Montana Spruit Upgrade, GAUTENG

ECOLOGICAL MANAGEMENT PLAN: VOLUME 2

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INTRODUCTION

The City of Tshwane Roads and Stormwater department wishes to implement measures to alleviate flooding of properties along the Montana Spruit in Doornpoort, northern Tshwane in the Gauteng province.

Environmental authorisation is required as the proposed development triggers a number of listed activities in terms of the regulations of the National Environmental Management Act, Act, 1998 (Act 107 of 1998), as amended (NEMA), and the Environmental Impact Assessment Regulations.

A Basic Assessment process was initiated in 2008 and after following the legislated process a Basic Assessment Report was submitted to the Gauteng Department of Agriculture and Rural Development (GDARD) in December 2009. Following a review the application, GDARD requested additional information including the development of an Ecological Management Plan that caters for the management of the riparian zones and water quality levels both during and after construction.

Strategic Environmental Focus (Pty) Ltd (SEF) was therefore appointed by TGM Environmental Services cc. to collate the relevant project information and compile a response to the GDARD request with regards to the development of an Ecological Management Plan.

Layout of Volume 2

The EcoMP consist of seven Chapters. Within each chapter, where applicable, references are made to supporting information within the corresponding chapter in Volume 2

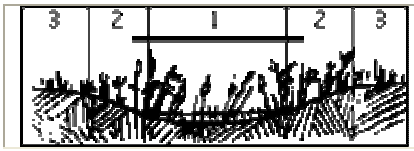
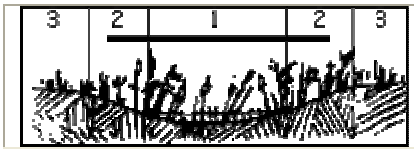
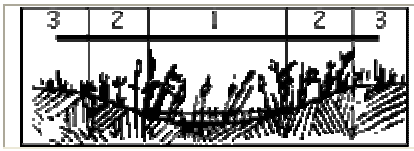
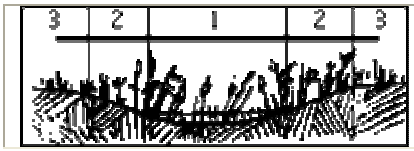
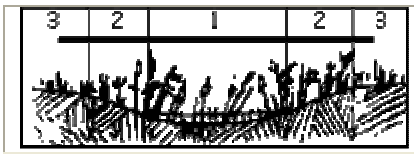
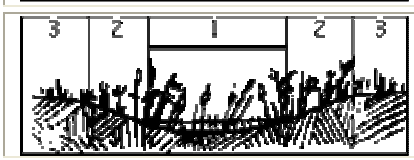
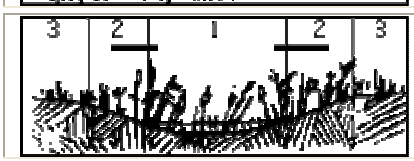
CHAPTER 1: RIPARIAN MANAGEMENT - REHABILITATION AND RE-VEGETATION GUIDELINES

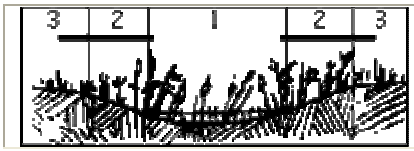
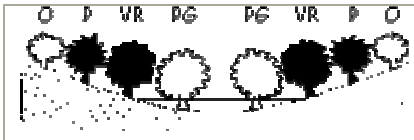
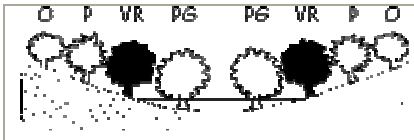
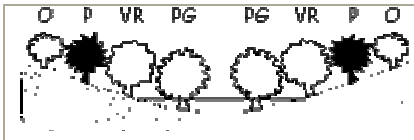
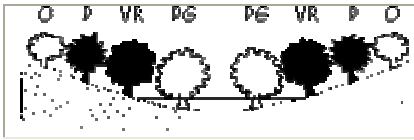
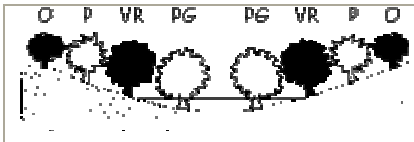
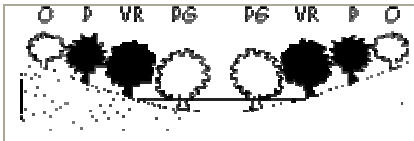
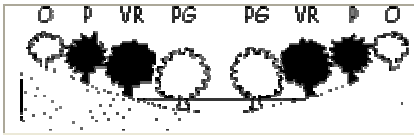
1. STEPS FOR RE-VEGETATION OF THE RIPARIAN AREAS

Steps listed below are have been amended from generic templates of re-vegetation in order to suit the present site conditions:

1. Ensure that there are no steep gradients after reshaping the new channel
2. The stripped topsoil (top 30cm) should be re-apllied to the newly shaped channel
3. Plants that are indigenous to the area and adapted to the climate and hydrology of the site, should be planted (Table 1). Species highlighted in bold should be planted in greater quantities. The dominant rehabilitation medium used within the reshaped channel should be *Bothriochloa insculpta* (Pinhole grass) and *Dicanthium annulatum* (Vlei Finger grass) as both species are able to grow in clayey soils and are able to obtain high basal coverage, therefore commonly used for soil erosion control. Dominant species used for revegetation of permanent wet areas should be *Typha capensis* (Bulrush), *Phragmites australis* (Common reed) and *Leersia hexandra* (Wild rice grass).
4. Revegetation should start immediately after each section's reshaping is completed to ensure that vegetation has stabilised soils before summer rains
5. Areas inside the floodplain which don't show sufficient basal cover after four weeks of the seed containing topsoil replacement should be complimented by hydro-seeding with a seed mixture that includes species as per Table 2.
6. Stabilise steep areas with geotextile to prevent erosion while grasses establish e.g. banks of attenuation and detention features.
7. Water with a temporary irrigation system during and after germination for a minimum period of two months (no water may be extracted from the Montana Spruit for this purpose).
8. Re-seeding where germination is not acceptable (minimum coverage of 75%) and continued maintenance of these areas.
9. The rehabilitation must be undertaken under supervision of a qualified ecologist or landscape architect and all engineering elements should be refined by a landscape architect to ensure a natural end-product.
10. Vegetation of the stormwater retention pond and outlet swale shall use plant species as specified in Table 3.

