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ALIEN INVASIVE PLANTS MANAGEMENT PLAN

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1. INTRODUCTION

The National Environmental Management Biodiversity Act, 10 of 2004 (NEMBA), Section 76, states that all organs of state are required to draw up an invasive and alien plant monitoring, control and eradication plan for the land under their control. Such a plan must include:

(a) a detailed list and description of any listed invasive species occurring on the relevant land;
(b) a description of the parts of that land that are infested with such listed invasive species;
(c) an assessment of the extent of such infestation;
(d) a status report on the efficiency of previous control and eradication measures
(e) the current measures to monitor, control and eradicate such invasive species; and
(f) measurable indicators of progress and success, and indications of when the control plan is to be completed.

In terms of Section 4(2)(a) of the NEMBA all municipalities are required to manage and conserve biological diversity. This includes taking steps to control and eradicate invasive alien plants (IAP) in areas that they own or manage. The purpose of this document is to respond to this obligation and to coordinate Stellenbosch Municipality's (the Municipality) approach in this regard in order to reduce future IAP control costs and improve the integrity of the natural areas and ecosystems in Stellenbosch Municipality.

Stellenbosch Municipality's 1st IAP Management Plan was developed and approved by Council in 2017. This document serves as Stellenbosch Municipality's 5-year review and update of the latter.

2. THE SIGNIFICANCE OF THE REGION & THE THREAT OF IAPs

A primary reason for the conservation of the natural environment of the Greater Stellenbosch Municipality is that it forms an integral part of the world-renowned Cape Floral Kingdom. The Cape Floral Kingdom is internationally recognised as one of the six Floral Kingdoms of the world (0,06% of the earth's surface). It is the only Floral Kingdom contained, in its entirety, within a single country (Figure 1). The Cape Floral Kingdom is characterised by its exceptional richness in plant species and its endemicity. More than 8 700 species are known to occur, with more than 68% of these species being confined to the Cape Floral Kingdom. Thus, this Floral Kingdom compares with some of the richest floras worldwide, surpassing many tropical forest regions in its floral diversity.

The enormous diversity found in the Cape Floral Kingdom is attributed to the age of this kingdom. The last Ice Age had far less of an influence on this area that it did on the Northern Hemisphere. Plant life in the Northern Hemisphere was almost wiped out while conditions in the Western Cape were altered very little. The diversity can also be attributed to the harsh conditions and infertile soil of the area which has forced plants to adapt to ensure their survival. The Cape Floral Kingdom is of immense scientific importance, both nationally and internationally. It covers only 4% of South Africa, but contains 45% of all plant species of Southern Africa. About 75% of all plants in the South African Red Data Book are found in the Cape Floral Kingdom. Of these species, 1 700 are

threatened. Many Fynbos species are extremely localized in their distribution, with sets of such localized species organized into 'centers of endemism'[1].

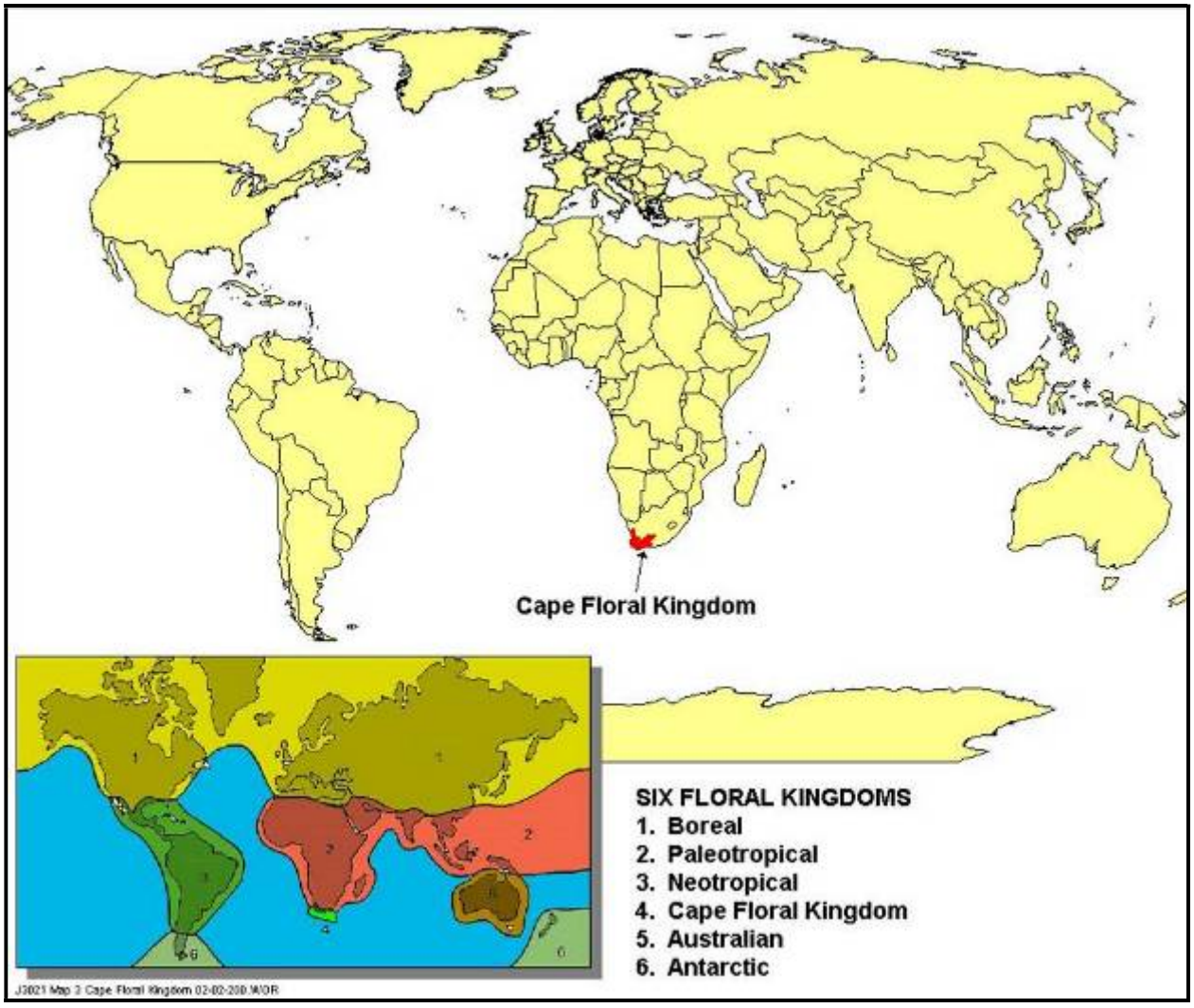

Figure 1: The Cape Floral Kingdom in International Context.

Biological invasion has become a major cause for concern worldwide. Being a result of human induced environmental change[2], biological invasion is not only threatening global biodiversity, but it plays a major factor in both global and local extinctions, as well as causing substantial economic and human health problems. Defined as exotic or non-endemic species, alien species become invasive by passing through a series of barriers and establish new populations in areas at a distance from their immediate area of introduction[3]. These barriers are geographic, environmental, reproductive, dispersal, environmental[4]. Consequently, the lack of native enemies and controlling agents enable these invasive species to out-compete native species for available

1 Low & Robelo, 1996.
2 Tsoar *et al*., 2011; Vitousek *et al*, 1997.
3 Richardson *et al*, 2000; Tsoar *et al*, 2011.
4 Richardson *et al*, 2000.

resources and space while altering the surrounding natural environment. This in turn leads to unnatural successions and the displacement of many natural vegetation communities[5]. The extent of this displacement of natural vegetation communities and thus the unnatural alteration of many native habitats has been of major concern for conservationists due to the dramatic effect they have on both native fauna and flora and, consequently, on many interactions and ecosystem structures which may have altering effects on ecosystem services that we as humans rely on[6]. As such, the main impacts of IAPs can be summarized as follow:

a) **Reduced stream-flow -** Invaded sites have a much greater biomass and total leaf area than un-invaded sites. This results in reduced infiltration, river and stream runoff through increased water uptake and evapo-transpiration per unit area. The conversion of fynbos to stands of invasive alien species may reduce water flow by up to 60%.
b) **Loss of indigenous plant species** - In the Fynbos Biome, invasion by invasive plants has resulted in the extinction of approximately 26 species, and approximately 750 plant species are currently at risk. It is predicted that the list of extinct species will grow rapidly as areas of invaded habitat increase. Probably more important is that the longer these thickets of alien invasive plants remain the greater their impact on the indigenous species. This is true because their presence prevents the germination of indigenous species and over time reduces the seed banks of available indigenous species.
c) Species in riverine areas and wetlands will **accelerate bank** erosion and alter the stream flow and thereby cause increased siltation of rivers, wetlands and dams, increase the risk of flooding, loss of suitable breeding habitat for indigenous fauna in particular fish and by reducing water quality.
d) I**ncrease in frequency and intensity of fires** - Not only do invasive plant species produce a greater volume of biomass (i.e. potential fuel), but they are often taller than indigenous plants, and thereby lead to more intense fires and greater flame lengths, than would be encountered in natural vegetation.

These impacts will have serious economic consequences which may could include:

i) Reducing the available water with the consequence that there is an increased need to build additional supply schemes, at considerable cost, reducing the total amount of water available for human use.
ii) Reduction in eco-tourism potential.
iii) Depletion of potential exploitable genetic stock of wildflowers and medicinal plants.
iv) Loss of potentially productive land.
v) Increased costs of fire protection and damage by wild fires.
vi) Erosion following fires in heavily impacted areas.
vii) Increased siltation of dams and rivers.

5 Enright, 2000; Le Maitre *et al*., 2002.
6 Le Maitre *et al*., 2002.

3. WHAT ARE INVASIVE ALIEN PLANTS

Invasive alien plants are plant species that have been introduced, either intentionally or unintentionally, to South Africa. They can reproduce rapidly in their new environments and, as mentioned above, tend to out-compete indigenous plants. The result usually includes a variety of negative ecological, social, and economic impacts. Invasive alien species pose the biggest threat to biodiversity after direct habitat destruction.

Approximately 8 750 alien species have been introduced into South Africa, 161 of which are seriously invasive species, and is estimated to cover over 10 million hectares (almost 8%) of South Africa's land surface. Expectations are that the impact will double every fifteen years if they are left un-managed[7]. Known for its renowned fynbos biome, the Western Cape is the most severely invaded province, with the wetter catchments of the coastal mountain ranges and the broad coastal lowlands being the most effected regions. The invasion of AIPs within the fynbos biome has called for elevated levels alarm since the early decades of this century[8]. Invasive plant species such as the *Acasia saligna* (Port Jackson), *Acacia mearnsii* (Blackwattle) and *Pinus pinaster* (Cluster Pines) are found in the fynbos introduced to enhance the value of the Cape's resources, pines originated from Europe while the *Acacias* are originally from Australia. Although many of these species still support several industries, their negative impacts are becoming more prominent, leading to an urgent need to protect our natural resources.

IAPs are characterised by being able to reproduce rapidly in their new environments, and this is usually due to a combination of factors, including:

- A lack of natural enemies in the new environment
- Resistance to local diseases and other plant pathogens
- Highly competitive growth and colonising strategies that provide them with a competitive edge, and an ability to out-grow local indigenous plants

IAPs can significantly alter the composition, structure and functionality of ecosystems. As a result, they degrade the productive potential of the land, intensify the damage caused by veld fires and flooding, increase soil erosion, and impact on the health of rivers and estuaries. Indigenous species may be reduced in numbers / coverage, or may be lost as a result of IAP infestations, posing a threat to South Africa's natural heritage in sensitive locations.

IAP infested natural habitats suffer reduced capacity to produce ecosystem services that help support a healthy and productive living environment for people. Availability of natural products, such as medicinal plants, fodder and building materials is decreased, and disease-carrying pests such as mosquitoes and rats may be more numerous due to a reduction in natural predators with declining ecosystem functioning. The aesthetic, recreational and cultural values of the natural environment are also significantly decreased where IAPs take over. IAPs also threaten local and national water security.

7 Schonegeval 2001; Versfeld, Maitre and Chapman, 1998.
8 Macdonals *et al*. 1985.

4. LEGISLATIVE CONTEXT

4.1 CONSERVATION OF AGRICULTURAL RESOURCES ACT, 43 OF 1983

In terms of the amendments to the regulations under the Conservation of Agricultural Resources Act, 43 of 1983 (CARA), all declared aliens must be controlled. Landowners are legally responsible for the control of invasive alien plants on their property. In terms of the above act IAPs are described to one of the following categories:

- Category 1: Prohibited and must be controlled.
- Category 2: May be grown in demarcated areas provided that there is a permit in place and steps taken to prevent spread.
- Category 3: May no longer be planted. Existing plants may be retained as long as all reasonable steps are taken to prevent spread, except within the flood line of watercourses and wetlands.

4.2 NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT, 10 OF 2004

The National Environmental Management: Biodiversity Act, 10 of 2004 (NEMBA), regulates all invasive organisms in South Africa. According to this act and associated regulations any species designated under Section 70 cannot be propagated, grown, bought or sold without a permit. Categories listed are:

- Category 1a: Invasive species requiring compulsory control. Any specimen of a Category 1a listed species must, by law, be eradicated.
- Category 1b: Invasive species requiring compulsory control as part of an invasive species control program. These species must be removed and destroyed.
- Category 2: Invasive species regulated by area. A demarcation permit is required to import, possess, grow, breed, move, sell, buy or accept as gift ant plants listed as Category 2 plants. No permits will be issued for Category 2 plants to exist in riparian zones.
- Category 3: Invasive species regulated by activity. An individual plant permit is required to undertake any of the following restricted activities: import, possess, grow, breed, move, sell, buy or accept as gift. No permits will be issued for Category 3 plants to exist in riparian zones.

Aliens that are regulated in terms of CARA as weeds and invader plants are exempted from NEMBA. This implies that the provisions of the CARA in respect of listed weeds and invader plants supersede those of NEMBA.

5. ALIEN MANAGEMENT PRINCIPLES

5.1 PLANNING & PREPARATIONS

Proper planning and preparations are fundamental to achieving cost-effective and successful IAP control. Once there is a formalised work plan for clearing IAPs preparation for clearing can begin. These preparations include procuring the required equipment and materials, having staff undergo the required training and ensuring that the relevant land-owners and neighbours are notified of the clearing activities before they are undertaken – if they are to be impacted on in any way.

NEM:BA – Section 75: Control and eradication of listed invasive species

(1) Control and eradication of a listed invasive species must be carried out by means of methods that are appropriate for the species concerned and the environment in which it occurs
(2) Any action taken to control and eradicate a listed invasive species must be executed with caution and in a manner that may cause the least possible harm to biodiversity and damage to the environment.
(3) The methods employed to control and eradicate a listed invasive species must also be directed at the offspring, propagating material and re-growth of such invasive species in order to prevent such species from producing offspring, forming seed, regenerating or re-establishing itself in any manner.

5.1.1 Planning

a) Species and areas have to be prioritized and cleared according to their impact on natural resources and their potential for spreading to non-invaded areas[9]. Considerations in this regard include:
   i) Aliens must be cleared in a manner that reduces the risk of cleared areas being re-invaded by other invaded areas. For example, upstream area should be cleared before downstream areas if the river transports the seeds.
   ii) A balance needs to be maintained between clearing new area and follow-up operations on previously cleared areas.
   iii) Prevention is cheaper than clearing and therefore un-invaded areas must be protected from invasion.
   iv) The economic benefits of clearing areas with high tourism, biodiversity, productivity or water yield potential are necessary to maintain the support for the continuation of the clearing project. In other words, the benefits of clearing, other than merely the cost, must be carefully considered.
   v) IAPs that pose a fire risk to houses or infrastructure should be targeted as a priority. Creating an effective “fire break” is important where woody/fire prone IAPs are located in dense stands near settlements, power lines etc.
   vi) Areas with young, less dense trees, which have smaller seed banks and a potential high rate of spread, should be targeted first. Focussing on these areas requires less

[9] Schonegevel, 2001.

resources and will prevent further invasion and the build-up of seed banks. Dense mature stands should be left for last, as they most probably won't increase in density or pose a greater threat than they are at the moment.

b) The ability and resources available for follow up operations should determine the size and location of the initial clearing operation.

c) Invasive trees located away from any structures or roads can be ring-barked, poisoned and left standing rather than felled.

d) To avoid the threat of soil erosion when clearing dense infestations of IAPs on steeper slopes, work should progress horizontally along the contours. IAPs should be cut in bands of approximately 3m in width along the slope contour; the cut material should then be rolled back so that it forms a "frill" along the band. This will help slow down water run-off. A 2m swath of uncut material should be left before starting on the next 3m wide band. As the cut bands start to re-vegetate, work on the uncut bands can begin.

e) On gentle gradients, clearing should start from the outside of a work block and move inwards towards the centre, to assist in containing potentially invasive plant material and seeds within a confined area.

f) Disposal of the cut IAP material needs to be carefully considered. Options may include: burning on site (this comes with serious risks that need to be managed, also, burning of some types of IAPs stimulates seed release or rapid seed germination), chipping and composting (this is not appropriate if the plant material contains seeds), use of the woody biomass for charcoal manufacture or transportation of the material to a garden refuse or landfill site for disposal. Whatever disposal method is selected must meet all legal requirements and must not create risk for local residents and infrastructure.

g) Identify the clearing methods that are best for the specific project site and target species, as well as associated field equipment and personal protective equipment (PPE) required.

h) Identify the required herbicides for IAPs if chemical control is to be used. Only herbicides registered for use on the target species may be used.

i) Identify training needs for project workers and supervisors based on the nature of the area to be cleared, the target IAPs and identified clearing methods. This may include IAP identification, safety training for use of specialised equipment such as chainsaws, specialised training for working in difficult or sensitive terrain.

5.1.2 Preparations

a) If there are neighbours to the area (where IAP clearing will take place) that may be negatively affected by noise, road- and pathway closures, or herbicide spraying associated with the clearing activities, they should be notified prior to the work starting.

b) Herbicides, equipment and PPE should be procured and be on site before the work starts.

c) A safe storage area for the herbicides must be established which is bunded to contain any leaking containers. Herbicide storage areas must be secured to ensure that children and animals cannot access the chemicals, and that the chances of theft are minimised.

d) A site camp may be set up to accommodate vehicles bringing workers onto the site, herbicide and equipment storage areas, ablutions and changing areas for workers. The site camp must be located outside of sensitive natural areas, must not restrict access routes or

points for local residents and businesses, and must not damage private property or community gardens. If the site camp is on private property, the land-owner must have given permission for use of this area.

e) All necessary staff and worker training must be completed prior to the clearing activities being started.

5.2 BUDGETING

AIP control is expensive. General items to be budgeted for include the following:

a) Labour
b) Equipment / tools
c) Herbicides
d) PPEs
e) Fuel

It should also be established to what extent follow-up action will be required so that provision in this regard can be made. If follow-up work is structured and done correctly the overall management costs should decline. If follow-up work is not done correctly, the initial investment in clearing is often lost. The latter must be avoided.

Always do sufficient research into the types of weeds present. Large gum trees will require significantly more resources to clear than a few bugweed plants. As such, a survey to determine species density and distribution, together with a table that assigns approximate costs to clearing each type of IAP present, is essential. If specialised IAP clearing contractors are to be used, be sure to compare quotations and qualifications / experience. If a team is not qualified or experienced, it is unlikely that they will implement effective IAP control.

5.3 CONTROL METHODS

5.3.1 Mechanical Control

Mechanical control involves the physical destruction or total removal of plants. Mechanical methods are generally appropriate for sparse infestations and for species that do not coppice after cutting. They include:

5.3.1.1 Hand Pulling

Hand pulling is the removal of plants by hand, ensuring that the root is also removed. Hand pulling is only recommended when an area is sparsely invaded, has a high rainfall (the soil should ideally be damp or soft), warm temperatures, sandy soils and the plants are small enough to be pulled out successfully with the roots intact. Hand pulling does create soil disturbance, but if the area is sparsely invaded such disturbances are unlikely to be ecologically damaging.

5.3.1.2 Manual removal using hand tools

Manual removal using hand tools such as cane knives, tree loppers and slashers can be used to remove IAPs. The use of hand tools is probably the most widely adopted and often the most effective of all the methods. This method is labour intensive creating numerous jobs. Methods of cutting the plants include:

Ring-barking: Useful for killing large trees. A cane knife or axe is used to remove the tree's bark and cambium, in a horizontal band about 30cm wide (about 50cm from the ground). Herbicide, if used, should be applied immediately after ring-barking on the cut area.

Cut-stumping: Plants with a stem/ trunk diameter larger than 10mm can be cut as low to the ground as possible with a saw or cane knife. Herbicide, if used, should be applied to the cut surface immediately after cutting.

Slashing: The seed stalks/branches of annuals (plants that die each year after they set seed) can be slashed with a cane knife, mattock, bill hook or slasher before the seeds have matured. This is an effective method significantly reducing the presence of viable seeds that will germinate in the new season. Costs are generally low for controlling annuals in this way, as no herbicide is required.

Strip-barking: With the use of a cane knife or axe, the bark of large trees can be stripped completely, from waist height down to the base of the trunk. Herbicide, if used, should be applied to the stripped surface immediately after strip-barking. This is an effective but time-consuming method.

Frilling: Small trees can be frilled by cutting an angled groove into the bark and cambium, right the way around the tree trunk. This can be achieved with either a cane knife or axe, depending on how hard the bark and cambium layers of the tree are. Herbicide is then applied into the groove, which kills the tree as it seeps into the cambium tissue. This is the preferred method of killing small trees, as it is usually much quicker and therefore more cost-effective than ring-barking or strip-barking.

Advantages	**Disadvantages**
Effective method in areas with low infestations	Not an effective method for dense infestations, as the cost of clearing is extremely high, with little or no impact
High job creation	Time consuming – may be slower to complete than other forms of control
No contamination of water with herbicides as these are applied directly to the tree	If no herbicides are used then the manual control techniques must be very well executed to ensure success

5.3.1.3 Manual removal using mechanised tools

A variety of mechanised tools can be used for IAP clearing. They include:

Brush-cutter: Heavy duty motorised brush-cutters that are usually powered by a small two-stroke engine are popular for controlling low-growing thickets of IAPs. Importantly, a suitable blade must be fitted to the brush-cutter. For example, fitting a steel blade will allow for cutting of thicker stems. Herbicide application to the cut stems should follow immediately after cutting.

Chainsaw: A chainsaw is ideal for felling large trees and can be used to cut logs and branches into shorter lengths. Common target species for felling include large specimens of Syringa, Pine, Gum and Wattle. Training for chainsaw operators is essential. Operators need to understand the techniques of felling, i.e. ensuring that the tree falls in the desired direction. Each operator must also understand and be able to apply the necessary safety precautions during the felling process. Understanding the effective use and operation of the chainsaw itself is critical. The operator should also have the means and knowledge to undertake any required onsite servicing of the motor and sharpening of the chain.

Advantages	**Disadvantages**
Dense stands of IAPs can be cleared	The cost of the equipment, fuel and servicing – although this may be balanced by reduced labour costs
May be possible to clear very large areas of IAPs faster than without mechanised tools	Requires specialised training and more safety equipment than non-mechanised methods
	Possible pollution caused by oil

5.3.2 Chemical Control

Chemical control of IAPs involves the use of herbicides (plant poison) to kill targeted plants. Managers and herbicide operators must have a basic understanding of how herbicides function, as this will guide the correct selection of herbicides for different purposes and plants. The use of inappropriate herbicides and the incorrect use of the appropriate herbicides are wasteful and expensive practices. They often do more harm than good. This is especially problematic when working in close proximity to watercourses. Some herbicides can quickly contaminate fresh water systems and/or be transported downstream where they may remain active in the ecosystem. This is especially the case for herbicides with a high soil residual effect, i.e. herbicides that remain active after contact with soil.

