To make a regular contribution to a developing picture of river quality in South Africa schools should their results to www.minisass.org

<u>FIELDWORK RECORD KEEPING: *how healthy is my wetland stream*?</u> (One per learner)

Class: ………………………………… My Group's name: ………………………………………..

My Name: …………………………………

<u>The Task:</u> To sample the aquatic invertebrates in a local river/stream using miniSASS to assess the water quality (whether or not it may be polluted). If it is polluted; to what extent is the pollution affecting the invertebrates in the stream?

TABLE A			
	GROUPS	NUMBER FOUND	SENSITIVITY SCORE
1	Flat Worms		3
2	Worms		2
3	Leeches		2
4	Crabs or Shrimps		6
5	Stoneflies		17
6	Minnow mayflies		5
7	Other mayflies		11
8	Damselflies		4
9	Dragonflies		6
10	Bugs or Beetles		5
11	Caddisflies (cased & uncased)		9
12	True flies		2
13	Snails		4
	TOTAL SCORE		
	Number of Groups		

	Average Score - miniSASS Score (Divide Total score by the number of groups you sampled) →		

Although an ideal sample site has rocky, sandy, and vegetation habitats, not all habitats are always present at a site. If your river does not have rocky habitats use the sandy type category below to interpret your scores.

Table B: Interpretation of the miniSASS score (Sa stream bottom / Rocky stream bottom)

Ecological Category (Condition)	**River Category**	
	Sandy Type	**Rocky Type**
NATURAL condition (Unchanged / Untouched – Blue)	> 6.9	> 7.2
GOOD condition (Few modifications – Green)	5.9 to 6.8	6.2 to 7.2
FAIR condition (Some modifications – Orange)	5.4 to 5.8	5.7 to 6.1
POOR condition (Lots of modifications – Red)	4.8 to 5.3	5.3 to 5.6
VERY POOR condition (Critically modified – Purple)	> 4.8	> 5.3

Findings

- In this space each learner must record the findings, describing the condition of the stream.

The research of the …………………………………………………….Group found that ………………… Stream is

……

……

……………..

MY FIELDWORK DRAWINGS
Name of invertebrate:

Class: …………………………..   Learner's Name …………………………………………………..

The Wetland Biosphere

(How healthy is my wetland stream?)

Example of a Rubric for assessing the learner's performance

Natural Science (Grade 7)

RUBRICS (Place the mark in the appropriate box)				
Learning Outcome used in the lesson (In the table the use of his/her gender descriptions are inter-changeable.)	**4 Marks:** **Learner's performance** **has exceeded the Assessment expectations for the grade.**	**3 Marks:** **Learner's performance** **has satisfied the Assessment expectations for the grade.**	**2 Marks:** **Learner's performance** **has partially** **satisfied the Assessment expectations for the grade.**	**1 Mark:** **Learner's performance** **has not satisfied** **the Assessment expectations for the grade.**
1. The learner performs all the fieldwork tasks with careful consideration.				
2. The learner gains useful experiences of sampling by looking in different habitats to collect as many water animals as possible;				
3. The learner uses the miniSASS technique to identify each macroinvertebrate from a local river/stream and records the results in the Report Table provided by the teacher.				
4. The learner uses the Sensitivity Test provided by miniSASS and the miniSASS scoring system to assess the health of the chosen river/stream and records the results in the Report Table.				

5. If the sampled indicator species suggest water that is free of pollution: The learners, working in their groups, must design a poster that will encourage the community to conserve the wetland environment ➢ Group mark for each learner				
Alternatively:				
5. If the wetland is showing signs of pollution then ask the learners to design a poster that would inform the community about the pollution and which would encourage households to combat the pollution at a personal level. ➢ Group mark for each learner				
TOTAL OF MARKS (OUT OF 20)				

Section D - Lesson Plans

- Geography
- Grade 10 FET

Rivers & their catchments: Examples of fieldwork lesson plans for Grade 10 FET

WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

WESSA
PEOPLE CARING FOR THE EARTH

This is a product of The Water Research Commission: Project No. K5/2350

SECTION D

RIVERS & THEIR CATCHMENTS

Some examples of Fieldwork Lesson Plans

For CAPS

GEOGRAPHY: GRADE 10 FET

CONTENTS

Dear Educator: The model Fieldwork Lesson Plans in this section have been developed in compliance with the CAPS curriculum documents. They are simply examples of what is possible. Why not work with a colleague to see how they suit your local situation and make any changes that might be necessary?

Geography: CAPS Further Education & Training Phase
Model Fieldwork Lesson Plan for Grade 10 Fieldwork
Scoping the wetland environment

Grade 10: Geographical fieldwork – Wetlands and Water Security

Term 4 Topic: Water Resources: Water management in South Africa
Lesson focus: Scoping the wetland environment (Personal experiences of the wetland ecosystem)
Duration: 1.5-2 hours of fieldwork

THE FET GEOGRAPHY CURRICULUM

Section 2.2 of CAPS FET Geography curriculum (*Geography Aims*) states that:
"*During Grades 10, 11 and 12 learners are guided towards developing the following knowledge, skills and attitudes."*

These include:

1. Describing and explaining the dynamic interrelationship between the physical and human worlds
2. Developing a commitment towards sustainable development
3. Making and justifying informed decisions and judgments about social and environmental issues

Section 4.3.2 of the Curriculum lists the formal assessment requirements for FET Geography.
The assessment tasks include the ability of learners to:

1. Identify and solve problems and make decisions using critical and creative thinking
2. Work effectively with others as members of a team, group, organisation and community
3. Organise and manage themselves and their activities responsibly and effectively
4. Collect, analyse, organise and critically evaluate information
5. Communicate effectively using visual, symbolic and/or language skills in various modes
6. Use science and technology effectively and critically show responsibility towards the environment and the health of others
7. Demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation.

Fieldwork: The Curriculum stipulates 4 hours of fieldwork during the first term. Why not use part of this allocation to encourage environmental learning for the year ahead amongst the learners?

Why not discuss with a colleague your understandings of the directives contained in the Curriculum as they apply to fieldwork in Geography?

SCOPING - AN IMPORTANT RESEARCH TOOL FOR GEOGRAPHY

Before starting a major programme of fieldwork, geographers may go into the field to see what has to be done. This is known as SCOPING (looking "widely"). This fieldwork is all about scoping the wetland environment with a view to planning a more in-depth study.

As in the fieldwork to follow: *What makes a wetland a wetland? Why are wetlands strategically important resources?*

A NOTE ON ECOLOGICAL NICHES

An **ecological niche** is the role and position a species has in its environment, how it meets its needs for food and shelter, how it survives, and how it reproduces.

The wetland environment has a number of different ecological niches. Be on the lookout for them during this discussion of wetland fieldwork.

THE AIM OF THIS FIELDWORK STUDY

- The aim of this fieldwork study is to develop ecological concepts relating to a wetland
- The prime objective of the study is to give practice to learners in the use of scoping techniques for environmental research
- Other objectives relate to curriculum details such as the importance of wetlands for controlling the effects of floods and the slow release of ground-water to the basin below

INTEGRATION WITH OTHER CURRICULA

Extracts from the curricula of other FET learning areas that provide links with Geography:
In preparing fieldwork at a local level, it might be helpful to consider how the work of other Grade 10 curricula relates to your fieldwork.

Languages (A selection of aims of particular reference to Geography fieldwork)
Learning a language should enable learners to:
- Use language appropriately, taking into account audience, purpose and context
- Use language and their imagination to find out more about themselves and the world around them. This will enable them to express their experiences and findings about the world orally and in writing
- Use language to access and manage information for learning across the curriculum and in a wide range of other contexts
- Use language as a means for critical and creative thinking, for expressing their opinions on ethical issues and values and for interacting critically with a wide range of texts.

Life Sciences (A selection of aims of particular reference to Geography fieldwork)
By studying and learning about Life Sciences, learners will develop:
- Knowledge of key biological concepts, processes, systems and theories
- An understanding of the ways in which humans have impacted negatively on the environment and the organisms living in it
- Deep appreciation of the unique diversity of past and present biomes in Southern Africa and the importance of conservation
- An awareness of what it means to be a responsible citizen in terms of the environment and life-style choices that they make
- A level of academic and scientific literacy that enables them to read, talk about, write and think about biological processes, concepts and investigations.

Life Orientation (Two aims of particular reference to Geography fieldwork)
Life Orientation aims to:
- Guide and prepare learners to respond appropriately to life's responsibilities and opportunities
- Guide learners to make informed and responsible decisions about their own health and well-being and the health and well-being of others

Tourism (Two aims of Tourism that link with wetland fieldwork.)
- Mapwork
- Sustainable and responsible tourism: This relates in particular to the place of conservation with regard to eco-tourism. Wetland habitats as conserved areas are also areas of interest and importance to bird-watchers, botanists and others.

PREPARING FOR THE FIELDWORK: PLANNING AND RESOURCES

Success depends upon previous preparation, and without such preparation there is sure to be failure.

PLANNING

Using a chalk-board summary you should first explain how the fieldwork will be undertaken. Using your own words and providing locally known examples, take time to revise or explain to the learners important concepts of ecosystems and habitats.

Ecosystem: A biological community of interacting organisms and their physical environment.

Habitat: The natural home or environment of an animal, plant, or other organism.

Then help the learners organise themselves into small groups (e.g. 4-6). Ask them to give their groups names that are appropriate to the research (e.g. Water Wonders, The Otters; The Weavers). In the home language of the learners if preferred.

FIELDWORK RESOURCES

The resources listed below are the minimum suggested for the fieldwork. If your school can access these they would add value to the fieldwork. For well-resourced schools, educators can also use a Google Earth image of the wetland together with the 1:50 000 topographic map.

FOR EACH GROUP:

- A 1:50 000 topographic map on which the wetland appears -One map for every 4-6 learners. Maps are easily available from: The Chief Directorate Surveys and Mapping, Van Der Sterr Bldg, Rhodes Ave, 7700, Mowbray, Cape Town, Western Cape, South Africa.
  Phone Number: 021 6584300. In July 2015 these maps were priced at R13.50 each.
  Please note that these maps are available on CD as well.
  NB: If your department has the resources each map can be supplied laminated at an additional cost of R27 per map.

FOR EACH LEARNER:

- RECORD KEEPING: MY WETLAND FIELDWORK RECORDS -Scoping the wetland ecosystem. The record sheets will be taken in by you to assess the work of each learner.

FIELD EQUIPMENT (To be taken to the field by the teacher):

- A thermometer to sample the air temperature at the time of the field-work
- If available - a wet and dry bulb thermometer (hygrometer) to measure the humidity of the air
- Sets of Water Clarity Disks - 1 per group
- A bucket for water - Rinsing of hands after the soil puddling tests
- Pictures of birds.

CLASSROOM PREPARATION

Mapwork orientation

To orientate the learners with regard to the fieldwork site (remember that Geography is all about place) use the topographic map in which the field- study area in the wetland is mapped.

Working in their groups the learners should complete the worksheet in the Mapwork (MY WETLAND FIELDWORK RECORDS: Scoping the wetland ecosystem).

THE FIELDWORK

Scoping the wetland environment will be undertaken in 8 stages. At each stage the learners will enter their observations in the Records table.

1. FIELD-SKETCHING (See example in the recording sheet at the end of these notes: *My Wetland Fieldwork Records: Scoping the wetland ecosystem)*

The learners should stand at a vantage point from where they can see the whole wetland study area. The field-sketch is intended to engage each learner with the environment of the fieldwork. By making a simple field-sketch the learner is starting to observe the environment of the study area.

Hint: The teacher should encourage the learners by referring them to the example in the Records table. Every learner should try to complete the sketch. Some will be better than others.

2. NOTES ON THE WEATHER

For details of the expected weather on any one day go to the website of the SA Weather Service:
http://www.weathersa.co.za/city-pages/
For climate data for your nearest large town go to https://en.wikipedia.org/wiki/Climate_of_South_Africa (Temperatures) and Rainfall for any location in South Africa go to: www.samsamwater.com/climate

THE FIELDWORK

At the time of the fieldwork the learners will measure:

1. The air temperature
2. The humidity of the air (if possible)
3. Cloud cover
4. Wind (Direction and Speed)

1. The air temperature: Measured by the teacher at a height of about 1 metre off the ground to avoid any radiated heat off the group. This measurement should also be taken in the shade if possible to avoid any heat from the sun affecting the reading.
2. Humidity: Measurement demonstrated by the teachers with use of a hygrometer and tables accessed off the internet (Example: *http://www.fpl.fs.fed.us/documnts/fpltn/fpltn-156.pdf)* Why not print a copy for your records?
3. Cloud cover: The learners assess the amount of cloud cover in the sky and record it in the circle. An effective way of doing this is to print an A4 pages divided into eight squares (as shown in figure 1 below) onto a clear sheet. The learner must then count the number of squares where clouds are present which will result in a score out of 8.

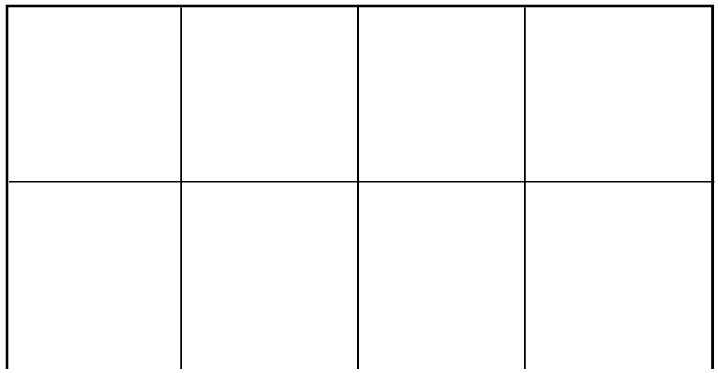


Figure 1: Example of a page divided into 8 for printing on a clear

4. The wind: Wind is measured in terms of both its direction and its speed. Wind speed is assessed in the field by observing the effects that it is having on the environment as shown in table 1 below. This is known as the Beaufort scale.

