A practical field procedure for identification and delineation of **wetlands and riparian areas**

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1. INTRODUCTION

This manual describes field indicators and methods for determining whether an area is a wetland or riparian area, and for finding its boundaries. Although the term "wetland" is often applied to a wide range of ecosystems, including estuaries, lakes and rivers, the scope of this manual is limited to wetlands and riparian areas as defined in the National Water Act. These definitions are discussed in sections 2 and 4.

Wetlands have many distinguishing features, the most notable being the presence of water at or near the surface, distinctive hydromorphic soils, and vegetation adapted to or tolerant of saturated soils. Observing evidence of the presence of each of these features, by means of indicators, has become widely accepted as a valid way to identify wetlands. The indicators described in section 3 have been developed through the study of wetland characteristics and can be considered accurate if used and interpreted correctly.

Similarly, riparian areas can be distinguished from adjacent terrestrial areas by observing the presence or absence of a few key indicators. Although some riparian areas display some wetland indicators, others are not saturated long enough or often enough to develop the wetland indicators described in section 3. As a result, a unique set of riparian indicators has been developed in order to assist in delineating these areas. These indicators, together with the difference between wetlands and riparian areas, are discussed in section 4. Riparian areas have been included in this manual because they often perform important ecological and hydrological functions, some of which are the same as those performed by wetlands. It is thus important that both wetlands and riparian areas be taken into consideration when making mandatory management decisions affecting water resources and biodiversity.

The manual provides the user with methods generally used to collect and interpret field data. The delineation procedure for wetlands and riparian areas, described in section 5, is scientifically robust, simple to apply and, most importantly, provides authorities with a standardised, affordable and auditable method of spatially defining these hydrologically sensitive areas. The methods and indicators described have been tested and refined under a wide range of conditions, and have proved consistent enough for use across South Africa.

Although the manual will provide the user with good technical information, the accuracy of delineation is directly dependent upon the training and experience of the user. A good delineator is a person who has extensive field experience, some knowledge of wetlands ecology, is knowledgeable of the region in which they are working and exercises sound and unbiased scientific and professional judgment. In order to ensure that accurate delineations can be done under a range of conditions, some form of training in the basics of wetland delineation is recommended.

It is also important to recognise that some wetlands will be more difficult to delineate than others and that all data collected must be used in conjunction with the knowledge and experience of the delineator. There are a few situations where the hydrological and pedological processes are more complex than usual, and a specialist may be needed in these cases. Two particular examples, the Zululand Coastal Plain and parts of the Southern Cape Coast, are discussed in detail in Appendix A.

This manual is the product of widespread collaboration between environmental managers, hydrologists and wetland ecologists, drawn from non-government organisations, the private sector and in particular the forestry sector, universities and national and provincial government. The major contribution made by the technical committee of the Land-use and Wetland/Riparian Habitat Working Group is acknowledged. This group consisted of national and provincial government departments, the forest industry, specialist scientists, Water Research Commission and various non-governmental wetland organisations. The working group has been incorporated into the Wetland and Riparian Zone Policy Committee, convened by the Department of Water Affairs and Forestry. Funding and support from Mondi, Water Research Commission, Forestry South Africa and the Mondi Wetland Project made the development of this manual possible.

This is a dynamic document, which will continue to evolve as the knowledge base for wetland delineation and riparian areas continues to grow in South Africa. Comments and suggestions on the manual will be incorporated in future editions.

2. WETLAND BASICS

What is a wetland?

The word "wetland" is a family name given to a variety of ecosystems, ranging from rivers, springs, seeps and mires in the upper catchment, to midlands marshes, pans and floodplains, to coastal lakes, mangrove swamps and estuaries at the bottom of the catchment. These ecosystems all share a common primary driving force: water. Its prolonged presence in wetlands is a fundamental determinant of soil characteristics and plant and animal species composition. Any part of the landscape where water accumulates for long enough and often enough to influence the plants, animals and soils occurring in that area, is thus a wetland.

For the purpose of this manual, wetlands are considered as those ecosystems defined by the National Water Act as:

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

Wetlands must have one or more of the following attributes:

- **Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation
- The presence, at least occasionally, of **water loving plants (hydrophytes)**
- A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil.

Why are wetlands important?

Few people understand what lies at the heart of the need for wetland conservation – real economic worth. Wetland systems have enormous monetary value and make huge, direct contributions to national economies and human well-being. Lest anyone think this is an exaggeration, *Nature* – one of the most respected scientific journals in the world – reported recently that, worldwide, wetlands are worth some $4 trillion a year.

Why are they so valuable? Because their primary task is to process water and regulate runoff. It has been estimated that the demand for water in South Africa is likely to meet the economically exploitable supply for the country as a whole by about the year 2030. Without sufficient water we cannot grow enough crops, support the growth of industry and mining, or develop a growing tourism industry. Our economy is therefore totally dependent on a continual supply of water of sufficient quality and quantity.

Wetlands protect and regulate the water resource. Acting like giant sponges, they hold back water during floods and release it during dry periods. In a dry country like South Africa, this is crucial. By regulating water flows during floods, wetlands reduce flood damage and help prevent soil erosion. Wetlands recharge ground water sources, and also remove pollutants from the water. Being natural filters, they help to purify water by trapping many pollutants, including sediment, heavy metals and disease causing organisms. Some wetlands, such as estuaries, serve as important breeding grounds for oceanic fish. Many wetlands (such as floodplains) can be used as grazing areas, if done on a sustainable basis.

Besides performing these vital functions at very little financial cost, wetlands, in association with appropriate buffer strips, are also natural storehouses of biological diversity, providing life support for a wide variety of species, some totally reliant on wetlands for their survival. Many of these species are used for food, craft manufacture, medicines, building material and fuel, both for subsistence and commercially.

Yet wetlands are some of the most threatened habitats in the world today. In some catchments in South Africa, studies reveal that over 50% of the wetlands have already been destroyed. The main culprits have been the drainage of wetlands for crops and pastures, poorly managed burning and grazing that has resulted in headcut and donga erosion, the planting of alien trees in wetlands, mining, pollution and urban development. All of these impacts alter the water flow and water quality, which kill or damage the wetland. We cannot continue to pollute wetlands, drain them, starve them of water and exploit them unsustainably for food and short-term economic development, without paying a heavy price in the long-term. Continued wetland destruction will result in less pure water, less reliable water supplies, increased severe flooding, lower agricultural productivity, and more endangered species.

3. WETLAND DELINEATION

Although the primary driving force behind all wetlands is water, due to its dynamic nature varying daily, seasonally and annually – it is not a very useful parameter for accurately identifying the outer boundary of a wetland. Long term monitoring is needed to accurately characterize the hydrology of a wetland and the extent of its saturation zones. As a result of this dynamic hydrology within and between wetlands, it is difficult to define the minimum frequency and duration of saturation that creates a wetland.

Instead, an approach is commonly followed which identifies the indirect indicators of prolonged saturation by water: wetland plants (hydrophytes) and wetland (hydromorphic) soils. The presence of these distinctive indicators in an area implies that the frequency and duration of saturation is sufficient to classify the area as a wetland. Terrain unit is another indicator, which will help identify those parts of the landscape where wetlands are more likely to occur.

In many wetlands, not all parts are saturated for the same length of time. Generally, there are three different zones in a wetland, which are distinguished according to the changing frequency of saturation (see figure 1). These three zones may not be present in all wetlands. The central part of the wetland, which is nearly always saturated, is referred to as the permanent zone of wetness. This is surrounded by the seasonal zone, which is saturated for a significant duration of the rainy season. The temporary zone in turn surrounds the seasonal zone, and is saturated for only a short period of the year that is sufficient, under normal circumstances, for the formation of hydromorphic soils and the growth of wetland vegetation.

The object of the delineation procedure is to identify the outer edge of the temporary zone. This outer edge marks the boundary between the wetland and adjacent terrestrial areas.

Wetland indicators

Finding the outer edge of the temporary zone requires the delineator to give consideration to four specific indicators:

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur.

- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

Take note

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries).

Despite hydrology not being one of the four indicators listed above, the delineation procedure is substantially facilitated by an understanding of the broad hydrological processes that drive the frequency of saturation (see Appendix B).

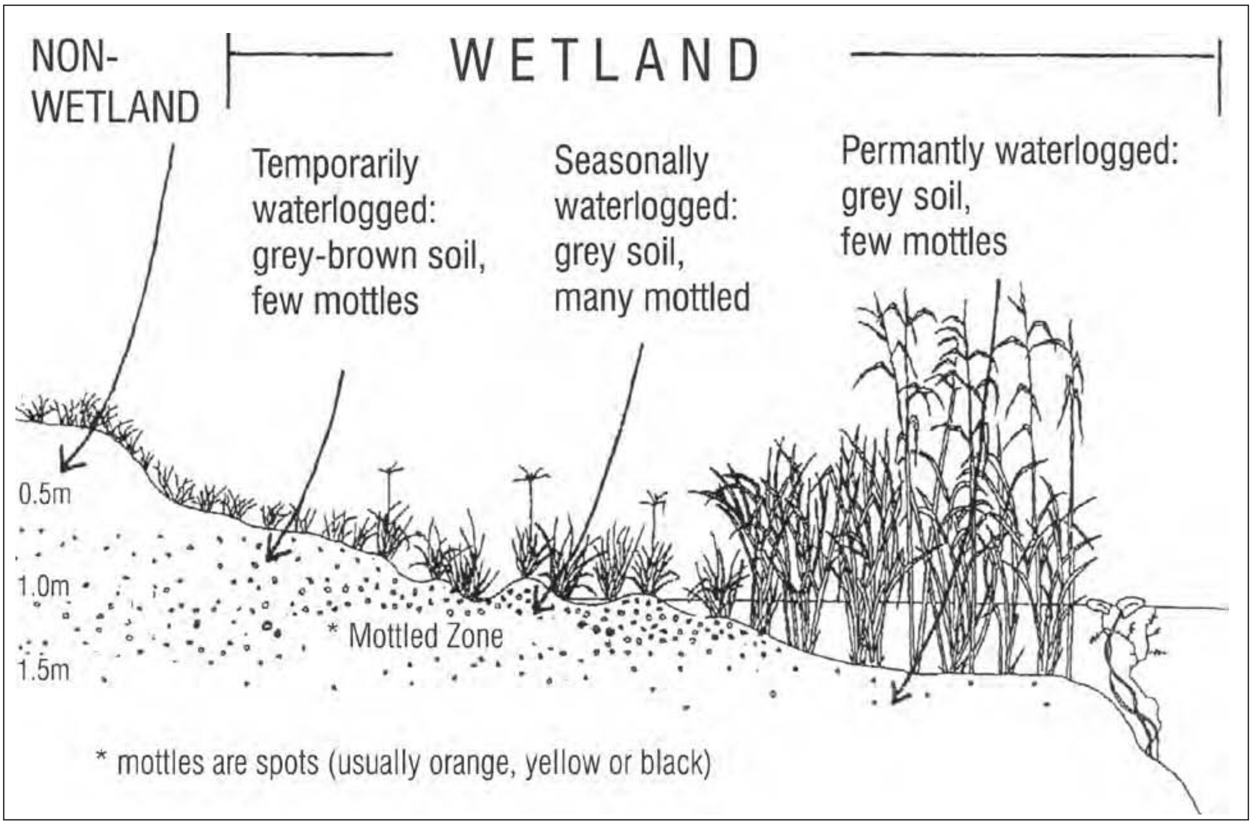

Figure1: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland.
Source: Donovan Kotze, University of KwaZulu-Natal.

Terrain Unit Indicator

A wetland usually qualifies as a valley bottom unit (see Figure 2) as defined by McVicar *et al* (1977, page 141). The valley bottom (unit 5) typically occurs in depression areas.

> **Take note**
>
> Unit 5 may also occur as a depression on a crest (1), midslope (3), or footslope (4), as depicted in Figure 2, and can then be described as 1(5), 3(5), or 4(5) respectively.

It should be noted that the terrain unit indicator is an important practical index for identifying those parts of the landscape where wetlands are likely to occur. Some wetlands occur on steep to mild slopes higher up in the catchment, where groundwater discharge is taking place through seeps, which may not be recognisable as depression areas. An area with soil wetness and/or vegetation indicators, but not displaying any of the topographical indicators described above should therefore not be excluded from being classified as a wetland.

Likewise, wetlands cannot be delineated or excluded by referring to flood-lines alone. Section 144 of the National Water Act defines flood-lines as the maximum level likely to be reached by floodwaters on average once in every 100 years.

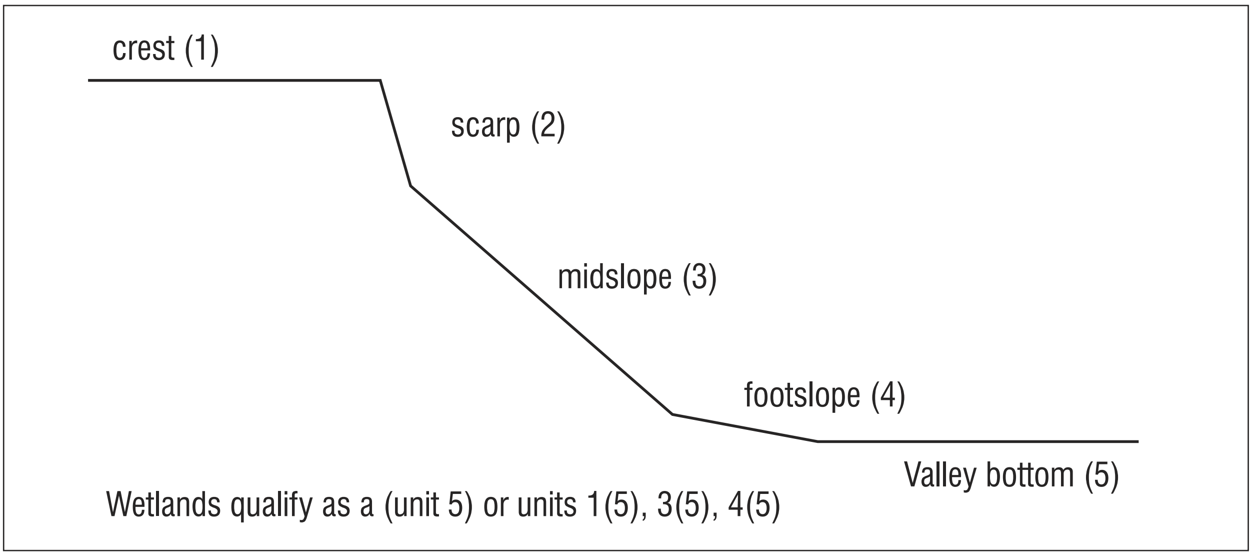

Figure 2: Terrain Units

Soil form indicator

The permanent zone will always have either Champagne, Katspruit, Willowbrook or Rensburg soil forms present, as defined by the Soil Classification Working Group (1991).

