

LET'S FIX OUR RIVERS!

A COMPANION SERIES TO THE WRC COMPREHENSIVE
MANUAL FOR RIVER REHABILITATION IN SOUTH AFRICA

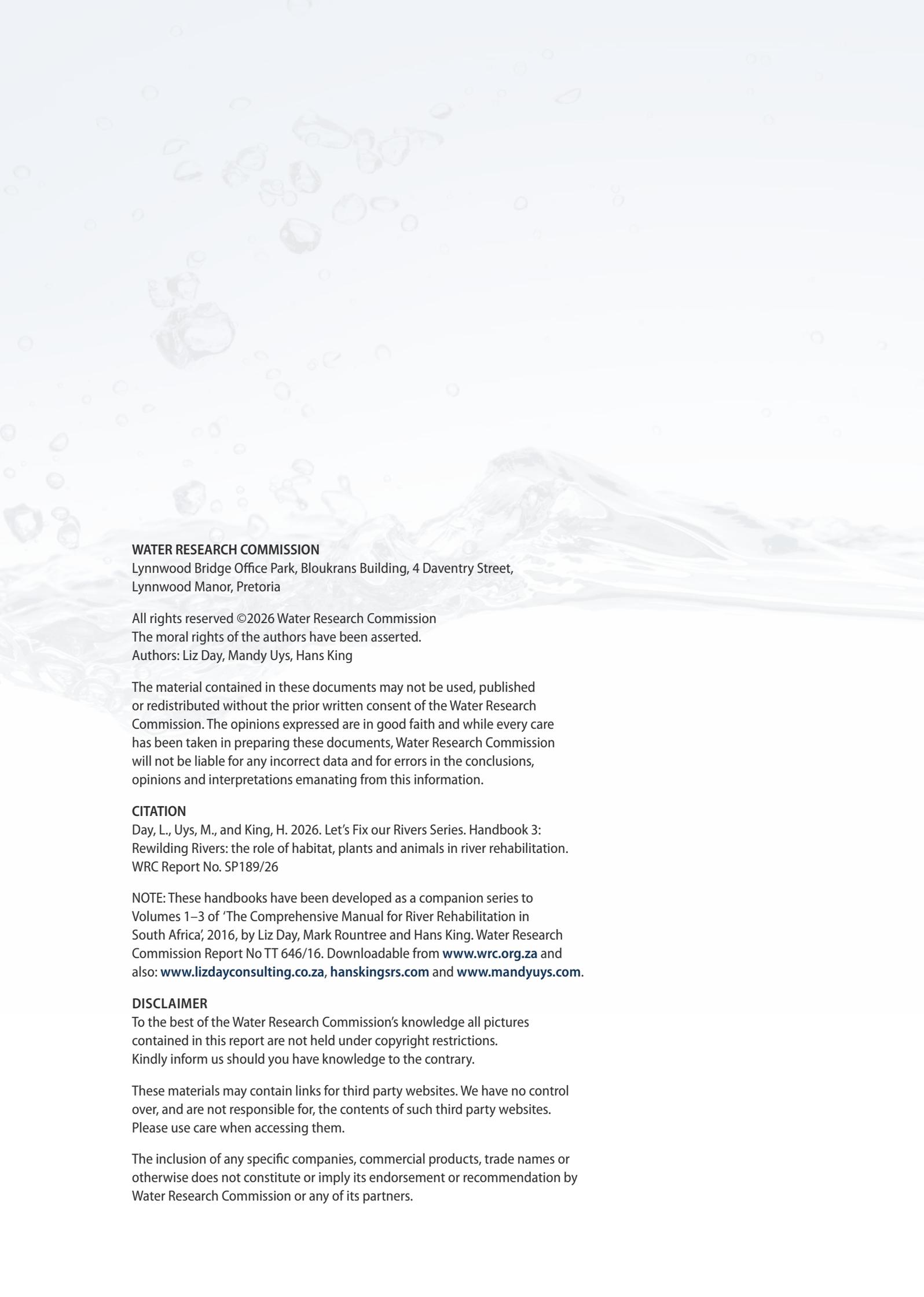
HANDBOOK

03



RE-WILDING RIVERS – THE ROLE OF HABITAT, PLANTS AND ANIMALS IN RIVER REHABILITATION

Liz Day • Mandy Uys • Hans King

A background image of water splashing, with numerous bubbles and droplets of varying sizes scattered across the upper and middle portions of the page. The water appears to be moving from the right side towards the left, creating a dynamic, energetic feel.

WATER RESEARCH COMMISSION

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This handbook explains the importance of habitat and biota in healthy rivers, and provides practical guidance for the improvement or creation of habitat, and the reinstatement of biota, in a river rehabilitation project.



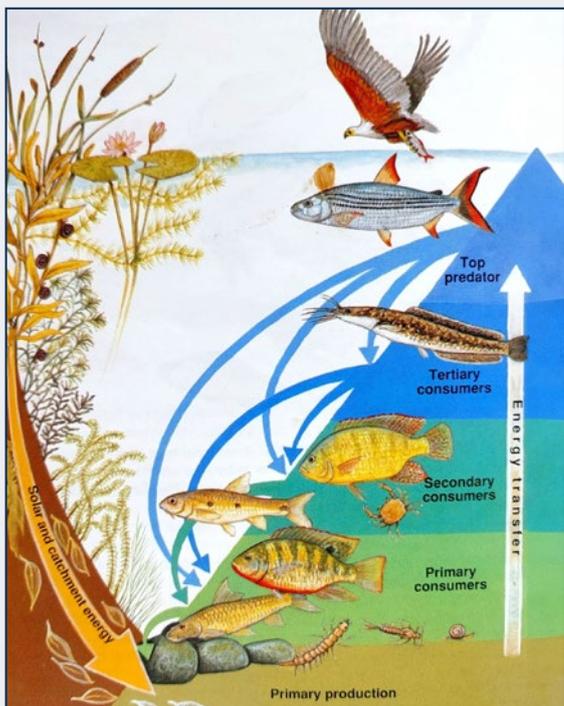
HABITAT AND BIOTA IN HEALTHY RIVER ECOSYSTEMS

A healthy river provides habitat for the animals and plants (biota) that live in it. The biota are adapted to this environment, and different species play different roles in keeping the system and its processes in a dynamic balance. The species composition of the community in a river changes with river zonation (e.g. mountain stream, foothill and lowland river zones).

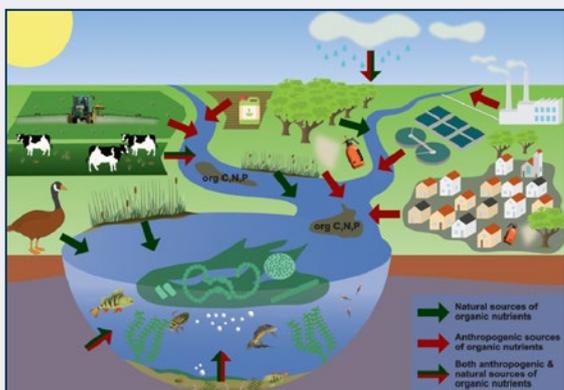
When the physico-chemical template of the river is healthy and communities of indigenous biota are intact, the biodiversity, balance and resilience of the system are intact. The processes that keep the ecosystem functioning healthily can continue, enabling the provision of goods and services, and often contributing to human livelihoods.

