Why is there an ecological reserve?

Although the concept of an 'ecological reserve' aimed at maintaining the ecological integrity of our water resources is now well known in water management circles, surprisingly little has been published about why such a reserve is necessary. This overview by Dr David le Maitre explores the rationale behind the ecological reserve, and links this to the concepts of ecosystem services and ecological infrastructure.

Many articles and reports refer to the ecological reserve but they mostly deal with what it is, how to estimate it, and how to implement it in practice. Not to why it is there. The concept of ecological infrastructure is explicitly linked to ecosystem services. But a recent article on that topic (see the *Water Wheel* July/August 2013) does not clearly link ecological infrastructure with the ecological reserve.

There seem to be no discussions of the concept which are generally or widely accessible to people. All the information is in documents that are typically only read by hydrologists and aquatic ecologists. This is quite surprising because a fundamental principle like this, which requires that water is set aside to meet its requirements (and basic human needs) before any other considerations, should surely be based on strong arguments?

So, how did the concept of an ecological reserve become a fundamental provision in the National Water Act of 1998? The ecological flow requirements introduced in the 1980s, and the explicit recognition that aquatic ecosystems should be protected because of their critical role in maintaining and improving water quality, both set precedents. The role of ecosystems in regulating water quality led the drafters of the Water Law Principles in 1996 and the 1997 Water Policy to recognise that maintaining water quality required maintaining the entire ecosystem which led naturally to the idea of resource quality and to the ecological reserve.

Another important factor was the need to fulfil the requirements of the Constitution and the fundamental principles of the water law finalised in 1996. The Constitution's Bill of Rights gives all South Africans the right *to an environment that is not harmful to their health or well-being*, as well as the right to have the *environment protected for the benefit of present and future generations.* Clearly, if we allow people's water supplies to become so contaminated they are harmful, then we have failed to fulfil that right.

The Constitution also provides for access to sufficient food and water, a right which was recognised by the provision of water for basic human needs in the reserve. It was a natural step from this line of thought to the principle that: *The quantity, quality and reliability of water required to maintain the ecological functions on which humans depend shall be reserved so that the human use of water does not individually or cumulatively compromise the long-term sustainability of aquatic and associated ecosystems.* This principle makes it crystal clear that the reserve is about maintaining ecological functions **on which humans depend** and, therefore, explicitly links the reserve to ecosystem services.

People have also been manipulating ecosystem and the services they provide to increase the benefit to us for thousands of years. For example, growing crops like vegetables involves capturing and modifying ecological processes to favour food production. There are indications that our use of ecosystem services is approaching and in some cases exceeding the capacity of the ecological infrastructure to deliver the necessary level of services. These limits apply both globally and locally and affect everyone.

We have seen these limits coming to light across South Africa, where many of our river systems have been so badly damaged by the pollutants that flow into them – sewage, industrial wastewater, acid mine drainage, return flow from agriculture – that they are hazardous to all life downstream. This situation has been aggravated by the fact that we also take out large volumes of water, not leaving enough to dilute the inflows and sustain the ecosystems that could assimilate the pollutants. Some impacts can and should be corrected quickly such as industrial pollution and dysfunctional wastewater treatment plants. Others will take longer to 'fix' and will be very expensive, much more expensive than if we had dealt with them when they first became evident.

An ecosystem service perspective tells us that the question is not how much water can we remove from a water source (e.g. a river) without compromising its ecology, it is how much and of what quality is needed to ensure that a given water source's ecosystem is able to continue supplying us with the same amount and quality of water in the future. And to understand this we have to view the water source as a system from which people benefit, at a particular site, as well as downstream and upstream.

Most of those benefits are sustained by regulatory services and the ecological infrastructure that supports them. There services regulate water quality and quantity and, therefore, the provision of water for us to use. So, how do these regulating services actually work? How does an ecosystem regulate the flow of water?

The best way to understand this is to follow the paths taken by water in the water cycle (see Figure below).