The seasonal and temporary zones will have one or more of the following soil forms present (signs of wetness incorporated at the form level):

Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu.

OR

The seasonal and temporary zones will have one or more of the following soil forms present (signs of wetness incorporated at the family level):

Inhoek, Tsitsikamma, Houwhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee.

What are hydromorphic soils?

A hydromorphic soil displays unique characteristics resulting from its prolonged and repeated saturation. Once a soil becomes saturated for an extended time, roots and microorganisms gradually consume the oxygen present in pore spaces in the soil. In an unsaturated soil, oxygen consumed in this way would be replenished by diffusion from the air at the soil surface. However, since oxygen diffuses 10 000 times more slowly through water than through air, the process of replenishing depleted soil oxygen in a saturated soil is significantly slower. Thus, once the oxygen in a saturated soil has been depleted, the soil effectively remains anaerobic. These anaerobic conditions make wetlands highly efficient in removing many pollutants from water, since the chemical mechanisms by which this is done need to take place in the absence of oxygen.

Prolonged anaerobic soil conditions result in a change in the chemical characteristics of the soil. Certain soil components, such as iron and manganese, which are insoluble under aerobic conditions, become soluble when the soil becomes anaerobic, and can thus be leached out of the soil profile.

Iron is one of the most abundant elements in soils, and is responsible for the red and brown colours of many soils. Once most of the iron has been dissolved out of a soil as a result of prolonged anaerobic conditions, the soil matrix is left a greyish, greenish or bluish colour, and is said to be gleyed.

A fluctuating water table, common in wetlands that are seasonally or temporarily saturated, results in alternation between aerobic and anaerobic conditions in the soil. Lowering of the water table results in a switch from anaerobic to aerobic soil conditions, causing dissolved iron to return to an insoluble state and be deposited in the form of patches, or mottles, in the soil. Recurrence of this cycle of wetting and drying over many decades concentrates these bright, insoluble iron compounds. Thus, soil that is gleyed but has many mottles may be interpreted as indicating a zone that is seasonally or temporarily saturated.

It is important to note, however, that not all soils associated with wetlands exhibit these characteristics and thus may lack the characteristic mottles. Prolonged wetness may be manifested in an abundant accumulation of organic carbon in the topsoil. This organic carbon does not break down. Although unusual, wetlands that lack soil wetness indicators (such as those described above) should not be excluded from being classified as wetlands simply because they lack the most common indicators, as described in Appendix A.

Soil wetness indicator

In practice, this indicator is used as the primary indicator. The colours of various soil components are often the most diagnostic indicator of hydromorphic soils. Colours of these components are strongly influenced by the frequency and duration of soil saturation. Generally, the higher the duration and frequency of saturation in a soil profile, the more prominent grey colours become in the soil matrix.

Coloured mottles, another feature of hydromorphic soils, are usually absent in permanently saturated soils, and are at their most prominent in seasonally saturated soils, becoming less abundant in temporarily saturated soils until they disappear altogether in dry soils.

Generally, in mineral soils, a grey soil matrix and/or mottles must be present for the soil horizon to qualify as having signs of wetness in the temporary, seasonal and permanent zones.

It is important to bear in mind that soils with high organic content, such as peat, may not display these characteristics.

The following grey, dry Munsell colours must be present for the horizon to qualify as having signs of wetness in the temporary, seasonal or permanent zones.

- If hue is 2.5Y, then values of 5 or more and chroma values of 2 or less; or values of 6 or more and chroma values of 4 or less.
- If hue is l0YR, then a value of 4 and chroma values of 2 or less; or values of 5 or more and chroma values of 3 or less; or values of 6 or more with a chroma of 4.
- If hue is 7.5YR then values of 5 or more with a chroma of 2 or less; or values of 6 or more with a chroma of 4 or less.
- If hue is 5YR, then a value of 5 and chroma values of 2 or less; or values of 6 or more and chroma values of 4 or less.
- If hue is 5Y, then values of 5 or more and chroma values of 2 or less.

The hydromorphic soils must display signs of wetness within 50cm of the soil surface. This depth has been chosen because experience internationally has shown that frequent saturation of the soil within 50cm of the surface is necessary to support hydrophytic vegetation.

The identification of signs of wetness within 50cm of the soil surface is usually a relatively simple procedure except for a few specific cases:

- The first case involves hydrophytic vegetation growing on alluvial deposits that are too recent to show morphological signs of wetness.
- The second case involves the sandy soil profiles that occur in the coastal aquifer systems such as those in the Zululand Coastal Area, Atlantis Coastal Aquifer and the Coastal Aquifer System of the Southern Cape (for example Tsitsikamma).
- The third case is Dolomite and Quartzite (for example Blyde in Mpumalanga).

These three cases are described in Appendix A.

The permanent, seasonal and temporary wetness zones can be characterised to some extent by the soil wetness indicators that they display:

Temporary Zone

The boundary of the wetland is defined as the outer edge of the temporary zone of wetness (see figure x), which is characterised by:

- Minimal grey matrix (<10%)
- Few high chroma mottles
- Short periods of saturation (less than three months per annum)

Nacelle Collins

Plate 1: Hydromorphic soil. High chroma mottles and grey matrix in lower sub soils indicating short to long periods of wetness i.e. temporary zone

Seasonal zone

The seasonal zone of wetness (see figure y) is characterised by:

- Grey matrix (>10%)
- Many low chroma mottles present
- Significant periods of wetness (at least three months per annum)

Nacelle Collins

Plate 2: Hydromorphic soil. Long periods of wetness i.e. seasonal zone

Permanent Zone

The permanent zone of wetness (see figure y) is characterised by:

- Prominent grey matrix
- Few to no high chroma mottles
- Wetness all year round
- Sulphuric odour (rotten egg smell)

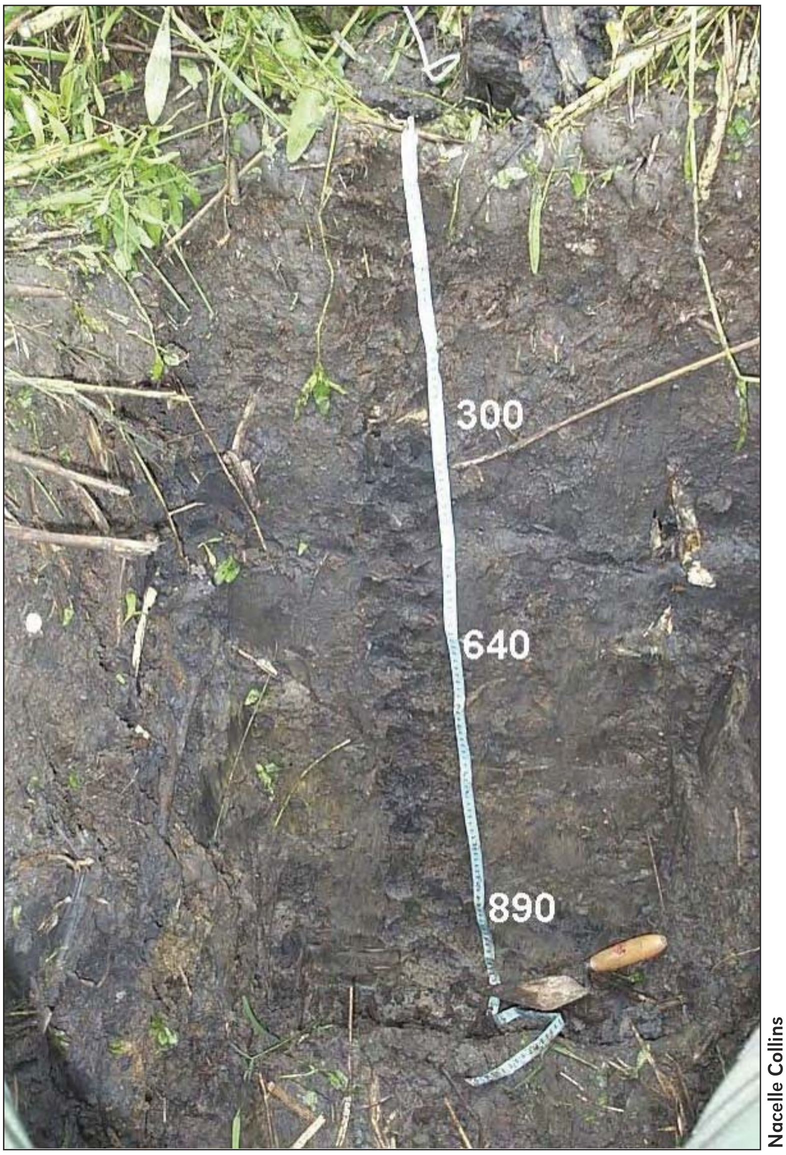

Plate 3: Hydromorphic soil. Very low chroma mottles and extensive grey matrix indicating wetness i.e. permanent zone

Take note

1. If a soil profile qualifies as Champagne, Rensburg, Willowbrook or Katspruit form, it is not necessary that grey colours be present for the profile or horizon to qualify as hydromorphic as the topsoil horizon may be thicker than 50cm. Topsoils are usually dark in the permanent wetness zone due to the accumulation of organic matter.
2. If a soil profile qualifies as Fernwood form, grey E horizon colours may not necessarily indicate signs of wetness. Soil forming processes via podzolization from aeolian parent material could be responsible. Signs of profile wetness are in this case usually associated with dark, extremely high organic carbon topsoils defined as having moist Munsell values of 4 or less and chroma values of 1 or less. (See Appendix A).

Vegetation indicator

Vegetation is a key component of the wetland definition in the National Water Act. However, using vegetation as a primary indicator requires undisturbed conditions and expert knowledge. As a result, greater emphasis is commonly placed on the soil wetness indicator. Nonetheless, vegetation in an untransformed state is a helpful field guide in finding the boundary of the wetland. Plant communities undergo distinct changes in species composition as one moves along the wetness gradient from the centre of a wetland to its edge, and into adjacent terrestrial areas (Figure 1). This change in species composition provides valuable clues for determining the wetland boundary, and wetness zones.

What are hydrophytes?

Wetlands are characterised by several environmental stresses that most plants are poorly equipped to handle. Aquatic plants are not equipped to deal with the periodic drying that occurs in many wetlands, whereas terrestrial plants cannot handle long periods of flooding. The most severe stress in wetlands is probably the anaerobic soil conditions associated with prolonged periods of saturation. Under these conditions, roots cannot respire through normal metabolic pathways, certain nutrients become unavailable to plants, and the concentrations of certain elements can reach toxic levels in the soil.

Despite these constraints, certain plant species, known as hydrophytes, have developed mechanisms to deal with these stresses. Through morphological, physiological, or reproductive adaptation these species have the ability to grow, compete, reproduce, and persist in anaerobic soil conditions. Examples of these adaptations are the presence of air spaces in roots and stems that allow the diffusion of oxygen from exposed parts of the plant into the roots, adventitious roots (roots growing from unusual places), shallow root systems, large internal pores (hypertrophied lenticels) and seed dispersal mechanisms by water.

Hydrophilic species differ in the degree to which they are dependent on, or limited to, wetlands. Some species are only found in wetland environments, and are thus termed obligate hydrophytes, while others can occur in both wetland and non-wetland soils, and are known as facultative hydrophytes.

When using vegetation indicators for delineation, emphasis is placed on the group of species that dominate the plant community, rather than on individual indicator species. Thus, the presence of scattered individuals of an upland plant species in a community dominated by hydrophilic species is not sufficient to conclude that the area is not a wetland. Likewise, the presence of a few individuals of a hydrophilic species in a community dominated by upland species is not a sufficient basis for concluding that the area is a wetland.

The emphasis in this document is on identifying the permanent, seasonal and temporary zones of a wetland, with specific emphasis on the latter for delineation purposes. To some degree, it is possible to characterise these zones by the types of hydrophilic vegetation they support (see Table 1).

A more precise method for employing vegetation as an indicator of wetland conditions uses a broad classification prepared by Kotze and Marneweck (1999, see Table 2). This classification, which is based on obligate wetland (OW) species and facultative wetland (FW) species, is applied using the procedure described in Figure 3. However, it must be cautioned that, although this method is quantitative and precise, its application is time consuming and requires expert knowledge. It must also be emphasized that the vegetation indicator is relatively region specific and needs refinement over time.

Table 1: Relationship between wetness zones and vegetation types

	Temporary	**Seasonal**	**Permanent/Semi-permanent**
VEGETATION If herbaceous:	Predominantly grass species; mixture of species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas (see Appendix D).	Hydrophilic sedge and grass species which are restricted to wetland areas.	Dominated by: (1) emergent plants, including reeds (*Phragmites australis*), a mixture of sedges and bulrushes (*Typha capensis*), usually >1m tall; or (2) floating or submerged aquatic plants.
If woody:	Mixture of woody species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas.	Hydrophilic woody species, which are restricted to wetland areas.	Hydrophilic woody species, which are restricted to wetland areas. Morphological adaptations to prolonged wetness (e.g. prop roots).