Herbicides are classified as either selective or non-selective. Selective herbicides are usually specific to a particular group of plants, e.g. those specified for use on broad leaf plants will be effective on most broad leaf plants, but should not kill narrow leaved species such as grasses. Non-selective herbicides can kill any plant they come into contact with, and are therefore not suitable for use in areas where indigenous plants are present.

The contractor needs to have a valid Pest Control Operators Licence (limited weeds controller) according to the "Fertilizers Farm Feeds, Agricultural Remedies and Stock Remedies Act", Act No. 36 of 1947. This is regulated by the Department of Agriculture, Forestry and Fisheries.

According to Government Notice No. 13424 dated 26 July 1992, it is an offence to "acquire, dispose, sell or use an agricultural or stock remedy for a purpose or in a manner other than that specified on the label on a container thereof or on such a container".

5.3.2.1 Chemical Application Training

Protective gear must be used at all times and applicable guidelines for mixing and storing of herbicides must be adhered to. Herbicide applicators should have completed a certified training course. Herbicide applicators need to understand the implications of splash and drift. When a plant is sprayed with herbicide it is almost certain that excess herbicide will leave the target area. This might not be problematic in areas of high-density infestations (excess herbicide will either drift or drip onto other target IAPs), it is, however, problematic when there are many non-target species close by. The misting effect, where tiny droplets drift via a breeze to non-target species, often occurs when using high velocity nozzles. Ideally, low velocity and high-volume nozzles should be used for drenching, while high velocity / low volume nozzles should be used for misting.

5.3.2.2 Chemical Application Techniques

Chemical application techniques include foliar (leaf) application, stem applications (basal stem, total frill, stem injection) and stump applications (cut stump, total stump, scrape and paint):

Foliar spraying: This method uses a knapsack sprayer to spray IAPs below 1 metre in height. Leaves are sprayed to the point of run-off. Correct training and certification is essential before a team member uses this method. Foliar spraying is generally regarded as a cheaper method than cut stump treatment, because fewer people are required to treat larger areas. It does, however, require large amounts of clean water (for mixing with herbicides), and therefore only practical where water is available.

Handheld spraying: Handheld spraying is a means to apply herbicide after cut stumping, ring-barking, frilling and strip-barking. The most common and convenient handheld sprayer has a 1.5 litre capacity and a nozzle that can be set to achieve the correct spray width. Handheld sprayers are cheap, and application of herbicide is accurate.

Aerial spraying: Application of herbicides from a fixed wing craft or helicopter is primarily used for spraying very high densities IAPs present in areas that might otherwise be difficult to reach or control. The results are good, but aerial spraying is expensive and selectivity is impossible. Careful consideration of the herbicide type and mix

are essential, given the risks of contaminating water and the impacts to fish and other aquatic biodiversity as well as impacts on human health.

Advantages	Disadvantages
Achieve results over a short period (within 6 weeks of application)	Herbicides are expensive.
Large areas can be treated quickly	The use of herbicides may contaminate sites used for drinking water, for washing and for fishing, and can therefore threaten human and animal health
Complements mechanical control methods, increasing the effectiveness of IAP control activities	May kill non-target plants or species
	Specialised training and certification is required for use of herbicides

5.3.2.3 How to choose the correct herbicide

Choose the most appropriate herbicide by considering the following:

Active ingredient: Each herbicide has a chemical compound or active ingredient that makes it effective. Herbicides sold under different brand names may have the same active ingredient. It is critical that a herbicide with the correct active ingredient is selected. The concentration of the active ingredient can also differ from one product to the next. As such, the mixing ratios may differ. It is critical that the recommended mixing ratios are adhered to and the guideline document and label supplied with the product should always be consulted prior to calibration.

Residual effect: The residual effect is the length of time that a herbicide will remain active once in the soil. Some herbicides denature immediately on contact with soil, while others can remain active in the soil for up to two years. The shorter the residual effect of an herbicide, the less likely it is that non-target species will be killed.

Dye: Dye is often mixed with herbicides to ensure a clear visual indication of which plants have been treated and which have not. This allows workers to see where they have applied the herbicide. Some herbicides contain a pre-mixed dye that eliminates the need for on-site mixing of dye. If a dye must be added, ensure that it is of good quality and that it is chemically compatible with the active ingredient and adjuvant. The use of different colour dyes for different herbicides is a useful approach. It makes it very easy for workers to differentiate which herbicide to apply to which plants where such a distinction is required (e.g. red dye can be selected for herbicide used to treat Lantana, and blue for Blue Gum, etc.).

Registered herbicides: A large variety of herbicides and their supporting products such as dyes, wetting agents, etc. are available on the market, which have been registered for a range of IAPs. Beware of cheap imports that do not carry a South African registration number.

Recommended adjuvants: Some herbicides require the use of a "wetter", or adjuvant, to be effective. Always check if a product has a recommended adjuvant or if an adjuvant must be added for targeting specific IAPs. Herbicides applied to leaves by foliar application often require a specific adjuvant, as do those applied to trees with very waxy stems.

5.3.2.4 Choosing the correct 'carrier'

Either water or diesel can be used as a "carrier" for certain herbicides. However, water is the preferred carrier, because diesel is expensive and can have negative impacts on the environment. There is also often a risk of diesel theft. Diesel should never be used for foliar applications due to its very negative impact on the environment. Diesel should only be used in direct application to stems and run-off is to be minimised. In general:

- Only use herbicides that are registered for use on the specific species to be treated.
- Spray plants during the active growing period. When leaf colour starts to turn for winter it is too late to apply herbicides.
- Spray plants before the seeds are produced.
- Avoid using herbicides on drought-stressed or diseased plants or in extremely hot or cold conditions.
- Herbicide should not be applied during wet conditions, before or after rain. If it rains after application, it is important to monitor the effect as one may need to re-apply.
- Carefully read and understand the instructions on the label prior to initiating chemical control.
- Always store herbicides in the original container and in secure storage areas out of reach of children and animals.
- All persons must wear the required PPE when working with herbicides.
- Avoid skin contact with herbicides and avoid breathing in the vapour.
- Herbicide should always be applied immediately after the selected mechanical control method. Once the stem has dried it will not absorb the herbicide.
- Keep herbicide in the shade at the work site to keep it cool.
- To avoid spills, keep herbicide containers on a waterproof tarpaulin, or inside a big plastic bucket. When mixing herbicides, ensure that you use a funnel to avoid spilling.
- Containers containing mixed herbicide should be clearly marked (e.g. 'glyphosate mix'). Likewise, containers filled with water to be used for mixing herbicide should also be clearly marked to ensure that people do not drink from them.
- Always use a measuring jug to measure the correct quantity required.
- Keep the herbicide away from food.

5.3.3 Biological Control

IAPs thrive and spread in an exponential manner partly due to the lack of natural enemies (e.g. browsers or pathogens) that might occur in their land of origin. Biological control, or bio-control, is the introduction of these natural enemies to remove the plants' competitive advantage and

reduce population vigour to a level comparable to that of the natural vegetation. These natural enemies are termed 'biological control agents' and most include insects, mites and micro-organisms such as fungi or bacteria. Biological control agents usually attack specific parts of the plant. They can either attack the reproductive organs directly, e.g. on the parent plant (flower buds, flowers, or fruit), or the seeds after they have dropped. The 'stress' caused by a bio-control agent may kill a plant outright, or it might impact on the plant's reproductive capacity. In certain instances, the reproductive capacity is reduced to zero and the population is thus effectively sterilized. All of these outcomes will help to reduce rates of spread of the species.

Advantages	Disadvantages
Most environmentally friendly and most sustainable of all IAP control methods	Generally slow, especially initially
Usually does not require high or long-term maintenance	Low levels of infestation, with occasional outbreaks, will remain a feature of systems under biological control
Relatively low-cost implication over the long term	Any use of chemicals around biocontrol agent colonies may adversely affect the potency of this control method
	Cannot be used where the biocontrol agent would threaten commercial populations of the target species that may exist nearby.

5.4 FOLLOW-UP AND REHABILITATION

There will always be some measure of regeneration of the cleared IAPs after the initial clearing work has been done. Proper follow-up work is essential and should be conducted regularly. If follow-up clearing is not done, the progress made in the initial clearing exercise may be lost within a few years as the IAPs become re-established. Research has shown that if follow-up IAP clearing is executed properly and consistently the costs and time expended on each consecutive follow-up reduces drastically. The "maintenance" stage can then be reached, where regular monitoring will be required for any seedlings that may have germinated. Where dense stands of IAPs have been cleared the re-establishment of indigenous vegetation needs to be supported to help reduce the re-emergence of IAP species and to reduce the risk of soil erosion where the soil surface is poorly vegetated.

In most soils the seeds from the plants of the former natural habitat that occupied the area prior to IAP infestation still survive. So, natural regeneration without the need for planting may be possible in many cases. However, if natural regeneration is not likely owing to the length of time that IAP infestation has been in place, or if the soil has been disturbed so that the natural seed stocks are destroyed, planting / seeding is required. When planting for restoration purposes, it is not always easy to continue to access these areas to water / maintain the plants. It is thus important to use only plants that have been properly hardened off from the nursery production system to minimize the loss of plants. For complex restoration projects (for example involving the stabilization of major erosion areas and wetland rehabilitation projects involving the construction of weirs) it is necessary to contract the services of a specialist environmental rehabilitation professional to provide a plan and guidance on implementation.

In terms of follow-up cleared areas should be monitored regularly for emergent seedlings and remove these (hand pulling or chemical control). Maintenance work should be done in late summer when seedlings can be seen amongst the other plants and follow-up work undertaken on a 3 to 6 monthly basis, depending on the rate of re-growth. All areas of exposed soil should immediately be protected by placing packed brush on the slope, or creating erosion control barriers using branches, sticks or logs placed horizontally across the slope at 1m intervals (the steeper the slope the closer the barriers should be placed to each other).

If the soil remains relatively undisturbed and the area has some indigenous vegetation left intact the natural regeneration processes of the indigenous vegetation on the site should be managed. This involves regular follow-ups to remove emergent IAPs and protecting the area from other forms of disturbance while the vegetation re-establishes naturally.

If required, indigenous vegetation can be planted on the cleared areas. Plants used for rehabilitation purposes must be sourced from within 50km of the rehabilitation site to ensure that the genetic composition of the introduced plants is not significantly different from that of naturally occurring indigenous plants in and around the rehabilitation area.

5.5 MONITORING

In order to assess the impact of the clearing activities, follow-ups and rehabilitation efforts, monitoring must be undertaken. Photographic records must be kept of areas to be cleared prior to work starting and at regular intervals during the initial clearing activities. Similarly, photographic records should be kept of the area from immediately before follow-up clearing activities, and after. Rehabilitation processes / efforts must also be recorded. Records must be kept of daily operations, e.g. area/location cleared, number of labour units and amount of herbicide used. This will assist with planning as each site will require work, once or twice a year, for a number of years and of evaluating the costs against the benefits of the work.

6. SAFETY STANDARDS & GUIDELINES

Safety is of the utmost importance when dealing with IAP control. Staff often work in remote areas and with potentially dangerous tools and chemicals. The proper safety training and equipment is required.

6.1 HERBICIDE SAFETY

The herbicide storeroom needs to comply with national Occupational Health and Safety standards, as well as the municipal Scheduled Trade and Occupational Bylaws. Section ‘H’ in the bylaw is triggered if there is *herbicide manufacture, bulk blending, storage and commercial usage of herbicides*. Contractors who trigger these requirements will therefore need to be in possession of a permit for these purposes and will need to produce evidence to the municipality that they have satisfied all the requirements of the bylaw (municipal staff managing clearing operations need to meet these requirements). In general:

- A herbicide storeroom should have adequate ventilation, thus allowing fresh air to circulate within.
- Clean water needs to be available in close proximity to the storeroom.
- The floor must be non-porous. This is important so that when the floor is cleaned (which needs to be done on a regular basis) no residue of herbicides remain.
- Place herbicide containers on wooden pallets to increase ventilation and make mopping up after spillages easier.
- 'No Smoking' and 'No Fire' signs should be posted on the door of the storeroom as well as a sign stating that it is chemical store and who the responsible person is for the store.
- Keep the storeroom locked.
- A spill kit needs to be kept in the storeroom to mop up any spill. The spill kit must contain a bucket with sand and a spade. The sand is to be placed on the spill to absorb the liquid. Once the sand has absorbed the spill it is to be collected and disposed of where it cannot contaminate the environment. It is preferable to keep contaminated sand in a bucket and dispose of it at a certified chemical recycling plant.
- Obtain the Material Safety Data Sheet from the supplier of the herbicide and ensure that you are familiar with the product before using it. Keep the Material Safety Data Sheet in the storeroom in case of an emergency.
- Always store herbicides in the original labelled container to avoid confusion with other products. Do not store other products in the store, such as protective clothing, food, etc. as they may become contaminated.
- All empty herbicide containers, or herbicides that have reached their expiry date, need to be safely disposed of. This must be done at a registered chemical recycling company. It is important that all empty containers are spiked before disposal. This ensures that they cannot later be used for carrying drinking water, food, etc.

6.2 PERSONAL PROTECTIVE EQUIPMENT

The use of PPEs by staff controlling IAPs in the field is required by law. The PPE specifications differ for the different types of control. Mechanised control includes the use of a chainsaws and brush-cutters and will therefore require slightly different PPE from someone using manual control.

Table 1: PPE required for manual control.

Item	Specifications
Overall	100% Cotton, two-piece overalls are the best for absorbing perspiration, they last longer and are cooler. However, various cotton / polyester blends are available and suitable.
Rubber gloves	Standard rubber gloves for fieldwork are sufficient.
Leather gloves	Standard wrist length leather gloves are appropriate.
Safety boots	Investing in a good quality safety boot might save you in the long run. Gumboots or standard safety boots, which support the ankles, are acceptable. Steel toecaps are recommended for workers working with hand tools or with large trees.
Hat – (hardhat/ wide brim hat)	If working with large trees, on steep gradients or if any other safety risks may be present, then wearing a hardhat is advisable. Alternatively, a wide brim hat can be used to protect the worker from the sun.

Safety glasses	Large, clear safety glasses, which allow air to pass through, are acceptable.
Face mask	A face mask which covers the nose and mouth is essential when mixing herbicides and for foliar spraying.

Table 2: PPE required for mechanised control.

Item	**Specifications**
Chainsaw safety pants	Standard safety chainsaw and long pants that provide protection against the chainsaw.
Leather gloves	Standard wrist length, leather gloves.
Safety boots with steel cap	Steel toecaps are essential for safety of the workers. Safety boots, not gumboots, are to be worn as they provide support around the ankle.
Hardhat	A hardhat with a visor and earmuffs are necessary for all mechanised control.
Safety glasses	Chainsaw safety glasses provide total cover around the eye area, thus preventing wood chips, stones, etc. entering.
Raincoat	A standard two-piece raincoat. However, it is better not to use mechanised control when it is raining.

6.3 HEALTH AND SAFETY REPRESENTATIVES AND FIRST AIDERS

For every 20 people employed, one person needs to be trained as a first aider and a separate person as a health and safety representative. Appointments need to be made in writing and the person needs to clearly understand his / her responsibilities before signing. Persons appointed can be one of the workers, with these appointments bearing additional responsibilities. It is advisable to train an extra person as people can resign or be absent which leaves no first aider in the field.

7. STELLENBOSCH MUNICIPALITY

7.1 CONTEXT

Stellenbosch Municipality constitutes a geographical area of approximately 830km² and forms part of the Cape Winelands District Municipality of the Western Cape Province of South Africa (refer to Figure 2). The Municipality adjoins the Cape Metropolitan Area to the west and the Breede Valley, Drakenstein and Theewaterskloof Municipalities to the east, south and north respectively.

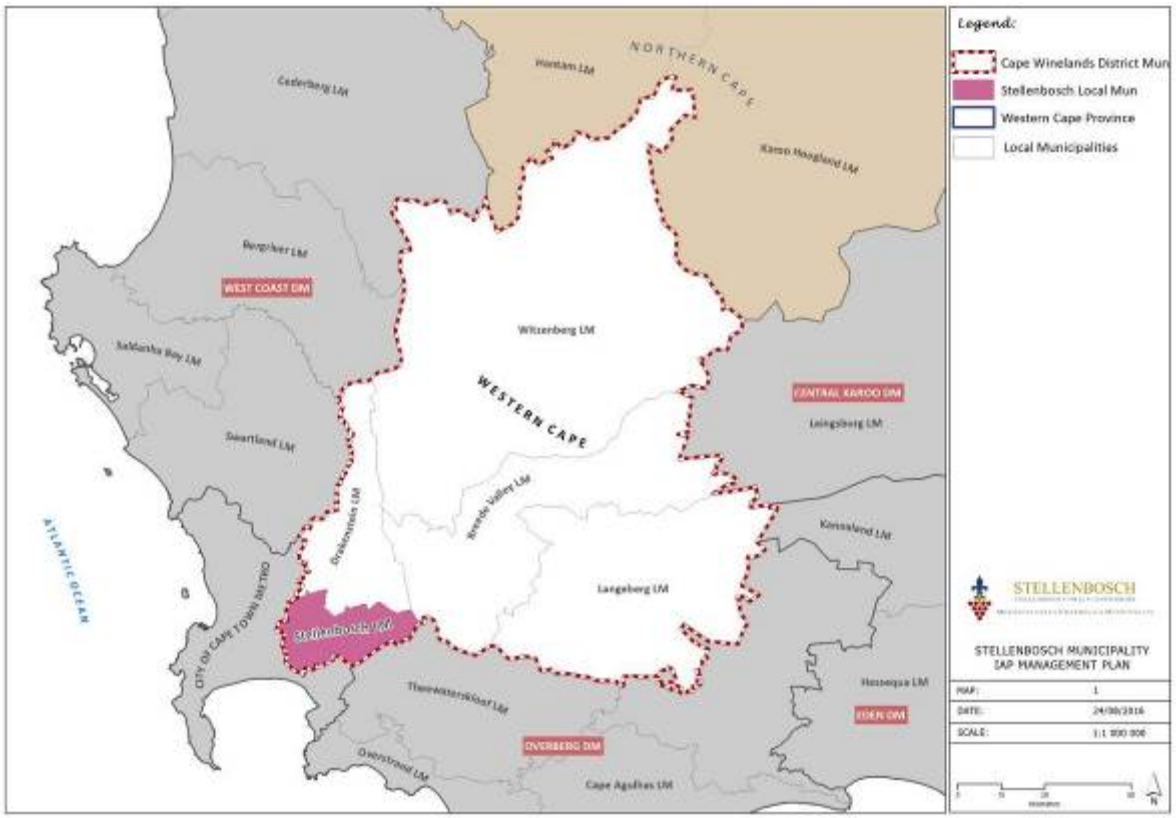

Figure 2: Location and context of Stellenbosch Municipality.

The Municipality is located in the heart of the Cape Winelands, which is dominated by agricultural land of historic and aesthetic value, and globally-important natural habitats. The Municipality is bounded to the east and south by the Drakenstein-, Wemmershoek- and Limietberg mountain ranges. The Hottentots Holland range (i.e. Stellenbosch, Jonkershoek and Simonsberg Mountains) and the Bottelary Hills are in the immediate vicinity of the town of Stellenbosch.

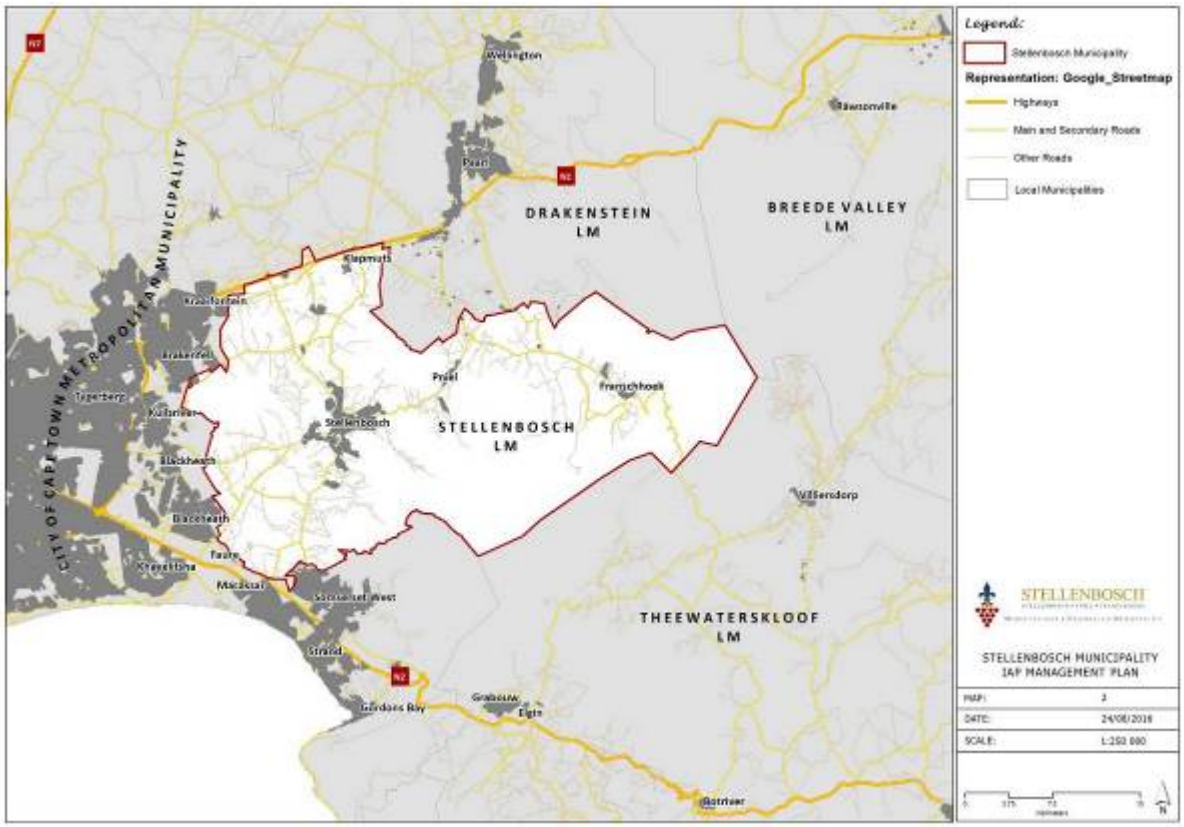

Figure 3: Local context of the Stellenbosch Municipality.

7.2 MUNICIPAL LAND FORMING PART OF THIS PLAN

Stellenbosch Municipality owns several properties with high conservation potential (Figure 4). These properties, that are the focus of this document, include:

Table 3: Properties included in the Stellenbosch Municipality IAP Management Plan.

Name	Farm Number	Area (ha)
Papegaaiberg Nature Reserve	175/5	138
	175/33	
	181	
	183	
Stellenboschberg	368/2	360
	369 (portion of)	
	366 (portion of)	
Idas Valley Dam Area	135/1	333
	135/2	
	119/4	
	119/7	
	119/8	
	169/1	
	171/RE	
	170/RE	
	165/1	

Botmaskop	3363 (portion of)	160
	119 (portion of)	
	119/7	
	333 (portion of)	
	328/12	
Louwsbos Plantation	502 (portion of)	58
Jan Marais Nature Reserve	2149	25
Mont Rochelle Nature Reserve	23	1 629
Wemmershoek Wetland Area	1024/1	40
Purgatory Outspan	1135/1	122

Culcattabos, that formed part of the previous Stellenbosch Municipality AIP Management Plan, no longer feature in this plan as this property will be developed for cemetery use.