Table 1: Indigenous plants suitable for rehabilitation in riparian areas and floodplain (modified from:Wyatt, J., Rennies Wetlands Project 1997 , SECOND EDITION)

Plant name	Distribution	Optimal position in the channel
Dichantium annulatum **Vlei Finger Gras**		All positions except permanent zone, including adjacent terrestrial zone.
Bothriochloa insculpta **Pinhole Gras**		All positions except permanent zone, including adjacent terrestrial zone.
Typha capensis **Bulrush**		
Phragmites australis ***P.mauritianus*** **Common reed**		
Echinochloa colona *E. crus-galli* Jungle rice Watergras		
Cynodon dactylon *Couch grass* Kweek isiFulwane		
Leersia hexandra **Wild ricegrass** **Wilde rysgras**		
Cyperrus papyrus Papyrus		
Juncus kraussli *J.effusus* Juncus iNcema		

Plant name	Distribution	Optimal position in the channel
Hermarthria altissima Red swamp grass Rooikweek		
Cynodon dactylon *Couch grass* Kweek isiFulwane		
Imperata cylindrica Cottonwool grass Dousgras um Thente		
Acacia karroo **Sweet thorn** **Soetdoring** **umunga**		
Acacia robusta Splendid thorn Enkeldoring		
Ceitis africana White stinkwood Witstinkhout um Vumvu		
Halleria lucida Tree fuchsia Notsung iMinza		
Llex mitis African holly Without iPhuphuma		
Leucosidea sericea Oldwood Ouhout umTshitshi		
Myrica piluifera Broad-leaved waxberry Breeblaarwasbessie		

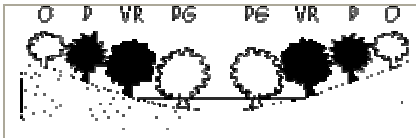
Plant name	Distribution	Optimal position in the channel
Searsia (Rhus) lancea **Willow rhus Karee** ***& Searsia (Rhus) pyroides***		

Table 2: Species that should be included in Hydroseed-mix

Scientific name	*Common name*
Bothriochloa insculpta	Pinhole grass
Themeda triandra	Red grass
Setaria incrassata	Vlei bristle grass
Digitaria eriantha	Finger grass
Cynodon dactylon	Couch grass
Eragrostis curvula	Weeping love grass
Imperata cylindrica	Cottonwool grass
Panicum maximum	Guinea grass

Table 3: Vegetation species for rehabilitation of stormwater retention pond and outlet swales

Scientific name	Common name
Shrubs, sedges and bulbs	
Berula erecta	
Cyperus spp.	
Gomphostigma virgatum	Otterbossie
Juncus kraussii	
Juncus effuses	Rush
Typha capensis	Bulrush
Melianthus major	
Wachendorfia thyrsiflora	Bloodroot
Grasses:	
Bothriochloa insculpta	Pinhole Gras
Acroceras macrum	Nile grass
Cynodon dactylon	Couch grass
Digitaria eriantha	Finger grass
Eragrostis curvula	Weeping love grass
Eragrostis teff	
Imperata cylindrica	Cottonwool grass
Leersia hexandra	Wild ricegrass
Panicum maximum	Guinea grass
Setaria sphacelata var *sphacelata*	

CHAPTER 2: STORMWATER MANAGEMENT - REHABILITATION AND RE-VEGETATION GUIDELINES

1. Proposed Ecological input into Storm Water Management Plan

A stormwater management plan should address stormwater volumes / velocities and storm water quality. The following management choices can be considered for use in controlling urban runoff volume and velocity. These are:

1. Provide permeable surfaces and address increased runoff volumes at source, which is a proactive, and efficient way of dealing with runoff;
2. Attenuate flows within the drainage system, to reduce runoff velocity and provide permeable surfaces. This can take the form of constructed retention / stilling basins, grassed swales, wetlands and weirs within a drainage system. The old quarries on the site, with rehabilitation, provide an ideal opportunity for attenuation and detention ponds.

Key storm water quality management issues that need to be addressed have been identified by Schoeman *et al* (2001) as:

1. Concentration of faecal bacteria should meet given water quality standards for recreational use of receiving water bodies at all times;
2. Unsightly litter in and along drains and natural water courses should be kept to a minimum;
3. Dissolved oxygen concentrations should ideally not be depleted below 80% of saturation in any part of a freshwater body that receives urban runoff;
4. Suspended sediment loads in urban runoff should be maintained at low levels to ensure that water quality is not adversely affected in the long run;
5. The nutrient balances in rivers receiving urban runoff should not be changed significantly (<15%) from their present status;
6. No toxic chemicals (pesticides, heavy metals, etc.) should be discharged into receiving waters;
7. Wetlands should not be disturbed by urban runoff to the point that their structure or function become adversely affected; and
8. Management actions aimed at reducing diffuse source pollution from urban runoff and informal settlements must form part of integrated catchment management.

These key management issues must form the basis for a storm water management plan for the study site. Various storm water management options exist, which do not only facilitate a reduction in storm water flow velocity and volume, through increased infiltration / retention, but also facilitate an improvement in storm water quality.

The following alternatives can be considered based on the limited capital works and maintenance required and the relative safety of these measures to the local community.

1.1 Grassed swales adjacent to major roads and parking areas.

This type of vegetated filter systems, not only ensures infiltration of storm water, thereby addressing storm water volume and velocity, but also enhances the storm water quality. This takes place because of filtration of solids by the soil matrix, adsorption of dissolved ions in the soil matrix as well as de-nitrification and oxidation by soil micro-organisms. Grassed swales (Photo 1) take the form of grassed linear detention ponds. Up to 80% suspended solid removal have been suggested, but only if the soil has a high infiltration rate, the flow velocities are less than 0.15 m/s and the land slope is less than 0.03m/m. These swales can be incorporated into the shoulders of main roads and parking areas. Adequate space, a minimum of 3 to 4 metres on either side of the road would however be required, and may limit the implementation of this option.

Photo 1. Example of a grassed swale.

Overflow from this grassed swale can then diverted into the existing storm water infrastructure and / or retention features.

1.2 Grass Plots

These consist of plots of open grassland, with a 1:60 to 1:120 slope. The runoff is spread over open grassland at a rate of 0.4 to 0.7 m^3/m^2/day. Reduction of 50% Suspended Solids and Biological Oxygen Demand have been recorded while up to 60% ammoniac nitrogen reduction and 30% nitrate nitrogen reduction have been observed (Campbell *et.al.*, 2001). The distribution of storm water over such a large undeveloped area would also facilitate a reduction in storm water volumes and velocities, due to the permeability of the grassland.

1.3 Buffer Strips

These are vegetated buffer strips that decrease storm water flow velocities, and act to filter pollutants, before storm water is released into drainage lines and streams. A grass buffer set back from the waterline is commonly used for urban runoff. The effectiveness

of the buffer zone is dependent on its ability to assimilate, cleanse, or delay pollutants to pass through. This ability is a function of soil hydrological properties, surface cover and vegetation, as well as topography (Campbell *et al*, 2001). In general terms, the detention time of the buffer zone determines the success thereof. Over time, natural processes break down and diffuse nutrients, organic matter and bacteria. Storm water delay does not only result in smaller volumes of storm water, reaching the drainage lines and streams with lower velocities, resulting in a decrease in the potential physical damage (i.e. erosion and sedimentation) to the water bodies, but also in smaller amounts of pollution reaching natural water bodies.