Summary of Vegetative Indicators by Wetness Zone

Table 2: Classification of plants according to occurance in wetlands

Obligate wetland (ow) species	Almost always grow in wetlands (> 99% of occurrences).
Facultative wetland (fw) species	Usually grow in wetlands (67-99% of occurrences) but occasionally are found in non-wetland areas
Facultative (f) species	Are equally likely to grow in wetlands and non-wetland areas (34-66% of occurrences).
Facultative dry-land (fd) species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% of occurrences)

Classification of plants according to occurrence in wetlands, based on U.S. Fish and *Wildlife Service Indicator Categories (Reed, 1988)*

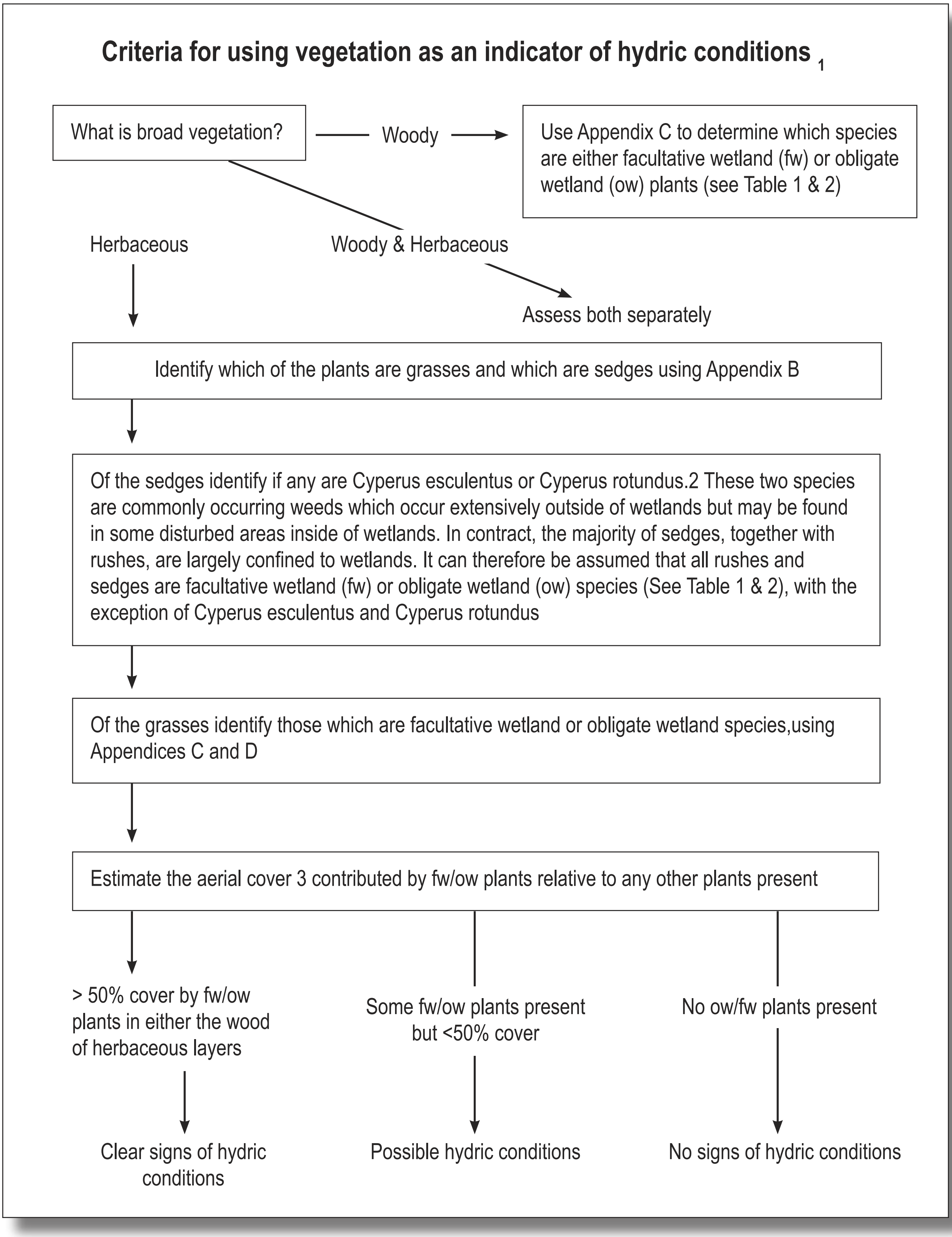

Figure 3: Method for utilising vegetation as an indicator of wetland conditions (Kotze and Marneweck, 1999)

1 Remember that if the degree of wetness of the wetlands has been reduced (e.g. through artificial drains) the vegetation is likely to indicate conditions less wet than historically so.

Combining the indicators

The decision as to whether a particular area qualifies as a wetland is based on the number of wetland indicators it displays. The edges of a wetland are established at the point where these indicators are no longer present. While some wetlands display all of the indicators under undisturbed conditions, the critical question is: "what is the minimum set of indicators that need to be present in order to qualify an area as a wetland?"

Sole reliance on any one indicator as the determinant of wetlands can sometimes be misleading. Many plant species can grow successfully both in and out of wetlands, and soil wetness indicators may persist for decades following alteration of the hydrology of a wetland. The presence of all indicators provides a logical, defensible, and technical basis for identifying an area as wetland, but an area should display a minimum of either soil wetness or vegetation indicators in order to be classified as a wetland. Verification of the terrain unit and soil form indicators increases the level of confidence in deciding the boundary. In other words, the more indicators present, the higher the confidence in the delineation.

4. Riparian Areas

At this time, quantitative indicators for the delineation of riparian areas have not yet been developed. Determining the boundary of riparian areas therefore relies heavily on professional judgement. This is not necessarily a problem, as delineating riparian areas is generally easier than delineating wetlands. The riparian-terrestrial boundary is often more distinctive than that of a wetland.

This section is under development and is provided as a guideline at this stage. Where the wetland procedure has adequately protected the riparian area, there is no need to delineate the riparian area and vice versa.

What is a riparian area?

The National Water Act defines a riparian habitat as follows: "Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas."

Riparian habitats, also known as riparian areas, include plant communities adjacent to and affected by surface and subsurface hydrologic features, such as rivers, streams, lakes, or drainage ways (see figure 4). These areas may be a few metres wide near streams or more than a kilometre in floodplains. Both perennial and non-perennial streams support riparian vegetation. Because riparian areas represent the interface between aquatic and upland ecosystems, the vegetation in the riparian area may have characteristics of both aquatic and upland habitats. Many of the plants in the riparian area require plenty of water and are adapted to shallow water table conditions. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth rate is high and the vegetation under the trees is usually lush and includes a wide variety of shrubs, grasses, and wildflowers.

Riparian areas:

- are associated with a watercourse;
- contain distinctively different plant species than adjacent areas; and contain species similar to adjacent areas but exhibiting more vigorous or robust growth forms; and
- may have alluvial soils.

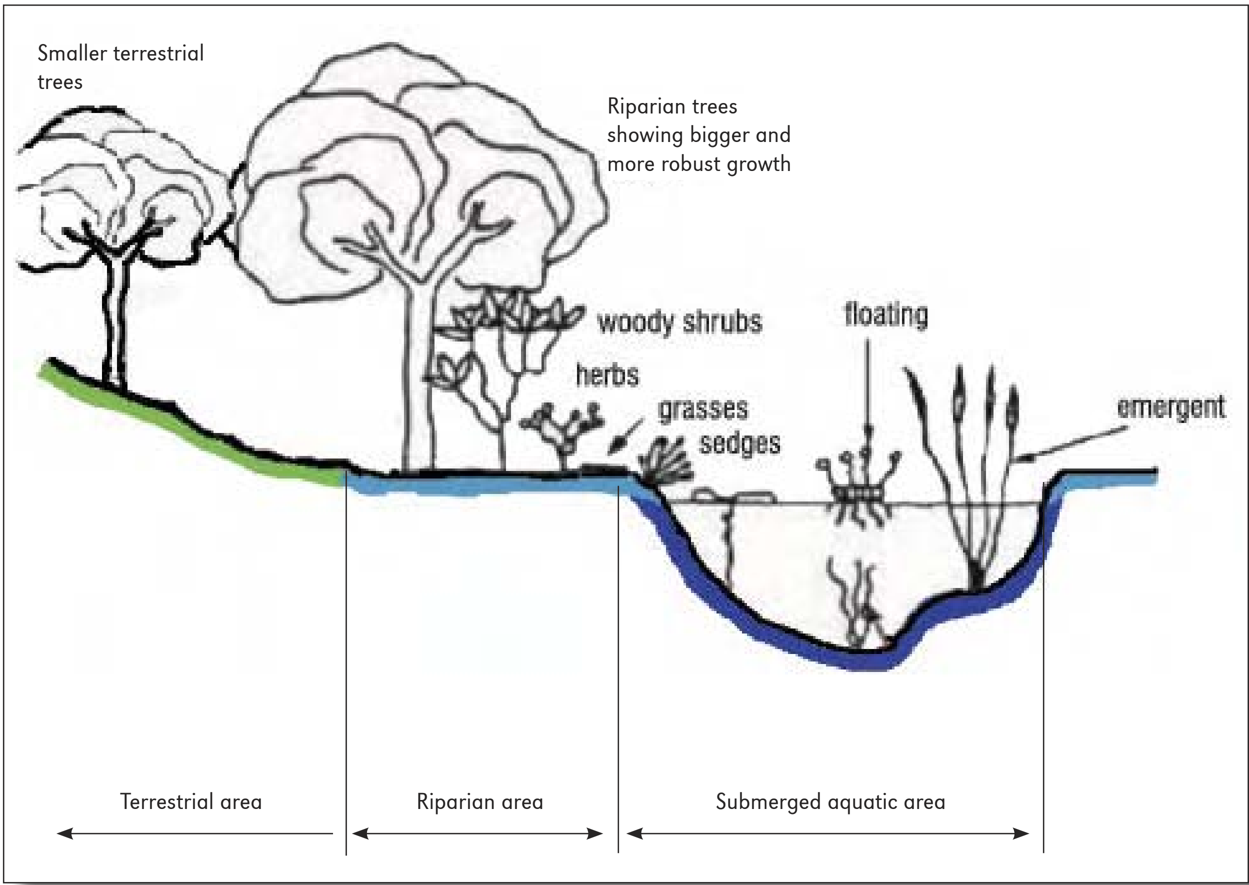

Figure 4: Typical cross section of a river channel

The difference between wetlands and riparian areas

Many riparian areas display wetland indicators and should be classified as wetlands. However, other riparian areas are not saturated long enough or often enough to develop wetland characteristics, but also perform a number of important functions, which need to be safeguarded. In these areas alluvial deposits can predominate and/or the water table is too deep for most of the year to produce hydromorphic features in the top 50cm of the soil profile. These conditions do not support vegetation typically adapted to life in saturated soil and it is therefore important to delineate these riparian areas in addition to wetlands.

Riparian areas commonly reflect the high-energy conditions associated with the water flowing in a water channel, whereas wetlands generally display more diffuse flow and are lower energy environments.

Why are riparian areas important?

Riparian areas perform a variety of functions that are of value to society, especially the protection and enhancement of water resources, and provision of habitat for plant and animal species.

Riparian areas:

- store water and help reduce floods
- stabilize stream banks;

- improve water quality by trapping sediment and nutrients;
- maintain natural water temperature for aquatic species;
- provide shelter and food for birds and other animals;
- provide corridors for movement and migration of different species;
- act as a buffer between aquatic ecosystems and adjacent land uses;
- can be used as recreational sites; and
- provide material for building, muti, crafts and curios.

Not all riparian areas develop the same way and may not perform these functions to the same extent. It is important that a riparian area's capacity to provide the benefits listed is not reduced. Many of these areas are best managed as natural areas, rather than being converted to other uses.

Riparian area indicators

Like wetlands, riparian areas have their own unique set of indicators. It is possible to delineate riparian areas by checking for the presence of these indicators. Some areas may display both wetland and riparian indicators, and can accordingly be classified as both. If you are adjacent to a watercourse, it is important to check for the presence of the riparian indicators described below, in addition to checking for wetland indicators, to detect riparian areas that do not qualify as wetlands.

The delineation process requires that the following be taken into account:

- topography associated with the watercourse;
- vegetation; and
- alluvial soils and deposited material.

Topography associated with the watercourse

A good rough indicator of the outer edge of the riparian areas is the edge of the macro channel bank. This is defined as the outer bank of a compound channel (see figure 5), and should not be confused with the active river or stream channel bank. Flood benches may exist between the active channel and the macro channel bank, and are often covered by alluvial deposits and may have riparian vegetation on them. The macro channel bank often represents a dramatic change in the frequency, duration and depth of flooding experienced, leading to a corresponding change in vegetation structure and composition.

Vegetation

Unlike the delineation of wetland areas, where hydromorphic soils are the primary indicator, the delineation of riparian areas relies primarily on vegetative indicators. Using vegetation, the outer boundary of a riparian area must be adjacent to a watercourse and can be defined as the zone where a distinctive change occurs:

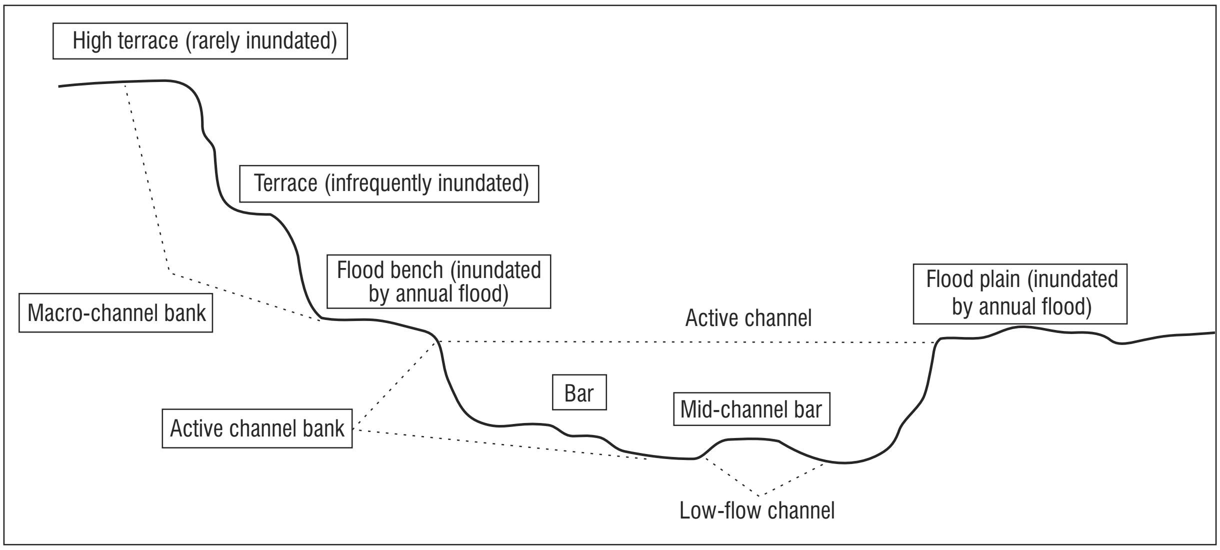

Figure 5: Typical cross section of a river channel indicating channel morphology
(Resource Directed Measures for Protection of Water Resources: River Ecosystems)

High Terrace (rarely inundated): relict flood plains which have been raised above the level regularly inundated by flooding due to lowering of the river channel.