Indigenous riverine biota are part of a complex and delicately balanced food web. Energy enters the system from the sun. Organic nutrients (carbon, nitrogen, phosphorus) enter the system from various sources (see graphic left). One form of processing of these nutrients is via uptake by instream, marginal and riparian (river bank) plants and phytoplankton (algae). These serve as **producers**, providing a food source for other biota, as well as habitat and shelter, surfaces for attachment of eggs and larvae, and bank stabilisation. Indigenous invertebrates and fish provide a 'cleaning service' for this organic matter. These are **primary consumers** and include insects, snails and some fish species (e.g. labeos and some tilapia). They consume producers (plants). For example, invertebrate 'grazers' feed on algae; 'shredders' break up coarse leaf-fall into finer organic matter; and 'collector-gatherers' collect and ingest this from the stream bottom. **Secondary consumers** feed on primary consumers and producers, and include predatory invertebrates, amphibians, birds and fish. These, in turn, are the diet of the **tertiary consumers**, preyed upon by the **top predators** (graphic top left). This complex food web enables nutrient processing and carbon cycling to occur along the length of a free-flowing river.

If even one element of the system is modified, reduced or lost, the balance of the system, and its ability to self-maintain, will be compromised.



A simplified graphic of the elements of an aquatic food web, and the roles of sunlight, plants, microscopic biota, invertebrates and fish in creating a self-maintaining river system. *Graphic courtesy of JLB Institute of Ichthyology (From Skelton 2023, see Field Guides page 19)*



A graphic illustrating the natural and non-natural (anthropogenic) sources of organic nutrients to the river system. If nutrient sources are excessive, the river ecosystem changes (see handbook 7). *Graphic: from Reinl et al. 2022.*



FOR FURTHER DETAIL:

Refer to the WRC River Rehabilitation Manual, Volume 1, Chapter 2.

THE ROLE OF HABITAT IN RIVER HEALTH



The word habitat comes from the Latin *habitare* which means 'to live or dwell'. Habitat includes all the elements that create a suitable living space for biota. The quality of the habitat determines which animals or plants survive and/or thrive in a river and its environs. For example, a concrete canal provides very poor quality habitat, with no refuge from floods or predators, and very limited biota (possibly algae). When habitat is healthy and diverse, the biotic community reflects this. The type of natural habitat that is found at a river site varies, depending on the locality of the site and the river zone it is in [SEE HANDBOOK 2](#).

There are many dimensions to habitat. 'Biophysical' habitat includes instream and riparian plants and natural substrate elements in the channel, from bedrock to cobbles and gravel, as shown in the graphic below. 'Hydraulic' habitat includes the dimensions of flow and depth. The depth of water over habitat, and the state of flow, can determine whether or not certain species can live there. Water chemistry / water quality is another essential element of habitat, being critical to the survival of biota immersed in or otherwise reliant on water.

Instream habitat is found in the channel and ranges from bedrock to boulders, rocks, cobbles, and stones (in or out of the current); sand, gravel, mud; floating, emergent or submerged aquatic vegetation; and algae. **Marginal habitat** includes the plants and overhanging grasses on the edge of the channel, some of which are rooted in the water. **Riparian habitat** includes the plants, shrubs and trees on the banks and floodplain, which have varying degrees of dependence on channel and floodplain water. Depending on its quality, riparian habitat along a river can provide a corridor for the safe movement of birds, reptiles, amphibians and small mammals along the river bank. This corridor also has the function of buffering (protecting) the river system from some of the negative effects of human activities. It is very important in otherwise ecologically sterile areas such as urban and agricultural areas, that provide limited options for ecological connectivity along a river.



A conceptual South African scene showing a natural river channel with assumed good water quality and some of the main habitat elements typical to a middle-reach river system. Gravels and sands would typically occur between the larger habitat elements and at the edge of the river in the still water.

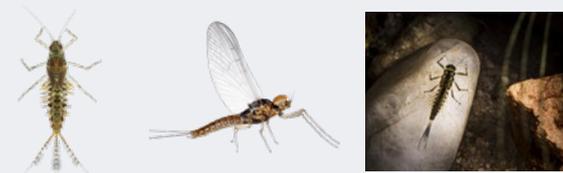


AQUATIC MACROINVERTEBRATES: THE CLEAN-UP CREW

SOME OF THE COMMON 'BUGS' OF RIVERS



L-R: Oligochaete worm, hydracarinid (water mite) and gastropod snail. *Images: Christian Fry*



L-R: Baetid mayfly nymph & adult. *Images: Christian Fry*
Baetid nymph in its riverine habitat. *Image: Jeremy Shelton*



L-R: Aeshnid dragonfly larva & terrestrial adult (different genera). *Images: Christian Fry*



L-R: Dytiscid (diving) and gyrenid (whirligig) beetle larvae and adults. All are aquatic life-forms. *Images: Christian Fry*



L-R: Gerrid (water strider) and nepid (water scorpion) true bugs, muscid (housefly) aquatic larva and terrestrial adult. *Images: Christian Fry*

Aquatic macroinvertebrates are informally referred to as the river 'bugs'. They are animals with hard exoskeletons and no spines, that live for part or the whole of their lives in water. They include freshwater sponges, water mites, hydras, flatworms, earthworms, leeches, nematodes, many insect orders molluscs and crustaceans. There are scores of indigenous aquatic macroinvertebrate families and hundreds of species present in healthy rivers of South Africa. A healthy, diverse invertebrate faunal community is the 'clean-up crew' for a river, critical to nutrient processing and healthy ecosystem function (see page 4).

Managing threats to invertebrates

The major threats to invertebrate habitat and biota are alien invasive biota, water quality deterioration, changes in habitat, and over-abstraction or other changes to flow regime (see page 8). Reportedly at least 75 alien freshwater invertebrate species have become naturalised in South Africa. These include insects, crustaceans and protozoans. While in most cases their invasiveness has not yet been established, many are considered a threat to habitat, fish and invertebrates. The redclaw crayfish (native to Australia), is listed as a Category 1B alien invasive species, which must be controlled and wherever possible, removed and destroyed. This species has already spread rapidly through the rivers of the Kruger National Park, and has to be actively managed. It can grow to 40 cm and 2.5 kg, and also carries parasites. Both the crayfish and its parasites are considered a threat to indigenous freshwater biota.

Ongoing monitoring of the invertebrates of river systems using the South African Scoring System (SASS5) and the popular mini-SASS citizen science tool, provides up-to-date information about riverine invertebrates. The data are also used to infer water quality. This information is publicly available on the Freshwater Biodiversity Information System (FBIS, see Resources page 27). While there is no known programme focussed on reinstatement of threatened indigenous aquatic invertebrates, habitat rehabilitation projects have been shown to yield benefits. For example, the clearing of invasive alien trees (IATs) – which shade out the habitat of sun-loving indigenous larvae such as dragonflies has yielded benefits for biodiversity recovery in general, although the project focus was on these dragonfly larvae. This illustrates the importance of viewing rehabilitation at the level of the system rather than the species. If the right habitat is available, biota often establish on their own.

INDIGENOUS FRESHWATER FISH UNDER THREAT



Freshwater fish are considered the country's most threatened group of animal species. Most recent literature indicates that of 105 formally described indigenous species, 25 are classified as threatened (Vulnerable, Endangered, or Critically Endangered) by the International Union for the Conservation of Nature (IUCN) in their Red List of Threatened Species. Of further concern is that, of the 40 endemic species (those only found in particular geographic regions), two-thirds are threatened.

The most serious threats to freshwater fish are habitat destruction and shrinkage, climate change, poor land-use management, over-abstraction of water, changes in flow regimes, poor water quality, and predation by alien invasive fish such as bass, carp and trout.

Rehabilitation and conservation of fish

In the rehabilitation of rivers for fish, the focus is on indigenous and endemic species, and most commonly those that are threatened. This is complex. It is necessary to understand the requirements of the fish species at each of its different life stages (in terms of flow velocity and depth, substrate type, refugia, etc.). It is also critical to understand what has caused the decline in a fish population. For this reason, when wanting to rewild fish, it is essential to engage with a specialist fish ecologist with a good knowledge of the species concerned and some experience in their rehabilitation.