1.4 Artificial Wetlands / Detention ponds /Attenuation ponds

Artificial wetlands, like natural wetlands, act as very efficient storm water management structures. Not only do wetlands deal with storm water volumes and runoff velocities, but also enhance water quality. Storm water flow velocities are decreased as a result of the hydraulic resistance associated with the vegetation and results in the settling of suspended solid, with concomitant adsorption of trace metals, phosphorous and hydrocarbons (Campbell *et al,* 2001) to sediment and organic particles. In addition, the plants and microbes assimilate nutrients and metals such as nitrogen, cadmium and zinc. Microbes facilitate nitrogen removal, through nitrification / de-nitrification and organic decomposition. This will facilitate storm water management and create additional habitat for waterfowl while contributing to the aesthetic appeal of the development. Similar developments have in the past successfully incorporated storm water detention features into the landscape design.

It is proposed to make use of on-site attenuation measures (vegetated infiltration systems) as well as man made artificial wetlands that will facilitate infiltration of storm water as close as possible to source. These measures are described the Riparian management plan and rehabilitation (Chapter 3).

It is also important to ensure that the vegetation is maintained as its survival is essential for effective infiltration. In addition, the incorporation of wetlands / detention ponds into the landscape design would add to the aesthetic appeal of the development.

Furthermore, it is recommended that the efficiency of the man made artificial wetlands be monitored. Therefore ecotoxicological tests are suggested at least on a biannual basis, within the in- and outlets as well as within the receiving waters in order to determine the impact of the stormwater on aquatic biota.

CHAPTER 3: SPECIES OF CONCERVATION CONCERN - IDENTIFICATION GUIDELINES

Table 4: Floral species of conservation concern (Species in bold have been identified on site)

Scientific Name	Protection Status	Suitable Habitat	Image
Crinum graminicola and ***Crinum bulbispermum*** Graslelie	Protected by the Gauteng Nature Conservation Ordinance 12 of 1983	Numerous specimens of *Crinum bulbispermum* have been identified within the floodplain of the study site.	
Hypoxis hemerocallidea	Gauteng Orange listed specie	Grassland, sometimes close to drainage lines and wetlands	 

Scientific Name	Protection Status	Suitable Habitat	Image
Boophane disticha Poison Bulb	Protected by the Gauteng Nature Conservation Ordinance 12 of 1983	Grassland, often in rocky places	 
Aloe species	Protected by the Gauteng Nature Conservation Ordinance 12 of 1983	Grassland, stony places	

Scientific Name	Protection Status	Suitable Habitat	Image
Eucomis autumnalis subsp. clavata Pineapple plant	Protected by the Gauteng Nature Conservation Ordinance 12 of 1983	Grassland, particularly moist places and rocky ridges	 
Scadoxus punicesu Red paintbrush	Protected by the Gauteng Nature Conservation Ordinance 12 of 1983	Shady places in grassland	 

Table 5: Potential Avifaunal Species of conservation concern

Scientific Name	Status	Description	Suitable habitat	Image
African Finfoot *Podica senegalensis*	VULNERABLE	Their plumage is dense, mainly olive-brown, spotted with white, finely barred black and buff in 1 spot and plain in 1 spot, all with whitish stripes above and below the eyes, or behind the eyes. The bill is bright red or yellow and the legs are bright black-and-yellow banded, green or red. The sexes differ in plumage. The female is usually browner, with a dull brown bill. The body is long in shape with very thin neck and head small. The legs set well back on the body with short Tarsus, long feet with lobed toes and strong claws. They swim silently and seldom dive. They submerge with only the head and neck showing when alarmed.	Wooded rivers and streams, particularly rivers with overhanging vegetation as occur on the site. They inhabit mostly quiet wooded streams and rivers, flanked by thick riparian vegetation and overhanging trees. They can also be found on dam verges, especially where there is sufficient overhanging vegetation and reed cover. Finfoot avoid both stagnant and very fast flowing watercourses and have a preference for clear rather than silted water. The nest is an untidy deep bowl of coarse grass, reed & rush leaves and thin twigs. It is normally placed 1-2.5 m (up to 4 m) above water on an overhanging branch and fairly well concealed. They also build nests in and on flood debris and in rushes above water level.	 African finfoot juvenile,. [photo Trevor Hardaker  African finfoot. [photo Sion Stanton ©]

Scientific Name	Status	Description	Suitable habitat	Image
Half-collared Kingfisher *Alcedo semitorquata*	NEAR THREATENED	The Half Collared Kingfisher has a blue head and back with a white coloured throat. The bill is black and the legs red.	A freshwater inhabitant that is uncommon and thinly distributed within its range, preferring narrow rivers, streams, estuaries and coastal lagoons that are associated with dense vegetation. Birds are often seen singly or in pairs, perched on tree branches over water in search of prey. Nests consist of burrows which are dug vertically into riverbanks. Characteristically, the entrance is usually wider than it is high and is often concealed by overhanging vegetation.	
Lanner Falcon *Falco biarmicus*	NEAR-THREATENED Marginally suitable habitat is potentially present on site.	The Lanner Falcon has a height of 48 cm and weighs around 690 g. The head is coloured brown while the bill is coloured grey. The *Falco biarmicus* has a white coloured throat, yellow legs and a brown coloured back. The eyes are brown.	Mountainous or open country. Generally, nests in cliffs or wooded areas associated with cliffs. Forage over grassland, savanna, agricultural land and urban to suburban areas. 	 Lanner falcon juvenile. [photo Johann du Preez]

Scientific Name	Status	Description	Suitable habitat	Image
White-bellied Korhaan *Eupodotis cafra*	VULNERABLE Marginally suitable habitat is present on site.	The White bellied-Korhaan is approximately 50cm tall, with a blue coloured head, black throat, brown back and white belly. The bill is red and the eyes black while the legs are yellow. The White bellied Korhaan is generally found living in territorial groups. It has a distinctive, far carrying vocalisation which is often used to identify the species as it is fairly inconspicuous due to the tall vegetation it is associated with.	Endemic to Southern Africa. The bird is largely sedentary not moving excessively between areas. Occur in taller grassland, occurs in fairly dense, tall savannah grassland which is lightly wooded or open. The presence of some bushes is preferred to provide shelter for adult and juvenile birds as well as nests.	 [photo Dennis Gerrans]