Macro Channel Bank: the outer bank of a compound channel. Flood benches between active and macro-channel banks are usually vegetated.

Terrace (infrequently inundated): area raised above the level regularly inundated by flooding.

Flood Bench (inundated by annual flood): area between active and macro-channel, usually vegetated.

Active Channel Bank: the bank of the channel(s) that has been inundated at sufficiently regular intervals to maintain channel form and to keep the channel free of established terrestrial vegetation.

Bar: accumulations of sediment associated with the channel margins or bars forming in meandering rivers where erosion is occurring on the opposite bank to the bar.

Mid-Channel Bar: single bar(s) formed within the middle of the channel; flow on both sides.

Flood Plain (inundated by annual flood): a relatively level alluvial (sand or gravel) area lying adjacent to the river channel, which has been constructed by the present river in its existing regime. Distinction should be made between active flood plains and relic flood plains.

- in species composition relative to the adjacent terrestrial area; and
- in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

These differences between riparian and terrestrial vegetation are primarily a result of more water being available to species growing adjacent to watercourses than to those growing further away. It is therefore not necessary to identify species in order to delineate the riparian boundary. All that is needed is to compare relative changes in species composition and growth forms. Where an area has been transformed, or in the absence of natural vegetation, alluvial soils and deposited material will serve as the primary indicators.

Alluvial soils and deposited material

Alluvial soils can be defined as relatively recent deposits of sand, mud, etc set down by flowing water, especially in the valleys of large rivers. Riparian areas often, but not always, have alluvial soils. Whilst the presence of alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas, it can be used to confirm the topographical and vegetative indicators.

Deposited material can also be used to delineate the areas where bank stabilisation, provided by the roots of riparian vegetation, is most important. This material may be deposited adjacent to the macro-channel bank during flooding, and can include vegetation debris as well as soil deposits.

Methods for identification of riparian areas

The general approach for delineating riparian areas in the field is described in section 5. There are a number of sources of information that will assist in the final delineation, and which should be consulted, if available, before going into the field.

Topographical maps

Riparian areas normally occur within the flood area of a river or stream. This is not conclusive and will have to be verified in the field.

Aerial photographs

As a result of alluvial deposits being visible from the air, aerial photography can assist in determining the extent of deposits, as well as the vegetation line indicating a difference in species composition or more vigorous growth (see Figure 6).

Aerial videos

As with aerial photographs, aerial videos indicate vegetation transitions and recent alluvial deposits. Aerial videos are usually taken after large flood events, in order to record the extent of flooding and damage. Every major river in South Africa has been covered at least once and these records can assist with the identification of riparian areas.

Figure 6: Aerial view of vegetation line between terrestrial and riparian vegetation

Ecoregions (predictive capability)

Plant species composition in riparian areas varies from one part of the country to another, according to factors like climate and geology. These factors have been incorporated into classification systems that divide the country into ecoregions, each of which may contain unique or distinctive vegetation communities. By using existing ecoregional classification systems to identify the types of species that can be expected in riparian areas in a particular part of the country, delineation of these areas is made easier.

5. DETERMINING THE BOUNDARIES OF WETLANDS AND RIPARIAN AREAS IN THE FIELD

Although this manual discusses wetlands and riparian areas as separate concepts, it makes good sense to delineate both habitats during the same field visit, if necessary. It is likely that wetlands and riparian areas will overlap, and delineating both habitats during the same visit can save much time and effort. The delineation procedure is summarised here.

Before going into the field, collect all relevant supplementary information, including aerial photos, orthophotos, topographic maps and soil maps (if available) of the area to be visited. Complete a desktop delineation by estimating the wetland boundary from the aerial photo and drawing it onto the image, using clues such as topography, presence of water and differences in vegetation. Wetland vegetation can be distinguished from adjacent terrestrial vegetation in aerial photos by differences in colour, shading, texture and elevation. This preliminary identification of wetland and riparian area boundaries from aerial photographs is made substantially easier by viewing the photos in 3-D using a stereoscope. In transformed areas this desktop delineation is more difficult.

Once in the field, find a convenient vantage point from which to assess the overall layout of the wetland and surrounding area. Use the framework provided in Appendix B to gain an understanding of the broad hydrology of the area. A topographic map will be particularly useful in gaining an understanding of the boundaries of the wetland in relation to topography. Do not overlook wetlands that are not directly associated with the drainage network of the catchment. These wetlands, such as hillslope seeps, should be given equal consideration in the delineation process.

Starting the delineation procedure from the downstream part of the area to be delineated, look for the wettest part of the wetland using cues such as the presence of water or obligate hydrophilic vegetation such as sedges, bulrushes or reeds. Use a soil auger to examine the first 50cm of the soil profile for the presence of soil wetness and/or soil form indicators. Determine the wetness zone according to the soil and vegetation indicators. Proceed outwards towards the estimated edge of the wetland, sampling at regular intervals to check soil wetness and vegetation indicators. The outer boundary of the wetland is defined as the point where the indicators are no longer visible.

IMPORTANT NOTE

- If a wetland has been drained, the soil wetness indicators may still be present, but terrestrial plants will replace the hydrophilic plants.
- Where the iron content of the soil is low, mottles may be scarce throughout the three wetness zones. Nevertheless, the general trend of an increase and then a decrease in mottle abundance, as one move from the temporary zone into the seasonal and then the permanent zone remains true.
- In wetlands that are covered in very sandy soil or coarse sediment, organic material and iron oxides are often leached out, giving the soil a white bleached look. In cases such as this, it is not possible to use normal soil wetness indicators for delineation. Reliance should instead be placed on other indicators.

Once the wetland boundary has been identified, mark the position with a flag. Complete several further transects at strategic points in the wetland, always moving from the wettest to the driest zone. After several flags have been placed, use these points to identify a contour that defines the wetland boundary. Follow the contour and check periodically that the relationship between the contour and the wetland boundary is still holding true. Pay particular attention to features that may disrupt this relationship, such as seeps entering the wetland.

Record the boundary on a topographic map, preferably using GIS technology.

Depending on the type of land use proposed, an appropriate buffer zone to protect the wetland should also be delineated. In the case of forestry, for example, the minimum buffer between the outer edge of the temporary zone of a wetland or the outer boundary of a riparian zone and the land use would normally be 20 metres.

In the case of a riparian area, look for the active channel or the lowest part of the river course. Most likely cues like water with associated emergent vegetation, sedges and reeds or alluvial soil and bedrock will be visible. From this point some topographic units like sandbars, active channel bank, flood benches and macro channel bank with associated riparian vegetation will be identifiable. Proceed upwards towards the macro channel bank, taking note of alluvial soil, topographic units and vegetation indicators. The outer boundary will be the point on the edge of the macro channel bank where there is a distinct difference between the riparian and terrestrial vegetation. In some cases where riparian vegetation is unrecognisable, because of land-use activities, indicators like alluvial material and topographical units can still be used to visualize the edge of a riparian area.

If you are adjacent to a watercourse, it is also important to check for the presence of riparian indicators. Although a specific method for delineating riparian areas has not been defined in this manual, the general approach and principles outlined for wetlands can be used, with substitution of riparian indicators for wetland indicators.

Remember that, in order to adequately protect the delineated riparian areas from adjacent land uses, it will also be necessary to insert an appropriate buffer zone.

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8. GLOSSARY

Active channel bank: the bank of the channel(s) that has been inundated at sufficiently regular intervals to maintain channel form and to keep the channel free of established terrestrial vegetation.

Aeolian: wind-blown.

Alluvial soil: a deposit of sand, mud, etc. formed by flowing water, or the sedimentary matter deposited thus within recent times, especially in the valleys of large rivers.

Bar: accumulations of sediment associated with the channel margins or bars forming in meandering rivers where erosion is occurring on the opposite bank to the bar.

Base flow: long-term flow in a river that continues after storm flow has passed.

Biodiversity: the number and variety of living organisms on earth, the millions of plants, animals, and micro-organisms, the genes they contain, the evolutionary history and potential they encompass, and the ecosystems, ecological processes, and landscapes of which they are integral parts.

Buffer: a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area.

Catchment: the area contributing to runoff at a particular point in a river system.

Channel section: a length of river bounded by the banks and the bed.

Coastal aquifer: groundwater systems found adjacent to the sea.

Chroma: the relative purity of the spectral colour, which decreases with increasing greyness.

Deflation hollow: a depression in the ground resulting from loss of material due to wind action.

Delineation (of a wetland): to determine the boundary of a wetland based on soil, vegetation, and/or hydrological indicators (see definition of a wetland).

Deep rooted crop: crops than can root deeper than two metres.

Ephemeral stream: a stream that has transitory or short-lived flow.

Fault line: a geological fault resulting from differential movement in the earth's crust

Facultative species: species usually found in wetlands (67% – 99% of occurrences) but occasionally found in non-wetland areas.

Flood bench: area between active and macro-channel, usually vegetated (inundated by annual flood).

Flood plain: a relatively level alluvial (sand or gravel) area lying adjacent to the river channel, which has been constructed by the present river in its existing regime.

Fluvial: resulting from water movement.

Footslope: the lowest portion of a hill-slope.

Geological control: the control over fluvial processes that results from the character of the geological structures in the area.

Gleying: a soil process resulting from prolonged soil saturation, which is manifested by the presence of neutral grey, bluish or greenish colours in the soil matrix.

Groundwater: subsurface water in the saturated zone below the water table.

Habitat: the natural home of species of plants or animals.

High terrace: relict floodplains which have been raised above the level regularly inundated by flooding due to lowering of the river channel (rarely inundated).

Hue (of colour): the dominant spectral colour (e.g. red).

Hydromorphic soil: a soil that, in its undrained condition, is saturated or flooded long enough to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).

Hydrology: the study of the occurrence, distribution and movement of water over, on and under the land surface.

Hydromorphy: a process of gleying and mottling resulting from the intermittent or permanent presence of excess water in the soil profile.

Hydrophyte: any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats.

Intermittent flow: flows only for short periods.

Macro channel bank: the outer bank of a compound channel.

Metamorphosed zone: an area in which sedimentary rocks have been altered by heat and gasses associated with intrusions of magma.

Mid-channel bar: single bar(s) formed within the middle of the channel; flow on both sides.

Midslope: that portion of a terrain unit, which occurs below a crest and/or scarp and above a footslope and/or valley bottom.

Mire: peat-containing wetlands also referred to as peatlands.

Mottles: soils with variegated colour patterns are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.

Munsell colour chart: a standardized colour chart, which can be used to describe hue (i.e. its relation to red, yellow, green, blue and purple), value (i.e. its lightness) and chroma (i.e. its purity). Munsell colour charts are available which show that portion commonly associated with soils, which is about one fifth of the entire range.

NEMA: National Environmental Management Act, Act 107 of 1998.

Obligate species: species almost always found in wetlands (> 99% of occurrences).

Organic carbon: carbon derived from or associated with the breakdown of vegetative material.

Peat: a dark brown or black organic soil layer, composed of partly decomposed plant matter, and formed under permanently saturated conditions.

Pedology: a branch of soil science dealing with soils as a natural phenomenon, including their morphological, physical, chemical, mineralogical and biological constitution, genesis, classification and geographical distribution.

Perched water table: the upper limit of a zone of saturation that is perched on an unsaturated zone by an impermeable layer, hence separating it from the main body of ground water (the saturated zone).

Perennial: flows all year round.

Permanent zone of wetness: the inner zone of a wetland that is permanently saturated.

Podzolization: the mobilization in and removal from an A and/or E soil horizon of organic matter and/or sesquioxides.

Preferential recharge: area in which a substantial proportion of recharge to groundwater takes place.

Raceme: a simple elongate inflorescence with stalked flowers.

Rhizomatous: with a rhizome (i.e. a horizontal underground stem).

Riparian area delineation: the determination and marking of the boundary of a riparian area. In terms of the delineation procedure described in this document, delineation means marking the outer edge of the macro channel bank and associated vegetation.

Riparian habitat (as defined by the National Water Act): includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils (deposited by the current river system), and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

Runoff: stream channel flow.

Saturation zone: the zone in which the soils and rock structure are saturated with water.

Scree Pan: a collection of rocks and coarse debris that accumulates at the foot of a steep slope.

Seasonal zone of wetness: the zone of a wetland that lies between the Temporary and Permanent zones and is characterized by saturation for three to ten months of the year, within 50cm of the surface.

Sedges: grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.

Sesquioxides: a general term to describe free iron, aluminium and manganese oxides in the soil.

Soil family: a hierarchical level within the S.A. Soil Classification System, below soil form.

Soil form: a hierarchical level within the S.A. Soil Classification System, above soil family.

Soil horizons: layers of soil that have fairly uniform characteristics and have developed through pedogenic processes; they are bounded by air, hard rock or other horizons (i.e. soil material that has different characteristics).

Soil matrix: the soil framework consisting of the spatially arranged solid particles, which enclose soil air, soil water and biological components.

Soil morphology: pertaining to the form and structure of the soil.

Soil profile: the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons.

Soil survey: the systematic examination, description, clarification and mapping of soils in an area for a specific purpose.

Soil wetness factor: an index indicating the period of wetness of a soil horizon; W1, W2 and W3 being short, long and all year round wetness respectively (correlated to the Forestry Soils Database).

Spike: a simple elongate inflorescence with stalkless flowers.

Stoloniferous: with a stolon (i.e. a horizontal stem that creeps above ground).

Temporary zone of wetness: the outer zone of a wetland characterized by saturation within 50cm of the soil surface for less than three months of the year.