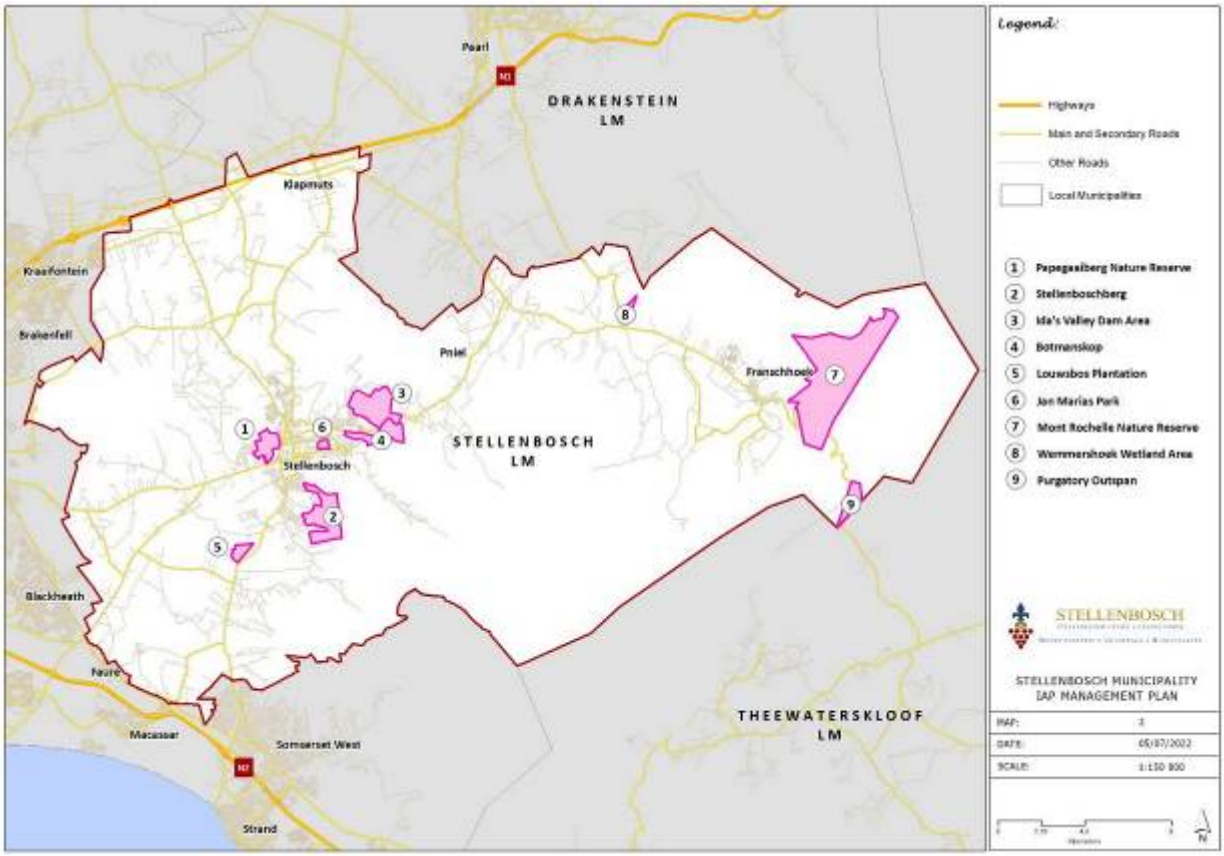

Figure 4: Stellenbosch Municipality properties that are the subject of this plan.

8. ALIEN INVASIVE PLANT SPECIES OF STELLENBOSCH MUNICIPALITY

There are several exotic plant species within the Stellenbosch region that has a negative effect on the indigenous fynbos biodiversity and ecosystems. The main invasive species are summarized in the table below. Each species has individual as well as collective negative environmental impact which effects the health and stability of the indigenous ecosystems in which they are found. If controlling methods of these invasive species are not implemented, continues invasive effects within indigenous areas may cause a loss of biodiversity with severe consequences on ecosystem health and -services.

Table 4: Description and impact of IAP occurring in Stellenbosch Municipality (Bromilow, 2010 / Striton, 1978).

Species Name	Category	Description	Environmental Impact
Scientific: *Acacia implexa* **Common**: Screw-pod wattle Lightwood Hickory wattle **Family**: Fabaceae	CARA Cat 1 NEMBA Cat 1a	Erect tree up to 15m tall, single-stemmed or divided near ground level into 2 or 3 main stems. Leaves dark green, narrowly elliptic and sickle shaped, 7-20 cm long and 6-25 mm wide, much narrowed at the base. Bi-pinnate leaves may persist on young plants. Bark rough and greyish. Flowers arranged in globular heads, creamy to pale yellow, flowering from December to March. Pods narrow, coiled and twisted to 25 cm long, 4-7 mm wide. Seeds are dark brown, longitudinal, fleshy tissue growing from the point of attachment of a seed.	• Fast growing • Invades agricultural land, planted forests and disturbed areas • Highly invasive if not controlled
Scientific: *Acacia mearnsii* **Common**: Black Wattle **Family**: Fabaceae	CARA Cat 2 NEMBA Cat 2	An evergreen tree growing 5-10m high, black wattle has dark olive-green finely hairy leaves. Pale yellow or cream spherical flowers in large fragrant sprays blooming from August to September. Fruits are dark brown, finely haired pods. Black wattle has invaded grasslands, competing with and reducing indigenous species, and reducing grazing land for wild and domestic animals.	• Decreases diversity of ground living invertebrates • Decreases stream flow • Destabilizations of stream banks • Can increase erosion, but also used for land stabilization
Scientific: *Acacia melanoxylon* **Common**: Australian Blackwood **Family**: Fabaceae	CARA Cat 2	An erect, evergreen, unarmed tree from 10 to 35 m in height, with a clean bole and dance crown. The bark is rough, fibrous and usually light grey-brown. The slightly curved, 6-12 cm long phyllodes (flattened-leaf-stalk) have 3-7 prominent longitudinal veins. A few feathery compound leaves are often present at the apex of phyllodes. The flowers are creamy white occurring in rounded inflorescences and are produced at the ends of branches or in the axils of phyllodes. Flowering usually occurs from August to September. Seeds are small, black and surrounded by a dull reddish seed-stalk.	• Fast growth rate • Major invader of forests, fynbos shrubland and grasslands • Transform native communities by replacing native non-tree vegetation

Species Name	Category	Description	Environmental Impact
Scientific: *Acacia pygnantha* **Common**: Golden Wattle **Family**: Fabaceae	CARA Cat 1 NEMBA Cat 1b	Slender, evergreen tree 4-8m high with drooping branches and dull green, leathery, distinctly curved leaves. Bright yellow, spherical flower heads in large sprays from August to September. Brown and almost straight pods.	• Competes with and replaces indigenous species • Invades coastal and mountain fynbos, rivers and roadsides
Scientific: *Acacia saligna* **Common**: Port Jackson **Family**: Fabaceae	CARA Cat 2 NEMBA Cat 1b	An evergreen tree, growing 3-7m high, with blue-green turning bright green leaves. Bright yellow, globe-shaped flowers bloom from August to November. Brown pods with hardened, whitish margins.	• Increases biomass • Changes nutrient chemistry in lowland fynbos • Changes seed dispersal dynamics • Changes size and distribution of fuel • Decreases moisture content resulting in change in fire regime • Attrition of seed banks of native plants in dense stands over time
Scientific: *Eucalyptus grandis* **Common**: Saligna gum **Family**: Myrtaceae	CARA Cat 2	A tall, evergreen tree with a shaft-like trunk 25-55m high with smooth bark except for the part of the trunk up to 4m from the ground. The bark peels in long, thin strips to expose a powdery, white, grey-white or blue-grey surface. Dark green leaves which are glossy above and paler below. Cream flowers appear from April to August. Brown fruit capsules with a bluish-grey powdery surface. This tree invades forest clearings, plantations, watercourses and roadsides.	• Reduces stream flow • Affects soil erosion to a variable degree • Competes with and replaces indigenous species
Scientific: *Paraserianthus lophantha* **Common**: Stink Bean **Family**: Fabaceae	CARA Cat 1 NEMBA Cat 1b	A fine bi-pinnate leaved evergreen shrub or tree growing 4-6m high, somewhat resembles the large-leafed black wattle (*Acacia mearnsii).* The dark green leaves are paler below, up to 300 mm or longer and golden-hairy. Cream-coloured flowers appear in dense, bottlebrush-like heads from June-August followed by brown compressed seedpods with raised edges. The seeds emit a nauseating odour when crushed and this tree is poisonous. It invades forest margins, riverbanks, moist slopes in fynbos and wooded kloofs.	• Competes with and replaces indigenous species • Reduce stream flow
Scientific: *Pinus pinea* **Common**:	NEMBA Cat 3	A coniferous tree 12-30m high, forming an umbrella-shaped crown with dense foliage at maturity. The trunk is straight, often forking with reddish-brown bark and deeply cracked into plates. Light green leaf needles in	• Out-competes native trees • Dense stands

Species Name	Category	Description	Environmental Impact
Umbrella Pine, Stone Pine **Family**: Pinaceae		bundles of two. Nut-brown, woody cones 10-15cm long. It invades grasslands and mountain fynbos.	limit options for fire management • Decreases stream flow
Scientific: *Pinus pinaster* **Common**: Cluster Pine **Family**: Pinaceae	CARA Cat 2 NEMBA Cat 2	A coniferous tree 8-15m high, conical when young, becoming cylindrical with a tall, bare trunk when older. Reddish-brown bark, which is deeply cracked into plates. Dull grey-green leaf needles in bundles of two. Cones initially purple, turning light brown 9-18cm long. This pine invades mountains and lowland fynbos.	• Out-competes and replaces indigenous trees • Dense stands limit options for fire management • Decreases stream flow • Reduces grazing
Scientific: *Pittosprum undulatum* **Common**: Australian chessewood **Family**: Pittosporaceae	CARA Cat 1 NEMBA Cat 1b	Evergreen shrub or broadly conical tree up to 12m high. Dark green, shiny leavers tapering at both ends and usually wavy margins at the end of the branches. Fragrant white flowers in terminal clusters from August to September. Showy, orange turning brown capsules.	• Competes with and replaces indigenous species • Indigenous birds might neglect the dispersal of indigenous plants due to their preference for the fruits of this alien species
Scientific: *Populus canescens* **Common**: Gray Poplar **Family**: Salicaceae	CARA Cat 2 NEMBA Cat 2	It is a medium-sized deciduous tree, growing to heights of up to 16-27 m (rarely more), with a trunk up to 2 m diameter and a broad rounded crown. The bark is smooth and greenish-white to greyish-white. The leaves are 4-15 cm long, five-lobed, with a thick covering of white scurfy down on both sides but thicker underneath. The flowers are catkins up to 8 cm long, produced in early spring. The female catkins lengthen to 8–10 cm after pollination, with several green seed capsules, maturing in late spring to early summer. It also propagates by means of root suckers growing from the lateral roots, often as far as 20-30 m from the trunk, to form extensive clonal colonies	• Form dense and uniform stands along riverbanks and in vleis. • Can spread into surrounding veld
Scientific: *Robinia pseudoacacia* **Common**: Black Locust **Family**: Fabaceae	CARA Cat 2 NEMBA Cat 1b	A deciduous tree up to 12m high, exceptionally 25m, with an oval or rounded crown and bark that is dark brown and deeply furrowed. It suckers freely and often forms thickets. Young stems and branchlets have short spines. Small, bright green leaves above and paler beneath which become yellow in autumn. White, fragrant flowers in drooping spray from September to November. Reddish-brown pods. The seeds, leaves and inner bark are poisonous seeds.	• Competes with and replaces indigenous species • Dense stands can cover vast areas • Can reduce and restrict water access to animals • Poisonous to human and domestic livestock

Species Name	Category	Description	Environmental Impact
Scientific: *Rubus fruticosus* **Common**: European Blackberry **Family**: Rosaceae	CARA Cat 2 NEMBA Cat 2	Thorny shrub to 2m high with strongly arching stems that root at the growing point of the shoot. Green leaves, sometimes grey-downy beneath. White or pink flowers with petals that is much longer than the sepals, appearing from September to January. The flowerheads are prickly. The edible fruits are red turning black.	• Hybridizes with native *Rubus* species • Competes with and replaces indigenous woody and grassland species • Dense stands are impenetrable and restrict access to forestry plantations • Restrict access to grazing and water by domestic and wild animals

Table 5: Summary of the IAP plant species within the relevant sites of Stellenbosch Municipality.

Species	Papegaaiberg NR	Stellenbosch-berg	Ida's Valley Dam Area	Botmaskop	Louwsbos Plantation	Jan Marais NR	Mont Rochelle NR	Wemmersh.	Purgatory
Acacia implexa	X	X	X	X					
Acacia mearnsii		X	X	X			X		
Acacia melanoxylon		X	X	X			X		
Acacia pygnantha		X	X	X					
Acacia saligna	X	X	X		X				
Eucalyptus globulus	X	X	X	X			X		
Hakea Sericea		X							
Paraserianthus lophantha									
Pinus pinea	X	X	X	X	X		X	X	
Pittosprum undulatum									
Populus canescens									
Robinia pseudoacacia									
Rubus fruticosus									

9. MANAGING ALIEN INVASIVE PLANT SPECIES IN STELLENBOSCH MUNICIPALITY

There have been many attempts to control the spread of invasive alien plant species since the 1940's, though success has been diminutive due to the easily spreading nature of these species. More recently studies have been researching the spread and effects of invasive species, though up until 1985 little has been written on the controlling aspects[10]. During more recent years many studies have been focused on prioritizing invasive species for their control and management[11].

Many management plans are at fault due to their focus on reducing the density of invasive species rather than the causing disturbance that leads to their establishment[12]. By only focussing on reducing the density of invasion species, and not the underlying causing disturbance, many of these plans lead to the control and management of one species, only to have another establish in the disturbed area[13]. Managing invasive species should thus firstly focus on managing for the ecosystem and the disturbance that caused their establishment in order to prevent further establishment of invasive species. Managing for the disturbance to ensure an increased ecologically and environmentally aware management plan should include ecosystem management, integrated environmental management and watershed management[14]. Though the general aim for invasive alien plant management is to clear and manage area by area, certain factors (such as the species present, terrain, availability of resources) may cause controlling efforts to be limiting and thus lead to an attempt for species controlling instead. An integrated controlling strategy is therefor required. An integrated controlling strategy involves the integration of control for management area ("block") in which more than one alien species may be encountered and the integration of mechanical-, chemical- and biological control of given species.

As described in more detail in the remainder of this document, during the last 5-year period, most of the areas listed under Section 7.2 above, or prioritised portions thereof. have undergone alien clearing efforts. These efforts have been documented to set new priorities, in line with those factors listed under Section 5.1.1 for the next 5-year period.

9.1 ALIEN INVASIVE PLANTS IN STELLENBOSCH MUNICIPALITY

The following sections were taken directly from the Management Plan for Alien Invasive Plants on Municipal Land in Stellenbosch Municipality[15], as contained in the Stellenbosch Municipality Invasive Alien Plant Management Plan (2017). The information has been updated as a result of the work done between the compilation of the above plan and this, the 2022, management plan. Actual implementation, however, will require verification and the degree of representation thereof as part of the planning of operations as described in Section 5.5.1 above.

10 Macdonals *et al*. 1985
11 Van Wilgen *et al*. 2007; van Wilgen *et al*. 2012
12 Edwards, 1998
13 Edward 1998; Allen and Starr, 1982; Allen and Hoekastra, 1992; Denny, 1992.
14 Edward 1998; Margerum and Born, 1995
15 Lizelle Koen, 2013

In the Management Plan for Alien Invasive Plants on Municipal Land in Stellenbosch Municipality[16] a general ecological description along with the current alien infestation was compiled for each site listed in Section 7.2 above. This was done to determine the best control strategy for the removal of invasive alien plants within each site. Within each site the densities of each invasive alien plant species was determined (see Table 5)[17] and recorded onto a generated map of each site. The table below has been simplified and the densities rounded off to facilitate mapping and classification. The table can also be used to convert between the different density measures e.g. from plants per ha and canopy diameter to density per ha.

Table 6: Guideline density conservation table for use in mapping aliens by species and size class.

	Size class	Tall shrubs	Medium trees	Tall trees
Rare				
Individuals are known to occur in the area, but are few and far between				
Occasional (>10 canopy diameters apart; <2% cover)				
Density (plant/ha)	Seedlings	<1100	<400	<400
	Young	<100	<40	<25
	adult	<40	<25	<10
Very scattered (6-10 canopy diameters apart; 2-3% cover)				
Density (plant/ha)	Seedlings	<3000	<1000	<1000
	Young	<250	<120	<75
	adult	<120	<75	<30
Scattered (3-6 canopy diameters apart; 3-5% cover)				
Density (plant/ha)	Seedlings	<10000	<3600	<3600
	Young	<900	<400	<220
	adult	<250	<150	<100
Medium (1-3 canopy diameters apart; 5-25% cover)				
Density (plant/ha)	Seedlings	1000-55000	3600-20000	3600-20000
	Young	900-5000	400-2100	220-1200
	adult	250-2200	150-1200	100-500
Dense (0.1-1 canopy diameters apart; 25-27%)				
Density (plant/ha)	Seedlings	55-350000	20-120000	20-120000
	Young	5000-30000	2200-14000	1200-7600
	adult	2200-14000	1200-7600	500-2000
Closed (<0.2 diameters apart; 75% cover)				
Density (plant/ha)	Seedlings	>3500000	>120000	>120000
	Young	>30000	>14000	>7600
	adult	>14000	>7600	>2000

For riparian strips: 10m wide = 0.1 ha per 100 m, 20 m wide = 0.1 ha per 50 m

9.2 ALIEN CLEARING WORK CONDUCTED

During the validity period of the previous Stellenbosch Municipality IAP Management Plan, especially during the financial years of 2020/21 and 2021/2022, extensive alien clearing work was conducted on a number of properties listed under Section 7.2 above. A total area of ±500ha

16 Lizelle Koen, 2013

17 Le Maitre and Versfeld, 1994

received attention during this time (Table 7). The mapping of these areas are included in the sections below.

Table 7: Areas cleared during the previous 2020/21 and 2021/2022 financial year.

	Blocks	Type / Implementer	Area cleared (ha)
Papegaaiberg Nature Reserve	3	Focus on acacia implexa / SANBI	13.4
Stellenboschberg	39	General / Stellenbosch Mun. and contractor	238.5
Idas Valley Dam Area	19	General / Contractor	84.1
Botmaskop	5	General / Stellenbosch Mun. and contractor	54.4
Louwsbos Plantation	13	General / Contractor	61.2
Raithby	11	General / Contractor	29.8
Wemmershoek Wetland Area	1	General / Stellenbosch Mun. and contractor	14.1
		Total	495.5

9.3 PRIORITIZING SITES FOR CLEARING STRATEGIES

The limitations of financial and labour resources prevent the simultaneous implementation of integrated controlling strategies within all invaded areas. Prioritizing of areas and invasive alien species is an important process when planning controlling strategies[18]. Factors to be recognized when prioritizing areas and IAPs for the implementation of integrated controlling strategies include the potential for maintaining control of priority areas, the relative cost effectiveness of embarking on a control programme, the role of visitor perception of the alien problem, the effect of alien plant species on water yield, and the identification of the source of invasion.

Le Maitre *et al*. (2002) also added that areas with high recreation value, indigenous biodiversity, low-density invasion (cover of less than 25%) and recent fire occurrence should have a high priority allocation. He also suggested that the identification of invasive alien species present is not as important as environmental characteristics of the area in which the site occurs. Another factor, which is important to consider is that of potential water release from removing invasive alien species. This is especially important within areas such as Stellenbosch where water availability becomes scarce during dryer seasons.

During the validity period of this Stellenbosch Municipality IAP Management Plan the listed municipal areas are prioritised as follows:

1. Ida's Valley Dam Area: The Ida's Valley Dam Area has a high functional value in the form of water supply to Stellenbosch. The removal of the IAPs from the area will aid in the increase of water availability. Extensive alien clearing was also done in the area during the past two years. Follow-up work should be implemented in these areas.
2. Papegaaiberg NR: Papegaaiberg NR contains highly endangered vegetation types. The NR did not receive a lot of attention during the past few years and must now be prioritized.

[18] Macdonald *et al*. 1985

3.	Mont Rochelle NR:	Mont Rochelle NR consist of a large area of intact undisturbed fynbos. It is of high recreational value visited by more than 13 000 tourists yearly. The NR did not receive a lot of attention during the past few years and must now be prioritized.
4.	Stellenboschberg:	Though this site is transformed, clearing efforts (change of land use from forestry) has led to disturbed areas which need to be continuously monitored and cleared to prevent the establishment of new populations of IAPs. The recreation value of the site is high due to its close proximity to residential areas. Because the above areas are located in close proximity to residential areas the threat of spread of wildfires through these areas. Extensive alien clearing was also done in the area during the past two years. Follow-up work should be implemented in these areas.
5.	Wemmershoek WA:	Wemmershoek Wetland Area contains highly endangered vegetation types.
6.	Louwsbos Plantation:	Louwsbos Plantation is located in close proximity to a residential area with the threat of wildfires spreading through the area. Extensive alien clearing was also done in the area during the past two years. Follow-up work should be implemented in these areas.
7.	Botmaskop:	Botmaskop has high recreational value, although it has been transformed for plantation. The upper portions of the area are of high biodiversity value. Extensive alien clearing was also done in the area during the past two years. Follow-up work should be implemented in these areas.
8.	Jan Marais NR:	Jan Marais NR is, in general, clear of IAPs. A section of the NR was burned during the April 2022. This section should be monitored for the accordance of any IAPs.

Purgatory Outspan is regarded as clear of IAPs and was not included in the prioritization list.

Importantly, in order to fully comply to the provisions of NEMBA, Stellenbosch Municipality will be applying for the relevant permits were listed species occur on its properties and such species will not be removed during the validity period of this management plan.

10. MANAGING ALIEN INVASIVE PLANT SPECIES ON A SITE SPECIFIC SCALE

10.1 PAPEGAAIBERG NATURE RESERVE

10.1.1 Location

Papegaaiberg is located within the town of Stellenbosch (Figure 5). Papegaaiberg Nature Reserve (NR) is bordered in the west by the Onder-Papegaaiberg residential area and the farm Middelvlei (Figure 6). Kayamandi forms the northern boundary while the industrial areas of Plankenbrug, the Bergkelder, Bosman's Crossing and Oudemolen collectively form the eastern boundary of the NR. The Stellenbosch cemetery and Oude Libertas borders the NR to the south. Papegaaiberg NR is approximately 140ha in size and rises gradually from all sides towards its highest point located more or less in the centre of the NR at approximately 159m above sea level. The area has been declared a NR in terms of Section 23 of the National Environmental Management: Protected Areas Act, 57 of 2003, in 2016.