Table 6: Amphibians of conservation concern

Scientific Name	Status	Description	Suitable habitat	Image
Giant Bullfrog *Pyxicephalus adspersus*	NEAR THREATENED	The Giant bull frog is one of the biggest frogs, weighing up to 2kg's. They are very broad, with a short, rounded snout, protruding jaw and tooth like projections in the lower jaw. Very little webbing is present on the feet. The hind legs are very strong allowing the bull frog to dig holes in the ground when it is ready to aestivate. Bull frogs are known to travel up to 1km to find an appropriate aestivation area within its preferred grassland habitat. The adults are dull green in colour with the males and females displaying yellow and cream coloured throats respectively. The juveniles are bright green and have a yellow stripe down their back which disappears as they mature. The tadpoles are fat and heart shaped having a grey to black colour. The eyes are close together and situated on the top of the head.	The Giant bull frog is found mostly in open grasslands in association with wetlands and / or pan depressions where water collects. They use these areas for breeding and foraging. They feed on insects, small rodents, reptiles, birds and amphibians. They are known to be highly aggressive and not afraid to defend themselves.	 Photo sourced from http://www.avertuqueentiendes.wordpress.com/.../  Photo sourced from https://www.ewt.org.za/newsletter/february2006/

Table 10: Mammals possibly inhabiting the site

Scientific Name	Status	Description	Suitable habitat	Image
Bush Baby *Ceropithecus albogularis*	LEAST CONCERN	The Bush Baby is about the size of a squirrel. It is very vocal and produces loud, shrill cries. They are arboreal (tree dwelling and nocturnal) and have large, round eyes and bat-like ears which enable them to track their food in the dark. Bush babies are fast and agile often jumping though thorn bush or thick growth as they travel through trees.	Bush Babies are in woodlands and bush lands, often in association with Acacia's. They prefer trees with little grass around them where they live in tree hollows that provide shelter. Nests are sometimes constructed in the forks of branches, although this is least preferred.	 Photo sourced from: http://www. awf.org
Hegehog *Erinaceus frontalis*	LEAST CONCERN	Body covered with small spines, except for their belly, face and ears, which have a fine fur covering them. The spines are dark chocolate-brown and black in colour with a well developed white band of fur across the forehead. The underbelly fur is greyish brown. The ears and tail are fairly short, and the snout is pointed. mostly solitary and nocturnal. They tend to be more active at dawn and dusk, when the weather is cool. Seasonally, hedgehogs are more active in the summer months.	Wide variety of habitats such as grasslands, scrub, rocky areas, savannah, and suburban gardens. Their requirement for good habitat is dry cover where they can rest and rear their young. Hedgehogs eat mainly insects such as beetles, grasshoppers, earthworms and centipedes although they will consume carrion, plant matter and birds eggs.	

CHAPTER 4: FIRE MANAGEMENT - LEGISLATION AND METHODOLOGIES

1. Legislation

National Veld and Forest Fire Act

The National Veld and Forest Fire Act (No. 101 of 1998) or NVFFA deals with the prevention and combat of veld, forest and mountain fires throughout South Africa, and should be adhered to when burning is considered.

Chapter 4 of the NVFFA emphasises the duty on owners to prepare and maintain firebreaks. Chapter 4 also explains the duty and procedure with regards to firebreaks and the role of adjoining owners and the Fire Protection Associations (FPAs).

Chapter 5 of the NVFFA deals with the duty imposed on all owners and equipment needed. It is the duty of the owner to acquire equipment and have available personnel to fight fires. It also provides a description of the roles and responsibilities of other persons and officials with the power to enter land and fight fires during an emergency. It provides also for agreements to be entered between the Minister and FPAs, or between such associations, to assist each other in case of an accidental fire.

Chapter 7 of the NVFFA deals with offences and penalties.

Chapter 8 of the NVFFA deals with law enforcement and sets out the powers of registered fire protection officers (FPOs) to police the provisions of the Act effectively. An interpretation guide to the National Forest and Fire Laws Amendment Act No. 12 of 2001 is attached in an appendix to this fire management plan.

2. Local Registered Fire Protection Association and FPOs

It is mandatory for any government or para-statal organisation to be a fully paid member of an FPA, but the private sector may become a voluntary member of an FPA. It is in the best interest of all landowners to join such an association. Membership will allow for co-ordination during fire management, allow the landowner to access data regarding the fire rating indexes and other useful climatic information available for his/her property.

The advantages of a registered FPA entail the following:

- Decreased risk of wildfires.
- Promotion of co-operation in managing veldfires.

- No presumption of negligence in civil claims.
- Cost saving through sharing of services.
- Advice and assistance to members from government and other services.
- Potential financial support from local government.
- Establishment of reasonable norms and standards for veldfire management in an area by means of FPA rules.
- Establishment of a fair and equitable basis for managing and sharing risk through an FPA's business plan.
- Powers under the Act conferred on registered fire protection officers (FPOs).
- Support from umbrella FPAs where these exist.
- Improved communication between FPA members.
- Improved communication between members and the Minister and other role players.
- Provision of possible relief from certain prevention measures, for example, the duty to create and maintain firebreaks.
- Stronger negotiation powers by virtue of being part of an organised group.
- Possibility of reduced insurance premiums.

When a landowner/proponent acquires a permit, they should notify the neighbours of their intentions in writing two weeks prior to any burning.

3. Training of Staff

All staff members engaged in burning should be at all times under strict supervision of an experienced manager. Basic fire fighting courses can be arranged through the FPO. Section 17 of the Act requires that an owner where there is a risk of veldfire, to have trained personnel for extinguishing veldfires. In addition, the Occupational Health and Safety Act applies to employees and anyone else who has been instructed to fight a fire. The Department is working with other role players to develop standards of training of personnel. Regulations under the Occupational Health and Safety Act provide minimum standards for protective clothing and training for fire fighters. A standby roster for staff is needed for weekends and public holidays.

4. Minimum Fire Fighting Equipment

Personal Protection Equipment (PPE) should include:
Fire retardant overalls, boots, hats and gloves.
Brightly coloured overalls and hats will to keep the fire fighting team visible.

Basic equipment for teams could include:

- Tractor with water cart and pressure pump;
- 4X4 vehicle with mobile water tank and pressure pump;

- Vehicle radios;
- Hand held radios;
- Cell phone;
- Kestrel 4000 (a pocket weather tracker);
- Drip torches (Flame throwers);
- Spot light;
- Venfire Knapsack sprayers;
- CP3 Chemical sprayers;
- Fire beaters;
- Tool box with necessary tools and spares;
- Steelbox for food and drinks; and
- First Aid box with additional oxygen apparatus.

The maintenance of fire fighting equipment is important and all equipment must be in 100 % working order. Water carts and Venfire Sprayers must be filled at all times.

5. Fire Management Sequence Events

The fire management plan adopts a policy whereby a natural fire-regime is simulated and includes active plot-burned monitoring to assess the status and success of the fire strategy. As general rule, all lightning-induced fires should be regarded as natural and must not be extinguished unless it endangers human lives, livestock, and infrastructure or if the conservation management plan dictates otherwise.

5.1 Timing of Burning

Burning during weekends (Fridays, Saturdays and Sundays), any public holiday or any day preceding a public holiday is prohibited.