Terrace: area raised above the level regularly inundated by flooding (infrequently inundated).

Terrain unit morphological classes: areas of the land surface with homogenous form and slope. Terrain may be seen as being made up of all or some of the following units: crest (1), scarp (2), midslope (3) footslope (4), and valley bottom (5).

Value (of colour): the lightness of colour of a soil.

Watercourse (as defined by the National Water Act): means

a) a river or spring;

b) natural channel in which water flows regularly or intermittently;

c) a wetland, lake or dam into which, or from which, water flows; and

d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes where relevant, its bed and banks.

Water table: The upper surface of groundwater or that level below which the soil is saturated with water. The water table feeds base flow to the river channel network when the channel bed is in contact with the water table.

Wetland (as defined by the National Water Act): land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which under normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

Wetland delineation: the determination and marking of the boundary of a wetland. In terms of the delineation procedure described in this document, delineation means marking the outer edge of the temporary zone of wetness.

APPENDIX A

SPECIFIC CASES

Vegetation on Recent Alluvial Deposits (with reference to riparian areas)

Note that the procedure for identifying morphological signs of wetness in the soil profile to a depth of 50cm to determine the outer edge of the temporary zone, works in most situations. However, we must consider the situation where recent alluvial deposits (fluvial processes) are too sandy or too young for the morphological signs of wetness to be readily detectable in the profile. In such cases, there may be important types of vegetation that should be protected by the delineation process. In these areas, it is the vegetation factor that is the dominant indicator in the delineation.

The unique nature of a river is in most cases a result of both short-term and long-term fluvial processes. The importance of the river to the floodplain and the floodplain to the river cannot be overemphasized. In the long-term, floodplains result from the combination of the deposition of alluvial materials (aggradations) and down-cutting of surface geology (degradation) over many years. Sometimes this substrate can be described as young fluvial soils with no hydromorphic characteristics. The pedogenetic processes are thus slower than the fluvial processes. This recent alluvial deposit is not a special case and is common throughout catchments.

In cases like this, the hydromorphic characteristics may not always be visible within 50cm of the soil's surface, but the vegetation component still indicates riparian characteristics, and can be used as an indicator to delineate the riparian area. The edge of the macro channel can consist of bank parent material, but the vegetation still depends on the water in the active channel.

Sandy Coastal Aquifers

Aeolian derived, sandy soils associated with sandy coastal aquifers often have grey profile colours, which are not necessarily associated with hydromorphic soil forming processes. The grey profile morphology could be attributed to stripping of sesquioxides off mineral grains via podzolization within the profile. Such grey soils, especially on upland sites and midslope sites, are thus not associated with zones of saturation and are thus not indicative of riparian or wetland habitats.

Specific soil properties (and thus indicators) on sandy coastal aquifers have been recognized which distinguish wetland habitats from drier sites. The delineation procedure is in essence similar to that described earlier but with refinement to the soil criteria.

The delineation procedure in sandy coastal areas involves.

- Classification of stream channels using hydrology (Appendix B)
- Recognition of the terrain morphological unit which must be in a bottom-land site (Section 3)
- Recognition of hydrophilic vegetation (Section 3) if undisturbed
- Recognition of specific soil criteria (detailed below) associated with sandy Aeolian soils in riparian habitats.

(i) Soil properties associated with the temporary zone of wetness in riparian and wetland habitats on sandy coastal aquifers

If the soil form is Fernwood then the profile:

- Has a dark topsoil (moist Munsell values of 4 or less and chroma values of 1 or less)
- Has an extremely high topsoil organic carbon content, amounts which vary but are usually more than 7% throughout the horizon
- Contains accumulation of plant residues which vary from finely divided to predominantly fibrous
- Has a low bulk density (soil material feels 'light' and foot stamping on the soil surface often results in vibrations)
- Has a peaty character
- Often exhibits vertical profile cracking in the dry state
- Is susceptible to ground fires

Excluded are layers of organic matter, which in certain cases accumulate on the soil surface e.g. layers of pine needles or leaves under commercial timber plantations.

If the soil form is Katspruit, Kroonstad, Longlands, Wasbank, Lamotte, Westleigh, Dresden, Avalon, Pinedene, Tukulu or Dundee then the profile:

- Has a dark topsoil (moist Munsell values of 4 or less and chroma values of 1 or less)
- Has a very high organic carbon topsoil content, usually more than 4% throughout the horizon
- Has signs of wetness (Section 3.2.3) within 50 cm of the soil surface
- Has a significant textural increase (within 50 cm of the soil surface) from the E or overlying horizon to the underlying soft plinthite, G horizon or unspecified material with signs of wetness, such that sandy profile textures in the E (or overlying horizons) become at least sandy clay loam in the underlying hydromorphic horizons

ii) Soil properties associated with the permanent and/or seasonal zone of wetness in riparian and wetland habitats on sandy coastal aquifers

Pedological criteria are similar as described for the temporary zone of wetness. However, excessively high organic carbon topsoils occur (organic carbon content >10%) and topsoils are typically peaty. Soil form is commonly Champagne. However, the other soil forms (described above) having >10% organic carbon in the topsoil may also occur.

Soils derived from Quartzides and Dolomites

Take note

Exceptions to this are Lamotte, Wasbank and Dresden soil forms which have as underlying material (similar textured) podzolic subsoil (Lamotte form) or hard plinthite (Wasbank and Dresden forms)

Delineation of wetlands and riparian habitats on soils derived from quartzites and/or dolomites requires special mention.

It is often the case that the permanent zone of wetness occurs immediately adjacent to ferralitic (and other soils lacking evidence of hydromorphy) and that the seasonal and/or temporary zone is absent. This is attributed to soils derived from these parent materials being very well drained (and often deep) resulting in the required soil forming hydromorphic process being absent. The lateral extent of wetness is thus extremely limited and is confined to the permanent zone of wetness.

Despite this apparent anomaly (where the seasonal and temporary wetness zones are absent) delineation should be conducted as per methodology in the document where the following indicators are assessed:

- position in the landscape (must qualify as a terrain unit 5). However, unit 5 may also occur as a depression on a crest (1), midslope (3), or footslope (4), as depicted in Figure 2, and can then be described as 1(5), 3(5), or 4(5) respectively.
- presence of hydrophytic vegetation
- presence of hydromorphic soil forms (Champagne and Katspruit forms commonly occur in the permanent wetness zone)
- soil wetness indicator (accumulation of peat occurs and/or topsoils have an extremely high organic carbon content (significantly higher than adjacent soils in the surrounding landscape). Profile mottles due to hydromorphic soil processes may be absent in the top 50cm of soil.

Soil piping frequently occurs immediately adjacent to the permanent wetness zone. In this case, delineation should be beyond the piping zone.

APPENDIX B

THE HYDROLOGICAL FRAMEWORK FOR WETLANDS

The essence of delineation of wetland and riparian habitats is the identification of those areas where the soils are saturated often enough for both the soils and the vegetation to be different to those in the surrounding area. The hydrological framework provides a basic understanding of the processes that control the frequency of saturation in soils and therefore facilitates sound decision making for both delineation and management of these valuable and sensitive areas. It is important to note that the hydrological classification given below does not formally constitute one of the criteria used for delineation but is provided to aid understanding and decision making in the field.

The Classification of River Channels (watercourses)

The classification of river channels that has been adopted to aid the delineation process is relatively simple. The channel network is divided into three types of channels, which are referred to as A Section, B Section, or C Section channels as shown in Figure 7. The essential difference between the "A", "B" and "C" Sections is their position relative to the zone of saturation in the riparian area. Figure 7 shows two levels of the water table; the one marked "wet" depicts the highest level that the water table would reach in a wet period when recharge of the zone of saturation has taken place, while the one marked "dry" depicts the level of the water table at its lowest after a dry period. The zone of saturation must be in contact with the channel network for baseflow to take place at any point in the channel and the classification separates the channel sections that do not have baseflow (A Sections) from those that sometimes have baseflow (B Sections) and those that always have baseflow (C Sections). This classification was adopted because it is based on the changing frequency of saturation of soils in the riparian zone; from very seldom (A), to quite often (B), and to always (C).

The A Sections are those headward channels that are situated well above the zone of saturation at its highest level and because the channel bed is never in contact with the zone of saturation, these channels do not carry baseflow. They do however carry storm runoff during fairly extreme rainfall events but the flow is of short duration because there is no baseflow component. It is important to note that these steep, eroding, headward watercourses do not have a riparian habitat (in terms of the definition in the National Water Act) because they are too steep to be associated with deposition of alluvial (or hydromorphic) soils and are not flooded with sufficient frequency to support vegetation of a type that is distinct from the adjacent land areas. This makes them different from "B" and "C" Sections which are in contact with the zone of saturation often enough to have vegetation associated with saturated conditions and to leave a hydromorphic signature in the soil.

The A Sections are the least sensitive watercourses in terms of impacts on water yield from the catchment. They are situated in the unsaturated zone and in this respect their position in the landscape is little different from non-riparian hillslope positions. In view of the fact that A Sections are not as hydrologically sensitive as B and C Sections and do not have riparian habitats or wetlands. If there is any doubt about the classification of a channel section as an A Section, the delineator should remember that the channel classification has been provided as a guide only and the delineation should rely on the soil and vegetation criteria described later in the text. In particular, the delineator should take care to recognize the following special cases for A Sections:

- Situations where geological control of the riverbed profile has given rise to one or more small areas of perched water table above the dominant zone of saturation. These small or 'mini' wetlands are easily identified by the vegetation and soils and may be important for biodiversity. They should be treated in the same way as a B Section during initial development. (It should be noted that perched water tables could give rise to wetlands at any position in the landscape, including areas that are non-riparian.)
- Situations where there is a concentration of soil moisture in the unsaturated zone in the riparian area (mainly as a result of steep topography, deep well drained soils and frequent rainfall) giving rise to

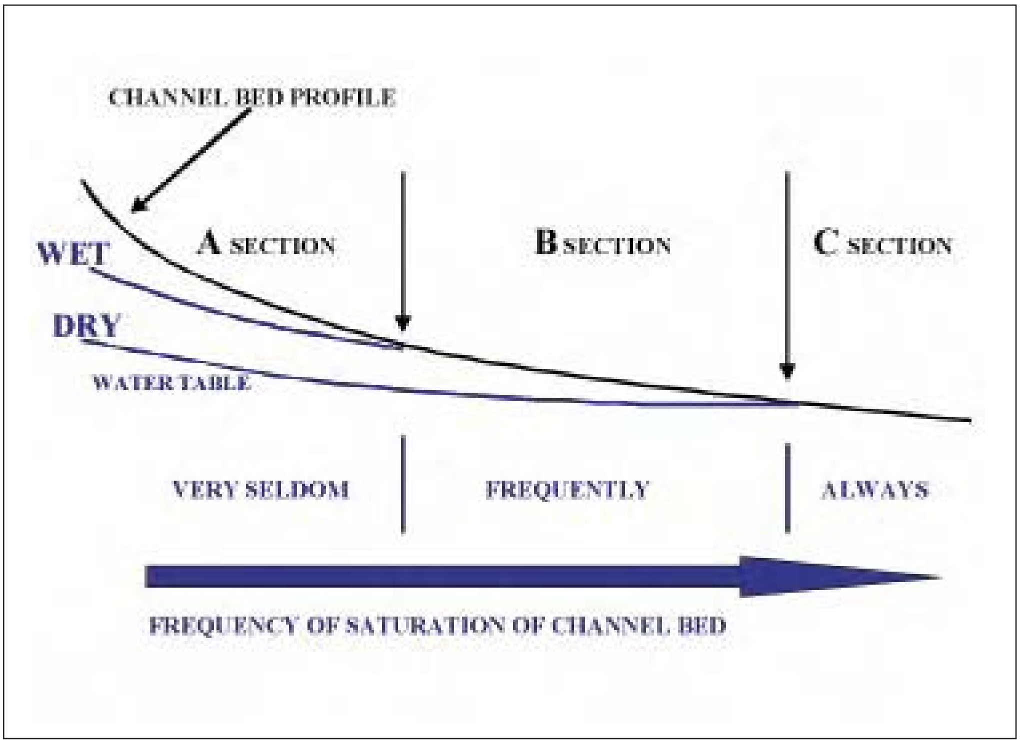


Figure 7: Classification of River Channels

an extended seepage area that is contiguous with a B Section. Soil hydromorphy with associated grey mottling may occur in these areas if the frequency of wetting is high enough to leave a signature in the soil even though the saturated zone is absent. These parts of A Sections should be treated as B Sections.

The B Sections are those channels that are in the zone of the fluctuating water table and only have baseflow at any point in the channel when the saturated zone is in contact with the channel bed. The top end of the B Section is marked by the most headward extent of base flow in the channel during wet periods, when the water table is high, and the bottom end of the B Section is marked by the most downstream extent of zero flow during dry periods (when the water table is low). In this section baseflow is intermittent, with flow at any point in the channel depending on the current height of the water table. Because the channel bed is in contact with, or in close proximity to, the water table, residual pools are often observed when flow ceases. The gradient of the channel bed is flat enough in these sections for deposition of material to take place and initial signs of flood plain development may be observed.

The C Sections are always in contact with the zone of saturation and therefore always have baseflow. They are perennial streams with flow all year round, except perhaps in times of extreme droughts. Channel gradients in these sections are very flat and a flood plain is usually present.

Summary of channel classification

In simple terms, A Sections never have baseflow, B Sections sometimes have baseflow (depending on the current height of the water table) and C Sections always have baseflow. In the steep, eroding A Sections where the channel bed is well above the zone of saturation, no riparian habitats or wetlands will be found (except in the case of perched water tables) because the frequency of saturation is much too low to change the character of the soils and vegetation. These channels are managed differently to B and C Sections where the proximity or presence of the saturated zone provides a frequency of saturation that is high enough to support a wetland/ riparian habitat.

Link between wetland zones and channel sections

It is important to note that the zone of saturation can sometimes be at or near the surface of the ground in a depression (usually a deflation hollow) that may be anywhere in the landscape and not necessarily linked with the river channel network. The frequency of saturation of the soils is often high enough to support a wetland in these cases. An example of a non-riparian wetland is shown in figure 8.