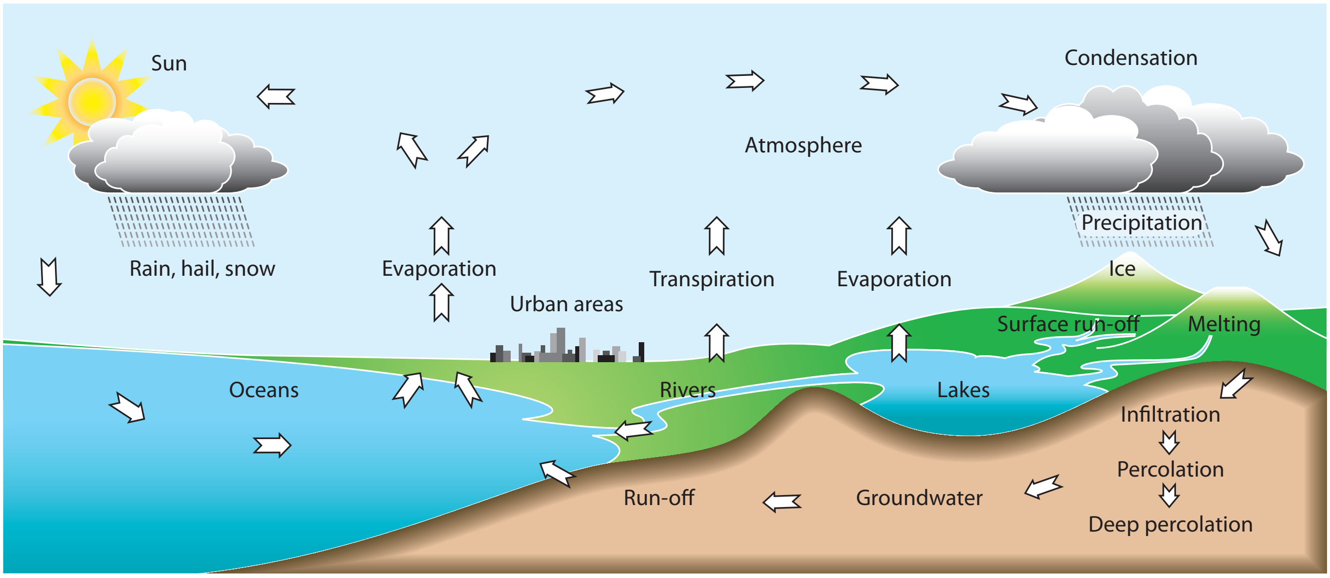
The regulation of flows is often seen as applying only to the movements of water from rainfall into rivers, often via groundwater, and back into the oceans. However, the vegetation that covers most of the land plays critical roles in the composition of the gases in the atmosphere (together with the plankton in the ocean) and the energy balance of the planet – how much sunlight is absorbed and reflected. Transpiration by plants also plays a critical role because water evaporation absorbs a lot of energy.

Vegetation and animals also protect, stabilise and maintain the porousness of soils which is important because the porousness determines how much rainfall infiltrates into, and moves through, the soil and how much runs off over the surface. Land degradation generally reduces vegetation cover, exposing the soil and reducing its porousness, increasing the runoff and facilitating soil erosion. This creates negative feedbacks which lead to further degradation. The eroded soil lands-up in rivers and is carried downstream to fill-up dams and clog estuaries.

Well-managed vegetation typically maintains high infiltration rates which are important because this limits how much rain water flows rapidly overland to reach rivers and how much filters more slowly through to sustain flows during dry seasons and droughts. When lots of water flows overland the rivers tend to produce floods which can do considerable damage.

Land degradation therefore tends to increase the risk of flooding downstream. At the same time, the reduced infiltration leaves less water for plant growth, which can reduce fodder and crop production in dry years and droughts. The reduced dry season

The water cycle.



Courtesy David le Maitre

Water quality regulation is a vital and critical service, especially for the poor who often live in highly degraded environments.

flows can also adversely affect aquatic ecosystems, reducing their biodiversity and resilience and compounding the effects of the higher sediment loads entering the river systems.

These impacts are important because the aquatic organisms, including those that live in or on the sediments in the river bed and banks or on the rock surfaces, play a critical role in regulating water quality. As rivers flow from their mountain sources to the sea, the rates of flow and river channel form changes. Headwater streams typically are narrow, slope steeply and flow rapidly over rock, boulder and pebble beds and have narrow strips of riverine vegetation.

In the more gently sloping middle slopes they tend to broaden, flow more slowly, accumulate more sediments, widen and have wider floodplains. One the lower slopes and plains the flow slows even more, sediments accumulate to form the entire river bed, its course meanders and it tends to form multiple channels. On the highveld even headwater streams are gently sloping.

All the way down a river there is continual interchange of water between the water on the and in its bed and banks and water is also taken up by the riverine, floodplain and wetland vegetation. This interchange is very important because it brings the substances in the water into close contact with the organisms living in or on the sediments and rocks and the roots of the riverine and wetland plants. The organisms and plant roots absorb these substances.

The microorganisms, in particular, are very effective at this and also at taking up chemical pollutants and breaking them down to harmless chemical compounds. The types of sediments also play a role. Sediments with a high proportion of clays can absorb large quantities of phosphorus because it binds chemically to the clay minerals. The coarse white sands of the Cape rivers are less effective as the clay content is low but can transmit larger volumes of water.

Research has found that wetland and river ecosystems can even cope with, and purify acid main drainage. As water moves through these sediments it loses oxygen which is important because different kinds of organisms, particularly bacteria, thrive under these low or no oxygen conditions and are capable of absorbing and breaking down different kinds of pollutants. As rivers change from their headwaters to the estuary they can offer different kinds and amounts of water quality regulation (i.e. purification) services.