5.2 Fire Frequency

It is generally decided that burns should follow a four year cycle. However, it could vary between annual burns to every four years, depending on outcomes from the monitoring programme. The condition or status of the vegetation will determine when and if burning should occur.

5.3 Tracer Lines

Tracer lines encompass the safe burning and implementation of firebreaks. It consists of two strips of approximately 100cm wide on both sides of the proposed firebreak. The fire team will then burn a firebreak between these tracer lines without wasting a lot of water during the burning process. A surveyor should mark out tracer lines along the borders of

the demarcated management areas to ensure that they are straight and parallel. Each tracer line should then be sprayed with a systemic herbicide.

Krige (1994) recommends the use of 2 % Roundup / water solution or 2.5 % solution when crossing wetlands, or Mamba (same active ingredient as Roundup) used in 2, CP 3 Spray cans with T-jet 8002 nozzles. All spraying should take place when the vegetation is still green and should correspond with windless days or when rain is not expected to occur within the next 6 hours after spraying (preferably during the months of January or February). Allow for at least two weeks for the chemical to work before burning commences. Tracer lines could then be burned from February until early April. All tracer lines must be sprayed and burned on a regular basis.

Tracer lines are unnecessary if the fire retardant, namely Fire Fix, is used during the burning of firebreaks. More water carriers will be needed and broad strips of about two meters on either side of the intended firebreak is sprayed about 50 meters in front of the progressing firebreak.

5.4 Firebreaks

The aim of firebreaks is to protect any piece of land or vegetation from external, runaway, or accidental fires. It facilitates block burns and protects human infrastructure against damage or at worst human lives. Firebreaks are to be applied along the borders of conservation open space and s*hould be 40 m broad.* Firebreaks should be excluded if a perennial river or tributary forms part of the border of a fire management area. In this case, the Juskei River will then perform the purpose of a natural firebreak.

Firebreaks should be burned in June when the grass is dead after severe frost. It becomes risky to burn in July due to the risk of run-away firebreaks. Burning should be avoided in May when late rain will cause re-growth of the grass. The firebreaks are burned between the two parallel tracer lines, and the direction of the wind will dictate the direction of burning.

The firebreaks around infrastructure do not need to be 40 meters broad, but must be broad enough to protect these facilities from controlled block burns. All infrastructure and prescribed blocks must be protected by mowed firebreaks (see 9). All boundaries on the study site should also be protected by firebreaks.

5.6 Mosaic Burns

Mosaic burns are defined as late-summer burns. These burns should only be implemented if appropriate knowledge of the standing biomass and veld composition is available and should be regarded as optional. Implementation of mosaic burns requires scientific input through years of trial burns, and if incorrectly applied, it could have

detrimental effects on the local plant composition and dynamics. Mosaic burns are commonly used to create patches of tall and short grassland at various stages of growth. This again is a simulation of a natural fire regime where lightning and grazing played an important role on vegetation dynamics.

Climatic conditions should be carefully analysed before ignition and must preferentially simulate conditions typical of an electrical storm. Mosaic burns occur during the late summer through point-ignition applied during the early mornings. These burns should correspond to areas that would have burned after the first spring rains. After ignition, the fire is left to burn on its own accord and will end on its own accord. These burns, if properly timed, will burn slowly since most of the vegetation is still green and the fire will die off at night at around 21h00 (Krige, 1994). *Please note that burning of wetlands should be avoided.*

5.7 Block Burns

Block burns should only take place when enough soil moisture is available to protect underground plant structures from damage. The time of burning should correspond with the start of the rainy season (preferably a day after precipitation occurred), but it is essential that the grasses and forbs are still dormant. As a general rule, ± 25 mm of rain is needed before enough soil moisture is available for burning to take place.
Block burns are burned to remove moribund material. A four year burn cycle is recommended for the grasslands within the conservation open space.

Ignition is done through point-ignition. Points are randomly chosen on relative high ground inside the selected block to simulate lightning-induced fires, whereby the fires will spread and burn the entire block. The different point ignitions allow animals to have flight paths (escape routes) away from the fire. Different blocks should not be burned simultaneously, but should be burned at least a week apart, depending on rainfall and soil moisture.

5.8 Monitoring

All fire activities should be mapped/recorded on an annual basis and a fire report must be compiled to keep track of annual burns. All burned areas, including accidental fires should be mapped accordingly. This information should inform the burning regime and fire management of the following fire cycle and provides for a detailed history of fire-driven events. Climate data (e.g. rainfall) should be noted and incorporated to the fire report. The build-up of such data across time will assist with decision-making regarding the appropriate timing of burns.

The veld condition should be monitored to assess the success of the fire management plan. The burning regime (frequency, timing or intensity) should be changed/altered if

veld deterioration or marked differences in species composition was noted. Thus monitoring of the compositional status (Decreaser vs. Increaser) and succession of the grassland will dictate current fire management practices. Also, the occurrence or decline of sensitive plant taxa provides information regarding the ecological health of a system.

6. Mowing and trimming

Mowing and trimming of natural grassland in close proximity of residential areas and other infrastructure is a necessary tool of successful fire management. However, mowing and trimming must be minimised in natural open space areas to encourage indigenous grasses to grow. If mowing is deemed necessary due to safety and maintenance concerns such as fire mitigation, the parcel closest to the houses may be mowed as follows.

- A strip 2m to 4.5m wide shall be maintained behind private property lot lines depending on adequate equipment access and grades on slopes that are no more than 4 to 1, unless fire mitigation requires a wider maintenance zone. The 2m strip is preferred to conserve staff time and to encourage a more indigenous character in open space areas.
- A strip 2m wide shall be maintained along improved landscape areas adjacent to open space unless fire mitigation requires a wider maintenance zone.
- A strip 2m wide shall be maintained behind curb lines adjacent to open space.
- Mowing is discouraged along trails within the conservation open space, unless necessary to allow for safe visibility or to address localized weed infestations. If deemed necessary, a strip 0.5-1.5m wide shall be created along trails depending upon terrain, availability of the proper size of equipment, and equipment access. The narrower 0.5m swath is encouraged to foster a more indigenous character in the open space.
- Mowed areas shall be cut at a height of 7cm to 15cm.
- Controlled burns may also be authorized in open space areas where no threats to private property would exist but must be limited to periods that would not impact on ground-nesting birds and when air temperature is cool (ideal time is prior to spring flush).

Table 11: A 12 month fire implementation strategy and sequence of fire events.

Month	Event
January	• Delineate tracer lines. • Start spraying tracer lines.
February	• Continue spraying tracer lines.
March	• Acquire and maintenance of equipment. • Start burning tracer lines. • Start burning mosaic burns (optional).
April	• Complete tracer line burns. • Complete mosaic burns (optional).
May	• Acquire fire/burning permits from FPO. • Employ labour and purchase PPE for June. • Notify neighbours regarding proposed burning. • Conduct veld condition and fuel load monitoring. • Test equipment.
June	• Train labour (1 day). • Notify FPA and start burning of firebreaks. • Complete burning of firebreaks. • Service and maintain equipment.
July	• Fight emergency and run-away fires (if occurring).
August	• Start block burns if rainfall is sufficient.
September	• Block burn if rainfall is sufficient.
October	• Complete block burns.
November	• Evaluate burning success through monitoring of veld condition.
December	• Compile annual fire report.

