

SOME, FOR ALL, FOREVER

Water Ecosystems and People



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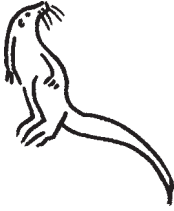
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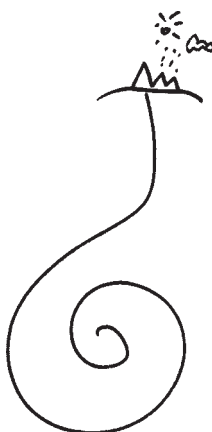
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1. Introduction

Water for people and people for water. We need water and water needs us. That is what this book is about.

Water is the basis of all life. No plant, animal or person on earth can survive without it. In fact, all organisms are mostly made up of water. Water shapes the earth's surface. It is a fundamental part of climate processes. Out in the natural world, water is not found in taps, buckets and glasses but in rivers, wetlands, lakes, dams, estuaries, groundwater and the sea. It falls from the sky as rain, runs off the landscape, filters into the soil, flows to the sea in rivers, is stored in dams, evaporates into the sky, and rains back onto the earth. This is the water cycle.

People need water for all sorts of things, for drinking, washing, cooking, growing food, in industries, and to dilute and transport wastes. But in the process of using water, people can damage rivers, wetlands, lakes and other watery places. Damaged ecosystems do not work very well and may fail us when we need them most.

The message of this book is – look after water in the places where it is naturally found – look after water and water ecosystems because you need them so much.

— Tally Palmer





2. Water, people and the law

South Africa is a dry country. We have less rain than many other countries, and the rain that does fall evaporates quickly under our hot weather conditions. Because rainfall is not distributed evenly, it is difficult to get water to everyone.

Water and democracy

In 1994, after the first democratic elections, water law was recognised as one of the important areas of legal reform.

There were two main reasons for this. Before 1994 there was enough water for people in dams, rivers and other systems, but previous governments did not provide the pipes, pumps and purification works to allow all the country's people to have safe, clean water close to their homes.

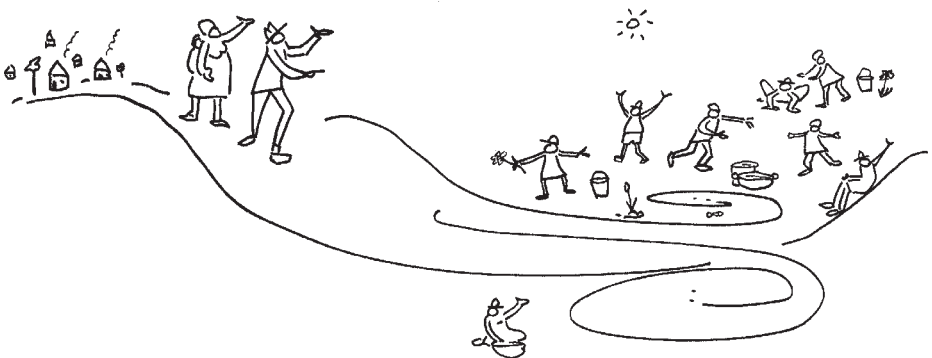


The other reason for legal reform was more fundamental. The 1956 Water Act was based on a principle called “riparianity”. This meant that the right of people to use water was linked to land ownership. If you owned land, you had a right to use the ground water under your land, and the right to use the water flowing through or beside your land. Land ownership was discriminatory, so a privileged few had much more access to water.

The new Minister of Water Affairs and Forestry led a process for a new water law. A team worked together to identify a set of basic principles on which the new law would be based. The two main principles were

Equity **(fairness to people living now)**

Sustainability **(fairness to people in the future and
to the environment)**



Equity is essential, and sustainability is just as important, because water only occurs naturally in ecosystems — rivers, stream, springs, lakes, ponds, wetlands and estuaries (dams are artificial water ecosystems). Water ecosystems, often called water resources, refer to the water itself and the environment in which it is found. These ecosystems are made up of water, the earth itself, the sun's energy, plants, animals, and small (and very small) bugs and microbes. If ecosystems are damaged too much they cannot sustain human water use.

Ecosystems and their plants and animals are silent. They cannot say what they need. They cannot cry out when they are damaged. Sometimes we only notice the damage when it is already serious and difficult to reverse. If we want healthy water ecosystems we have to give them a voice — listen and watch for their distress calls. The concept of sustainability tells us: use water ecosystems, but also watch out for the distress signals and respond to them. Then we and our grandchildren can go on using water and water ecosystems, now and on into the future. That is sustainability.



The water law review process

After the two main principles of equity and sustainability were established, supporting principles followed. In 1996 two workshops were held in each province, and farmers, industrialists, local authorities, and rural communities met to discuss their needs and views. Their comments were taken to a national conference, where international water law experts were invited to listen and to share their experiences. After cabinet and parliamentary approval, a National Policy for Water in South Africa was written, based on the principles. Finally lawyers, scientists and water managers met to draft a new law: the National Water Act, No. 36 of 1998 (NWA). This Act has been acclaimed internationally for its long-term vision.



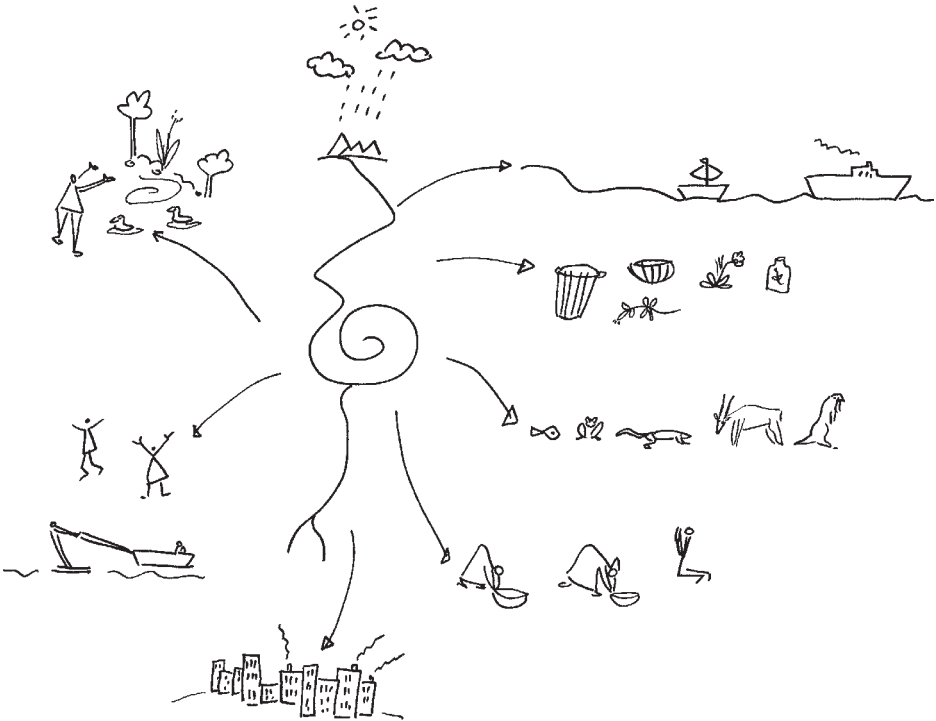
Some, for all, forever

The main aim of the law is captured well in a Department of Water Affairs and Forestry's slogan: "Some, for all, forever"

Some: acknowledges that water is a limited resource,

for all: emphasises fairness – all people must be able to use the resource,

forever: reminds us to use water and water-linked ecosystems wisely so that they are not damaged for the future.



The NWA requires that there is sufficient water allocation from dams, rivers and groundwater systems to supply people with the water they need for washing, cooking and drinking. Another law, the Water Services Act, ensures that we get water to people. The NWA pays attention to how we manage, use and look after our water resources so that, in addition to these basic needs, we can also use water for social and economic development, poverty alleviation and job creation.

The Reserve

The NWA emphasises that all aspects of water on earth are connected and that we have to manage water resources within that connected cycle. The Act recognises that water belongs to the whole nation and is administered by the government for the good of the people. The Act protects the rights of all people to have water for their basic needs, but also takes into account the needs of aquatic (watery) ecosystems. The flow and water quality needed for basic human needs and for ecosystems to function and is termed the Reserve. The Reserve includes both the basic human needs Reserve and the ecological Reserve. Water for the Reserve is a right guaranteed by law. All other water use is allocated by licence.



Protection and use

The NWA protects the rights of water ecosystems because they provide people with many free services necessary to life — water supply, waste processing and dilution, natural products (reeds, fish, medicinal plants), nature conservation, flood control, recreation, and places for beauty and religious rituals. The purpose of the Act is to protect water resources to make sure we have sustainable resource use.



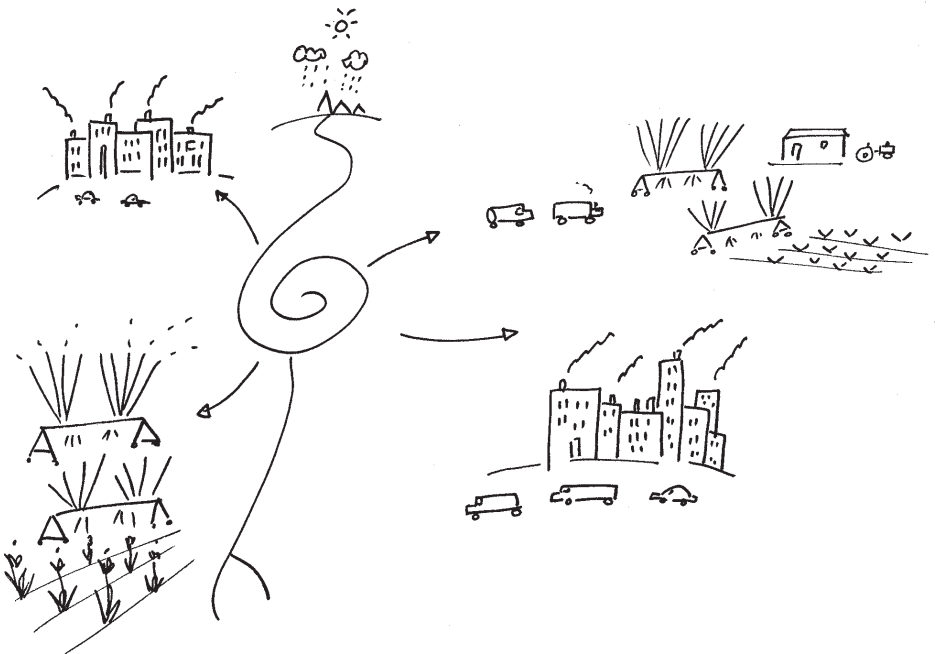
Protection means “look after and use wisely” – it does not mean “keep separate and do not use”. We must use water and water ecosystems for social and economic development. We must use water and water ecosystems for poverty alleviation. We must also notice and decide about how much to use. Protection is not “all or nothing” — we can decide which areas and ecosystems can have more intensive use, and which need more protection.

Water resource protection is closely linked to water resource use. The law requires us to protect the resource so that we can continue to use water and water ecosystem services now and in the future. Water for human purposes is taken out of water ecosystems. The environment, the water ecosystem, is not a water user – it is a water provider. People are water users.

Water needs to be left in an ecosystem so that the ecosystem remains alive. The amount of water left in the ecosystem, and the amount of waste put into the ecosystem, determines its health or ill-health. We can choose a particular level of ecosystem health by deciding how much water we want to leave in the ecosystem, and what the water quality should be. If we choose wisely, we can protect each ecosystem area by the right amount.

Catchments and ecosystem health

With rights come responsibilities. Everyone lives in a catchment – the area of land that catches the rain that runs into a river. The people living in the catchment are all stakeholders in the management of its water resources. Activities on the land affect the river. The river’s ecosystem health deteriorates as more water

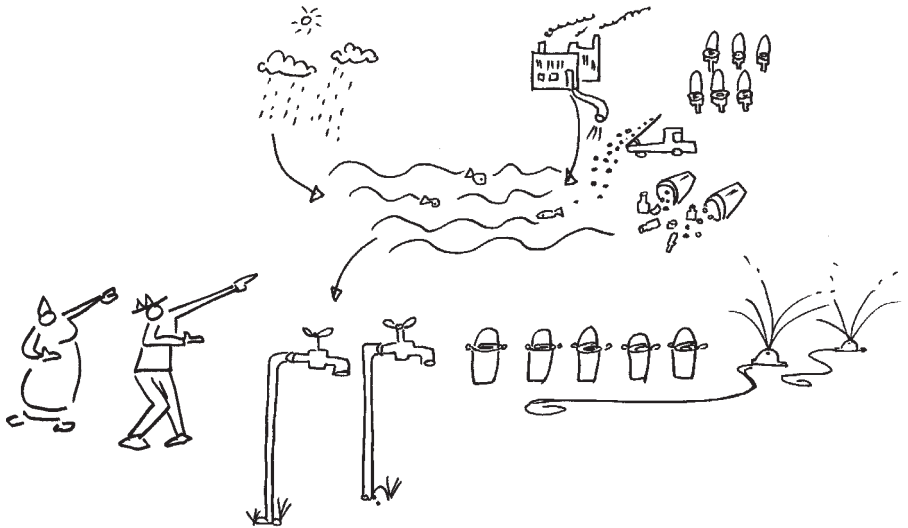


is abstracted to supply industry, agriculture, and households, and as more wastes are disposed. If we moderately stress river ecosystems they can continue to provide a range of services. But if we overstress them, they provide fewer services. It has been suggested that river ecosystem health in South Africa should be classified as Natural, Good, Fair or Poor.

