Learning and Teaching About Water in our Classrooms:

A Series of Lesson Plans for Grades 8 -10

Clare Peddie,
Debbie Hibbert &
Caroline Conway-Physick

TT 346/08

Water Research Commission

LEARNING AND TEACHING ABOUT WATER IN OUR CLASSROOMS:

A SERIES OF LESSON PLANS FOR GRADES 8 - 10

Report to the
Water Research Commission

by

Clare Peddie[1], Debbie Hibbert[2] and Caroline Conway-Physick[3]

[1]Share-Net, Wildlife and Environment Society of South Africa (WESSA)
[2]Independent consultant
[3]WESSA/WWF Eco-Schools Programme

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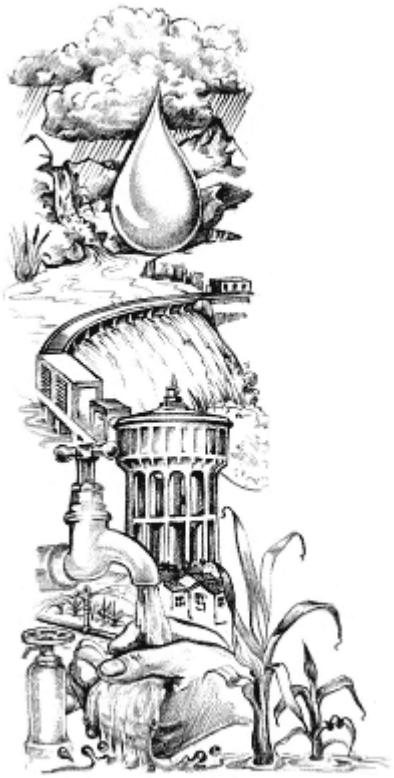


South Africa is extraordinarily rich in natural resources – except for water. Water is a vital but scarce resource, distributed unevenly in time (frequent droughts alternate with periods of good rainfall) and space (the eastern half of the country is markedly wetter than the western half). Increasing demand for water, and decreasing water quality, make careful water management a priority in our country. It has been estimated that by the year 2025 South Africa's human population will have doubled, and there will not be sufficient water for domestic use, agriculture and industry.

Our average rainfall is less than 500 mm a year. The driest part of the country receives less than 200 mm a year and the wettest part receives more than 2 500 mm a year! Rain does not always fall where it is most needed, and some areas of high demand, such as Gauteng, receive less water than they need. Most rain falls in a narrow belt along the eastern and southern coasts. The rest of the country receives only 27% of South Africa's total rainfall. In addition, hot dry conditions result in a high evaporation rate.

Water is thus a very scarce resource in South Africa.

In support of learning and teaching about water and water-related issues, the Water Research Commission of South Africa and Share-Net (a project of the Wildlife and Environment Society of South Africa) have developed a series of lesson plans on water. These lesson plan packs, from Grade R to Grade 10, are linked to the South African National Curriculum.

Each pack contains five lessons, with each lesson focusing on a different learning area – these can either be used as they are, or adapted to suit the local context. Each lesson is concluded with a rubric of criteria to assess the learners. Learning Outcomes and Assessments Standards covered during each lesson are given in the summary at the beginning of the pack.

Did you know?

- the Northern Cape receives very little rain and many of the people living there rely on groundwater;
- the Western Cape, south western Cape and KwaZulu-Natal are areas with many RAMSAR wetland sites;
- the Free State is home to one of the most important river catchment areas in the country.

Use the map on the following page to, wherever possible, contextualise your lesson plans – in other words, if you live in the Northern Cape, bring groundwater and evaporation issues into your lessons, if you teach in KwaZulu-Natal or the Western Cape, wetlands could form the focus areas of your teaching lessons.

All these lesson plan packs are available on www.envirolearn.org.za Other useful websites are the Water Research Commission's website www.wrc.org.za and the Wildlife and Environment Society of South Africa's website www.wessa.org.za

WESSA

Share-Net

Water use at home, school and in our community

Share-Net

This pack supports an introduction for learners to an Eco-School's focus on resource management

Grade 8

This pack contains:

Activity One: This **SOCIAL SCIENCES : HISTORY** reading and questioning activity looks at early Nguni people of southern Africa and their commonsense ways of collecting and storing "sweet" water.

Activity Two: In this **ARTS AND CULTURE** activity, learners conduct interviews in their local community and then share their findings with the rest of the class in small group role-plays.

Activity Three: This **NATURAL SCIENCES** activity allows learners to prepare for a water audit, collect data in and around their home, school and community and then develop a school water-wise management plan.

Activity Four: This **LANGUAGES** lesson encourages learners to investigate an environmental situation and debate, discuss and communicate their ideas.

Activity Five: This **TECHNOLOGY** and **NATURAL SCIENCES** activity can be used to highlight different phases of water as well as the outcomes of what occurs when water changes phase. This activity can be done in the classroom or learners could try it out at home.

WESSA

This pack of lesson plans is part of a series of lesson plans from Grade R to Grade 10 which focus on water and water-related issues. This resource development project has been funded by the Water Research Commission, Private Bag X03, Gezina, Pretoria, 0031 (Website: www.wrc.org.za).
This pack is available electronically on www.envirolearn.org.za

Activity	Learning Area covered in this activity	Learning Outcomes covered in this activity	Assessment Standards covered in this activity
1. This reading and questioning activity looks at early Nguni people of southern Africa and their commonsense ways of collecting and storing "sweet" water.	Social Sciences: History	**Learning Outcome 1:** Historical Enquiry: The learner will be able to use enquiry skills to investigate the past and present. **Learning Outcome 2:** Historical knowledge and understanding. The learner will be able to demonstrate historical knowledge and understanding.	• Evaluates the source used (e.g. 'Who created the source?', 'Is it reliable?', 'How useful is the information?' [works with sources]. • Explains changes in a wider historical and environmental context [change and continuity].
2. Learners conduct interviews in their local community and then share their findings with the rest of the class in small group role-plays.	Arts and Culture	**Learning Outcome 2:** Reflecting: The learner will be able to reflect critically and creatively on artistic and cultural processes, products and styles in past and present contexts.	• Uses the Arts to demonstrate an awareness of environmental concerns. **Drama:** • Researches human rights and environmental issues and interprets these in small group role-plays.
3. Learners prepare for a water audit, collect data in and around their home, school and community and then develop a school water-wise management plan.	Natural Sciences	**Learning Outcome 3**: Science, Society and the Environment: The learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and the environment.	• Understands sustainable use of the earth's resources: Identifies information required to make a judgement about resource use. (e.g. Plans and carries out an audit of all uses of water around the school premises and develops an implementation plan to improve water management at school.
4. This lesson encourages learners to investigate an environmental situation and debate, discuss and communicate their ideas.	Languages	**Learning Outcome 2:** Speaking: The learner will be able to communicate confidently and effectively in spoken language in a wide range of situations.	• Communicates ideas, facts and opinions on challenging topics clearly and accurately and with a greater degree of coherence, using a range of factual oral text types (e.g. discussions, debates). • Demonstrates a range of interaction skills by participating actively in group discussions, conversations, debates and group surveys and while doing so: tackles important issues; acknowledges others' opinions and disagrees politely when necessary; motivates own point of view; gives and receives criticism. • Persuades others.
5. This activity highlights different phases of water as well as the outcomes of what occurs when water changes phase. It can be done in the classroom or learners could try it out at home.	Technology and Natural Sciences	-	-

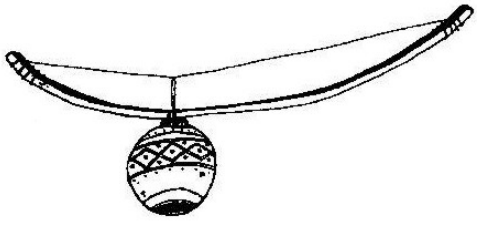
ACTIVITY ONE: SWEET WATER AND EARLY NGUNI PEOPLE

This SOCIAL SCIENCES : HISTORY reading and questioning activity looks at early Nguni people of southern Africa and their commonsense ways of collecting and storing "sweet" water.

(In the story that follows, comments and scientific observations are in brackets and italised so that the learners can see the practical wisdom behind some water collection myths and techniques of the past).

Before the time of the Zulu King, Shaka, sweet water was called "amanzi amnandi". Shaka's mother was called Nandi and it is said that because it was not considered respectful to use the queen mother's name in this way, Shaka referred to sweet water as "amanzi amtoti". *(This is how the town of Amanzimtoti, south of Durban, got its name).* Today both terms are used and many people of Nguni origin will sniff, smile and hold up "sweet" water, collected from a river, spring or well for their daily household needs. *(Water quality scientists today still have people smell and taste household water. Human senses give a refined indication of whether water is good and clean and fresh).*

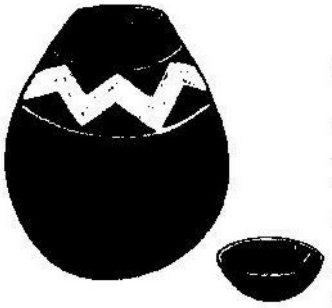
Historically, water was usually collected in areas where people could hear it running over stones or dripping down rocks *(well oxygenated water supports natural biological cleansing processes).* If a spring was for human use, it was protected by a circle of rocks with a small outlet. Cattle drank elsewhere.



An area nearby was cleared and the site soon became a meeting place for young people. Young men would hang around these water collection sites, playing musical instruments and admiring the maidens who came to collect water. The girls would saunter along slowly and gracefully, singing and flirting. Water collecting was rarely seen as a tiring or boring chore because of the prospect of courtship!!

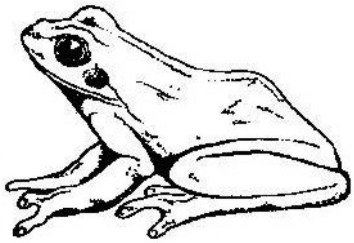
A water source would always be approached with care so as not to frighten crabs and other small water animals. When disturbed, their movement would stir up sediments and the collector would have to wait for the silt to settle. The surface film was brushed aside for "sweet water" to be collected. *(Sediments*

and surface films have higher bacteria numbers than the middle waters of pools and rivers. Today scientists take water samples below the surface film, taking care not to suck up sediments. In this way, scientists can get consistent and reliable measures of bacterial contamination).

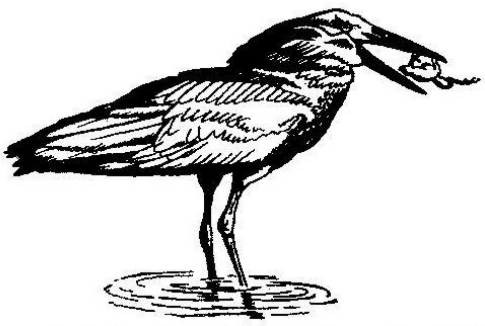


Clay pots were filled with water and covered with a collecting bowl, a piece of skin or a mat made from incema (*Juncas kraussii*) grass. The water would thus stay cool and fresh. *(Water evaporating through the sides of a porous clay pot cooled the contents. Most water bacteria cannot reproduce in cool, dark conditions. Some micro-organisms envelop themselves in a calcium secretion in the pores of clay pots. Scientists spoken to were uncertain about the detail of these issues but it is of note that, in earlier times, great care was taken to scour out a calcium-like scale in water pots. Also of note is that when the grass "lids" and head rings for carrying pots became old they were simply thrown away and new ones were woven. Discarded lids did not pollute the river like today's bottle tops and plastic waste).*

There were many other customs and traditional practices surrounding water. Children were warned that urinating in a river would change them to the opposite sex! *(This myth was probably sufficiently frightening to prevent people urinating in streams and rivers. This would have limited a disease like bilharzia. The bilharzia parasite is passed on from human urine and faeces to small water snails. From these, its life cycle takes the disease back to people through river water).*



Nguni water collectors say that where there are frogs, one does not find sweet water. Frogs are eaten by hammerkops (*uthekwane*, the "lightning bird") and the prospect of collecting water while being watched by a "witch-bird" must have been terrifying in earlier times when spirits, myths and mystery had a more central place in everyday social life. Children were told that if they killed this bird or stole its eggs, their homes would go up in flames. *(Where there are frogs, one will usually find snakes. Both animals are feared by many people today, not least the children who were told the Nguni myths of witches and lightening to fill their hearts with terror. Today, scientific tests suggest that many frog species need "sweet water" if they are to live and reproduce successfully. There must be some doubt about the Nguni suggestion that frogs are an indication of water that is not fit for human consumption).*



It is also said that it was not advisable to collect water from a river after heavy rain at the start of the annual rainy season. Indigenous commonsense told

people to put out pots to collect rain-water. River water would again be collected four days after the rains stopped and the water had cleared. *(Heavy rains wash human and animal wastes into rivers. There is thus a rapid increase in faecal bacteria and disease. In KwaZulu-Natal, health workers have to warn rural people not to collect river water after heavy rains as few remember the earlier Nguni practice of collecting rain-water only four days after the rains have stopped).*

Today human and livestock numbers have increased vastly, catchments have become degraded and rivers are often polluted dumping places. The best indigenous practices for the collection of "sweetwater" may not prevent people getting serious diseases from river water. Learning about historical water collection and storage practices can, however, develop a respect for early people and might also help our understanding of water quality issues.

Read the story of 'Sweet Water and Early Nguni People' to the class or make photocopies and allow the learners to read it on their own.

As a class, discuss the following questions:

1. How many of you have collected water from a nearby river? What was the water used for? (If for drinking, how were you certain that it was safe to drink?)

2. How many of you have heard the story that has just been read? Who told you this story?

3. Do any of you have stories of other ways of collecting water long ago?

4. Many stories from long ago are passed down orally from one generation to another. One does not find them written down in books and one has to ask the older people in a community who may remember how things were done long ago. How reliable is this information? What is the danger of not writing down stories from different cultures?

5. Why do you think it is important to look after our rivers and streams?

6. Does the class think that rivers and streams throughout South Africa have changed over the last 100 years? In what way? Why? Have any of you seen changes taking place in a river in your life-time? *(Keen young fishermen in the class may have noticed a decrease or increase in fish species and a change in the water quality or path of the stream/river).*

7. How can we find out what the rivers, streams and other water sources were like in our own community 50 years ago so that we can compare them with what we see today?

Criteria to assess learners during this social sciences: history lesson

Criteria	Exceeded requirements of the Learning Outcome	Satisfied requirements of the Learning Outcome	Partially satisfied requirements of the Learning Outcome	Not satisfied requirements of the Learning Outcome
The learner was able to discuss how reliable and useful stories told by older members in the community were (question 4)				
The learner was able to give reasons why we should conserve and look after our rivers and streams (question 5)				
The learner was able to discuss possible or real changes that have taken place in rivers or streams (question 6)				

ACTIVITY TWO: LOCAL INTERVIEWS, INDIGENOUS STORIES AND CATCHMENT HISTORY

In this ARTS AND CULTURE activity, learners conduct interviews in their local community and then share their findings to the rest of the class in small group role-plays.

A watershed and its catchment is the land from which rainwater flows into wetlands, streams or rivers.

Many of the river catchments of southern Africa have been changed by historical land use practices, settlements and industrial growth to cater for a rapidly expanding population. In many cases, wetlands have been destroyed and riverine vegetation removed, decreasing natural flood control so that the amount and quality of water released by our river catchments is decreasing.

Interviewing local people and collecting stories can develop a sense of how things have changed. Local information and stories are essential for our understanding of local water quality issues.

ACTIVITY

- In small groups of 4 or 5, the learners must work out a set of questions to ask local people, particularly older folk, who have lived in the area for many years.

Some ideas for questions for older people could be:

1. How long have you lived here?
2. Have you noticed any changes, since you were young?

3. What are these changes?

4. How did you collect water long ago?

5. Have you noticed any change in the water? Quality? Amount of water?

6. Have you noticed any changes in the amount of rain that falls?

7. Do you know any local stories about water? (Or animals linked to water?)

Learners also need to work out another set of questions about the present conditions of their catchment and possible problems. These questions can be asked to their friends, parents and other members of the community.

1. How long have you lived here?

2. Where do you get your water?

3. Have you noticed any problems with the quality of water here, in this community? What are these problems?

4. Are the streams and rivers clean in this area? Can one drink from them?

5. Is the community involved in any river clean-up / alien plant eradication projects that you know of?

NB: Only use the questions above if learners are struggling to work out their own sets of questions

Time needs to be set aside, either during or after school, to conduct these interviews, using the questions prepared during the lesson. These local interviews will give the learners information on water and the water quality situation both in the past and today.

And now … it's time for some drama in our lives!!

What is role-play?

We use role-play to explore different situations and ideas. This is done by acting out a usually authentic situation, without a script.

Now that the water quality and catchment interviews have been completed, each group will role-play their experiences of:

- Deciding what questions the group was going to ask the interviewees;
- Deciding who they were going to interview;
- The interviews themselves;
- Some of the funny/sad/interesting/unusual things that may have happened during the interviews;
- Their interactions with one another during this activity – any conflicts that arose, any differing of opinions (how they were sorted out, or not!), any laughs and good times.

One of the first tasks of the role-play is for each group to decide who are the different characters involved. It is a good idea to use simple props for each character (such as a hat, wig, jacket or jewellery to help characters get into their 'role').

Role-play is a fun way of exploring environmental issues and concerns. At the end of the role-plays, a list of all the main points that emerged from the interviews can be drawn up and shared with the whole class, thus giving a broader and fuller overview of the water and water quality situation in your local catchment.

Criteria to assess learners during this arts and culture lesson

Criteria	**Exceeded requirements of the Learning Outcome**	**Satisfied requirements of the Learning Outcome**	**Partially satisfied requirements of the Learning Outcome**	**Not satisfied requirements of the Learning Outcome**
The learner was able to research the issue of water quality by conducting interviews within their local community				
The learner was able to work in a group and play a part in the role-play of water and water quality				

ACTIVITY THREE: AUDITING OUR WATER CONSUMPTION

Auditing our individual family's water consumption is a good start to investigating how we can all reduce water waste and together, as a community, develop a water-wise management plan. This NATURAL SCIENCES activity allows learners to prepare for a water audit, collect data in and around their home, school and community and then develop a school water-wise management plan.

To prepare for an audit of the school, home or community water-supplies, current patterns of use must be calculated and averaged. This makes an audit a simple matter of recording the number of times each activity happens. Preparation activities also point to wasteful practises that can be changed.

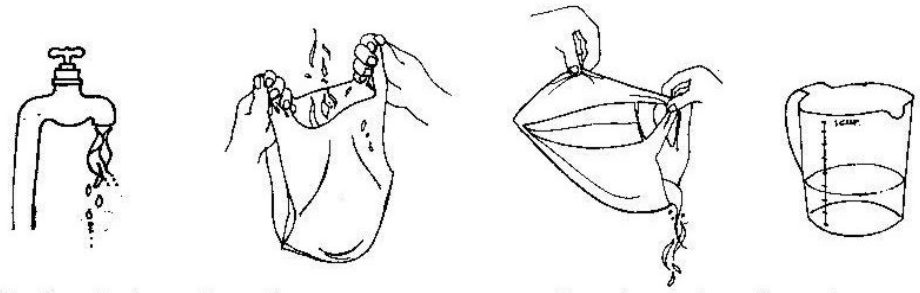
For example: People with piped water often clean their teeth or take a drink with the tap running. In this way, fresh water is wasted when it would have been more sensible to use a cup.

Let the learners try this activity:
Calculate the water used when brushing teeth or taking a drink from a running tap. Use a plastic bag to collect the wasted water and measure the amount wasted using the measuring equipment *(see box on the next page)*

Calculate the difference:

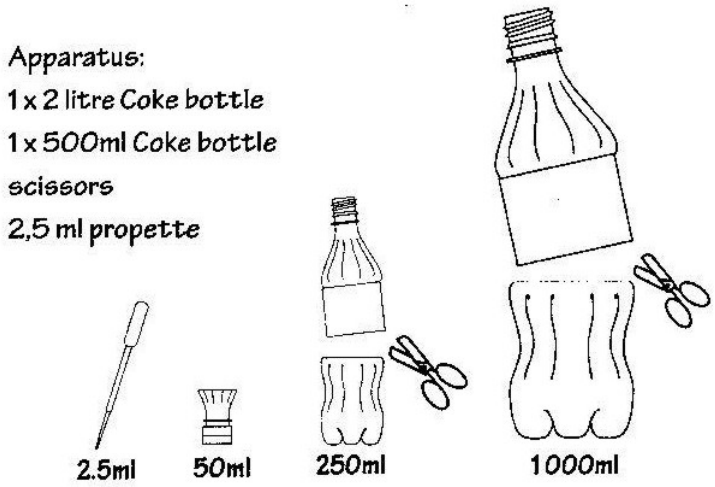
Water used with the tap left running	……/
Water used with a cup	……/
Difference (not wasted when cup used)	……/

BAG MEASURE



For fast leaks and running taps, use a supermarket plastic bag. Pour the water collected into a container and use a measuring jug to measure. A cheaper alternative is to make your own measuring equipment.