Whether a wetland is associated with the current watercourse or not, the wetland delineation procedure described in subsequent sections of this document attempts to identify that part of the wetland that is permanently saturated, that part that is seasonally saturated and that part that is temporarily saturated. These permanent, seasonal and temporary zones of a wetland are located by moving upslope at right angles to the river channel (or from the centre of a depression wetland outwards) and should not be confused with the classification of the channels themselves. The relationship between the wetland zones (which are described in more detail in later Section 3 of the text) and the channel classification system is illustrated in Figure 9, where the frequency of saturation of soils not only decreases up the channel network (from C Sections to A Sections) but also decreases up the hillslope at right angles to the channels (from permanent zone to temporary zone of saturation). It is the dynamics of the riparian saturated zone that drives the frequency of saturation in both cases.

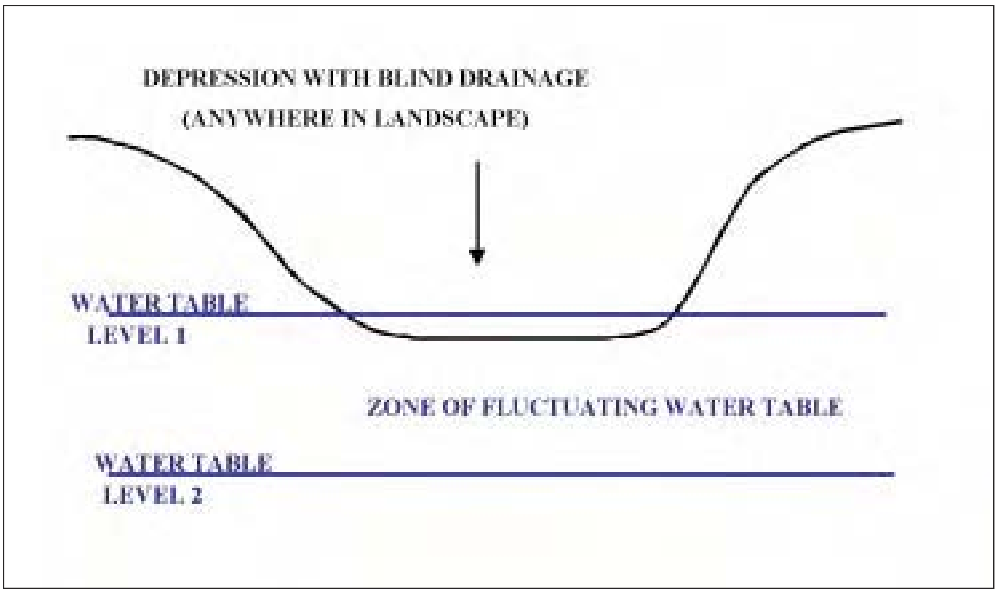


Figure 8: Non-riparian Wetlands

Referring back to Figure 8, it represents a hillside sloping down to a saturated area, whether a river channel saturated area or an isolated wetland area, and shows the fluctuating water table and its relationship to the wetland zones. Note that the signs of wetness in the soil profile as indicated in Figure 1 can be very difficult to detect in some specific cases as described in the text under "Specific Cases".

Preferential recharge areas

The baseflow in a river channel is derived from the zone of saturation (as discussed above) and is important to all water users because it is the only river water available during dry periods. Consequently, consideration must be given as to how the zone of saturation is recharged with water in each catchment. Recharge to groundwater takes place when there is adequate rainfall but the recharge is not uniformly distributed across the catchment. A lot more recharge takes place in some areas than in others because rain water can move quickly to the water

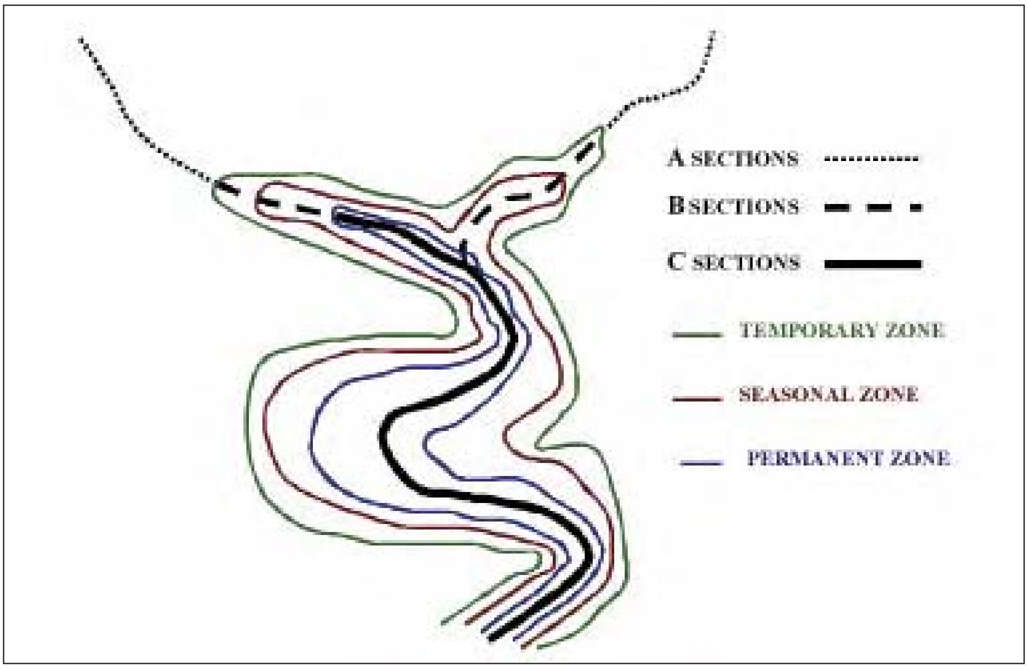


Figure 9: Wetland Zones and Channel Sections

table via direct paths (such as fractured rock outcrops) while in other areas deep soil profiles need to be wetted to field capacity before significant recharge can take place. The high recharge areas are known as preferential recharge areas. They need to be identified and managed to maximize the recharge process. Some examples are; outcrops of fractured hard rock, riparian zones (including A Sections of channel), metamorphosed zones, fault lines, scree fans and very shallow (or very sandy) soil profiles.

Appendix C

Vegetation listed in this Appendix is typical of species found in The KwaZulu-Natal area in a grassland biome

C1 Introduction:

C2 *Gramineae* (Grasses)

- C2.1 *Imperata cylindrical*
- C2.2 *Setaria sphacelata*
- C2.3 *Pennisetum thunbergii*
- C2.4 *Hemarthria altissima*
- C2.5 *Paspalum urvillei*
- C2.6 *Paspalum dilatatum*
- C2.7 *Paspalum distichum*
- C2.8 *Andropogon appendicularis*
- C2.9 *Ischaemum fasciculatum*
- C2.10 *Arundinella nepalensis*
- C2.11 *Andorpogon eucomis*
- C2.12 *Festuca caprina*
- C2.13 *Aristida junciformis*
- C2.14 *Eragrostis plana*
- C2.15 *Eragrostis planiculmis*
- C2.16 *Phragmites australis*
- C2.17 *Leersia hexandra*
- C2.18 *Miscanthus capensis*
- C2.19 *Miscanthus junceus*

C3 *Cyperaceae* (Sedges)

- C3.1 *Cyperus sexangularis*
- C3.2 *Cyperus latifolius*
- C3.3 *Cyperus fastigiatus*
- C3.4 *Cyperus marginatus*
- C3.5 *Fuirena pubescence*
- C3.6 *Kyllinga erecta*
- C3.7 *Scleria welwitschii*

C3.8 *Eleocharis dregeana*

C3.9 *Eleocharis limosa*

C3.10 *Schoenoplectus brachycerus*

C3.11 *Schoenoplectus corymbosus*

C4 *Juncaceae* (Rushes)

C5 *Typhaceae* (Bullrushes)

C5.1 *Typha capensis*

C6 *Potamogetonaceae* (Pondweeds)

C6.1 *Potamogeton thunbergii*

C7 *Asphodelaceae* (Red-hot pokers)

C7.1 *Kniphofia species*

C7.2 *Kniphofia linearfolia*

C8 *Amaryllidaceae* (Vlei lilies)

C8.1 *Crinum species*

C8.2 *Crinum macowanii*

C9 *Polygonaceae* (Knotweeds)

C9.1 *Persicaria attenuata*

C10 Additional species form other families

C10.1 *Xyris capensis*

C10.2 *Satyrium hallackii*

C10.3 *Ranaculus multifidus*

C10.4 *Sium repandum*

C10.5 *Gunnera repandum*

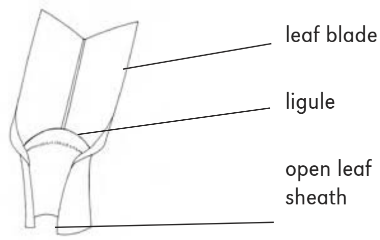
C10.6 *Mentha aquatica*

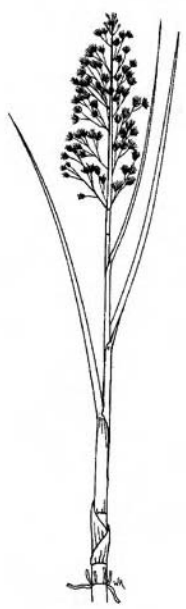
1. Introduction

Some of the plant families common to wetlands are listed, followed by descriptions of how to identify selected species, including their general height and the wetness zones in which they characteristically occur. Use a hand lens or binoculars upside-down to observe any fine detail required. The focus of this appendix is on grasses, sedges and rushes. There are many wetland species in these and other families that are not included. Reference was made to the following documents: Gibbs Russell et al. (1991); Gordon-Gray (1995); Obermeyer (1985); and Pooley (1998) from which more detailed information can be obtained. The publishers thank Dr Donovan Kotze for the narration and Mrs Wilma Roux for the illustrations.

2. Gramineae (Grasses)

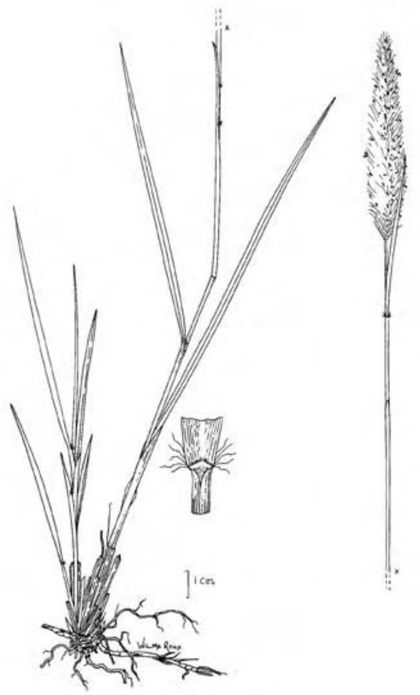
All grasses have an open leaf sheath and stems with nodes, unlike sedges. The family includes wetland-dependant and non-wetland species.





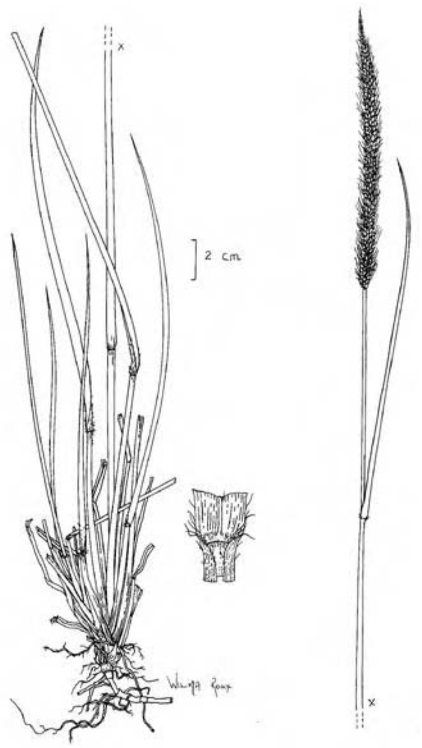
2.1 Imperata cylindrical

Strongly rhizomatous; leaves broad in the middle, narrow at tip, red in winter; inflorescence white; temporary wetness.



2.2 Setaria sphacelata

Rhizomatous or tuftted; 0,3-1.5cm; inflorescence golden yellow; 7-40cm long; temporary and seasonal wetness.



2.3 Pennisetum thunbergii

Tufted; 0.3-1.0m; inflorescence purple; 3-5cm long; temporary and seasonal wetness.

Pennisetum macrourum: tufted; 0.4-1.5m; inflorescence light green; 12-25cm long; temporary and seasonal wetness.

2.4 Hemarthria altissima

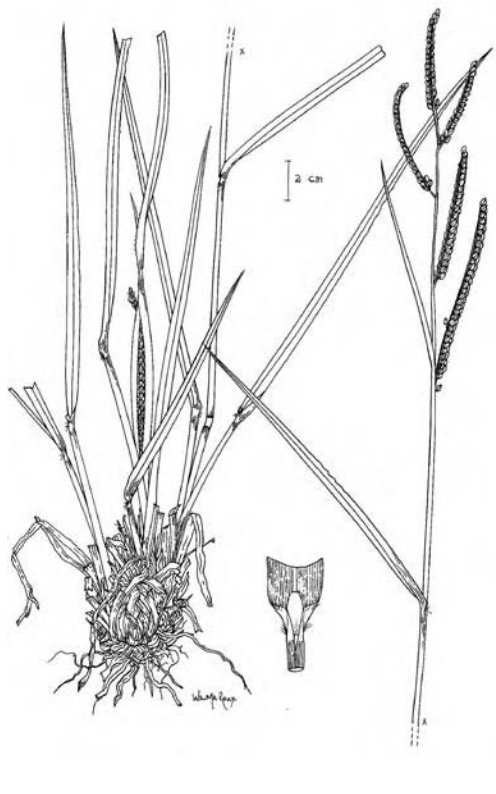
Creeping; stoloniferous; leaves turn red; temporary and seasonal wetness.

2.5 Paspalum urvillei

Rhizomatous or tufted; 1.0-2.5cm; inflorescence with 10-30 racemes on axis; conspicuous membranous ligule; temporary wetness.