People can choose how healthy they want their ecosystem to be – and which goods and services they want. This choice is part of a process called an ecological Reserve assessment. The first step in this assessment is to find out the present health of the resource (river, wetland, groundwater or estuary). To do this, scientists get together and pool information about rainfall, river flow, water chemistry, sediment movement, plant and animal habitat requirements. The scientists then work out what how much water and what chemicals in the water are needed for the system to function at a chosen level of ecosystem health. The scientists and managers then discuss the health of the ecosystem with communities and stakeholders who use it. They can communicate with stakeholders about what can be done to keep the ecosystem the way it is, how much more it can be used, or what can be done to improve it. They can further assess how much development the ecosystem can sustain before it becomes less healthy.



Choosing the class of river that you want



Stakeholder participation

The NWA provides for stakeholder participation in the management of the ecosystem. Stakeholders are represented on water committees, water user associations and catchment management agencies. These organisations discuss, form opinions and contribute to decisions about how much water is taken out of the ecosystem, how the water is used, and for what purpose. They make decisions about waste disposal, using water for recreation, and nature conservation. All institutions concerned with water-linked ecosystems, including local government and provincial government, are required to be representative and gender-sensitive.

Empowerment comes from knowledge. Anyone can participate in the management of their local water resource or ask questions about it. Everyone involved should know something about the law, and something about how ecosystems function and what they do for us. This is the purpose of this book.

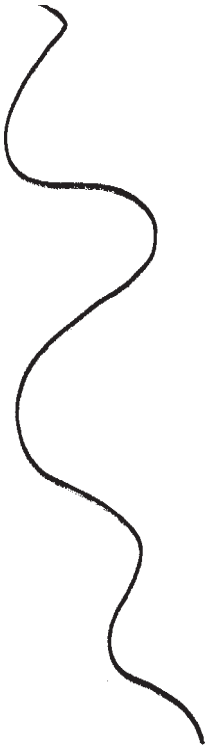




3. What rivers do for people

In South Africa most of our freshwater resources are found in rivers. In recent years a lot of attention has been paid to measuring what rivers need to be healthy. For this reason, rivers are used in this book as the main example of water ecosystems. However, all other water ecosystems are just as important, and all have their own particular needs for ecosystem health.

What rivers do for people



Rivers supply water

Rivers process and dilute wastes

Rivers supply natural products such as reeds, fish and medicinal plants

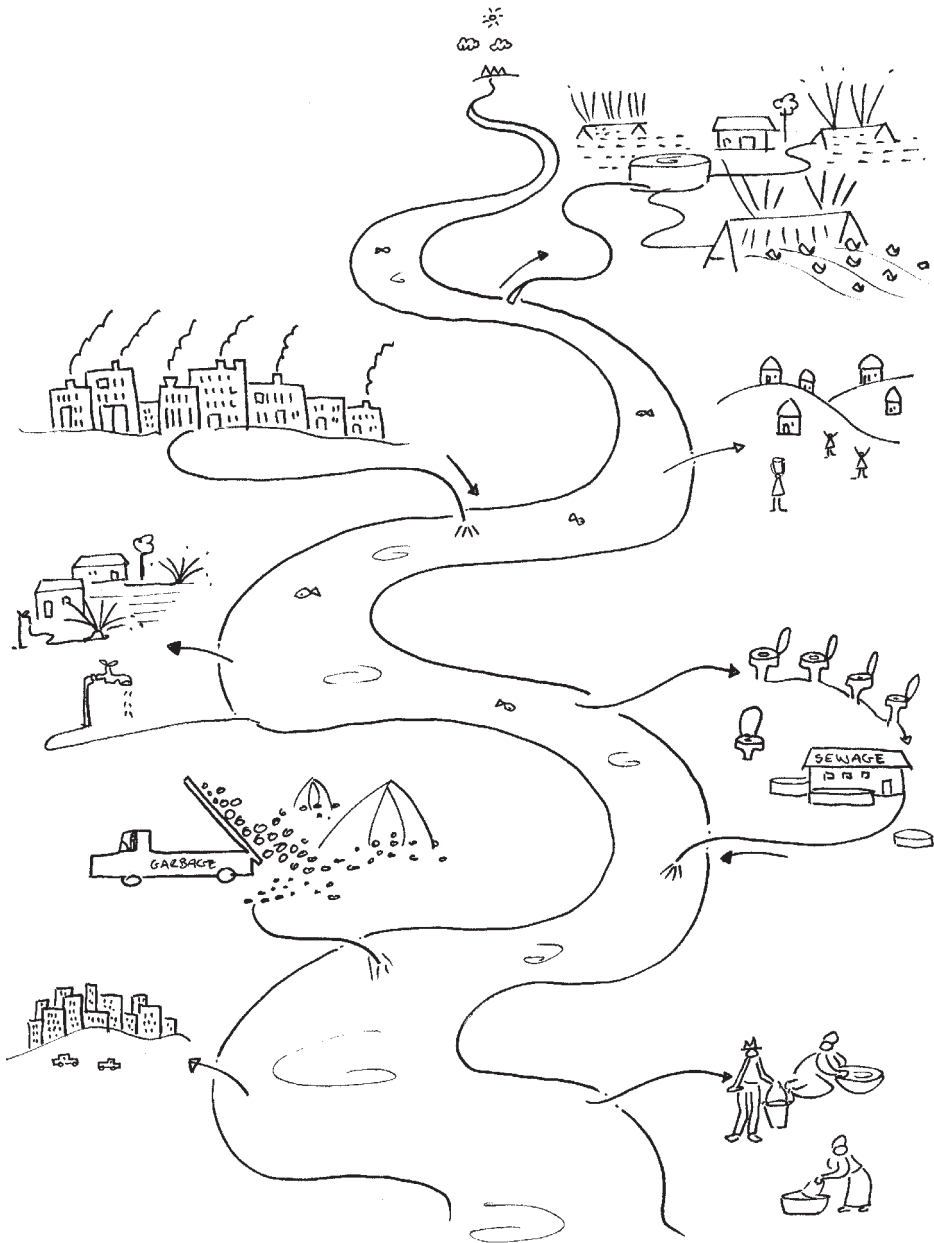
Rivers sustain the plants, animals and habitats that are important in nature conservation

Rivers help with flood control

Rivers provide places for recreation

Rivers provide places where our need for beautiful places can be satisfied

Rivers provide places for religious rituals



Rivers supply water

In most places in southern Africa there is more rain in summer than in winter. Not only is rainfall seasonal, it is also unpredictable. We cannot tell when we are going to have wet years or years of drought, so the supply of water from rivers is also unpredictable. We have built dams to store water from the wet times for use in the dry times, but even so the water in dams can fall to low levels. Not even the biggest dams can help us if the rainfall has been low for several years.

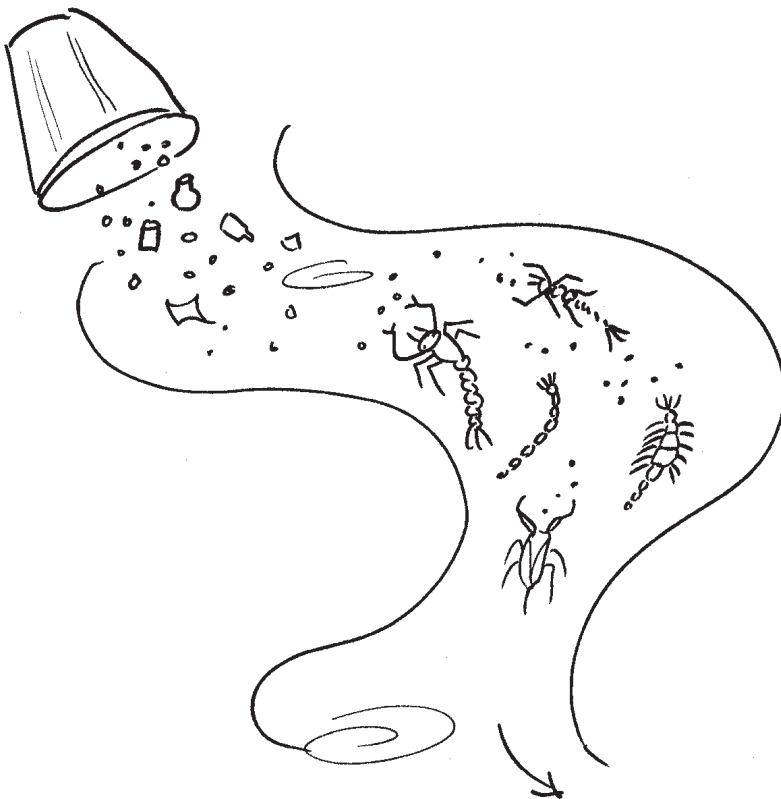
The biggest users of water in South Africa are irrigation farmers. The next biggest users are industries. Compared with these, water for basic human needs — drinking, washing and cooking — is a tiny amount. In rural areas, people often get their water directly out of the river. In towns, water is supplied to people's homes in pipes. Rich people, who have gardens, washing machines, and swimming pools, use more water than poor people. But no matter who the users are, people everywhere can learn not to be wasteful of water.

Rivers process and dilute wastes

Not all water is of the same quality. Quality differences can be natural. For example in Western Cape rivers, the water is more acid and has more organic chemicals in it. Water in some areas is “hard” (making it difficult to lather soap) because of salts and carbonates; in other places it is “soft” because of low levels of salts and carbonates. Water in mountain streams is generally clear, whereas water in lowland rivers is muddy because of the soil washed into these rivers by the rain.

However the largest differences in water quality come about because of people. People pollute rivers by adding wastes. There are different kinds of pollution: salts, toxic substances, sewage and nutrients. If the water in the river is polluted, it cannot be used for certain purposes.

Salts: Crop farmers pump water from rivers and spray it onto the land. As the water evaporates, salts are left behind. Then the next rainfall washes the salts back into the river. In this way, the river water slowly becomes saltier. This damages agriculture because most crops are sensitive to salts and do not grow well in salty water.



Industrial waste water often contains salts. Even the water that leaves our houses in pipes and sewers is saltier than river water. Salts tend to accumulate, which means our rivers are getting saltier each year. Taking salts out of water is very expensive, so it is much better — and much cheaper — for us to control how much salt gets into the rivers in the first place.

Toxic (poisonous) substances: The water discharged as waste water by industries is often of a poor quality and may contain poisonous substances such as metals. Toxic substances can be safe for humans and still damage the ecosystem. Some of these toxic substances are held in tiny soil particles, which sink in a river and become trapped in sand and mud. These poisonous substances can be harmful to animals, people, crops, and even to the industry itself. Insecticides are toxic, and when they are sprayed on crops they can wash into the river and kill or damage organisms like young insects living there.

Sewage: One of the most common types of waste in rivers is sewage. In towns and areas where there are toilets, sewage enters rivers from sewage works. In underdeveloped areas, where there are pit toilets, sewage enters the ground through seepage. Sewage is the easiest kind of pollution for a river to deal with, because tiny organisms such as fungi and bacteria use the sewage as food, breaking it down into other substances. There are only a certain number of these natural river cleaners, and if too much sewage enters a river, it cannot be processed properly. When the river cannot clean itself, pollution becomes a health hazard, and diseases such as dysentery and cholera begin to spread quickly. It is possible to build special sewage works that are better at processing sewage, but they are more expensive, and it would mean that people would have to pay more for their water services.

Nutrients: Certain chemicals in fertilisers, washing soaps and sewage make plants grow faster. These chemicals, mainly phosphates and nitrates, are known as nutrients. When nutrients get into rivers, algae grows much faster, turning the water bright green. In these circumstances bacteria and fungi and algae grow so fast that they use up the oxygen in the water, causing fish and young insects to die. If nutrient levels become too high, all that may be left is slimy fungus and bacteria.