Making your own measures



- Cut the bottles as shown in the picture. This will give you 50ml; 200ml; 1 000ml; measuring apparatus.

- Accurate apparatus is important so check by filling the larger from the smaller:

* The 2.5ml is pre-calibrated
* 50ml is 20 x 2.5ml
* 250ml is 5 x 50ml
* 1 000ml is 4 x 250ml

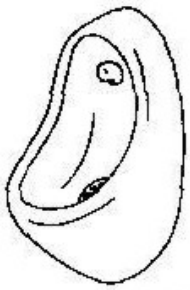
Although not as accurate as a measuring jug, this equipment is more than adequate for auditing water use.

To measure a bag of water, simply fill the 1 000ml, counting each time until a part-filled container remains. Pour this into the 250ml until a part-filled container remains and do the same right down to a part-filled 50ml measure which is determined by the propette. Written like this, it seems a little complex but with practise a bailing and counting method is both quick and accurate.

Make a list of common water use activities in preparation for doing an audit of water use.

Flushing toilet

.....ℓ



Urinal

.....ℓ

Washing hands

.....ℓ

brushing teeth

.....ℓ

Drinking

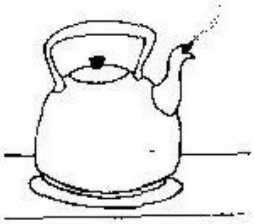
.....ℓ

Bathing

.....ℓ

Taking a shower

.....ℓ

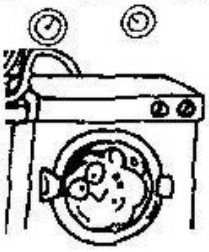


Kettle

.....ℓ

Hand washing clothes

.....ℓ

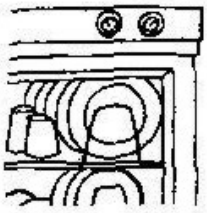


Washing machine

.....ℓ

Washing dishes

.....ℓ



Dishwasher

.....ℓ

Garden hose (litres per minute)

.....ℓ

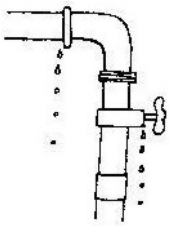
Cooking pots

.....ℓ

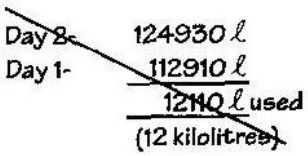
REMIND THE LEARNERS THAT …

Despite sound preparation and knowing how much water is used for each activity, a water audit is never an easy matter. You will only be successful if, from the beginning, you keep it simple and have ways of checking your work for accuracy.

For example:
If a check of results against the meter reading shows that more water is used that the audit records then:



1. There may be a leak in the pipes (check this by switching all the taps off and seeing if the meter keeps ticking)
2. You may have missed measuring an important water activity, or
3. Your calculations may be wrong!



In this way, an audit of water use will always present challenges and problems to be solved. Here are some ideas to help the learners plan an audit of the school, home and community water use.

SCHOOL: Start with each person in the class doing an audit of the water they use in a day. This can then be combined into an audit of the water used by the whole class. During National Water Week, try an audit of water use in the school and check the accuracy of your records using the water meter if there is one.

HOME: Get the learners to plan an audit with their family, using simple record sheets at each site of water use. Totals for the day should be matched with the meter reading or monthly water bill.

COMMUNITY: Patterns of use at home and at school can give the learners an idea of domestic water use in the community. Offices, industries and agriculture often use vast amounts of water when compared with domestic consumption. There are also many people in our communities who do not use piped water.

Remember that we need clean water for our health. Water conservation is not about people drinking or using less water but a challenge of working out ways to reduce unnecessary waste so there is more clean water to go around.

Let the learners adapt this table or develop their own to calculate school, home and community water use. Results should be compared with metered use. This is a good check of how accurate the audit has been:

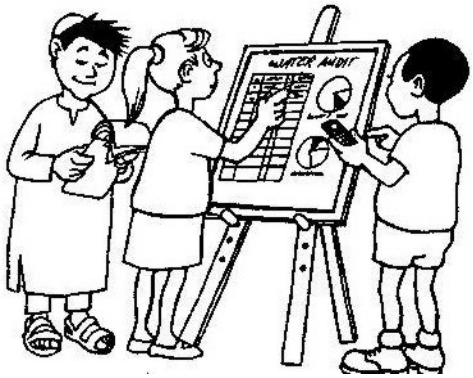
	Name of person	Washing hands	Drinking	Kitchen use	Washing machine	Toilet	Urinals	Hand basin	Shower	Garden hose	Washing carpets	Leaks detected	Other	Total Meter Reading *kl*		*l*
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
Total:																

Once the audits have been conducted – at school and home, discuss the results with the class.

Water audit actions can help us to reduce water wastage and thus save money. Many schools are now developing water wise management plans to make changes in their water consumption.

Has your school got a water wise management plan?

- If not, get the class to develop a plan for the entire school? Divide the class into small working groups and let them come up with five to ten ways of reducing water consumption in the school. As a class, go through the list and write down the most useful ones. Pass this plan to the head and management team of the school.



Criteria to assess learners during this natural sciences lesson

Criteria	Exceeded requirements of the Learning Outcome	Satisfied requirements of the Learning Outcome	Partially satisfied requirements of the Learning Outcome	Not satisfied requirements of the Learning Outcome
The learner adapted the water audit record sheet, where necessary, and added in more headings				
The learner was able to carry out a water audit around the school				
The learner contributed ideas in his/her group and during class to developing a school water wise management plan				

ACTIVITY FOUR: THE WATER CONFLICT GAME

Development in a sensitive wetland area! Is it a yes, is it a no? Can the environment, the culture, the people who live there and the economic future be considered, in a sustainable way, without one aspect compromising the other? This LANGUAGES lesson encourages learners to investigate an environmental situation and debate, discuss and communicate their ideas.

Read the following story to your class:

The Strong River system rises in the majestic 7 000m peaks of the Molombi mountain range. After cascading down the mountain slopes it winds down into the Strong River valley where the river channel widens to form a large wetland area. From here, the river continues to flow into the river estuary and the ocean.

There are five groups of people involved in the area. They are:

- The nomadic indigenous Bongo tribe which has migrated between the floodplain and the mountains for over two thousand years. They are dependent on water and the land for their existence. Nomadic pastoralism, fishing and crop cultivation are some of their livelihood activities.

- The Wildlife and Environment Society of South Africa (WESSA) who are dedicated to maintaining the social and ecological biodiversity of the wetland system. They want to install research facilities in the area to obtain a better understanding of the dynamics of the wetland system.

- The Goodgrip Tyre Company wants to build a tyre factory in the area. Vast quantities of water will be consumed and the waste from the factory will need to be disposed. No environmental impact assessment (EIA) has been conducted in the area where they want to build the factory. Three hundred job opportunities will be created.

- The Fitness Fanatics Group is planning to develop a huge sports centre which will provide accommodation, canoeing, golfing, yachting, hiking and fishing.

- The Provident Engineering Firm wants to build a dam to provide water and electricity to the tyre factory and the sports centre.

ACTIVITY:

- Divide the learners into groups to represent each of the five groups involved in the area.

- Each group will need:
    - a map (Worksheet 1),
    - a set of the enviro fact sheets (Enviro Fact 1 to 9)
    - a marker (you can use stones, leaves, bark, a small piece of rubber etc).

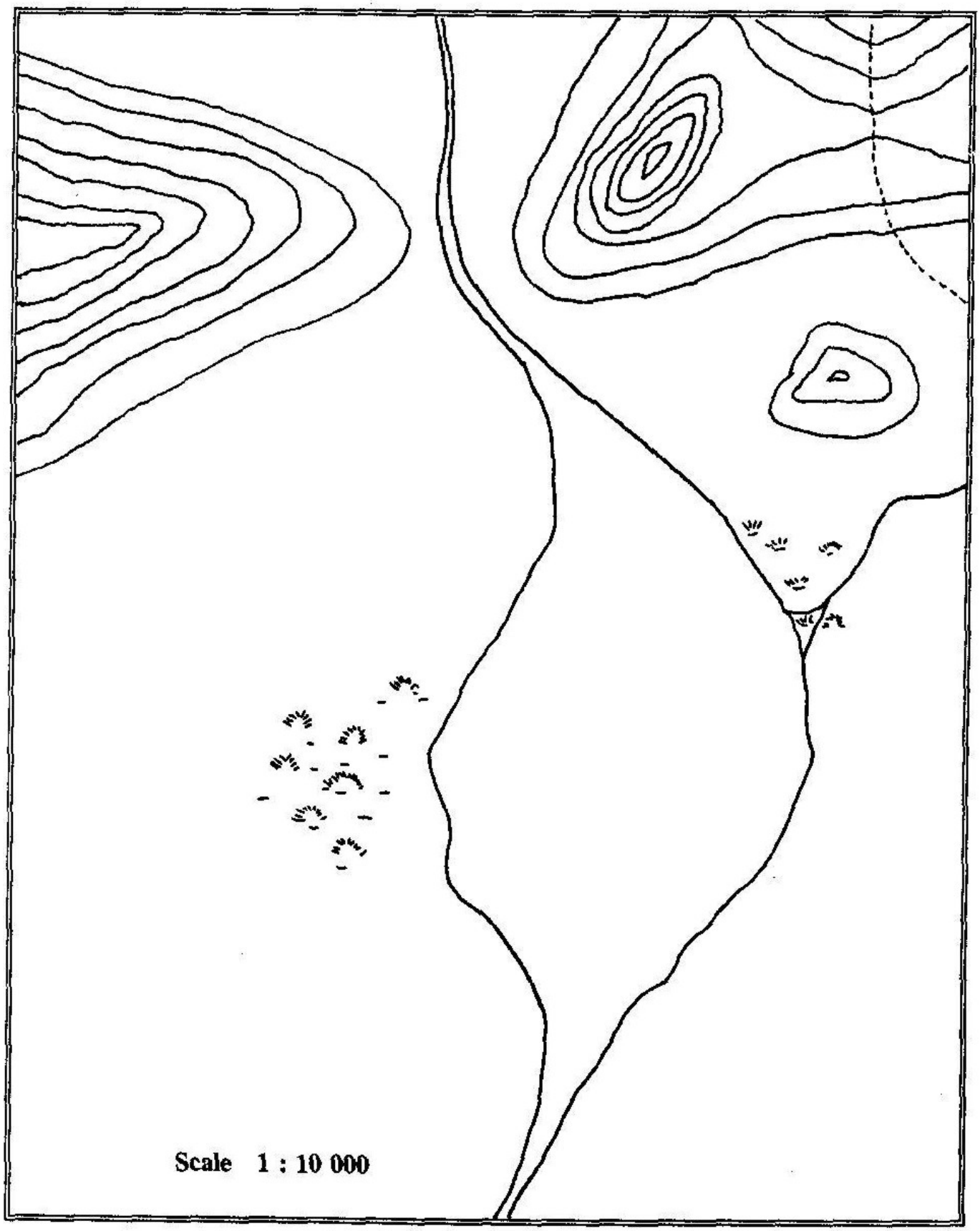
Each group spends time planning where they would like to complete their development – this is then marked on their worksheet. They must consider the advantages and disadvantages of their choices. *(The groups need to consider all the other groups – they are more likely to make a better decision if they focus on a sustainable and long-term view rather than a quick, unthoughtful decision which is based only on the money that will be made over a short period of time).*

1. The groups then gather around a larger copy of the map (you can enlarge the A4 sheet to A3 size), and place their markers where they plan to develop.

2. Two or more groups can use the same space (if they have both decided on that during their earlier discussions).

3. Each group is then given the opportunity to state the reasons for their choice. Through the guidance of the teacher, the groups argue their cases. It is important, that, despite conflicts that may arrive, the groups find a solution.

Worksheet 1



Enviro Fact 1: Sustainable Development

Historically, development and conservation have been in conflict, because conservation has been understood as the protection of resources. Recognising the need for both, the United Nations appointed, in 1987, a commission on environment and development to advise on development and conservation. In the commission's report called "The Bruntland Report" or "Our Common Future", the concept of sustainable development was emphasised. The report's definition of sustainable development as "… development which meets the needs of the present without compromising the ability of future generations to meet their own needs", is one of many definitions of sustainable development, and is the most commonly used. There are many definitions, principles and criteria for sustainable development, however, the concept is seldom explained or deeply understood, and is thus difficult to put into practice.

Historical perspective. During the Industrial Revolution, development was associated with economic growth through industries such as mining, manufacturing and large-scale farming. Industrialisation began in Britain and spread to mainland Europe, North America and Japan, all of which became known as the First World. Characteristics of First World countries are high economic growth, many and varied job opportunities, and high incomes. The Soviet Union and its satellite states, governed under the economic system of communism, became known as the Second World. Third World countries, such as those in Africa, South America and parts of Asia, have slow, if any, economic growth, with a high level of unemployment and very low incomes, but often substantial natural resources. In fact, the wealth of many First World countries is founded in part on the exploitation of resources (natural and human) from Third World countries.

Environmental problems. The environmental problems of the First World are associated with economic wealth, high resource consumption and industrialization. These have contributed to, for example, ozone depletion and global warming. Environmental problems of the Third World, however, can be associated with poverty, high population growth rates, lack of food, shelter and water, and a lack of technical capacity.

Development as a solution? The solution to the devastating poverty, environmental problems of Third World countries is often seen as 'development'. For example, the development of Third World countries towards the First World ideas of economic growth through Industrialisation and high consumption patterns. However, many people have begun to seriously question the wisdom of this approach. Thabo Mbeki, South Africa' present president, believes Africa must use African resources, especially human, in order to achieve a strong, well-developed and competitive continent - he has called this process the 'African Renaissance'.

Limited resources. It is argued that the Earth's finite resources would not be able to support the entire world' s people if everyone had the high consumption patterns of those living in First World countries. Mahatma Gandhi, when asked if, after independence, India would attain British standards of living, commented that "… it took Britain half the resources of the planet to achieve its prosperity, how many planets will a country like India require?"

A different type of development? Development is conventionally seen as economic growth, dependant upon 'throughput growth', i.e. growth which depends on ever increasing consumption of energy and natural resources. This type of development is unsustainable. One alternative being suggested is qualitative development, with minimum inputs and outputs, maximum reuse, recycling and repair, and little or no growth in throughput. Organisations would thus try to deliver the same high standards of service, but use fewer material resources such as fossil fuels, minerals and water. Development programmes in Third World countries probably need both quantitative growth (to address poverty), and qualitative development. The First World also needs to minimise its throughput growth, and replace it with qualitative growth. For example, an industry-oriented economy (high throughput) might be characterized by coal mining and steel manufacture, whereas a service-oriented economy might focus on information technology including the use of fibre optics and electronics (low throughput).

Who benefits? Third World development programmes that focus on economic growth as a solution to widespread poverty, assume a 'trickle down' effect, i.e. the benefits of economic growth will trickle down to all members of society. However, economic growth does not always benefit the poor in a country. Many development programmes now give special attention to human needs, improved participation in programmes, and the distribution of development benefits, rather than focusing all efforts on economic development. A more people-oriented development should empower people to take greater control over all aspects of their lives: social, political, economic and ecological.

Indicators of economic performance. If we are to move towards sustainable development, we will need tools with which to measure our performance. At present the performance of an economy is measured in term of its gross domestic product (GDP). The GDP is the total value of all the money transactions that take place, and is a poor measure of the effect of economic policies and practices on people and the environment. The GDP does not differentiate between different kinds of economic activity. For example, if a new prison is built, this amount is added to the GDP - the more prisons built the better the GDP!

However, there are no simple answers to how sustainable development can be assessed. Many attempts endeavour to value, or put a price to, the depletion and degradation of natural resources as a way of ensuring that this is taken into account when assessing economic performance. Other approaches argue that valuing the environment is often impossible or undesirable, and maintain that environmental quality should be measured in purely physical terms, which should then be published alongside the GDP as an environmental account. As situations and conditions change, so will our understanding of sustainable development change. Sustainable development is not a model to be imposed, but can be seen as a process of learning how to live on the Earth. Ultimately the focus of sustainable living and sustainable development is to find a balance between the social, economic and ecological aspects of our existence.

Agenda 21
Agenda 21 is a global action plan for socially, economically and environmentally sustainable development. It was adopted at the United Nations Conference on the Environment and Development held in Rio de Janeiro in June 1992 (Earth Summit). The conference proposed that Agenda 21 be implemented at the local authority level, and this came to be known as Local Agenda 21. The principles guiding Local Agenda 21 in South Africa are: people-centred development, meeting basic needs, integrated planning and development. Several South African cities and provinces have developed Local Agenda 21 programmes.

Enviro Fact 2: Pollution

Pollution is an unwelcome concentration of substances that are beyond the environment's capacity to handle. These substances are detrimental to people and other living things. In an undisturbed ecosystem, all substances are processed through an intricate network of biogeochemical cycles, such as the nitrogen and carbon cycles. During these cycles, substances are taken up by plants, move through the food chain to larger and more complex organisms, and when the latter die, are decomposed (broken down) into simpler forms to be used again when they are taken up by plants. Biodegradable substances are those that can be broken down by the environment's biological systems. Pollution occurs when the environment becomes overloaded beyond the capacity of these normal processing systems.

Examples include:

- An excess of normally helpful substances, such as the nutrients, nitrogen and phosphorus.
- An excess of substances that are harmless, and perhaps even necessary in tiny amounts, but toxic in concentration. Copper, for example, is necessary in small amounts for healthy plant growth, but becomes a pollutant if it occurs in greater quantities.
- Synthetic (human-made) compounds that are poisonous in the environment, often even in trace amounts, such as DDT, dioxin, PCBs and organochlorines.
- Substances that, in any amount, are not biodegradable, such as plastics and highly persistent chemicals like DDT and other organochlorines.
- Some pollutants kill living organisms outright, other sub-lethal pollutants do not kill, but may cause long-term biological damage, interfere with organisms' reproductive cycle, or make them more vulnerable to disease.

Types of pollution. Pollutants can be grouped according to the main ecosystem which they affect. One pollutant often affects more than one ecosystem.

POLLUTANTS AND MAIN SOURCE	HEALTH AND ENVIRONMENTAL EFFECTS
AIR	
Sulphur dioxide - burning of coal	Acid rain and respiratory problems
Nitrogen oxides - vehicle emissions Volatile hydrocarbons - vehicle emissions	Combine to form photochemical smog; causes respiratory problems
Carbon monoxide – vehicle emissions	Restricts oxygen uptake, causes drowsiness, headaches, death
Carbon dioxide - burning of coal	Global warming
CFCs - aerosol, refrigeration, air-conditioning and foam-blowing industries	Destroy ozone layer
Methane - feedlots, rubbish dumps	Global warming
Noise - industry, traffic	Affects hearing, stressful
Asbestos dust - construction, mining, industry	Asbestosis, mesothelioma
FRESH WATER	
Sewage - inadequate sanitation	Pathogens cause typhoid, cholera, gastroenteritis; nutrients cause eutrophication
Fertilizers – agriculture	Eutrophication
Silt - agriculture, construction, mining	Smothers aquatic organisms; affects light penetration
Pesticides - agriculture, and health services	Toxic; interfere with breeding of mammals and birds
Toxic metals – industry	Health and life threatening
Salinisation - industry, agriculture, landfill	Reduced crop yields; scale and corrosion in domestic and industrial water systems
MARINE	
Sewage - inadequate sanitation	Pathogens cause typhoid, cholera, gastroenteritis; nutrients cause eutrophication
Fertilizers – agriculture	Eutrophication
Oil spills	Smother marine plants and animals
Plastics	Death of marine animals
Pesticides - agriculture, and health services	Toxic; interfere with breeding of mammals and birds
LAND	
Solid waste is classified as hazardous (radioactive, pesticides, medical, poisons), or non-hazardous (domestic, urban, mining, industrial, scrap metal)	Hazardous waste is health- and life-threatening; non-hazardous is unsightly and disposal takes up much space

Dealing with pollution
In the past, most approaches to handling pollution could be summed up by the phrase `dilution is the solution to pollution'. However, pollution levels have increased so much in amount and toxicity that this approach is no longer acceptable. An alternative approach is source reduction, i.e. a reduction in the amount of pollution where produced.

- Point source pollution: pollutants are produced from a stationary location, e.g. industrial plants, mines, and municipal sewage works.
- Non-point source pollution: this pollution cannot be traced to a specific spot, and is far more difficult to monitor and control. Common examples are veldt fires, motor vehicle emissions, fertilizer runoff, sediment from construction and erosion, plastic packaging, and gases from aerosol cans. Some non-point sources can be addressed by laws, such as banning CFCs (chlorofluorocarbons), or requiring car manufactures to install emission controls.