CHAPTER 5: ALIEN INVASIVE MANAGEMENT - METHODOLOGIES AND GUIDELINES

1. Removal Methods and Guidelines

There are three commonly used methods of alien plant removal. An effective approach often entails a combination of methodologies. The mechanical method involves tree felling and a 'hands on' removal approach often paired with the use of fire. For chemical methods, environmentally safe herbicides are used, while adhering to all relevant health and safety regulations pertaining to the use of hazardous chemicals. Mechanical and chemical methods are often combined. The third method of biological control involves introducing species-specific insects and diseases that control the alien plant in its country of origin. Mechanical and chemical methods are seen to have short-medium term effectiveness. Follow-up removals are needed periodically to prevent plant re-colonization. Biological control is seen to be an effective long-term approach to controlling alien plants. However, an ethical issue arises with trying to control an alien plant with an alien insect or pathogen. Specialist knowledge is crucial to guide biological control measures.

The initial control in most cases, involves mechanical methods and machinery (Table 2). The initial control aims to drastically reduce the number of adult and often large individuals of invasive plants. After initial clearance, tree stumps can readily coppice and in the absence of follow-up treatments, the infestation will proliferate and negate the initial control efforts. In addition, some plant species such as the Wattles produce large number of seeds that can lie dormant in the soil for a number of years. Soil disturbance and the removal of large trees that shaded the soil, often result in the copious germination of weedy plant species, which can easily be removed or sprayed when young. Follow-up control of alien seedlings and coppice re-growth is thus essential to achieve and sustain the progress made with initial control work (Table 3).

2. Integrated Control Strategies for Smaller Alien Plants (annuals)

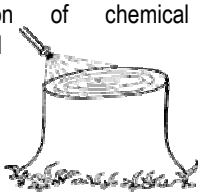
When clearing large blocks of aliens it is highly likely that alien herbs such as *Bidens* sp., *Tagetes minuta* and *Cirsium vulgare* would form part of the pioneering community which replaces the previous community.

Chemical control:

There are many alien herbaceous (soft/ non-woody) species. Alien herbs are called "broadleaf weeds" and some have pre-and post-emergent herbicides registered for their control e.g. in maize or sugar cane crops. However, where

alien herbs are associated with woody alien plants, herbicides registered for control of woody aliens are often also used for control of broadleaf weeds. Alternatively, glyphosate is used, as this is often registered for both woody alien species and alien herbs. NB: glyphosate is a post-emergent (foliar-applied) herbicide that is inactivated by soil.

Table 12: Initial control methods (adapted from Working for Water, 2007):

Initial control	Method	Methodology
Hand Pull Method	Mechanical	Gripping the young plant low down and pulling it out by hand (using gloves).
Tree felling	Mechanical	Trees can be felled and removed with the use of chainsaws, bow saws, brush cutters or cane knives
Cut stump treatment	Combination of chemical and mechanical 	Stems should be cut as low as possible. Apply the recommended herbicide mixed in water to the cut surface of stumps. *NB: Do not spray the sides of the stumps*. Apply herbicide mix within 1 hour after felling or the cut wound will seal.
Total Stump Treatment	Combination of chemical and mechanical	Apply the recommended herbicide mixed in diesel to the cut surface, down the sides of the stumps and to any exposed roots. Diesel carries the herbicide through the bark to the cambium. The herbicide mix can be applied even several days after felling. *Not all herbicides can be mixed with diesel – the label should be checked for the recommended carrier*.
Basal Bark Method	Combination of mechanical and chemical	The application of a suitable herbicide with diesel can be applied to the bottom 250 mm of the stem. Diesel carries the herbicide through the bark to the cambium. Applications should be by means of a low pressure, coarse droplet spray from a narrow angle solid cone nozzle. Stems with a diameter up to 50 mm should be treated to a height of 250 mm and stems above 50m diameter to a height of 500 mm. This method is only suitable for stems up to 100 mm in diameter.
Ring Barking Method	Mechanical and possibly also chemical	Bark must be removed from the bottom of the stem to a height of 0.75-1.0m. All bark must be removed to below ground level for good results. Where clean de-barking is not possible due to crevices in the stem or where exposed roots are present, a combination of bark removal and basal stem treatments should be carried out. Bush knives or hatchets should be used for debarking.
Frill Method	Mechanical 	Use an axe or bush knife and make angled cuts downward into the cambium layer through the bark in a ring. Cuts should be distributed around the entire stem and herbicide applied into the cuts.
Herbicide Plugs	Combination of chemical and mechanical	After felling holes should be made in the stump and plugs inserted to contain the herbicide. The herbicide will be released into the stumps.
Strip Bark	Mechanical	Bark should be stripped away from the tree from waist down into the soil. Bark comes away readily in the rainy season. Cambium is stripped with the bark. This cuts off the supply of food from the leaves to the roots, which slowly die. Bush knives are more effective than hand axes. No herbicide is used.
Burning Stem Bases		Branches are stacked around the base of stems and the wood is burned. This will control most of the trees. Spray any coppice re-growth.

Initial control	Method	Methodology
Soil Applied herbicide	Chemical	Certain herbicides are taken up by the trees and plants through the roots. Such herbicides are applied to the soil surface, leach into the target plant root zone and taken up by the plant, which will then die.
Shrubs smaller than 1m	Chemical	Where possible hand pull. Foliar application of a registered herbicide is required where shrubs cannot be hand pulled. Where grass is present, use selective broadleaf herbicides that do not harm the grass. Where dense seedling growth of uniform height is present, use knapsack sprayers with flat nozzles. Use solid cone nozzles of seedling of uneven height, coppice growth, root sucker and short saplings.
Shrubs taller than 1m	Chemical	Where shrubs are taller than 1.5m the height must be controlled by cutting, using sharpened hoes, cane knives or motorized brush cutters. For large areas of dense growth, use a tractor-mounted gyro-mover. After slashing or cutting plants, treat the freshly cut stumps or allow re-growth to knee height and then spray with a suitable registered herbicide.
Mechanical uprooting	Chemical	Uprooting of large volumes of shrubs promotes soil disturbance and erosion. This result in exposure of weed seeds. Germination of these seeds re-infests the cleared areas. Mechanical uprooting should be applied where the soil can be stabilized, e.g. by dense grass cover. When soil has been disturbed, it is advisable to sow grass seed immediately after uprooting and soil levelling has been completed.
Stem injection	Chemical (for invasive cactus species) 	Stem injection: Punch downward slanting holes into the main stem using a sharpened metal spike. Space holes around entire circumference of lower stems. Inject the herbicide directly into the plant – ensuring to inject around the stem. Follow label recommendations -