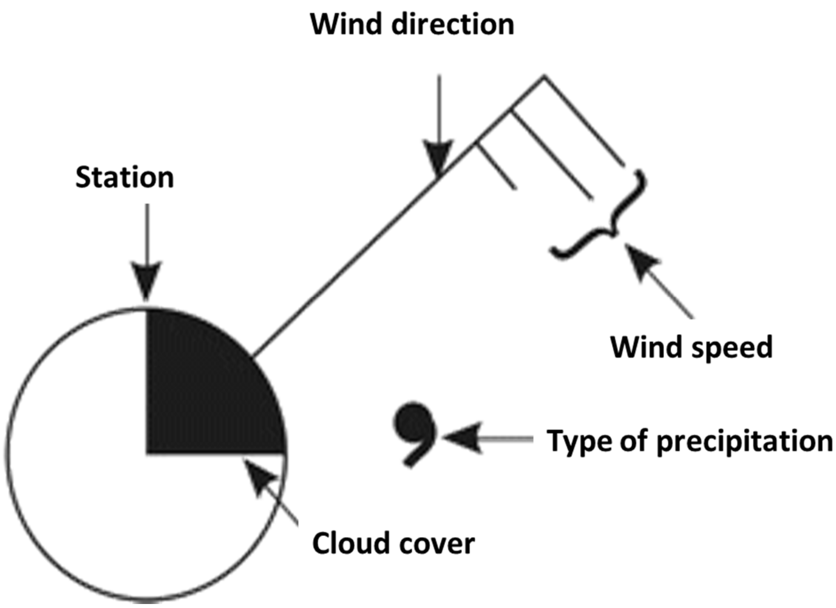


Figure 2: This weather station diagram is recording information for one particular place (The exact place where the measurements are being taken).

Print a table for each group of learners.

The Beaufort scale			
Beaufort Number	**Description**	**Km/h**	**Visual**
0	calm	0 - 2	smoke rises vertically
1	light air	2 - 5	smoke drifts slowly
2	slight breeze	6 - 12	leaves rustle
3	gentle breeze	13 - 20	leaves and twigs in motion
4	moderate breeze	21 - 29	small branches move
5	fresh breeze	30 - 39	small trees sway
6	strong breeze	40 - 50	large branches sway
7	moderate gale	51 - 61	whole trees in motion
8	fresh gale	62 - 74	twigs break off trees
9	strong gale	75 - 87	branches break
10	whole gale	88 - 101	trees snap and are blown down
11	storm	102 - 115	widespread damage
12	hurricane	116 - 130	extreme damage

Table 1: The Beaufort scale

NB: Wind direction is recorded by the direction it is blowing FROM. Look at the figure 2. Can you see that the wind is coming from the north-east with a speed of 25 kph? (2½ 'feathers' on the arrow).

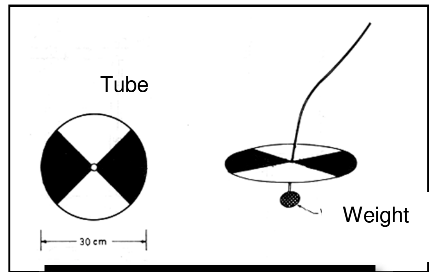
3. NOTES OF THE LOCAL GEOLOGY

The learners should pick up and examine rocks in the study area. To distinguish between igneous rocks, which have a have a crystalline structure without layers and sedimentary rocks which show layers.

4. NOTES ON THE STREAM BED AND WATER IN THE STREAM

- The stream bed: Is the stream bed sandy with few rocks or rocky with many rocks? Which of the two will provide more /better habitats for river species?
- Are there any logs or other objects that might provide habitats for water animals?

- Water clarity: To check if the stream water has any suspended solids in it (e.g. pollution) use a home-made water Clarity Disk. - One for each group of learners.



The disk is a circle cut out of thick cardboard and coloured as shown. Push a length of string through the centre of the disk and tie a weight (e.g. a washer or nut) below it. Place another weight above the disk so that it will sink.
Lower the Disk into the water and check the depth to which you can still see the patterns clearly - If you can still see the pattern clearly to a depth of 30 cm (the length of a ruler) this will show that the water is not polluted with solids.

Using your Water Clarity Disk to measure its clarity; describe the water in the wetland with regard to colour, clarity and suspended material, accounting for each observation. A Clarity Tube can also be used, this is a tool developed by GroundTruth to measure clarity (http://www.groundtruth.co.za/equipment/clarity-tube.html).

5. WETLAND SOIL PUDDLING (See diagrams below)

Farmers and other people interested in the soil sometimes use a simple puddling test to sample the soil. In this activity:

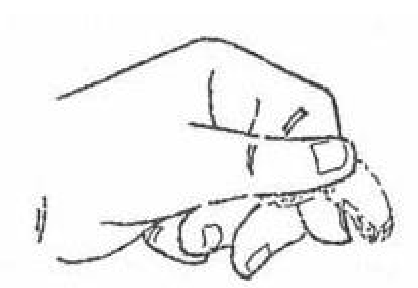
- Each learner takes a small handful of soil / mud
- If the material is dry the learner closes her fist over the sample and plunges her hand into a bucket of water to wet the sample. She removes her fist and squeezes excess moisture out of the sample.

Puddling the sample (With educator's guidance)

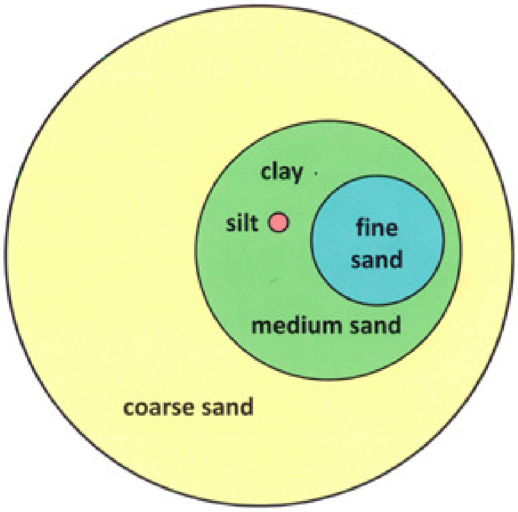
To get an idea of the sand, silt and clay content gently rub the sample between thumb and forefinger:

- If the sample is sticky this tells you that there is clay
- If you can feel slippery parts this shows the presence of silt
- The gritty parts of the sample show the presence of sand
- Try rolling the sample into a 'sausage'. If this is possible try bending it around to make a circle
  If the sample is able to roll easily and bend then this shows it has a high percentage of clay

Rub the sample between thumb and forefinger



Rolling the sample to make a "sausage"



The learners record their findings in the Records table.

Figure 3: Diagram showing the size proportions of different types of sand. Please note: this diagram is not to size.

6. HABITATS MAKE HAPPY HOMES

Apart from the water itself look for other animal habitats in the stream. Encourage the learners to look for logs, reed stems and rocks which might provide habitats for animals.

7. NATURAL VEGETATION

Using the Record table as a guide the learners should take note of the plant life. Noting some general classifications of vegetation. For example - away from the streams edge: "trees", "thick bushes", "tall grass" and "short grass" - close to the stream: reeds and bulrushes; and in the stream: reeds, water lilies and green algae.

- In the sheltered valleys of the hills above the wetland
- Some 50 metres from the stream
- At the edge of the wetland
- In the water of the wetland stream (Floating and submerged plants)

8. THE WETLAND ANIMALS

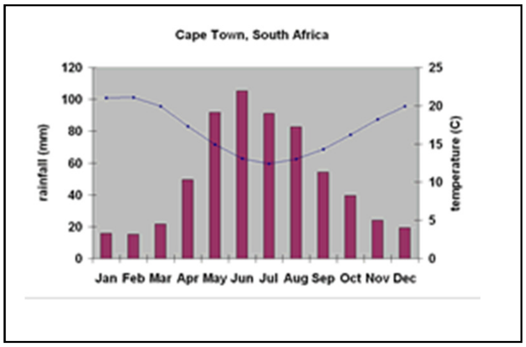
Using the Record table as a guide the learners should take note of the animal life that they might encounter. If not seen or heard the learners should look for signs such as birds' nests and tracks of mammals or crabs in the mud.

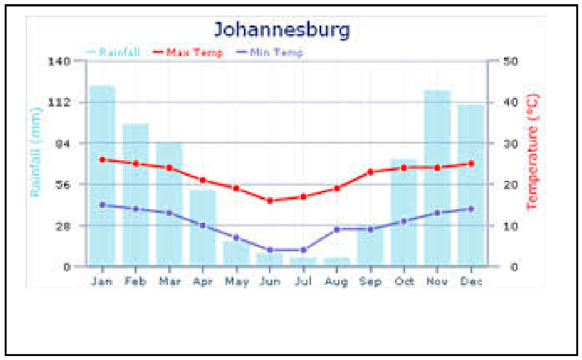
- If the learner does not know the name of the animal she should make up one of her own.

BACK IN THE CLASSROOM

Weather patterns in your study area.

The flow of the river will be affected by the local climate. If your school is in a winter rainfall area (e.g. Cape Town), the wetland will be in a different condition to one in a summer rainfall area (e.g. Johannesburg).





- For climate data for your nearest large town go to https://en.wikipedia.org/wiki/Climate_of_South_Africa (Temperatures) and Rainfall for any location in South Africa go to: www.samsamwater.com/climate
- For details of the expected weather on any one day go to the website of the SA Weather Service: http://www.weathersa.co.za/city-pages/

REPORT: SCOPING THE WETLAND ENVIRONMENT

Wherever possible teachers should make suitable reference books relating to the fieldwork relating to the field work. Some examples may be found in Appendix E. The internet is also a useful source of information. Where learners have this access they should be encouraged to refer to this very useful source.

REPORT

The following is an example of instructions that you might give to your learners. Why not adapt the questions to suit your situation?

1. Write your own understanding (definition) of environmental scoping.
2. In a paragraph say what you have learned about environmental scoping as a tool for finding out about the ecological environment of a place.
3. Using the Internet or other sources of information, choose an animal species that interests you and prepare a short report that will include the following:
   a) Your reason for choosing this animal
   b) A description of the animal. (Appearance, behaviour - Include a sketch if possible)
   c) The ecological niche that it occupies
   d) It's sources of food
   e) Threats it faces in its daily life
   f) Suggestions regarding the conservation of the species.

MY WETLAND FIELDWORK RECORDS: Scoping the wetland environment.

Follows on the next page

Our Group name: ………………………………………….. My class ……………………………….

My name: …………………………………………………..

MY WETLAND FIELDWORK RECORDS: Scoping the wetland environment (One set per learner.)

<table>
<tr><td colspan="5">MY NOTES: WHAT I LEARNED TODAY</td></tr>
<tr><td colspan="5">IN THE CLASSROOM</td></tr>
<tr><td rowspan="8">Mapwork
(In the classroom)</td><td colspan="4">The coordinates for the centre of the wetland being studied are:

……………………°…………’………’’ South ……………………°…………’………’’ East</td></tr>
<tr><td colspan="4">Topographic features related to wetlands. Use the map key to find the following conventional signs: (Use the correct colour OR write the name of the colour below the symbol)</td></tr>
<tr><td>Feature</td><td>Symbol</td><td>Feature</td><td>Symbol</td></tr>
<tr><td>“Marsh (swamp)”</td><td></td><td>Perennial streams”</td><td></td></tr>
<tr><td>Land subject to controlled inundation”</td><td></td><td>Non perennial stream”</td><td></td></tr>
<tr><td>Large wash (a mass of alluvial material transported and deposited by a river during flooding.)</td><td></td><td>Rapids</td><td></td></tr>
<tr><td>”Submerged Marsh”</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">The distance from the wetland to the next river confluence is …………………………………………… metres.</td></tr>
</table>

A sketch map is a simple drawing of an area that illustrates the position of important features in the area.

How to create a sketch map:

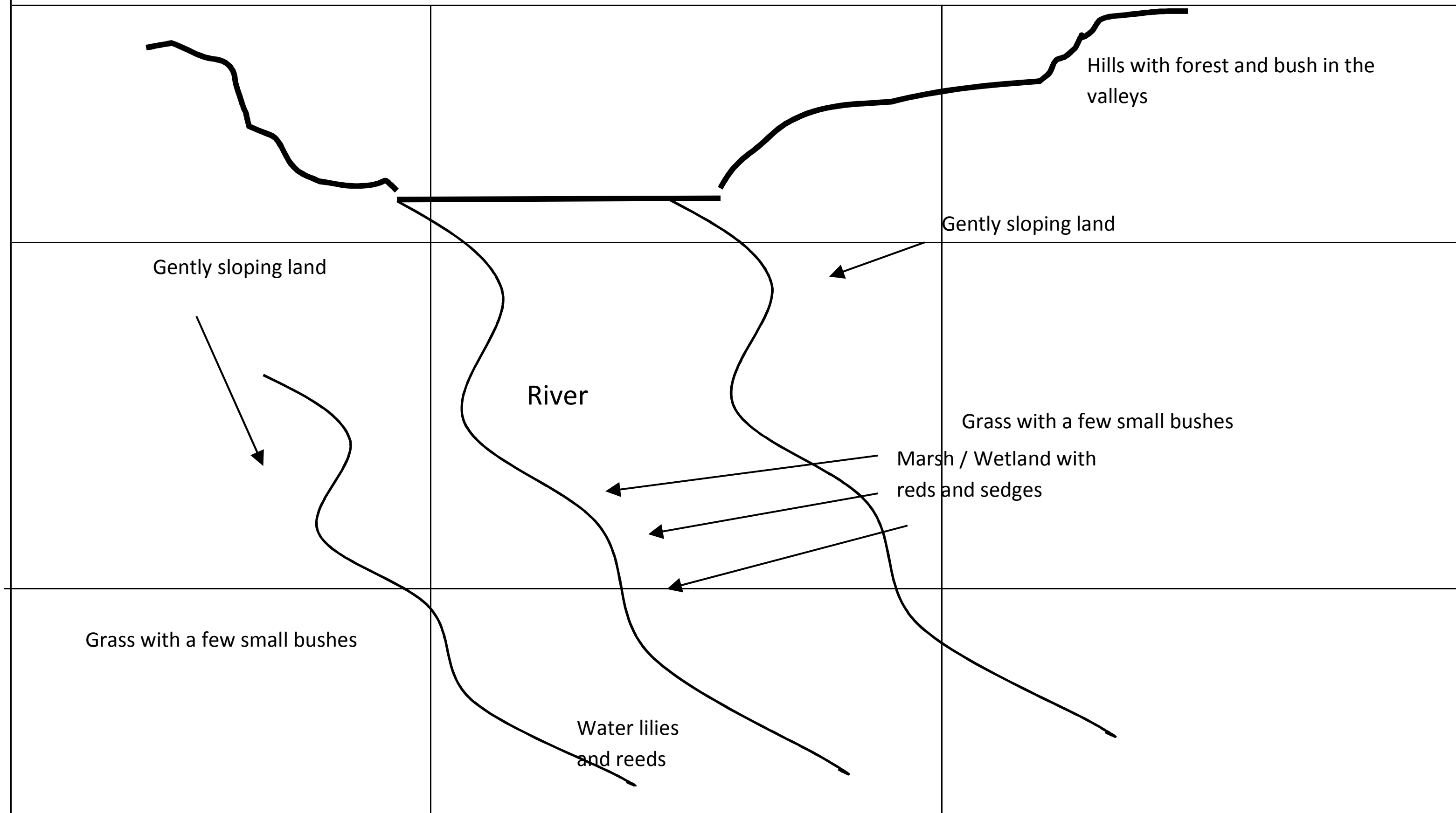
1. Take a blank page and turn it so that it is horizontal, this is so that you will have more space to work.
2. Divide your page up into three equal, horizontal sections using a pencil and a ruler; these will represent the foreground, middle ground and background.
3. Next, add three more equal sections but this time they must be vertical to represent the right, left and centre of the sketch map. You should now have a page divided equally into 9 blocs.
4. Now imagine that the area you are sketching will fit into this page, look at which features fit into which block.
5. Sketch the outline of each of these main features into the corresponding block.
6. Label the features that you have sketched and do not forget to include a heading.