Polluter-must-pay principle
This means that a polluter should bear the costs of avoiding pollution, or remedying its effects. This principle is difficult to apply when the source of pollution cannot be identified, as is often the case with atmospheric pollution. The principle can be usefully applied following a pollution disaster, such as an oil spill from a tanker. However, the consumer often pays for such pollution costs. For example, Eskom estimates that the fitting of scrubbers on the chimneys of their power stations will increase the cost of electricity by 30%.

Movement of pollution
Pollution does not stay in one place but is moved around the world by air and water, as well as by living organisms. Even in Antarctica, birds and marine mammals show traces of pollutants such as DDT and PCBs. Some pollution is deliberately moved abroad. Companies restricted by pollution control regulations at home, sometimes move their plants to other less restrictive countries, as was the case with the plant involved in the Bhopal chemical disaster. Or while remaining at home, they may sell products abroad that are classed in their own countries as too dangerous for sale, such as banned pesticides. In some cases hazardous waste may also be shipped abroad, generally from industrialised countries to developing countries willing to accept such waste for a fee, despite the hazards. When such pollutants turn up again in the originating country, as when food is imported that contains banned pesticides, the process is said to be completing the `circle of poison'.

What can you do

- *Avoid the creation of waste.*
- *Find out all you can about pollution and protest loudly when you see it happening.*
- *Report air pollution to the Chief Air Pollution Control Officer (CAPCO), Department of Health.*
- *Report freshwater and land pollution to the Department of Water Affairs and Forestry.*
- *Report marine pollution to the Department of Environment Affairs and Tourism, Marine Pollution Division.*

Enviro Fact 3: Energy and Environment

Some of South Africa's most serious environmental problems are associated with our use of energy. Coal-fired and nuclear power stations for electricity generation, coal combustion in the townships, SASOL coal-to-oil processes, petrol and diesel use in vehicles for bulk transport, and over exploitation of fuelwood resources, all result in serious, long-term environmental damage.

Pollution from burning coal
More than three-quarters of South Africa's energy comes from coal, approximately half of which is used to generate electricity, a quarter to produce synthetic liquid fuels and another quarter directly by industry and in homes. Air pollution problems from coal combustion are serious. Medical studies are revealing increased rates of respiratory disease in residents in polluted areas.

Acid rain
Most of South Africa's power stations are concentrated within a 100 km radius in Mpumalanga and this leads to pollution problems. While all of Eskom's coal-fired power stations are designed to remove dust and other particles from waste gases produced during coal combustion, none are fitted with flue-gas scrubbers (cleaning equipment) to remove oxides of sulphur and nitrogen. Tall chimney stacks in power stations assist in releasing oxides of sulphur and nitrogen into the upper atmosphere where atmospheric conditions are more favourable for their dispersal and dilution. Although this reduces ground level concentrations of these pollutants, they may combine with moist air and rain at higher levels and cause acid rain in areas far from the source of pollution.

Whilst South Africa's coal has a relatively low sulphur content there is considerable concern about the potential environmental and economic impact of acid rain. Half of South Africa's agriculturally productive land, half of its commercial forests and a quarter of its surface water run-off are in Mpumalanga.

Pollution from vehicles
Motor vehicle fumes make air pollution problems worse and are the main cause of photochemical smog in cities. Unleaded fuel has recently been introduced to South Africa and this may reduce the amount of lead in exhaust fumes. Catalytic converters fitted to exhausts would result in a significant reduction in the release of carbon dioxide, hydrocarbons, and nitrogen oxides. However, South Africa lags far behind other countries (e.g. Japan, Germany) in legislation to control vehicle emissions. Solutions to transport pollution and vehicle congestion require long-term planning to introduce efficient public transport systems in our cities.

Deforestation
Another environmental concern associated with energy use is the reliance by a significant number of South Africans on fuelwood, once a renewable resource, but now being used at a rate much greater than that at which it is naturally regenerated. Fuelwood is an inefficient source of energy for cooking and heating and its use can cause increased respiratory illnesses. It has been estimated that if current consumption trends continue, all natural woodland in the former "homelands" will be denuded by 2020. In addition to the environmental consequences of deforestation, diminishing supplies of wood require rural people (particularly women) to travel further and further from home to gather wood, placing a great burden on them.

Global warming
South Africa uses a great deal of energy, very much more per unit of gross domestic product (GDP) than most other countries. The combustion of coal, oil and wood results in increased carbon dioxide production. This gas acts likes a greenhouse - it lets short-wave, natural light through but traps out going long-wave (infra-red or heat) radiation. The potentially devastating consequence is that the earth is slowly getting warmer, causing the climate to change and sea levels to rise. Although South Africa produces only a small percentage (1,6%) of the total, global carbon dioxide emissions, it plays a disproportionately large role per person in contributing towards the greenhouse effect and global warming. As a country needing rapid economic growth in the medium-term to satisfy the country's developmental needs, South Africa's potential contribution to global warming is an area of concern.

Nuclear energy
South Africa currently has one commercial nuclear power station at Koeberg near Cape Town. It provides 1 800 MW of Eskom's installed electricity generation capacity of 37600 MW, less than 5% of the total. There is intensive debate among energy planners as to whether nuclear energy should play a role in South Africa. In addition to being a costly option, nuclear fission produces dangerous radioactive by-products. There is considerable concern about their safe containment in the case of accidents at nuclear power stations, the closing down (decommissioning) of old power stations, and the storage of highly toxic wastes. At present, low-level radioactive wastes are stored in sealed containers which are buried underground at disposal sites. No long-term solution has been agreed on for the safe storage of high-level radioactive wastes, some of which remain harmful for thousands of years. At present there is no national policy to deal with radioactive waste.

Enviro Fact 4: Energy Options

Coal supplies most of South Africa's electrical energy. It is a finite, non-renewable resource. Burning coal to produce electricity causes serious environmental problems. Pollution from power stations contributes to global warming and acid rain. In addition to the environmental challenges associated with energy supply, South Africa faces significant social challenges. Although we produce half of the electricity on the African continent, 40% of South Africans do not have access to electricity and rely instead on fuelwood and other inconvenient fuels such as coal, paraffin, gas, or candles. It is important that South Africa addresses both the environmental problems associated with energy supply, and the inequalities in access to adequate and affordable energy.

How can we provide adequate and affordable energy for all, while promoting environmental sustainability?
Many of South Africa's medium- and long-term energy needs could be addressed through regional cooperation. This could include the establishment of a regional electricity transmission grid and a SADC power pool, and regional energy planning. Such coordination would create opportunities for SADC countries to provide their people with clean and sustainable energy into the next century. Regional cooperation does however require political and economic stability. There are also several technologies that could improve the sustainability of the regional electricity industry.

In addition to reducing pollution from coal-fired power stations, hydroelectric and solar power, natural gas, wind, tide and wave power may all help the region address its energy needs with minimum impact on the environment.

Reducing pollution from coal-fired power stations. This pollution can be reduced by using equipment which removes oxides of sulphur and nitrogen from the gases released when coal is burnt. This could result in electricity being more expensive, but this should be weighed against the benefits to the environment.

Hydro-power. Coal stocks are finite and sooner or later we shall have to rely on another source of energy. A possible medium-term alternative is to harness the huge hydro-electric potential of the sub-Saharan Africa region, estimated to be more than twice Eskom's current generating capacity. For example, the Zaire River alone is capable of providing in excess of 70 000 MW (megawatts) of hydroelectricity. There are many other rivers in Zambia, Zimbabwe, Angola and Mozambique suitable for hydroelectricity.

Hydroelectricity is renewable and does not pollute. However, it is expensive, and requires the construction of large dams which have significant social and environmental costs. In addition, this option requires regional co-operation and political stability.

Solar energy. Solar energy can be used to produce heat. In Israel more than two-thirds of houses are fitted with solar water heaters. South Africa experiences more sunshine than most places and there is much potential for widespread use of solar water heaters, particularly in mass, low-income housing projects. However, the initial outlay for solar panels is expensive as large areas of panels are needed to collect useful amounts of energy. Solar energy could be particularly useful in remote areas far from the electricity grid, such as farms, rural clinics, and water pumping stations.

Nuclear energy. There is much debate among energy planners in South Africa as to whether nuclear energy should play a role in this country's future. Using current technology it is a costly option, with unresolved environmental problems such as the disposal and storage of waste products.

Natural gas. Although natural gas is a non-renewable energy resource, it has great potential as a future energy source for South Africa. South Africa has a limited amount of natural gas reserves, but strong regional ties would allow us to import gas from Namibia and Mozambique. Natural gas produces less pollution that other fossil fuels. In fact, latest natural-gas-burning turbines can produce electricity 50% more efficiently than those burning coal. Natural gas can also be burned cleanly in co-generation (see below). Because of its advantages over coal and oil, some analysts see natural gas as the best fuel for the transition to energy efficiency and renewable energy.

Wind power. As global energy resources become more and more scarce, wind power is becoming increasingly attractive. Wind energy is freely available and poses less of a threat to the environment than fossil and nuclear energy sources. Wind energy can provide electricity for communities not linked to the electricity grid. Telecommunications companies currently use small wind turbines to support cellular networks in the region. In addition, wind energy can be exploited on a large grid-tied scale through the development of wind farms. However, wind is not a reliable source of energy, and its use is limited to areas with steady winds. These areas are often found near coastal regions and in some arid and semi-arid areas.

Energy efficiency. South Africa uses more energy per unit of economic output (GDP or gross domestic product) than many other countries. There is much potential for energy saving. European countries and Japan have shown in recent years that industrial production can be increased while using less energy through energy-efficient manufacturing processes. Passive solar design principles and more efficient lighting and insulation contribute to energy savings in buildings. Industry is able to save energy through cogeneration, advanced heat recovery systems and better control of energy usage. (Cogeneration is a process which produces both electricity and heat at the same time, while advanced heat recovery systems economize on, and use the heat generated in industrial and chemical processes). Recycling waste materials can also save energy, for example aluminium produced from scrap uses 95% less energy than when it is manufactured from ore. New motor vehicles are also becoming more fuel efficient.

Planning in towns and cities should encourage the use of efficient public transport systems rather than private motor vehicles. In the long term we shall also have to find alternative fuels for transport. Hydrogen offers a clean alternative and as one of the elements in water it is plentiful. But it still requires energy to separate hydrogen from oxygen in water. Nuclear fusion (the combination of hydrogen atoms to form helium, i.e. the reaction which powers the sun) may also be a future option, but scientists do not foresee major progress in this area for many years to come.

Enviro Fact 5: Soil Erosion

Soil erosion is a natural process. It becomes a problem when human activity causes it to occur much faster than under natural conditions, and it impacts on the lives of people and their environment.

Wind and water are the main agents of soil erosion. The amount of soil they can carry away is influenced by a number of related factors: rainfall intensity, speed of flowing water and blowing wind, slope steepness, soil erodibility and soil cover.

The importance of plants
Plants provide protective cover on the land and prevent soil erosion for the following reasons:

- Plants break the impact of raindrops before they hit the soil, improving rainfall infiltration into the soil, reducing the amount and rate of runoff and therefore its ability to erode.
- Plants slow down water as it flows over the land (runoff) and this allows much of the rain to soak into the ground.
- Plant roots hold the soil in position and prevent it from being washed or blown away.
- Plants in wetlands and on the banks of rivers are of particular importance as they slow down the flow of the water and their roots bind the soil, thus reducing erosion.

The loss of protective vegetation through deforestation, over-grazing, under-grazing, ploughing, and fire, makes soil vulnerable to being swept away by wind and water. In addition, over-cultivation and compaction cause the soil to lose its structure and cohesion and it becomes more easily eroded.

Erosion will remove the top-soil first. Once this nutrient-rich layer of soil is gone, few plants will grow in the soil again. Without soil and plants the land becomes desert-like and unable to support life - this process is called desertification. It is very difficult, very expensive, and often impossible to restore desertified land.

Politics, economics and soil erosion
To understand soil erosion we must be aware of the political and economic factors affecting land users.

In South Africa apartheid policies ensured that 42% of the people lived on 13% of the land (the 'homelands'). This overcrowding has resulted in severe erosion. As the land became increasingly degraded and thus less productive, subsistence farmers were forced to further overuse the land. The intensive agriculture and overgrazing that followed caused greater degradation. A reduced ability to produce, invest one's profit and increase productivity, contributes to increasing poverty, and can lead to desertification, drought, floods, and famine.

On commercial farmlands, overstocking, over-resting (plants become moribund and unproductive), injudicious burning, mono-cropping, and the ploughing of marginal lands unsuitable for cultivation, have led to soil erosion and desertification. Frequently these practices have been unwittingly encouraged by the state offering subsidies which made it profitable to exploit the land in the short-term. Economic pressure (caused, for example, by falling commodity prices and rising input costs) can also drive some farmers to over-exploit their land.

Preventing soil erosion
Preventing soil erosion requires political, economic and technical changes. Political and economic changes need to address the distribution of land in South Africa as well as incentives to encourage farmers to manage their land in a sustainable manner. Technical changes include:

- the practice of conservation tillage on cultivated land;
- the use of contour tillage, the construction of contour banks for runoff control, and the use of wind breaks;
- avoiding excessive cultivation that will deplete soil organic matter;
- ensuring that there are always plants growing on the soil, and that the soil is rich in humus (decaying plant and animal remains) - this is the glue that binds soil particles together and is significant in preventing erosion;
- the use of cover crops and crop rotations;
- withdrawal of low potential land from annual cultivation by establishing a suitable perennial crop;
- allowing indigenous plants to grow along the river banks instead of ploughing and planting crops right up to the water's edge;
- encouraging biological diversity by planting several different types of plants together;
- conservation of wetlands.

Did you know?

- An estimated 25 tonnes/ha of soil are lost from annually cultivated fields in KwaZulu-Natal. Where this has been carrying on for 50 years, the production potential of the land has been reduced by 20%.
- 27 000 ha of rangeland in the Weenen thornveld of KZN have been destroyed through overgrazing, while the grazing capacity of a further 34 000 ha has been halved.
- Major storage dams are under constant threat from sediment entering their basins through floodwaters. An example is that of Hazelmere Dam on the KZN north coast where 20% of its capacity has been replaced with sediment over a period of 12 years. The Welbedacht Dam on the Caledon River lost 32% of its capacity within 3 years of its construction.
- 45 of KwaZulu-Natal's 73 estuaries have been degraded through sediment from inland areas.

Enviro Fact 6: Water

South Africa is extraordinarily rich in natural resources - except for water. Water is a vital but scarce resource, distributed unevenly in time (frequent droughts alternate with periods of good rainfall) and space (the eastern half of the country is markedly wetter than the western half). Increasing demand for water, and decreasing water quality, make careful water management a priority in our country. It has been estimated that by the year 2025 South Africa's human population will have doubled, and that there will be insufficient water for domestic use, agriculture, and industry.

Rainfall
Our average rainfall is less than 500 mm a year, with the driest part of the country receiving less than 200 mm/year and the wettest receiving more than 2 500 mm/year! Rain does not always fall where it is most needed, and some areas of high demand, such as Gauteng, receive less water than they need. Most rain falls in the narrow belt along the eastern and southern coasts. The rest of the country receives only 27% of South Africa's total rainfall. In addition, hot, dry conditions result in a high evaporation rate.

Water is thus a very scarce resource in South Africa. Large-scale engineering has been used to store water behind dam walls, and to distribute water from regions of plenty to regions of need.

Rivers
There are few natural lakes in South Africa. We depend on rivers, dams and underground water for our water supply. Approximately 75% of the water flowing from South Africa into the sea occurs along the eastern and southern seaboards, where many short rivers occur. Flowing from east to west is the largest river in the country, the Orange River, which drains most of the rest of the country. Its water comes from sources in the Drakensberg and Maluti Mountains, and it flows into the Atlantic Ocean on the west coast.

Dams
About half of South Africa's annual rainfall is stored in dams. We have about 550 government dams in South Africa, with a total capacity of more than 37 000 million m^3.

Dams have both positive and negative impacts. They can be beneficial for people in that they regulate the flow of a river, reducing flood damage and contributing to perennial rather than seasonal flow. In addition, sediment is deposited in a dam, and the growth of aquatic plants means that nutrients are removed from the water. Thus water leaving a dam may be cleaner than water entering it. The riverine ecosystem is usually affected negatively by a dam. Alterations in flow regime (quantity of water and timing of periods of high and low flow), temperature and water quality may cause reductions in biodiversity of riverine organisms below dams. Reduction in water flow reduces the river's scouring ability and this can lead to silting of estuaries.

South Africa's landscape is not well suited to dams. There are few deep valleys and gorges, with the result that most dams are shallow with a large surface area. Together with the hot, dry, climate, this results in much water evaporating from dams. In addition, the high silt load (a result of an arid climate, steep river gradients and poor farming methods) of our rivers means that the capacity of South Africa's dams is quickly reduced as they become silted. The rivers of the western Cape carry relatively less silt than those in the rest of the country.

Water abstraction
A growing problem for South Africa's rivers is a lack of water! Reduction in river flow, owing to abstraction (removal), and damming, has affected many of our rivers, for example those flowing through the Kruger National Park.

Intercatchment transfer of water
This involves the transfer of water from catchments with good supplies and low demand, to those where demand for water is high and the supply is poor. There are numerous intercatchment transfer schemes already in operation, and more are under construction or proposed. A major scheme is the Orange-Fish River scheme, where water gravitates from the Orange River at the Gariep Dam, and is piped through tunnels and canals to the Sundays and then the Fish Rivers in the Eastern Cape.

Transfers of this nature will have far-reaching ecological, political and socio-economic implications. As yet, little research has been carried out to establish the ecological consequences of intercatchment water transfers. However, areas of concern include reducing streamflow and water levels in one system, changes in water temperature and chemistry, and the transfer of invasive species between catchments.

Water pollution
Industrial and agricultural pollutants common in South Africa include: agricultural fertilizers, silt, toxic metals, litter, hot water and pesticides. These pollutants affect aquatic ecosystems and human health. Disease-producing bacteria are common in urban waste water, particularly from informal settlements that lack sewage and water purification facilities. For example, typhoid, cholera and gastroenteritis are transmitted by water contaminated with untreated sewage. Gastroenteritis is one of three main causes of death in South African children under the age of five.

Did you know?
- South Africa has a National Water Bill that attempts to ensure an equitable and sustainable water supply.
- Some 12 - 14 million South Africans do not have access to safe drinking water and some 21 million have inadequate sanitation. As a result, about 50 000 children die each year from diarrhoeal infections.

Enviro Fact 7: Wetlands

Wetlands are difficult to define because of their great variation in size and location. The most important features of wetlands are: Waterlogged soils or soils covered with a shallow layer of water (permanently or seasonally), unique types of soil, and distinctive plants adapted to water-saturated soils. Marshes, bogs, swamps, vleis and sponges are examples of wetlands.

Why are wetlands important?
Wetlands associated with streams and rivers slow floodwaters by acting as giant, shallow bowls. Water flowing into these bowls loses speed and spreads out. Wetland plants, particularly reeds and sedges, play an important role in holding back the water. The wetland acts as a sponge as much of the flood water is then stored in the wetland and is slowly released to downstream areas, instead of it all rushing to the sea within a few days. This greatly reduces flood damage, particularly erosion, and ensures a more steady supply of water throughout the year.

Filters: Wetlands improve water quality as they are very good natural filters, trapping sediments, nutrients (e.g. nitrogen and phosphorus), and even pathogenic (disease-causing) bacteria. In addition, pollutants such as heavy metals (e.g. mercury, lead) and pesticides, may be trapped by chemical and biological processes. In other words, the water leaving the wetland is cleaner than the water entering it.

Wetlands and wildlife: Wetlands are filters where sediments and nutrients accumulate, so many plants, such as bulrushes, grasses, reeds, waterlilies, sedges and certain trees grow there. The plants, in turn, provide food and a place for attachment and shelter for many creatures. There is more life, hectare for hectare, in a healthy wetland than in almost any other type of habitat. These productive places support huge numbers of insects, fish, birds and other animals. Some animals are completely dependent on wetlands, whilst others use wetlands only for part of their lives. The wattled crane, for example, is dependant on wetlands for breeding. The rich diversity of waterbirds in southern Africa (totalling 130 species) is possible because of the many wetlands spread across the sub-continent. The wetlands of southern Africa are of international importance as they are the southern destination for many migratory water birds.

People and wetlands: Wetlands have been used for centuries as grazing for domestic stock, and as a source of reeds used for thatching, hut construction and basket weaving. They provide fishing and hunting, and the opportunity to observe wildlife, especially birds. Wetlands are appreciated for their beauty as open spaces and also for their educational value.