Dilution: Water dilutes wastes. In summer, in a wet year, there may be enough water in a river to make the concentration of wastes low, and the flow may be fast enough to wash away the wastes and poisons. But in winter or dry years or droughts, the same amount of waste is produced and there may not be enough water to dilute or wash it away. If the river flow is low, this pollution can become very bad. Sometimes the water flow stops altogether, leaving only dirty pools. When water is this dirty, it can be dangerous, breeding disease organisms such as dysentery and cholera.

Rivers supply natural products

All over the world, rivers and riverbanks provide for people. The river provides fish, reeds, medicinal plants, and wood. As long as the river is naturally healthy, and people do not harvest too much, the river can provide these natural products forever.

Rivers provide plants, animals and habitats important in nature conservation

Humans do not live alone on this planet. The other animals and plants have the same right to life that we do. Sometimes we need them because of what they can do for us, as fish provide us with food or plants provide us with medicines. But we also have a responsibility to protect plants and animals whose use we do not need or understand. Most countries conserve some areas to grow



naturally as wilderness areas. Rivers that are protected and kept in a natural state, with good quality water, provide places where all their animals and plants can live safely into the future. In these places even animals that can be dangerous to people, such as lions and hippos and crocodiles, live safely. Our grandchildren will be grateful that we protect these rivers.

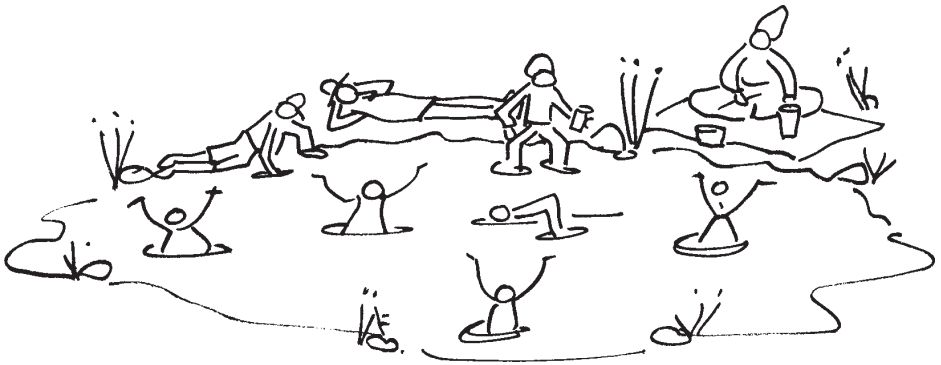
Rivers help with flood control

Southern Africa is a region of extremes. We have frequent droughts and floods. People may build their houses in areas which are usually safe and dry, only to see their homes washed away in times of flood. In natural river systems, wetland areas help to control floods by soaking up floodwaters so that the water level does not rise very much. When wetlands are cleared and drained, floodwater rushes faster and higher. Sometimes dams can be used to contain and store floodwater for later use, but they cannot replace wetlands.

Rivers provide places for recreation

A healthy river is a good place to relax. You can walk or fish or watch birds. Or have a meal outside, or sleep. Where there is bad pollution or very little water, rivers are not good places to relax, and can even become dangerous if the water carries diseases.





Rivers provide for our need for beautiful places

Human beings love beautiful things. Each of us has a place in our heart that is warmed when we see something beautiful. For this we need to protect beautiful places where our spirit can rest and we can feel at peace. Rivers are special places for this, as they have healthy water and lovely trees. It is necessary to the human spirit to keep some places beautiful.

Rivers provide places for religious rituals

Humans have a spiritual need for wild, empty, natural places in order to feel whole and healthy. Religious rituals such as baptism are conducted in rivers. In traditional cultures, people communicate with powerful water spirits. They need places in the river to be preserved for visiting these spirits.

So, rivers do many things for us:

- *water supply for homes, farming and industry*
- *water for the dilution, processing and transport of wastes*
- *water for nature conservation and ecotourism*
- *water for beauty - so that our human spirit will grow*

but

***rivers cannot do all these things at the same place
and at the same time***

Why? Because a river can get overloaded. It will become overloaded if it supplies large quantities of water for industry or irrigation and if at the same time it accepts too much waste from industry, sewage from towns, and salts, fertilisers and pesticides from irrigation lands. Such a river will not be in a good condition.



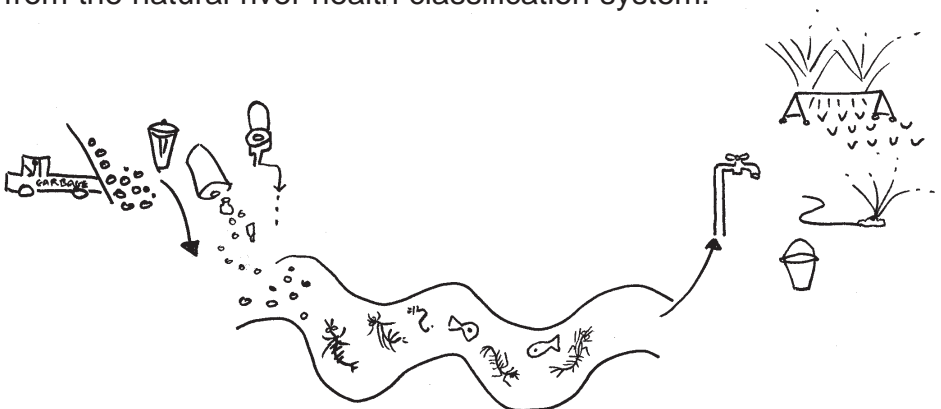


4. River health and classification

Rivers clean themselves naturally. They provide habitats for a wide range of plants, animals and microbes, with some animals eating plants, some animals eating each other, and some animals eating broken-down plant and animal detritus. When a river is used by many people, the number and kinds of plants, animals and habitats change. Feeding processes change. The structure and function of the river changes. The health of the river suffers.

Even a river that is less healthy can still function as a river, but it is useful to know exactly how healthy a river is. To help with this, a classification system for river health is being developed.

In some cases people have modified a natural system forever so that it will not behave as a natural system anymore. Some urban rivers, for example, have been turned into concrete canals. Here the environmental concern is not ecosystem health, but how to avoid health hazards and how to use biological processes so that they are as pleasant as they can be. Severely modified systems can still serve good functions within an urban setting, but they are excluded from the natural river health classification system.



Rivers in each health class offer different goods and services

In order to choose what class of health we want our rivers to be in, we need to know which services each health class can offer us. In this section we look at how much of each service each of the river health classes can offer.

Rivers classed as *natural* are relatively unused except for nature conservation, and offer the best services of biodiversity, low impact recreation, places for spiritual renewal and religious ceremonies.



Rivers in the *good* health class offer some water and waste disposal, but more recreation, nature conservation, opportunities for eco-tourism and beauty.

Rivers in the *fair* health class usually offer high water supply and high waste disposal use.



Rivers classed as *poor* are over-used and their ability to provide services in the long term is low.

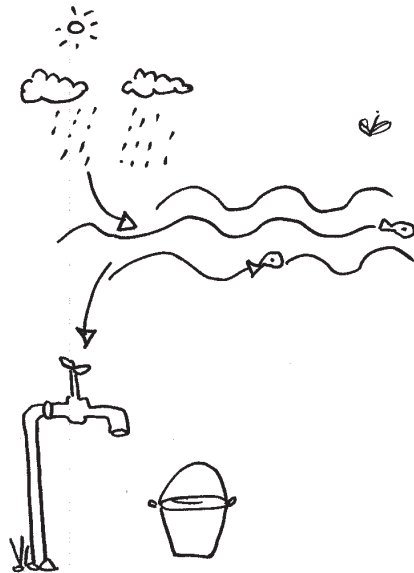
WATER SUPPLY from different classes of river

Water supply from protected rivers

A very small amount of water can be taken out, for tourist accommodation and recreation only. The water quality of the river is natural or nearly natural — and is probably excellent to good, with no health hazards. The amount of water flow is good, and all flow-related habitats are present. This river has the potential to support its full range of plants and animals. But it needs most of its water to do this — if water goes to any more users, the river will begin to lose its vibrant health.

Water supply from good rivers

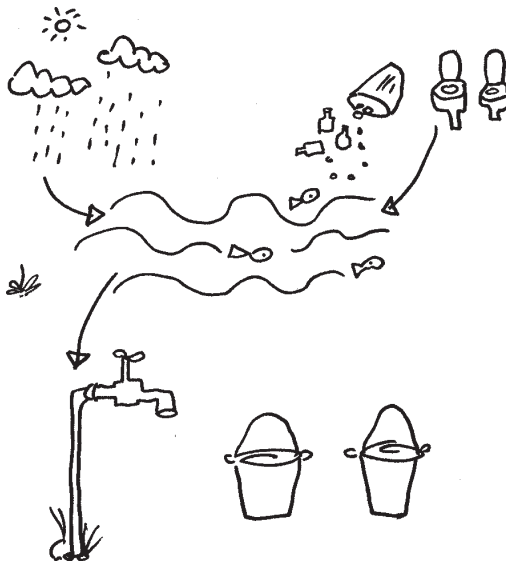
In a river classified as good, larger quantities of water are taken out and supplied to users. This leaves less water for dilution of wastes, so there needs to be high control of waste disposal to keep the water quality good. When the river's water is supplied for domestic use, it needs purification, but the purification costs are reasonable. The river's seasonal pattern and amount of flow is sufficient to allow a good range of flow related habitats, and a good range of plants and animals. There may be potential to allocate water to more users, but if too much is allocated the river health will drop.



Water supply from fair rivers

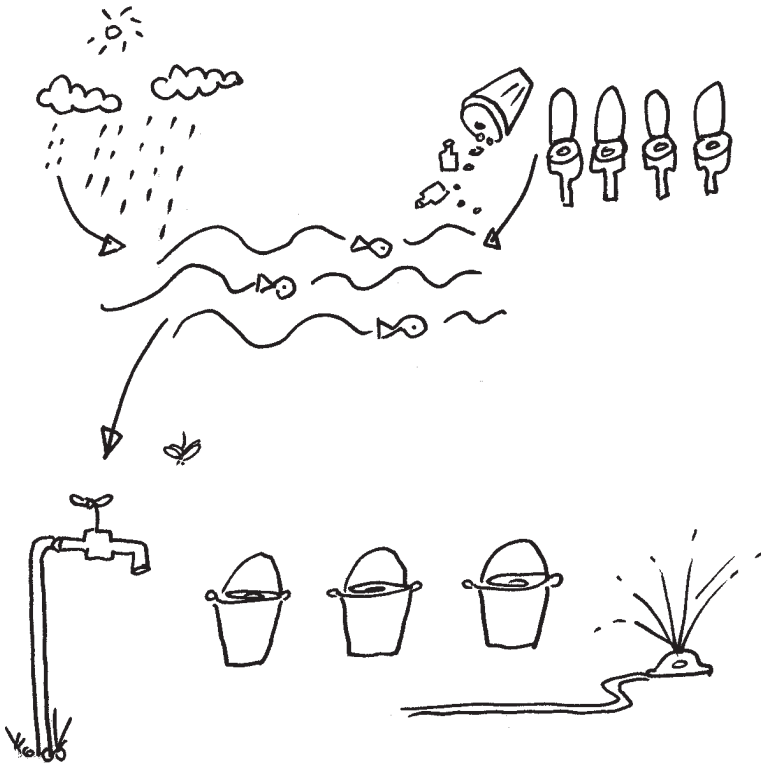
In a fair river, an even larger amount of the natural flow is taken out and supplied to users. The water quality becomes even more dependent on how well waste disposal is controlled, because there is now so little water for dilution. If there is not good waste disposal control, water quality could be poor. If this water is supplied for domestic use it requires expensive purification.

In a fair river the seasonal pattern and amount of flow is very far from natural. Many habitats have disappeared, and with them the plants and animals that used to live in these habitats. Any more water use from this river has severe impacts on the health of the river.



Water supply from poor rivers

In a river classified as poor, too much water has already been taken out. Restoring the river's health is only possible with less water use and rehabilitation from the effects of over-use.



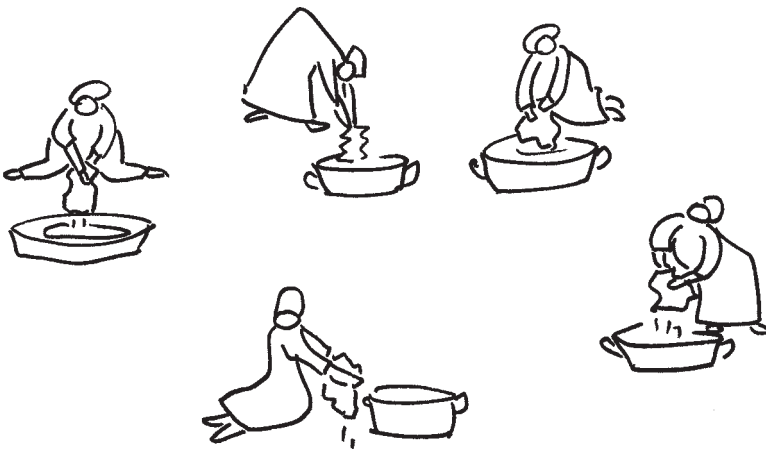
WASTE PROCESSING in different classes of rivers

Waste processing, transport and dilution in protected rivers

In protected rivers, minimal or no waste can be discharged into the river. The natural breakdown processes cope easily, but to remain in this class the river cannot process more waste.