See example on the next page:

AT THE WETLAND (Looking and feeling to find out more)

Standing at a place where you can comfortably see the wetland and the area around it.

1. Field sketch	Sketch the area that you can. Keep your drawing very simple just highlighting the main features as in the example on the next page. Use this sketch to add any notes as your fieldwork progresses.



An example of a fieldwork sketch-map (keeping it simple)

Air temperature: Use a thermometer to measure the air temperature about 2 m above the ground.

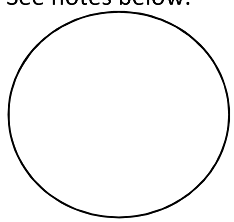
2. Notes on the weather

Record it here: ……………………………..°

Air humidity: If you have a hygrometer (a wet and dry bulb thermometer), measure the relative humidity. How much moisture is there in the air compared to what it could hold if saturated? (e.g. RH= 50% The air is half to being saturated).

……………………………………………….. %

Use the circle to show the cloud cover. See notes below.



If clouds are present - name them (There may be more than one type).

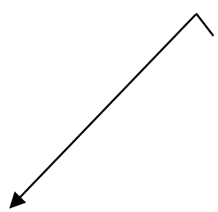
Explanation the presence/absence of clouds. If you have measured the Relative Humidity of the air refer to this measurement in your explanation.

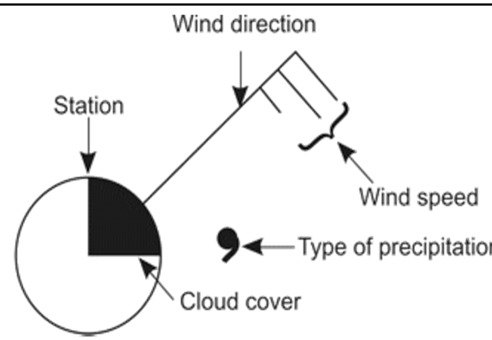
RH = ………………………… %

Wind.

Use an arrow to show the wind in terms of the direction from which it is blowing (the arrow) and its strength (the ‘feather’ on the arrow). One ‘feather’ = 1 knot. Refer to the Wind Speed scale to add the ‘feathers’ to the diagram.

For example, a wind from the NW. Strength of 1 on the Beaufort Scale





Draw your own Weather Station diagram here

<table>
<tr><td rowspan="2">3. Notes on the local geology</td><td colspan="2">Find a rock in the study area. Describe its general colour and comment on its crystalline structure.</td></tr>
<tr><td colspan="2">What is the origin of the rocks you can see? (Clues: igneous rocks have a crystalline structure without layers; sedimentary rocks show layers.)</td></tr>
<tr><td rowspan="2">4. Notes on the stream bed and the water in the stream</td><td colspan="2">The stream bed: Is the stream bed sandy with few rocks or rocky with many rocks? Two different habitats may affect the number of animal species.</td></tr>
<tr><td colspan="2">Using your Water Clarity Disk to measure its clarity, describe the water in the wetland with regard to colour, clarity and suspended material, accounting for each observation.</td></tr>
<tr><td rowspan="3">5. Soil puddling: An investigation of soil structure</td><td>At the edge of the wetland:</td><td>50 metres from the wetland.</td></tr>
<tr><td colspan="2">From your observations of the plant-life (recorded below) how do you think the soil texture has affected the species of plants in the wetland?</td></tr>
<tr><td colspan="2">In the water of the wetland stream (Floating and submerged plants)</td></tr>
</table>

6. Habitats make happy homes (apart from the water itself look for other animal habitats in the stream) - It should be noted that the learners may not find all of the different habitats in one wetland	Are there any logs or other objects that might provide habitats for water animals?
7. Natural vegetation In a few sentences describe the vegetation in general terms. Draw pictures if you prefer. If you don't know the names of the plants, give them a name of your choosing.	In the sheltered valleys of the hills above the wetland
	50 metres from the wetland
	At the edge of the wetland

	Habitat (The place in nature that an animal can call home)	Examples of species
8. The wetland animals	In the forested valleys:	

If not seen or heard, look for signs such as birds' nests and tracks of mammals or crabs in the mud. If you don't know the name of the animal, make up one of your own.		
	In the grassland:	
	In the reeds:	
	In the wetland next to the open water:	
	On the water surface:	
	Below water habitats:	

MY WETLAND REPORT

Write a report of +- one page, use the headings below in your report:

1. Scoping the wetland environment

   What is scoping? (Write a paragraph saying what this fieldwork technique involves and how you used environmental scoping to get an overview (big picture) of the wetland environment

2. Using the Internet or other sources of information choose an animal species from the wetland that interests you and prepare a short report that will include the following:
   a) Your reason for choosing this animal
   b) A description of the animal (Appearance, behaviour - Include a sketch if possible)
   c) The ecological niche that it occupies
   d) It's source of food
   e) Threats it faces in its daily life
   f) Suggestions regarding the conservation of the species.

Class: ……………………………………….. Learner's Name: ………………………………………………………..

Model Lesson Plan: The Wetland Biosphere

(Scoping the wetland environment)

Example of Rubrics for assessing the learner's performance

The Assessment will be based on observations of learner participation in the field as well as on an assessment of the "**Scoping the wetland environment"** individual recording sheets.

SUGGESTED RUBRIC FOR ACTIVITIES (Place the mark in the appropriate box)					
Learning Outcome used in the lesson In the table the use of his/her gender descriptions are inter-changeable.	8 Marks: Meritorious achievement expected for the grade	6-7 Marks: Substantial achievement expected for the grade.	4-5 Marks: Adequate achievement expected for the grade.	2-3 Marks: Elementary achievement for this grade	0-1 Mark: Not achieved
1. The learner completes the sections on map-work neatly and accurately.					
2. The learner completes the sections on geology and soils and shows an understanding of their contribution to the ecology of the wetland ecosystem.					
3 The learner understands and completes the section on the weather for the day and is able to observe and record the required weather elements.					
4. The learner completes the sections on vegetation and shows an understanding of their contribution to the ecology of the wetland ecosystem					
5. The learner completes the sections on wetland animals and shows an understanding of their contribution to the ecology of the wetland ecosystem					
TOTAL OF MARKS (OUT OF 40)					

SUGGESTED RUBRIC FOR REPORT (Place the mark in the appropriate box)					
Learning Outcome used in the lesson In the table the use of his/her gender descriptions are inter-changeable.	5 Marks: Meritorious achievement expected for the grade	4 Marks: Substantial achievement expected for the grade.	3 Marks: Adequate achievement expected for the grade.	2 Marks: Elementary achievement for this grade	1 Mark: Not achieved
1. The learner completes the report with evidence of relevant research on a selected wetland animal					
2. The learner writes neatly and in a proper academic manner, including proper layout (introduction, body, conclusion)					
3 There is evidence that the learner has understood the task, this is proved by the content of the report					
4. The learner has showed creativeness in terms of suggesting conservation methods					
5. The learner has included a correct bibliography and has not plagiarised					
TOTAL OF MARKS (OUT OF 30)					

Geography: CAPS Further Education & Training Phase
Model Fieldwork Lesson Plan for Grade 10 Fieldwork

What makes a wetland a wetland? Why are wetlands strategically important resources?

Geography	**Grade 10: Geographical fieldwork – Wetlands and Water Security**
Duration: 2 hours	**Term 4: Topic Water Resources: Water management in South Africa** **Lesson focus: What makes a wetland a wetland?**

THE AIM OF THIS FIELDWORK STUDY

The aim of this field-work study is to encourage and promote insights into the strategic importance of South Africa's wetlands

The objectives of the study include improved understandings with regard to:

- The environmental (ecological) conditions that create wetlands
- The contribution of wetlands with regards to water security in the river basins that they are part of
- The role of wetlands in reducing the impact of abnormal rainfalls
- The critical importance of community involvement with regards to the management and conservation of local wetlands.

THE CURRICULUM CONTEXT

The Geography Curriculum

Appendix Two of this document lists important guidelines for effective Geography teaching and learning. Why not refresh your memory on these before reading further?

Section 2.2.4 Asking Geographical questions (Starting with the end in sight)

The Geography curriculum offers good advice when it comes to preparing for fieldwork activities. The table below offers suggestions with regard to the approach to fieldwork.

Why not work with a colleague to see how this approach might work in terms of fieldwork in general. As you go through the table, also consider the challenges facing fieldwork (in general) at your school and start to consider how these may be improved.

ASKING GEOGRAPHICAL QUESTIONS		
Method of enquiry	Key questions	Concepts
Observation	• What is it? • What is it like? • Who or what is affected?	Physical and human processes, awareness, perception, characteristics, similarities and differences.
Description	• Where does it occur? • Why is it there?	Location, place, region, space, distribution, pattern, scale and spatial association
Analysis and explanation	• What happened or is happening? • Why did it happen? • How is it changing?	Interdependence, causes and processes
Evaluation and prediction	• What are the effects? • What is likely to happen?	Environmental impact, social impact, interdependence, spatial interaction, spatial organisation, human-environment interaction, cause, process, time, behaviour, consequence, justice, quality of life, environmental quality, welfare, costs and benefits.
Decision making	• Who benefits? • What decisions must be made? • What are the costs and benefits of decisions? • How should it be managed?	Choices, decisions, costs and benefits, planning, management, power, inequality and problem-solving.
Personal evaluation, judgment and Response	• What is my position? • What action can I take?	Cultural sensitivity, diversity, ethics, opinion forming, empathy, values, action and personal responsibility

INTEGRATION WITH OTHER CURRICULA

Extracts from the curricula of other FET learning areas that provide links with Geography

The table in the previous section illustrates the importance of SIX processes in fieldwork. In preparing fieldwork at a local level, it is wise to consider the support being given by other school curricula in support of these processes.

Languages (A selection of aims of particular reference to Geography fieldwork)
Learning a language should enable learners to:

- Use language appropriately, taking into account audience, purpose and context
- Use language and their imagination to find out more about themselves and the world around them. This will enable them to express their experiences and findings about the world orally and in writing
- Use language to access and manage information for learning across the curriculum and in a wide range of other contexts
- Use language as a means for critical and creative thinking, for expressing their opinions on ethical issues and values, for interacting critically with a wide range of texts.

Life Sciences (A selection of aims of particular reference to Geography fieldwork)
By studying and learning about Life Sciences, learners will develop:

- Knowledge of key biological concepts, processes, systems and theories
- An understanding of the ways in which humans have impacted negatively on the environment and organisms living in it
- Deep appreciation of the unique diversity of past and present biomes in Southern Africa and the importance of conservation
- An awareness of what it means to be a responsible citizen in terms of the environment and life-style choices that they make
- A level of academic and scientific literacy that enables them to read, talk about, write and think about biological processes, concepts and investigations.

Life Orientation (Two aims of particular reference to Geography fieldwork)
Life Orientation aims to:

- Guide and prepare learners to respond appropriately to life's responsibilities and opportunities
- Guide learners to make informed and responsible decisions about their own health and well-being and the health and well-being of others.

Tourism (Two aims of Tourism that link with wetland fieldwork.)

- Mapwork
- Sustainable and responsible tourism, this relates in particular to the place of conservation with regard to eco-tourism. Wetland habitats as conserved areas are also areas of interest and importance to bird-watchers, botanists and others.

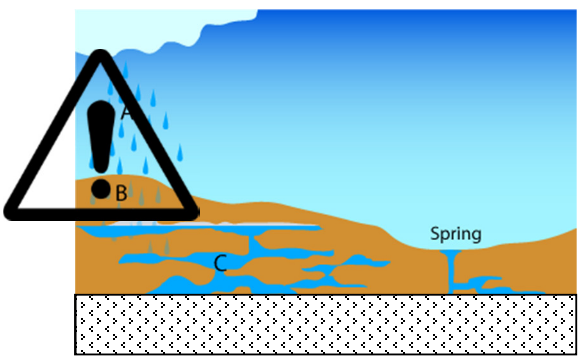
THE FIELDWORK

What makes a wetland a wetland? Why are wetlands strategically important resources?

Educators: During this fieldwork the learners will be asked to investigate the unique characteristics of wetlands and to discuss their strategic importance with regard to their dual functions of flood control and water security in South Africa.

Wetlands as ecosystems: A w*etland* is an area that is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem.

- Wetland ecosystems usually occur in low-lying or flat areas where river water is allowed to spread out.
- At the coast wetlands are found at the mouths of estuaries
- Away from the coastal areas, wetlands usually form where the river flows slowly over gently sloping or flat land. The river meanders over a floodplain and where occasional flooding floods the land on either side if the river.
- Wetlands may also occur where the underlying rock presents an impervious layer of rock so that the water cannot penetrate (commonly a sill of dolerite) the rock. See diagram below.