Wetlands in trouble: To many people the thought of a marsh, swamp, bog or vlei is associated with dampness, disease, difficulty and danger. Because of this wetlands are often seen as wastelands that should be converted to cropland, dams, commercial timber plantations of alien trees, waste disposal sites and pastures. Many wetlands have been "reclaimed" for industry and the construction of airports, harbours and sewage treatment plants. Historically wetlands have been drained in attempts to control malaria.

All wetlands in southern Africa are threatened. Botswana's magnificent Okavango Delta is threatened by the possible canalisation of the Boro River to supply South Africa with water for both domestic and industrial use. Throughout the region, smaller seasonal wetlands in urban areas have virtually disappeared, while riverine wetlands are constantly under threat of being turned into agricultural land.

What you can do?

- *Get to know the wetlands in your area and list the plants and animals living there. Draw a map of the wetland's position, size and use. Take photographs of the wetlands from fixed vantage points, and at different seasons of the year, to compare the changes between seasons and from year to year.*
- *Report the abuse of wetlands to your local nature conservation officer, agricultural extension officer or Department of Environmental Affairs and Tourism. Always make your report in writing to ensure that the officer concerned has to investigate.*

Enviro Fact 8: Protected Areas

South Africa has a remarkable diversity of animals, plants, vegetation communities, landscapes, geological features, and numerous sites of archaeological, historical and cultural significance. Arguably one of the most effective ways to preserve and conserve this diversity is through the establishment of protected areas

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Classification of protected areas. At present there are over 700 state owned protected areas, including more than 100 marine protected areas, covering about 75 000 km^2 (6.1% of S.A.). In addition there are over 200 privately owned protected areas, covering about 9 000 km^2 (0.8% of S.A.), thus bringing the total to about 7%. This proportion is small by international standards, being below the ideal of not less than 10% set by the Convention on Biodiversity

.

An enormous variety of protected areas occur in South Africa ranging from large national parks to comparatively tiny, little known reserves. A range of authorities is involved in the management of these protected areas, including state departments, parastatal organisations, local authorities, non-governmental organisations, communities and private individuals. The situation is further complicated by legislation, as more than ten Acts of Parliament, numerous Provincial ordinances, and various local by-laws govern the administration of protected areas, and it is commonplace for two or more pieces of legislation to be relevant for one protected area.

To simplify the situation a classification system has been adopted for protected areas in South Africa. It follows the international guidelines devised by the IUCN (International Union for the Conservation of Nature). Six broad categories of protected areas are recognised and these are defined by the primary management aims of the protected area under consideration.

- Scientific reserves and wilderness areas are the most pristine of all protected areas where human intervention is non-existent or minimal. Scientific reserves are for the purpose of preserving areas of outstanding scientific importance for research. The only scientific reserve belonging to South Africa is the Prince Edward Island group (Marion Island and Prince Edward Island). Wilderness areas, e.g. Cedarberg Wilderness Area in the Western Cape, and Ntendeka Wilderness Area in KwaZulu-Natal, are large undeveloped and uninhabited areas where access is strictly controlled and only non-mechanised tourism is permitted.
- National parks and equivalent reserves are relatively large outstanding natural areas of land or sea, or both, which are not materially altered by human occupation or exploitation. They are managed mainly for ecosystem conservation and recreation. National Parks, e.g. Tsitsikamma National Park, are scattered throughout South Africa and are managed by the South African National Parks. Equivalent reserves refers to the large provincial reserves, e.g. De Hoop Nature Reserve, that have many similarities to national parks, the major difference being that they are managed by the relevant provincial authorities according to different legislation. A process is underway to ensure that all protected areas which qualify should be designated as national parks, and that an appropriate management authority operating within national policy and guidelines is appointed.
- National monuments and areas of cultural significance are areas containing at least one unique or outstanding natural feature recognised for its rarity, beauty or cultural significance. Natural monuments are established for the primary purposes of protecting and conserving the feature/s at the site, and making them available for education and tourism. Examples include botanical gardens, e.g. Kirstenbosch, and Paarl Mountain.
- Habitat and wildlife management areas are areas of land or sea where the protection and conservation of habitat is essential for the survival of important fauna and flora. Conservation of the habitats or species in these areas may require active intervention and even habitat manipulation. Most of the provincial reserves, e.g. Willem Pretorius Game Reserve, and many local reserves, belong in this category. Private nature reserves, e.g. Timbavati Game Reserve, proclaimed in terms of provincial ordinances, are distinct from conservancies, e.g. Bitterputs Conservancy, where landowners agree to combine resources to improve the conservation of a larger area, but which lack legal conservation status
- Protected landscapes or seascapes are scenic areas where traditional customs, lifestyles, and practices such as traditional fishing methods, exist in harmony with nature. They are managed to ensure that the integrity of the site is maintained, whilst allowing tourism, e.g. Kosi Bay
- Sustainable use areas are areas of land or sea, or both, which are predominantly natural and where harvesting of natural resources is permitted. These areas are established for the primary purpose of maintaining biological diversity whilst benefiting local communities by allowing them to harvest natural resources in a sustainable way.

Citizens' role. Protected areas are not only the responsibility of the state, and many have been established and managed by communities and private landowners. These can be designated formally in terms of the relevant legislation to provide greater protection. A developing trend is for partnerships to be forged among the state, communities and private sector interests to develop and manage protected areas and ensure that communities, especially in disadvantaged rural areas, benefit from the many opportunities which protected areas can generate. In some cases, e.g. in KwaZulu-Natal, statutory Local Boards for protected areas have been established, giving communities a direct say in the planning and management of these areas, e.g. the Hluhluwe-Umfolozi Park.

International recognition. Inter-governmental treaties or conventions to which South Africa is a signatory afford opportunities to register outstanding natural sites of international significance. The sites identified could belong to any of the categories of protected area described above. The special recognition accorded these sites through registration raises their conservation status and improves international support. Examples include Ramsar sites, e.g. Ndumo Game Reserve; Biosphere reserves, e.g. Kogelberg Biosphere Reserve; and World Heritage Sites, e.g. Robben Island, the Greater St Lucia Wetland Park, and the uKhahlamba-Drakensberg Park. The latter park is one of only 23 areas worldwide which has been listed as a World Heritage Site on both natural and cultural grounds.

Peace parks. Transfrontier parks (transboundary protected areas or peace parks) involve the collaboration of protected areas across an international border to form a single large protected area. The first transfrontier park in South Africa was created by linking the Kalahari Gemsbok National Park in South Africa with the Gemsbok National Park in Botswana to form one area now called Kgalagadi Transfrontier Park. There are initiatives to develop more transfrontier parks to enhance regional cooperation and biodiversity conservation, e.g. the Gaza-Kruger-Gonarezhou Transfrontier Park.

Did you know? The area under the jurisdiction of South African National Parks covers 50% of the total protected area network. Protected areas cover less than 7% of South Africa - significantly less than Botswana (18%), Namibia (14%), Zimbabwe (13%) and Mozambique (9%), and only 25th among countries in Africa. To rectify this a number of national parks (Karoo, West Coast, Addo, Mountain Zebra) have been enlarged recently, and new protected areas are being planned and developed.

Enviro Facts 9: Hazardous Waste

The widely used term hazardous waste is difficult to define. In this fact sheet it includes substances harmful to life and the environment, i.e. wastes with any of the following characteristics: infectious, poisonous (toxic), radioactive, flammable, explosive, corrosive, carcinogenic (cancer causing), mutagenic (damages chromosomes), teratogenic (causes defects in the unborn), or bio-accumulative (accumulating in the bodies of plants and animals and thus in food chains).

Hazardous wastes are produced during industrial, medical, chemical and biological processes. Even household, office and commercial wastes contain small quantities of hazardous wastes (e.g. batteries, pesticides, bleach, paint thinners and their containers).

Examples of hazardous waste

- **PCBs (polychlorinated biphenyls):** Non-flammable, insulating materials used by big electrical networks such as Eskom. South Africa lacks the technology to safely treat and dispose of waste PCBs.
- **Dioxins:** A by-product of industrial processes, e.g. incineration and refining of oil. Used to bleach paper in the paper and pulp industry.
- **Heavy metals:** Widespread industrial use, such as in cadmium and nickel plating. Found in batteries (e.g. mercury, cadmium, lead), fluorescent tubes, mercury thermometers, and leaded petrol.
- **Radioactive waste:** By-product of nuclear power generation; and used in medicine (e.g. cancer therapy).
- **Medical waste:** Waste generated by health-care institutions may contain infectious material, which can transmit diseases such as tuberculosis, hepatitis, and HIV/AIDS.

Options for treatment and disposal

There is no completely safe way of disposing of hazardous waste and the best option is the prevention and reduction of hazardous waste production, and the reuse of waste. Recently introduced minimum standards for the disposal of hazardous waste have decreased the risk of pollution, however no guarantees can be given. Some of the safer methods of dealing with hazardous waste are:

- ***Land-disposal:*** Waste is co-disposed (buried with domestic waste) and/or pre-treated in landfills that are designed with various layers of clay and plastic liners.
- ***Encapsulation:*** Waste, which cannot be pre-treated or does not biodegrade, is encapsulated in concrete.
- ***Incineration (burning):*** Incineration of hazardous waste is dangerous and should not be considered as an option for treating or 'disposing' of hazardous waste. Such incineration produces dioxins and furans, and releases heavy metals into the atmosphere. Most medical waste produced in South Africa is incinerated by private contractors or hospitals.
- ***Chemical or biological treatment:*** This treatment includes adding chemicals to waste to make it less hazardous, or adding bacteria to break it down into a less toxic residue. A good example of this is the use of algae to break down liquid hazardous waste from landfills and tanneries.
- ***Plasma arc conversion:*** This treatment subjects waste to temperatures of approximately 4 000 ^{O}C, thereby reducing it to its molecular form. This new and expensive technology produces virtually no hazardous by-products. Possible drawbacks of this process are yet to be investigated in South Africa.

International trade in hazardous waste

In the late 1980s, a tightening of environmental regulations in industrialised countries led to a dramatic rise in the cost of hazardous waste disposal. Searching for cheaper ways to get rid of the wastes, 'toxic traders' began shipping hazardous waste to developing countries and to eastern Europe. When this activity was revealed, international outrage led to the drafting and adoption of the Basel Convention. During its first decade (1989-1999), the Convention was principally devoted to setting up a framework for controlling the transboundary movements of hazardous wastes, that is, the movement of hazardous wastes across international frontiers. It also developed the criteria for environmentally sound management. A control system, based on prior written notification, was also put into place.

The Bamako Convention is an OAU (Organisation of African Unity) convention - this means that it applies only within Africa. It bans the importation of hazardous waste into Africa.

South Africa is a signatory to the Basel Convention, but not the Bamako Convention.

Shipping waste to other countries is no solution; it merely moves the problem. Each country should take responsibility for its own hazardous waste.

Hazardous waste and the law

Realising that pollution legislation (as well as other environmental legislation) was inadequate, the South African government embarked on a major reform of all environmental laws in 1994. Aspects of this reform process that are relevant to hazardous wastes include first, the establishment of the Integrated Pollution and Waste Management Committee (IP&WMC). This committee has been set up to streamline and co-ordinate pollution control and waste management legislation, and to develop a new National Pollution Control Act to co-ordinate pollution control.

Second, NEMA (National Environmental Management Act) increases the ambit of people who can be held responsible for pollution damage from not only any person, company or government department causing pollution, to any person, company or department owning, using or controlling the land on which the problem exists - even if the pollution causing activity was authorised by law.

What can industry do about hazardous waste?

The ultimate solution is the reduction of hazardous waste production. This can be achieved in a number of ways:

- substitution of non-polluting alternatives, e.g. the use of chlorine to bleach wood and paper results in the formation of dioxins - chlorine could be replaced with oxygen;
- efficient production processes and good maintenance of machinery can reduce waste production. This can be achieved through adopting one of a number of Environmental Management Systems, such as ISO14001, Life-Cycle analysis; cradle-to-grave, and the reduction of illegal dumping;
- recycling waste reduces pollution and can result in cost-savings, e.g. expensive, toxic heavy metals could be re-used.

Criteria to assess learners during this language lesson

Criteria	Exceeded requirements of the Learning Outcome	Satisfied requirements of the Learning Outcome	Partially satisfied requirements of the Learning Outcome	Not satisfied requirements of the Learning Outcome
The learner participated and contributed to the group discussions, prior to the debate				
The learner participated in the debate, putting forward his/her views and opinions				
The learner spoke confidently and expressively during the group discussions and the class debate/discussion				
The learner was able to acknowledge other people's opinions during the debate and agree or disagree politely				
The learner was able to give and receive criticism, during the debate of the 'Water Conflict Game'				

ACTIVITY FIVE: JUST FOR FUN! MAKING A JET-PROPELLED SPEEDBOAT

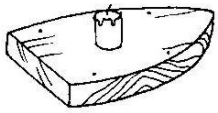
This TECHNOLOGY and NATURAL SCIENCES activity can be used to highlight different phases of water as well as the outcomes of what occurs when water changes phase. This activity can be done in the classroom or learners could try it out at home on their own.

You will need:

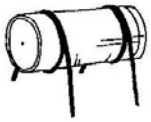
- A metal tube or small tin with a tight-fitting lid
- Wood (very light wood is best)
- Stiff wire (a coat-hanger works well)
- Candles and matches
- A nail

1. Make a hole in one end of the metal tube / tin

2. Saw a piece of wood to create the outline of a boat and make a shallow hole near each corner.

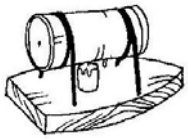


3. Using the wire, make a “cradle” for the tube – see drawing – and wind wire around the tube.



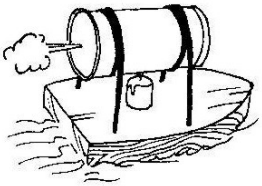
4. Place the feet into the holes in the wood.

5. Half fill the tube with water and replace lid.



6. Place the candle underneath the tube and light it.

7. Place the boat onto water.



Water power!

Share-Net

This pack supports an introduction for learners to an Eco-School's focus on resource management

Grade 9

This pack contains:

Activity One: Learners find out more about energy and energy options in South Africa during this **LANGUAGES** lesson and then debate whether water as an energy option is the way forward for our country.

Activity Two: During this **TECHNOLOGY** exercise, learners investigate, design, make and evaluate their own design based on water or steam power.

Activity Three: This **ARTS AND CULTURE** lesson looks at marketing and advertising our water or steam power designs that were made in Activity Two.

Activity Four: During this **NATURAL SCIENCES** activity, learners develop a school environmental policy to improve water management.

Activity Five: Just for fun – learners make a jet-propelled steam boat and a water-powered wheel.

WESSA

This pack of lesson plans is part of a series of lesson plans from Grade R to Grade 10 which focus on water and water-related issues. This resource development project has been funded by the Water Research Commission, Private Bag X03, Gezina, Pretoria, 0031 (Website: www.wrc.org.za).
This pack is available electronically on www.envirolearn.org.za

Activity	Learning Area covered in this activity	Learning Outcomes covered in this activity	Assessment Standards covered in this activity
1. Learners find out more about energy and energy options in South Africa and then debate whether water as an energy option is the way forward for our country.	Languages	**Learning Outcome 2:** Speaking: The learner will be able to communicate effectively in spoken language in a wide variety of situations. **Learning Outcome 5:** Thinking and reasoning: The learner will be able to use language to think and reason, as well as to access, process and use information for learning.	• Demonstrates a range of complex interaction skills by participating actively in group discussions, conversations, debates, group interviews and surveys. • Extends sources and methods for locating relevant information (e.g. electronic and other media such as newspaper archives, documentary films, specialist libraries).
2. Learners investigate, design, make and evaluate their own design which makes use of water or steam power.	Technology	**Learning Outcome 1:** Technological processes and skills: The learner will be able to apply technological processes and skills ethically and responsibly using appropriate information and communication technology.	**Investigates:** • Identifies and explains a problem, need or opportunity from a given real-life context, and investigates the context, the nature of the need, the environmental situation, and the people involved. • Uses a variety of available technologies and methods to locate (e.g. use library referencing system, database searches, indexes). **Designs:** • Writes or communicates a short and clear statement or a design brief for the development of a product. • Lists product and design specifications and constraints. **Makes:** • Develops plans for making that include resource lists, formal drawings and manufacturing sequence. • Chooses and uses appropriate tools and materials to make designed products with precision and control by measuring, marking, cutting or separating, shaping or forming, joining or combining and finishing a range of materials accurately and effectively. • Demonstrates knowledge and understanding of safe working practices and efficient use of materials and tools. **Evaluates:** • Evaluates the product or system and suggests sensible improvement or modifications that would clearly result in a more effective or higher-quality end product.
3. This lesson looks at marketing and advertising our water or steam power designs that were made in Activity Two.	Arts and Culture	**Learning Outcome 4:** Expressing and communicating: The learner will be able to analyse and use multiple forms of communication and expression in Arts and Culture.	Applies skills of media production, while considering target group, purpose and design elements (e.g. create an advertisement, class newsletter, poster, T-shirt, logo or jingle).
4. During this activity, learners develop an environmental policy to improve water management at their school.	Natural Sciences	**Learning Outcome 3:** Science, society and the environment: The learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and the environment.	Understands sustainable use of the earth's resources: responds appropriately to knowledge about the use of resources and environmental impacts: • Contributes to formulating a school environmental policy, including constructive ways to deal with waste material and to improve water management.
5. Just for fun – learners make a jet-propelled steam boat and a water-powered wheel.	Technology and Natural Sciences	-	-

ACTIVITY ONE: WATER POWER – THE WAY TO GO?

Learners find out more about energy and energy options in South Africa during this LANGUAGES lesson and then debate whether water, as an energy option, is the way forward for our country.

ACTIVITY:
Ask the learners:

1. Have you seen or taken part in a debate?
2. What was it about?
3. Where did it take place?
4. Who was taking part in the debate? *Prompt: Politicians, general public, members of a group or organisation.*

Ask the learners:

1. What is a debate?
2. If you were going to define it in a dictionary, what would you write? *Suggestion: A formal argument where groups or individuals present opposing views about a particular issue according to a set of rules.*

ACTIVITY:

- Explain that a debate is based around a suggestion or motion.

  An example of a motion is: The voting age should be lowered to 16.

- Explain that the people who are arguing to support the motion are called the proposers. The people arguing against the motion are the opposers. Print out copies of the worksheet on the following page which contains a muddled debating process and hand out to each learner.

- Ask learners to correctly order the stages of the debate.

See if you can un-muddle the steps in this debate…

An opposer sums up their group's main argument.

The first proposer presents the arguments for the motion.

The Speaker announces the result of the vote.

One of the proposers presents their arguments for the motion.

Everyone votes (apart from the Speaker) by leaving the debating chamber and coming back through a door marked 'aye' or 'no.'

The debate is chaired by the Speaker, who reads out the motion.

This side to side motion continues until everyone has had their say. You can only speak ONCE during the debate.

Two people, called tellers, count up the votes (bodies), as they come through each door.

A proposer sums up their group's main argument.

The first opposer presents the arguments against the motion.

An opposer presents their arguments against the motion.

The speaker re-reads the motion.

Check answers against the correct order:

1. The debate is chaired by the Speaker, who reads out the motion.
2. The first proposer presents the arguments for the motion.
3. The first opposer presents the arguments against the motion.
4. One of the proposers presents their arguments for the motion.
5. An opposer presents their arguments against the motion.
6. This side to side motion continues until everyone has had their say.
7. You can only speak ONCE during the debate.
8. An opposer sums up their group's main argument.
9. A proposer sums up their group's main argument.
10. The speaker re-reads the motion.
11. Everyone votes (apart from the Speaker) by leaving the debating chamber and coming back through a door marked 'aye' or 'no.'
12. Two people, called tellers, count up the votes (bodies), as they come through each door.
13. The Speaker announces the result of the vote.

Ask the learners:

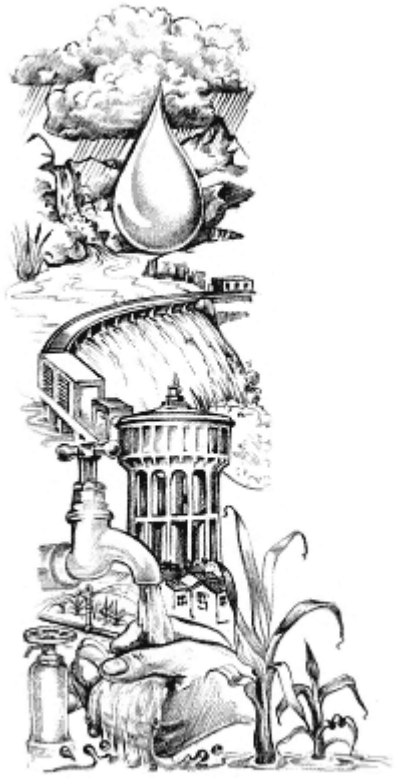
1. Why do you think there is a rule about people only speaking once during the debate?
2. What other rules do you think you will need to make the debate run smoothly?