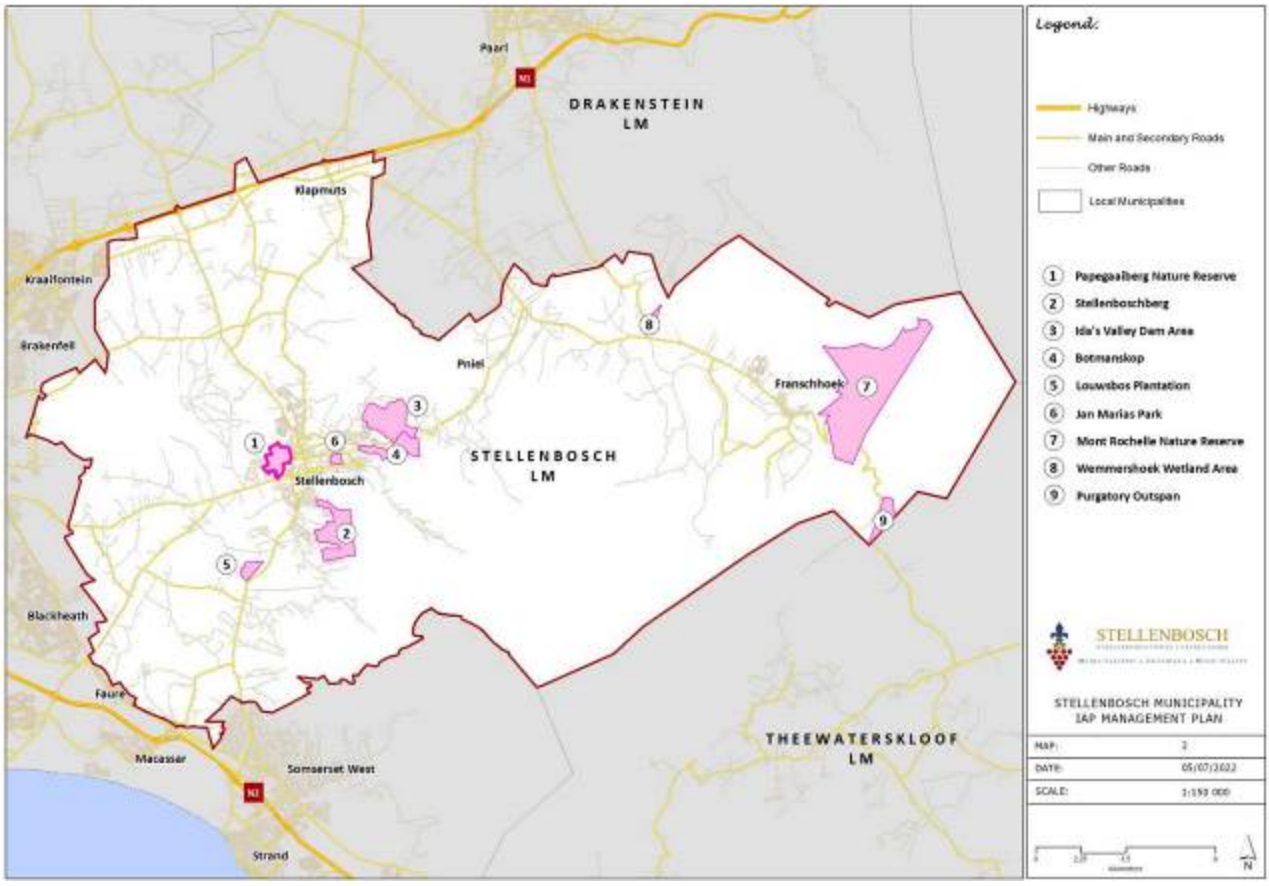

Figure 5: Papegaaiberg Nature Reserve.

Papegaaiberg NR is of high biodiversity importance, as explained in the sections below, with a high risk of erosion given the topography of the site.

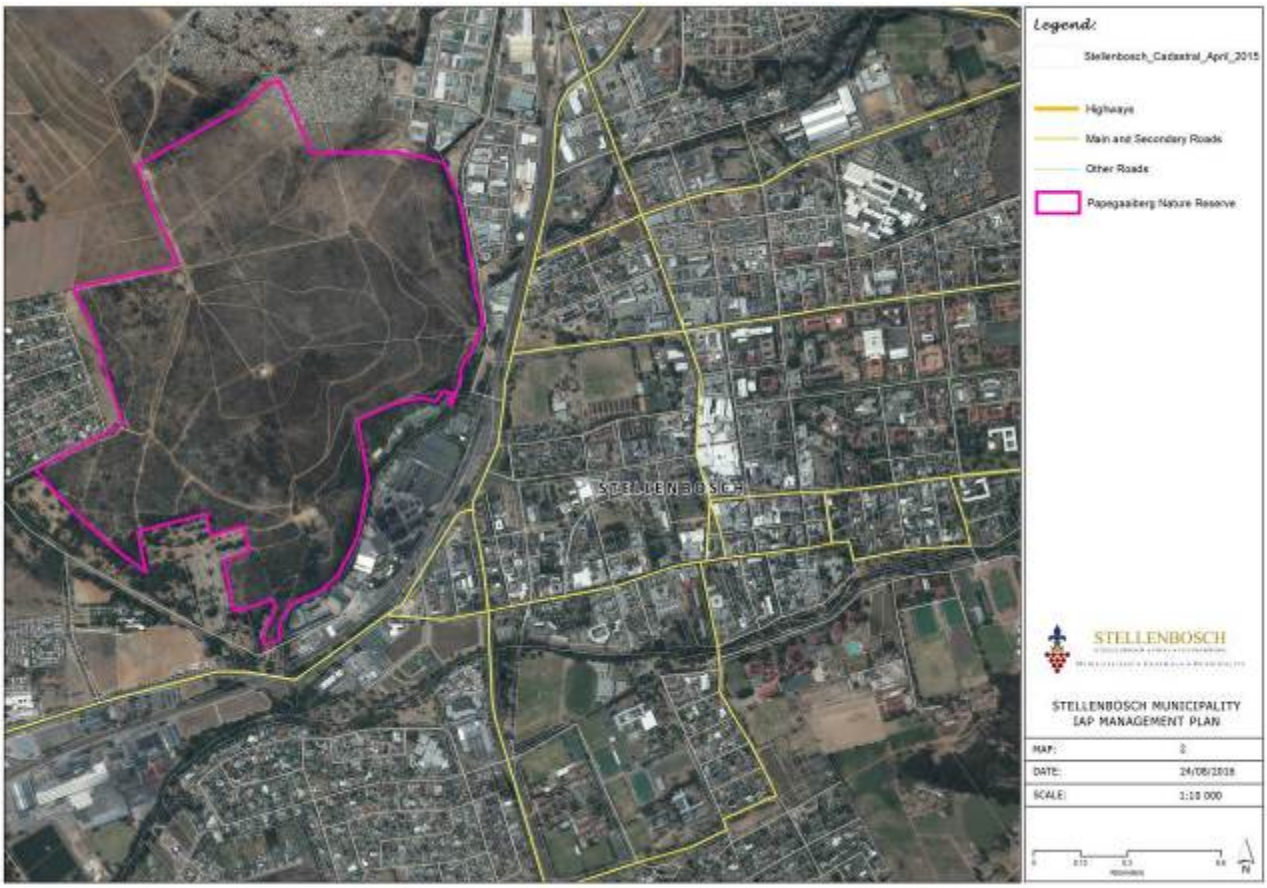

Figure 6: Local context of Papegaaiberg Nature Reserve.

10.1.2 Soil

The soil of Papegaaiberg is well-drained dark alluvial to clay soils with a low to medium base status.

10.1.3 Hydrology

Papegaaiberg forms part of quarternary catchment[19] No. G22G and G22H. There are two rivers that flow adjacent to the foot of Papegaaiberg, namely Krom River and Plankenbrug River. The Plankenbrug River joins the Eerste River south of Papegaaiberg. The Plankenbrug River is especially polluted and modified.

10.1.4 Vegetation

Remnants of almost extinct Renosterveld vegetation types, Swartland Shale Renosterveld and Swartland Granite Renosterveld, are found on Papegaaiberg, making it significantly important in

[19] Catchment (or catchment area) is defined as the entire land area from which water flows into a river; catchments can be divided into smaller 'sub-catchments' which are usually the area which drains a tributary to the main river or a part of the main river.

terms of its conservation status. Both species are critically endangered vegetation types. It has been estimated that as little as 10% of the area in which Swartland Renosterveld occurs is left undisturbed or intact. This is mainly due to its high fertility quality that it has been transformed for agricultural reasons. Only approximately 20% of the areas where Swartland Granite Renosterveld occurs remains undisturbed.

10.1.5 Current Alien Invasive Plant Infestation

Invasive alien plants located within Papegaaiberg NR include *Acacia implexa, Acacia saligna, Acacia mearnsii*, *Pinus pinea* and *Eucalyptus grobulus*. Of these *Acacia saligna* and *Acacia mearnsii* has the highest densities. Though invasion density on Papegaaiberg itself is less than 50%, there is a high invasion density at the foot of the mountain. This has largely been addressed with recent alien clearing work that has focused on the southern slopes of Papegaaiberg (Figure 7). The western slope of Papegaaiberg contains both *Acacia saligna* and *Acacia mearsnii*. *Eucalyptus grobulus* is mostly contained along the southern slope. *E. grobulus* also occurs on the previously burnt western slope. *P. pinea* densities are relatively low, with several large pine trees located along the foot of Papegaaiberg.

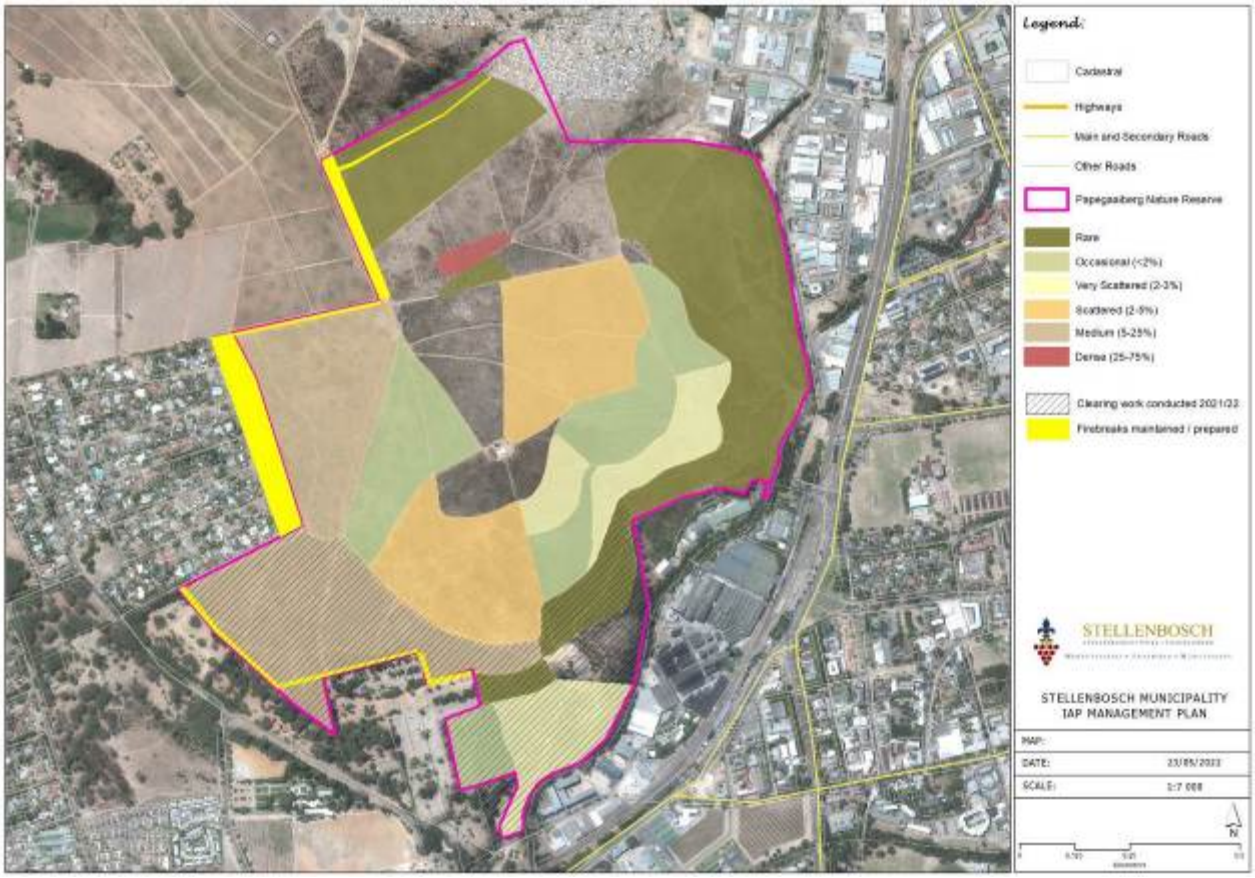

Figure 7: Alien invasive plant density (%) on Papegaaiberg Nature Reserve.

10.1.6 Clearing Methods

The high conservation significance of the Renosterveld within the Papegaaiberg NR makes the removal of IAPs a high priority. The NR did not receive a lot of attention during the past few years and the whole of the site must now be prioritized. Given the topography of the site erosion control measures must be put in place following any clearing work conducted. Clearing strategies should initiate at the top of the slope and continue downwards. Strategies for clearing IAPs should be a combination of mechanical and chemical methods (Table 7, Section 11). All species should be removed mechanically by uprooting young plants and tree felling of larger trees followed by the application of chemical herbicides to the cut surface to prevent resprouting. Biomass accumulated from clearing work should be chipped and/or burned (subject to a burn-permit acquired).

10.1.7 Zonation as an aid to the management of invasive alien plant species

The zonation map included as Figure 8 is to aid clearing IAPs on Papegaaiberg NR. Roads on the property were used for zone boundaries. The property is divided into 5 large zones (A-E) and divided into smaller zones to assist clearing strategies. To prevent spread of alien invasive plants down the slope into cleared areas during clearing and follow-up efforts, clearing and maintenance should start at the summit of Papegaaiberg marked as zone A. When zones A1-A5 are cleared, continue downward to zones B, followed by C. Zones E1-E3 should be cleared last.

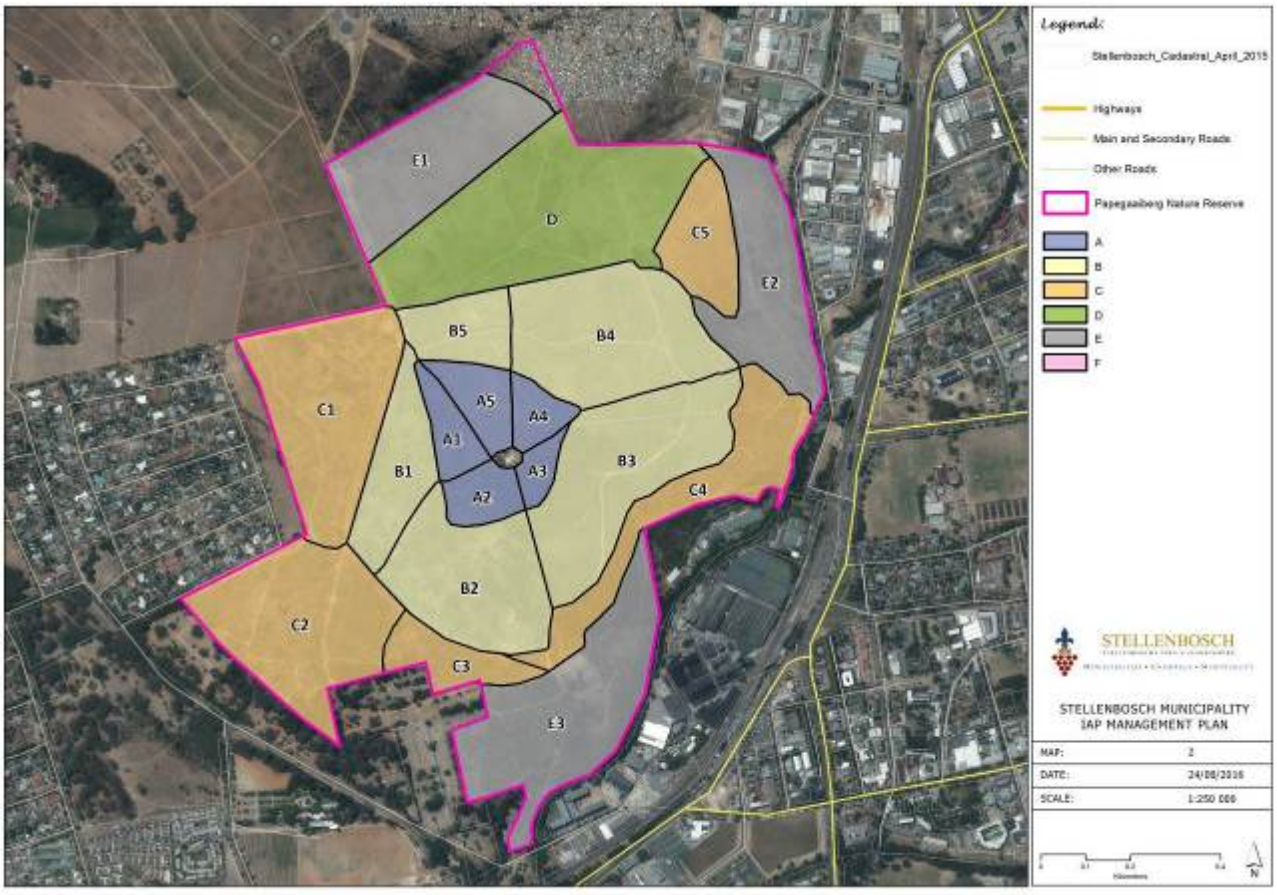

Figure 8: Zonation of Papegaaiberg as an aid for IAPs clearing.

10.2 STELLENBOSCHBERG (including the areas of Paradyskloof and Brandwacht)

10.2.1 Location

The area is located on the south-eastern edge of the town of Stellenbosch (Figure 9). It is bordered by University of Stellenbosch owned farmland and nature areas to the north, Stellenbosch Mountain to the east and privately-owned farm land to the south. To the west the area is bordered by the Paradyskloof- and Brandwacht neighbourhoods of Stellenbosch town and land used for farming purposes (Figure 10). The area is approximately 360ha in size. The relevant property is municipal owned land and zoned for agricultural purposes.

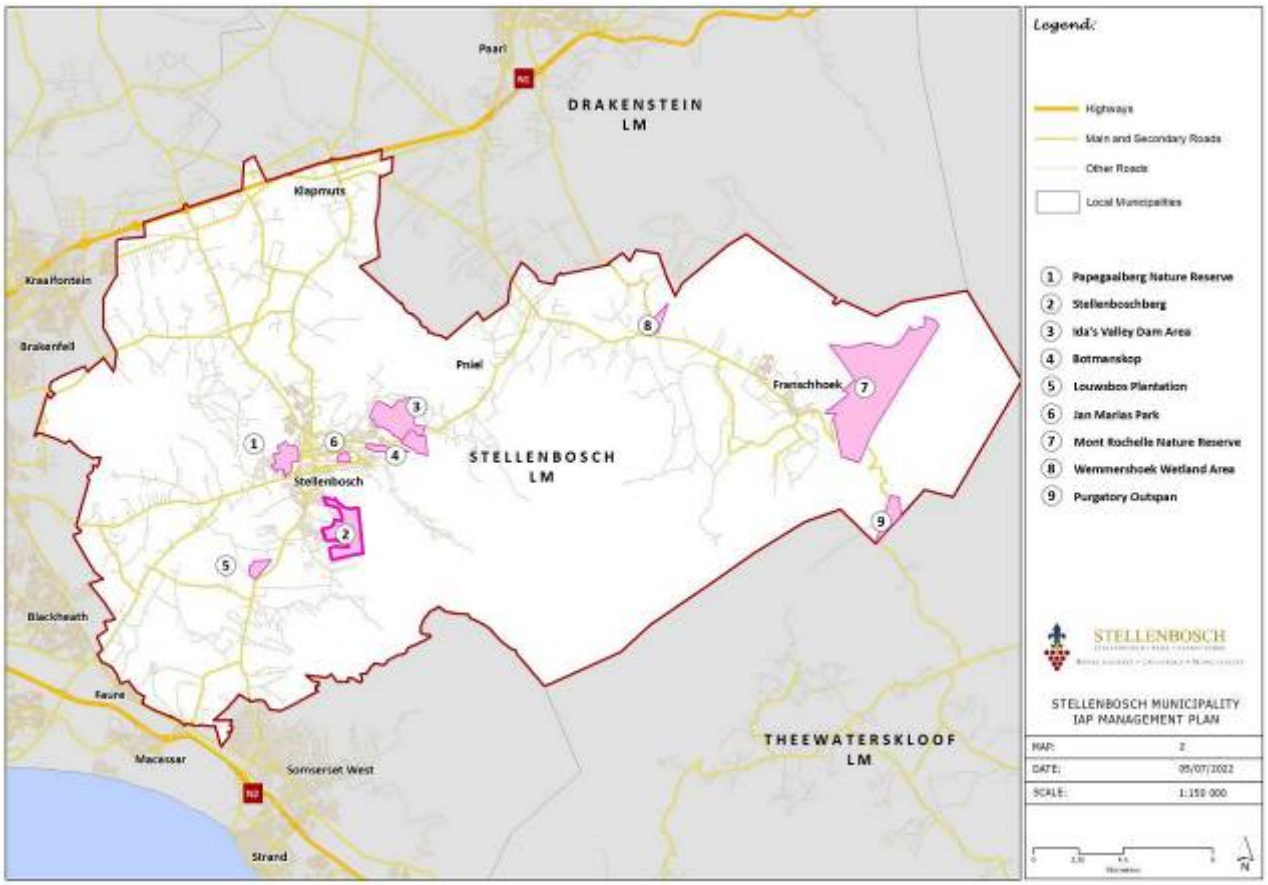

Figure 9: Stellenboschberg.

The eastern, mountainous, portion of the area has always been kept in a natural state with the western lower-lying areas used for forestry at some point in the past. Most of the timber have, however, been harvest with an approximately 40 ha portion of pine forest that still remain.

Stellenboschberg is of high biodiversity importance, as explained in the sections below, with a high risk of erosion given the topography of the site. Due to its proximity to residential areas it also presents a fire risk.

10.2.2 Soil

The soil of the property is red and a yellow soil which is freely drained, structure-less and has a low to medium base status.

10.2.3 Hydrology

The sites borders the Hottentots-Holland mountain catchment area, which is a quaternary catchment and play an important role in the water resources of the broader area.

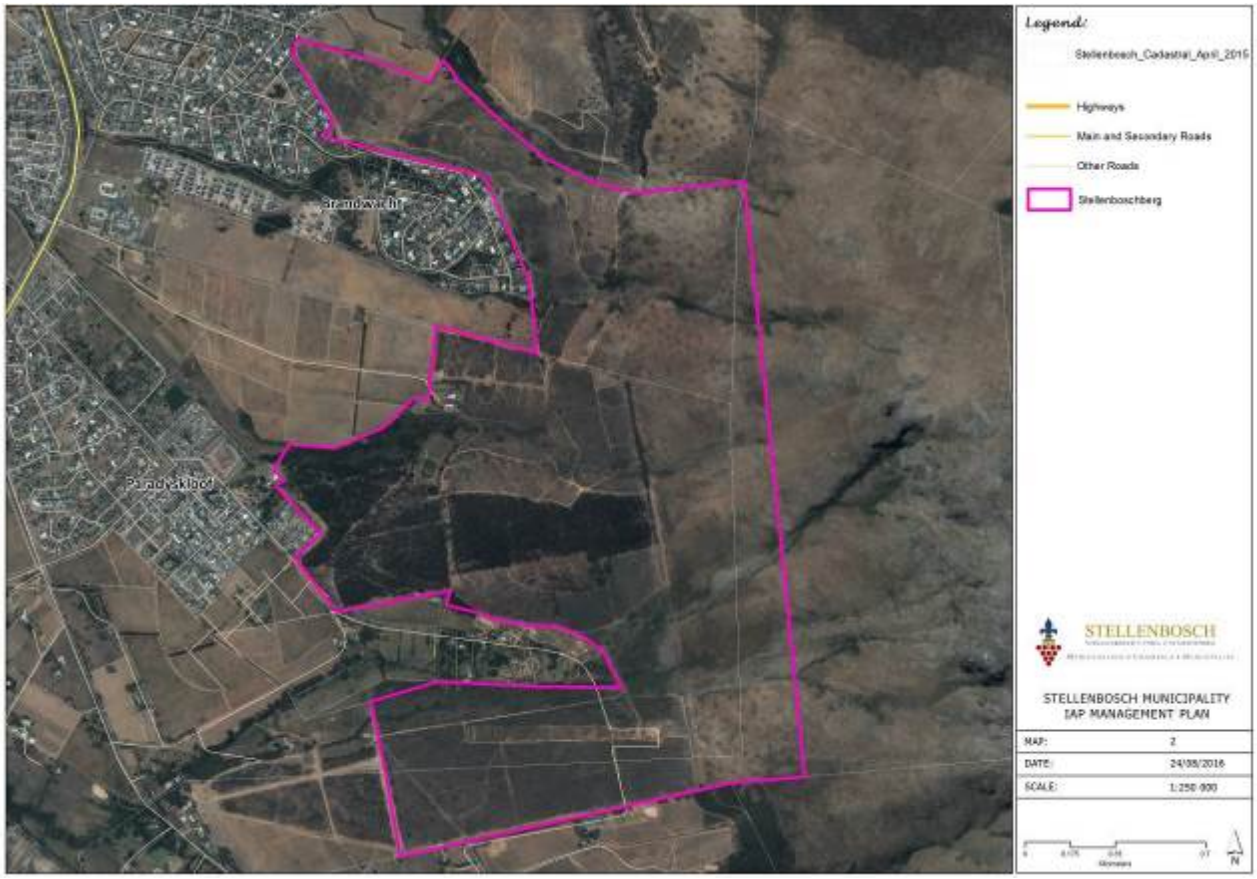

Figure 10: Local context of Stellenboschberg.