Rainwater percolates through cracks in the rock. The impervious layer prevents further flow and eventually emerges at the surface to create a spring or small flow of water. If the area is flat and water accumulates a wetland may form around the spring.

Impervious rock layer

Figure 3: Diagram showing an impervious layer underneath a wetland

WHAT WILL WE NEED TO HELP US FIND ANSWERS?
(Planning the work. Working the plan)

Prior knowledge:	Looking forward:	Prior planning:
From the Grade 9 studies of the biosphere, learners would have studied the elements of the biosphere: the lithosphere (soil and rocks), all living organisms (plants, animals and, microorganisms) and dead organic matter. Use a chalkboard summary diagram or print as a handout) of a part of a wetland ecosystem picture showing the sun, the air, the substrate (soil, mud), plants and animals. See figure 4 below.	The learners can look forward to finding out for themselves about the role of wetlands in the provision of the region's water supplies and in the control of flooding during times of high rainfall.	To plan the learning program it is essential that you visit the study area beforehand.

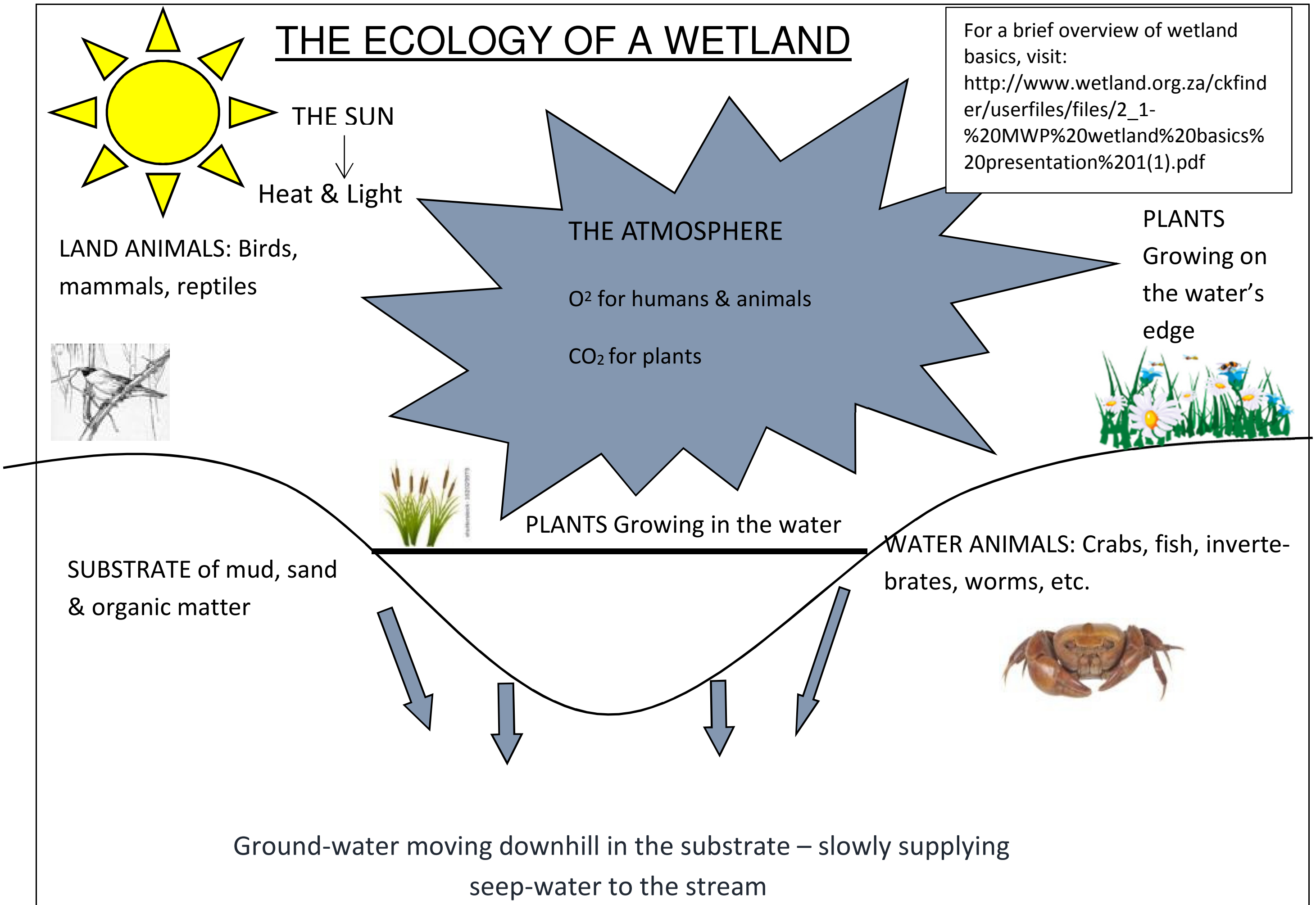


Figure 4: Example of a possible chalkboard/print-out diagram

PREPARING FOR THE FIELDWORK: PLANNING AND RESOURCES

⚠ *Success depends upon previous preparation, and without such preparation there is sure to be failure.*

PLANNING

Using a chalk-board summary to explain how the fieldwork will be undertaken, this should include the equipment needed, the time it will take and the what is expected from the learners. Then help the learners to organize themselves into small groups (e.g. 4-6). Ask them to give their groups names that are appropriate to the research (e.g. *Water Wonders, The Otters; The Weavers).*In the home language of the learners if preferred.

FIELDWORK RESOURCES

The resources listed below are the minimum suggested for the fieldwork. If your school can access these they would add value to the fieldwork. For well-resourced schools, educators can also use a Google Earth image of the wetland together with the 1:50 000 topographic map.

FOR EACH GROUP:

A 1:50 000 topographic map on which the wetland appears. In July 2015 these maps were priced at R13.50 each. If you haven't already done, why not invest in a set? - One map for every 4-6 learners.

1:50 000 Topographic Maps are easily available from: The Chief Directorate Surveys and Mapping. Van Der Sterr Bldg, Rhodes Ave, 7700, Mowbray, Cape Town, Western Cape, South Africa.
Phone Number: 021 6584300
NB: If your department has the resources each map can be supplied laminated at an additional cost of R27 per map.

FOR EACH LEARNER
RECORD KEEPING: *What makes a wetland a wetland? Why are wetlands strategically important resources?* One per learner

THE FIELDWORK INVESTIGATIONS: A GEOGRAPHICAL APPROACH

As discussed earlier the steps in the wetland investigation are in accordance with Section 2.2.4 of the FET Geography curriculum which lists six key questions that a Geographer can ask to ensure an effective investigation. These are questions relating to

1. Observation
2. Description
3. Analysis and explanation
4. Evaluation and prediction
5. Decision-making
6. Personal evaluation, judgment and response

To this list of six we can add an introductory step - that of ORIENTATION. Since Geography is essentially a study of PLACE all geography studies should be located at particular sites (places).

MAPWORK ORIENTATION

In the classroom: Orientation (The exact location of the wetland)

What to do

- Divide the class into manageable groups
- What you will need per group of learners:
  - 1:50 000 Topographic map (To find out how to purchase the map for your area go to Section E - Useful Explanations, E-References & Appendixes)
  - Lengths of string (30 cm)

Focusing on the 1:50 000 Topographic map

- Referring to the topographic map key on the next page ask the learners to find the coordinates for the centre of the wetland study area.
- In small group discussions ask the learners to find out more about the Map Symbols used to show:
  - A wetland: "Marsh (swamp)" in the key
  - Land subject to controlled inundation
  - A "Large wash'' (a mass of alluvial material transported and deposited by a river during flooding)

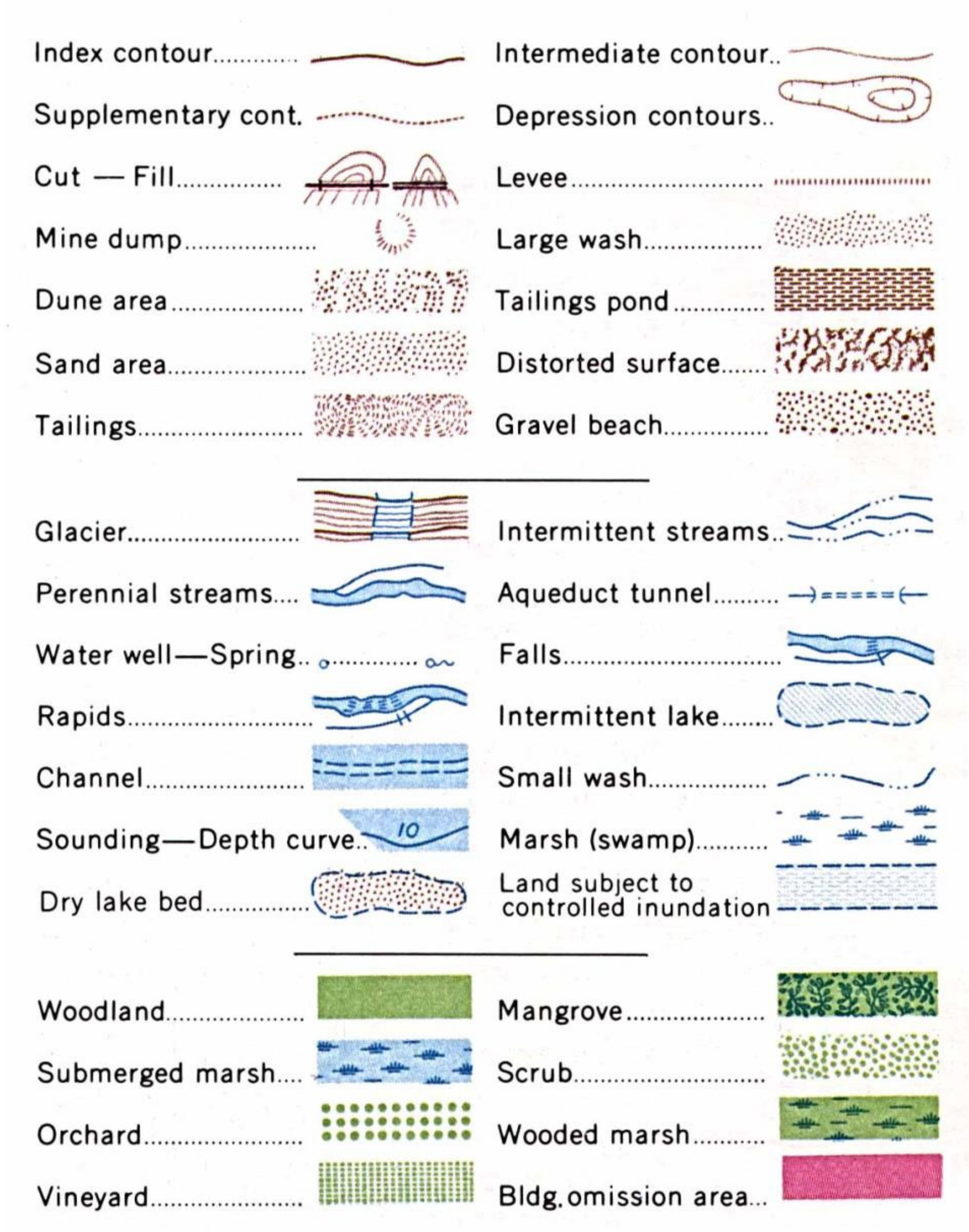
The learners should then record their findings in the ***My Fieldwork Records*** recording sheet.

Fieldwork site

The learners should find the exact site (position) of the wetland on the topographic map. Ask the learners to check the drainage basin to which the river belongs, naming the river basins that are further downstream. Using the piece of string as a measuring device the learners must then measure the distance from the wetland to the next river confluence.

The learners must enter the information on the ***My Fieldwork Records*** sheet

1:50 000 Topographic Map KEY



THE FIELDWORK: WHAT MAKES A WETLAND A WETLAND?
(OBSERVATION AND DESCRIPTION)

At the wetland - Ecological Investigation: The Substrate

Observing and describing the wetland substrate: The soil and mud in the wetland

You will need a bucket of clean water handy so that the learners can rinse their hands from time to time.

This simple experiment will help the learners compare the **sand, silt and clay** content of TWO soil samples – one from the wetland and the other a distance from it.

What you will need:

- Two plastic or glass jars / bottles with screw tops with the labels removed (e.g. peanut butter jar) - Two jars per group.
- Plastic rulers - one ruler per group.

Wetland Puddling (Soil or mud) (See figure 5 below)

Farmers and other people interested in the soil sometimes use a simple puddling test to sample the wetland soil / mud. In this activity

- Each learner takes a small handful of soil / mud
- If the material is dry the learner closes her fist over the sample and plunges her hand into a bucket of water to wet the sample. She removes her fist and squeezes excess moisture out of the sample.

The Soil Shake Investigation (See figure 6 on the next page)

- Divide the class into convenient chat-groups (e.g. 4)
- Give each group TWO jars – marked A and B (Use a label or mark with a koki pen)
- Each group is to sample two lots of soil:
  - One as close to the water's edge as possible (Sample A)
  - The second away from the wetland's edge. (Sample B)
- Each sample is placed it in the jar to a depth of about 1/3 of the jar
- Each jar is then topped up with water and the lid firmly replaced
- The water in each jar is shaken well for a few seconds until the contents are well mixed
- The jars are then placed on a steady surface (e.g. a log or stone) where they can be easily viewed
- While the class waits for the mixtures to settle they can go on to the next activity (Mud puddling).

Puddling the sample (With educator's guidance)

To get an idea of the sand, silt and clay content gently rub the sample between thumb and forefinger.