Here are some rules of debate that we will follow:

1. The debate is chaired by the Speaker, whose decision on all matters is final.
2. You can only speak ONCE during the debate. Your speech should be about two minutes long. If you can, develop an argument rather than making a single point.
3. But you CAN 'intervene' as many times as you like. To intervene is to ask a question about a point being made, such as … are those statistics up-to-date?
4. You can use notes to help you with your speeches and make notes during the debate.
5. If you want to speak during the debate, you should catch the Speaker's eye by standing up as soon as someone has finished speaking. The Speaker will pick someone from those standing up.
6. If you spot someone breaking these rules you should tell the Speaker. This is called a point of order.

SO, WHAT ARE WE GOING TO DEBATE??

Read the following extract to the class:
Have you ever watched surfers riding the ocean waves at the coast? It is the power of water that moves them along.



People have used water-power for centuries. Since early days, it has been used to drive machines, and in the 18th century steam-power, a different form of water power, was invented.

Water-power
In the past, water-mills were built on the banks of streams to grind cereal to flour. These mills had huge paddle-wheels that were turned by the flowing water. Gears connected to the water-wheel turned the grindstones inside the mill.

The power of water is still used to turn wheels, but today they are turbines that drive generators to produce electricity. Power from water is an important source of renewable energy, unlike coal and oil that cannot be replaced once they are used up.

Steam power
Another source of water-power is steam. The steam is produced by boiling water over a fire and keeping the steam under pressure so that it has the power to drive engines. The first engines were all steam-engines and coal was used to boil the water. The engines were a good substitute for human muscle-power and increased the amount of work that could be done in factories.

CLASS ACTIVITY:

1. Divide the class into two groups.
2. Give them the following debate topic.

   Water as an energy option is the way forward for our country.

3. One group needs to prepare their debate agreeing with the topic (the proposers), the other needs to argue against it (the opposers).

4. Using the two enviro facts sheets (*Energy Options* and *Energy and Environment*) as an introduction to energy options, learners need to find out as much as they can about this topic. If you have a well-resourced library (school or community), make use of it; use the Internet; search for newspaper articles or magazines, see if there are any environmental films or videos on energy and energy options as well as energy issues (if possible, take out the movie 'An Inconvenient Truth' all about global warming and watch it as a class) as well as any other sources of information that will be useful. *(Learners need to keep*

a record of where they found their sources and what these sources were – this will help you, the teacher, when it comes to the assessment of this lesson). Some of the learners may have parents or relatives that work either for Eskom or for non-governmental organisations that are promoting the use of sustainable energy so they will be able to interview these people. Encourage the learners to make use of as many varied sources and methods of locating information as possible.

5. When the groups are ready and well prepared, you need to select seven learners to be:
    - Speaker. This person chairs the debate but cannot take part or vote.
    - First proposer to speak
    - First opposer to speak
    - Opposer to sum up
    - Proposer to sum up
    - Two tellers to count the votes

Hold the debate according to the formal order and rules.

Ask the learners:

1. What are the advantages of debating?
2. What are the disadvantages of debating?
3. Describe the strengths of a good debater. *Prompt: persuasive, confident, calm.*
4. Can you think of a better way to settle a difference of opinion?

Source: http://news.bbc.co.uk/cbbcnews/hi/newsid_4530000/newsid_4537100/4537177.stm

Criteria to assess learners during this languages lesson

Criteria	**Exceeded requirements of the Learning Outcome**	**Satisfied requirements of the Learning Outcome**	**Partially satisfied requirements of the Learning Outcome**	**Not satisfied requirements of the Learning Outcome**
The learner used a range of sources and methods (Internet, books, magazines, enviro facts) to prepare for the debate on water energy – *teacher, you may want to use the list of where and what the learners found and what sources they used*				
The learner took an active role in the preparation for the debate				
The learner took an active role in the debate				

Enviro Fact: Energy Options

Coal supplies most of South Africa's electrical energy. It is a finite, non-renewable resource. Burning coal to produce electricity causes serious environmental problems. Pollution from power stations contributes to global warming. In addition to the environmental challenges associated with energy supply, South Africa faces significant social challenges. Although we produce half of the electricity on the African continent, 40% of South Africans do not have access to electricity and rely instead on fuelwood and other inconvenient fuels such as coal, paraffin, gas, or candles. It is important that South Africa addresses both the environmental problems associated with energy supply, and the inequalities in access to adequate and affordable energy.

How can we provide adequate and affordable energy for all, while promoting environmental sustainability?

Many of South Africa's medium- and long-term energy needs could be addressed through regional co-operation. This could include the establishment of a regional electricity transmission grid and a Southern African Development Community (SADC) power pool, and regional energy planning. Such co-ordination would create opportunities for SADC countries to provide their people with clean and sustainable energy. Regional co-operation does however require political and economic stability.

There are also several technologies that could improve the sustainability of the regional electricity industry.

In addition to reducing pollution from coal-fired power stations, hydroelectric and solar power, natural gas, wind, tide and wave power may all help the region address its energy needs with minimum impact on the environment.

Reducing pollution from coal-fired power stations
This pollution can be reduced by using equipment which removes oxides of sulphur and nitrogen from the gases released when coal is burnt. This could result in electricity being more expensive, but this should be weighed against the benefits to the environment.

Hydro-power
Coal stocks are finite and sooner or later we shall have to rely on another source of energy. A possible medium-term alternative is to harness the huge hydro-electric potential of the sub-Saharan Africa region, estimated to be more than twice Eskom's current generating capacity. There are many other rivers in Zambia, Zimbabwe, Angola and Mozambique suitable for hydroelectricity.

Hydroelectricity is renewable and does not pollute. However, it is expensive, and requires the construction of large dams which have significant social and environmental costs. In addition, this option requires regional co-operation and political stability.

Solar energy
Solar energy can be used to produce heat. In Israel more than two-thirds of houses are fitted with solar water heaters. South Africa experiences more sunshine than

most places and there is much potential for widespread use of solar water heaters, particularly in mass, low-income housing projects. However, the initial outlay for solar panels is expensive as large areas of panels are needed to collect useful amounts of energy. Solar energy could be particularly useful in remote areas far from the electricity grid, such as farms, rural clinics, and water pumping stations.

Nuclear energy
There is much debate among energy planners in South Africa as to whether nuclear energy should play a role in this country's future. Using current technology it is a costly option, with unresolved environmental problems such as the disposal and storage of waste products.

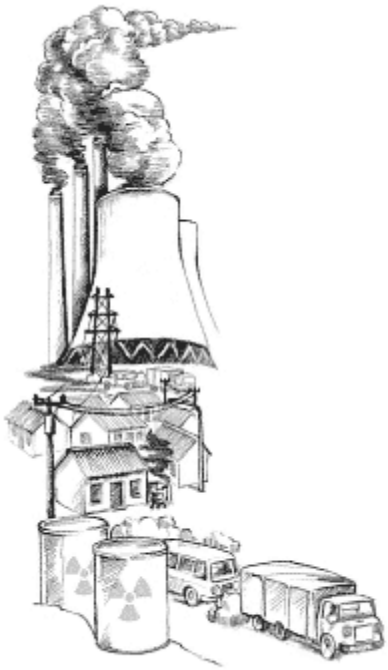
Natural gas
Although natural gas is a non-renewable energy resource, it has great potential as a future energy source for South Africa. South Africa has a limited amount of natural gas reserves, but strong regional ties would allow us to import gas from Namibia and Mozambique. Natural gas produces less pollution than other fossil fuels. In fact, latest natural-gas-burning turbines can produce electricity 50% more efficiently than those burning coal. Natural gas can also be burned cleanly in co-generation (see below). Because of its advantages over coal and oil, some analysts see natural gas as the best fuel for the transition to energy efficiency and renewable energy.

Wind power
As global energy resources become more and more scarce, wind power is becoming increasingly attractive. Wind energy is freely available and poses less of a threat to the environment than fossil and nuclear energy sources. Wind energy can provide electricity for communities not linked to the electricity grid. Telecommunications companies currently use small wind turbines to support cellular networks in the region. In addition, wind energy can be exploited on a large grid-tied scale through the development of wind farms. However, wind is not a reliable source of energy, and its use is limited to areas with steady winds. These areas are often found near coastal regions and in some arid and semi-arid areas.

Energy efficiency
South Africa uses more energy per unit of economic output (GDP or gross domestic product) than many other countries. There is much potential for energy saving. European countries and Japan have shown in recent years that industrial production can be increased while using less energy through energy-efficient manufacturing processes. Passive solar design principles and more efficient lighting and insulation contribute to energy savings in buildings. Industry is able to save energy through co-generation, advanced heat recovery systems and better control of energy usage. (Co-generation is a process which produces both electricity and heat at the same time, while advanced heat recovery systems economize on, and use the heat generated in industrial and chemical processes). Recycling waste materials can also save energy, for example aluminium produced from scrap uses 95% less energy than when it is manufactured from ore. New motor vehicles are also becoming more fuel efficient.

Planning in towns and cities should encourage the use of efficient public transport systems rather than private motor vehicles. In the long term we shall also have to find alternative fuels for transport. Hydrogen offers a clean alternative and as one of the elements in water it is plentiful. But it still requires energy to separate hydrogen from oxygen in water. Nuclear fusion (the combination of hydrogen atoms to form helium, i.e. the reaction which powers the sun) may also be a future option, but scientists do not foresee major progress in this area for many years to come.

Enviro Fact: Energy and Environment



Some of South Africa's most serious environmental problems are associated with our use of energy. Coal-fired and nuclear power stations for electricity generation, coal combustion in the townships, SASOL coal-to-oil processes, petrol and diesel use in vehicles for bulk transport, and over exploitation of fuelwood resources, all result in serious, long-term environmental damage.

Pollution from burning coal
More than three-quarters of South Africa's energy comes from coal, approximately half of which is used to generate electricity, a quarter to produce synthetic liquid fuels and another quarter directly by industry and in homes. Air pollution problems from coal combustion are serious. Medical studies are revealing increased rates of respiratory disease in residents in polluted areas.

Acid rain
Most of South Africa's power stations are concentrated within a 100 km radius in Mpumalanga and this leads to pollution problems. While all of Eskom's coal-fired power stations are designed to remove dust and other particles from waste gases produced during coal combustion, none are fitted with flue-gas scrubbers (cleaning equipment) to remove oxides of sulphur and nitrogen. Tall chimney stacks in power stations assist in releasing oxides of sulphur and nitrogen into the upper atmosphere where atmospheric conditions are more favourable for their dispersal and dilution. Although this reduces ground level concentrations of these pollutants, they may combine with moist air and rain at higher levels and cause acid rain in areas far from the source of pollution.

Whilst South Africa's coal has a relatively low sulphur content there is considerable concern about the potential environmental and economic impact of acid rain. Half of South Africa's agriculturally productive land, half of its commercial forests and a quarter of its surface water run-off are in Mpumalanga.

Pollution from vehicles
Motor vehicle fumes make air pollution problems worse and are the main cause of photochemical smog in cities. Unleaded fuel has recently been introduced to South Africa and this may reduce the amount of lead in exhaust fumes. Catalytic converters fitted to exhausts would result in a significant reduction in the release of carbon dioxide, hydrocarbons, and nitrogen oxides. However, South Africa lags far behind other countries (such as Japan and Germany) in legislation to control vehicle emissions. Solutions to transport pollution and vehicle congestion require long-term planning to introduce efficient public transport systems in our cities.

Deforestation
Another environmental concern associated with energy use is the reliance by a significant number of South Africans on fuelwood, once a renewable resource, but now being used at a rate much greater than that at which it is naturally regenerated. Fuelwood is an inefficient source of energy for cooking and heating and its use can cause increased respiratory illnesses. It has been estimated that if current consumption trends continue, all natural woodland in the former "homelands" will be denuded by 2020. In addition to the environmental consequences of deforestation,

diminishing supplies of wood require rural people (particularly women) to travel further and further from home to gather wood, placing a great burden on them.

Global warming
South Africa uses a great deal of energy, very much more per unit of gross domestic product (GDP) than most other countries. The combustion of coal, oil and wood results in increased carbon dioxide production. This gas acts likes a greenhouse - it lets short-wave, natural light through but traps out going long-wave (infra-red or heat) radiation. The potentially devastating consequence is that the Earth is slowly getting warmer, causing the climate to change and sea levels to rise. Although South Africa produces only a small percentage (1,6%) of the total, global carbon dioxide emissions, it plays a disproportionately large role per person in contributing towards the greenhouse effect and global warming. As a country needing rapid economic growth in the medium-term to satisfy the country's developmental needs, South Africa's potential contribution to global warming is an area of concern.

Nuclear energy
South Africa currently has one commercial nuclear power station at Koeberg near Cape Town. It provides 1 800 MW of Eskom's installed electricity generation capacity of 37600 MW, less than 5% of the total. There is intensive debate among energy planners as to whether nuclear energy should play a role in South Africa. In addition to being a costly option, nuclear fission produces dangerous radioactive by-products. There is considerable concern about their safe containment in the case of accidents at nuclear power stations, the closing down (decommissioning) of old power stations, and the storage of highly toxic wastes. At present, low-level radioactive wastes are stored in sealed containers which are buried underground at disposal sites. No long-term solution has been agreed on for the safe storage of high-level radioactive wastes, some of which remain harmful for thousands of years.

ACTIVITY TWO: WATER POWER!

During this TECHNOLOGY exercise, learners investigate, design, make and evaluate their own water or steam power designs.

Coal supplies most of South Africa's electrical energy. It is a finite, non-renewable resource. Burning coal to produce electricity causes serious environmental problems. Pollution from power stations contributes to global warming. In addition to the environmental challenges associated with energy supply, South Africa faces significant social challenges. Although we produce half of the electricity on the African continent, 40% of South Africans do not have access to electricity and rely instead on fuelwood and other inconvenient fuels such as coal, paraffin, gas, or candles. It is important that South Africa addresses both the environmental problems associated with energy supply, and the inequalities in access to adequate and affordable energy.

How can we provide adequate and affordable energy for all, while promoting environmental sustainability?

What the learners need to do:

1. Investigate whether water or steam can generate electricity

The investigation phase is the research phase. Learners need to understand and explain the energy problems that South Africans are facing today; they need to locate information on existing water or steam generators by looking at pictures of water wheels and steam engines and at books and any other material that they can find on water power. They can also discuss their ideas with friends, in small groups and with you, the teacher. Let the learners write a paragraph on their "research" which should include what sources of information they used, where they found these sources, what they found out, what they think they would like to design.

2. Design

- Each learner will need paper and pencils so that they are able to write and draw their design ideas. There needs to be a short, clear statement (or design brief) for their design. The design must be on paper and learners should make rough drawings first. When they are happy with their designs, they need to make a neat drawing with a heading and labels or a colour key. The dimensions of the design must be written down and the materials that will be used must be listed. Any constraints/restrictions that the learner can see/anticipate in the future must also be noted. In addition, the learner must work out the cost of the design, how safe it will be, what the product will do.

- It is very important that you, the teacher, guide the learners through this design phase. Some of the learners' designs may be wonderfully creative but very impractical, so you need to be on hand to make sure that their designs will work.

3. Make

- The learners need to gather together the materials they will need to construct their design. They will need to develop plans for their designs which include a resource list (the materials and tools needed and their costs; formal drawings showing dimensions or quantities (such as 'exploded views [An exploded view is a representative picture or diagram that shows the components of an object slightly separated by distance, or suspended in surrounding space]; orthographic views [orthographic drawings are front, side, top, etc views of an object. An orthographic view is only one side. It takes several views to show the whole object], isometric views [a method of visually representing three-dimensional objects in two dimensions]; sequence drawings [a drawing of each stage of manufacture and includes brief notes or instructions. It normally follows a flowchart which simply lists each stage]; and the sequence (by way of a flow chart) of how the product will be built.

- Encourage the learners to use recycled objects if possible. When they have all they need, the designs need to be constructed. Remind them that they need to make sure they are precise and careful when making their design and they need to work safely with any tools they use.

4. Evaluate

- Test the designs!! Do they work, how well? After testing individual designs, learners can set up their designs at the front of the class and demonstrate them to everyone. Learners need to ask themselves if their designs could be improved on – how? There may even be some constructive comments from the rest of the class during the demonstrations.

Criteria to assess learners during this technology lesson

Criteria	Exceeded requirements of the Learning Outcome	Satisfied requirements of the Learning Outcome	Partially satisfied requirements of the Learning Outcome	Not satisfied requirements of the Learning Outcome
The learner was able to identify that energy generation is an environmental problem in South Africa *(teacher, the learners will have written a paragraph on this during the investigation phase)*				
The learner located and made use of a number of references (such as books, used the Internet, newspapers) during the investigation process				
The learner wrote a clear statement (design brief)				
The learner listed the products and design specifications				
The learner made a note of any constraints				
The learner drew formal drawings of the design				
The learner drew a flow chart of how the design would be built				
The learner worked carefully and safely				

ACTIVITY THREE: MARKETING OUR WATER POWERED DESIGNS

This ARTS AND CULTURE lesson looks at marketing and advertising our water or steam power designs that were made in Activity Two!!

The term, MARKETING, was first academically defined in 1937 when the American Marketing Association (AMA) stated that:

> "*Marketing consists of those activities involved in the flow of goods and services from the point of production to the point of consumption.*

Although marketing is often interchangeably used with the word *advertising*, marketing can be more specifically described as the game plan by which the advertising will be carried out, as in a *marketing strategy*.

ADVERTISING is a paid form of communicating a message by the use of various media. It is persuasive, informative, and designed to influence people's purchasing behaviour or thought patterns.

DISCUSS WITH THE CLASS:

1. What are ways that a product can be advertised?
2. Are there any adverts (radio, television, in newspapers or magazines) that you remember from a long time ago?
3. Why do you think you remember them? Do you think that company that developed that advert, so many years ago and that you can still remember, had an effective marketing strategy?
4. Which ways are the most effective ways of advertising for teenagers (these will vary from learner to learner)?
5. Should one always 'tell the truth' in advertising? Why? Why not?

ACTIVITY:

You will need:

- Paper – white or coloured
- Paint
- Pastels
- Kokis
- Chalk
- Wax and / or wax crayons
- Plain T-shirts and fabric paint

WHAT TO DO:

Using your research information gathered in Activity Two, design and create a poster, T-shirt, logo or music 'jingle' to advertise your steam- or water-power

design. Those creating a T-shirt, will need to do the initial design on paper and then, time and the availability of T-shirts permitting, transfer the design onto the material.

Remember to consider your target group, the purpose of your design and design elements.

Criteria to assess learners during this arts and culture lesson

Criteria	**Exceeded requirements of the Learning Outcome**	**Satisfied requirements of the Learning Outcome**	**Partially satisfied requirements of the Learning Outcome**	**Not satisfied requirements of the Learning Outcome**
The learner participated in the discussions about advertising				
The learner considered target group, purpose and design elements				
The learner created a music jingle, poster, T-shirt or logo				

ACTIVITY FOUR: DEVELOPING A SCHOOL POLICY TO IMPROVE OUR WATER MANAGEMENT

During this NATURAL SCIENCES activity, learners develop a school environmental policy to improve water management.

A school environmental policy is a statement of intentions and principles for improving a school's educational and environmental performance. The policy development process involves learners, teachers and other stakeholders and encourages schools to audit existing practices, activities and other elements of the curriculum and to select, evaluate and review environmental education goals and management plans.

A simple school environmental policy is shown below:

At all times the staff, learners and community will try to:

- *Engage with environmental issues for more meaningful learning in a healthy, happy school*
- *Manage resources more wisely*
- *Minimise wastage*
- *Minimise water and electricity use*
- *Improve our school grounds and environment*
- *Share ideas, improve co-operation throughout the school community*

From Georgenau Primary, Pietermaritzburg

One way to further develop a school policy is to develop two sub-points for each of the main points in the policy. The sub-points should describe what you will do in more detail.

At all times the staff, learners and community will try to:

- ***Engage with environmental issues for more meaningful learning in a healthy, happy school:***
  - *Through developing and teaching environmental lesson plans, and*
  - *Through creating opportunities for learners to enjoy the school's natural environment in the context of lessons.*
- ***Manage resources more wisely***
  - *Reduce electricity consumption in the school*
  - *Reduce water consumption in the school*
- ***Minimise wastage***
  - *Reduce the number of resources used*
  - *Establish a recycling programme*
- ***Improve our school grounds and environment***
  - *Plant a food garden*
  - *Reduce soil erosion by planting indigenous water-wise vegetation in bare areas*
- ***Share ideas, improve co-operation throughout the school community***
  - *Involve parents in more environmental projects*
  - *Establish an environmental club for teachers and learners*

It is useful to assess the current status of our school by means of an audit. An audit can be described as a careful look at the way things are. A policy then attempts to address what has been discovered in the audit. In the following activity, we will start with an audit and this will lead to the development of a water policy for the school.