There are a number of initiatives underway to conserve or rewild threatened freshwater fish species and to restore the rivers they inhabit. These include the identification of Fish Sanctuary Areas or FSAs (catchments in which threatened species are found) throughout the country; control of alien fish during strategic seasons (pre-spawning) e.g. by catching and elimination; removal of migration barriers; establishment of physical barriers to prevent the upstream movement of alien fish into indigenous fish habitats; and projects to enhance numbers of indigenous species through special breeding programmes.



FOR FURTHER DETAIL:

Refer to 'Resources' on page 27; the WRC River Rehabilitation Manual, Volume 2, Chapter 7, and Handbook 9.



The IUCN lists Breede River redbfin (*Pseudobarbus burchelli*) as Critically Endangered, mainly due to predation from alien fish species, such as largemouth bass and banded tilapia (which is indigenous in other systems).



Berg-Breede witvis (*Cheilobarbus capensis*)



Largemouth bass (*Micropterus salmoides*)



Nile tilapia (*Oreochromis niloticus*)



ADDRESSING THE MAJOR THREATS TO HABITAT AND BIOTA IN SOUTH AFRICAN RIVERS

COMMON INVASIVE ALIEN SPECIES IN SOUTH AFRICAN RIVERS



Common carp (*Cyprinus carpio*) is considered one of the world's worst invasive fish species. It was introduced to South Africa in the 18th century as an ornamental fish, but is now found in almost all of the country's rivers and impoundments.



Water hyacinth (*Pontederia crassipes*)



Red-claw crayfish (*Cherax quadrinatus*)

Invasive biota

Intentional and unwitting species introductions have resulted in biological invasions of our rivers. Invasive aliens include fish, macroinvertebrates, floating aquatic vegetation, marginal vegetation and tree species in the riparian zone. These are among the greatest threats to habitat and indigenous biota. Some biological invasions are managed through national, regional and non-government organisation (NGO) projects and programmes (see **Useful Resources page 27**), while others remain unchecked. Communities who want to conserve or rehabilitate riverine habitat for indigenous biota should start by building awareness of the indigenous and alien invasive species in their local catchments, and engage with existing programmes or get specialist advice on how to initiate their own.

Storage and abstraction

The need for water storage results in construction of dams and weirs. These alter the hydrology, sediment movement, habitat availability and quality, water quality, and upstream-downstream connectivity of a river. Direct abstraction of water by pumping from rivers can also alter the flow, particularly in drier months or droughts. Responsible river management requires the delivery and monitoring of Environmental Flows and the construction of fishways on any cross-channel structures which obstruct indigenous fish migration **SEE HANDBOOK 1**. Management of abstraction is in the hands of authorities, but land-owners should be vigilant in taking only their rightful allocation.



Dams



Direct abstraction



FOR FURTHER DETAIL:

Refer to the WRC River Rehabilitation Manual, Volume 2, Chapters 10 and 11.

Loss of floodplains and their wetlands

Too often, floods are seen as a problem on floodplains, rather than an ecosystem service. In urban and agricultural areas in particular, many floodplains and/or riparian areas have been cleared for planting of crops, development, or the provision of recreational spaces. Loss of riparian and floodplain areas is associated with loss of flood attenuation capacity, river shading, indigenous leaf-fall, bank stabilisation by roots, and natural riparian corridors. Infilling or drainage of floodplain wetlands has also resulted in the loss of these important ecosystems and their many natural functions, including their role as 'sponges' and filtration systems in the landscape. Recovery of functionality requires integrated planning, which could include reinstatement of riparian vegetation, rehabilitation of floodplain wetlands, and actions to ensure that flood flows can move unimpeded across floodplains. It is important to consult with specialist ecologists and hydrologists when considering changes to floodplains.

Channel modification, canalisation

Many rivers and floodplains have been straightened, realigned, canalised, excavated, built over, diverted or landscaped for the perceived benefit of flood management and human developments or agriculture on the floodplain. These interventions severely compromise instream, riparian and floodplain habitat and ecosystem function. Rehabilitation actions include 'daylighting' (opening up) of covered rivers, removal of concrete canals, reinstatement of instream and riparian habitat, realignment and naturalisation of channels, planting of indigenous riparian and floodplain species, and rehabilitation of floodplain wetlands (including addressing unlawful drainage canals). All of these interventions are complex and require specialist teams to assist. This is only possible where space permits.

Pollution

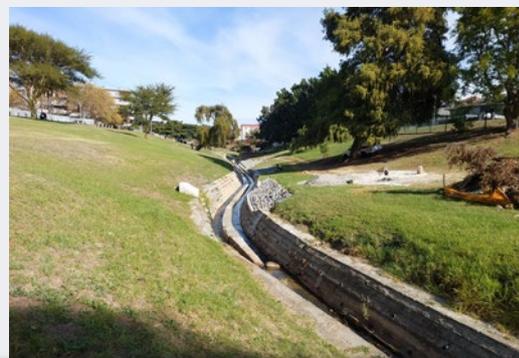
Industrial effluents, solid waste, acid mine drainage (AMD), sewage spills and litter/solid waste can have a devastating effect on riverine habitat and biota, and over time will reduce abundances or eliminate the more sensitive taxa in the system. Management of this situation is very difficult in a politically challenged environment and requires catchment-level interventions (e.g. rehabilitation projects, removal of solid waste at source; adequate sewage treatment). Effectiveness of measures also depends on political will and funding. More sensitive policy and regulation is worth arguing for.



Cleared floodplain



Berming of banks



Modified banks and lined channel (canalisation)



Point source pollution



10 PRINCIPLES FOR REHABILITATION OF HABITAT AND BIOTA

If you are wanting to reinstate habitat or biota in a section of a local river, it is important to recognise the multi-dimensional nature of the river and the complexity of the system you are trying to 'fix'. Any one action will result in a number of effects, which may not serve your purpose. Always consult with specialists who have some track record in rehabilitation, and keep an open engagement with relevant authorities and the local community.

- 1** Gather information about the river in its natural historic condition versus its present condition. This picture is built over time using sources including historic aerial imagery and biological survey data. This baseline will help you set goals for the habitat and fauna you envision restoring. Success is monitored against these goals. **SEE HANDBOOK 1**.
- 2** If you are focussing on reinstatement of biota, understand their biology and flow and habitat preferences. The focus of instream habitat rehabilitation is on ensuring that biota have sufficient appropriate habitat for all their life history stages. This requires the input of ecologists who have good knowledge of the focus species, as well as their preferences for water quality, flow depth and velocity, and physical habitat.
- 3** Work from the large-scale to the site-scale. Understand processes and historical changes at the catchment scale, and prioritise your local actions in the context of this bigger picture.
- 4** Understand the causes of habitat or water quality deterioration. For rehabilitation actions to have longevity, causes must be addressed as well as symptoms.
- 5** Aim to reinstate a more natural state. Be realistic though. Where the river has been so modified that it no longer resembles the natural system (e.g. a canal), provision of different habitat types may be more feasible. A river specialist should advise.
- 6** Aim to reinstate process, not just form. Rivers are dynamic and process-driven. The species that live in them also rely on natural diurnal/seasonal changes in flow, light and vegetation.
- 7** Aim to reconnect wherever possible. Re-establishing connectivity between the upper and lower river and ocean, and between the channel, riparian zone and floodplain is important. Ensuring fish passage for indigenous fish should be a consideration. There are different angles to this however, and specialists must be consulted. In some cases it is appropriate to install fishways on weirs or dams, or to decommission these structures entirely if redundant, to reinstate connectivity and indigenous fish passage. In other cases, where the objective is to keep alien fish out of areas populated with indigenous fish, it is possible to install barriers preventing alien intrusion (**see Resources page 27**).
- 8** Understand the natural physical and hydraulic habitat diversity in the river section you are working with. Increasing habitat diversity can include increasing hydraulic diversity (e.g. adding slow-flow areas, riffles, runs, pools if appropriate).
- 9** Set goals in the context of constraints and opportunities. Monitor your rehabilitation effectiveness against your goals, using extent of vegetation establishment (**see Maintenance page 26**) and citizen science tools like Mini SASS (**see Resources pg 27**).
- 10** Know what authorisations you need. Any interventions in a river can trigger a requirement for authorisations. A local Environmental Assessment Practitioner (EAP) will be able to advise.