- If the sample is sticky this tells you that there is clay
- If you can feel slippery parts this shows the presence of silt
- The gritty parts of the sample show the presence of sand
- Try rolling the sample into a 'sausage'. If this is possible try bending it around to make a circle
  If the sample is able to roll easily and bend then this shows it has a high percentage of clay

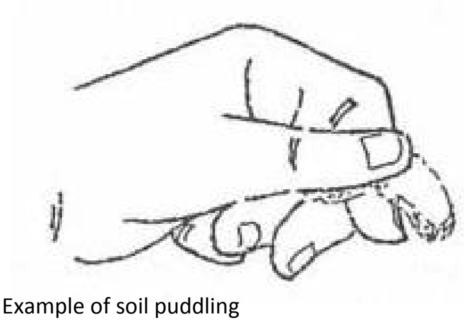


Figure 5: Example of soil puddling

THE SOIL / MUD-SHAKE INVESTIGATION

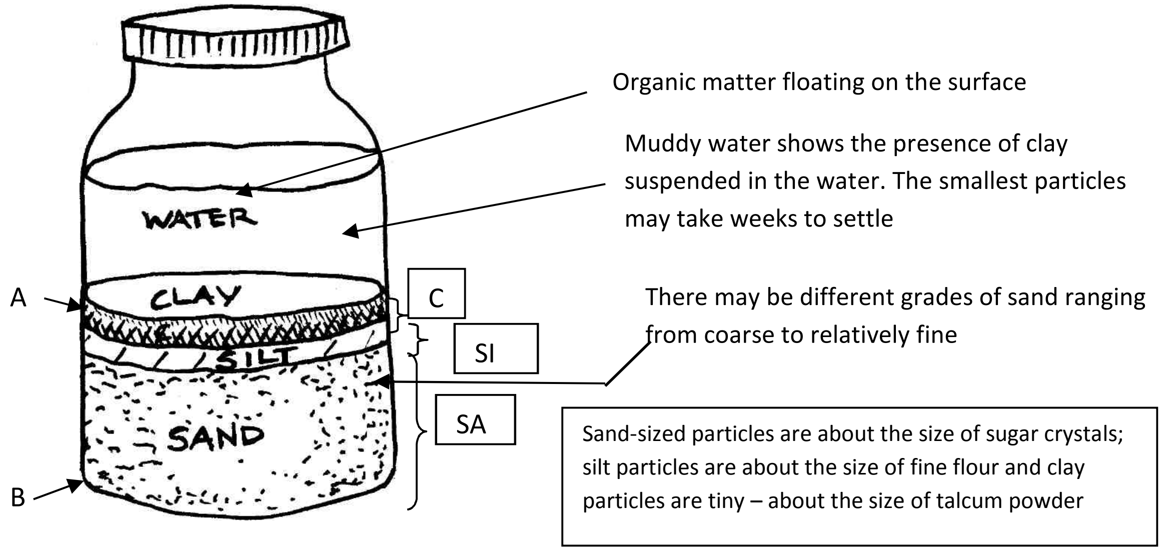
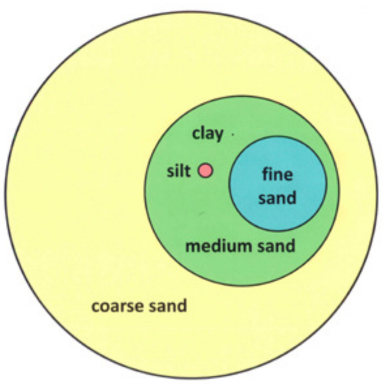


Figure 6: Diagram showing the soil shake investigation

What's in the soil? How important is each part? (Initial discussion with educator)

- The organic material (pieces of leaves, sticks) floating on the top indicates the presence of organic matter in soil.

Soils have different amounts of sand, silt and clay.



Sand sized particles allow air into the soil. This is important for soil organisms such as bacteria, fungi, protozoa, nematodes, arthropods and earthworms – all of which are essential parts of the soil's ecology.

Silt sized particles (just bigger than a pin-head) help the soil structure to support plants.

Clay sized particle (smaller than a dot on this page) also provide structure but they are most important because they hold the nutrients that the plant needs (Nitrogen, Potassium, Phosphate and other plant foods).

Assessing the relative percentages of each particle size (Educator to demonstrate with one example from the class)

FIELD OBSERVATION ARE IMPORTANT

Soil colour also indicates clay content

Dark brown or black colours in soil indicate that the soil has a high organic matter content. Wet soil will appear darker than dry soil. In South Africa most wetland soils are dark colour because of these two factor

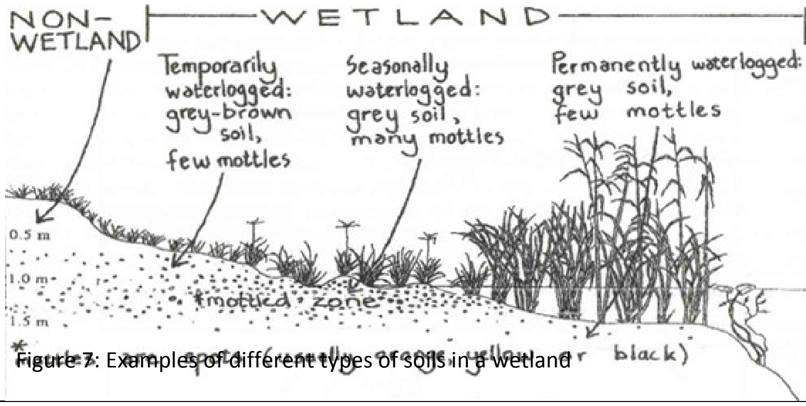


Figure 7: Examples of different types of soils in a wetland

Gley soils – Additional indicators of wetland soils

Wetlands often have gley (or gleyed) soils. These are mottled soils showing spots of orange, yellow or black, that have formed under conditions of poor drainage, resulting in a chemical reaction affecting the iron compounds in the wetland soil.

Discussion of the wetland soils/ mud

The learners enter their observations and findings in the "My Fieldwork Records" table.

At the wetland - Ecological Investigation: Plant life

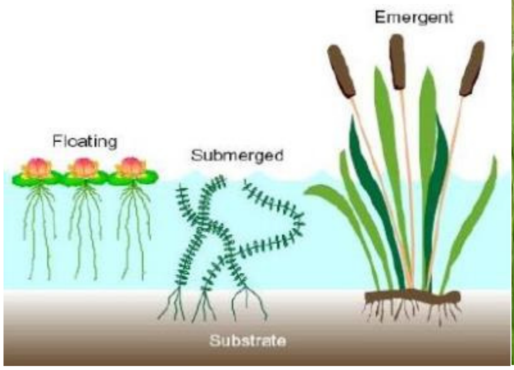
Observing and describing the indicator species of plant-life in the wetland

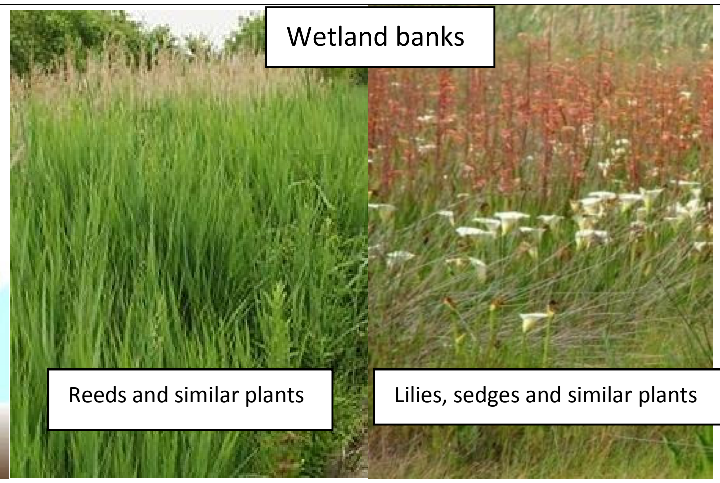
Habitats make happy homes

Before any discussions on plant and animal life in a wetland, revise with the learners the concept of 'habitat' (find out what they understand by this word before assisting). For Example: *A habitat is the natural home of an animal, plant or other organism; it is a place in the environment where a species can live.*

Wetlands as plant habitats

Certain species of plants will only grow in wetlands. Allow the learners 30 minutes to look for species and record their findings in their *fieldwork record sheets* (example attached at the end of these notes). Examples of these indicator species for each of the five categories given below. Examples for educator information only. The learners will make their own observations as discussed below on the next page.





Floating plants; Submerged plants; Emergent plants; Wetland bank plants. Refer to Appendix One: Water plants as indicator species of wetlands.)

There are two broad categories of wetland plants

- Plants that grow in the water itself (floating, submerged or emergent)
- Wetland plants that grow in soil that is permanently wet or which stays wet in the rainy season (Reeds, sedges, lilies, etc.).

In preparing for the fieldwork the educator should identify as many different plant species as possible. Scientific names are not necessary, but wherever possible common names should be applied e.g. In the water: Reeds, water lilies, green algae, bulrush, At the water's edge: Sedge, bulrush, and arum lily.

- The learners should choose at least three plants growing in the water and three plants growing at the water's edge
- If the English names are not known to the group an appropriate English name should be chosen by the group.
- If a vernacular name is know it should be recorded.
- For each plant the learners should consult together to provide a way in which the plant is adapted to its habitat.
- Observations should be entered in the record sheet: "*My fieldwork record sheet*"

At the wetland - Ecological Investigation: Animal life

Observing and describing the indicator species of animals in the wetland

Wetlands as animal habitats

As with plants certain species of insects, arachnids, molluscs, reptiles, birds and mammals are also indicators of proximity to wetlands. Refer to Appendixes 2 and 3 for details.

Sampling the animal life

Ask the class to look for and give names to as many of each species as possible.

Allow each group 30 minutes to observe and record in the table provided as many species as possible. From actual sightings of animals or evidence such as tracks and droppings.

Instructions to be given:

Insects: Ask the learners to observe and/or find and record the insects.

Insects (Both in the water as nymphs or above the water as adults): Dragon flies, Mayflies, Damsel flies, Mosquitoes.

Choose the most appropriate key(s) for the wetland and issue each group of learners with a key or keys. See Appendix Two.

- Above the water: Adult animals may be seen flying above the water
- In the water: The learners to collect a full container of stream water from the wetland and then sample the various habitats, carefully lift up rocks and branches to inspect them for insect larvae. Any animal that is found should be gently removed with the end of a pencil or stick and placed in the container of water.
- The learners to use the key(s) supplied to identify the animals they find.

Molluscs: Learners to record any snails they may see (live animals or shells).

Arachnids: Learners to observe, name (choose their own descriptive name if necessary) and record any spiders that they observe.

Reptiles: Evidence or sightings of water monitors (leguaans), snakes, lizards living in the wetland. Appendix Three

Birds: Observe, name and record any birds that have the wetland as a habitat – both spending time in the water and in the vegetation around the wetland. Appendix Three

Mammals: Evidence or sightings of field mice, rats, otters, water mongoose or other wetland species. Appendix Three

Wetlands, slow release of water and flood attenuation

At the wetland - Ecological Investigation: The benefits of wetlands

At the wetland, as final group work, ask the learners to consider the benefits of wetlands by providing them with the following headings:

1. The regulation of the flow of water in the stream below the wetland
2. The potential for wetlands to reduce the impact of heavy rains.

The learners should note their findings in the record sheet. These will be discussed as part of the follow-up work in the classroom.

Classroom Note-making and Action Steps

At the wetland - Ecological Investigation: Note-making

Note-making
Discuss the findings with the learners by referring back to your original chalkboard diagram and asking the learners to help you place examples of THEIR findings on the diagram.

- Discuss with the learners
  - The ecological role of wetlands in regulating the flow of water to streams and rivers below the wetland
  - The function of wetlands with regard to the slow release of water as a strategic resource for both the environment and for people.
  - The value of wetlands as conservation areas for indicator species of plants and animals
- Once done allow time for each learner to complete their Fieldwork Record Sheets.

Taking action

- Ask the learners for their ideas regarding improving community awareness of the importance of wetland conservation. Sources of water, conservation of species, soil conservation, places for school fieldwork, etc.
- Using this information the learners must now design a poster that will encourage their community to protect the local wetland. The poster should show the diversity of life in a wetland and indicate what ecological services the wetland provides (they can work individually or in their groups).

MY WETLAND FIELDWORK RECORDS:

What makes a wetland a wetland? Why are wetlands strategically important resources?

Follows on the next page

My name: ………………………………………………. **Class: ………………………………..**

MY WETLAND FIELDWORK RECORDS: ***What makes a wetland a wetland? Why are wetlands strategically important resources?***

<table>
<tr><th></th><th colspan="2">MY NOTES: WHAT I LEARNED TODAY</th></tr>
<tr><td rowspan="6">Mapwork</td><td colspan="2">The coordinates for the wetland being studied are:
South: …………°………………’……………….’’ East: ……………°…………………’………………’’</td></tr>
<tr><td>Topographic features related to wetlands</td><td>Symbol</td></tr>
<tr><td>Map symbol for a “Marsh”:</td><td></td></tr>
<tr><td>Map symbol for “Land subject to controlled inundation”</td><td></td></tr>
<tr><td>Map symbol for a “Large wash’’ (a mass of alluvial material transported and deposited by a river during flooding.)</td><td></td></tr>
<tr><td colspan="2">The distance from the wetland to the next river confluence is …………………………………………… metres.</td></tr>
<tr><td>The water in a wetland</td><td colspan="2">Describe the water in the wetland with regard to colour, clarity and suspended material, accounting for each observation.</td></tr>
<tr><td rowspan="3">Observation & Description:

Wetland Soils</td><td colspan="2">Colour:</td></tr>
<tr><td colspan="2">Texture: Describe and use the soil triangle to give the wetland soil a name.</td></tr>
<tr><td colspan="2">Other observations:</td></tr>
</table>

Observation & Description: **Plants**	Floating plants:
	Submerged plants:
	Emergent plants
	Wetland banks:

	Species (Seen or found signs of – spoor, droppings feathers, etc.)	Adaptation to the wetland habitat (How living in or near the wetland benefits the animal)
Observation and Description: **Animals** If not seen or heard, look for signs such as nests of birds or tracks of mammals or crabs in the mud.	Insects: Larvae	
	Insects: Adults	
	Arachnids	
	Birds: Spending time on the water	
	Birds: Spending time above the water or in the wetland vegetation.	
	Mammals	
	Reptiles	

THE IMPORTANCE OF WETLANDS

On a separate sheet of paper motivate a case for prioritizing the protection of wetlands using the following headings:

a) **The role of wetlands in the functioning of riverine ecosystems**
b) **The potential of wetlands for ecotourism**
c) **The critically important contribution that wetlands make to the South African economy**

Class: ……………………………..   Learner's Name ……………………………………………………..

Model Lesson Plan: *The Wetland Biosphere*

(*What makes a wetland a wetland? Why are wetlands strategically important resources?)*

Example of a Rubric for assessing the learner's performance

The Assessment will be based on observations of learner participation in the field as well as on an assessment of the "*My Wetland Fieldwork Records"* individual recording sheets.