ACTIVITY:

- Divide the class into five groups. Every learner needs a copy of the water audit worksheet on the following page. All learners need to check the water meter (if your school has one) each day. Each group needs to do the audit on a different day of the week (one group of learners will do it on Monday, the next group on Tuesday etc) and report any leaking taps to the teacher.

Name: _____

Date of audit: _____

Time of audit: _____

WATER	**YES**	**NO**
1. Does the school have access to water-on-tap?		
2. Is the drinking water clean and safe for consumption?		
3. Does the school have tanks to collect rainwater?		
4. Are teachers and learners aware of ways to save water?		
5. Is water management recognised and promoted at your school?		
6. Who amongst teachers, school governing body members, learners and other staff members know how to change a tap washer?		
7. How many taps are dripping?		
8. How many taps including baths and showers are in the school and school grounds?		
9. How many flush toilets are in the school?		
10. How many toilets are leaking?		

If the school has access to municipal water, find and read the water meter in the school grounds. Record the daily use in the table below:

DAY	**DATE**	**TIME**	**METER READING**	**LITRES USED**
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Total for the school week (Monday to Friday)				

- Now that the audits are complete, learners (individually or in small groups) need to brainstorm ideas around how the water management in their school can be improved, based on what they discovered during their audits. Water management actions can include individual learner and teacher actions and whole class/grade/school actions.

- Learners then need to write down all the ideas on paper.

- Go round the class, asking individuals (or groups) for their contributions and ideas. List these on the board. As a class, decide which (between five and ten) are the most likely that your school will be able to implement. Eliminate the rest. If necessary, expand the initial idea to include two sub-points (see example on page 14).

- Once everyone is happy with the policy, write or type it up neatly and present it to the school governing body or headmaster. Your school may already have an environmental policy so your water management policy can become part of that.

Remember, we can ALL work towards managing our water resources more wisely, whether it is on an individual, group, class, grade or school level!

Criteria to assess learners during this natural sciences lesson

Criteria	**Exceeded requirements of the Learning Outcome**	**Satisfied requirements of the Learning Outcome**	**Partially satisfied requirements of the Learning Outcome**	**Not satisfied requirements of the Learning Outcome**
The learner carried out the water audit on her/his own				
The learner contributed ideas towards better water management at the school				

ACTIVITY FIVE: JUST FOR FUN – MAKE A JET-PROPELLED STEAMBOAT AND A WATER-POWERED WHEEL

These two TECHNOLOGY and NATURAL SCIENCES activities highlight water power as well as the outcome of what occurs when water changes phase. They can be done in the classroom or learners could try them out at home.

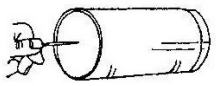
1. MAKE A JET-PROPELLED SPEEDBOAT

You will need:

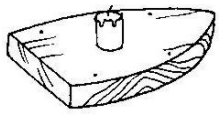
- A metal tube or small tin with a tight-fitting lid
- Wood (very light wood is best)
- Stiff wire (a coat-hanger works well)
- Candles and matches
- A nail

What to do:

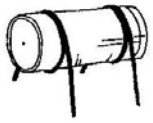
1. Make a hole in one end of the metal tube / tin



2. Saw a piece of wood to create the outline of a boat and make a shallow hole near each corner.

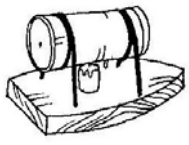


3. Using the wire, make a “cradle” for the tube – see drawing – and wind wire around the tube.



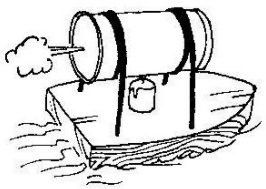
4. Place the feet into the holes in the wood.

5. Half fill the tube with water and replace lid.



6. Place the candle underneath the tube and light it.

7. Place the boat onto water.

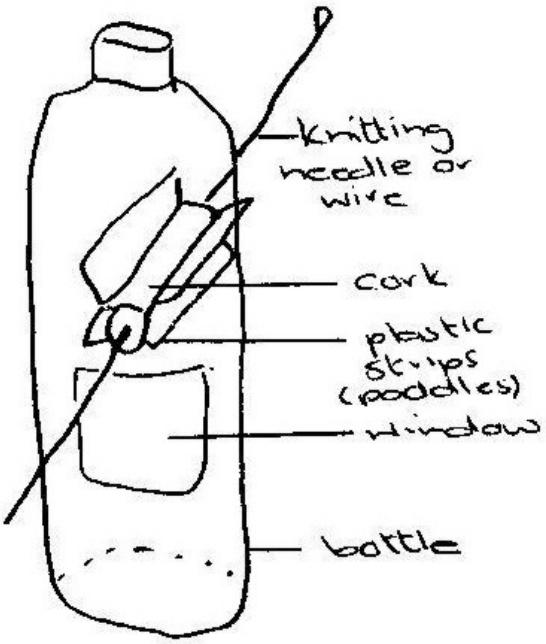


2. MAKE A WATER-POWERED WHEEL

You will need:

- A clear plastic cool-drink bottle
- Three pieces of cork
- Knitting needle

What to do:

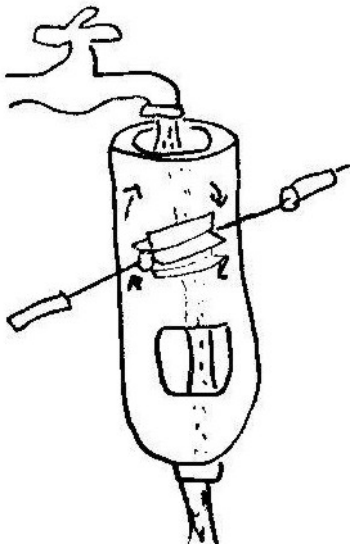


1. Cut a window out of one side of a clear plastic cold-drink bottle. Cut the window into four equal strips.

2. Make a hole in a cork by pushing a thin knitting needle down the centre. Remove the needle. Use a sharp knife to cut four slits down the sides of the cork and push a plastic strip into each one.

3. Use the needle to pierce the small holes opposite each other below the window. Push your needle through one hole, then through the waterwheel held inside the bottle and out the hole on the other side. See that the needle spins freely. Push a piece of cork onto each end of the needle to stop it from coming out.

4. Make a hole in the base of the bottle and push it onto a tap. Gently trickle water over your water-wheel to make it turn.



- *Note how fast the water-wheel turns. What happens when you increase the water flow?*

- *See how the outer corks turn as well. This part of the water-wheel would turn a grindstone or motor.*

Investigating water quality in South Africa

Share-Net

This pack supports an introduction for learners to an Eco-School's focus on environmental information and community knowledge

Grade 10

This pack contains:

Activity One: How healthy are our rivers? This **LANGUAGES** research and writing activity looks at water quality in South Africa. Learners research the topic of water quality, using a wide range of sources and methods. They then write up their information in essay format.

Activity Two: This **LIFE SCIENCES** lesson looks at visible animal life to determine the health of our rivers and streams.

Activity Three: This **PHYSICAL SCIENCES** lesson looks at water quality, water-borne diseases and some simple ways of purifying water. This is followed by a case study on the water collecting ways of Nguni people.

Activity Four: Water bodies in southern Africa suffer from many problems – all of which are linked to the way in which the catchment area is used. This **PHYSICAL SCIENCES** lesson looks at water use in a catchment and encourages learners to look at ways of conserving and caring for our water catchments.

Activity Five: 5. We all use water every day for things like drinking, cooking and washing. We could not survive without water! This **LIFE SCIENCES** activity looks at how small or large our eco footprint is.

WESSA

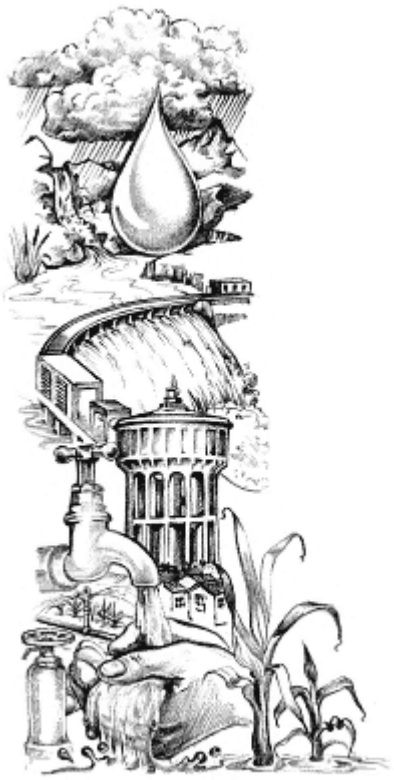
This pack of lesson plans is part of a series of lesson plans from Grade R to Grade 10 which focus on water and water-related issues. This resource development project has been funded by the Water Research Commission, Private Bag X03, Gezina, Pretoria, 0031 (Website: www.wrc.org.za).
This pack is available electronically on www.envirolearn.org.za

Activity	Learning Area covered in this activity	Learning Outcomes covered in this activity	Assessment Standards covered in this activity
1. How healthy are our rivers? This research and writing activity looks at water quality in South Africa. Learners research the topic of water quality, using a wide range of sources and methods. They then write up their information in essay format.	Languages	**Learning Outcome 3:** Writing and presenting: The learner is able to write and present for a wide range of purposes and audiences using conventions and formats appropriate to diverse contexts.	Research topics from a variety of sources and records findings. Locate, access, select, organise and integrate relevant data from a variety of sources. Apply paragraph conventions to ensure coherence by using topic sentences, introduction and ending, logical progression of paragraphs, cause and effect, comparison and contrast. Prepare a final draft by proofreading and editing. Present final draft paying attention to appropriate style such as a neatly presented text.
2. This lesson looks at visible animal life to determine the health of our rivers and streams.	Life Sciences	**Learning Outcome 1:** Scientific enquiry and problem-solving skills: The learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using enquiry, problem solving, critical thinking and other skills.	Plans an investigation using instructions. Systematically and accurately collect data using selected instruments and/or techniques and following instructions. Displays and summarises the data collected.
3. This lesson looks at water quality, water-borne diseases and some simple ways of purifying water. This is followed by a case study on the water collecting ways of Nguni people.	Physical Sciences	**Learning Outcome 3:** The nature of science and its relationships to technology, society and the environment.	Discusses knowledge claims by indicating the link between indigenous knowledge systems and scientific knowledge.
4. This lesson looks at water use in a catchment and encourages learners to look at ways of conserving and caring for our water catchments.	Physical Sciences	**Learning Outcome 3:** The nature of science and its relationships to technology, society and the environment.	Describes the interrelationship and impact of science and technology on socio-economic and human development. • States the impact of human demands on the resources and products in the earth's system.
5. We all use water every day for things like drinking, cooking and washing. We could not survive without water! This activity looks at how small or large our eco footprint is.	Life Sciences	**Learning Outcome 3:** Life Sciences, technology, environment and society: The learner is able to demonstrate an understanding of the nature of science, the influence of ethics and biases in Life Sciences, and the interrelationship of science, technology, indigenous knowledge and society.	Describe different ways in which resources are used and applied to the development of products, and report on their impact on the environment and society.

ACTIVITY ONE: FINDING OUT ABOUT THE WATER SITUATION IN SOUTH AFRICA

How healthy are our rivers? This LANGUAGES research and writing activity looks at water quality in South Africa. Learners research the topic of water quality, using a wide range of sources and methods. They then write up their information in essay format.

Hand out the following information on pages 1 and 2 to your learners:



Water in South Africa

South Africa is extraordinarily rich in natural resources – except for water. Water is a vital but scarce resource, distributed unevenly in time (frequent droughts alternate with periods of good rainfall) and space (the eastern half of the country is markedly wetter than the western half). Increasing demand for water, and decreasing water quality make careful water management a priority in our country. It has been estimated that by the year 2025 South Africa's human population will have doubled, and there will be insufficient water for domestic use, agriculture, and industry.

- **Rainfall:** Our average rainfall is less than 500 mm a year, with the driest part of the country receiving less than 200 mm/year and the wettest receiving more than 2 500 mm/year! Rain does not always fall where it is most needed, and some areas of high demand, such as Gauteng, receive less water than they need. Most rain falls in the narrow belt along the eastern and southern coasts. The rest of the country receives only 27% of South Africa's total rainfall. In addition, hot, dry conditions result in a high evaporation rate.

- **Rivers:** There are few natural lakes in South Africa. We depend on rivers, dams and underground water for our water supply. Approximately 75% of the water flowing from South Africa into the sea occurs along the eastern and southern seaboards, where many short rivers occur. Flowing from east to west is the largest river in the country, the Orange River, which drains most of the rest of the country. Its water comes from sources in the Drakensberg and Maluti Mountains, and it flows into the Atlantic Ocean on the west coast.

- **Dams:** About half of South Africa's annual rainfall is stored in dams. We have about 550 government dams in South Africa, with a total capacity of more than 37 000 million m^3.

  Dams have both positive and negative impacts. They can be beneficial for people in that they regulate the flow of a river, reducing flood damage and contributing to perennial rather than seasonal flow. In addition, sediment is deposited in a dam, and the growth of aquatic plants means that nutrients are removed from the water. Thus water leaving a dam may be cleaner than water entering it. The riverine ecosystem is usually affected negatively by a dam. Alterations in flow regime (quantity of water and

timing of periods of high and low flow), temperature and water quality may cause reductions in biodiversity of riverine organisms below dams. Reduction in water flow reduces the river's scouring ability and this can lead to silting of estuaries.

South Africa's landscape is not well suited to dams. There are few deep valleys and gorges, with the result that most dams are shallow with a large surface area. Together with the hot, dry climate, this results in much water evaporating from dams. In addition, the high silt load (a result of an arid climate, steep river gradients and poor farming methods) of our rivers means that the capacity of South Africa's dams is quickly reduced as they become silted. The rivers of the Western Cape carry relatively less silt than those in the rest of the country.

- **Water abstraction:** A growing problem for South Africa's rivers is a lack of water! Reduction in river flow, owing to abstraction (removal), and damming, has affected many of our rivers, for example those flowing through the Kruger National Park.

- **Intercatchment transfer of water:** This involves the transfer of water from catchments with good supplies and low demand, to those where demand for water is high and the supply is poor. There are numerous intercatchment transfer schemes already in operation, and more are under construction or proposed. A major scheme is the Orange-Fish River scheme, where water gravitates from the Orange River at the Gariep Dam, and is piped through tunnels and canals to the Sundays and then the Fish Rivers in the Eastern Cape. Transfers of this nature will have far-reaching ecological, political and socio-economic implications. As yet, little research has been carried out to establish the ecological consequences of intercatchment water transfers. However, areas of concern include reducing streamflow and water levels in one system, changes in water temperature and chemistry, and the transfer of invasive species between catchments.

- **Water pollution:** Industrial and agricultural pollutants common in South Africa include agricultural fertilizers, silt, toxic metals, litter and pesticides. These pollutants affect aquatic ecosystems and human health. Disease-producing bacteria are common in urban waste water, particularly from informal settlements that lack sewage and water purification facilities. For example, typhoid, cholera and gastroenteritis are transmitted by water contaminated with untreated sewage. Gastroenteritis is one of three main causes of death in South African children under the age of five.

Water Quality

Healthy streams and rivers support a wide variety of water life. Rainwater and cool, tumbling mountain streams contain high levels of oxygen. Low concentrations of nutrient substances which are washed into the system provide both key growth chemicals (such as nitrates) and food (like rotting plants – detritus). Water plants, in turn, photosynthesise to provide more life supporting oxygen and food sources for water organisms. All of these factors interact as a complex web of life both within the river itself and in its surrounding catchment. Much human activity has unfortunately disrupted these ecological processes and degraded water quality.

ACTIVITY:
How healthy are our rivers?

1. Learners research the water quality situation in South Africa. They need to use at least five different sources (excluding the fact sheet on 'Water in South Africa') to gather information. These can include, but are not limited to, books, journals, newspapers, the Internet, interviews, visits to local water suppliers (such as Umgeni Water or Rand Water) or documentaries. Once the research has been completed, learners present their findings in an essay.

2. The following points need to be considered when writing an essay:
    - The **introduction** should be designed to attract the reader's attention and give the person an idea of the essay's focus. You could begin your introduction with an attention grabber such as startling information (which must be true) or even an anecdote (a story which illustrates a point) – but make sure your anecdote is short, to the point and relevant to your topic.

    - Each main idea will become one of the **body paragraphs**. If you had three or four main ideas, you will have three or four body paragraphs. The topic can now be explained, described, or argued.

    - The **conclusion** sums up your points or provides a final perspective on your topic. All the conclusion needs is three or four strong sentences which do not need to follow any set formula. Simply review the main points (being careful not to restate them exactly) or briefly describe your feelings about the topic. Sometimes, even an anecdote can end your essay in a useful way.

Remember to:

- Read and reread your essay.
- Does it make logical sense?
- Leave it for a few hours and then read it again. Does it still make logical sense?
- Do the sentences flow smoothly from one to another?
  If not, try to add some words and phrases to help connect them. Transition words, such as "therefore" or "however," sometimes help. Also, you might refer in one sentence to a thought in the previous sentence. This is especially useful when you move from one paragraph to another.
- Finally, have you checked your spelling?

Criteria to assess learners during this languages lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner used at least five sources when researching 'how healthy are our rivers'						
The learner organised and integrated their information into a concise, well-presented essay						
The essay had an introduction, paragraphs and conclusion and was in a logical order						
The final essay was neatly written and presented						

ACTIVITY TWO: INVESTIGATING THE HEALTH OF OUR RIVERS

This LIFE SCIENCES lesson looks at visible animal life to determine the health of our rivers and streams.

MiniSASS is a simplified form of the South African Scoring System. It is a technique that can be used to measure the health of a river and the general quality of the water in that river. Developed by Umgeni Water and Ezemvelo KZN Wildlife, it uses the composition of invertebrates living in rivers and is based on the sensitivity of the various animals to water quality. It does not, however, measure contamination of the water by bacteria and viruses and thus does not determine if the water is fit to drink without treatment.

The MiniSASS is a miniature version of the more sophisticated SASS method that is used as part of the National River Health Programme. The results produced using MiniSASS have been tested against the more rigorous SASS method and have been found to be sufficiently close to be of real value.

Are you ready for some environmental action?

Method:

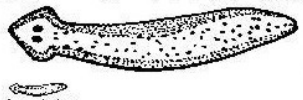
1. The best sites to find insects in a nearby river are where the current is fairly fast moving and where there is some vegetation growing in the water, along the sides of the river.

2. Look for invertebrates in as many of the different habitats (biotopes) you can find at a river site. Insects are collected holding a small net (a kitchen sieve will do) in the current, and then disturbing the stones, vegetation and sand using your feet (with boots on!) or hands just upstream of the net. Be bold in turning the stones over. The insects will be dislodged and will flow into the net. Do this for about 5 minutes while ranging across the river to a number of different habitats. You can also lift stones and pick off the insects with your fingers or you can brush off the underside of the stones with a clean paintbrush.

3. Rinse any mud out of the net then turn the contents into a plastic tray (a 2 litre ice-cream container is ideal). Identify each group using the sheet given on page 6 (keep a tally of the number of each group). If the river is in reasonable condition, you should have several hundred individual insects in the sample.

Flat worms

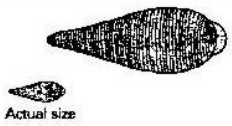
SCORE 3



Soft bodied worm-like form but flattened shape. Dark grey colour, head arrow shaped with a pair of dorsal eye spots. Move with a gliding movement over the substrate and are generally scavengers or carnivorous.

Leeches

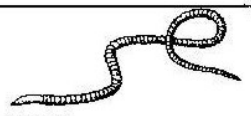
SCORE 2



Variable colour from grey to red, brown and black. Body very flexible, extending long and thin while moving but contracting into a short stubby shape when disturbed. Often uses suckers at front and rear to aid movement and will stick tightly onto the surface. Also swim with a fast snaking movement. Often found under stones, vegetation or debris and are common in polluted water. Mostly carnivorous on other invertebrates, with a few blood suckers occurring mainly in the more tropical regions.

Worms

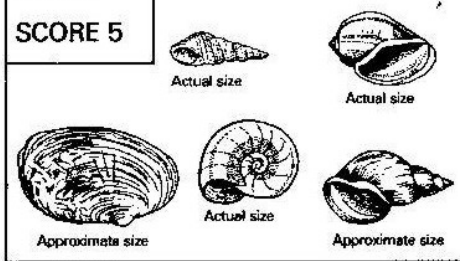
SCORE 2



Elongate cylindrical shape much like small earth worms. Colour usually pink to brown. Seen writhing around in debris where they feed on deposits. Tolerant of very polluted water.