FOR FURTHER DETAIL ON METHODS AND APPROACHES:

Refer to WRC River Rehabilitation Manual, Volumes 1 and 2; and to Handbooks 1 and 9.

PLANNING FOR PLANTING



Now you have an idea of the kinds of habitats that functional rivers need – **let's get started with some of the rehabilitation implementation.** The remainder of this handbook focusses on rehabilitation of river banks and riparian areas. **For guidelines about broad project planning** [SEE HANDBOOK 1](#).

Set realistic goals

Where a river would naturally have a robust, planted riparian zone, rehabilitation of river banks and riparian areas on both side of the river would be the ideal outcome. This is often more achievable in small rivers / streams than large rivers.

Make sure your objectives are clear and achievable

Up-front, it is important to define objectives and understand constraints.

Objectives must be practical. For instance, some rivers may need structural measures to address erosion. The design and placement of these should also be identified up-front, and an engineer consulted to check the feasibility of such measures. (Note: It is also important to ensure that you get the correct legal permissions).

Constraints include budget, land ownership, available space, existing development, river condition and competing land uses (such as space for walking, seating, parking and other activities along riverine areas).

Understand the river profile

Steep, eroded banks limit the scope for replanting. Plants usually establish best at the base (or toe) of the river bank, where they have more access to water and can reduce channel erosion. Note that planting of the channel edge is a challenge in deeply incised rivers. In high flows, the water rises high up the bank and low-growing plants can be drowned, while plants on the top of the bank remain mainly dry, with their roots well above the water table.

Consider bank reshaping

Firstly, do you need to reshape the banks? If so, consider re-shaping river banks to achieve flatter grades. Flatter banks (1:3 or preferably flatter) provide much better planting habitat than steep banks and are less prone to erosion. You can also create a diversity of planting zones, and provide quality riparian habitat.

How to re-shape banks

The best results are often achieved using machinery such as excavators, run by skilled operators. These allow bank shaping at scale. Small projects can use manual labour. In all projects, the aim should be to create as natural a product as possible, with varying slopes and no hard lines or edges. Any machine works require careful supervision to prevent damage or pollution.



Effective rehabilitation of both sides of a small perennial river.



Gently graded river banks, prior to re-planting.



Steep banks can provide important nesting habitat for birds, such as kingfishers and bee eaters.



REMEMBER:

Earthworks and infrastructure such as gabion mattresses may need authorisation through the National Environmental Management Act (NEMA) and /or the National Water Act (NWA). **Refer to the WRC River Rehabilitation Manual, Volume 1, Appendix 1)** and always consult an Environmental Assessment Practitioner (EAP) if you are not sure.



CLEARING THE SLATE (Invasive alien vegetation removal)



Dense wattle invasion along the Langtou River, promoting channel incision.

Removing alien vegetation is an important preparation for establishing more natural riverine plants. Plants listed as invasive aliens must be removed. These are mainly tree and shrub species. Where appropriate, problematic invasive indigenous species should also be managed. **See the WRC River Rehabilitation Manual, Volume 2, Chapter 1 for currently listed species.**

Alien clearing practicalities and maintenance

A risk of rehabilitation on one side of an alien-infested river only, is that remaining stands of dense aliens on the other side of a river may promote erosion of the cleared and rehabilitated bank during floods. Liaise with neighbouring landowners around shared alien clearing if this is the situation.

Alien plant clearing needs to be followed up by regular maintenance, removing seedlings as they appear, to prevent rehabilitated river banks being lost to re-invasion.

Where to clear?

Alien clearing and removal can be expensive. Ring-barking trees or felling trees to stump level and painting the stumps with appropriate herbicides can be cheaper ways of reducing alien impacts. Note that herbicides containing glyphosates must be avoided, and any product used must be safe for use in and near water bodies. Leaving stumps and root masses in place also reduces bank disturbance and erosion.

However, where alien trees are in the flow channel and are promoting erosion by deflecting flows and narrowing the channel, any obstructing parts of the tree that are likely to snag debris should usually be removed.

Evaluate these situations carefully, and get specialist advice.



REMEMBER: The chipped wood from alien vegetation can be useful for lining pathways, and logs can create path edging or be used in bridges or other infrastructure. Examples of this are Tsitsikamma National Park forest walkways and Umhlanga Rocks dune forest walkway.



Ring-barked gum trees along a river channel

Dealing with non-woody aliens

Alien grasses and creepers do not pose the risks to river flows that many alien trees do. However, they can out-compete and smother indigenous plants, especially if newly planted.

In many cases, it is just not practical to eliminate such pests, especially if there are upstream sources of seeds or plants. Short-term removal of them in patches from areas earmarked for rehabilitation can allow indigenous plants time at least to establish, and controlling the spread of these plants is an important **maintenance activity** (see page 26).



WARNING

The use of herbicides in and along watercourses can have dire consequences for aquatic biota. Herbicides containing glyphosates are particularly risky to non-target species, including humans (e.g. recreational river users). They should be used as a last resort only; kept well away from wetted wetlands and rivers; and should not be used during frog, fish or bird breeding season. The above said, careful herbicide application by qualified agents can be a useful intervention before planting. See the **WRC Rehabilitation Manual: Volume 2, Chapter 2** for further guidance

Invasive weeds along the wetted channel, often carried from upstream areas, can be a major impediment to establishing indigenous vegetation along the channel margins, as they snag on new plants, smothering them or pulling them out of the channel in high flows. Ongoing maintenance is critical to address this issue.

Working with upstream landowners to attempt river-scale eradication is an ideal outcome. This is possible in smaller river systems, with some invasive species (e.g. water hyacinth).



Check the **WRC River Rehabilitation Manual (Volume 1 Chapter 2)** for guidelines for removal of some common invasive plants, or ask local botanists, landscape architects, or landscapers for advice.



Kikuyu grass is a pervasive alien grass, that overgrows indigenous plants and thrives on watercourse margins. It is however difficult to eradicate.



Dense alien creepers and water hyacinth, smothering planted Palmiet along the wetted channel of the Berg River.



UNDERSTANDING RIVER ZONES, SEASONAL CHANGE AND FLOW REGIME IN PLANTING

When planning rehabilitation works that involve planting, it is essential to understand many aspects of the setting including the climate of the area; the river zone you are working in (mountain stream, foothill etc); the implications of seasonal change for plant establishment; and the river flow regime (high and low flow levels, velocities, seasonality etc).

Here are important questions to answer upfront:

1. Is the site in a summer or winter rainfall area?
2. What is the micro climate – is it on a south-facing or north-facing slope, and does this affect the plant species required? Is the site exposed to strong winds or deep shade ?
3. What river zone is it in? (headwaters/upper/source area, mountain stream, foothill, lower or lowland river) (see **The WRC River Rehabilitation Manual: Volume 1, Chapter 2.5, and Handbooks 1 and 2**). Different plant species often occur in different zones.
4. What areas of saturation or inundation (see **graphic on page 15**) are present or will be created ? Again, different plant species will occur in different conditions.