SUGGESTED RUBRICS (Place the mark in the appropriate box)					
Learning Outcome used in the lesson In the table the use of his/her gender descriptions are inter-changeable.	5 Marks: Meritorious achievement expected for the grade	4 Marks: Substantial achievement expected for the grade.	3 Marks: Adequate achievement expected for the grade.	2 Marks: Elementary achievement for this grade	1 Mark: Not achieved
1. The learner participates well in using the topographic map to locate the fieldwork area.					
2. The learner participates well in the soil investigations and recognizes the four soil components of: humus (organic matter), clay, silt and sand.					
3. The learner chooses names and describes at least 3 wetland plants.					
4. The learner is able to explain the ecological role of the wetland plants identified.					
5. The learner is able to use simple identification keys to identify and record 3 wetland animal species					
6. The learner is able to explain the ecological role of the wetland plants identified					
7. The learner is able to present a sound argument for the conservation of South Africa's wetlands.					
8. The learner demonstrates through the poster picture an understanding of the strategic importance of the wetland biosphere.					
TOTAL OF MARKS (OUT OF 40)					

Section E – References & Useful Explanations

This is a product of The Water Research Commission: Project No. K5/2350

USEFUL EXPLANATIONS

1. **A Learning Programme** specifies the scope of learning and assessment for the relevant grade. It is the plan that ensures the learners achieve the Learning Outcomes as prescribed by the Assessment Standards for a particular grade. The Learning Programme Guidelines assist teachers and other Learning Programme developers to plan and design quality learning, teaching and assessment programmes.
2. **A rubric** is a scoring tool that states the expectations for an assignment by listing the criteria (what counts) and describing levels of quality from excellent to poor (Possible levels of achievement along a continuum, e.g. from poor to excellent). Rubrics can teach as well as evaluate, when used as part of a formative approach to assessment, rubrics can help learners to develop understanding and skill as well as make dependable judgments about the quality of their own work.

REFERENCE BOOKS

Apart from the E-References listed in the next section schools are advised to purchase copies of good reference books for environmental education. For example:

Wetland Plants

- *Easy Identification of some South African Wetland Plants.* Ginkel & Glen *et al,*. 2011

Freshwater life

Freshwater Life. Charles Griffiths, Jenny Day, Mike Picker ISBN 9781775841029

Trees

- *How to identify trees in southern Africa.* Braam van Wyk and Piet van Wyk. ISBN 9781770072404

Birds

- *Newmans Birds of southern Africa* Kenneth Newman ISBN 0869541366

Reptiles and amphibians

- *Field Guide to Snakes and Other Reptiles of Southern Africa*. William R. Branch ISBN *868720403*

Mammals

Field Guide to Mammals of Southern Africa. Chris and Mathilda Stuart. *ISBN* 9781770074040

Insects

Field Guide to Insects of South Africa Alan Weaving, Charles Griffiths, Mike Picker ISBN 9781770074040

E-REFERENCES – Hyperlinksa

http://csg.dla.gov.za/contact.htm : The Surveyor General's Office with branches in most provinces) provides a national cadastral survey management system that includes 1:50 000 Topographic maps. Refer to the website to find out where you can obtain your local map.

Focus on fieldwork activities

http://www.groundtruth.co.za/projects/minisass.html : The GroundTruth website details the Stream Assessment Scoring System. In addition, if you scroll down to the end of the miniSASS project screen, there are a number of resources that can be downloaded including lesson plans of activities for Grades 5, 7, 9 and 11.

https://www.capetown.gov.za/en/CSRM/Documents/A_practical_field_procedure_for_identification_and_delineati.pdf : An excellent article on the identification of wetlands using, *inter alia,* plant species.

http://sageography.myschoolstuff.co.za/ : A useful site for accessing information on the content of all grade levels plus information regarding teaching and learning methods.

https://www.flickr.com/photos/schoolsriverhealthprogram/ : The Schools River Health Program is an initiative of the University of KwaZulu-Natal. This site shows the excellent work being done by communities around the country and is constantly being updated.

http://www.fao.org/docrep/003/x9419e/x9419e08.htm- Case study: South Africa contains many useful tables regarding water availability and management as well as future projections of usage.
http://www.dwaf.gov.za/iwqs/gis_data/river/rivs500map.html : This is a useful GIS resource that allows you to view the drainage basins of Southern Africa in detail.

http://www.rvatlas.org : The South African Risk and Vulnerability Atlas provides a good explanation of seasonal variations in precipitation and the link between temperature variations, weather systems and changing rainfall patterns.

http://www.enviropaedia.com/topic/default.php?topic_id=240 : *Enviropaedia: Rethinking Reality* – The Water topic is easy to read and has well-presented information on water issues.

http://www.neok12.com/Water-Cycle.htm : The Water Cycle for Kids website has interesting games and activities on the water cycle, including a vocabulary game.

http://www.mitchellteachers.org/WorldHistory/AncientEgyptNearEastUnit/UnderstandingGeographyEffectSettlementActivity.html : A World History website with lesson topics and ideas on human settlement patterns.

http://e-classroom.co.za/measuring-water-usage-grade-4-oasis/ : The e-classroom website has a water use worksheet that could be used with Activity 3 in this unit.

Focus on Wetland Conservation

www.randwater.co.za : Useful information and ideas for educators from Rand Water.

http://www.dwa.gov.za/ : Information from the Department of Water Affairs.

http://www.wetland.org.za/ : Important information on the Mondi Wetlands Programme - a joint Programme of South Africa's two largest NGO conservation organisations, WWF-South Africa and the Wildlife and Environment Society of South Africa (WESSA), together with two corporate sponsors; the Mazda Wildlife Fund and the Mondi Ltd.

http://www.worldwater.org/data.html : An overview of the world's freshwater supply.

http://www.ispotnature.org/communities/southern-africa : Ispot.org is a website where one can upload a photograph of any species and get help in the identification process.

REVISED BLOOM'S TAXONOMY

(After David R. Krathwohl *et al)*

<table>
<tr><th></th><th>1. Remember</th><th>2. Understand</th><th>3. Apply</th><th>4. Analyze</th><th>5. Evaluate</th><th>6. Create</th></tr>
<tr><td>Fact</td><td>Remember facts</td><td>Understand facts</td><td>Apply facts</td><td rowspan="3">Analyze using facts, concepts, principles and procedures</td><td rowspan="3">Evaluate using facts concepts, principles and procedures</td><td rowspan="3">Use facts to create concepts, principles and procedures</td></tr>
<tr><td>Concept or Principle</td><td>Remember concepts</td><td>Understand concepts</td><td>Apply concepts</td></tr>
<tr><td>Procedure</td><td>Remember procedures</td><td>Understand procedures</td><td>Apply procedures</td></tr>
<tr><td>Metacognition

(Awareness and understanding of one's own thought processes)</td><td>Remember strategies</td><td>Understand strategies</td><td>Apply strategies</td><td>Analyze strategies</td><td>Evaluate Strategies</td><td>Create strategies</td></tr>
<tr><td></td><td colspan="2">Knowledge</td><td>Skill</td><td colspan="3">Ability</td></tr>
</table>

Making the most of every learning opportunity (Fieldwork in particular!)

"Taxonomy" simply means "classification". Bloom's taxonomy of learning objectives is an attempt to classify forms and levels of learning.

We use the taxonomy as a guide to help us enable effective learning.

- The top row shows that there are six parts to the taxonomy. These show the ways in which we learn best.
- The column to the left shows the outcomes of effective learning.
- The bottom row shows how having knowledge of any field of life, when taken together with the skills used to perform tasks that present themselves, will result in the ability to perform to our best potential.

VERBATIM EXTRACT FROM THE CAPS CURRICULUM FOR GEOGRAPHY IN THE FET PHASE

These extracts provide the guidelines for developing fieldwork for Grade 10 Learners

Section 2.2 Geography Aims

During Grades 10, 11 and 12 learners are guided towards developing the following knowledge, skills and attitudes:

- Explaining and interpreting both physical and human geographical processes
- Describing and explaining the dynamic interrelationship between the physical and human worlds
- Making and justifying informed decisions and judgements about social and environmental issues

Section 2.2.1 Geography's four Big Ideas

Any topic in Geography can be explored by applying a conceptual framework that embraces Geography's four big Ideas, namely:

- Place
- Spatial processes
- Spatial distribution patterns
- Human and environment interaction

2.2.2 Geographical Skills

The Geography curriculum aims to develop the following subject-specific skills:

- Using verbal, quantitative and symbolic data forms such as text, pictures, graphs tables, diagrams and maps
- Practising field observation and mapping, interviewing people, interpreting sources and working with statistics
- Applying communication, thinking, practical and social skills
- Practising the following specific skills:
    - Identifying questions and issues
    - Collecting and structuring information
    - Processing, interpreting and evaluating data
    - Making decisions and judgements
    - Deciding on a point of view
    - Suggesting solutions to problems

- Working co-operatively and independently

2.2.3 Attitudes and values

The Geography curriculum aims to foster the following values and attitudes in learners:

- A concern for the sustainable and fair use of resources for the benefit of all
- Recognising the significance of informed decision making
- The application of geographical knowledge and skills in learners' personal lives
- Respect for the rights of all people
- A sense of fairness, sustainability and equality

Appendix One
Water Plants as Wetland Indicator Species

WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

WESSA
PEOPLE CARING FOR THE EARTH

This is a product of The Water Research Commission: Project No. K5/2350

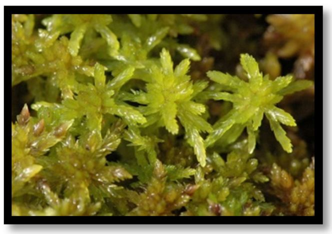
APPENDIX ONE

WATER PLANTS AS WETLAND INDICATOR SPECIES

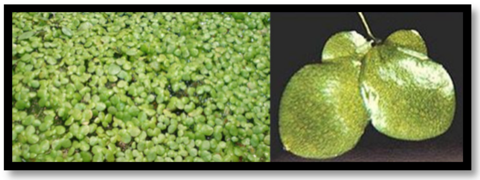
For details of websites that you might find useful please refer to:

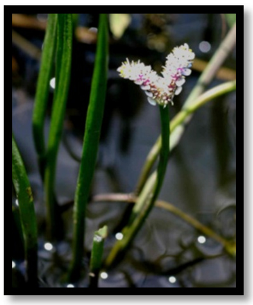
Section E: Appendix **USEFUL EXPLANATIONS, E-REFERENCES & APPENDIXES**

Vegetation of Wetland Systems

	Water Crystalwort *(Riccia fluitans)*	This is a floating plant that is actually made up of hundreds of smaller, interlinked plants.
	Peat Moss *(Sphagnum)*	Peat moss in South Africa grows in open swamp-like environments. However, there is not as much Peat moss in South Africa as in other parts of the world. This species stores water in its leaves.
	Mosquito Fern *(Azolla Pinnata)*	This fern is an aquatic alien species in South Africa. It has become invasive because it spreads quickly and creates dense vegetation near still water.
	Cape Bullrush Typha Capensis	This is a very common species that is well adapted to wet and muddy environments. It has very strong fibrous roots that help to anchor the plant so that it is not affected by strong winds.

	Floating Pondweed *(Potamogeton natans)*	This pondweed grows on muddy banks and still/ very slow-flowing water. It can potentially take over in confined areas.
	Day Water Lily *(Nymphaea Nouchali)*	This is an alien species. The flowers can be white, yellow, pink or blue. They only open in the sunshine.
	Saw-Weed *(Najas Pectinata)*	Saw-Weed grows below the surface of the water and forms large clumps. When this species is in abundance it can cause a problem with the stream flow.
	Papyrus *(Cyperus Papyrus)*	This species requires full sunshine and protection from strong winds to thrive. It grows in wetlands and on the edges of rivers and dams.
	Water Lettuce *(Pistia stratiotes)*	Water Lettuce is an alien invasive species in South Africa. It is problematic but it does provide habitats for water birds.

	Duck Weed *(Lemna Gibba)*	Duck weed is a very small, light green floating plant that grows on stagnant or very slow flowing water.
	Water Hyacinth *(Eichhornia Crassipes)*	This is a very invasive alien species that causes a lot of damage in South Africa. It thrives in wetland environments.
	Arum Lily *(Zantedeschia aethiopica)*	This species requires a wet area or high rainfall to thrive.
	Vlei Bluestem *(Andropogon appendiculatus)*	The Vlei Bluestem is a water dependent grass that is endemic to Southern Africa.
	Red Hot Poker *(Kniphofia)*	This species grows next to rivers or in areas that are marshy/wet most of the year.

	Ngongoni Grass ***(Aristida junciformis)***	This is a very tall grass that inhabits damp areas. It is unpalatable to grazers which may cause problems because the animals then overgraze the other grasses.
	Upright Waterblommetjie *(Aponogeton Junceus)*	This species is very common in shallow water and flood plains.
	Drooping Sedge *(Carex Austro-Africana)*	The leaves of this indigenous plant are very rough. It grows in shallow water in streams and wetlands.
	Tall Slender Sedge *(Cyperus Fastigiatus)*	This species requires a permanent water source to grow.

	Smooth Flat Sedge *(Cyperus Laevigatus)*	This species is relatively short sedge that can be used for the prevention of soil erosion. It is a very popular meal amongst water birds.
	Butterfly Gladiolus *(Gladiolus Papilio)*	This species thrives in wet but sunny conditions.
	Scarlet River Lily *(Hesperantha Coccinea)*	The Scarlet River Lily occurs on stream banks. The flowers are usually red but can also be pink or white.
	Prickly Rush *(Juncus Punctorius)*	This species is found near permanent water sources. It is identifiable by the clumps of brown flowers.

	Rigid Rush *(Juncus Rigidus)*	Rigid rush generally grows in wet, sandy areas.
	Common Reed *(Phragmites Australis)*	This reed is very tolerant and is abundant in many places. It grows in almost all types of aquatic environments.