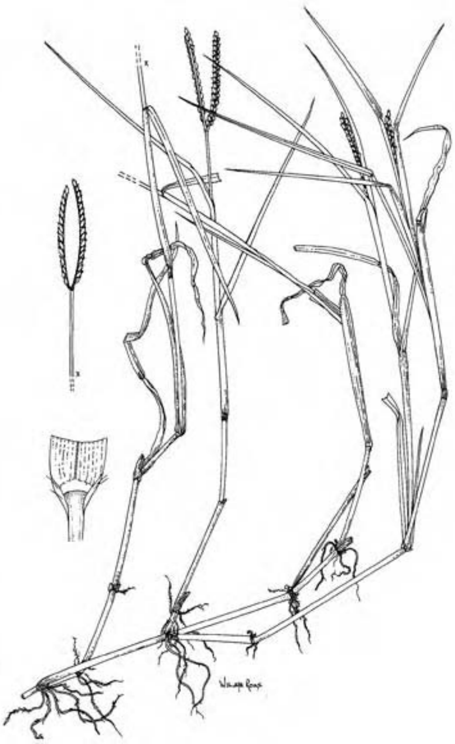
2.6 Paspalum dilatatum

Rhizomatous or tufted; 0.3-1.3m; inflorescence with 4-9 racemes on axis; conspicuous membranous ligule; temporary wetness.



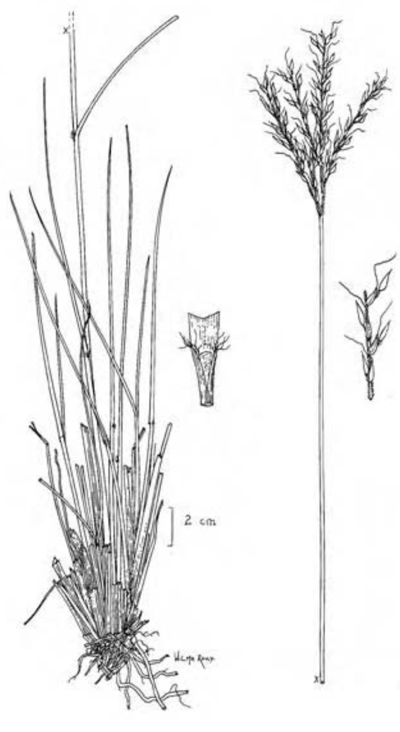
2.7 Paspalum distichum

Rhizomatous or stoloniferous (strongly creeping); <1.0m; inflorescence with a pair of racemes on end of stem; seasonal and permanent wetness.



2.8 Andropogon appendicularis

0.3-1.2m; dense tuft; leaves folded; leaf bases flattened; temporary and seasonal wetness.

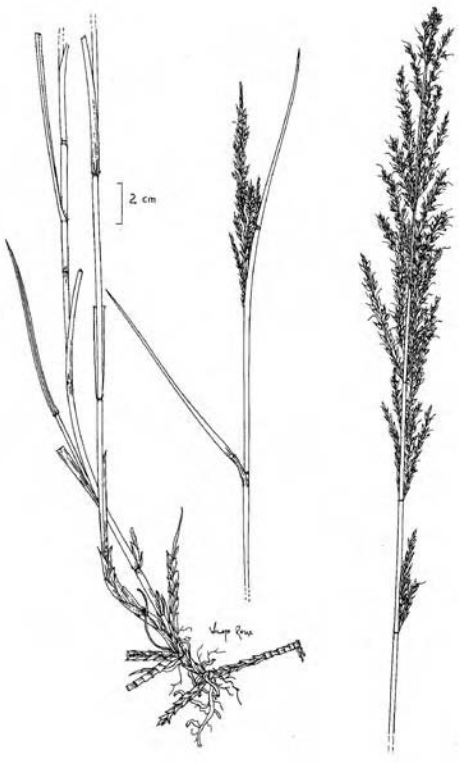


2.9 Ischaemum fasciculatum

Rhizomatous; 0.3-0.9m; leaves light green turning reddish; common on edge of streams; seasonal to permanent wetness.

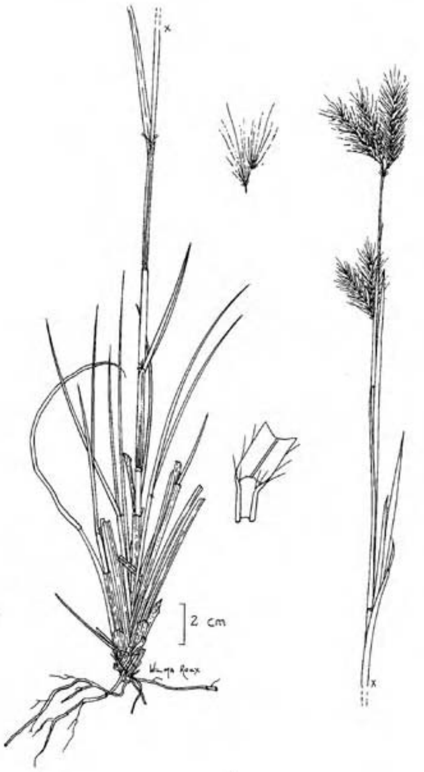
2.10 Arundinella nepalensis

Rhizomatous; 0.6-1.5m; coarse, stiff-leaved with expanded blades; rigid inflorescence; temporary and seasonal wetness.



2.11 Andorpogon eucomis

Tufted; 0.2-0.9m; inflorescence with white silky hairs; temporary and seasonal wetness.

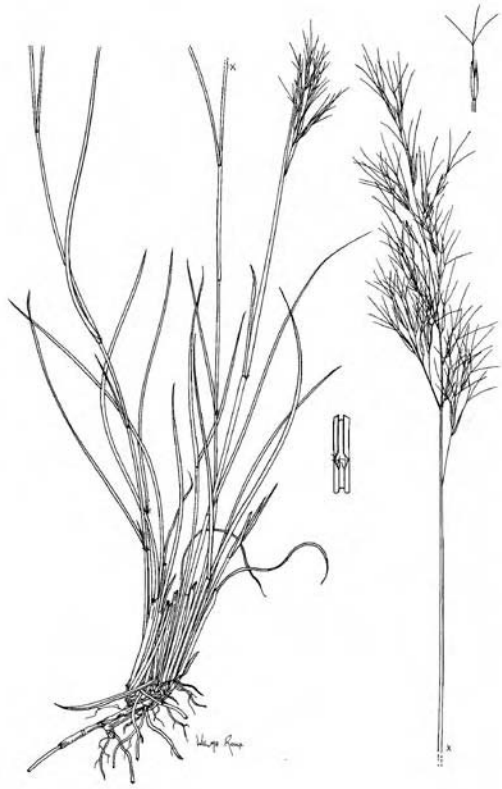


2.12 Festuca caprina

Tufted; 0.2-0.6m; leaves fine; old leaf bases persist as fine fibres; >1500m altitude; temporary and seasonal wetness.

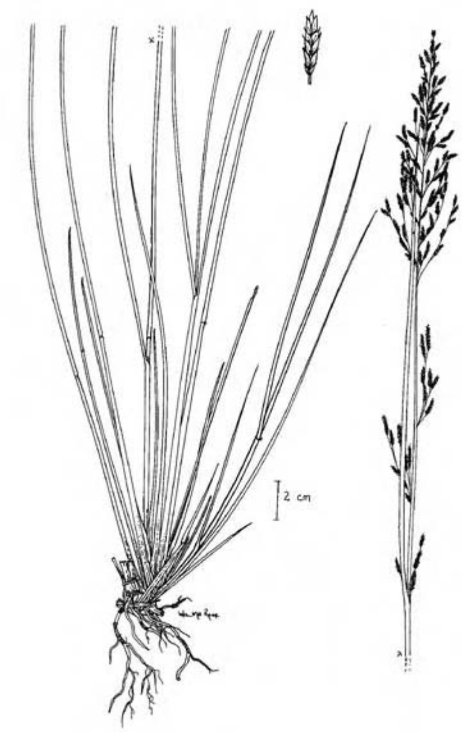
2.13 Aristida junciformis

Densely tufted; 0.3-0.9m; leaves wirey, rolled and narrow; temporary and seasonal wetness.



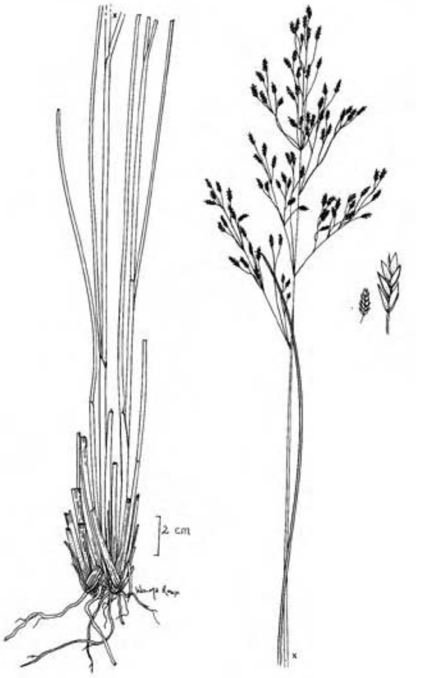
2.14 Eragrostis plana

Tufted; 0.2-1.0m; flattened fan-shaped leaf base; leaves strong and smooth; temporary wetness.



2.15 Eragrostis planiculmis

Resembles Eragrostis curvula but hairs absent from the base of the plant; inflorescence much branched; temporary and seasonal wetness.



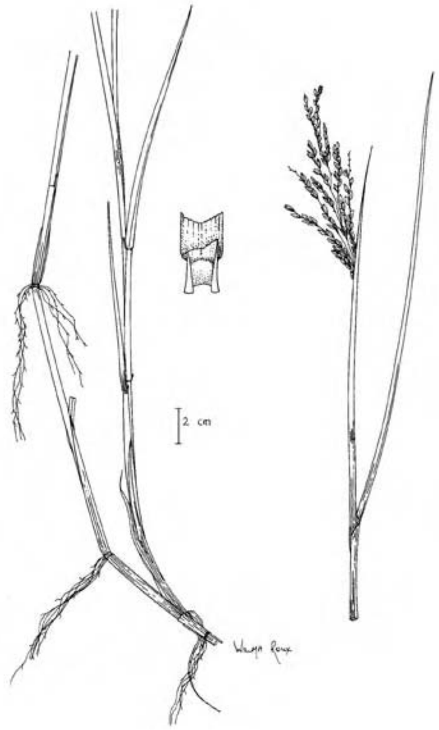
2.16 Phragmites australis

0.6-4.0m; leaves break off at base leave blade; usually permanent wetness.

Phragmites mauritianus: resembles Phragmites australis, but leaves break off at base of the sheath and have rigid sharp points; temporary to seasonal wetness.

2.17 Leersia hexandra

Toothed ligule; tiny hairs on nodes; temporary to seasonal wetness.

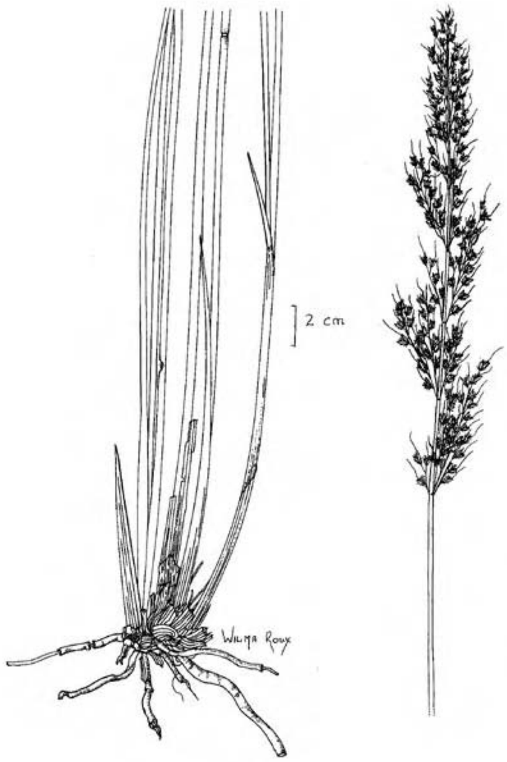


2.18 Miscanthus capensis

Tufted and robust; 0.5-2.5m; leaf blades >1.0cm wide; distributions generally south-east of Ladysmith; temporary and seasonal wetness.

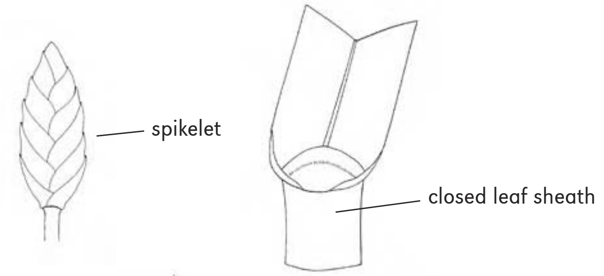
2.19 Miscanthus junceus

Tufted and robust; 0.5-2.5m; resembles Miscanthus capensis but leaf blades <0.4cm wide and rounded; generally north-west of Ladysmith; temporary to seasonal wetness.



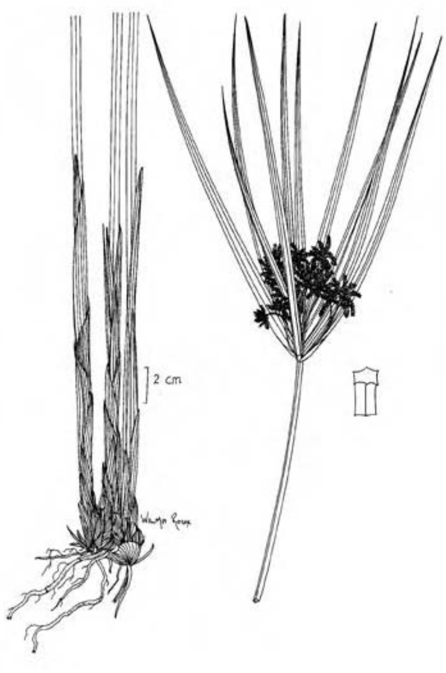
3 Cyperaceae (Sedges)

Sedges resemble grasses, but most sedges lack stem nodes. All sedges have a closed sheath, if present. Most of the species in the family are dependent on wetlands.