10.2.4 Vegetation

The vegetation type of the site is Cape Wineland Shale Fynbos and is a vulnerable terrestrial ecosystem. Cape Wineland Shale Fynbos soil is naturally poor in nutrients, moist and slightly acidic. Mostly found in lower mountain slopes and high, rolling plains in the Western Cape, the biodiversity of the Cape Wineland Shale Fynbos is incredibly high, comprising of a diversity of protea, erica, geophyte and daisy species as well as some endemic species.

10.2.5 Current Alien Invasive Plant Infestation

The site, in general, has been heavily invaded (Figure 11), mainly due to past disturbances and use. The Brandwacht area contains some *Acacia saligna*, *Acacia mearnsii* and *Eucalypus grobulus*.

The remainder of the site have been transformed into a pine plantation during past years. Approximately 40ha of this plantation remains today. *Pinus pinea* is the main invading species in this area (Figure 11). New pine seedlings sprout from the seed bank when vacant space becomes available after harvesting or clearing activities. Within the disturbed areas opportunistic recruitment of other invasive species, such as *Acacia saligna* and *Acacia mearnsii*, occurs. Though their infestation is less severe than that of *Pinus pinea*, it is important to consider the fast spreading nature of the latter species. The remainder of the Paradyskloof area contains *Eucalyptus grobulus*, *Acacia implexa, Acacia melanoxolyn, Acacia mearnsii, Acacia saligna* and *Acacia pygnantha,* of which *Acace saligna* and *Acacia mearnsii* infestation is the most severe. The reoccurrence of some hakea above the windbreak-line have also recently been oibserved.

Most of the site have had a round of clearance work during 2021/22 (Figure 11) and all the existing firebreaks were maintained.

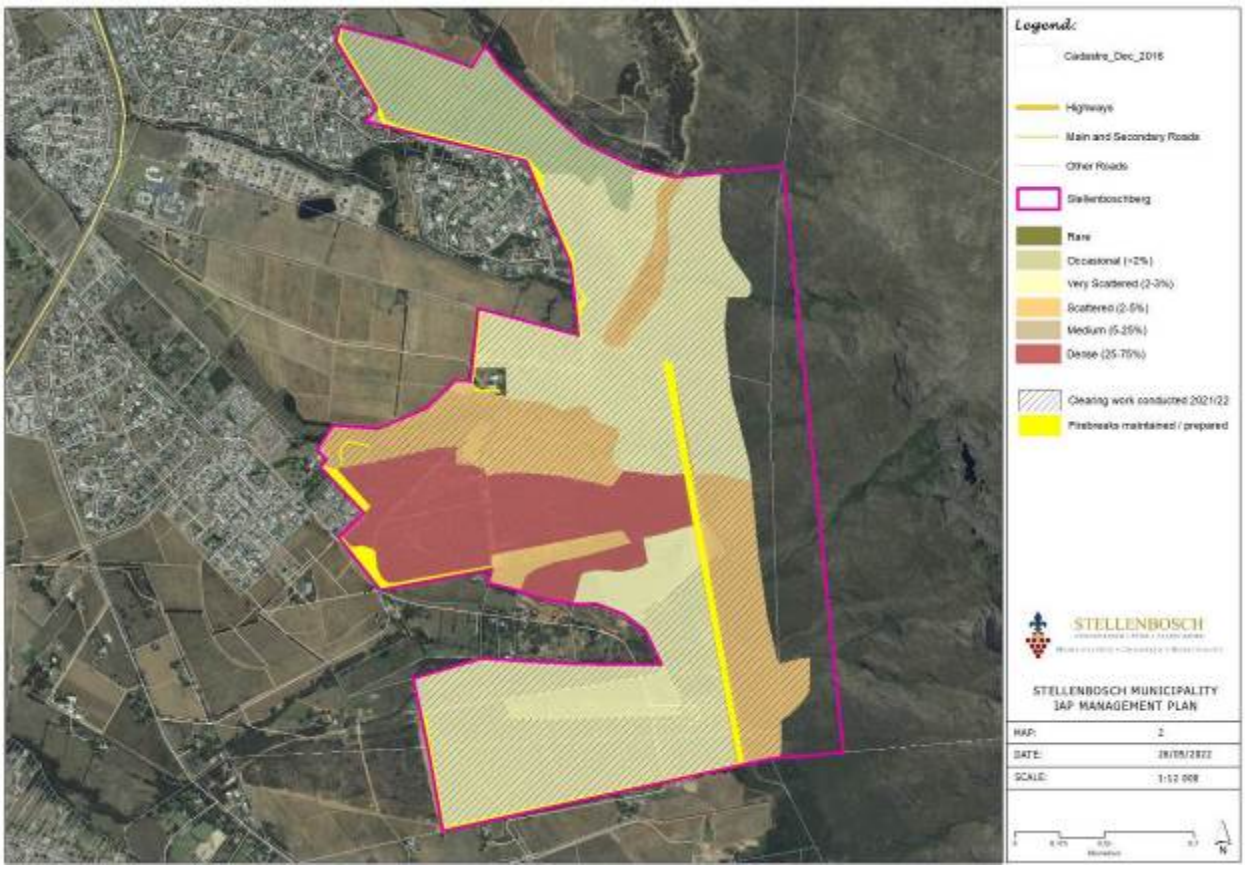

Figure 11: Alien invasive plant density (%) on Stellenboschberg.

10.2.6 Clearing Methods

Follow-up clearing, following the recent efforts on the relevant site is crucial. The whole site is rich in native biodiversity. To reduce the threat of biodiversity loss remaining invasive alien plants should be removed. Clearing- and follow-up strategies should start on the upper slope of the area and continue downwards with the necessary measures put in place to prevent soil erosion. Removal strategies for clearing IAPs from the site should be a combination of mechanical and chemical methods (Table 7, Section 11). All species should be removed mechanically by uprooting young plants and tree felling of larger trees, followed by the application of chemical herbicides to the cut surface to prevent resprouting. The use of herbicides may have negative effects on the health of soil composition and the natural ecosystem and should thus be used with caution and in reasonable amounts. Follow ups and monitoring should occur annually and remaining or re-established IAPs should be removed when located. Biomass accumulated from clearing work should be chipped and/or burned (subject to a burn-permit acquired).

10.2.7 Zonation as an aid to the management of invasive alien plant species

A zonation map (Figure 12) was constructed as an aid for clearing alien invasive plants in Brandwacht, Stellenboschberg and Paradyskloof. The property boundaries and internal service road was used as zone boundaries. The property is divided into 4 large zones (A-D). Clearing operations should start from the highest points within zones A, B and D and proceed downhill.

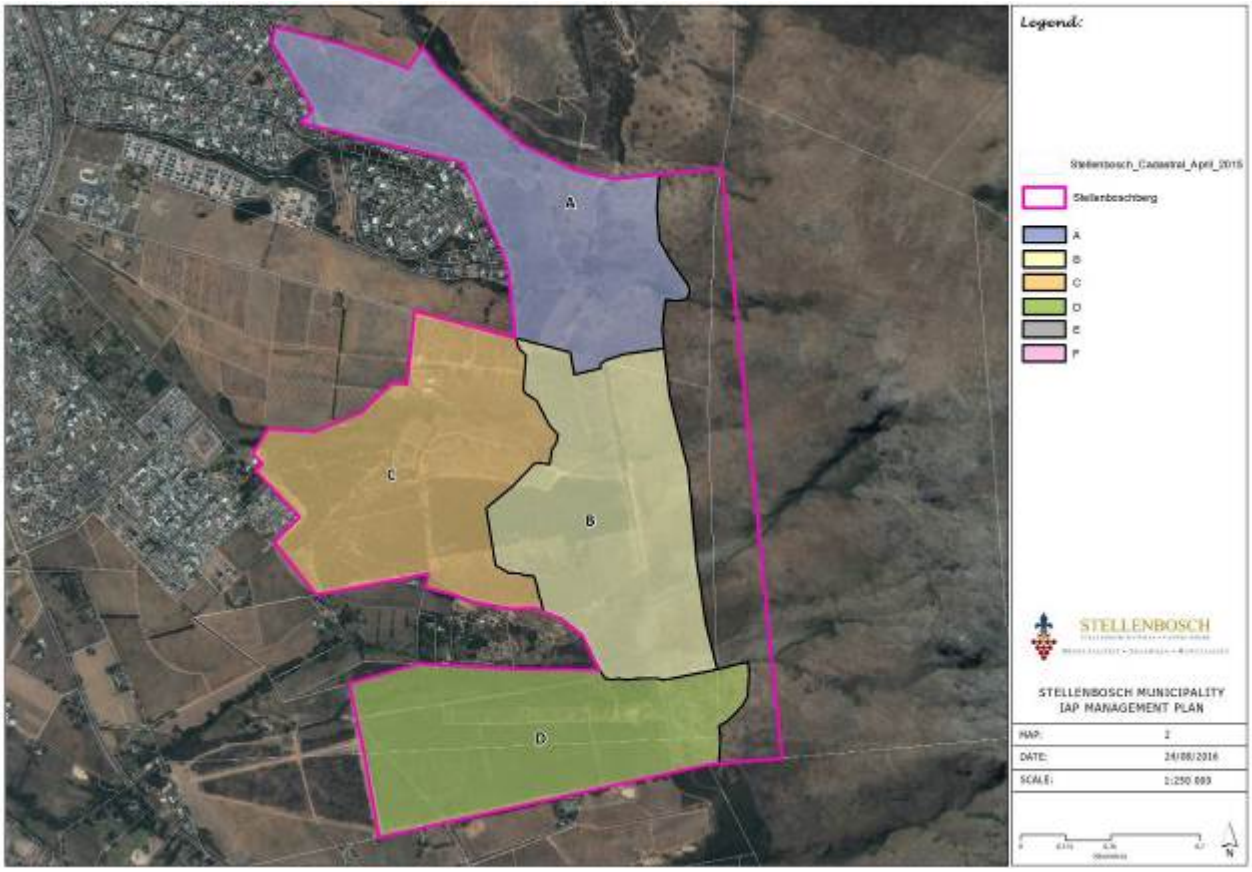

Figure 12: Zonation of Stellenboschberg as an aid for alien invasive plant clearing

10.3 IDA'S VALLEY DAM AREA

10.3.1 Location

Ida's Valley Dam Area is situated on the edge of the town of Stellenbosch, above the Helshoogte pass across from Botmaskop. Ida's Valley residential area borders the area on its southern boundary, while the western-, northern and eastern boundary is bordered by privately owned land (Figure 14). The area is more or less 333ha in size and contains infrastructure that is the main potable water supply for Stellenbosch town.

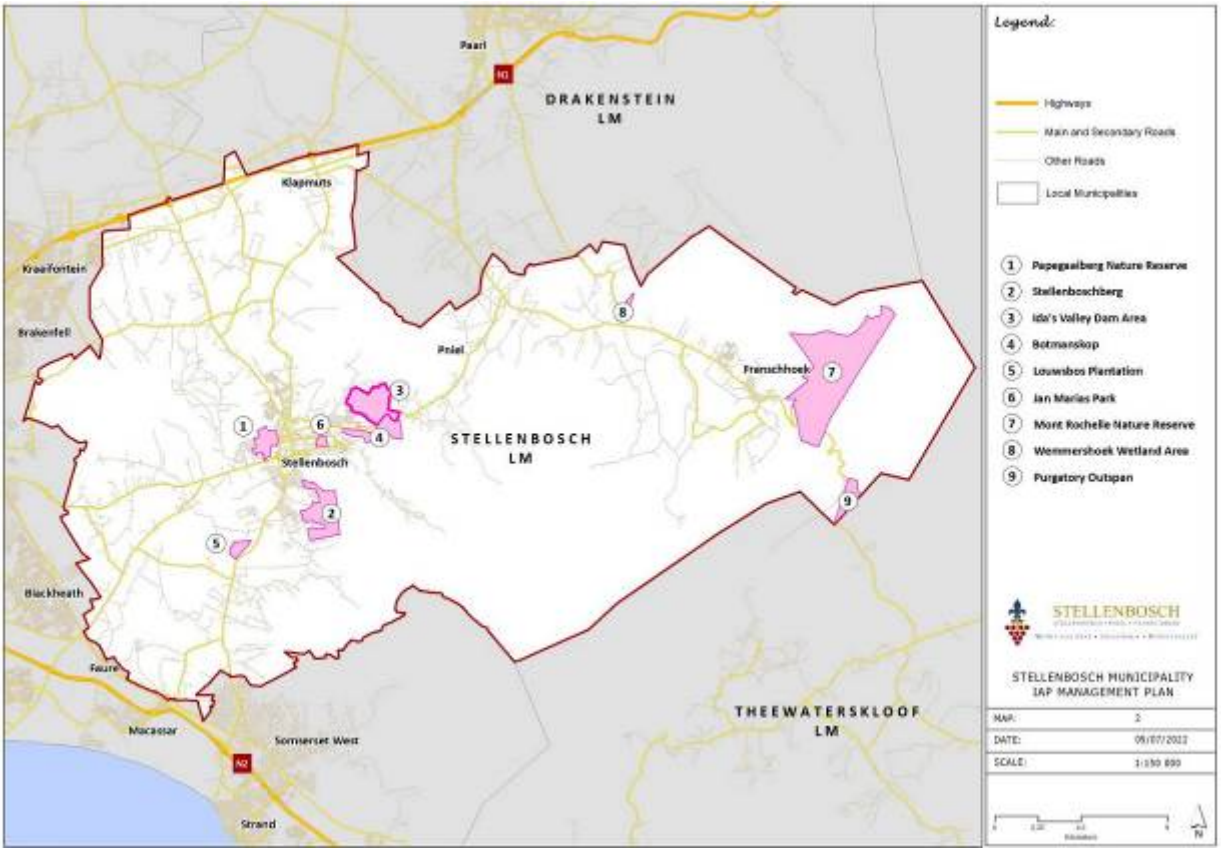

Figure 13: Ida's Valley Dam Area.

The Idas Valley Dam Area represents a functional value, in terms of the infrastructure it contains, and therefor a water security risk. Due to its proximity to residential areas and farms it also presents a fire risk.

10.3.2 Soil

The soil of the Ida's Valley Dam Area is red and yellow soils with low-medium status that is freely drained and structure-less.

10.3.3 Hydrology

The Ida's Valley Dam Area is located in a quarternary catchment draining from Simonsberg and the Hottentots Holland Mountain Catchment Area. Although the catchment functions of the planning area may seem insignificant, it is important to note that the latter forms part of an integrated group of ecosystems that collectively determine the health of the total catchment[20]. The Krom River arises in the Simonsberg Mountains approximately 9 km north east of Stellenbosch. The river feeds the Ida's Valley Dam. The river flows through forestry and agricultural areas before entering Ida's Valley. The value of the river as a habitat for indigenous flora and fauna has been substantially altered and compromised due to the growth of IAPs.

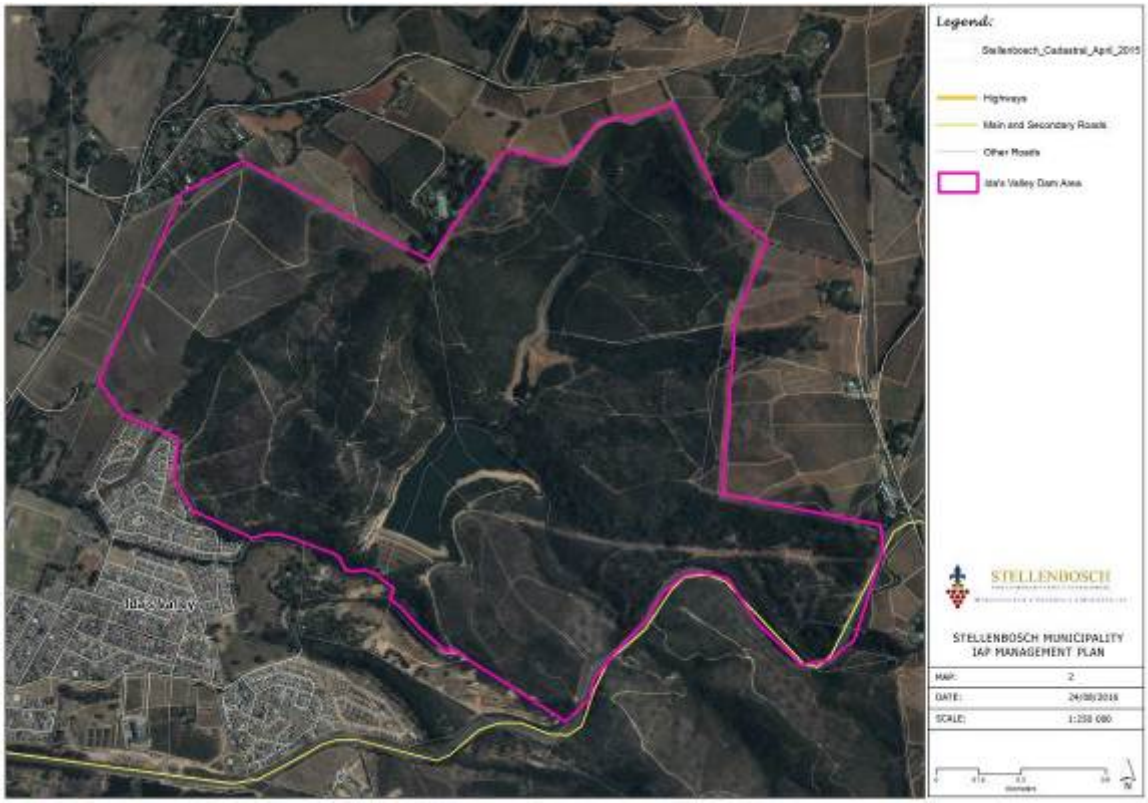

Figure 14: Local context of Ida's Valley Dam Area.

10.3.4 Vegetation

The area consists of two vegetation types, namely Boland Granite Fynbos and Cape Wineland Shale Fynbos. Both are vulnerable vegetation types. Boland granite fynbos has 56 Red Data plant species and 23 endemic plant species. There are approximately 62% remaining natural areas, of which 14% is protected in the Hawequas-, Hottentots Holland- and Paarl Mountain Nature Reserve. The Cape Wineland Shale Fynbos comprises of a diversity of Protea, Erica, geophyte and daisy species as well as some endemic species.

[20] Catchment (or catchment area) is defined as the entire land area from which water flows into a river; catchments can be divided into smaller 'sub-catchments' which are usually the area which drains a tributary to the main river or a part of the main river.

10.3.5 Current Alien Invasive Plant Infestation

Over 80% of the Ida's Valley Dam Area's land surface is either infested with- or has been transformed by IAPs (Figure 15). The most widespread IAP species of Ida's Valley Dam Area are *Pinus pinea* and *Eucalytpus globulus*. Both species occur in large, dense stands, which cover over 50% of the sites land surface. Other invasive alien plant species such as *Acacia implexa, Acacia melanoxylon* and *Acacia pygnantha* also occur in the Ida's Valley Dam Area. Approximately 90ha (Figure 15) of the area have been cleared during 2021/22.

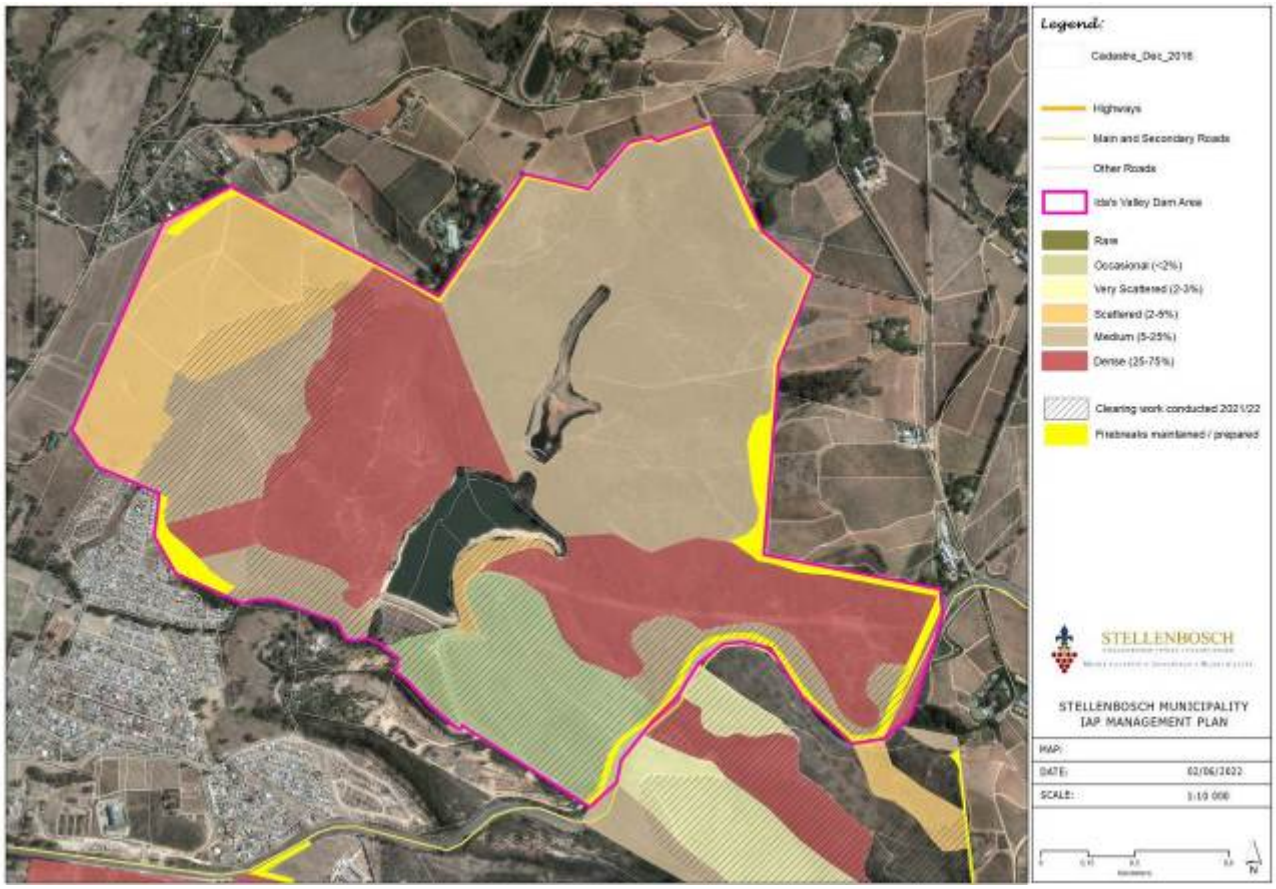

Figure 15: Alien invasive plant density (%) on Ida's Valley Dam Area.