Waste processing, transport and dilution in good rivers

Here the waste is mainly from sewage, with little or no waste discharged into the river from industry and irrigation. The natural breakdown process copes with most of the waste, and a short distance downstream of the discharge the river is in a reasonable state of health. When this water is supplied for domestic use, it needs purification, but the purification costs are reasonable. There may be potential for more waste to be processed by the river, and licenses to discharge may be given.



Waste processing, transport and dilution in fair rivers

In this class of river a lot of waste is discharged — from industry, irrigation and sewage. The natural breakdown processes only just cope with most of the waste. There may be a high risk of toxicity and health hazard. The river is in fair state of health. The natural populations of plants and animals are stressed, and sensitive species disappear. When this water is supplied for domestic use it requires expensive purification. The river cannot process much more waste, and it is unlikely that more licences to discharge can be given.

Waste processing, transport and dilution in poor rivers

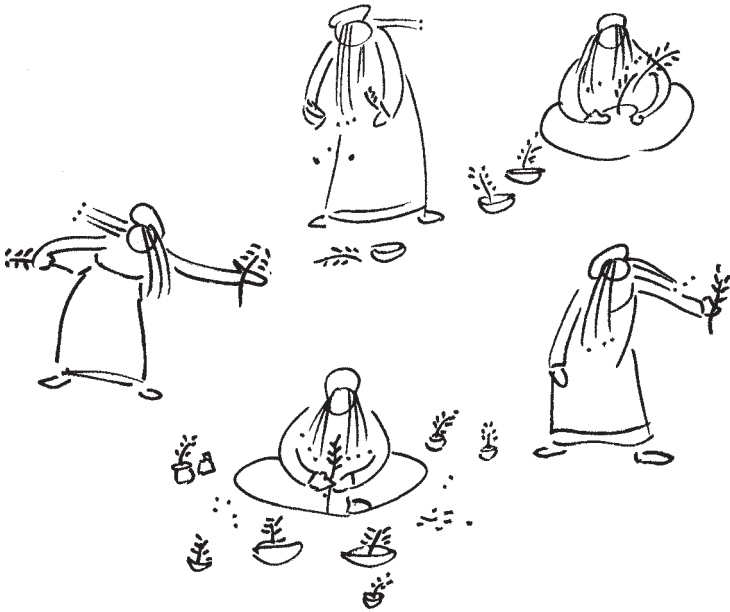
Too much waste has already been put in the river. The river can only recover if there is less waste disposal combined with rehabilitation to reverse the damage.

The supply of NATURAL PRODUCTS by rivers

Natural products can be collected from the river itself, or from the land on both sides of a river (the riparian strip). Useful products include medicinal plants, plants for thatching, weaving, fuel and dyes, as well as food and water for people and animals.

Supply of natural products from protected rivers

Protected rivers are wilderness rivers with a full range of medicinal plants, reeds and fish. Activities in and around a protected river are restricted, although limited harvesting and use may be allowed. Protected rivers act as important breeding and refuge areas for animals and plants. It is from these areas that animals move out and plants are distributed into good or fair reaches where they can be harvested more freely.



Supply of natural products from good rivers

Good rivers are the best kind for supplying natural products to people. A wide range of plant and animal species is available, and people are able to harvest these in an appropriate way. Sustainable harvesting leaves enough plants and animals to reproduce and grow for future harvesting.

Supply of natural products from fair rivers

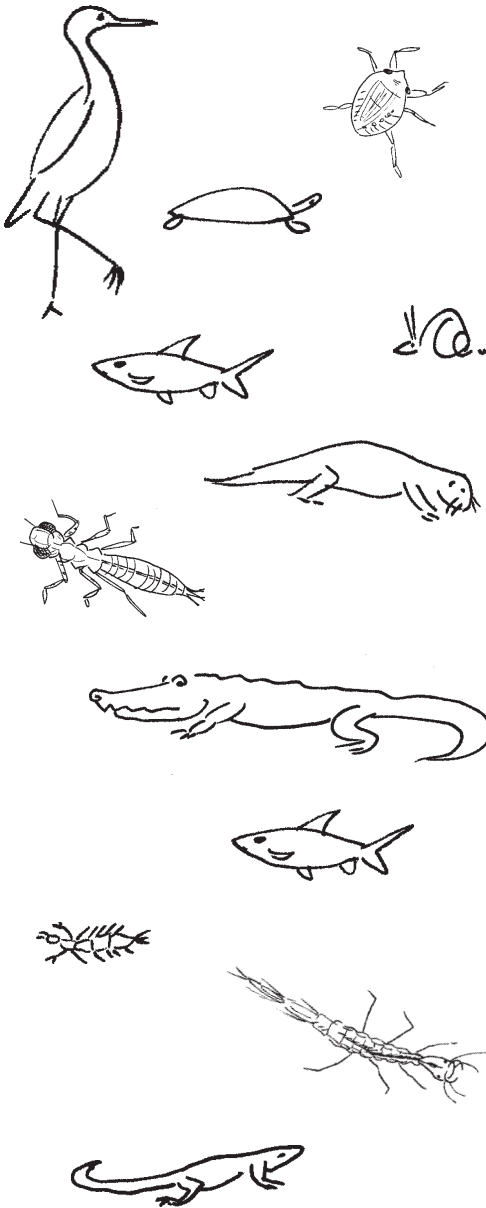
Rivers classified as fair are “workhorse” rivers. Their main function is to supply water for agriculture, industry and people, and to dilute, transport and process wastes. Their riparian strips are often damaged because of industry, agriculture and domestic use in towns, causing a loss of the species used in medicines, crafts, and building. Some tough species may remain, but fair rivers are not generally good for offering natural products. Fair rivers may also have the problem of alien (exotic) plants which move quickly and aggressively into the riparian strip.



Supply of natural products from poor rivers

Poor rivers generally provide very few natural products because they no longer provide habitats to the organisms that could live there to maintain the river as a functioning system.

How rivers contribute to NATURE CONSERVATION



South Africa has signed the Convention on Biological Diversity, meaning that our country is committed to the conservation of its natural heritage of plants and animals. Biodiversity is the wide range of living organisms and their interactions with each other and the diverse physical environment found naturally in any one place.

Nature conservation in protected rivers

One of the main services offered by protected rivers is nature conservation and maintaining biodiversity. In a protected river all naturally occurring plants, animals, microbes, habitats, and processes are conserved, and the natural level of biodiversity is maintained.

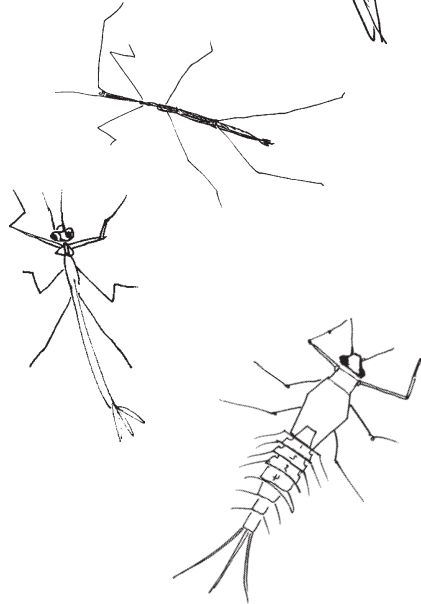
Nature conservation in good rivers

When a river is in a good state of health, a wide range of the animals, plants and natural processes will be present. Good rivers exist in game parks and in well managed agricultural and rural areas. Nature conservation in areas around good rivers can be used for the tourism industry, which has the potential to generate jobs.



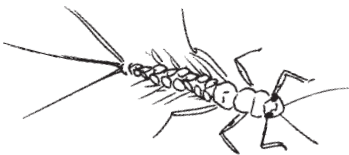
Nature conservation in fair rivers

Fair rivers may not be appropriate for nature conservation as mainly the tough animals and plants remain.



Nature conservation in poor rivers

These rivers are barely functioning and not suitable for nature conservation.



Recreation, beauty and SPIRITUAL NEEDS

The value of a river's services for recreation, appreciation of natural beauty, and for satisfying spiritual needs depends on the cultural values of people living in the catchment or visiting the area. Subsistence fishing might be more important to a poorer community that relies on the river as a food source. Sacred water sites require limited access and low disturbance, and so may need special community consultation and protection. Recreational uses such as fishing, boating or skiing, may be more important to one community than another.



Recreation and beauty - protected rivers

Recreation around protected rivers is available to relatively small numbers of people at one time to ensure a low development impact on the environment. Hiking, camping, and canoeing are ideal recreational uses. Protected river areas offer the highest quality of natural beauty and spiritual renewal. (In the USA these rivers are called “wild and scenic rivers”).

Recreation and beauty - good rivers

Most people have the opportunity to experience beauty and spiritual renewal in and next to good rivers. These are rivers where people fish, picnic, swim and have fun. Good rivers attract tourism, and are a resource for economic growth.

Beauty and recreation - fair or poor rivers

Heavily used or damaged and degraded rivers are unlikely to be places for recreation and peace.

Rivers and spiritual needs

For most people rivers are spiritually important just because they offer the experience of silence, space and natural beauty. But for many indigenous people rivers have a greater spiritual significance because of their sacred sites. Water spirits are very important within the Zulu, Xhosa and Shona healing traditions. The calling of people to become healers happens at a sacred site in a river or at a sacred pool, and they then get taken under the water, often by the river snake or mermaid. When they return, they have developed skills in healing, and gained sacred knowledge.

Many of the images or messenger animals that call the chosen ones to the water, are water animals like water snakes, leguaans, hippopotami, frogs or crabs. These callings often happen at places known as living waters, such as below waterfalls. The presence of certain plants near pools and rivers, such as the umkumzi reed, indicate the presence of the water spirits. Reed mats are often used by healers as they are directly linked with the water.

Rituals are performed for water spirits at rivers throughout Southern Africa. Some Nguni people place seeds to be planted on the surface of sacred pools. It is believed that the river spirits will return half

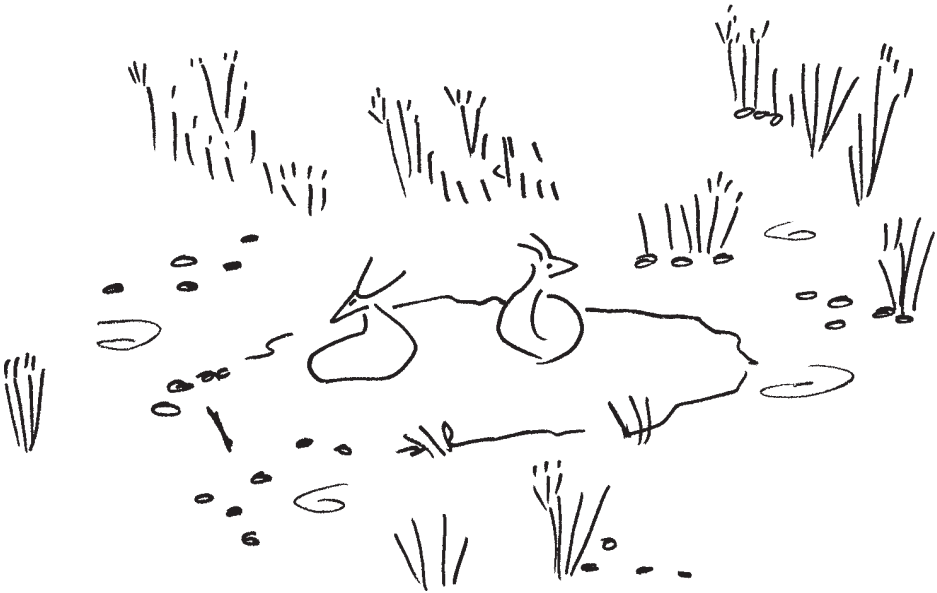
the seeds, and if mixed with other seeds for planting, there will be a good crop. People are not generally allowed to approach these sacred pools. Nobody is allowed to remove plants or other resources from the water's edge near these pools unless they are a healer taking them for medicinal use. Killing or injuring any of the water or riparian animals is also not allowed, so as not to offend the spirits. In this way spiritual beliefs and practices also help to protect the river.