Snails

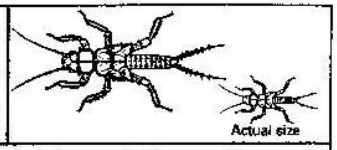
SCORE 5



There are a range of snails in rivers, including small black limpets which cling to rocks, clams or muscles found in sand, and the more common snails which move over stones and vegetation. Some of the latter are host to bilharzia, a most serious health hazard for humans.

Stoneflies

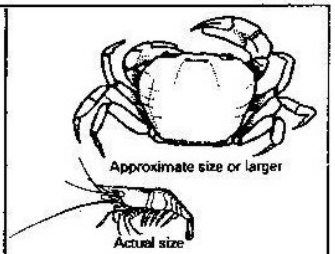
SCORE 14 (26)



The nymphs of an adult terrestrial fly, stoneflies usually have two long tails, robust bodies and legs each having two claws at the tip. Wing pads on the thorax are often dark and obvious. Some species (usually brown and yellow) run across the substrate very efficiently and are potent predators on other invertebrates. Other species are smaller and feed on plant material. Most live in well oxygenated clean water. When confined in a bottle or sample container, they soon start to bob up and down as if doing "press ups" as they try to get oxygen.

Crabs and shrimps

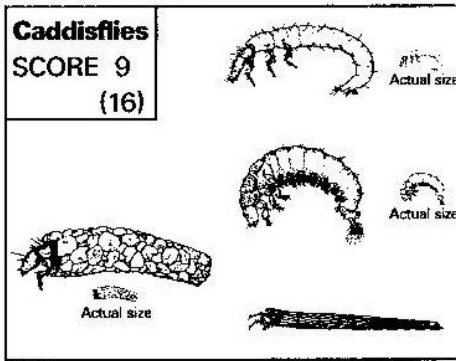
SCORE 6



A large diverse group including crabs, shrimps, water fleas, sand fleas and pill bugs. Crabs and shrimps are the largest and most commonly seen in rivers. Crabs are scavengers feeding mainly on leaf litter but will feed on animals when given the chance. Shrimps are mostly scavengers or deposit feeders.

Caddisflies

SCORE 9 (16)



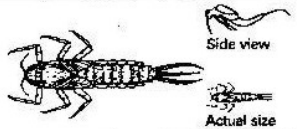
These are the aquatic larvae of adult caddisflies. Most caddisflies have a hard head with three pairs of legs. The abdomen is long and smooth except for some which have gills along the under surface. Some caddisflies swim freely in rivers, other take up a "house" made up of a reed or piece of grass, or construct a case of grains of sand or other matter. Still others construct nets under stones which they use for protection and also to catch food. Some feed on algae and deritus while others are predators.

Mayflies

These are the nymphs of small delicate mayflies that fly close to rivers and lakes, usually swarming in the early evenings. Most only live for a day or two, never feed, and live to mate and lay eggs in the water. The nymphs hatch from the eggs and take months to develop. Most mayflies have three tails although occasionally some have two which can lead to confusion with stoneflies. Mayflies have only a single claw at the tip of each leg and have visible gills on the side or back of the abdomen.

Minnow mayflies

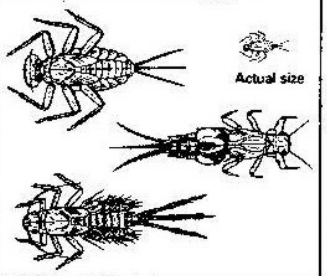
SCORE 5



Minnow mayflies all belong to the family Baetidae. These mayflies are most easily recognised by their strong, fish-like way of swimming, darting rapidly about in the container. They have a narrow head and a humped back which gives them an arched appearance when viewed from the side. Their bodies are slender but not flattened. Minnow mayflies are very common in rivers and feed in a variety of habitats. A few species are tolerant of some pollution but others are sensitive.

Other mayflies

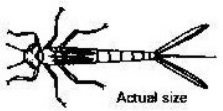
SCORE 13



Besides the minnow mayflies above, there are a number of other mayfly families present in rivers, many of which are less tolerant of pollution than the minnow mayflies. They occupy a variety of habitats, from burrowing in mud, to crawling amongst decaying leaves, to scurrying over stones in the fastest of currents. They have a variety of different shapes as illustrated and also feed on a range of foods.

Damselflies

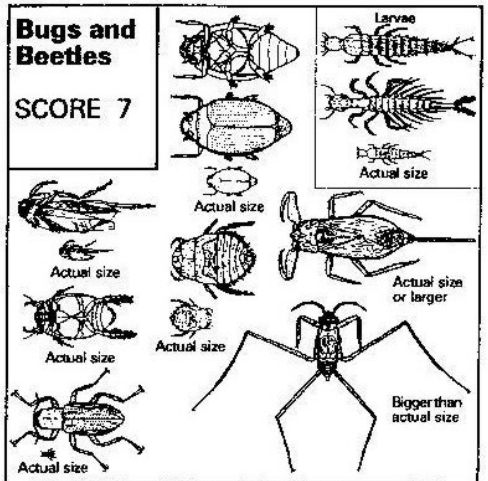
SCORE 4



The nymphs of damselflies are all carnivorous feeding on other invertebrates. They have a "mask" over the lower part of the "face", which hinges out to reveal a pair of pincers with which they catch their prey. Damselflies have elongated bodies with three broad tails on the tip of the abdomen. They walk slowly over the substrate, or swim slowly with a sideways flexing movement.

Bugs and Beetles

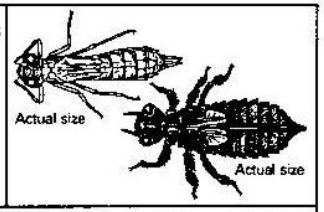
SCORE 7



These are two very distinct groups of insects, bugs having a piercing and sucking beak with two pairs of membranous wings, while beetles have "jaws" and the outer pair of wings are hardened.
In most of these insects, both the adult forms with wings, and the larvae, occur in water. There is a range of bugs including water boatmen, backswimmers, water scorpions, water bugs, pond skaters and water striders. Most are carnivorous but some like the backswimmers feed on algae. Others like the water scorpion and water bugs, catch prey with their front legs and pierce the body with the beak, sucking out the insides. The beetles have proper mandibles or "jaws" and feed on a range of foods including vegetation and other animals. Included here are whirligig beetles, predacious diving beetles and riffle beetles. They are often seen in the larval form which differs from the adult form. Some of these are illustrated.

Dragonflies

SCORE 6



Dragonfly nymphs are more robust than damselflies having stouter bodies with a larger head and "mask". Some have short while others have very long legs. They are generally large and will usually be the largest organism found in a sample with the exception of crabs. The do not have any tails and when disturbed, will swim using "jet propulsion" by forcefully ejecting water from the abdomen. Some species live under rocks while one common species crawls over sandy river beds making snake-like tracks in the sand. Dragonfly nymphs are probably the most powerful invertebrate predators in rivers, and will even take small fish and tadpoles.

miniSASS

RIVER HEALTH

UMGENI WATER · AMANZI

A community river health monitoring tool for South Africa.

March 2000

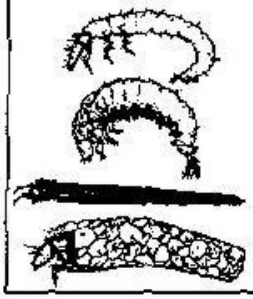
SCORE SHEET

Circle the score of each group found

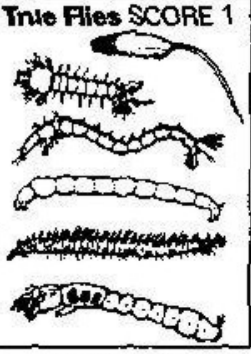
(Scores in brackets- to be used in Western Cape)

GROUPS	SENSITIVITY SCORE	
FLAT WORMS	3	
WORMS	2	
LEECHES	2	
CRABS OR SHRIMPS	6	
STONEFLIES	14	(26)
MINNOW MAYFLIES	5	
OTHER MAYFLIES	13	
DAMSELFLIES	4	
DRAGONFLIES	6	
BUGS OR BEETLES	7	
CADDISFLIES	9	(16)
TRUE FLIES	1	
SNAILS	5	
TOTAL SCORE		
Number of groups		
AVERAGE SCORE (divide total by number of groups)		

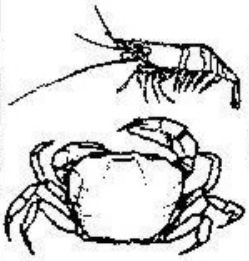
Caddisflies SCORE 9 (16)



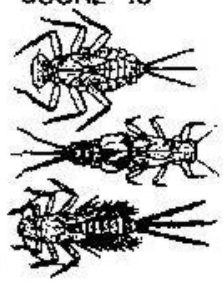
True Flies SCORE 1



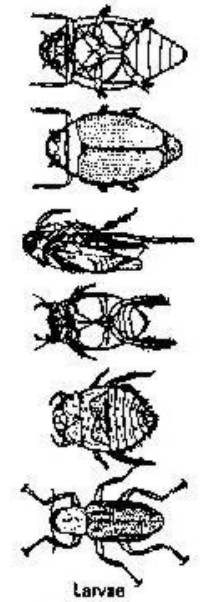
Crabs or shrimps SCORE 6



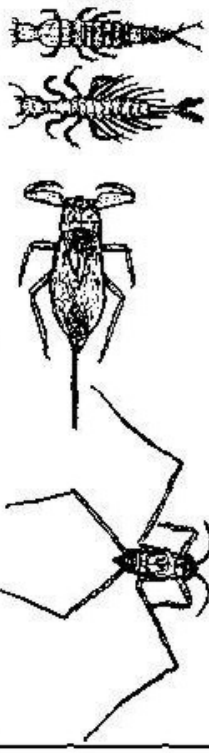
Other mayflies SCORE 13



Bugs or Beetles SCORE 7



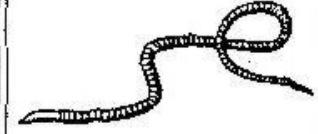
Larvae



Damselflies SCORE 4

Minnow mayflies SCORE 5

Worms SCORE 2



Stone flies SCORE 14 (26)

Leeches SCORE 2

Dragonflies SCORE 6

Snails SCORE 5

Flat worms SCORE 3

Calculating your river's MiniSASS score

1. For each of the groups found in your sample, circle the score on the table on page 8.
2. Total the scores and divide by the number of groups found. This will give you an average score. MiniSASS produces a single score which is similar and comparable to the average score which is produced by the more complex version of SASS.

Interpretation

0 – 2	Highly impacted stream (poor condition)
2 – 4	Impacted stream (fair condition)
4 – 6	Slightly impacted stream (good condition)
> 6	Good quality stream (probably approaching natural condition)

On rare occasions, an incorrect result will be obtained when the average score is high but the sample only contained a few (1 to 3) insect groups. When this happens this means that the river is impacted or disturbed but in a way that favours some organisms.

Now that you have calculated and interpreted your river's MiniSASS score, display a summary of your results in the form of a poster – be creative and add as much details as possible, without making the poster too text heavy.

Remember to return all the insects back to the river.

Criteria to assess learners during this life sciences lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner followed the instructions given by the teacher						
The learner collected insects and added the data to a table						
The learner designed a poster to display a summary of their MiniSASS results						

ACTIVITY THREE: WATER QUALITY IN THE PAST

This PHYSICAL SCIENCES lesson looks at water quality, water-borne diseases and some simple ways of purifying water. This is followed by a case study on the water collecting ways of Nguni people.

READ THE FOLLOWING TO YOUR LEARNERS:

Water from rivers and dams is often not clean and may contain bacteria and dissolved substances, such as salts from the soil and gases from the air. Other contaminants include solid substances and debris, such as mud and refuse. Before we drink any water, we need to ensure that it is safe to drink and that solid substances and any bacteria have been removed.

Water often carries diseases that kill about 25 million people each year. The need to ensure clean adequate water supplies is one of the most urgent problems facing our country.

Some major water-borne diseases include:

- **Cholera** is an acute intestinal infection caused by the bacterium *Vibrio cholerae*. It causes watery diarrhoea and vomiting that can quickly lead to severe dehydration and death if treatment is not promptly given.

- **Typhoid Fever** is an acute illness associated with fever caused by the *Salmonellae Typhi* bacteria. The bacteria are deposited in water or food by a human carrier, and are then spread to other people in the area.

  Typhoid Fever is contracted by the ingestion of the bacteria in contaminated food or water. People with acute illness can contaminate the surrounding water supply through the stool, which contains a high concentration of the bacteria. Contamination of the water supply can, in turn, taint the food supply.

- **Bilharzia** is a human disease caused by parasitic worms called *Schistosomes.* Approximately 300 million people in the world are infected. Bilharzia is common in the tropics where ponds, streams and irrigation canals are home to bilharzia-transmitting snails. Parasite larvae develop in snails from which they infect humans, their ultimate host, in which they mature and reproduce.

  Within days after becoming infected, you may develop a rash or itchy skin. Fever, chills, coughing, and muscle aches can begin within 1-2 months of infection.

- **Gastroenteritis** is an infection of the guts (intestines). The severity can range from a mild tummy upset for a day or two with some mild diarrhoea, to severe diarrhoea and vomiting for several days or longer. Many viruses, bacteria, and other microbes (germs) can cause gastroenteritis. Food poisoning (infected food) causes some cases of gastroenteritis. Many different types of germs can cause food poisoning. Common examples are bacteria called campylobacter and salmonella. Water contaminated by bacteria or other germs is a common cause of gastroenteritis, particularly in countries with poor sanitation.

- **Dysentery** is an infection usually spread from person to person. It is caused by bacteria called "shigella". It causes inflammation of the bowel, which gives bloody diarrhoea, headaches, fever, nausea and sometimes vomiting and stomach cramps. These symptoms usually only last for a few days, and need no treatment other than rest and plenty to drink. After having dysentry, people may still carry the bacteria for a while, even though they feel better.

In South Africa, tap water is safe to drink as all the bacteria that may have been in it, are killed during the purification process. You should never drink water from rivers or dams without treating it first.

ASK THE LEARNERS:

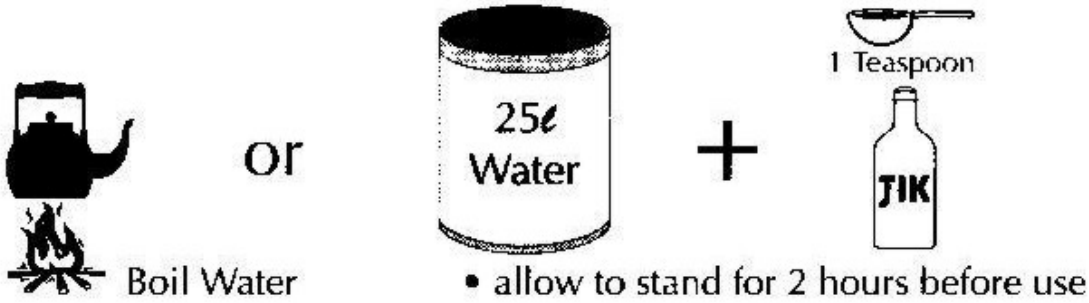
- Do they know of anyone who has had one of the diseases you have read about?
- Many water-borne diseases can be prevented through being careful about where water for drinking is collected and good hygiene practises. Where do the learners in the class get their drinking water? How can they be sure that it is clean and safe for drinking?
- What personal hygiene practises can your class adopt to prevent the spread of diseases *(such as washing hands before meals, when working with food, after going to the toilet, after changing babies' nappies)?*

ASK THE LEARNERS:

Do any of you know of any simple way that you can clean (purify) your drinking water (especially if you are collecting it from a river or spring and are not sure that it is clean)?

- A simple way of purifying water is to add a teaspoon of jik to every 25 litres of water. Jik is very strong and kills all the bacteria, making it safe to drink.

- You can also boil the water, and that will kill any germs or bacteria that may be living in it. The water can be left to cool. It does not need to be drunk hot.



- What are other good hygiene practises?

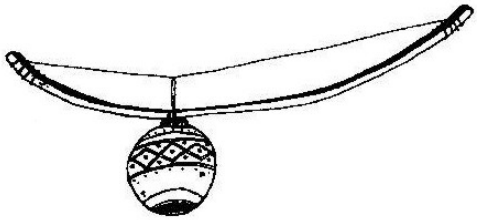
INDIGENOUS KNOWLEDGE AND WATER QUALITY

LEARNER ACTIVITY:
Read the case study below and then answer the questions that follow:

(In the story that follows, comments and scientific observations are in brackets and italised so that the learners can see the practical wisdom behind some water collection myths and techniques of the past).

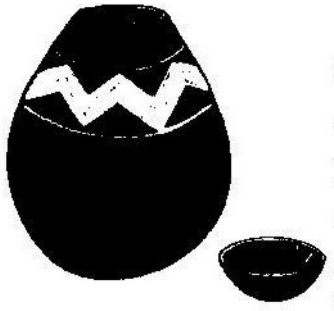
Before the time of the Zulu King, Shaka, sweet water was called “amanzi amnandi”. Shaka’s mother was called Nandi and it is said that because it was not considered respectful to use the queen mother’s name in this way, Shaka referred to sweet water as “amanzi amtoti”. *(This is how the town of Amanzimtoti, south of Durban, got its name).* Today both terms are used and many people of Nguni origin will sniff, smile and hold up “sweet” water, collected from a river, spring or well for their daily household needs. *(Water quality scientists today still have people smell and taste household water. Human senses give a refined indication of whether water is good and clean and fresh).*

Historically, water was usually collected in areas where people could hear it running over stones or dripping down rocks *(well oxygenated water supports natural biological cleansing processes).* If a spring was for human use, it was protected by a circle of rocks with a small outlet. Cattle drank elsewhere.



An area nearby was cleared and the site soon became a meeting place for young people. Young men would hang around these water collection sites, playing musical instruments and admiring the maidens who came to collect water. The girls would saunter along slowly and gracefully, singing and flirting. Water collecting was rarely seen as a tiring or boring chore because of the prospect of courtship!!

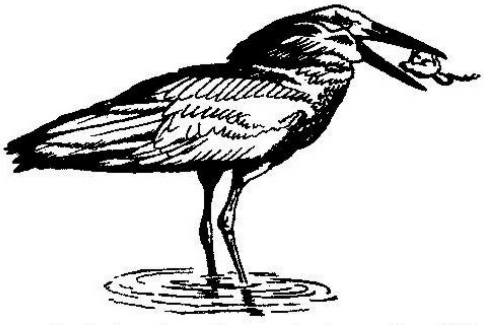
A water source would always be approached with care so as not to frighten crabs and other small water animals. When disturbed, their movement would stir up sediments and the collector would have to wait for the silt to settle. The surface film was brushed aside for “sweet water” to be collected. *(Sediments and surface films have higher bacteria numbers than the middle waters of pools and rivers. Today scientists take water samples below the surface film, taking care not to suck up sediments. In this way, scientists can get consistent and reliable measures of bacterial contamination).*

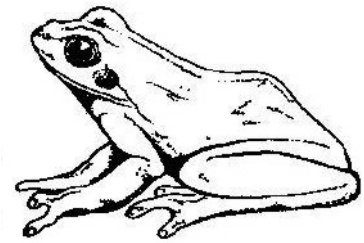


Clay pots were filled with water and covered with a collecting bowl, a piece of skin or a mat made from incema (*Juncas kraussii*) grass. The water would thus stay cool and fresh. *(Water evaporating through the sides of a porous clay pot cooled the contents. Most water bacteria cannot reproduce in cool, dark conditions. Some micro-organisms envelop themselves in a calcium secretion in the pores of clay pots. Scientists spoken to were uncertain about the detail of these issues but it is of note that, in earlier times, great care was taken to scour out a calcium-like scale in water pots. Also of note is that when the grass*

"lids" and head rings for carrying pots became old they were simply thrown away and new ones were woven. Discarded lids did not pollute the river like today's bottle tops and plastic waste).

There were many other customs and traditional practices surrounding water. Children were warned that urinating in a river would change them to the opposite sex! *(This myth was probably sufficiently frightening to prevent people urinating in streams and rivers. This would have limited a disease like bilharzia. The bilharzia parasite is passed on from human urine and faeces to small water snails. From these, its life cycle takes the disease back to people through river water).*





Nguni water collectors say that where there are frogs, one does not find sweet water. Frogs are eaten by hammerkops (*uthekwane*, the "lightning bird") and the prospect of collecting water while being watched by a "witch-bird" must have been terrifying in earlier times when spirits, myths and mystery had a more central place in everyday social life. Children were told that if they killed this bird or stole its eggs, their homes would go up in flames. *(Where there are frogs, one will usually find snakes. Both animals are feared by many people today, not least the children who were told the Nguni myths of witches and lightening to fill their hearts with terror. Today, scientific tests suggest that many frog species need "sweet water" if they are to live and reproduce successfully. There must be some doubt about the Nguni suggestion that frogs are an indication of water that is not fit for human consumption).*

It is also said that it was not advisable to collect water from a river after heavy rain at the start of the annual rainy season. Indigenous commonsense told people to put out pots to collect rain-water. River water would again be collected four days after the rains stopped and the water had cleared. *(Heavy rains wash human and animal wastes into rivers. There is thus a rapid increase in faecal bacteria and disease. In KwaZulu-Natal, health workers have to warn rural people not to collect river water after heavy rains as few remember the earlier Nguni practice of collecting rain-water only four days after the rains have stopped).*

Today human and livestock numbers have increased vastly, catchments have become degraded and rivers are often polluted dumping places. The best indigenous practices for the collection of "sweetwater" may not prevent people getting serious diseases from river water. Learning about historical water collection and storage practices can, however, develop a respect for early people and might also help our understanding of water quality issues.