10.3.6 Clearing Methods

Follow-up clearing, following the recent efforts of clearing the Ida's Valley Dam Area, is crucial. The remainder of the area, with specific reference to the eastern (valley section), not recently cleared should receive attention during the validity period of this management plan.

Given the topography of the Ida's Valley Dam Area erosion control measures must be put in place following any such work conducted. Clearing strategies should initiate at the top of the slope / or valley walls, and continue downwards. Strategies for clearing IAPs should be a combination of mechanical and chemical methods (Table 7, Section 11). All species should be removed mechanically by uprooting young plants and tree felling of larger trees followed by the application

of chemical herbicides to the cut surface to prevent resprouting. Follow ups and monitoring should occur annually and remaining or re-established invasive species should be removed when located. Biomass accumulated from clearing work should be chipped and/or burned (subject to a burn-permit acquired).

10.3.7 Zonation as an aid to the management of invasive alien plant species

A zonation map (Figure 16) was constructed as an aid for clearing alien invasive plants on the Ida's Valley Area. Roads on the property were used for zone boundaries. The property is divided into 6 large zones (A-E) and each larger zone is further divided into smaller zones.

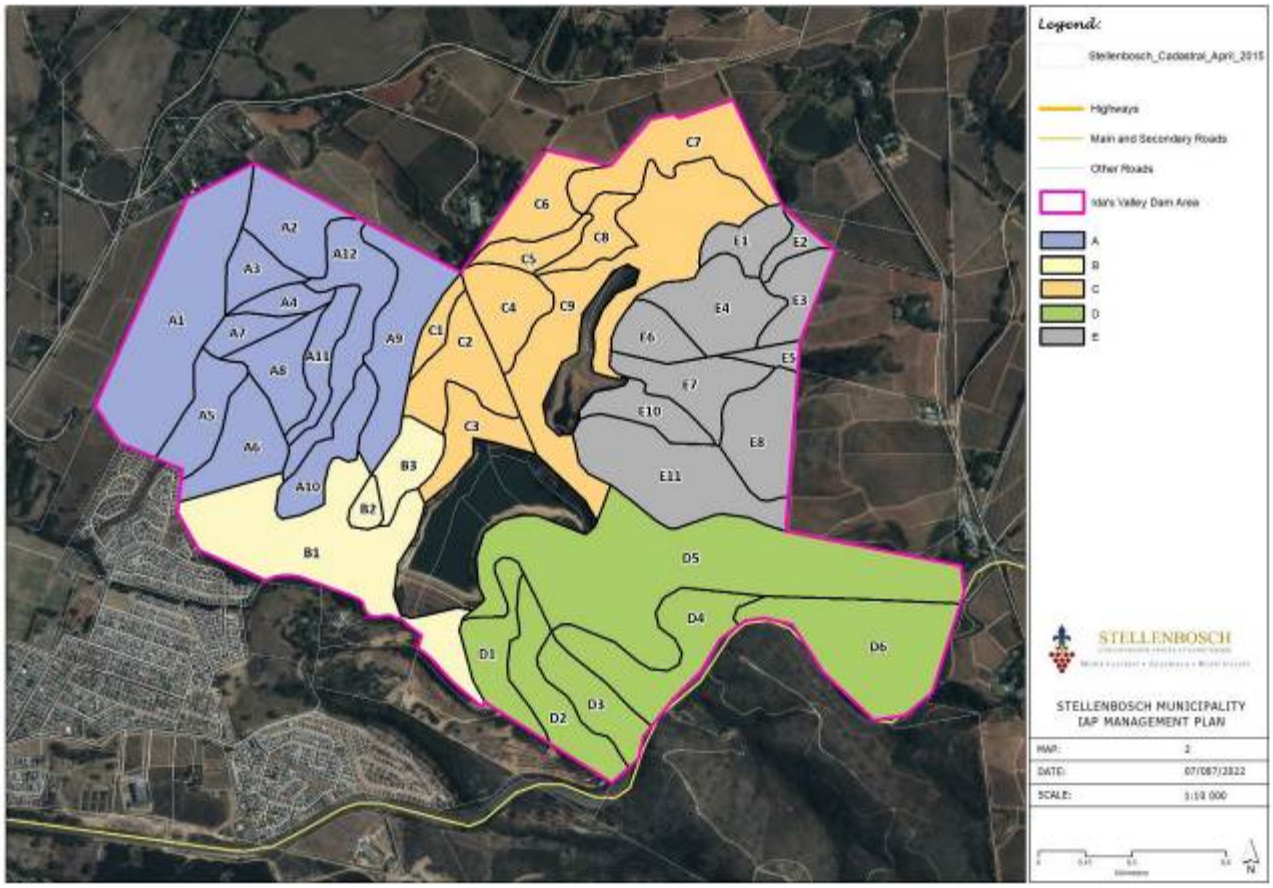

Figure 16: Zonation of Ida's Valley Dam Area as an aid for alien invasive plant clearing.

Clearing should start within zones C and E (these zones are at the highest point within the Ida's Valley Dam Area) and continue in all four directions towards the boundaries of these zones. When zones C and E are cleared, clearing within zone D. Once zone D is cleared, clearing should start at the highest points within B and continue to the boundary of the zone after which clearing will continue into zone A. Once clearing of both sites has been concluded, follow-up and monitoring strategies should occur annually following the same strategy.

10.4 BOTMASKOP

10.4.1 Location

Botmaskop is situated above the town of Stellenbosch (see Figure 17) south of the Helshoogte pas. The area is bordered by Rozendal residential area on the western boundary, while the Plumbago Cottage property borders the site on the southern boundary. The northern and eastern boundaries are adjacent to private farmlands. The Helshoogte pass forms the northern boundary, across from the Ida's Valley Dam Area. Botmaskop reaches a height of approximately 300m. Most of the area was previously used as pine and bluegum plantation with a size of approximately 160ha. The site is located at the base of the Jonkershoek mountain range and gradually rises from the southern boundary to the northern boundary.

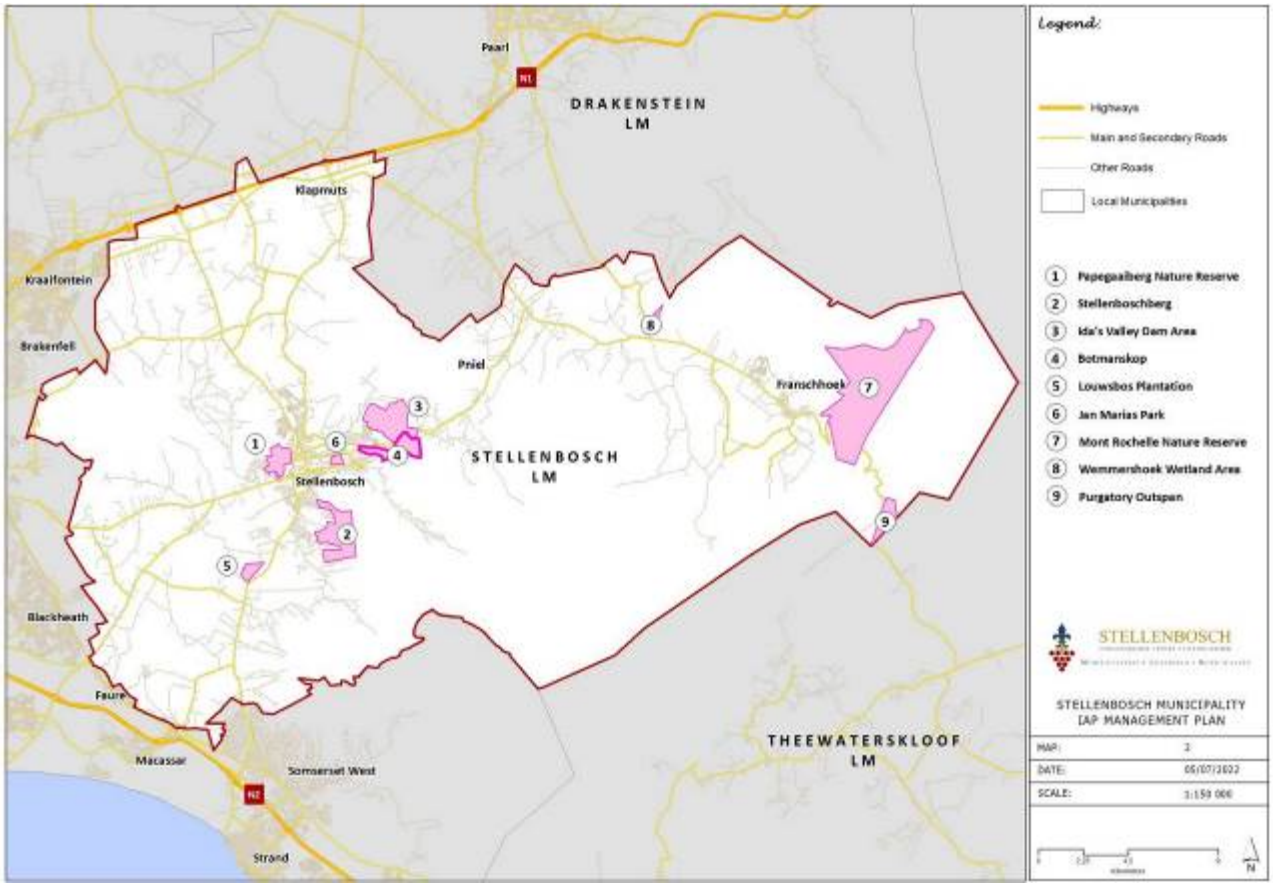

Figure 17: Botmaskop.

Even though the site has been heavily transformed during the past sections of Botmaskop is of high biodiversity importance. It also has high risk of erosion given the topography.

10.4.2 Soil

The soil of Botmaskop is red and yellow with low-medium base status and rock with limited soils that is freely drained, structure-less soils and has a non-soil land class.

10.4.3 Hydrology

Botmaskop is situated on the edge of the catchment described in the Ida's Valley Dam Area section above.

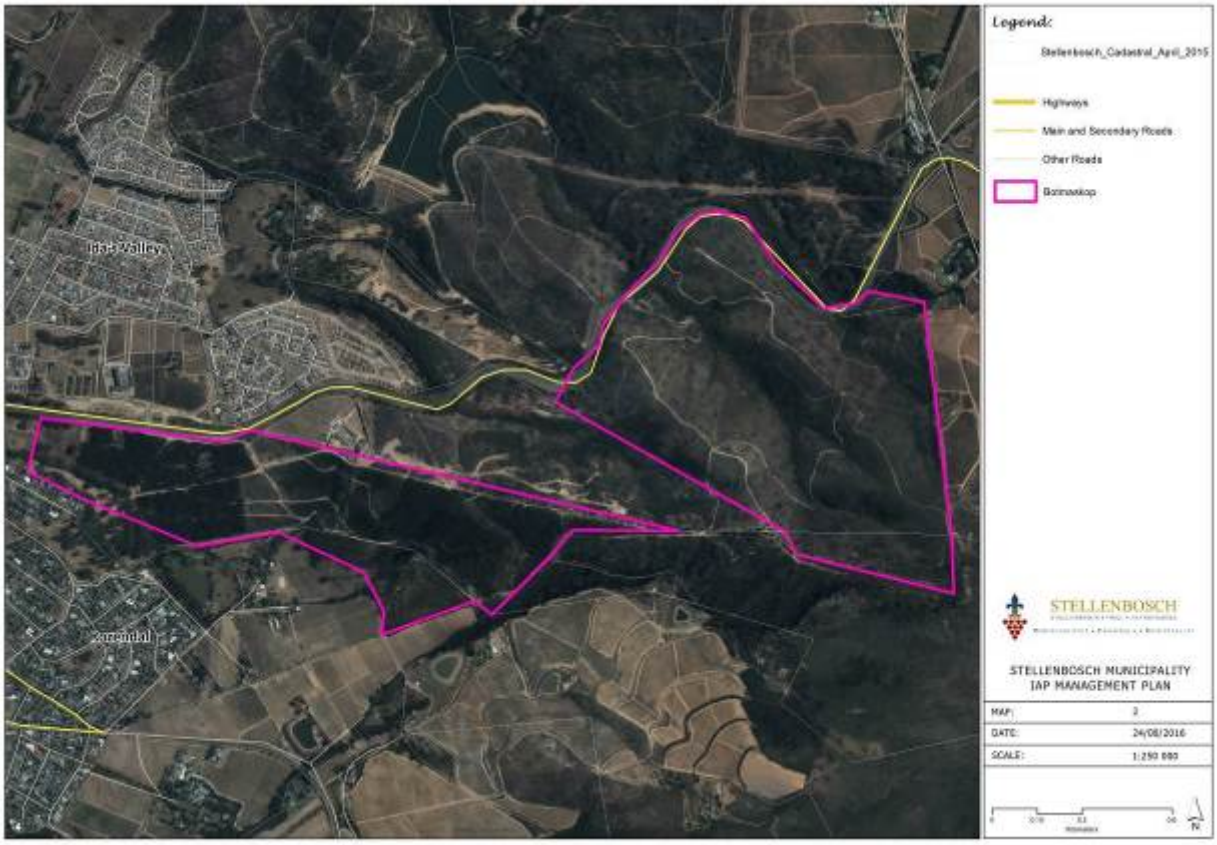

Figure 18: Local context of Botmaskop.

10.4.4 Vegetation

Botmaskop consists of two vegetation types, namely Boland Granite Fynbos and Cape Wineland Shale Fynbos. Both are vulnerable vegetation types.

10.4.5 Current Alien Invasive Plant Infestation

The original vegetation of Botmaskop has been completely transformed due to the use of the area for *Pinus pinea* and *Eucalyptus grobulus* plantation purposes (Figure 19). The transformation and introduction of pine trees onto the site, for extensive pine production intended for industrial use, has led to the complete infestation of the area by these species. Other invasive alien species such as *Acacia implexa, Acacia melanoxylon, Acacia mearnsii* and *Acacia pygnantha* is also located within the site. Invasion densities within the site increase within valleys and near water resources where conditions are most favourable. The less invaded areas, on the lower plains of the site, are natural Fynbos vegetation.

Recent clearing work in this site, covering a total area of ±95ha, have been focussed on the eastern most, higher lying sections (Figure 19).

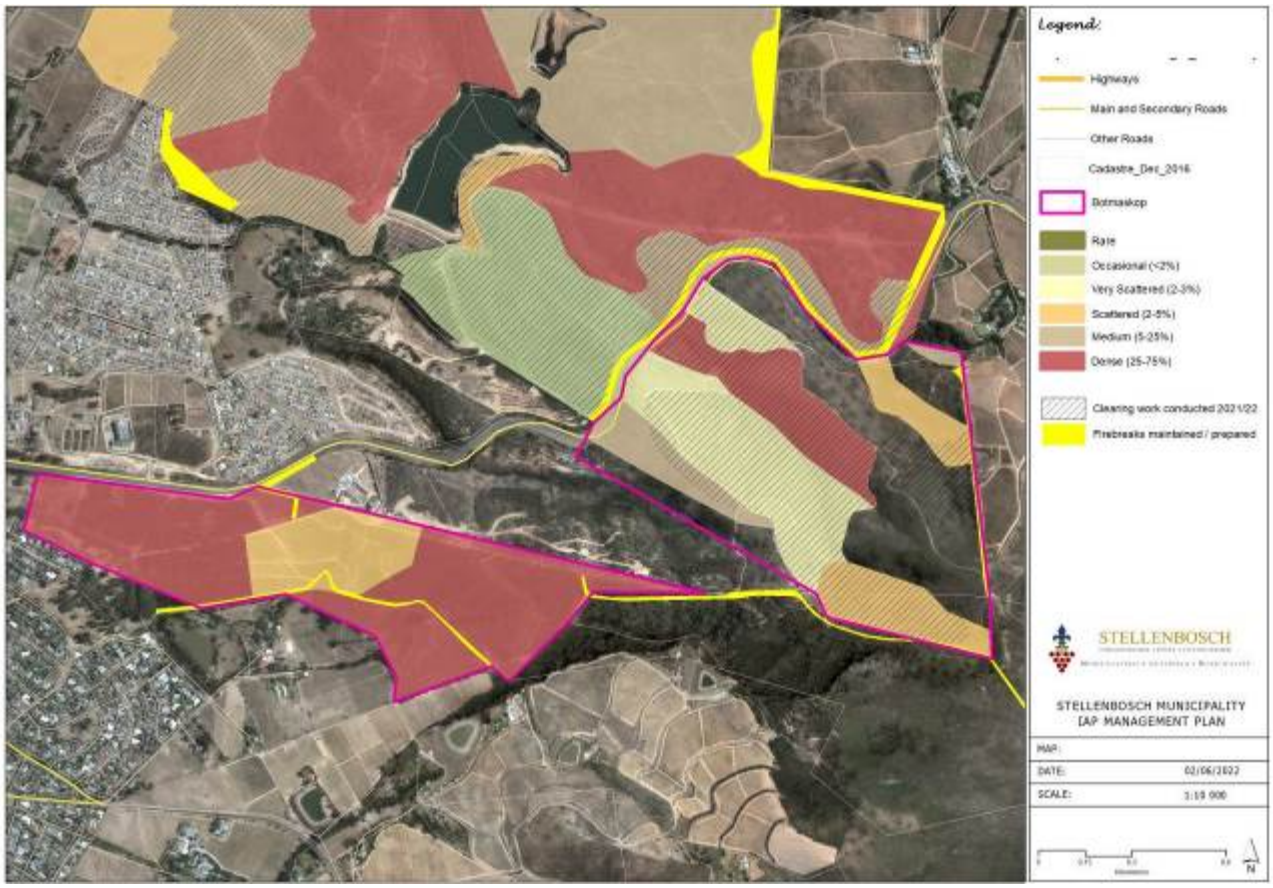

Figure 19: Alien invasive plant density (%) on Botmaskop.

10.4.6 Clearing Methods

Follow-up clearing, following the recent efforts of clearing the upper slopes of Botmaskop, is crucial. The remainder of the area, with specific reference to the drainage areas, not recently cleared should receive attention during the validity period of this management plan.

Given the topography of the area erosion control measures must be put in place following any such work conducted. Clearing strategies should initiate at the top of the slope / or valley walls, and continue downwards. Strategies for clearing IAPs should be a combination of mechanical and chemical methods (Table 7, Section 11). All species should be removed mechanically by uprooting young plants and tree felling of larger trees followed by the application of chemical herbicides to the cut surface to prevent resprouting. Follow ups and monitoring should occur annually and remaining or re-established invasive species should be removed when located. Biomass accumulated from clearing work should be chipped and/or burned (subject to a burn-permit acquired).

10.4.7 Zonation as an aid to the management of invasive alien plant species

A zonation map (Figure 20) was constructed as an aid for clearing alien invasive plants on Botmaskop. Roads on the property were used for zone boundaries. The eastern site is divided 5 large zones (A-E) and the western site into 6 large zones (A-F) and each larger zone further divided into smaller zones.

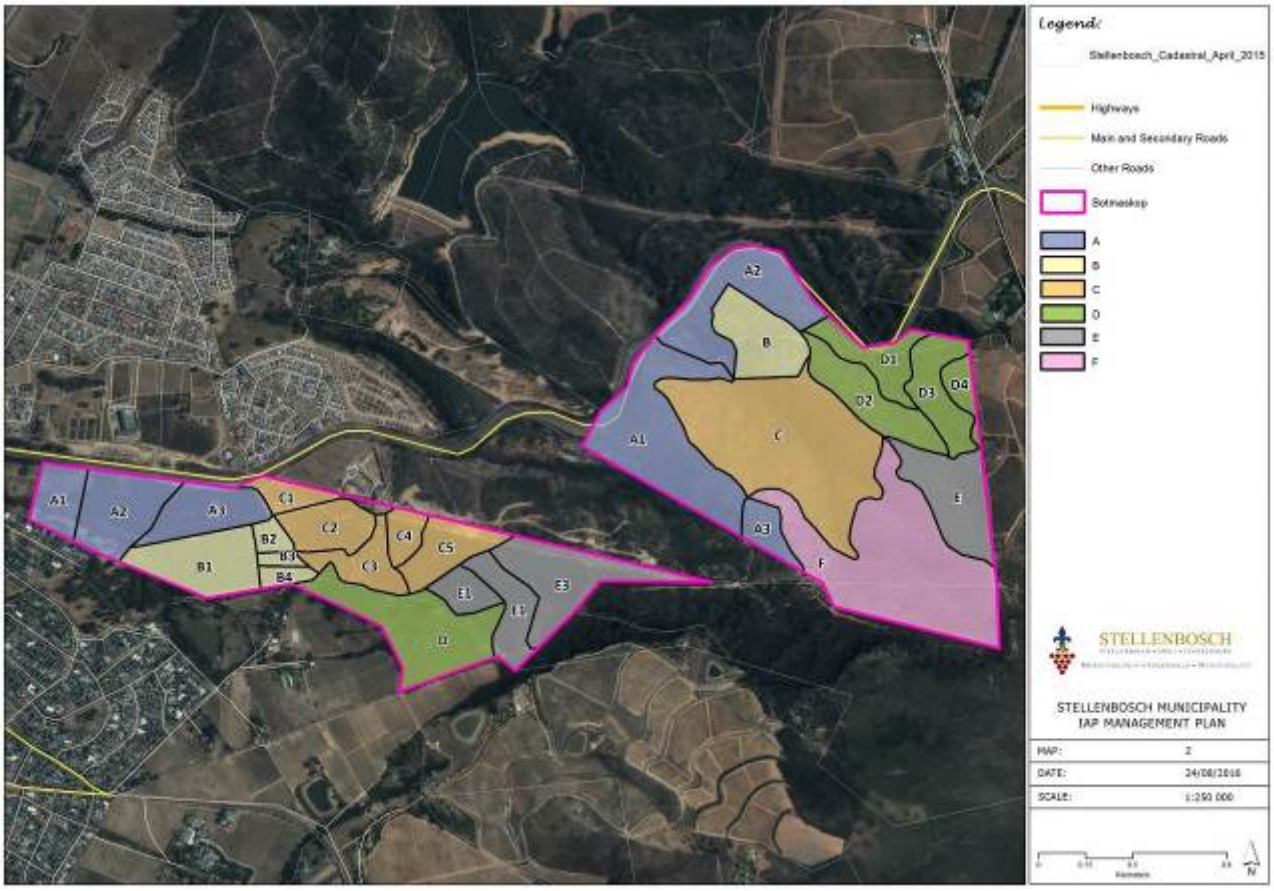

Figure 20: Zonation of Botmaskop as an aid for alien invasive plant clearing

Clearing should start at on the highest point and continue downward in both northern and southern directions to the adjacent zones. Once clearing of both sites has been concluded, follow-up and monitoring strategies should occur annually following the same strategy.

10.5 LOUWSBOS PLANTATION

10.5.1 Location

Louwsbos Plantation is located along the R44 road between Stellenbosch and Somerset West. The western boundary is bordered by the Stellenbosch Flying Club and several farms. On the southern boundary the property is bordered by a water storage dam and greenhouse agricultural property. De Zalze borders the property to the north. Louwsbos Plantation is a stone pine plantation and is approximately 58ha in size. Due to its proximity to a residential area Louwsbos Plantation presents a fire risk.