Choosing the planting season

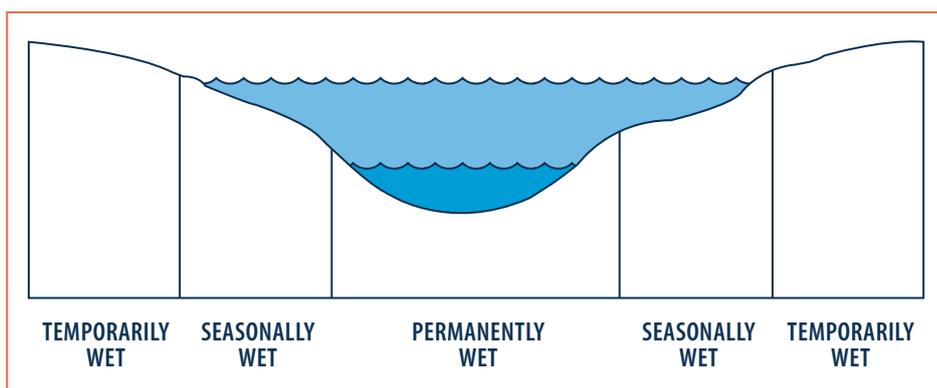
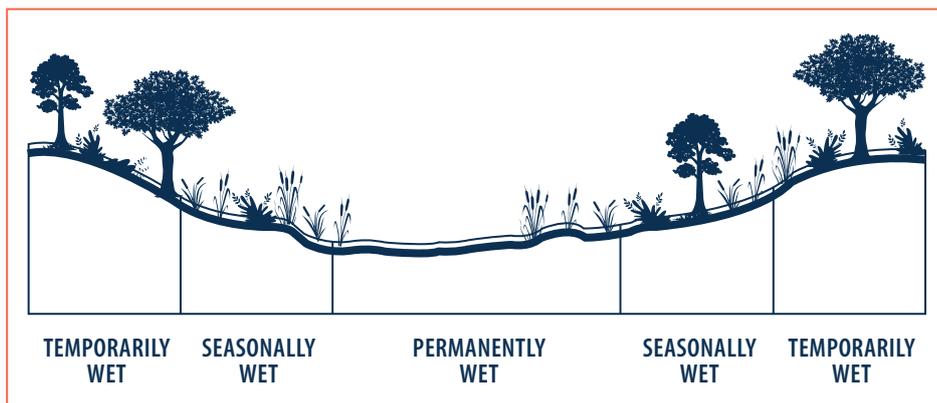
The river shown above is seasonally dry. This has implications for its rehabilitation and planting regime.

In South Africa, winter rainfall areas (southern Western Cape) have a warm temperate, Mediterranean-type climate with dry, warm, subtropical summers (normally above 10° C) and cool, wet winters. The optimum planting season in the winter rainfall areas is late autumn.

By contrast, summer rainfall areas have hot summers and cold winters, with frost in some parts. This climate is typical of most of the Gauteng and Limpopo Provinces, the Free State and Mpumalanga Highveld, North West and Northern Provinces and KwaZulu Natal. The optimum planting season in these areas is in spring and early summer – the beginning of the plant's growing season.

Considerations for planting in wet versus dry seasons

- Planting in the wet season (i.e. during the rainfall season) one runs the risk of the plants or seed being washed away by high river flows, and either erosion of, or deposition over, the young plants.
- Planting in the dry season one will need to irrigate the plants. This will add to costs and requires practical consideration about water sources and irrigation methods.



Understanding river zones is important for deciding what plant species to plant in different zones, and how many.

When you are unsure as to which river zones your site includes (perhaps because it has undergone change or you have re-shaped it), one approach is to include plants or seeds from different zones and see which ones are best suited to conditions. This can be a more costly approach than one where conditions are well understood.

Doing cross-sections through a river at different points will help you to understand the site and what to plant where.

OTHER IMPORTANT QUESTIONS TO HELP DECIDE ON SUITABLE PLANTS TO USE:

- What is the surrounding landuse? For example, if it is a residential area, safety requirements may dictate the use of low growing plants that do not provide visual screening or places to hide;
- What is the conservation status of the river? Is biodiversity of utmost importance? Will only genetic material from the river itself be allowed? Or is the river degraded and is improving its function of most importance?



PRACTICAL PLANT SELECTION AND SOURCING

Selecting plant species for use in river rehabilitation projects is an important part of project planning and these decisions will affect the final project outcome. The first step is to be clear about project objectives – is the aim to **restore biodiversity** and ecological process, or is it to improve biodiversity where possible but mainly to **improve aspects of functionality** (e.g. address erosion and improve water quality) while adding to **amenity** (e.g. safe spaces for walking). Other objectives may include the improvement of the riverine environment for the mental and physical benefit of the local community, for increase of property values, or for conservation and education purposes.

General rules for plant selection

As a general rule, plant selection for river rehabilitation projects should focus on:

- Locally indigenous species that occur naturally on river banks in the area;
- Species suitable to meet rehabilitation objectives;
- Species for which the availability, costs and maintenance requirements are in keeping with realistic overall cost and other project parameters;
- Species that will not invade the area and become problem dominants (affecting habitat diversity and resilience) and will not hybridise with locally indigenous species, or require excessive maintenance (e.g. thinning, cutting, burning).

Sourcing plants

An important question is: Where will plants be sourced from?

If plants are commercially sourced, material may be readily available and lead times will not be required to get the plants to site.

If plants need to be propagated from material on site, or to meet specific plant species lists, the material will need to be collected from seed or cuttings (in the spring months) or be directly transplanted (in winter when the plants are dormant), and this will have to be factored in to project scheduling.



J. VAN BILJON

Sorting and processing seeds for use on river rehabilitation projects in the Western Cape.



J. VAN BILJON

Quality control in seed collection and treatment

Pros and cons:

Using commercial plants (from nurseries):

- Readily available in a variety of sizes and quantities;

BUT

- Plant species are limited to the plants that are available – so there may not be a wide range of suitable species, and alternatives might need to be considered.

Using propagated plants:

- Allows specific desired plants to be propagated in the numbers required;
- Can limit the genetic material to that from the river catchment itself.

BUT

- There may be long lead times for planting (allow for at least 12 months and sometimes longer);
- Since plants are being purpose-grown for the project, to be ready at a certain time, delays in other aspects of the project (e.g. obtaining budgets or completing earthworks) may mean that plants get root-bound or are otherwise affected by delays;
- Propagating facilities such shade/hot houses, hot beds, automated irrigation and skilled labour are needed.

Plant size

Commercially sourced trees are usually available in bags between 4 and 1000 litres. Select as desired and based on budget. If planting in seasonally flooded areas, one should use plants in the 10–50 litre range, where plants are small enough to establish on slopes and large enough to withstand most seasonal high flows.

Shrubs, groundcovers and herbaceous plants are usually available in sizes ranging from ecotrays of 20 small plantlets to 20 litre plastic bags and plastic plots. Select plant size practically, based on access (how easy is it to get plants there) and budget (small plants are cheaper but may not survive as well as large ones). Remember that it is usually easier to carry trays of many smaller plants further than larger bags, and smaller plants are often easier to plant into steeper marginal areas.

Propagated plants are usually in trays and smaller bags – as they don't outgrow these in a 12 month growing span.



A list of some key plants suitable for streambank stabilisation is provided in the **WRC River Rehabilitation Manual, Volume 2, Chapter 12 (Appendix A–2)**.