If developments are to take place near a river, it is important for catchment managers and scientists to know about the spiritual and religious beliefs connected to the site.



The ECOLOGICAL RESERVE and river health

The ecological Reserve is a legal provision in the National Water Act. It makes sure that the amount of water, the timing and pattern of flow, the shape and structure of the physical environment, the water quality, and the composition of the biological communities are all provided for. (Water quality includes the physical and chemical characteristics of the water and the sediment.) The ecological Reserve is different for different classes of river health. Once the water quantity and quality needs have been quantified, people can choose which health class they want. Only after





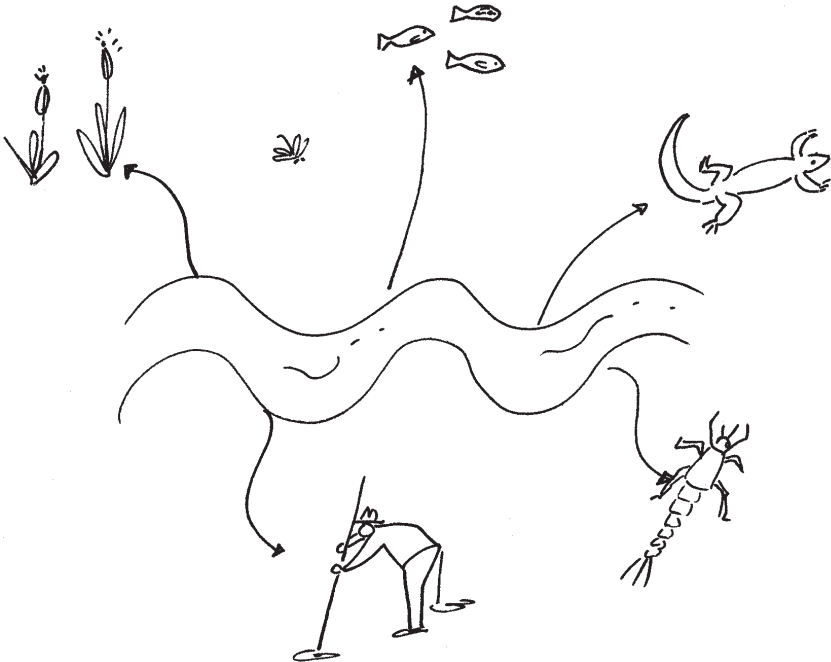
ecosystem health and people's basic needs have been met can the river's water be allocated for domestic, industrial and agricultural use.

An ecological Reserve assessment involves quantifying the water needs of plants, animals, microbes and the physical habitat. All the plants, animals and microbes found in a water ecosystem have particular habitat requirements. Ecological Reserve assessments are therefore usually done by biologists who know about plants and animals. They use their knowledge to define what the plants and animals need.

It is important to understand that the National Water Act does not put the needs of plants and animals above the needs of people. The needs of fish, mayflies and plants is a measure — if they are healthy and happy, the ecosystem will be at a level of health capable of delivering the ecosystem's goods and services to people.

The ecological Reserve provides what rivers in all health classes need:

- enough water to maintain their structure and to provide habitats for plants and animals
- water in the right season so that plants and animals can complete their life cycles
- variability of flow so that the groups of animals that thrive in either wetter or drier conditions can be maintained
- enough water in severe droughts so that rivers that usually flow all year continue to do so, and seasonal rivers do not dry up for longer than they would naturally.





5. Water in the environment



The National Water Act requires that for any water ecosystem, the amount of water, the quality of water, and the timing and pattern of flow and chemical concentrations, must allow healthy ecosystem function.

People with specialised scientific knowledge have to be called in to describe what watery ecosystems need – but if people who live in catchments know enough about ecosystems, they can work with scientists to choose the health class they want and participate in ecological Reserve assessments. This section provides some basic information about river and other water ecosystems.

The water cycle

Water is found in several forms - seawater, freshwater, ice, water vapour, and in the bodies of plants and animals. Most of the water on earth is the seawater of the oceans. A lot of fresh water is locked up as ice in the polar regions, and is not directly accessible to plants or animals. Water vapour is the water in the air, in clouds, fog, mist, and rain. Fresh water is found in rivers, lakes, groundwater, dams and wetlands.

The water cycle starts with clouds, caused by evaporation from the oceans, lakes, rivers, wetlands and dams, and from water vapour released by plants. Clouds can travel long distances, and under particular conditions, they release water in the form of rain, hail or snow. Most of the rain falls over the ocean and becomes part of seawater again, but some falls on land.

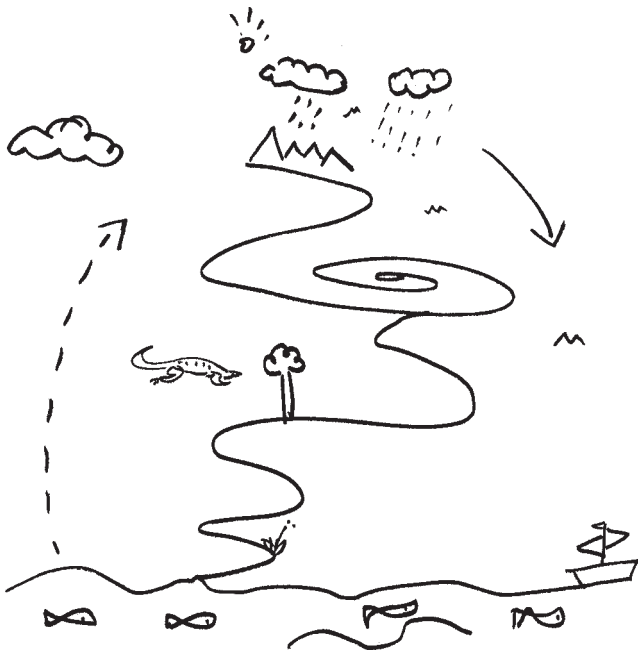
The rain that falls on the earth seeps into the soil and remains there, or moves through and between the soil and rocks into groundwater storage areas (aquifers) which feed rivers. Rainwater flowing over the earth's surface also feeds rivers. The rivers all flow to the sea.

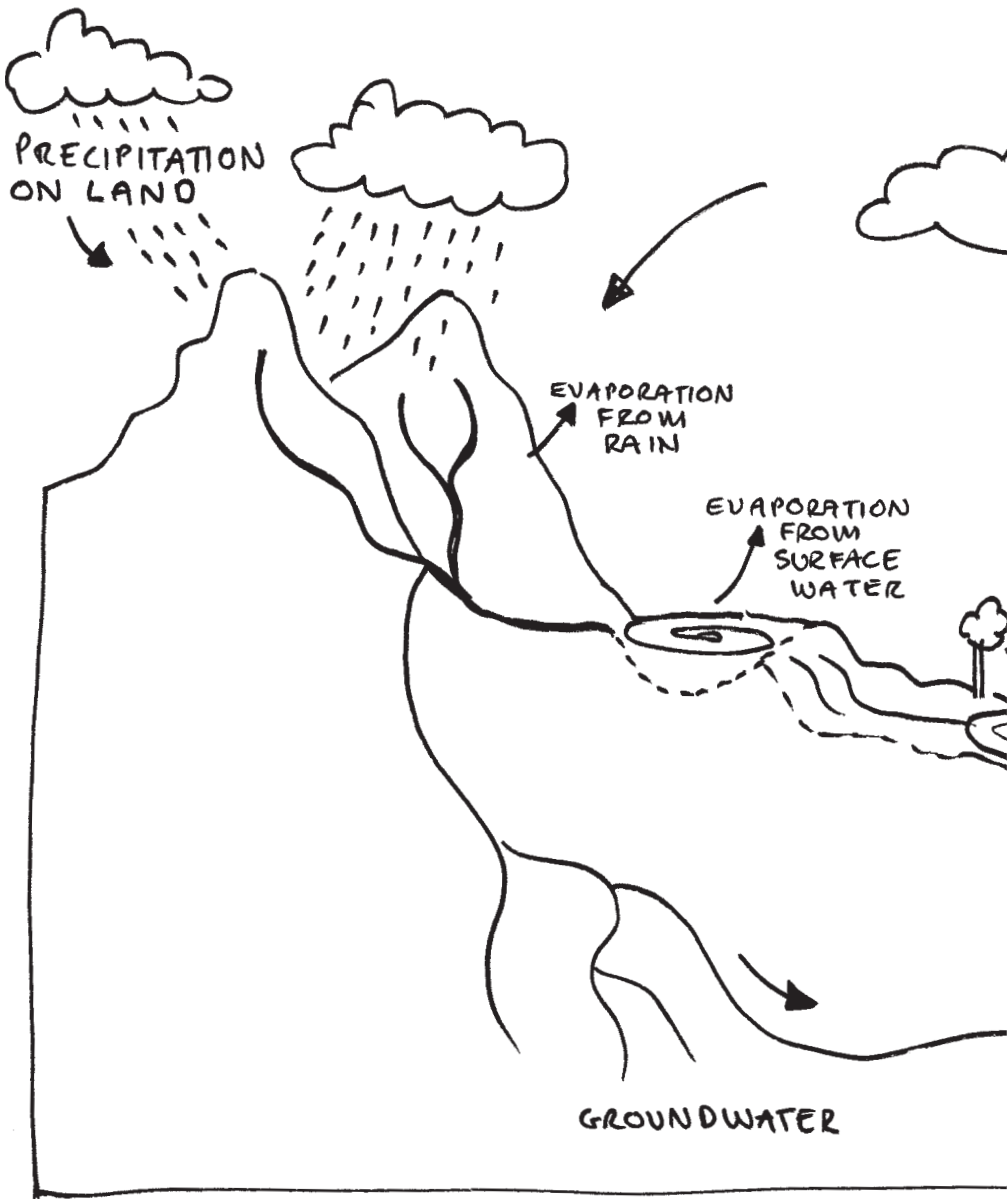
Water ecosystems

An ecosystem is any community of living creatures interacting with each other and their external environment. Ecosystems consist of non-living parts such as water, air, nutrients and sunlight; and living parts – the plants, animals and micro-organisms. Ecosystems come in different sizes, from a few trees to an entire forest, from a puddle of water to a river. They can be natural, like rivers, or artificial, like dams.

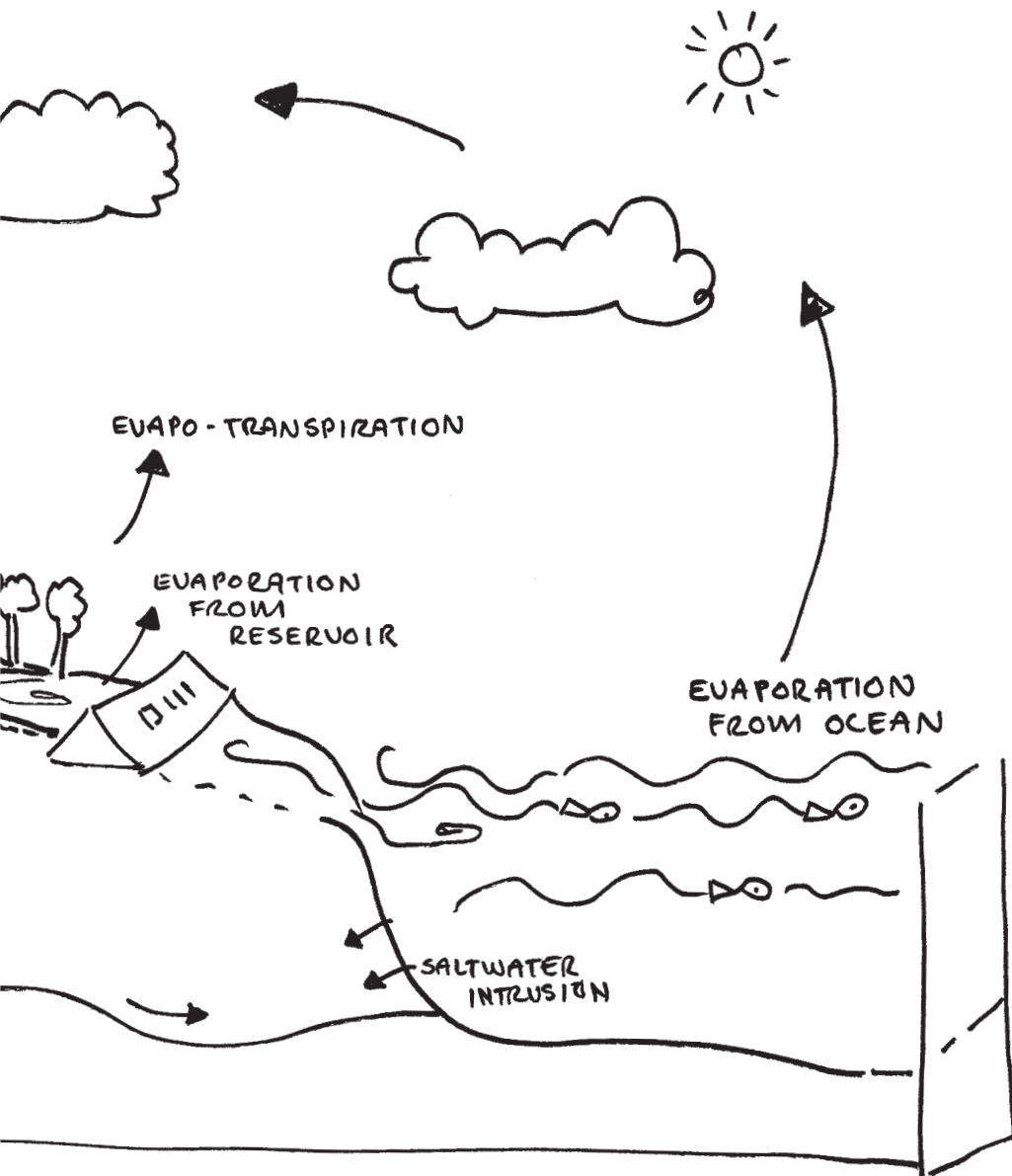
Water forms the basis of several kinds of ecosystems — rivers, lakes, groundwater, dams, wetlands and estuaries. Each of these provides a range of water habitats (places to live) for plants, animals and microbes. Dams are artificial ecosystems built by people, to store water. Dams are particularly important in a country like South Africa where rainfall is unpredictable and unevenly distributed. Dams function as ecosystems similar to lakes.