Healthy rivers and wetlands, therefore, play a vital, unnoticed and essentially invisible role in delivering water we can safely use for drinking, washing, irrigating crops, processing minerals from mines. It would cost a lot of money to replace these services. If water purification plants had to be built and maintained to achieve the same levels of water purification the costs would run to billions of Rand – huge amounts of money we could otherwise have spent on houses, schools, or creating jobs.

We have also physically modified many rivers by converting them into canals to get rid of the stormwater, often to protect buildings and other structures that should never have been built there in the first place. Far more damaging and pervasive though are the habitual, and illegal, bulldozing of river channels and the clearing of riverine and floodplain vegetation so that fields and other things can go right up to the river bank.

There is a lot of research which clearly shows that those strips of riverine vegetation play a critical role in buffering the riverine ecosystems

Courtesy David le Maitre

Eroded soil lands-up in rivers and is carried downstream. This river should be clear, but has a high sediment load due to erosion.

from the effects of activities on the adjacent land. Even a 30 m strip can make a substantial difference. Commercial forestry companies have adopted environmental guidelines which do not allow them to plant their trees up to the edge of the river or wetland. The distance is determined by inspecting the soil for signs of seasonal or permanent water logging. The rationale is that trees planted close to wetlands or rivers use far more water than those away from wet or waterlogged soils. But there is another important benefit which is that tree planting and felling activities are also kept out of these areas with their fragile soils.

Unfortunately, the same cannot be said of agricultural fields which often extend well into floodplains and livestock which are allowed free access to these areas. They do so despite regulations which state that permission is required for cultivation within 10 m of the flood area of a water course, in the floodplain or in wetlands.

The effects of unwise cultivation are exacerbated by the intensive use of fertilisers, pesticides and herbicides in the cultivated land. Some of these substances end up directly in the river or are transported there when rainwater runs over the surface. When the cultivated lands are irrigated, some of the irrigation and rainwater is not used by the crop and filters down into the soil to end up in the groundwater. The groundwater then flows downslope until it discharges into a river as return flow.

The soils and soil organisms do absorb and break-down some of the substances *en route*, but some is transported with the groundwater and ends up in the rivers. The Green Drop initiative and its findings have highlighted the direct impact of discharges from dysfunctional wastewater treatment plants on water quality, both chemical and microbial. These discharges also have an indirect effect by exceeding the water quality regulation capacity of the riverine and wetland ecosystems. The same applies to other direct discharges of industrial wastes and outflows of acid mine water.

More subtle but no less significant damage is caused by acid mine drainage via groundwater. There are many routes by which pollutants enter our rivers and wetlands and most are not easily seen. The variety of substances is huge and we know very little about how they mix when in the water. The organisms living in river and wetland ecosystems can also reduce the quantities of infectious organisms in the water. Some, like the *Escherichia coli* bacterium are quickly neutralised because they do not live for long out of the body but others are attacked and controlled.

Thus the abundance of many disease causing and transmitting organisms is regulated by other organisms in ecosystems. The operation of these regulatory systems is not well understood but they are believed to play a critical role in limiting disease outbreaks and protecting human health. All this should make it very clear that water quality regulation is a vital and critical service, especially for the poor who often live in highly degraded environments and cannot afford the protective measures available to the wealthy.

Should we be surprised by the poor state of the water in our rivers and wetlands? I would argue that we should actually be surprised by the fact that these ecosystems continue to deliver services despite all we have done to degrade them, either deliberately or through neglect. Even ones that seem to be damaged beyond repair have surprised us by their ability to recover when given even half a chance. We need to acknowledge the wisdom of those who recognised the immense value of these ecosystem services and included the ecological reserve in water policies and legislation to protect them for us. Each of us needs to do our best to ensure that our wetlands and rivers are respected and protected. ❑

SOURCES OF USEFUL INFORMATION

- Department of Water Affairs policy documents: http://www.dwaf.gov.za/Documents/default.aspx?type=policy
- The African Water Page (http://www.africanwater.org/) has many useful links including copies of the 1996 Fundamental principles of the Water Law and the 1997 Water Policy White Paper
- MacKay, H. 2000. Moving Towards Sustainability: The ecological Reserve and its role in implementation of South Africa's water policy www.africanwater.org/ecosystems_and_water_law.PDF
- Ecosystem services: http://en.wikipedia.org/wiki/Ecosystem_services
- Folke et al. 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society 14(2): 32. (http://www.ecologyandsociety.org/vol14/iss2/art32/)
- Van Wyk, E, Breen, CM, Roux, DJ, Rogers, KH, Sherwill, T and van Wilgen, BW (2006) The Ecological Reserve: Towards a common understanding for river management in South Africa. *Water SA* **32**, 403-409.

Courtesy David le Maitre

Cows drinking from a river affected by dysfunctional wastewater treatment.