Seed sorting and storage



Seed propagation

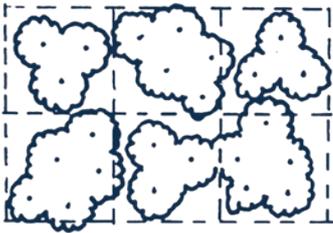
If genetic integrity is important in your catchment and river, you should consult a botanist as to what plant species to use, and use a horticulturalist to grow them up for you.



Herbaceous non woody plants, grasses and sedges should be planted in groups of three, at a density of 5/m².

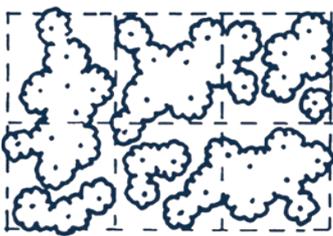
Groundcovers, low-growing and spreading plants should be planted at a density of between 5 and 7/m².

Veld sods, usually grasses, sedges, groundcovers, transplanted directly from adjacent areas with clumps of soil around roots, should be planted at densities of 3–5/m².



PLANTING LAYOUTS FOR:

- SMALL SHRUBS
- HERBACEOUS NON-WOODY PLANTS, GRASSES AND SEDGES
- VELD SODS



GROUND COVER DENSITIES

PLANT DENSITY AND LAYOUT

Now you know what species you need, it's time to think about where to plant them. Here it is best to call upon the services of a registered Landscape Architect or Botanist, to provide a Plant Species Plan which incorporates species, planting and maintenance specifications. The following guidelines (provided in more detail in the **WRC River Rehabilitation Manual, Volume 2, Chapter 12**).

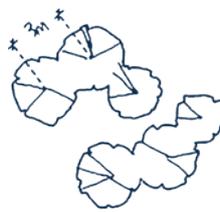
Trees

Where tree planting is appropriate and suitable, trees should be planted randomly or staggered, with gaps of between 3 to 10 m between stems, depending on the size of the trees. They should not be planted in straight lines, and should not be planted where they will block secondary channels or floodplains.

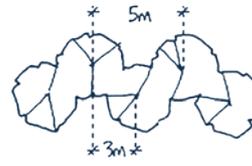


AS A RULE OF THUMB:

Plant trees and shrubs in small groups, not rows, and use small groups of the same species, rather than isolated specimens.



RANDOM

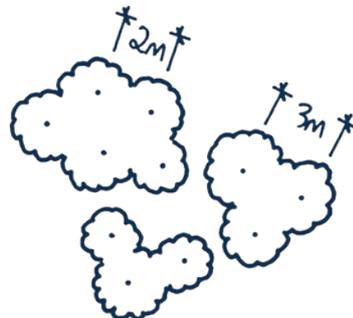


STAGGERED

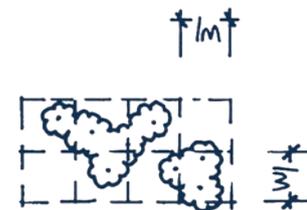


STRAIGHT LINE

TREE PLANTING CONFIGURATION OPTIONS



1 LARGE SHRUBS



2 MEDIUM SHRUBS

SHRUB PLANTING CONFIGURATION OPTIONS

Shrubs

1. Large shrubs that will grow up to 3 meters in height and spread should be planted in groups at 2 or 3 meter centres;
2. Medium shrubs that will grow up to 1.5 meters in height and spread should be planted in groups of 3 to 5 at a density of 1 or 2 per m²;
3. Small shrubs that grow up to about 750 mm in height and spread should be planted in groups of 3 to 5 (or more) per m².

Achieving a natural look and function

Ideally, river rehabilitation projects should seek to re-create, as far as possible, a natural assemblage of plants that emulates natural conditions and creates habitat and/or cover or shelter for the movement of animals along the river corridor. This approach can however be at odds with landscape designs that seek to create attractive park-scapes at the expense of habitat quality. Where river habitat rehabilitation is the main project objective, choosing ecologists, landscape architects and landscapers with rehabilitation expertise is crucial to success.



Early-phase river rehabilitation using naturalised mixed planting methods.



Planting with focus on amenity and aesthetics, resulting in reduced natural cover and planting, but still providing quality aquatic habitat in places.

HYDROSEED AS AN OPTION?

Hydroseed is a slurry of mulch, seed (usually grass species), soil amendments and water that is sprayed over a prepared surface using specialised equipment. This technique is often used when large disturbed areas need to be planted, and time or budget are constrained. Although some seed mixes may include indigenous plants, they are usually grasses and provide low habitat quality but fast cover.



See the WRC River Rehabilitation Manual, Volume 2, Chapter 12 for guidelines for path and lighting installations along rivers.



SOIL PREPARATION AND IRRIGATION



Preparing the area to receive the plants is an important part of the planting phase.

It includes three main steps.

STEP 1 Excavating the plant hole

As a rule, plants should be planted into a square hole that is twice their volume.

STEP 2 Preparing the soil

- Use soil excavated from the planting hole in the soil mix, so long as it is free of solid waste and alien seeds;
- If topsoil or compost are imported, they must also be free of weeds and alien seeds;
- In most cases the use of fertilizers is not recommended in any riparian or riverine area, as they add nutrients that are likely to create water quality problems or alter natural plant communities.

STEP 3 Planting the plants

- Backfill the hole to half its depth with the prepared soil mix;
- Remove the plant from its container and place in the middle of the planting hole;
- The final level of the soil around the plant must be at the same height as the top of the hole. Mounding or a depression will lead to exposure of the roots or rotting, respectively;
- Backfill the hole and water the plant as required or as specified;
- If it is a tree, use a stake to stabilise it until its roots are established.

Filling in the gaps

In some situations, planting may be done in nodes created in disturbed or previously alien-infested areas, to improve habitat quality, enhance land-use and recreation, improve landscape design, provide cover and increase biodiversity. Localised clearing of grasses and weeds may be necessary around the planting holes, so that small plants are not smothered.

In smaller rivers, it may be easier to plant at high densities, although the budget for planting should not be underestimated.

Irrigation

As a rule, irrigating newly planted areas over the first two to five dry seasons is important, especially in winter rainfall areas, where the summers are hot and dry. The aim should be to irrigate enough to establish healthy planted areas, but not so much that plants come to depend on external water sources. Over time, irrigation should be gradually decreased. Irrigation can be costly and should be budgeted for up-front. Consider threats of theft and vandalism when selecting an irrigation method. Also consider water sources. Using the river as an irrigation source might require permission from the Department of Water and Sanitation (DWS), although some low volumes are permissible if not for commercial purposes. **See the WRC River Rehabilitation Manual Volume 1, Appendix 1 for some legal considerations, or consult a specialist.**

Irrigation water quality is also important. If the available water supply is polluted, or too salty, or too nutrient-enriched for the vegetation you wish to establish, the plants will not thrive.



Erosion in this river was first stabilised with gabion weirs (see Handbook 4) and then the banks were graded and planted by the homeowners association.



Indigenous planting on one side of the river.