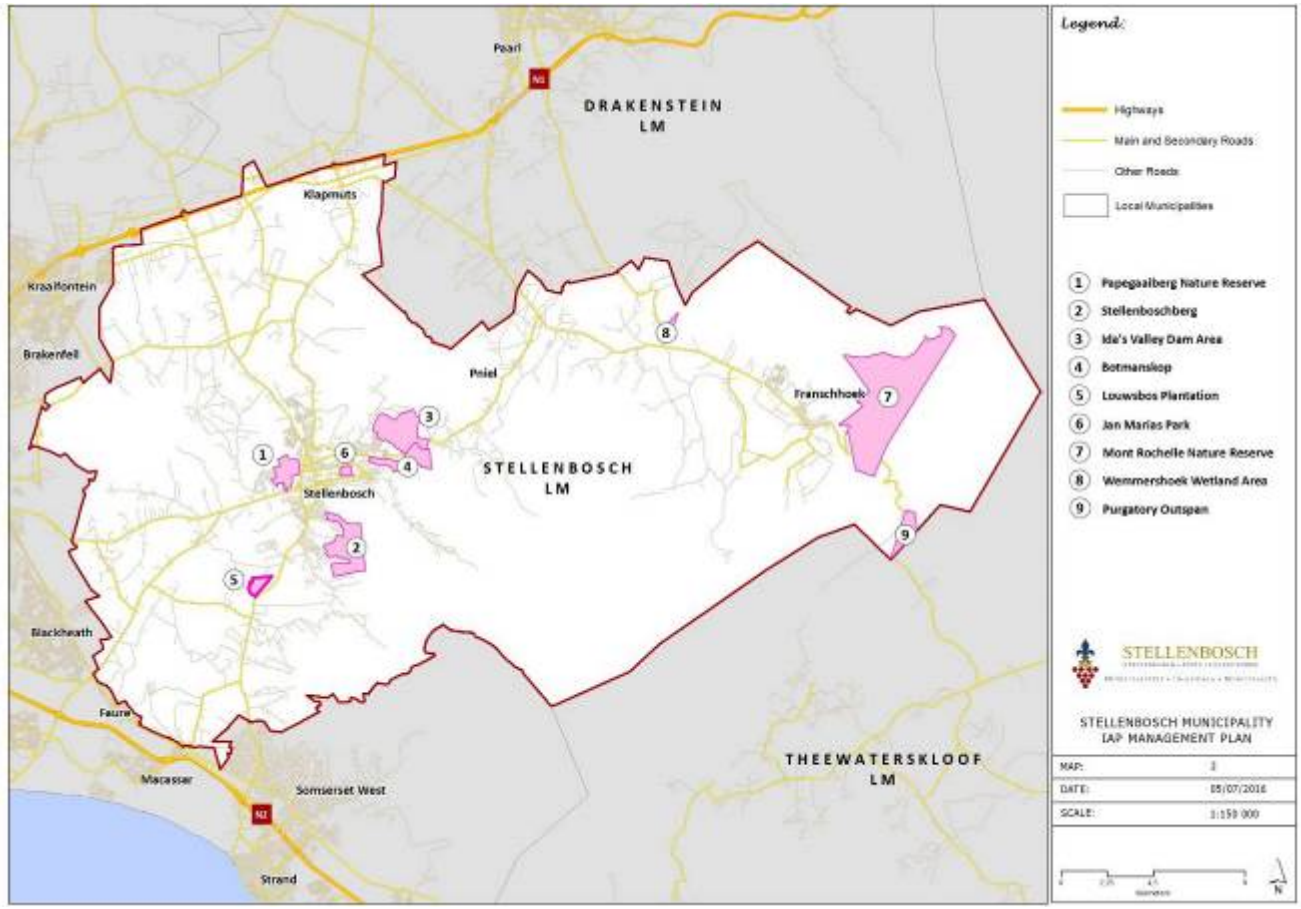

Figure 21: Louwsbos Plantation.

10.5.2 Soil

The soil is imperfectly drained soil which is shallow with a plinthic horizon. It is a marked clay accumulation which is strongly structured and is a non-reddish colour.

10.5.3 Hydrology

Though there are no rivers flowing through the property.

Figure 22: Local context of Louwsbos Plantation.

10.5.4 Vegetation

The Swartland Granite Renosterveld vegetation type of Louwbos Plantation is an almost extinct vegetation type. Approximately 85% of all Swartland Granite Renosterbos has been transformed to agricultural and urbanization activities. Of the 15% remaining natural area, less that 1% is actively protected. The vegetation type contains about 127 Red Data plant species and 27 endemic plant species. The near extinct status of this vegetation type makes the conservation and rehabilitation efforts of its remaining remnants of high conservation importance (SANBI 2009).

10.5.5 Current Alien Invasive Plant Infestation

The natural vegetation originally occurring in Louwbos Plantation has been transformed due to the use of the property for forestry purposes. The transformation and introduction of pine trees into the site has led to the infestation of invasive alien plants.

The Pinus species *Pinus pinea* is the main invading species in Louwbos Plantation and have occupied more than 75% of the sites land surface. Most of these trees have been removed by the latest clearing efforts. The above infestation has, however, lead to the existence of a pine seed bank. New seedlings sprout from the seed bank when vacant space becomes available. As stated

above the whole of the site has undergone a clearing operation during 2021/22 (Figure 23). Follow-up to this work will now be critical.

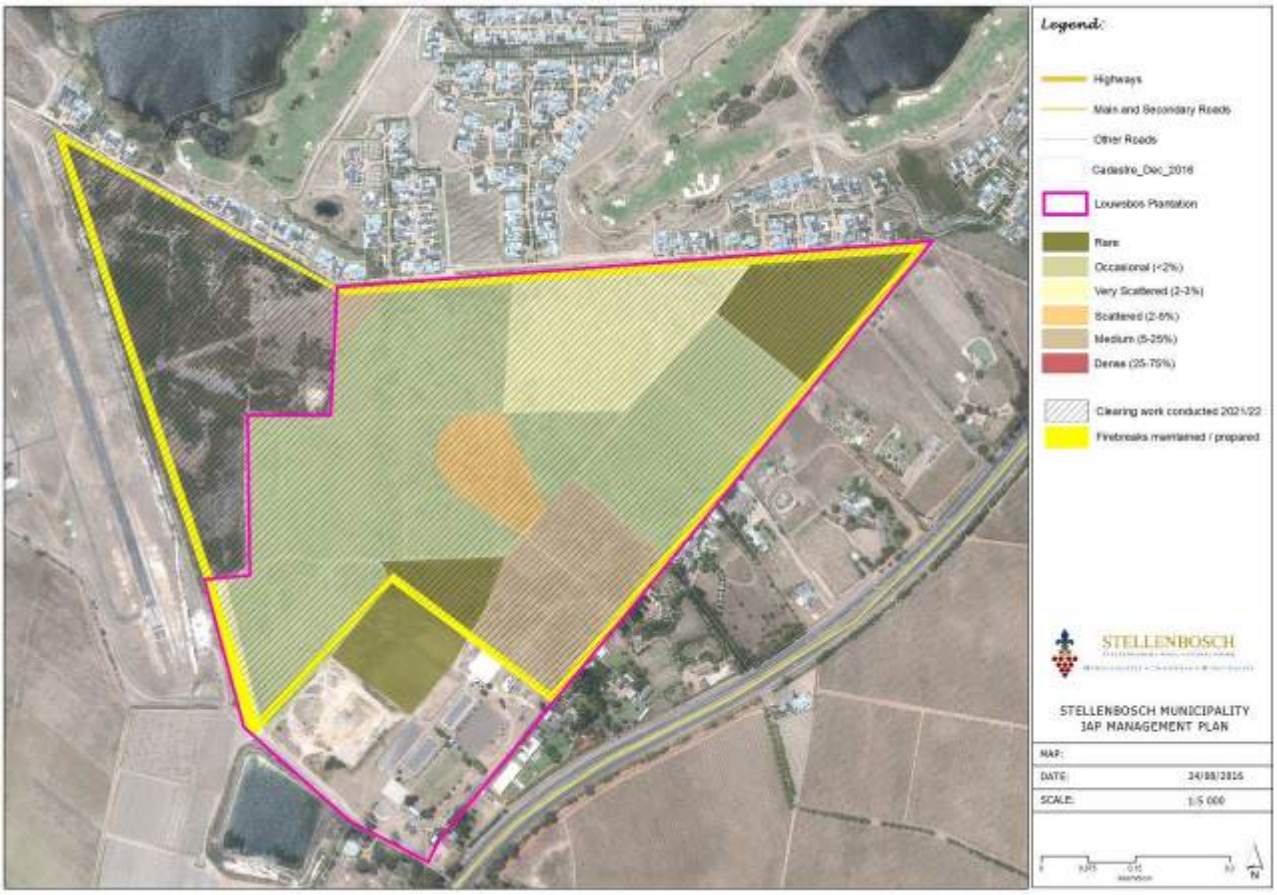

Figure 23: Alien invasive plant density (%) of Louwsbos Plantation.

10.5.6 Clearing Methods

As stated above follow-up clearing, following the recent efforts of clearing Louwsbos Plantation of IAPs is crucial. Strategies for follow-up should be a combination of mechanical and chemical methods (Table 7, Section 11). Both P. *pinea* and *A. saligna* have resprouting characteristic and herbicides should be applied to the cut surface. Each species has its own corresponding herbicide requirements to prevent resprouting activities and should be applied soon after tree felling (see Table 7, Section 11). Biomass accumulated from clearing work should be chipped and/or burned (subject to a burn-permit acquired).

10.5.7 Zonation as an aid to the management of invasive alien plant species

A zonation map (Figure 24) was constructed as an aid for clearing alien invasive plants on the Louwbos Plantation siet. Roads on the property were used as zone boundaries. The property is divided into 6 large zones (A-F) and each larger zone is further divided into smaller zones. Clearing of alien invasive plants in Louwsbos Plantation should start at the western boundary of zone A1 and move in a north eastern direction towards A2. Continue to clear zones A2 to A4. When Zone A

is cleared, continue onto zones B1 and C1, then D1 and finally E1 and F1 and finish clearing in zone F3. Repeat this working cycle when conducting monitoring and removal of re-establish alien species.

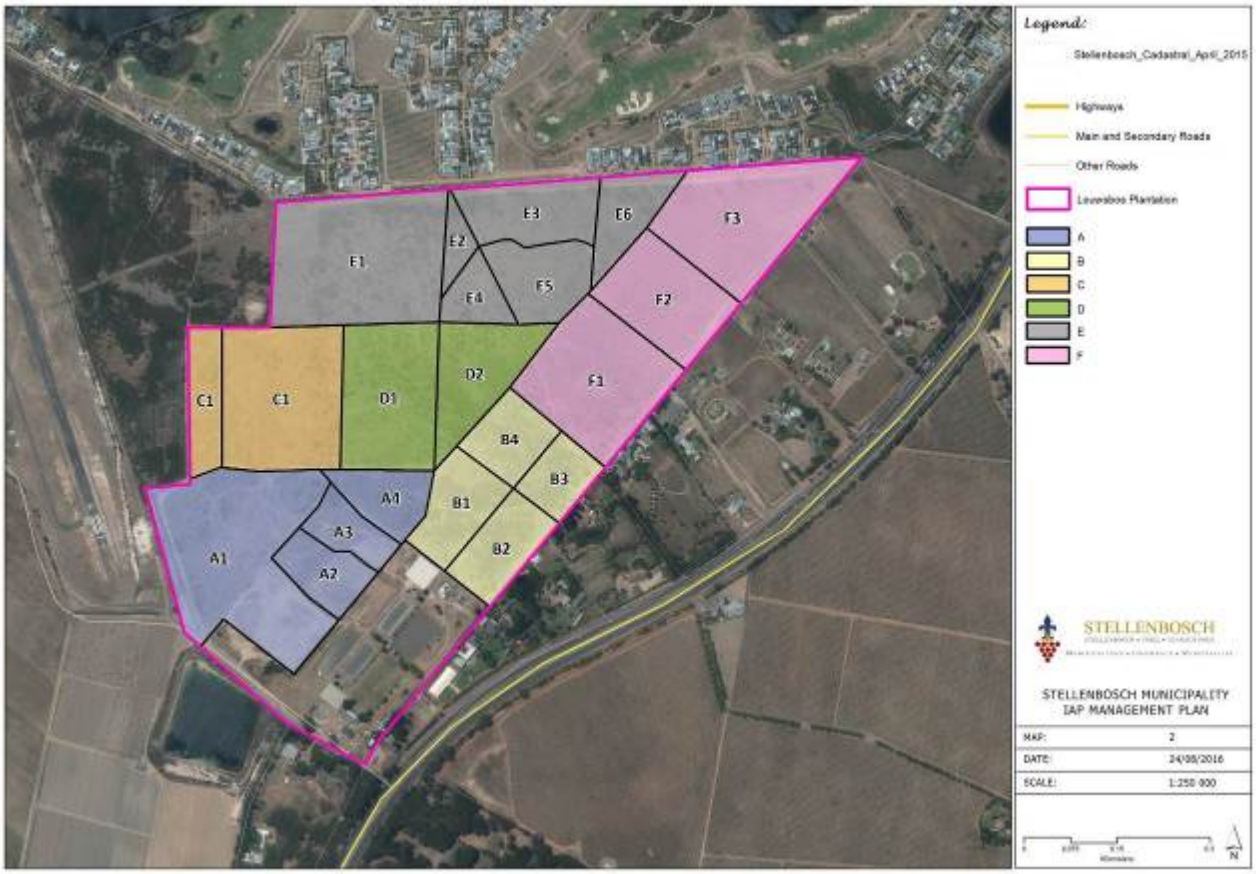

Figure 24: Zonation of Louwsbos Plantation as an aid for alien invasive plant clearing

10.6 JAN MARAIS NATURE RESERVE

10.6.1 Location

Jan Marais Nature Reserve is situated within the town of Stellenbosch and covers an area of about 25ha. There are private residential properties adjacent the reserve's northern, western and southern boundaries. Along the eastern border, separated by a road, is Stellenbosch School. The terrain is relatively flat and open to the public during the day. Jan Marais NR is of high biodiversity importance, as explained in the sections below. Due to its location within town it also presents a fire risk.

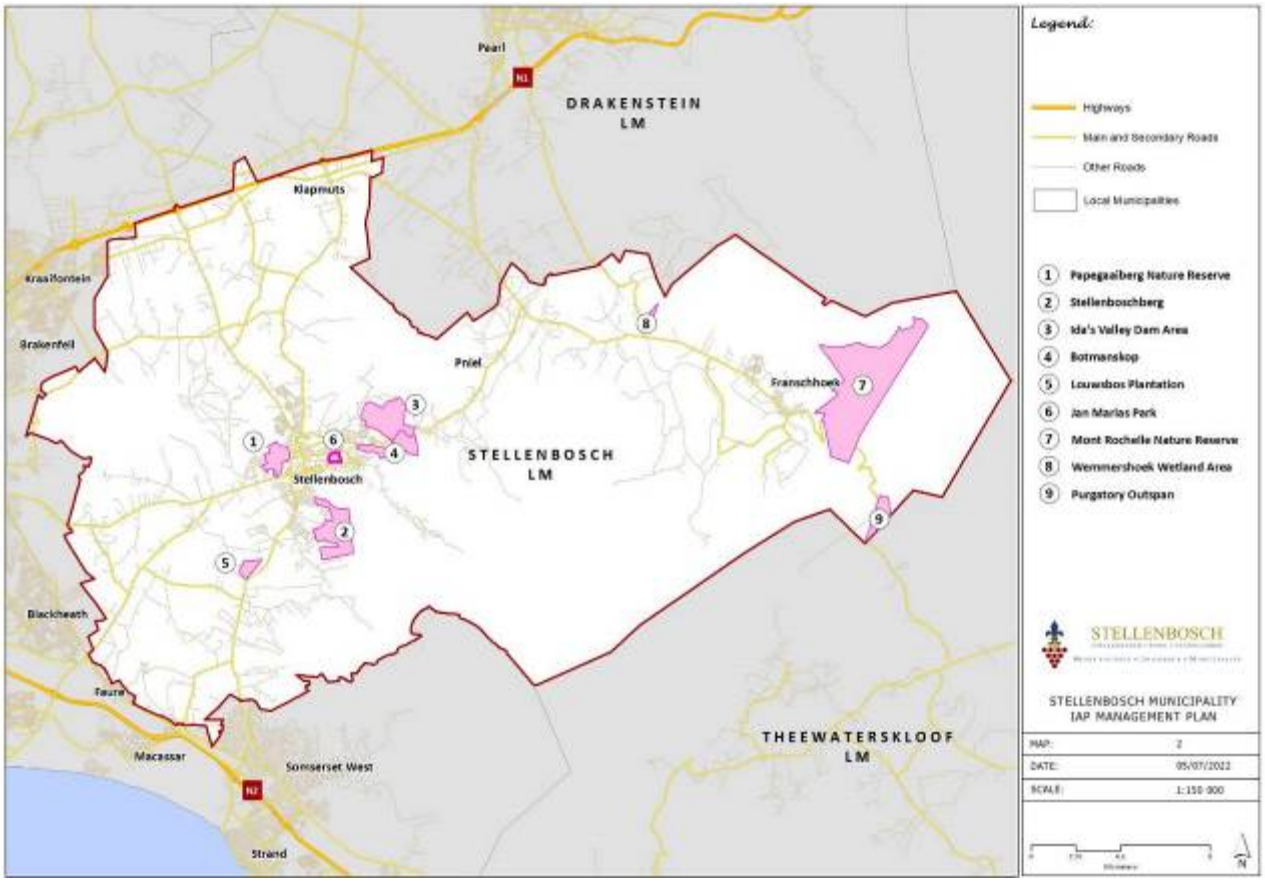

Figure 25: Jan Marais Nature Reserve.

10.6.2 Soil

The soil is imperfectly drained sandy soil and is mostly comprised of rock with limited soil.

10.6.3 Hydrology

There are no rivers that flow through the reserve, though there is a wetland. This wetland is an important habitat for many species such as dragon and damselflies.

10.6.4 Vegetation

The reserve is a formal land based protected area with Boland Granite Fynbos vegetation type, which is highly threatened due to extensive farming activities and thus falls within the vulnerable terrestrial ecosystem. Boland granite fynbos has 56 Red Data plant species and 23 endemic plant species. There are approximately 62% remaining natural areas, of which 14% is protected in the Hawequas, Hottentots Holland and Paarl Mountain Nature Reserve.

10.6.5 Current Alien Invasive Plant Infestation

There are no major infestations of alien invasive plants within Jan Marais Nature Reserve with the exception of several large *Eucalyptus grobulus* and large *Pinus pinea* trees along the northern border of the reserve. Continuous monitoring regularly occurs to ensure no regrowth of any invasive species.

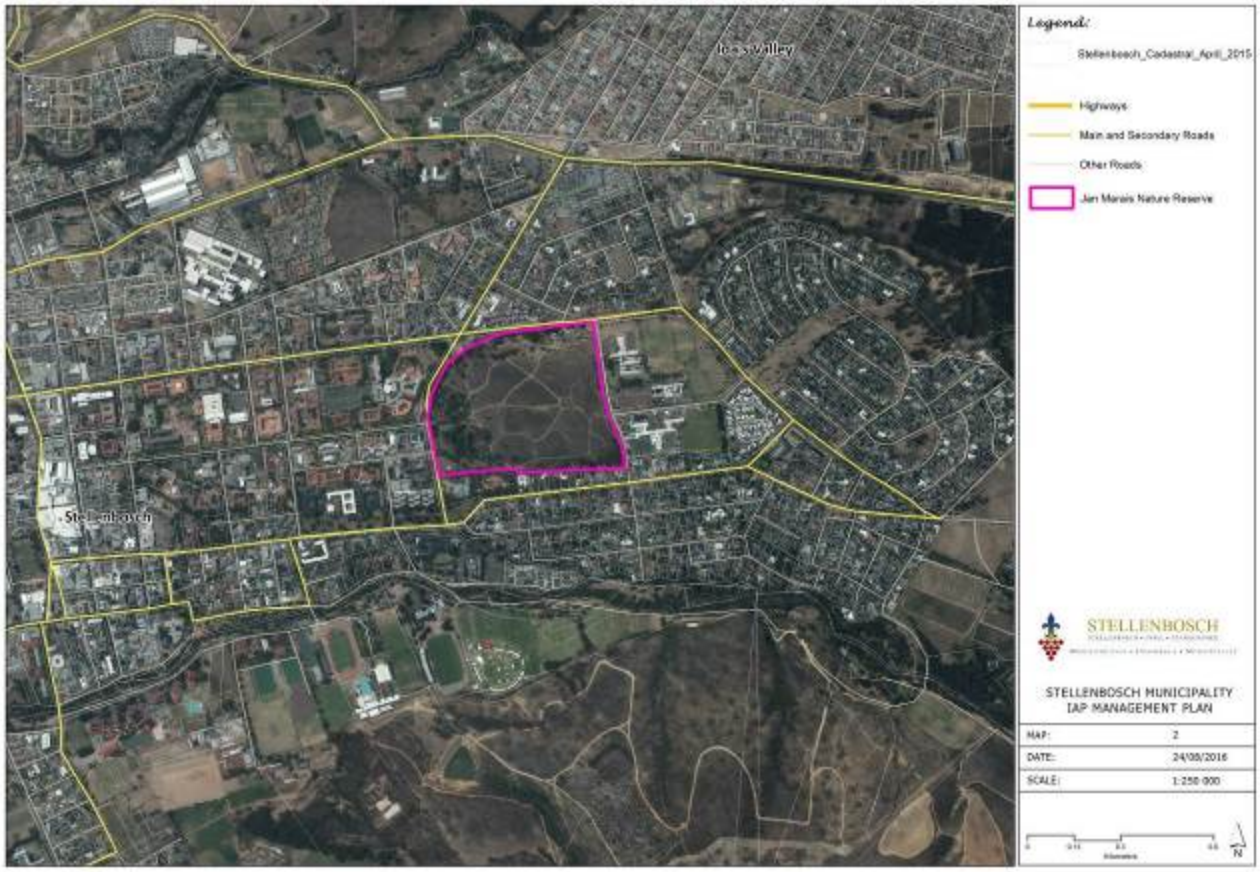

Figure 26: Jan Marais Nature Reserve.

10.6.6 Clearing Methods

Jan Marais Nature Reserve is by al standards cleared of alien invasive species, though continuous monitoring for possible establishment of invasive species should occur regularly. If an alien invasive plant is found within the reserve it should be removed (by uprooting it) and disposed of

away from the reserve. During April 2022 a controlled ecological burn within a two management blocks, with a total area of ±4ha, was executed (Photograph 1 and 2). These blocks, especially, should be monitored for any occurrence of IAPs.

Photograph 1: Law Enforcement Drone footage captured a day before the burn 20 April 2022.

Photograph 2: Law Enforcement Drone footage captured a day after the burn 22 April 2022.

10.7 MONT ROCHELLE NATURE RESERVE

10.7.1 Location

Mont Rochelle Nature Reserve occurs on the edge of Franschoek town, on the slope of the Franschoek Mountain Range. Mont Rochelle Nature Reserve is approximately 1 630ha in size. Mont Rochelle NR is of high biodiversity importance, as explained in the sections below, with a high risk of erosion given the topography of the site.