A catchment, also known as a drainage-basin, is the land area where a river is formed and through which the river flows. It catches surface runoff from rain, hail or snow. As run-off water flows downhill, towards the lowest part of the catchment, it forms streams. As more water joins the stream, it becomes larger, joins other streams, and forms a river. As the river flows, it collects more water from the catchment and from the groundwater, and grows larger, flowing downstream towards other rivers or the sea.



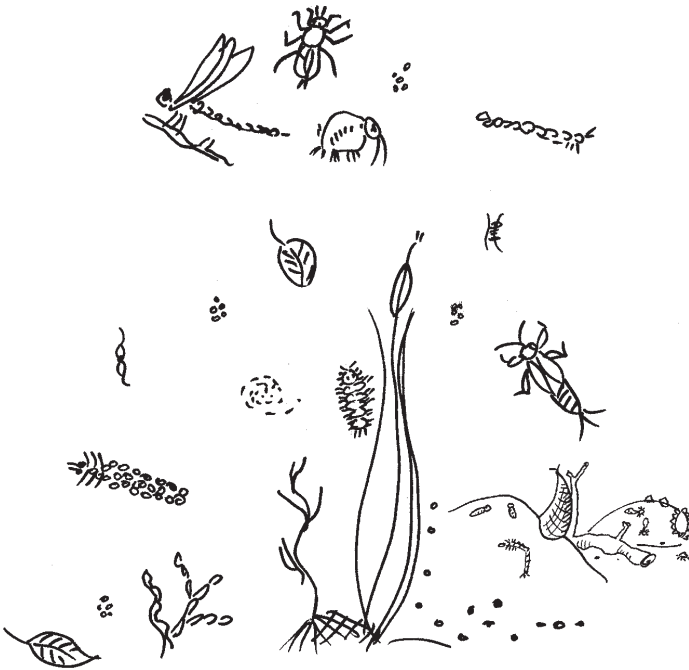


THE WATER CYCLE



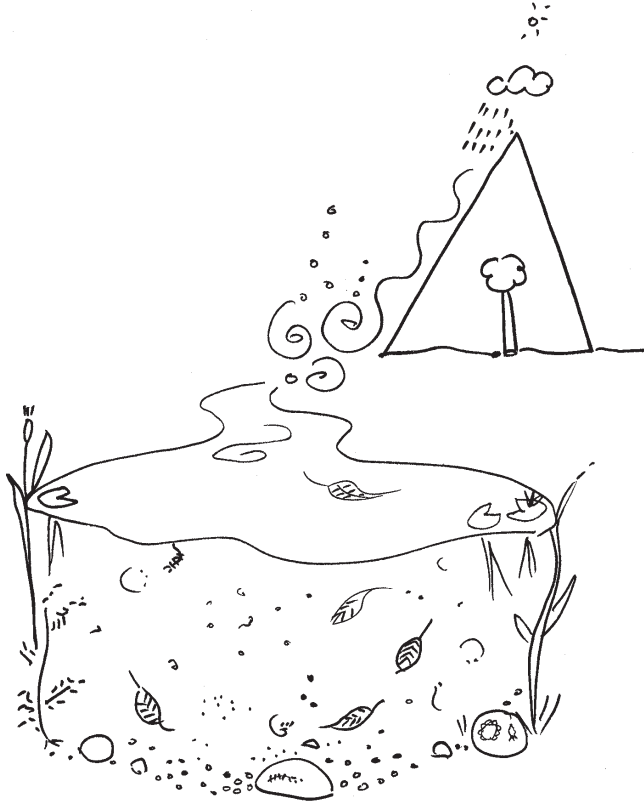
Sediment (sand and mud) and other substances, including chemicals that cause pollution, also flow into the river. The water and all substances dissolved or suspended in it, affects the health of the river and the quality of its water. If the dissolved substances are harmful then water is described as being of poor quality, or polluted. Good water quality means that the water has few or no harmful substances.

Many dissolved substances are necessary for life. These nutrients are essential for organisms to survive, grow and reproduce. Some nutrients are needed in large amounts, like carbon, oxygen, hydrogen, nitrogen and phosphorus. Others, known as trace elements, are needed in much smaller amounts, like sodium, copper, and zinc. If any of these substances is present in high enough concentrations to cause harm, it becomes a pollutant.



Characteristics of rivers

Flowing water makes a river different from other water ecosystems. The energy or power of the river depends on the slope of the riverbed and how much water flows through it. The amount of water depends on the rainfall. Rivers usually start in the high mountain areas, where there is the most rainfall.



A river passes through three zones on its way from its headwaters to the sea. These are known as the headwaters or upper reaches, the middle reaches, and the lower reaches. Distinct processes and activities take place in each zone, providing habitats for different organisms.

In the headwaters, water flows fast and is colder than lower down. If few people and domestic animals live in the upper catchment, the water is usually clean. Oxygen levels in the headwaters are high and nutrient concentrations are usually low. The plants and animals living in this part of the river are adapted to cool, fast-flowing water, which has high oxygen levels and is usually poor in nutrients.

As the river flows on downstream, the slope of the catchment changes and becomes less steep, and the river becomes wider and flows more slowly. It is deeper here than upstream. These are the middle reaches. The water in this part of the river is warmer, and has slightly lower oxygen levels.

The lower reaches of the river meander across broad flat areas of the landscape. Here the river is wide and deep. The temperature of the river is higher here than upstream, and the amount of oxygen in the water is lower. The lower reaches have had a long time to accumulate material (sediment, chemical compounds, plant material) from the catchment and from the upper reaches. Nutrients enter the river from the catchment as leaves, fruits, dead insects, dead animals and wastes (urine and faeces), together with sediment. These materials usually enter the river during heavy rainfall.

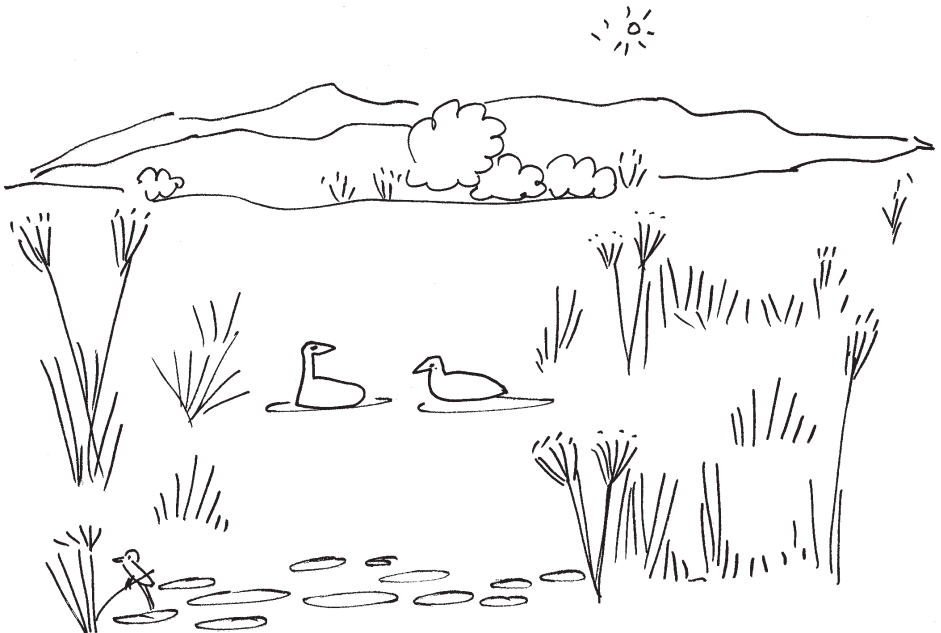
Human activities in the catchment affect the river in many ways. If there is overgrazing and ploughing, the river will have a lot of sediment, because rain will wash the loose eroded soil into the river. Irrigated lands can increase salt loads — when irrigation water evaporates, salts are left behind and are washed back into the river by the next rainfall. Mining and industry often contribute sediment and pollutants. Sewage works, and the run-off from settlements with poor sanitation facilities also contribute pollutants.

Characteristics of wetlands

Wetlands are areas that are covered in water part or all of the time. There are different kinds of wetland, depending on how they are formed, the type of soils and plants present, and whether the water is flowing water or still. Wetlands can be fed by surface water or groundwater.

Wetlands are important in the water cycle for many reasons. They are very good at cleaning the water that flows through them. The cleaning is done by the combined activity of plants, animals and microbes, as well as the filtering action of the sand or sediment.

Another important function of wetlands is to reduce floods and erosion by absorbing surface runoff in times of high rainfall. Wetlands also provide extensive food and habitats for fish and birds and all sorts of plants and smaller animals.



Characteristics of lakes

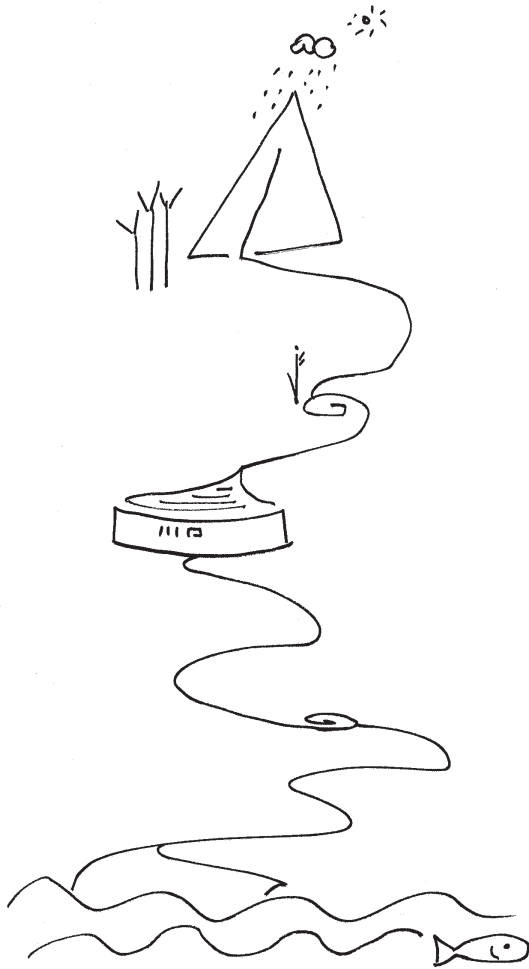
Lakes form where a natural depression in the earth's surface fills with surface runoff or groundwater seepage. The depth of the lake depends on the size of the depression as well as the amount of rainfall. Because lakes are bodies of still water, sediment settles on the bottom, and pollutants may be trapped in the sediments. Lakes are habitats for still-water plants and animals. If too many nutrients reach a lake from fertilisers or sewage, then algae may grow too well in the water, and the lake becomes eutrophic (green and smelly).

Characteristics of dams

Dams or reservoirs are built to store water. A dam can either be built in a river, or built away from the river with river water pumped to the dam. Dams provide many services, from recreation and water supply to the generation of electricity and irrigation. They become populated with plants and animals, and effectively act like artificial lakes.