Edition – October 2015

Appendix Two
Water Animals – Identification Guides

This is a product of The Water Research Commission: Project No. K5/2350

APPENDIX TWO

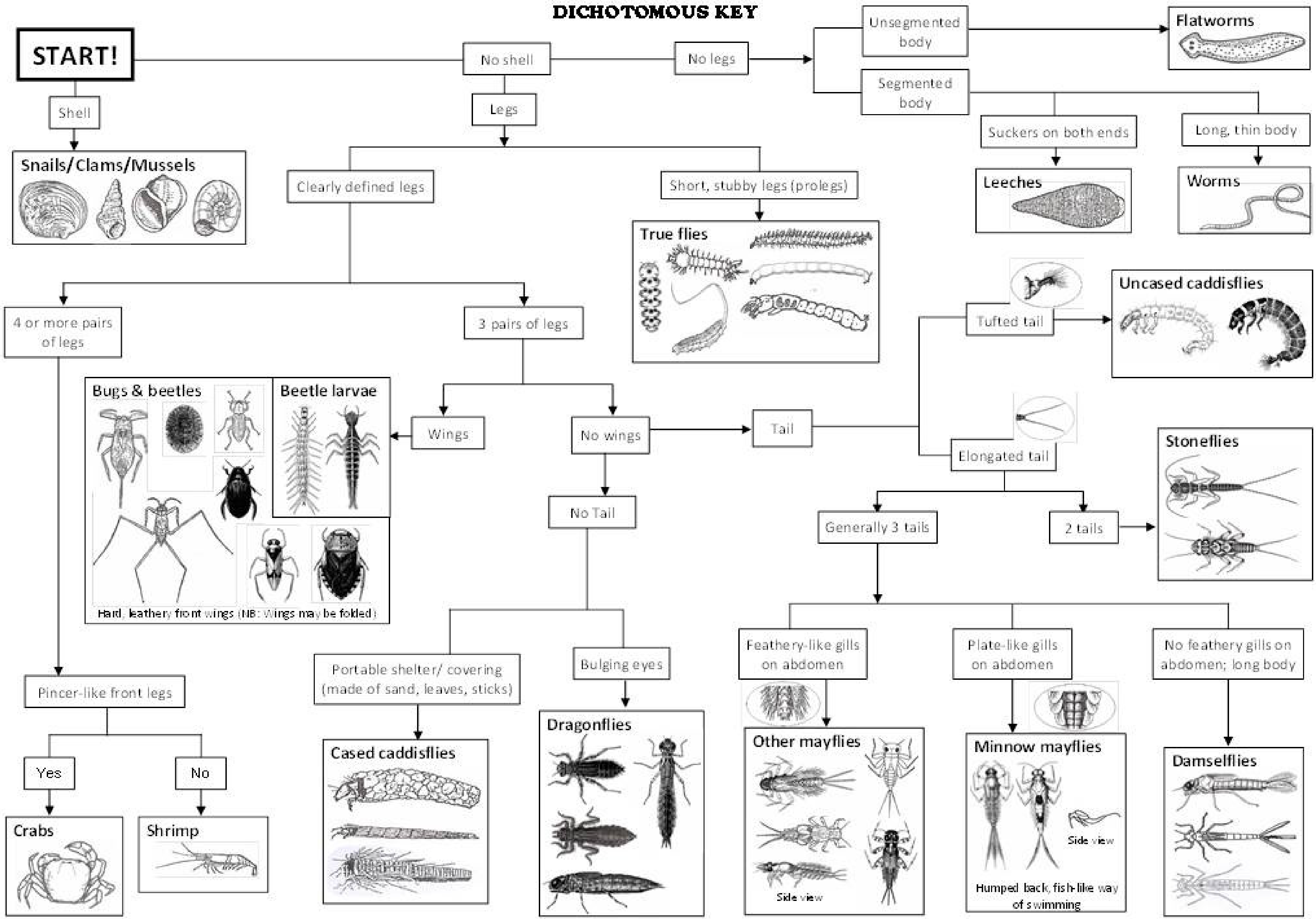
SMALL WATER ANIMALS

The Fieldwork Modules in Section B, C and D refer to one or more of the Identification Keys in this Appendix.

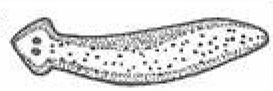
Why not look at them all and decide for yourself which would be most suitable for your learners and for your own fieldwork site?

Why not make your own identification sheet to include examples of the most commonly seen wetland birds, animals, reptiles and insects?

Water Creatures – Macro Invertebrates

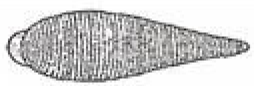


Flat worms



Flat worms are characterised by their flattened shape and soft bodied, worm-like form. They have an arrow-shaped head with two dorsal eyespots and are generally mottled or dark grey in colour. Flat worms move with a gliding action and are generally scavengers or carnivores.

Leeches

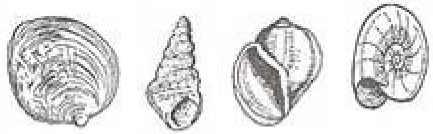


Leeches are segmented organisms that have very flexible bodies. When moving they expand to become long and thin, and then contract to become short and stubby. They have suckers on both ends of the body used for feeding and locomotion. Leeches are variable in colour, from grey, to red-brown and black. They swim with a fast, snaking movement and are found under stones, vegetation and debris.

Worms

Worms are long and segmented, with a cylindrical shape much like small earthworms. Their colouring is usually pink to brown. They are usually seen writhing around in debris, digesting the substrate they fed on.

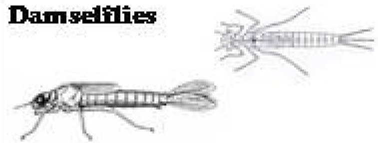
Snails / Clams / Mussels



Snails are molluscs with hard shells that vary in size, shape and colour. Habitats vary, with some snails, such as limpets, clinging to rocks, whereas clams and mussels are found in sand. The more common snails move over stones and vegetation. Some snails are host to bilharzia, a serious health hazard for humans.

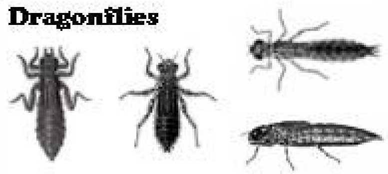
Images not to scale

Damselflies



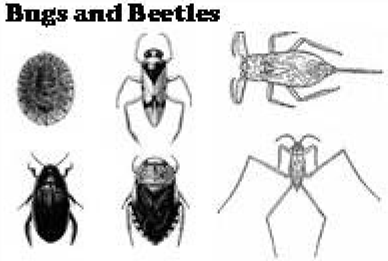
Damselflies have elongated bodies generally with three broad tails/gills on the tip of the abdomen. Damselflies are carnivorous and have a 'mask' over the lower part of the face, which hinges out to reveal a pair of pincers used to catch their prey. They are often found in vegetation growing on the edges of rivers.

Dragonflies



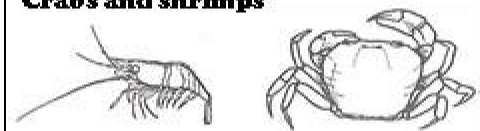
Dragonflies are robust creatures that are stout and have a large head and protruding eyes. Some have short legs whilst others have long legs. They do not have tails, but swim using 'jet propulsion' by forcefully ejecting water from the abdomen. Dragonfly nymphs are usually the largest organisms found in a sample and are the most powerful invertebrate predators in the water.

Bugs and Beetles



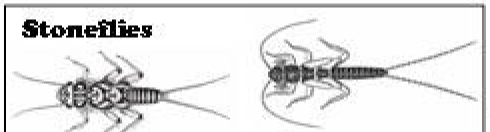
Bugs can be defined as having a piercing and sucking beak for mouthparts, and two pairs of membranous wings. Beetles on the other hand have 'jaws' and outer wings that are hardened to protect the inner wings. Some bugs and beetles are well adapted to swimming, such as water boatmen, backswimmers, pond skaters and water striders. Most bugs and beetles are carnivorous, but some feed on algae.

Crabs and shrimps



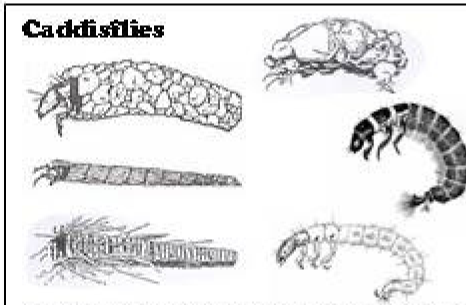
Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs. Their eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the chance. Shrimps are mostly scavengers or deposit feeders.

Stoneflies



The nymphs of adult stoneflies usually have two long tails and three pairs of legs, each having two claws at the tip. A characteristic feature of stonefly nymphs are the tufts of gills on the side of the body as well as gills between the two tails. Wing pads on the thorax are often dark and obvious. Some species run across the substrate very efficiently and are potent invertebrate predators. Other species are smaller and feed on plant material. Most live in well-oxygenated, clean water.

Caddisflies

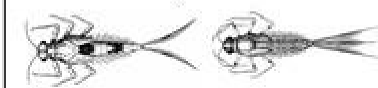


The aquatic larvae of adult caddisflies have a hard head with three pairs of legs attached to an elongated, soft body. Finger-like gills on the abdomen and anal appendages can be seen with the naked eye. Some caddisflies construct portable shelters from sand grains, bits of vegetation and/or silk that are glued together to form a characteristic case shape. Most case-building types cannot swim whereas the caseless types swim freely across the substrate. Some feed on algae and detritus whereas others are predators.

Mayflies

Mayfly nymphs vary greatly in shape and size and can survive for months in the water. However, the adults only live for a day or two. In this time, adults never feed, only mating and lay eggs in the water.

Minnow mayflies

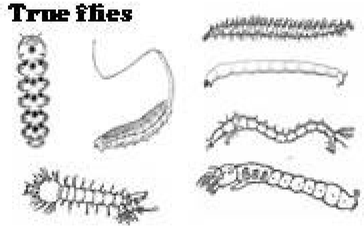


These mayflies have a narrow head and a small, slender, but not flattened body. They have leaf shaped gills on both sides of the abdomen and two but more commonly three tails, depending on the species.

Other mayflies

Other mayflies are characterised by an elongated body, large head, well-developed mouthparts and stout legs. They live in a variety of habitats, including burrowing in mud, crawling amongst decaying leaves, and scurrying over stones in fast flowing water.

True flies

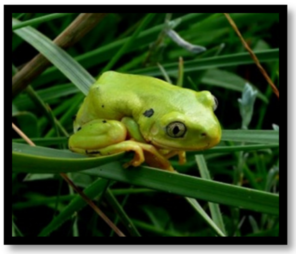


Most fly larvae have a fairly indistinct head but elaborate tail ends. They often have small, soft legs (prolegs), segmented bodies and have the appearance of maggots. Some have bristles/spines and antennae. True flies live in a variety of habitats including sand, mud and stones in fast flowing water. They can either be carnivorous or filter feeders.

Images not to scale

Amphibians of Wetland Systems

	Cape Caco *(Cacosternum capense)*	This frog is an endemic South African species that occurs in wetlands.
	Common Caco *(Cacosternum boettgeri)*	Also known as Boettger's Dainty Frog, it lives in marshy areas.
	Flat Back Toad *(Amietophrynus maculatus)*	This toad has very prominent warts and it's colour varies. They are associated with water because they breed in shallow water. They are usually nocturnal unless there has been heavy rainfall.
	East African Puddle Frog *(Phrynobatrachus acridoide)s*	This frog is very well adapted to many different environments, including wetlands. It is usually found in puddles but also in swamp-type environments.
	Natal Sand Frog (Tomopterna natalensis)	This species is found in many different habitats including wetlands. These frogs sit on exposed mud or rocks near water and call.

	<u>Greater Leaf-Folding Frog</u> *<u>(Afrixalus fornasinii)</u>*	This frog grows to a maximum of 4cm but has a very prominent stripe pattern so it can be easily identified.
	<u>Long Toed Tree Frog</u> *<u>(Leptopelis xenodactylus)</u>*	This species is endemic to KZN; it perches on grasses during misty/rainy conditions.
	<u>Natal Leaf Folding Frog</u> *<u>(Afrixalus spinifrons intermedius)</u>*	This species inhabits wet areas, usually dams and ponds but it is possible to find this frog in wetland environments. It is bright yellow and covered in tiny black spines.
	<u>Natal Puddle Frog</u> *<u>(**Phrynobatrachus natalensis**)</u>*	This frog is covered in warts. It occurs in a variety of places and habitats including wetlands.
	<u>Cape River Frog</u> *(Amietia fuscigula)*	This frog occurs in wetlands and can grow to a length of approximately 12 cm.

	Clicking Stream Frog *(Strongylopus grayii)*	Despite the name, this frog is a relatively common wetland species.
	African Bullfrog *(Pyxicephalus adspersus)*	This is one of the most iconic frogs in South Africa. It is a carnivorous frog that eats small rodents, birds and other amphibians.

Fish of Wetland Systems

	Sharptooth Catfish *(Clarias gariepinus)*	This species is well adapted to a live in wetlands because it has the ability to survive in shallow mud during dry periods. It feeds on living and dead animals.
	Large Mouth Bass *(Micropterus salmoides)*	Although this fish is an introduced alien species and its main habitat is dams, its preferred habitat is reed beds which creates the potential for it to occur in wetland systems.
	Small Mouth Yellowfish *(Labeobarbus aeneus)*	This species occurs predominantly in river systems but it is a highly adaptable, tolerant species, so it should be noted that it is possible to find them in wetland systems.

		
	<u>Mozambican Tilapia</u> <u>*(Oreochromis mossambicus)*</u>	This fish feeds on invertebrates, diatoms and algae.
	<u>Vlei Kurper</u> <u>*(Tilapia Sparrmanii)*</u>	The Vlei Kurper is the prey of bass in South Africa. Its population does extremely well in water with abundant vegetation.
	<u>Longfin Eel</u> <u>*(Anguilla Mossambica)*</u>	This eel lives between rocks and in soft sediment. It feeds on crabs, fish and frogs.
	<u>Chubbyhead Barb</u> <u>*(Enteromius Anoplus)*</u>	This fish lives in shoals; it inhabits small streams and feeds on invertebrates.
	<u>Straightfin Barb</u> <u>*(Enteromius Paludinosus)*</u>	The Straightfin Barb lives in slow flowing water, its colour varies but usually look silver. The female lays eggs in surrounding vegetation.

	Moggel *(Labeo Umbratus)*	Moggels feed on soft sediments. It lives in very slow/still water.