Table 13: Follow-up control methods (adapted from Working for Water, 2007):

Follow-up control	Method	Methodology
Burning	Mechanical	• Fire can destroy the seedling of invader species and increases the competitive ability of the grass sward. • Burning can also stimulate even growth of seedlings so that follow-up control measures are easier.
Cutting of coppice	Mechanical and chemical For re-sprouting or re-growth	• This is suitable for medium – high density infestations. Slash plants at a convenient height, e.g. knee height. Cutting dense plants is good winter work but it is tiring and must be well-organized. • Spray coppice re-growth during the active growing season, when there is enough leaf cover to absorb the herbicide.
Seedlings and saplings	Mechanical and chemical For re-sprouting or re-growth	• Hand pull seedlings when soil is wet, using gloves to protect the hands. • Burn grass to control saplings – the controlled burning of high grass fuel loads is another option in an integrated control program. NB: Any burning must be done in a controlled safe manner, and according to local burning regulations. Protect neighbouring veld during burning. Contact your local extension office for burning guidelines. • Fire can destroy the seedling of invader species and increases the competitive ability of the grass sward. • Many shrubs and trees coppice after burning. Treat any coppice growth with herbicide. If this is not done, the coppice will form multi stemmed plants. • Cut the plant with a brush cutter and treat the stumps. • Untreated plants can be controlled with foliar herbicide application during follow-up work.

Biological control:
Where alien herbs are found together with alien woody species, e.g. along roadsides, it is easier to use chemical control for all species than biological control that is only effective on one species. NB: Do not use chemical control where biological control agents have been released.

Rehabilitation:
Planting a quick-growing grass species on bare soil results in a dense rapid cover that successfully competes with establishing pioneer grasses and herbs, e.g. *Eragrostis teff* prevents invasion by *Bidens* species and *Tagetes minuta* after wattle control. Follow-up control of wattle seedlings using selective herbicides is sometimes used simultaneously to control these alien herbs.

3. Rehabilitation

Once the initial removal efforts are complete, the following measures ought to be applied:

3.1 Replanting

As the removal of alien plants leaves the ground bare, it is necessary to re-vegetate these bare areas immediately. Since indigenous plants may also be invasive, re-vegetation ought to be with indigenous plants that previously occurred on site, and are well adapted to the local conditions. For the grass layer, grass seeds may be used in the re-planting efforts. However, in the herb layer, young and established indigenous trees and shrubs should be planted instead of seed. This is due to the longer germination and growth times of herbaceous plants from seed.

3.2 Monitoring

Follow-up control and on-going monitoring is necessary to ensure that the indigenous plants are establishing themselves, and that alien plants are not returning to a site. This is necessary because the seeds of alien plants may remain dormant in the soil for years to come. The stringent removal methods outlined previously should be undertaken with each removal effort to ensure an alien plant is effectively removed.

Table 14: Invasive Alien species found within the study area.

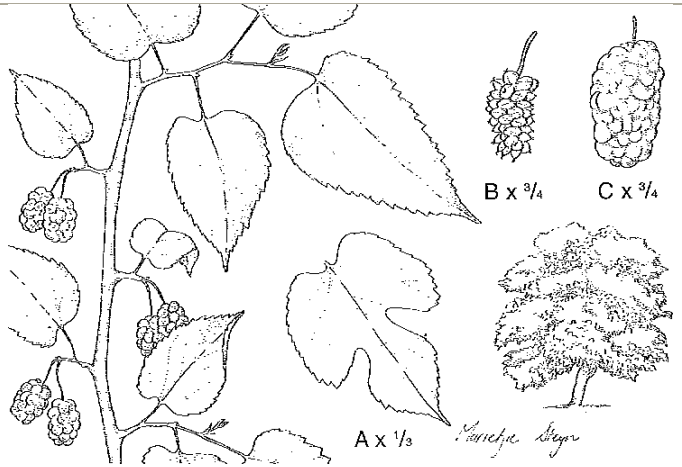
Scientific Name	Description	Image	Control Area
Acacia dealbata **Silver wattle** **Category 2**	• Winter flowering plant; flowers are yellow and occur in glabose (clustered) heads; and • Leaves appear to form a silvery grey crown and, though similar to *Acacia mearnsii* in appearance, the leaves are silvery grey or light green in colour.		Riparian area (River)
Agave americana **American agave / Garingboom** **Declared weed Category 2**	• Succulent shrub with a basel rosette of thick heavy leaves up to 2m long; • Suckers from the base; and • Leaves, succulent and grey with toothed margins. ☠ **Spines and sap are a skin irritant**		

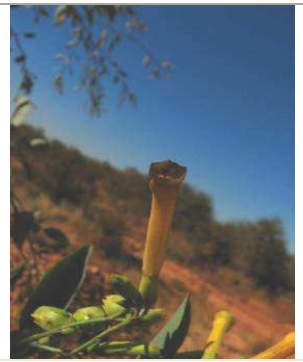
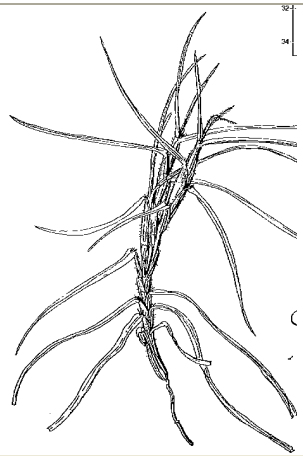
Scientific Name	Description	Image	Control Area
Arundo donax **Giant Reed** **Category 1**	• Large robust reed (2-6m); • Spreading from a horizontal rootstock; • Leaves are pale green to bluish green; Leaves tips soft or firm but no penetrating like *Phragmites mauritanus;* and • Flowers: cream-brown silky and compact spear headed.		Riparian and wetland areas; Quarries.
Camplinium macrosephalum **Pom-pom weed** **Category 1**	• Erect perennial herb with fluffy pink flowerheads (Dec-March); • Stems green to purplish; • Light green, lanceolate leaves; and • Invades grasslands.		Conservation Open Space.