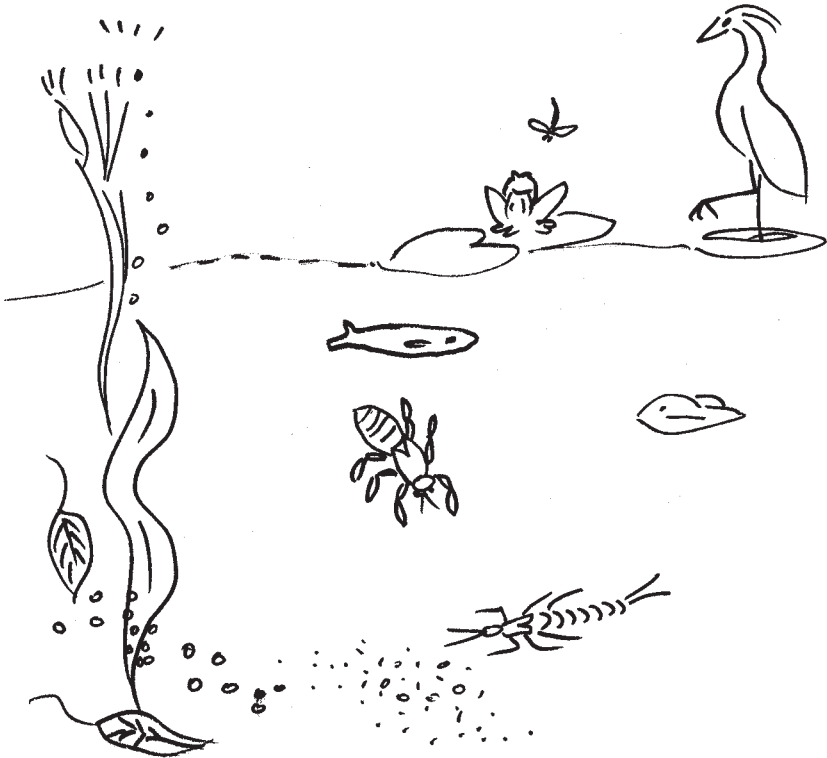
Characteristics of groundwater

Groundwater is rainwater that has seeped into the ground. The top layer of groundwater is known as the water table. The water table moves closer to the surface if there has been a lot of rain, and sinks deeper beneath the surface when there is no rain. In some places groundwater stays locked in the ground. In other places it forms underground rivers, or returns to the surface and enters rivers. Specialised animals can live in these underground waters. They tend to be very small, such as bacteria and small invertebrates.



Living organisms in rivers

Living organisms are either producers or consumers. Producers make their own food from nutrients, carbon dioxide and sunlight in their environment, usually through a process called photosynthesis. Plants and algae are producers. All other organisms are consumers which depend directly or indirectly on producers. Consumers get their energy by feeding on other organisms. They can be grouped according to the type of material they eat. Herbivores eat producers, carnivores eat other animals, omnivores eat both plants and



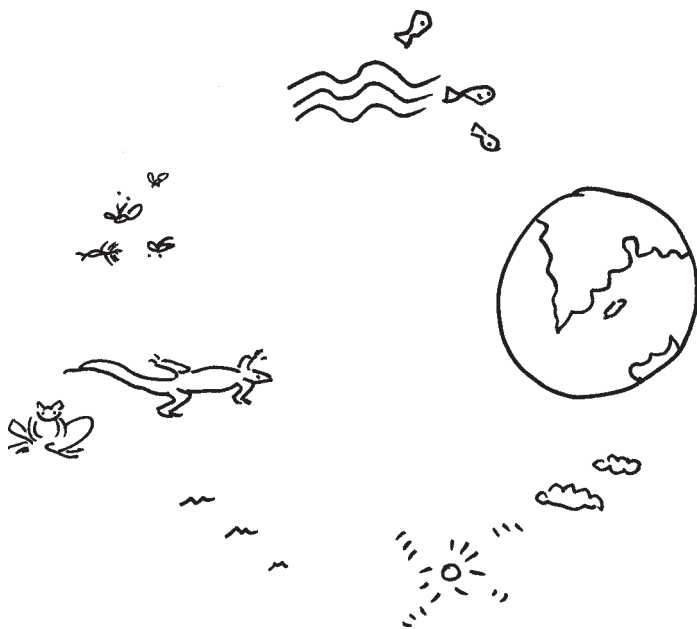
animals. Scavengers feed on dead organisms. Detritivores feed on fine bits of decayed plant and animal material. Detritus feeders eat partly decomposed material. Decomposers break down dead material and release nutrients to be taken up by the producers.

The living, feeding, reproducing, excreting and dying of animals are all links in the life-processes of the earth. Feeding and photosynthesis are energy intake processes, reproduction uses energy, and excretion gets rid of wastes. Excretions and dead bodies are energy sources for other plants and animals. In a river, as in all ecosystems, the nutrients available to the organisms are an important factor in determining which organisms can be found where. Organisms allow ecosystems to be of service to people. Water ecosystems are cleaned by the feeding activities of bacteria, fungi, and filter feeders as well as by physical filtering by plants and sediments. Organisms which can withstand a wide range of different conditions are called tolerant, and those which die easily if conditions change are called sensitive. Healthy ecosystems will have a good mix of sensitive and tolerant organisms. Less healthy ecosystems will have fewer or no sensitive organisms and perhaps only tolerant ones.

The number of different types of plants and animals found in an ecosystem is known as its biodiversity. When there is loss of natural biodiversity, the number of services in the ecosystem is reduced. The ecosystem becomes less able to adapt to changing environmental conditions, more fragile, and easier to damage.

The types of organisms able to live in a river depend on the number of different habitats. Each habitat can be described by the speed of the water flow, the depth of the water, the kind of substrate (mud, sand, pebbles, boulders or solid rock) and the presence or absence of vegetation in the water and the riparian strip. Examples of habitat are pebbles in shallow fast flowing water; boulders in deep slow

flowing water, or reeds in deep still water. In each habitat live a different group of plants, animals and microbes. Some plants and animals are found suspended in the water itself, in or on the substrate, or among the vegetation on the edges of the river.



Animals and plants found in and next to rivers

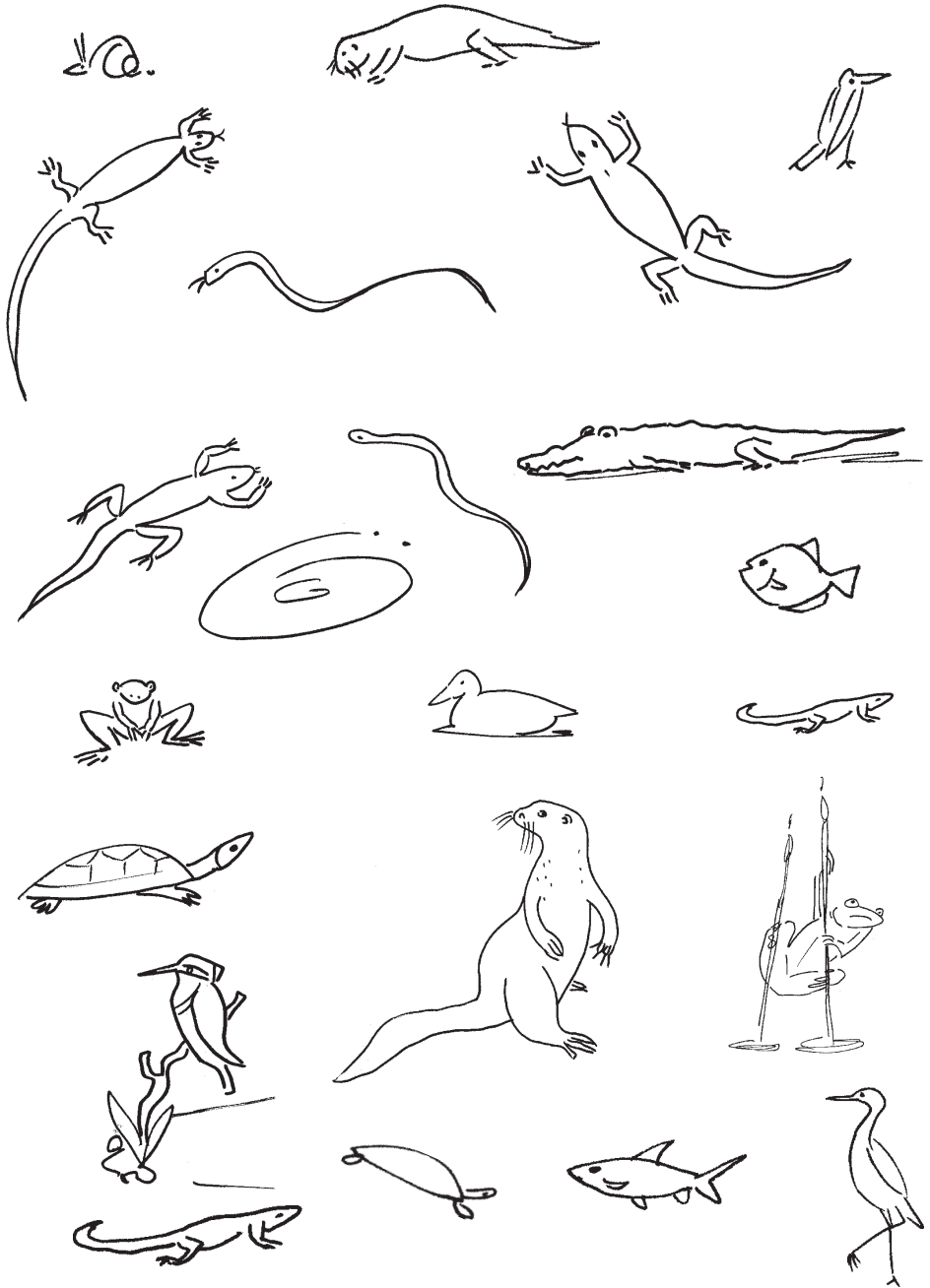
Vertebrates

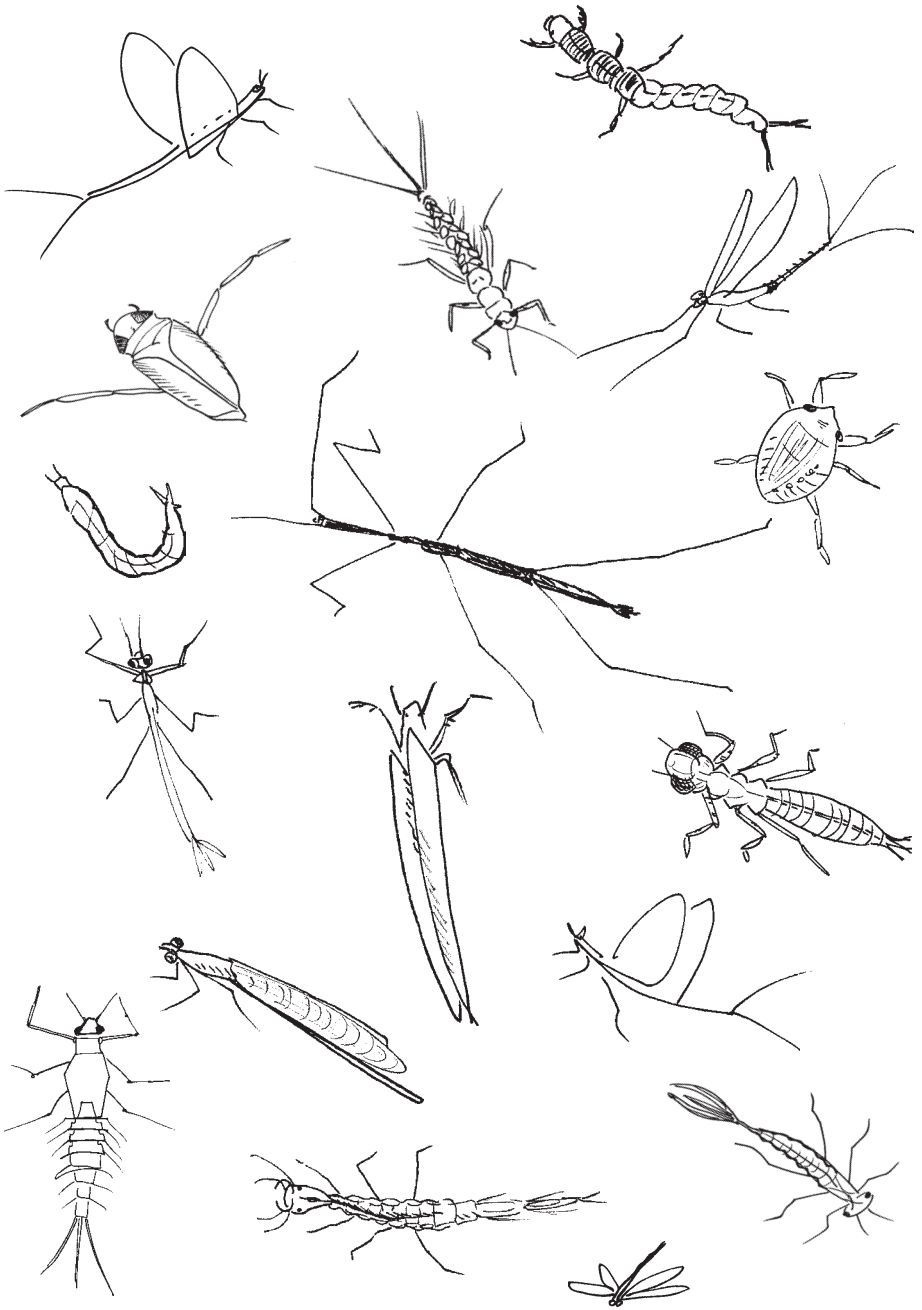
Vertebrates are animals with backbones, usually big enough to see with the naked eye. They include amphibians (like frogs), reptiles (like lizards, crocodiles and snakes), fish, birds and mammals. All these groups live in and around rivers eating plants or else eating the smaller animals that eat plants or algae.