QUESTIONS:

1. Have you collected water from a nearby river? What was the water used for? (If for drinking, how were you certain that it was safe to drink?)
2. What do you think 'well oxygenated water' means?
3. Why do scientists take water samples below the surface of the water?
4. Why did the Nguni scour their clay pots regularly?
5. Name the methods that the Nguni people used to reduce the contamination of their drinking water?
6. Do you think that these practices of collecting water are still relevant today?

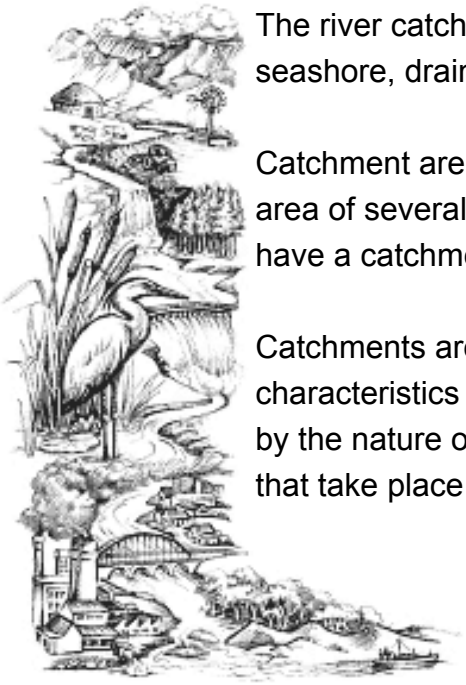
Criteria to assess learners during this physical sciences lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner contributed to discussions about water-borne diseases and personal hygiene practises						
The learner adequately answered all six questions at the end of the reading (written answers)						

ACTIVITY FOUR: INVESTIGATING WATER QUALITY IN CATCHMENTS

Estuaries are silting up, inland wetlands are disappearing, some perennial rivers are drying up, and rivers, lakes and dams are polluted! Water bodies in southern Africa clearly suffer from many problems – all of which are linked to the way in which the catchment area is used. This PHYSICAL SCIENCES lesson looks at water use in a catchment and encourages learners to look at ways of conserving and caring for our water catchments.

What is the river catchment?



The river catchment, or drainage basin, is all the land from mountain top to seashore, drained by a single river and its tributaries.

Catchment areas vary greatly in size – a big river may have a catchment area of several thousand square kilometres, whereas a smaller tributary will have a catchment area of only a few hectares.

Catchments are separated from each other by watersheds. The characteristics of any river (physical, chemical, biological) are determined by the nature of the catchment and the activities, both human and natural, that take place in it.

The importance of plants

In catchments which have not been cultivated or developed, the ground cover or vegetation is still in place. Ground cover is important for the following reasons:

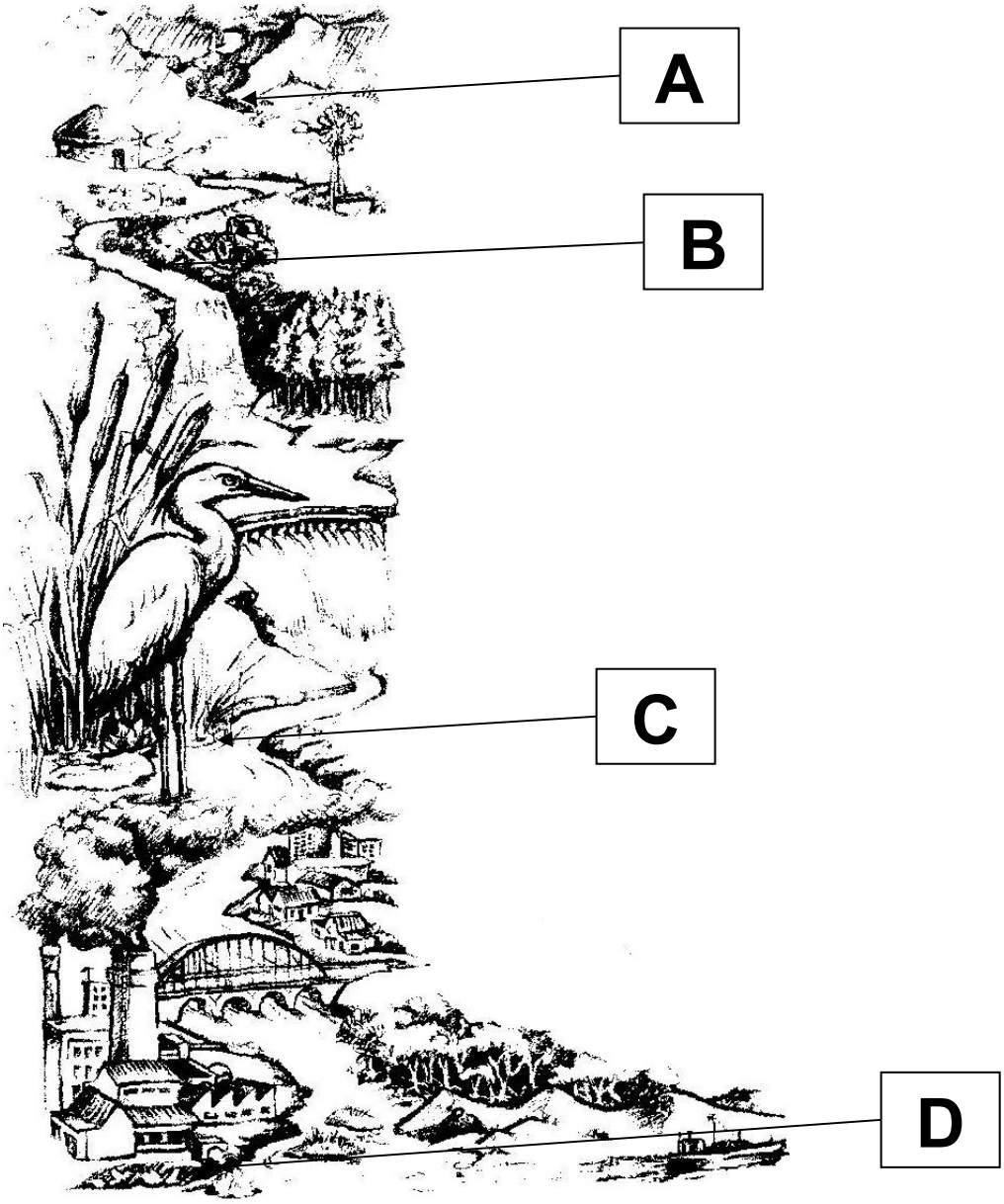
- Plants slow down water as it flows over the land (runoff) allowing much of the rain to soak into the ground and replenish underground waters (aquifers). Water seeps from these aquifers into rivers, which are therefore usually perennial (flow throughout the year).
- Plants prevent soil erosion as their roots hold soil in position, preventing it from being washed away. In addition, plants break the impact of a raindrop before it hits the soil, thus reducing its erosive potential. Rivers running through an undisturbed catchment are clean, erosion is slow and limited to periods of very high rainfall.
- Vegetation in wetlands and on the banks of rivers is of particular importance. The roots of the reeds, sedges, trees, shrubs and grasses growing in wetlands and next to rivers bind the soil of the riverbank and prevent erosion, whilst cleaning the water and regulating its flow.

Disturbed catchments

Where plant cover in river catchments has been disturbed by farming, industry or settlements, soil erosion increases. In addition, without plants, runoff increases and the supply of water to aquifers are reduced because less water soaks into the ground. Consequently rivers do not have a continuous supply of water from the aquifers and flow only in the rainy season. Much of the deposition of silt into estuaries results from erosion of riverbanks. When riverbank (riparian) vegetation is removed, the banks are at the mercy of the erosive forces of flood waters which scour away the river bank allowing the adjacent slope to collapse.

In many catchments the indigenous vegetation has been replaced by alien plants such as black wattle, pine and eucalyptus. These trees use large amounts of water from the rivers and streams that they thrive next to, thus reducing the amount of water available. In addition, invasive plants tend to smother the natural ground cover and this leads to soil erosion, and of course, a reduction in the biodiversity of that area. Invasive plants tend to be bigger than the indigenous vegetation, and when they burn the fires are very hot - this in turn damages the soil and contributes to more severe erosion.

ACTIVITY:



Results of tests carried out on samples of water taken from A, B, C and D are shown below:

Test	Sample A	Sample B	Sample C	Sample D
Temperature (ºC)	11	12	12	16
Dissolved oxygen (ppm)	16	14	16	4
pH	7	9	6.5	4.5

Temperature
Temperature is one of the most important and most influential water quality characteristics to life in water. An important physical relationship exists between the amount of dissolved oxygen in water and its temperature. The warmer the water, the less dissolved oxygen, and the colder the water, the more dissolved oxygen.

For this reason, heat or "thermal pollution" may be a problem, especially in shallow slow-moving streams or rivers. Most fish simply cannot tolerate warm water and/or low levels of dissolved oxygen. Thermal pollution may also result when industries release the water used for cooling

their machines into waterways. Water temperatures, even kilometres away from the release points, may rise dramatically. The result may be dead fish, fish eggs that won't hatch or a total change in the fish population as warm water varieties replace the original trout or other cold water fish.

Dissolved oxygen in fresh water

Waters with consistently high dissolved oxygen are usually considered to be healthy, capable of supporting many different kinds of water organisms. Much of the oxygen in water comes from the atmosphere through rainfall, through tumbling water in fast moving streams and from water plants (photosynthesis). In some dams dissolved oxygen may increase owing to photosynthesis during the day but at night it may decrease owing to plant respiration. Large daily fluctuations in dissolved oxygen may be found in rivers and dams choked with invasive water plants. Water temperatures also affect dissolved oxygen levels as oxygen is more easily dissolved and retained in cold water. Effluent and agricultural chemicals enrich water, promoting the growth of algae and other water plants. Sewage effluent promotes large populations of bacteria which consume oxygen as they decompose organic matter. Low oxygen levels are often associated with sewage effluent enrichment.

Ppm stands for parts for million and is a measure of concentration. This is a way of expressing very dilute concentrations of substances. Just as per cent means out of a hundred, so parts per million or ppm means out of a million. It usually describes the concentration of something in water or in soil. One ppm is equivalent to 1 milligram of something per litre of water (mg/l) or 1 milligram of something per kilogram soil (mg/kg).

pH

The "p" stands for "potenz" (this means the potential to be) and the "H" stands for Hydrogen. So you must write pH with a lower case (little) p and an upper case (capital) H.

Water (H_20) contains hydrogen ions (H^+) and hydroxyl ions (OH^-). Pure deionised water contains equal numbers of H^+ and OH^- ions and is considered neutral (pH 7), neither acid nor basic. If the sample measure has more H^+ ions it has a pH less than 7 and is considered acid. If it has more OH^- ions than H^+ ions it is considered basic and has a pH greater than 7.

Rainwater is naturally slightly acidic but the type of rocks and minerals in a catchment usually determines the pH. Atmospheric pollution (nitrogen oxides and sulphur dioxides) from vehicles and thermal power stations usually produce acid rain, a serious threat to aquatic systems. Sewage and industrial effluent discharges can also affect the pH balance of rivers.

ANSWER THE FOLLOWING QUESTIONS:

1. What would you imagine the water to be like at A?
2. What would you imagine the water to be like at D?
3. Suggest why the town’s water supply is taken from the river at C and not D.
4. What is the most likely reason for the high water temperature found D?
5. At B, the river is becoming choked with water plants. Suggest a reason why this is happening.
6. Why do you think the dissolved oxygen has increased at C?
7. Do you think you will find the same species of water creatures at D and A? Explain your answer.
8. What does ppm stand for?
9. If the pH at point D is 4.5, will it be acidic or basic? Will it have more hydrogen ions or more hydroxyl ions?
10. Do you think there is a human impact on this river catchment? Discuss.

Criteria to assess learners during this physical sciences lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner was able to adequately answer all the questions in the exercise						
The learner was able to see the impact of human settlements and technology on a river catchment (question 10)						

ACTIVITY FIVE: JUST FOR FUN! YOUR ECO FOOTPRINT

We all use water every day for things like drinking, cooking and washing. We could not survive without water! This LIFE SCIENCES activity looks at how small or large our eco footprint is.

This activity can be done as a class with you, the teacher, reading the questions and learners writing down their answers, or the learners can work out their eco footprint on their own.

The ever-increasing pressures on our environment will have touched all of us in some way and we need to take a careful look at how the choices we make in our everyday lives impact on the Earth. That is, we need to ask “How big is my ecological footprint?” The following questions will encourage learners to think about different ways they impact on the Earth and ultimately stimulate ideas of ways that we can all make improvements to reduce our ecological footprint.

QUESTIONS TO ASK THE LEARNERS:

1. WATER USE

The amount of water used often depends on whether you have running water in your home, a tap in your yard, or whether you carry water from a river or dam. The way that you use water in your home can sometimes be very wasteful especially when that water is readily available on tap!

When you wash, do you use:
a. A bucket?
b. A shower?
c. A bath?

What points did you get for your answer to question 1?
a. 0 points b. 5 points c. 20 points

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2. RE-USING WATER

South Africa is a water-scarce country. It is believed that by the year 2025 we will have insufficient water for use in our homes, for agriculture and for industry.

By using water carefully, you can help to conserve our water sources.

When you have finished washing at home:
a. Does your water run straight down the drain?
b. Do you use the water on your plants?

What points did you get for your answer to question 2?
a. 20 points b. -10 points

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3. ENERGY USE

Whether you use electricity, coal or paraffin for energy in your home, you are polluting the air – which causes acid rain, global warming and health problems. You can conserve energy by using energy-saving devices (such as a hot box for cooking), solar-powered energy systems, and energy-saving bulbs.

In your home do you have at least one energy-saving method?
a. Yes b. No

What points did you get for your answer to question 3?
a. -10 points b. 20 points

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4. INDIGENOUS PLANTS

By growing indigenous plants in your garden, you can contribute to biodiversity because you will attract indigenous insects, birds and other animals. Indigenous plants have many advantages over alien plants, for example, they require less water.

Excluding your home-grown fruit and vegetables*, in your garden at home are:
a. Most of the plants are indigenous?
b. More than half the plants are indigenous?
c. Less than half the plants are indigenous?
d. None of the plants are indigenous?

What points did you get for your answer to question 4?
a. -10 points b. 0 points c. 10 points d. 20 points

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5. ANIMAL-BASED PRODUCTS

Producing animal products (beef, chicken, pork, eggs, fish, dairy etc) puts much more pressure on the environment than producing vegetables. Many people eat more meat than their bodies need. People who eat a lot of meat have more impact on the environment than those who eat less meat or no meat at all.

How often do you eat animal products?

a. Never
b. A few times a week
c. Once a day
d. Small amounts at every meal
e. A large part of every meal

What points did you get for your answer to question 5?

a. -10 points b. 0 points c. 5 points d. 10 points
e. 20 points

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6. LOCALLY GROWN FOOD

Much of the energy cost of food production is spent transporting food from harvest to market, and for processing, packaging and storage. Growing food yourself or buying locally grown, in-season, unprocessed food can therefore reduce energy consumption. Buying food from local farmers can greatly reduce your ecological footprint.

How much of the food that you eat is locally grown, unprocessed and in-season?

a. Most b. About three quarters c. About half d. About a quarter e. Very little

What points did you get for your answer to question 6?

a. -10 points b. 0 points c. 5 points d. 10 points
e. 20 points

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7. LIVING SPACE

An unnecessarily large home uses more materials from the environment (for building and maintenance) and takes up more space (which could be better used for agriculture and nature reserves).

In your home, do you have:

a. More people than bedrooms?
b. The same number of people and bedrooms?
c. More bedrooms than people?

What points did you get for your answer to question 7?

a. -10 points b. 5 points c. 20 points

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8. POISONS IN THE HOME GARDEN

Poisons – more correctly called biocides – are often used to kill rats, insects and weeds. Many of the ingredients in these biocides cause allergies, trigger cancer growth and cause genetic defects.

Frequently we don't actually need to kill in the first place! The flat spider on the wall won't hurt you at all. But if we really do need to kill, we need to decide which option of removal is the most environmentally friendly.

In your home, when you have a problem do you:

a. Use the strongest insecticide or other poison and use until the problem is solved?
b. Buy specially designed environmentally friendly products?
c. First attempt to solve the problem with a less destructive alternative?

What points did you get for your answer to question 8?

a. 20 points b. 0 points c. -10 points

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9. RE-USING

Re-use of some of your waste helps to reduce the impact on the environment; reduces the amount of waste that goes into landfill sites (rubbish dumps) and reduces the amount of raw materials required.

At home do you re-use:

a. PAPER
Never Sometimes Often

b. GLASS
Never Sometimes Often

c. TINS
Never Sometimes Often

d. PLASTICS
Never Sometimes Often

What points did you get for your answers to question 9?

a. Never – 20 points, Sometimes – 5 points, Often – -10 points
b. Never – 20 points, Sometimes – 5 points, Often – -10 points
c. Never – 20 points, Sometimes – 5 points, Often – -10 points
d. Never – 20 points, Sometimes – 5 points, Often – -10 points

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10. RECYCLING

Recycling of some of your waste helps to reduce the impact on the environment, reduces the amount of waste that goes into landfill sites (rubbish dumps), and reduces the amount of raw materials required.

At home do you recycle:

a. PAPER
Never Sometimes Often

c. GLASS
Never Sometimes Often

c. TINS
Never Sometimes Often

d. PLASTICS
Never Sometimes Often

What points did you get for your answers to question 10?

a. Never – 20 points, Sometimes – 5 points, Often – -10 points
b. Never – 20 points, Sometimes – 5 points, Often – -10 points
c. Never – 20 points, Sometimes – 5 points, Often – -10 points
d. Never – 20 points, Sometimes – 5 points, Often – -10 points

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11. REDUCING

You can reduce your eco footprint by shopping carefully. Buy in bulk to reduce packaging; buy refills (e.g. deodorants); chose well-made articles that will last well and those with recycled content; and avoid over-packaged products.

When you buy products do you:

a. Always think of the amount you will throw away?
b. Often try – but take into consideration price and brand?
c. Sometimes – depending on the price and brand?
d. Never think of how goods are packaged or how long they will last?

What points did you get for your answer to question 11?

a. -10 points b. 0 points c. 5 points d. 20 points

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12. CONSUMER CHOICES

Some goods available in supermarkets pollute the environment more than others – a roll-on deodorant is better than a spray containing CFCs (which break down the ozone layer); a brightly coloured toilet cleaning liquid is not necessary as that colour doesn't clean the toilet!

When you shop do you choose the least polluting product?

a. Always
b. Often – depending on price, brand or what you have seen on television
c. Sometimes – depending on price, brand or what you have seen on TV
d. Never think about such things

What points did you get for your answer to question 12?

a. -10 points b. 0 points c. 5 points d. 20 points

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13. TRAVEL

Poisonous gases and substances released by cars and other motor vehicles include nitrogen oxides, hydrocarbons and lead which contribute to acid rain, smog, health problems and global warming.

How do you get to work/school/college?

a. On foot b. By bicycle c. By taxi d. By car

What points did you get for your answer to question 13?

a. -10 points b. 0 points c. 5 points d. 20 points

Add up all your points!!!

Your final ecological footprint

- Score less than 50: Green Footprint (You have a TINY ecological footprint)
- Score from 51-110: Yellow Footprint (You have a small ecological footprint)
- Score from 111-180: Blue Footprint (You have a medium ecological footprint)
- Score from 181-290: Orange Footprint (You have a large ecological footprint)
- Score from 291-400: Red Footprint (You have a HUGE ecological footprint)

With your class:

- Each learner to think of one product that they have, or one thing that they consume. What is its impact on the planet?
- Discuss ways that our school can practically reduce our ecological footprint.
- Discuss ways that our class can reduce our ecological footprint.
- Discuss ways that individual learners can reduce their ecological footprint.

Criteria to assess learners during this life sciences lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner contributed to the discussion on the impact of products on our environment						