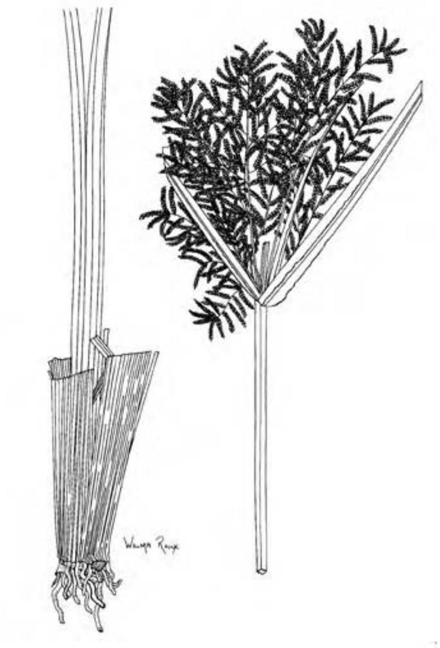
3.1 Cyperus sexangularis

Leaves absent, but several leaf-like bracts; surrounding inflorescence; stems 6-angled; rough textured; temporary and seasonal wetness.



3.2 Cyperus latifolius

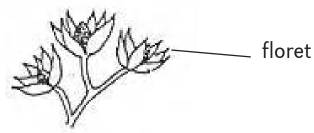
0.5-2.5m; robust plants; leaves stiff; usually>1cm wide; leaf margins smooth; seasonal and permanent wetness.



Cyperus dives: resembles Cyperus latifolius, but leave margins rough and and readily cut one's finger; <900m altitude; permanent wetness.

4 Juncaceae (Rushes)

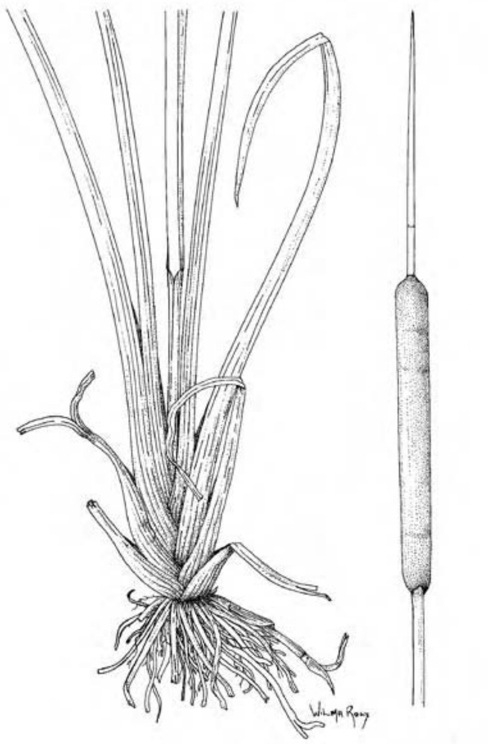
Rushes characteristically have cylindrical stems and leaves. They may be confused with certain sedges (e.g. Eleocharis species and Schoenoplectus species) but their flowers are distinctly different. Most of the species in the family are dependent on wetlands.

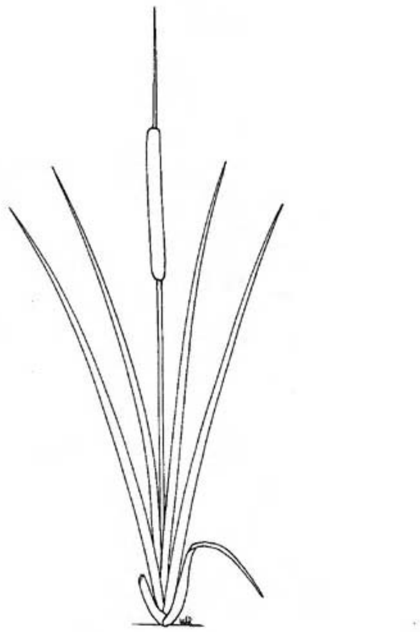


Florets with 6 stamens and 6 whorled bracts

5 Typhaceae (Bullrushes)

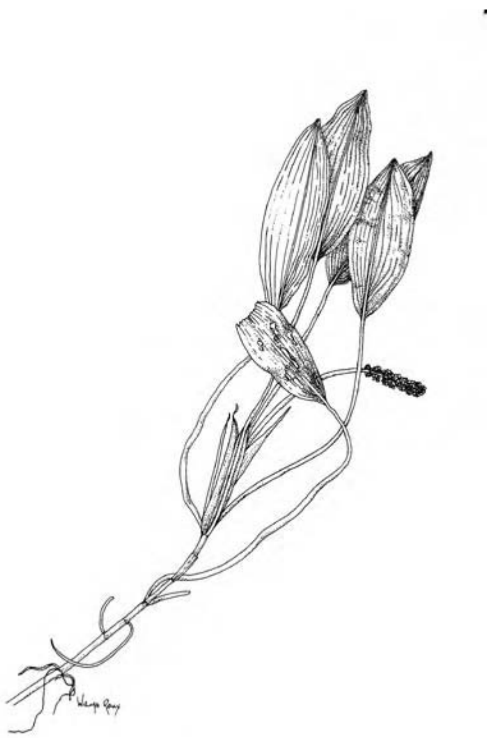
Inflorescence cigar shaped with leaves in a single plane. Most of the species in the family are dependent on wetlands.





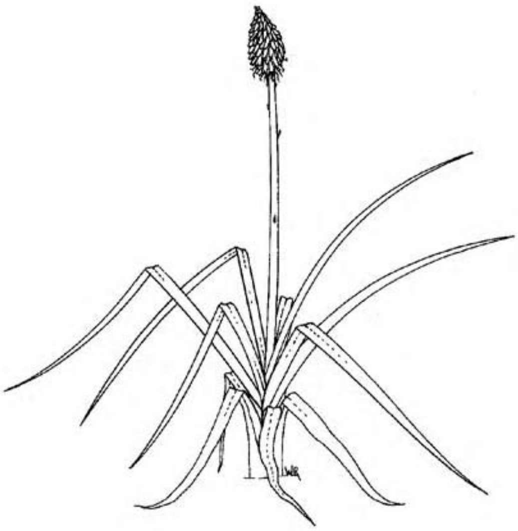
6 Potamogetonaceae (Pondweeds)

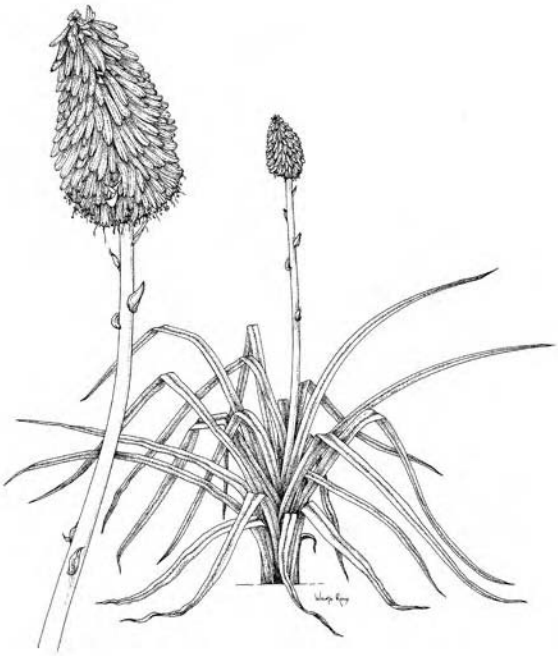
Submerged or floating leaved flowers in erect spikes. Most of the species in the family are dependent on wetlands.



7 Asphodelaceae (Red-hot pokers)

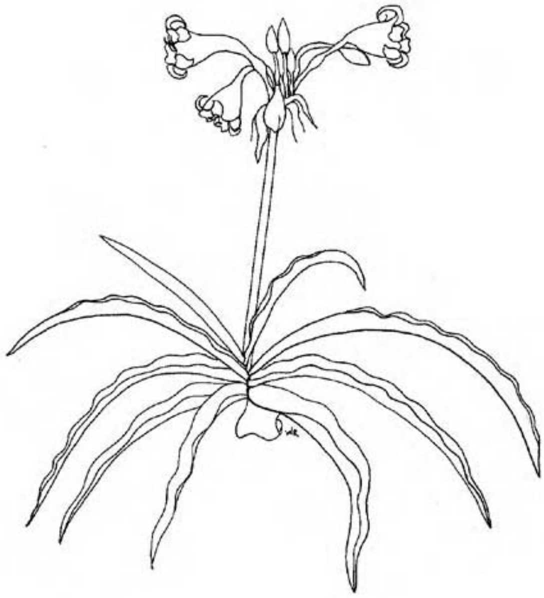
Inflorescence cigar shaped with leaves in a single plane. The family includes wetland-dependant and non-wetland species.





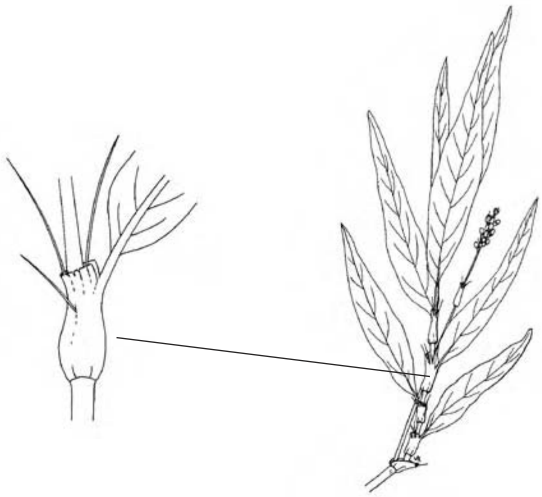
8 Amaryllidaceae (Vlei lilies)

Submerged or floating leaved flowers in erect spikes. The family includes wetland-dependant and non-wetland species.

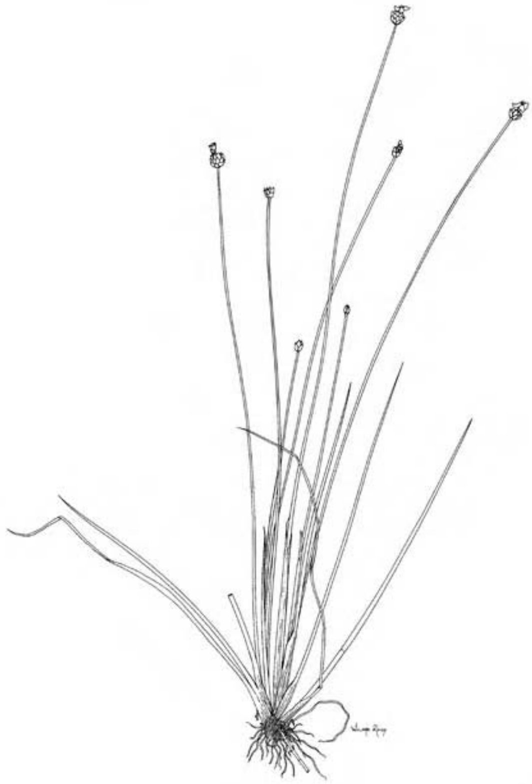


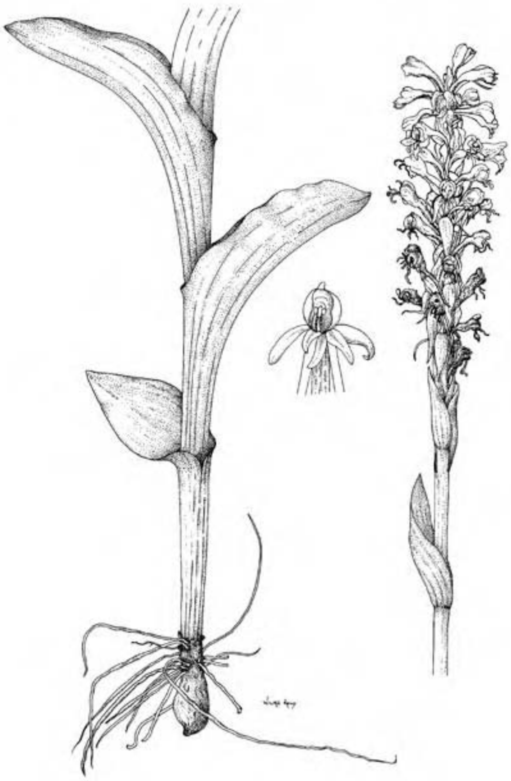
9 Polygonaceae (Knotweeds)

Base of the stem often swollen like a knot and with a sheath. Flowers in dry bracts. Most of the species in the family are dependent on wetlands. Persicaria (Polygonum) species rely on seasonal and permanent wetness.



10 Additional species from other families





APPENDIX D: GRASS SPECIES OCCURRING IN THE UPLAND AREAS OF THE EASTERN SEABOARD, WHICH INDICATE WETLAND CONDITIONS.

(Appendix C aids in the identification of some of the common species given below)

Agrostis eriantha	fw
Agrostis lachnantha	ow
Andropogon appendiculatus	fw
Angropogon eucomis	fw
Arundinella nepelensis	fw
Brachiaria eruciformis	fw
Diplachne fusca	ow
Echinochloa crus-galli	fw
Echinochloa jubata	fw
Eragrotis lappula	fw
Eragrotis plana	fw (dry climate) f (wet climate)
Eragrotis planiculmis	ow
Festuca caprina	fw
Fingerhuthia sesleriiformis	ow
Helictotrichon turgidulum	fw
Hemarthria altissima	fw
Imperata cylindrica	w (dry climate) f (wet climate)
Ischaemum fasciculatum	ow
Koeleria capensis	fw
Leersia mexandra	ow
Merxmuellera macowanii	fw
Miscanthus capensis	fw
Miscanthus junceus	ow
Panicum coloratum	fw

Panicum hymeniochilum	ow
Panicum repens	ow
Panicum schinzii	fw
Paspalum dilatatum	fw
Paspalum distichum	ow
Paspalum scrobiculatum	fw
Paspalum urvillei	fw
Pennisetum macrourum	ow
Pennisetum natelense	ow
Pennisetum sphacelatum	ow
Pennisetum unisetum	fw
Phalarus arundinacea	ow
Phragmites australis	ow
Phragmites mauritianus	fw
Setaria sphacelata	fw
Stiburus alopecuriodes	fw