Some vertebrates live close to rivers but do not live in water all the time. They feed on other plants or animals living in the water. Examples are waterbirds, otters and crocodiles. Some use rivers to hide in during the day or to stay cool. They might eat water plants and come out to feed on land plants during the night as hippos do. Some, like frogs, use the river to grow their young.

Fish live permanently in water and rely on what the river can provide for them to feed, grow and reproduce. They eat other organisms, such as plants, algae or other animals. Habitat destruction is one of the main threats to fish populations. It can be caused by a number of things — drainage of wetlands, bulldozing of streambeds, dams and weirs which restrict movement. Another cause of fish habitat destruction is sedimentation caused by overgrazing, poor land use, or ploughing right to the edge of a river.





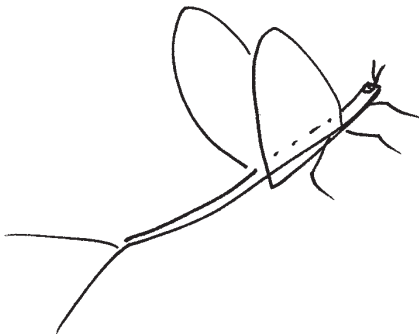
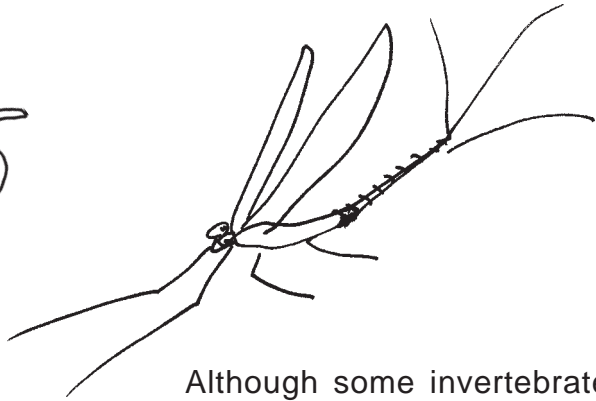


Invertebrates

Invertebrates are animals without backbones. There are many different kinds, but often we don't notice them because they are much smaller than vertebrates. They play an important role in rivers, especially in nutrient cycling, and as the food source for fish and frogs.



Invertebrates that live in rivers include insects (dragonflies and mayflies), crustaceans (crabs and shrimps), water snails and worms. Invertebrates are able to use all the different habitats provided by rivers, from fast flowing water with high oxygen levels, to slow-moving deep water in pools with low oxygen levels.



Although some invertebrates live entirely in the water their whole lives, many live on land during at least one of their life stages. It is common for young insects to live in the water and then emerge onto the land as they become adults.

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Plants and algae

Plants are the only living organisms that can capture the energy in sunlight and change it into food. They are important in river systems because of their roles in the nutrient cycle and photosynthesis. During photosynthesis, plants turn carbon dioxide gas and water into food, using energy from sunlight and minerals from the soil. Plants and algae provide both oxygen and food to many other organisms in rivers. There are many different kinds of plants and algae. Some of them can survive in fast flow, but most prefer slower flowing water, where there are more deposits of sand, mud and nutrients, which provide the ground for plants to grow their roots. Plants often provide habitat (living space) for different kinds of animals.

Some plants live in the river channels, while others live on the side of the river and rely on regular flooding to supply their roots with water and nutrients. Some live completely under water and have roots in the mud, while others (like the water lily) have their leaves floating on the surface of the water and their roots fixed in the mud. Others (like duckweed or water hyacinth) float on top of the water with their leaves above the water and their roots in the water.

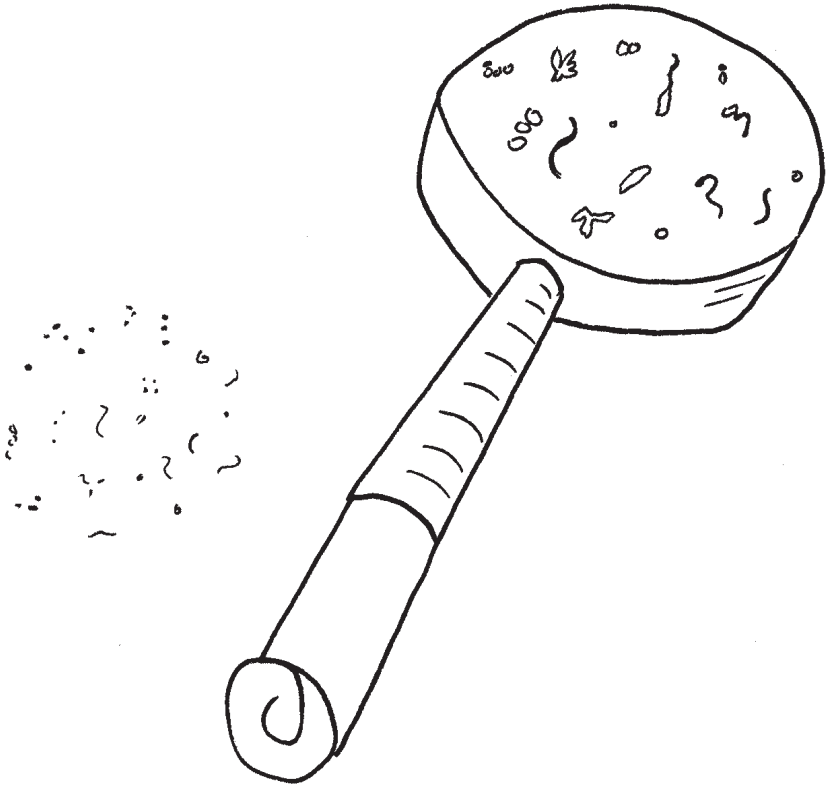
Black wattle, prickly pears, lantana, gum trees and pine trees are all alien plants. They use up water and reduce the number of useful plants that can be harvested from the riparian strip. Some alien plants, like water ferns and water hyacinth, grow in the water itself. Water hyacinth can double its weight in four days, and can grow right across a river, cutting out the light needed by smaller plants and algae. When these plants are killed by water hyacinth, they rot, oxygen is used up, and many other animals in the river are affected. Alien water plants can block water pipes and channels used for irrigation, and can provide breeding places for malaria mosquitoes and bilharzia snails.

Algae are simple plants which can be found floating on the surfaces of rivers, in flowing water, although they also grow on rocks and underwater surfaces such as plant stems. Algae prefer clear, slow, flowing water, where the sunlight can penetrate. More sunlight means increased water temperature and more light – which allows a higher rate of photosynthesis. The stronger the light and higher the temperature, the faster the algae grow. When there are lots of nutrients in the water, algae can grow very fast. When you see thick green mats of algae on the sides of rivers, it shows that the water contains too many nutrients.

Microbes

Microbes are everywhere. They are the smallest organisms on earth. They include bacteria, protozoa, fungi and yeasts. Most of them are too small to see with the naked eye. Although some of them can cause diseases, microbes play an important role in making the rest of life on earth possible. They are responsible for breaking down dead and rotting material into nutrients for plants. In this way they provide an important food source for other animals.

All plants, animals, and microbes interact with each other, and with the physical environment. We depend on them – they depend on us.



Measurement of river health

The health of a river can be measured by its plants and organisms. Protected, good, fair and poor health classes characteristically have different groups of plants and animals living in them. The South African National River Health Programme regularly samples the small invertebrates in rivers, and a higher score of sensitive invertebrates means a healthier river. A scoring system has been developed for the invertebrates found in water ecosystems on a scale from 1 to 15, where 1= very tolerant and 15 = very sensitive.

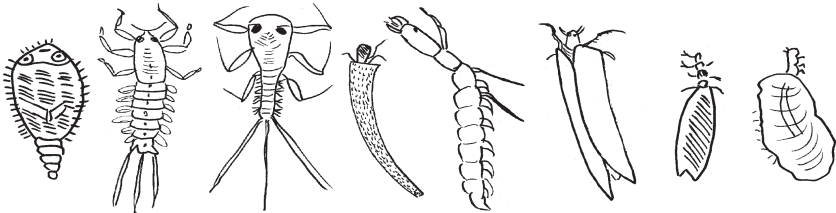


SENSITIVE

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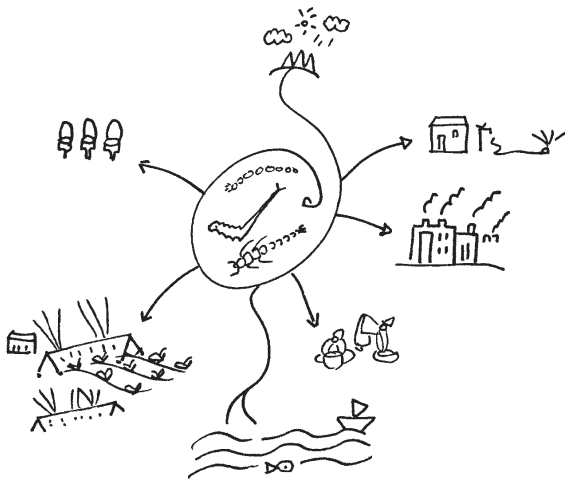
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Other ways of measuring health involve assessing fish samples, assessing the general health of habitats, and assessing the health of the river by its shape. (Shape can be damaged by too much, or too little water, and also by bulldozing). Frogs can be good indicators of a river's health. Because they breathe through their very thin skins, they are sensitive to pollution.

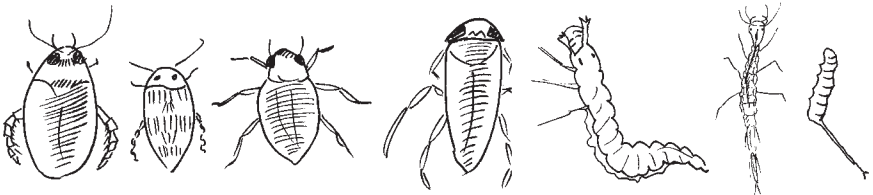
A river's health is assessed by how far away it is from the way it would have been naturally, when the impact of people was very low. The assessment asks, for each stretch of the river, how close



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>> **TOLERANT**



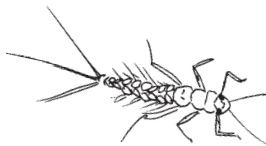
to natural are the patterns of flow, the kinds of plants and animals, the shape and structure of the ecosystem, and the chemistry of the water.

From these measurements we can work out the class of river health. Natural systems are, of course, still natural. Good systems are slightly changed from natural but still have most of the plants and animals they used to have, including sensitive ones. A few sensitive species may have disappeared, but there is a good natural diversity, and all the natural processes function well. Some water can be or is being used for domestic supply, and some sewage waste is discharged.

Fair systems are “hanging in there”. They have lost their sensitive species but are well populated by tough organisms which keep the basic processes going. They provide people with water for domestic use and economic growth and their waste water is transported and diluted.

Poor rivers have lost many species and many functions – they need help. They have had too much water taken out and too many wastes put in. They may be a health hazard.

In some cases, such as canalised urban rivers, a river system has been completely modified and will never function as a natural ecosystem. The main aim for the management of these systems is to avoid health hazards and to maximise use and enjoyment by people.





6. What needs to be done

All South Africans use water. Everyone can become involved in choosing the health of the water ecosystems closest to them, whether these are river reaches, dams, wetlands, lakes, groundwater systems or estuaries. Contact your nearest Department of Water Affairs and Forestry (DWAF) office and find out how you, your school, or your community can participate in a Catchment Forum or Water Users Association.

We need to make sure we have representatives of natural, good and fair watery ecosystems in each region. There are not many natural water ecosystems left. Good systems are quite rare and some of them are dependent on undeveloped tributaries.

Let us work together to have the water ecosystems we want.
Let us act now!