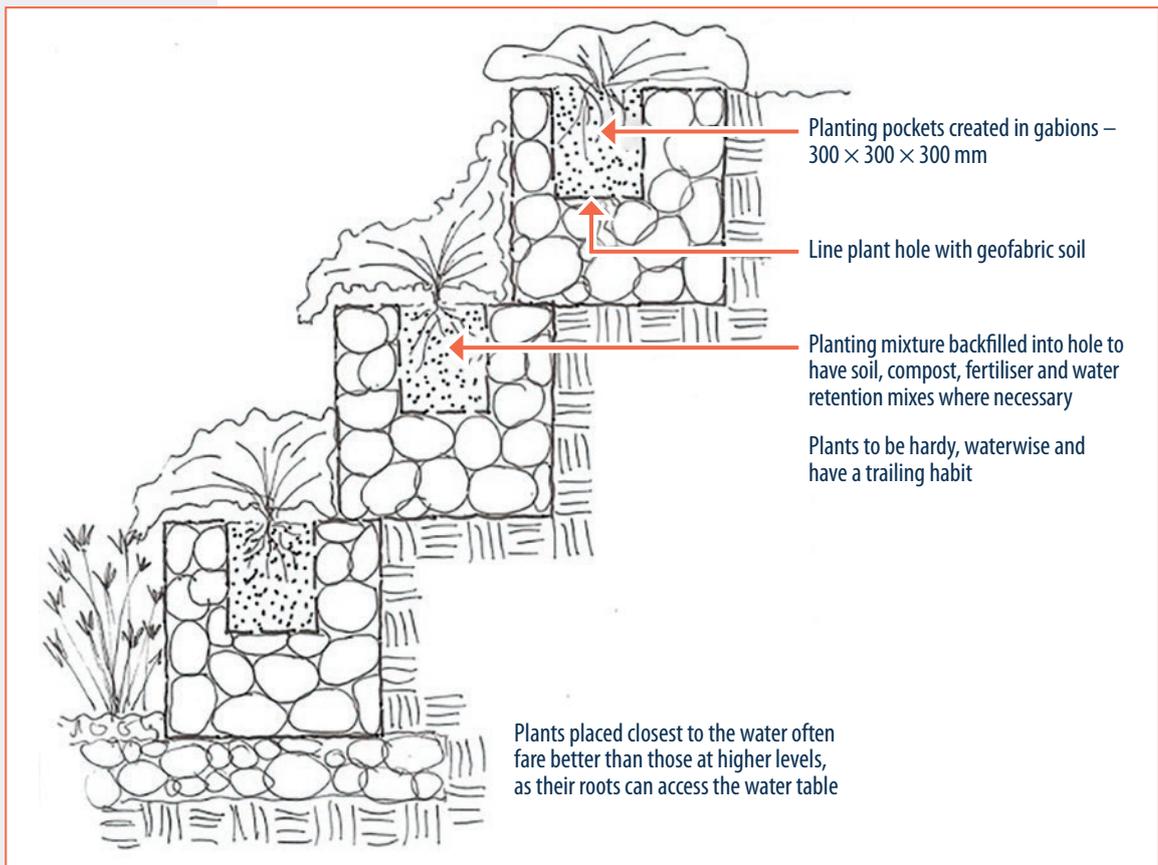
PLANTING INTO CANALS AND OTHER ARTIFICIAL STRUCTURES

Canal removal and /or reshaping of river banks to allow wide riparian planting is often simply not realistic, particularly in urban areas. Even where the river includes hardened engineered structures, there are still ways of improving habitat quality; attenuating flow velocities; assisting with cooling; and creating a greener, more aesthetically appealing space.

Gabions, comprising rock-packed wire mesh baskets, are often used for bank stabilisation, but they can be harsh and ecologically sterile.

Planting pockets can however be created within the gabion or reno mattress (a flat, thinner form of gabion). These need to be large enough for the receiving plant (twice the volume of the plant) and must be lined by a geofabric that will retain the soil mixture but allow water to drain through it. Water retention products and slow-release fertilizers should also be added to the planting mix.

An alternative approach is introducing wide (300 mm diameter) PVC pipes to the gabion basket, allowing plant roots (eventually) to access water through the basket. The pipes should be closed at the bottom (to retain soil) but fitted with cuts or slots near the base, to allow drainage.



Concrete block-type retaining walls (e.g. terraforce and loffelstein) provide opportunities for planting but these are often only small openings with little place for soil. This means that soil dries out quickly and exposes plants to both heat and drought. The plant species used must be able to survive the extreme hot and dry conditions as well as periodic inundation. The geofabric and drainage gravel/stone chips required at the back of these walls for drainage purposes, further compromise successful plant growth as they restrict root growth into the adjacent *in situ* soil.

Generally, the most effective riverine habitat change is created on the base of these walls, where plants have access to river water. Planting higher up the walls may at best simply improve aesthetics and greening, and planted gabions usually offer better ecological alternatives.

Block-type retaining walls afford poor quality bank habitat, although effective at erosion control



Canals provide ecologically sterile habitats, with little refuge for biota (particularly in times of strong flow), no shelter from predators and no easy access into or out of the canal.

Habitat quality can be improved by including planters (see photo on the right) or even reducing maintenance effort in some areas and allowing indigenous plants to establish on sediment.

The implications of both approaches for flooding must however be checked, as any plants will increase surface roughness, slow down flows and so increase water levels, particularly in floods. A specialist engineer should always be consulted.



Planting densities on a slope without gabion protection.



Introduction of a PVC pipe to the gabion basket, for planting purposes.



Early-establishment gabion planter blocks attached to one wall of a gabion-lined canal. Plants access the water table from below. The planter is 1 m wide, lined with geofabric and filled with topsoil.



EXAMPLES OF MATERIALS USED IN RIVER REHABILITATION

Gabion baskets, mattresses, sacks

USES

Gabions are commonly used in wetland and river rehabilitation in South Africa. They are used for erosion control (river beds and banks, wetlands); and to create: hydraulic structures (e.g. low-level weirs); mass-gravity retaining walls; and reinforced soil structures. Gabions play the dual role of stabilising banks and creating habitat as a result of the surface area provided by the rocks and interstitial spaces in the baskets. Gabions can also be set back from the river, allowing steep slopes to be managed and the intervening flat space to be planted. They should not be used where there is space for less intrusive stabilisation (e.g. as bank shaping and planting).



CONS:

Gabions can overstabilise and constrain natural channel dynamics (see photos right). Even weatherproofed gabions have a restricted lifespan (10–20y) after which they may need repair or replacement. They can prevent natural channel adjustments and limit floodplain connectivity.

INSTALLATIONS



Gabions including gabion groyne structures allow plant establishment in places along the Liesbeek River, Cape Town



Section of Baakens River, Gqeberha, over-stabilised with gabions.

Permeable pavers

USES

In using any of the many available types of permeable pavers and blocks, the aim is to provide stabilisation and encourage infiltration. Permeable pavers have generally been used in wetland rather than river rehabilitation, to facilitate planting into the wetland. Permeable blocks are often installed in a vertical or terraced format to stabilise areas around culverts and stormwater pipes next to rivers.



CONS:

Permeable pavers do not create good habitat for biota. On steep slopes, permeable blocks can collapse over time. **They are not recommended for river rehabilitation.**

INSTALLATIONS



Permeable pavers

Geofabric

USES

Geofabrics are available in many different materials and gauges for different applications and budgets. They are engineered materials used for sediment control and stabilisation. Generally, geofabrics are laid over cleared and landscaped surfaces (e.g. river banks), and may be stapled on to the underlying soil. Habitat is created by planting into gaps or matrices in the fabric. The geofabric provides erosion-protection while the plants establish. This facilitates long-term stabilisation.



CONS:

Geofabrics can move or be disturbed by events such as high flows. Once they are exposed, the surface below is destabilised and undercutting can occur.

EFFECTIVE INSTALLATIONS



Geofabric (hyson cells) covering a rehabilitated system, anchored with plants.



An eroded wetland is stabilised, and habitat created, by the combination of installing low gabion walls and geofabric. Planting was done into the geofabric cells which were first filled with gravel.