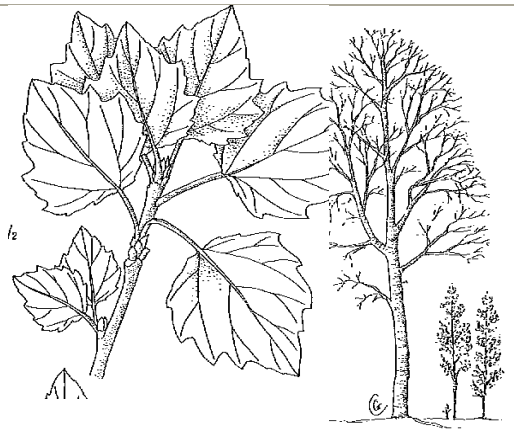
Scientific Name	Description	Image	Control Area
Cirsium vulgare **Scotch Thistle** **Category 1**	• Spiny herbaceous plant; • Leaves are large, flat rosette leaves; dark green with stiff hairs above, white woolly beneath, deeply lobed – lobes ending in strong spines; and • Pink-mauve flowers, surrounded by spiny bracts (September to April). ☠ **Spines may cause skin irritation**		Riparian and terrestrial areas.
Datura stramonium **Common Thorn Apple** **Category 1**	• Annual up to 1.5m tall; • Leaves dark green to purple, veins prominent purplish stems; and • Flowers white, mauve or purplish, narrowly funnel-shaped. ☠ **Whole plant and seeds are poisonous**		Riparian and terrestrial areas.

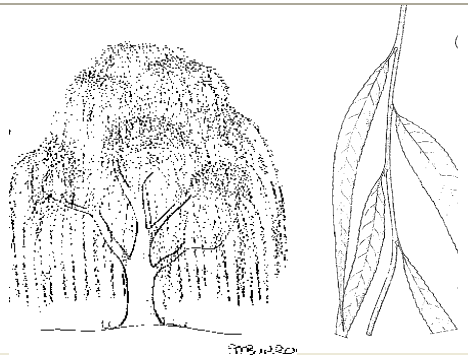
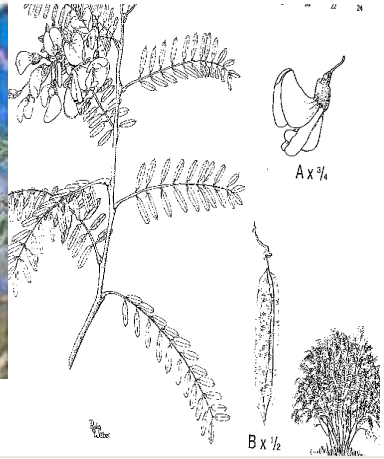
Scientific Name	Description	Image	Control Area
Eucalyptus camaldulensis **Red River Gum** **Category 2**	• Mainly single-stemmed; • Leaves of the mature plants are lanceolate (thin and tapering) and alternate (not opposite each other) with a waxy or glossy texture and aromatic when crushed; and • The bark varies with the age of the plant and can peel in strips.	 	Riparian areas;
Impomoea purpurea **Morning Glories** **Category 3**	• Climbing/twinning annual plant with hairy stems; • Funnel-shaped flowers ranging from purple, blue, red, magenta or white, sometimes with contrasting stripes; • Twining and hanging from trees/shrubs; and • Invades woodland and riverbanks.		Riparian areas

Scientific Name	Description	Image	Control Area
Lantana camara **Lantana** **Category 1**	• Square stems with rows of small thorns; • Thick, rough, pointed leaves that smell strongly when crushed; • Flowers are trumpet shaped and are borne in clusters which change colour with age; • Fruit is green changing to shiny purple-black when ripe; and • Perennial in growth and is a much-branched shrub or scrambler. ☠ **Whole plant and seeds are poisonous**		Riparian and terrestrial areas.
Melia azedarach **Syringa** **Category 3**	• Flowers are blue-mauve in color, borne in clusters at the ends of branches and pleasant smelling; • Flowering time is between October and November; • The fruit is an oval-shaped, three-seeded berry which becomes yellow and wrinkled when ripe; • Deciduous spreading tree with feather-like, compound leaves that are toothed at the margins. ☠ **Poisonous**		Riparian and terrestrial areas

Scientific Name	Description	Image	Control Area
Mimosa pigra **Giant Sensitive Plant** **Category 3**	• Shrub or tree, stems and leaves hairy armed with thorns • Compound leaves, yellowish-green with a straight thorn at the junction of each pinnae • Leaves sensitive to touch, folds up • Flowers pink or mauve • Pods are densely bristly, breaking transversely into segments each containing a seed	 	Riparian area;
Morus alba **Mulberry/ Moerbei** **Category 3**	• Deciduous tree with a dense, rounded canopy; • Leaves are bright green, turning yellow in autumn; • Small green flowers in Sept-Oct; and • Mulberry fruits turn black when ripe, juicy.		Riparian areas

Scientific Name	Description	Image	Control Area
Nicotiana glauca **Wild tobacco / Wildetabak** **Category 1**	• Evergreen, slender shrub or small tree, blue-green all over; • Blue-green leaves are leathery on long petioles (leave stalk); • Flowers are tubular yellow to light orange, drooping clusters, all year; and • Invades road sides, riverbanks and waste lands.	 	Riparian area
Pennisetum clandestinum **Kikuyu Grass** **Invasive grass**	• Mat-forming perennial grass commonly used in the past for garden lawn; • Grass creep by underground stems or runners; and • Bright green leaves with short hairs, folded at first then expanded.		Riparian area

Scientific Name	Description	Image	Control Area
Populus alba **Poplar** **Category 2**	• Deciduous tree, suckering freely; • Bark grey to white becoming rough and darker with age; • Leaves are dark green and shiny above and white or grey woolly beneath; and • Does not produce fruits.		Riparian areas
Ricinus communis **Castor-oil Plant** **Category 2**	• Annual, can grow up to 4m tall, shiny big leaves, palmate with 5-9 lobes (fingers), margins serrated; • Flowers: reddish (upper), cream (lower) on stalks; and • Fruits green, brown or reddish, 3-lobed capsul. covered with soft spines ☠ **Highly toxic seeds**	 	Riparian area

Scientific Name	Description	Image	Control Area
Salix babylonica **Weeping Willow** **Category 2**	• Branchlets slender, hanging down to the ground; • Leaves are bright green above and paler t grey beneath; • Leaves are finely toothed; • Fruits are greenish capsules; and • Tree reproduces from detached branches.		Riparian areas
Sesbania punicea **Red Sesbania** **Category 1**	• Deciduous shrub or small tree with slender branches; • Dark green, drooping pinnate leaves, ending in tiny, pointed tips; • Red-orange pea-like flowers in September to March; and • Brown seed pods, four winged with the tip sharply pointed. ☠ **Whole plant is poisonous**	 	Riparian and terrestrial areas.

Scientific Name	Description	Image	Control Area
Solanum mauritianum **Bugweed** **Category 1**	• Grow up to 8m tall; • All parts of the plant are hairy except for the older stems; • The oval shaped leaves are rather like tobacco leaves with 1-2 smaller leaflets (with no stalks) at the base of each leaf; • Leaves emit a strong smell when bruised; • Flowers are purple and produced in clusters at the ends of branches; • Fruits are also borne in clusters of 20-80. Each fruit may have 100-250 seeds; • Fruits are yellow and soft when ripe; and • Flowers all year round.	 When removed mechanically, the clouds of fine hair that are dislodged from leaves contain toxins that have been blamed for respiratory problems (Wear masks as part of safety clothing	Riparian areas