Edition – October 2015

Appendix Three
Larger Animals of Wetland Systems

This is a product of The Water Research Commission: Project No. K5/2350

APPENDIX THREE

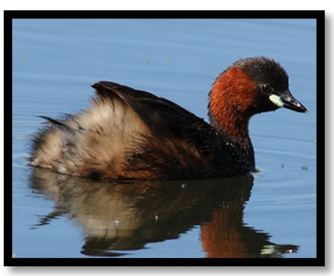
LARGER ANIMALS OF WETLAND SYSTEMS.

For details of websites that you might find useful please refer to:

Section E: Appendix **USEFUL EXPLANATIONS, E-REFERENCES & APPENDIXES**

Birds of Wetland Systems

	Egyptian Goose (*Alopochen aegyptiaca)*	This species is adapted to living in wetlands because it has webbed feet for swimming and water resistant feathers (as do many other geese and ducks). It is a common bird and is often spotted both in the water and on land.
	Grey Heron (*Ardea cinerea*)	This species is perfectly adapted to wetland environments because it wades in shallow water and feeds on frogs, crabs, fish and other small animals. It is often seen standing very still while hunting or wading through shallow water.
	Pied Kingfisher (*Ceryle rudis*)	This species is well adapted to most fresh water environments as it feeds on small fish and large crustaceans. It is known for its distinctive diving action when catching its prey.
	Red-Knobbed Coot (*Fulica cristata)*	This species is very territorial. Although it spends most of its time on the water it also occupies nesting spots in the reeds. It has lobed toes which allow it to walk on muddy banks.

	Red Bishop (*Euplectes orix*)	Wetlands are important to this species because it breeds in the reeds of wetlands and is extremely distinctive because it is so bright in colour during this time. Red bishops live in flocks so it is uncommon to see one on its own.
	Great White Egret (*Ardea alba*)	This species breeds in trees close to reed beds or large wetlands. It feeds on fish, frogs and small mammals. Its long legs are adapted well to a wetland environment as they allow the bird to walk through the water with ease.
	Little Grebe (Dabchick) (*Tachybaptus ruficollis)*	This species spends a lot of its time feeding on small fish and invertebrates in open water but is very skilled at hiding in the reeds. It is unmistakable as it resembles a very small duck.
	Reed Cormorant *(Microcarbo africanus)*	The Reed Cormorant is also known as the Long-Tailed Cormorant. This species is a lot smaller than the well-known White Breasted Cormorant and not as distinctive. It may have slight colour variations but its size and behaviour make it easy to identify. It will often be seen with its wings held out to dry (this is typical Cormorant behaviour). It breeds in freshwater wetlands.

 	<u>Little Bittern</u> *<u>(Ixobrychus minutus)</u>*	This species is part of the heron family but is very small. It is a relatively uncommon wading bird, the juvenile is more heavily streaked then the adults. This bird feeds mostly on water insects. Little Bitterns occur mostly in thick vegetation on the edges of freshwater wetlands.
	<u>Hamerkop</u> *<u>(Scopus Umbretta)</u>*	This species is not necessarily classified as a water bird but it requires a habitat with water availability at all times which makes wetlands the perfect environment for it. It feeds mostly on amphibians and nests in trees or cliffs near water.
	<u>African Fish Eagle</u> *<u>(Haliaeetus vocifer)</u>*	This Iconic African species is found at all types of water bodies and its most preferred materials for nest building are bulrush and papyrus so wetlands are an ideal habitat for this bird. They feed on fish.

	African Black Crake (*Amaurornis flavirostra*)	This species is most suited to a wetland environment although it does occur on the edges of rivers and dams as well. Its' diet consists mainly of water insects, molluscs, crustaceans and the seeds of wetland plants.
	African Jacana (*Actophilornis africanus*)	This species prefers wetlands because there are floating plants for it to walk on, this is where an African Jacana spends most of its' time.

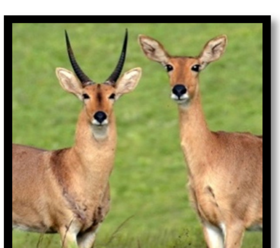
Reptiles of Wetland Systems

	Common Brown Water Snake *(Lycodonomorphus rufulus)*	This snake is a very skilled swimmer. It feeds on tadpoles, small fish and rodents.

	Marsh Terrapin *(Pelomedusa subrufa)*	The Marsh Terrapin (also known as the African Helmeted Turtle) inhabits any wet environment. It feeds on water vegetation, insects and frogs. They are often seen sunning themselves on rocks in the water.
	Water Leguaan *(Varanus niloticus)*	Wetlands are perfectly suited to this species because it lives a semi-aquatic life. This species will eat anything available but they have special appetite for crocodile eggs.
	Green Water Snake *(Philothamnus hoplogaster)*	This snake feeds on frogs, fish and lizards. The Green Water Snake occurs where there are reeds.
	Black Water Snake *(Lycodonomorphus laevissimus)*	The Black Water Snake (also known as the Dusky Bellied Water Snake) has a very bad temper. They occur in wetlands and moist savanna and they feed on frogs and fish.
	Serrated Hinged Terrapin *(Pelusios sinuatus)*	This terrapin secretes a nasty smelling odour when it feels threatened. It eats snails, insects and water plants.

Mammals of Wetland Systems

	Greater Cane Rat (*Thryonomys swinderianus*)	The Greater Cane Rat is one of the largest rodents in South Africa. They occur in grasslands but also marshy areas and reed beds.
	Southern African Vlei Rat *(Otomys irroratus)*	As the name suggests, this rat inhabits damp vleis. The live in the grass on the edge of wetlands and the feed on the grass.
	African Water Rat (*Colomys goslingi*)	This rat eats mostly crustaceans, it spends most of its time in shallow water with its muzzle under water waiting and watching for food.

	Swamp Musk Shrew *(Crocidura mariquensis)*	This species occurs in marshy environments and feeds mostly on snails and termites. Because shrews are so small they are very hard to see in amongst the grass.
	Cape Clawless Otter *(Aonyx capensis)*	This otter occurs near water bodies, with particular preference to reed beds. It feeds on crustaceans and small fish. They are very well adapted to water because they are streamlined and have webbed feet.
	Water/Marsh Mongoose *(Atilax paludinosus)*	This is a large mongoose that lives in semi-aquatic environments and feeds on small water animals. It also has non-retractable claws which make it easy to catch prey.
	Common Reedbuck *(Redunca arundinum)*	As the name suggests, Common Reedbuck inhabit environments where there are reeds/long grass, wet grassland is optimum. They are grazers and a nearby or permanent water source is a necessity for this species.

	<u>Serval Cat</u> *<u>(Leptailurus serval)</u>*	This species is a solitary animal. Although Serval Cats are not wetland animals, they should be noted because their habitat needs to include a water source and they often prey on animals that do inhabit wetlands. So it is not uncommon to see one in or near a wetland.

Glossary of Terms

ΔH: Change in height (delta H)

Active Learning: Using activities to learn themes in classroom learning areas

Adaptation: The process of an organism becoming better suited to its' environment

Aerial Photograph: A photograph taken from the air (e.g. from an aeroplane), useful when looking at river systems

Algae: A typically aquatic, non-flowering plant

Amphibian: A cold blooded vertebrate (i.e. Frogs)

Anoxic water: Water that contains little to no oxygen

Aquatic: Anything relating to water (e.g. aquatic species: a species that live in water)

Atmosphere: Refers to the gases that surround the earth

Awareness Programmes: A programme aimed at sharing general information through workshops and the distribution of literature

Beaufort scale: A scale measuring wind speed, ranging from 0-12

Bio-monitoring: The monitoring of life

Biome: A large area of naturally occurring species in that habitat (e.g. forest, desert, etc.)

Biodiversity: The diversity of species in an area

Biosphere:	Refers to the all parts of the earth where living organisms exist
Botany:	The scientific study of all aspects of plants
Canal:	A channel of water
Catchment:	An area where water collects
Citizen Science:	Scientific research conducted, in whole or in part, by amateur or nonprofessional scientists. In past times this usually referred to adult members of society, but today it is acknowledged as a science that may involve ‘citizens’ of any age
Classification:	The way species are classified into their taxonomic groups
Clay:	A very fine, firm type of soil that can be easily moulded when wet
Clay content:	The amount of clay present in soil
Climate:	Weather conditions and patterns in an area over long period of time
CO_2	Carbon Dioxide
Conservation:	The prevention of the decay, waste, destroying or loss of an environment or species
Community based learning:	The process of combining classroom learning objectives with improving life in a community
Co-production:	A way of social learning through the gaining of information and experiences
Decaying:	The process of rotting or decomposing with assistance from bacteria and/or fungi
Discharge:	The volume of water flowing through a river channel

Eco-tourism:	Tourism that is directed at contributing to conservation
Ecological services:	Benefits that come from healthy ecosystems that can benefit all living organisms
Ecology:	The relationships between organisms, each other and their surroundings
Ecosystems:	A community of different species in an environment
Endangered:	A species that is under threat of possibly being killed off
Environmental management:	The management of human impact on the environment
Extinct:	No longer an existing species
Evaporation:	Water loss through absorption by heat or air.
Fieldwork Toolkit:	A document that is a guideline with regards to possible field work activities
Flood:	Flow of water that is beyond the water sources' natural limit
Flow:	The steady, continuous movement of a current
Food chain:	A chain of organisms where each is dependent on the next for food
Food web:	A system of interconnected food chains
GIS (Geographic information system):	A system used to capture, store, manipulate, analyse, manage, and present spatial/geographical data.
Geography:	The study of place and its characteristics/relationship
Gley soil:	A layer of sticky, clay type soil that often forms beneath water logged soil
Global:	The whole world

Graphicacy:	The understanding that a person has for maps/graphic representation
Groundwater:	Water that is stored underground or in spaces (pores) inside rock
Habitat:	An environment where a species exists in a natural way.
Hand lens:	Magnifying glass type device, usually plastic and made for children
Hydrosphere:	The water that is present on and over the earth's surface (includes clouds)
Hygrometer:	An instrument used to measure the humidity of the air
Identification key:	A device/document that aids the identification of a species
Igneous rock:	Rock that is formed by the cooling and solidifying of magma/lava
Impervious rock layer:	A layer of rock that cannot be penetrated/influenced by rain
Indicator:	A sign
Indicator species:	Species that are sensitive to certain aspects and so they can be an indicator of the state of an area/specific site
Indigenous Knowledge:	Knowledge acquired by our forebears. It often shows unique understandings of the natural environment.
ICT (Information communication technology):	Includes all types of communication devices
Impermeable:	A substance that liquid cannot pass through
Invertebrate:	Organisms with no backbone
Larvae:	The immature from of an adult insect

Literacy:	The ability to read and write
Lithosphere:	Refers to the soil and rocks of the earth
Macro-invertebrates:	Invertebrates that can be seen with the naked eye
Mammals:	Warm blooded animals
Microorganisms:	An organism that is microscopic
miniSASS:	A tool based on the stream assessment scoring system (SASS) that uses bio-monitoring to measure the health of a river
Mottled soil:	Mottling refers to the specks (usually orange) in a soil, this is caused by iron and/or anaerobic conditions
Natural phenomena:	Any event that is not manmade
Natural Resources:	All kinds of supplies that nature provides for animal and human consumption
Niche:	The place within an ecosystem that a particular species is perfectly suited/adapted to
Numeracy:	An understanding on numbers and the ability to work with them
O_2	Oxygen
Oracy:	The fluency of a person’s speech and ability to express themselves
Organic material:	Natural matter that is a result of the remains of plant/animal matter
Organism:	A living thing
Orthophoto map:	An aerial photo that has been manipulated to create a map

Oxygenated water:	Water containing high levels of oxygen
Parasites:	Living organisms that live or feed on others
Pilot project:	Test project for trying out something in order to learn from it
Process skills:	Using our senses to make observations and gather information
Quadrant	A square marked off on the ground with the purpose of defining the research area
Relief:	The difference in elevation on the earth's surface
Respiration:	The process of taking oxygen in and releasing carbon dioxide (breathing)
River health index:	An index on which to measure the health of a river
River studies:	Activities related to rivers and learning about rivers
Rubric:	A set of marking guidelines
Sedimentary rock:	Is formed by the collection of particles, often carried by water bodies
Silt:	Very fine sand or other material in flowing water that is deposited as a sediment
Soil conservation:	The prevention of soil erosion and/or other processes that reduce the fertility/productivity of the soil
Soil texture:	The look and feel of the soil determined by the size and type of soil particles
Soil triangle:	Used to classify soil by using the proportions of sand, silt and clay in the soil
Species:	Various kinds of organisms

Strategy:	A method of doing something
Stream bed:	The bottom of a stream channel
Stream flow:	The volume of water (discharge) that moves over a specific point for a certain amount of time
Stream velocity:	The speed at which the water in the stream is flowing
Sustainability:	That which enables something to last a long time
Sustainable development:	Economic development that is achieved without causing any depletion of natural resources
Table of velocities:	A table where ΔH can be looked up and the corresponding velocity determined
Taxa:	Plural of taxon, is the classification of a group of animals (i.e. A species)
Taxonomy:	The way species are classified in the scientific world
Template:	A document containing a format that can be used as a reference for planning
Threatened:	Species that are under threat of being killed off
Topographic map:	A map representing relief using contour lines
Transparent velocity head rod:	A tool that can be used to measure the velocity of a stream
Turbidity:	The measure of water clarity with relation to suspended particles
Velocity:	The speed of water in a specific direction
Vlei:	An area of very slow flowing water
Water clarity tube:	A tool used to measure the clarity of water
Waterborne:	Something that is carried by water

Water life:	Animals that live in water
Water resources:	Water sources that are useful or potentially useful in any way/for any activity
Water security:	The ability to access reasonable quantities of clean water to maintain life, production, sanitation, etc.
Water quality:	The measure of the condition of water in terms of the requirements of the species relying on the water source (animals, plants and humans)
Water quality audit:	The process of investigating/studying, done at the water source to determine how healthy the water is
Water quantity audit:	The process of determining the amount of water that is being used and wasted. A water audit kit is supplied to do a water quantity audit
Wetland:	An area the is wet the whole year of most of the year round, wetlands are very specialised environments
World wetlands day:	The day that marks the signing of the convention on wetlands – It is celebrated on the 2nd of February every year