Rip-rap

USES

Rip-rap comprises rock or cement used to stabilise and protect lower-slope areas such as embankments, river channel edges, the toe of banks, and shorelines. Rip-rap generally involves the use of a combination of size classes of material. The rip-rap layer dissipates the energy of flowing water, and if natural rock is used it can create habitat. Geofabric may be stapled in beneath the rip-rap layer to protect underlying soils. Planting in to rip-rap can create a longer-term solution to stabilisation.



CONS:

The type of stone used determines the extent to which rip-rap creates habitat. If very large rocks are used, without infilling the gaps with soils, the area may be hot and dry, with poor quality habitat.

EFFECTIVE INSTALLATIONS



Berg River riprap – subsequently planted



DON'T FORGET ABOUT MAINTENANCE

It is easy to focus on the implementation phase of river bank rehabilitation – bank shaping, plant selection, planting ... but many river bank rehabilitation projects fail in the medium to long-term, because of lack of maintenance.

This can be because project implementers lose energy; there are inadequate budgets or human resources; no-one is assigned maintenance responsibilities; alien and indigenous vegetation invade; impacts occur upstream (e.g. solid waste accumulation, sedimentation, sewage overflows and nutrient loading). Recognising these risks and trying to build them into the rehabilitation project up-front is critically important.

Establishment phase maintenance

- Allow for at least 24 months maintenance post-planting;
- Maintenance should allow for watering, weeding, disease and pest control, pruning, irrigation and accessory maintenance, litter removal, clearing and plant replacement;
- The extent of the planted area will determine how often the maintenance visits must occur and the size of the team required. As a rule of thumb, the area should be inspected weekly for the first 12 months;
- All alien invasive species, including kikuyu grass, should be controlled. Where seedlings occur sparsely, they should be removed manually, so that they do not become more problematic larger specimens (see the WRC River Rehabilitation Manual, Volume 2, Chapter 2, for alien clearing guidelines).

Note that sites that were previously alien-invaded or that lie downstream or downwind of densely invaded areas may require intense ongoing clearing of alien seedlings in the early years, or rehabilitation interventions will have been in vain.

The establishment maintenance period can also be used to advantage if **phased planting** approaches are used. Phasing can allow for hardy pioneer species to be established initially and stabilise the soil, before introducing other plants that will add to biodiversity but may not be so useful for early phase soil stabilisation. Such additional planting can be carried out in an extended maintenance phase.

Measuring success

With the exception of desert and karoo regions, indigenous plant cover, after 12 months, should be 75% of the area and there should not be bare patches, excluding pathways, of more than 500 mm maximum dimension.

Ongoing maintenance

Rivers in urban and agricultural areas often lack natural disturbance drivers such as small floods, fires and grazing, wallowing, and trampling by large herbivores. Without these effects, rehabilitated rivers may slowly fill in with sediment or be overgrown by reeds and senescent (aged) woody plants. Management measures should allow for periodic, phased removal of woody vegetation; cutting of reeds; and careful removal of sediment as necessary. **SEE HANDBOOK 5 FOR LEGAL ISSUES**.



Post-implementation maintenance



In urban areas, solid waste removal is an ongoing maintenance requirement



Periodic sediment removal and thinning of plants is a requirement in this rehabilitated stream

ACKNOWLEDGEMENTS

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- Christian Fry and Jeremy Shelton for the use of their excellent photographs.
- Bruce Paxton and Dean Impson for their inputs on fish rehabilitation which are largely captured in the WRC River Rehabilitation Manual, Volume 2.
- Professor Paul Skelton and JLB Institute of Ichthyology for use of the graphic on page 4. Source: Guide to the Freshwater Fish of Southern Africa. 2023. By Paul Skelton. Struik Nature.
- Johan van Biljon (Green Intaba) for review of this handbook, for photographs, and for his wealth of practical experience from major long-term river rehabilitation projects.
- Megan Anderson for her original recommendations around riverine planting, which have been condensed in this booklet.

USEFUL RESOURCES

Freshwater Biodiversity Information System (FBIS): This is an online database that was launched by Dallas and Team (Freshwater Research Centre, Cape Town) to improve access to freshwater biodiversity data in South Africa. <https://freshwaterbiodiversity.org>. The User Manual is required, and is available on the website.

Fish conservation projects: There are a number of fish conservation projects on the Freshwater Research Centre website: <https://www.frca.org.za/resource-protection-and-conservation/>

MINI SASS: Teaching videos and repository for your citizen science mini SASS data. <https://minisass.org/>

National Biodiversity Assessment. 2018: The status of South Africa's ecosystems and biodiversity. Synthesis Report. South African National Biodiversity Institute, Pretoria

National Environmental Management: Biodiversity Act (NEMBA). Invasive alien species regulations and lists: <https://invasives.org.za/nemba-alien-and-invasive-species-regulations-and-lists/>

Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. By J.L. Nel, A. Driver, W.F. Strydom, A. Maherry, C. Petersen, L. Hill, D.J. Roux, S. Nienhaber, H. van Deventer, E. Swartz and L.B. Smith-Adao. **WRC Report No TT 500/11**

FIELD GUIDES

This is a limited list to get you started.

A FIELD GUIDE TO FRESHWATER MACROINVERTEBRATES OF SOUTHERN AFRICA. By C. Fry. 2021. Jacana Media.

AQUATIC INVERTEBRATES OF SOUTH AFRICAN RIVERS. FIELD GUIDE AND ILLUSTRATIONS. By A. Gerber and M.J.M. Gabriel. 2002. Institute for Water Quality Studies, Department of Water and Forestry (now DWS).

GUIDES TO THE FRESHWATER INVERTEBRATES OF SOUTHERN AFRICA. A Water Research Commission Series. Downloadable at <https://www.wrc.org.za>.

GUIDE TO THE FRESHWATER FISH OF SOUTHERN AFRICA. By P. Skelton. 2023. Struik Nature.

EASY IDENTIFICATION OF AQUATIC PLANTS. A GUIDE TO THE IDENTIFICATION OF WATER PLANTS IN AND AROUND

SOUTH AFRICAN IMPOUNDMENTS. By A. Gerber, C. Cilliers, C. van Ginkel, and R. Glen. 2004. Department of Water Affairs (now DWS). ISBN: 062135113X

CREDITS FOR OPEN-SOURCE IMAGES:

Graphic Bottom page 4: From Reintl et al. 2022. The role of organic nutrients in structuring freshwater phytoplankton communities in a rapidly changing world, Journal of Water Research. <https://doi.org/10.1016/j.watres.2022.118573>

Pump on Orange River, page 8: Orania Beweging, https://commons.wikimedia.org/wiki/File:Water_pumping_station_on_the_Orange_River,_Orania.jpg

Berg River Dam, page 8: Daniel Saaiman, https://upload.wikimedia.org/wikipedia/commons/4/4c/Berg_River_Dam.jpg

Red-claw crayfish, page 8: nature.catcher, <https://creativecommons.org/licenses/by-sa/4.0>

AI Generated Images

Riverine habitat picture: Microsoft CoPilot. Prompted and accessed 2024-8-09

HANDBOOK

01

Planning a river rehabilitation project:
What you need to know to get started

HANDBOOK

02

Understanding South African Rivers

HANDBOOK

03

Rewilding rivers: the role of
habitat, plants and animals in
river rehabilitation

HANDBOOK

04

Dealing with river erosion in
South Africa

HANDBOOK

05

Responding to sediment problems
in South African rivers

HANDBOOK

06

Addressing changes in river channel,
floodplain and wetland form

HANDBOOK

07

Responding to changes in water
quality and flow in urban, farming
and rural environments

HANDBOOK

08

Infrastructure in and near rivers
(fences, pipelines, bridges, culverts
and other crossings)

HANDBOOK

09

River rehabilitation case studies