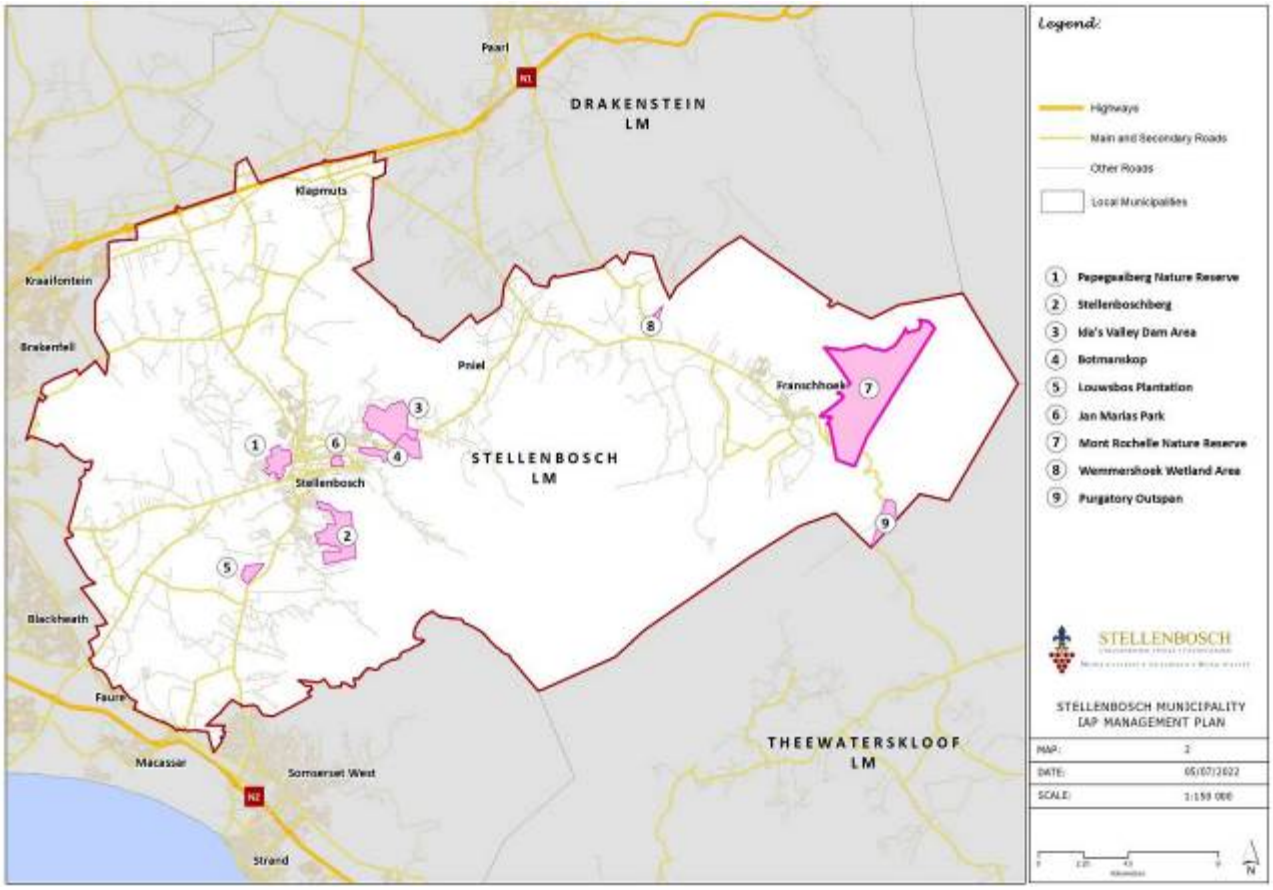

Figure 27: Mont Rochelle Nature Reserve.

10.7.2 Soil

The soil type is rock with minimum development soils that is usually shallow on hard, weathered rock and is with/without intermediate diverse soils. It has a non-soil land class with structure less and poorly drained soils. Lime is rare or absent in the landscape.

10.7.3 Hydrology

Du Toits River flows adjacent to the reserve. The Franshoek River originates from within the area.

10.7.4 Vegetation

The Boland granite fynbos and Kogelberg sandstone fynbos vegetation types found in Mont Rochelle Nature Reserve are of significant conservation importance. Boland granite fynbos has 56 Red Data plant species and 23 endemic plant species. There are approximately 62% remaining natural areas, of which 14% is protected in the Hawequas, Hottentots Holland and Paarl Mountain Nature Reserve. Kogelberg sandtone vegetation is well protected with a remaining 88% in existence of which approximately 58% is actively protected in the Hottentots Holland and Groenlandberg Nature Reserve. There are 99 Red Data plant species located within the Kogelberg sandstone fynbos with 176 endemic plant species (SANBI 2009).

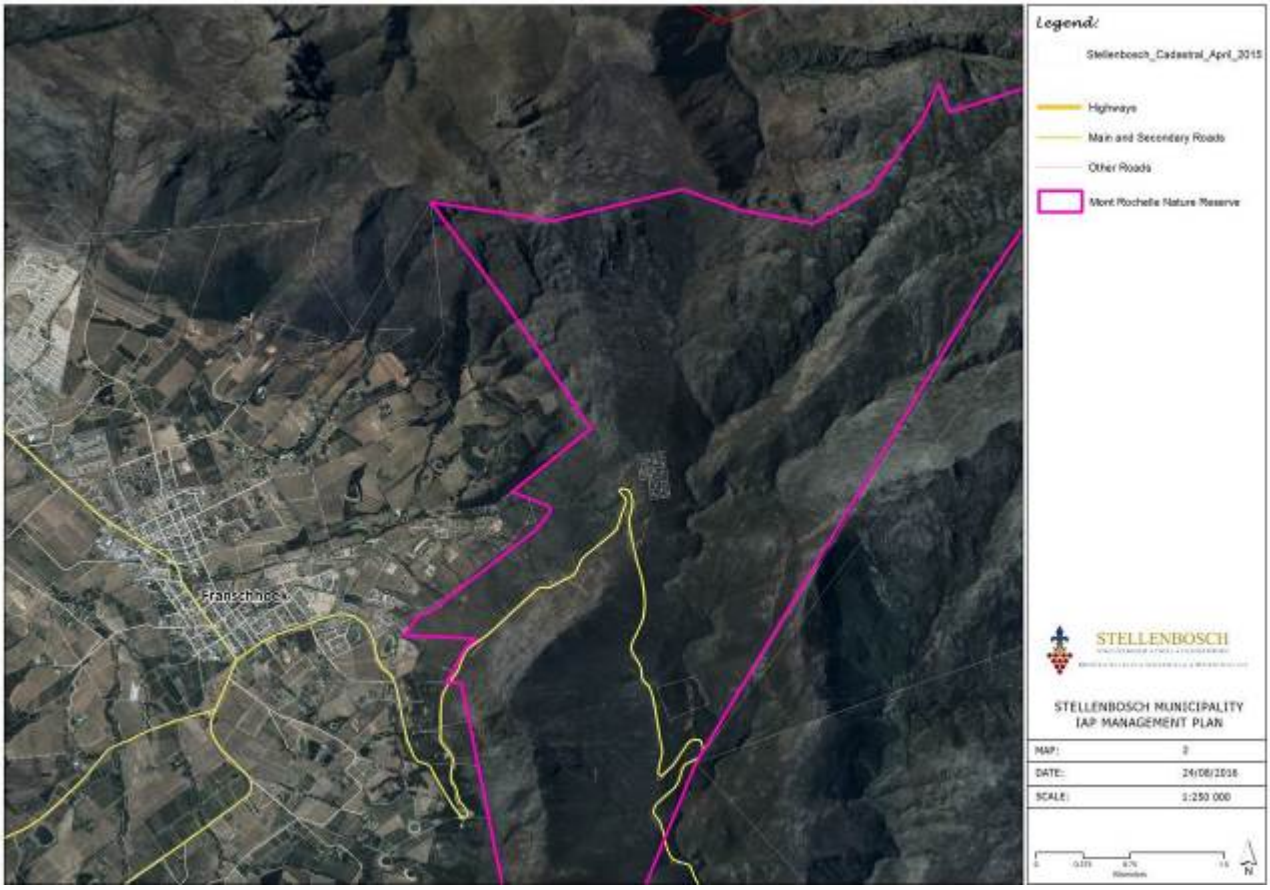

Figure 28: Local context of Mont Rochelle Nature Reserve.

10.7.5 Current Alien Invasive Plant Infestation

There are no major infestations of alien invasive plants within Mont Rochelle Nature Reserve. The presence of *Pinus* species, *Eucalyptus* species, *Acacia Mearnsii* and *Acacia melanoxylon* is classified as exceedingly rare and was thus not recorded. Continuous monitoring, however, should transpire regularly to ensure no regrowth of any invasive species occurs. If a species sprouts it is removed almost immediately and destroyed.

10.7.6 Clearing Methods

The NR did not receive a lot of attention during the past few years and the whole of the site must now be prioritized. Isolated pine clusters, located within the NR, has potential to spread and needs to be monitored and where possible removed. Given the topography of the site erosion control measures must be put in place following any clearing work conducted. Clearing strategies should initiate at the top of the slope and continue downwards. Strategies for clearing IAPs should be a combination of mechanical and chemical methods (Table 7, Section 11). All species should be removed mechanically by uprooting young plants and tree felling of larger trees followed by the application of chemical herbicides to the cut surface to prevent resprouting. Biomass accumulated from clearing work should be chipped.

10.8 WEMMERSHOEK WETLAND AREA

10.8.1 Location

Wemmershoek Wetland Area is located at the intersection of the R45 and the R301 at Wemmershoek on the way to Franschhoek town. The whole of the property is approximately 40ha in size sloping towards the Franschhoek River with a wetland at the lowest point. Wemmershoek Wetland Area is of high biodiversity importance and, being a wetland, presents a water security risk if not maintained.

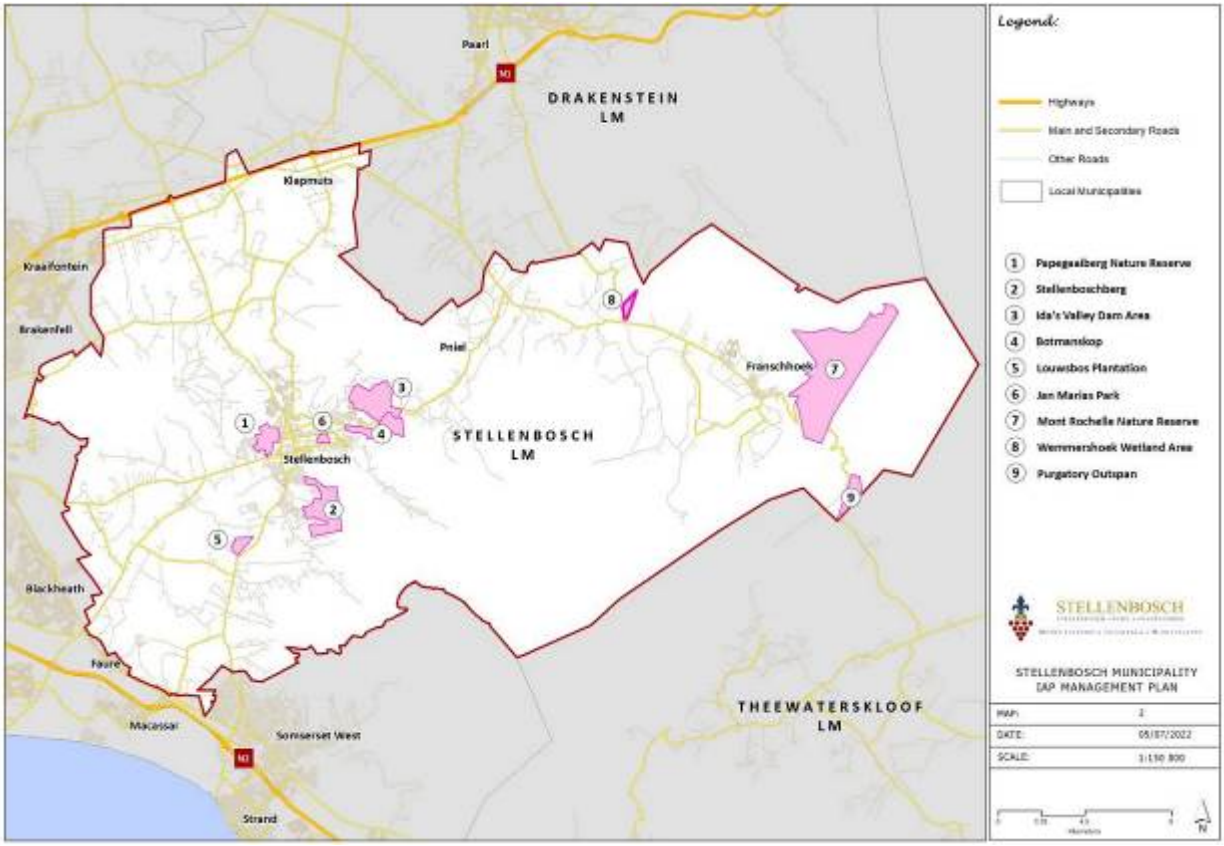

Figure 29: Wemmershoek Wetland Area.

10.8.2 Vegetation

Although the property has no formal protection status, a recent survey listed various Red Data plant species, especially in the vicinity of the wetland.

10.8.3 Current Alien Invasive Plant Infestation

There are no major infestations of alien invasive plants within the Wemmershoek wetland area. Continuous monitoring, however, should transpire regularly to ensure no regrowth of any invasive species occurs. If a species sprouts it should be removed immediately and destroyed.

Figure 30: Wemmershoek Wetland Area.

10.8.6 Clearing Methods

Wemmershoek wetland area is by all standards cleared of alien invasive species. Continuous monitoring for possible establishment of invasive species should occur regularly. If an alien invasive plant is found within the area it should be removed (by pulling the plant out). Biomass accumulated from clearing work should be chipped.

10.9 PURGATORY OUTSPAN

10.9.1 Location

Purgatory Outspan is located on the Theewaterskloof Dam's side of the Franschhoek Pass (see Figure 53 below). It is located at the foot of the pass on the municipal boundary and consists of an area of approximately 120ha. The site is of high biodiversity importance.

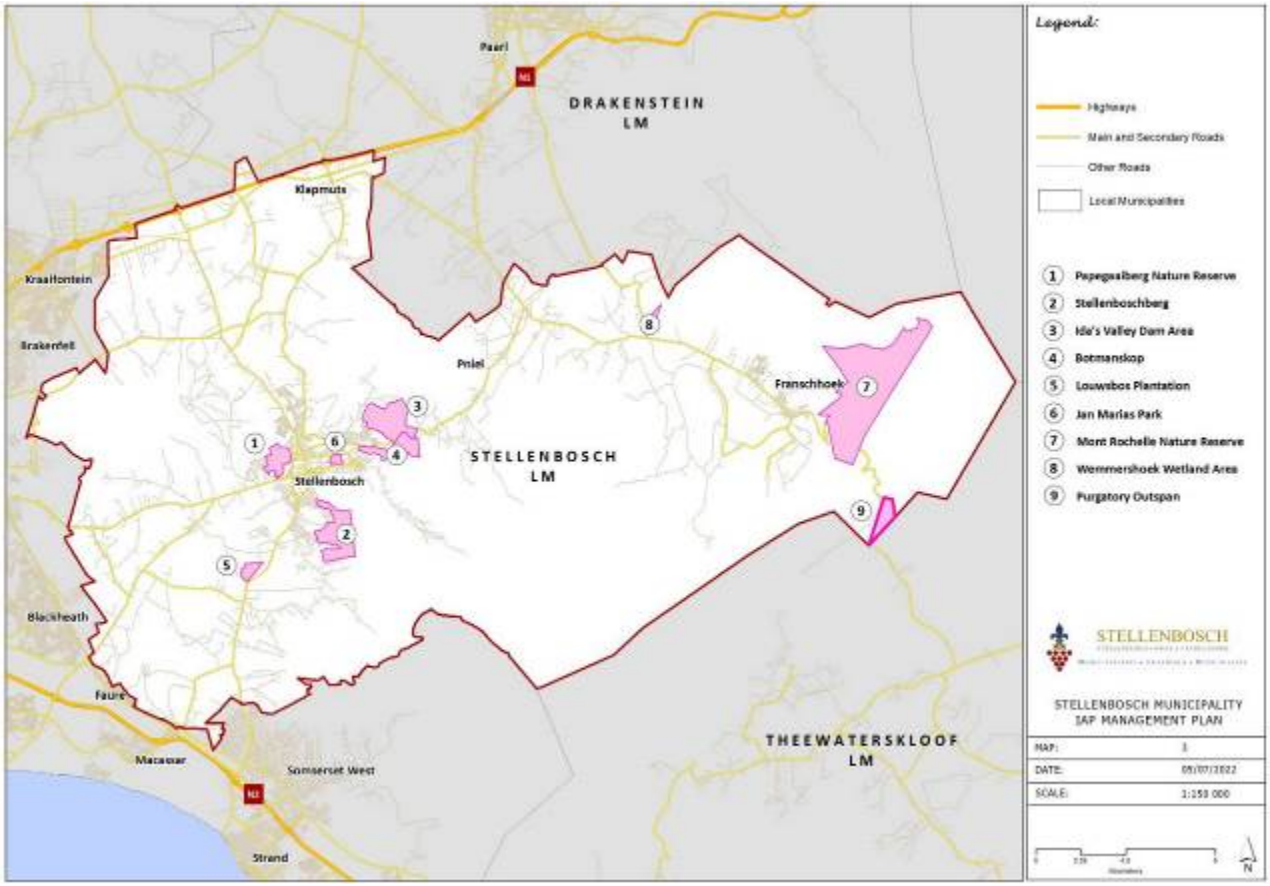

Figure 31: Purgatory Outspan.

10.9.2 Hydrology

Purgatory Outspan is located in a drainage area feeding the Theewaterskloof Dam.

10.9.3 Vegetation

The Boland granite fynbos and Kogelberg sandstone fynbos vegetation types found in the Purgatory Outspan area are of significant conservation importance. Boland granite fynbos has 56 Red Data plant species and 23 endemic plant species. There are approximately 62% remaining natural areas, of which 14% is protected in the Hawequas, Hottentots Holland and Paarl Mountain Nature Reserve. The 38% area lost has been transformed into vine orchids.

Kogelberg sandtone vegetation is well protected with a remaining 88% of which approximately 58% is actively protected in the Hottentots Holland and Groenlandberg nature Reserve as well as the Kogelberg Biosphere Reserve. There are 99 Red Data plant species located within the Kogelberg sandstone fynbos, and has 176 endemic plant species (SANBI 2009).

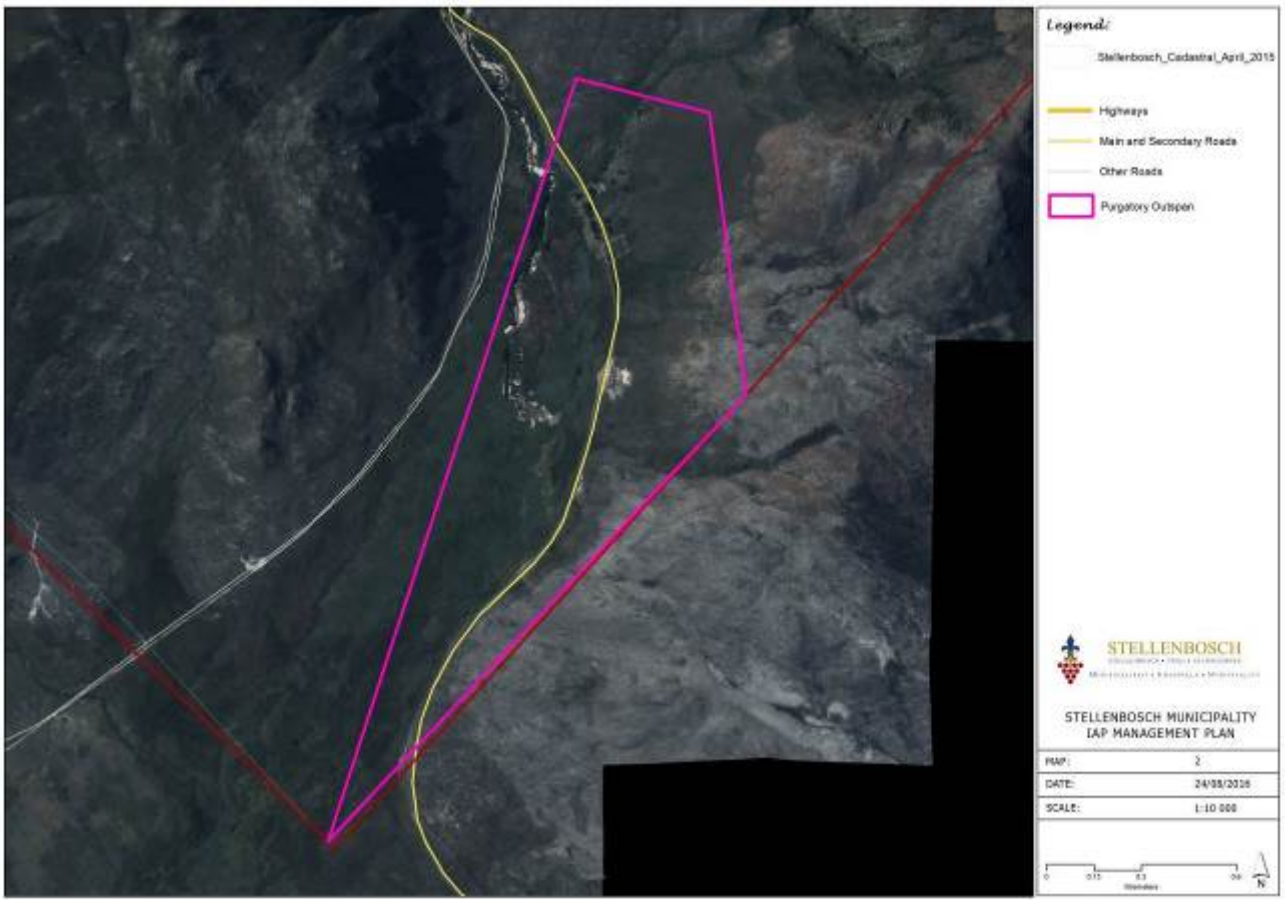

Figure 32: Local context of Purgatory Outspan.

10.9.4 Current Alien Invasive Plant Infestation

There are no major infestations of alien invasive plants within the Purgatory Outspan area. Continuous monitoring, however, should transpire regularly to ensure no regrowth of any invasive species occurs. If a species sprouts it is removed almost immediately and destroyed.

10.9.5 Clearing Methods

The Purgatory Outspan area is by all standards cleared of alien invasive species. Monitoring for possible establishment of invasive species should occur regularly. If an alien invasive plant is found on the property it should be removed by pulling the plant out. Biomass accumulated from clearing work should be chipped.

11. BUDGET

Over the next three years about R11 mil (Table 8) is budgeted for for the clearing of alien plant species from the properties listed in this management plan. This includes work required to maintain firebreaks.

Table 8: Three-year budget for alien clearing.

Financial Year	Amount
2022/23	R3 640 000
2023/24	R3 785 600
2024/25	R3 937 024
Total	**R11 362 624**

This budget is prioritized according to the prioritization list under Section 9.3 above and areas cleared during 2021/22.

12. STRATEGIES FOR CLEARING

Table 9: Control methods of alien invasive plant species occurring in the Stellenbosch Municipal Area[21].

Species	Plant Invasion Impact	Control methods	Control Caution
Acacia implexa (Screw-pod wattle)	Screw-pod wattle is a fast-growing tree and invades agricultural land, planted forests and disturbed areas.	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. **Chemical:** No registered herbicide for this species.	No registered chemical for this species, thus mechanical removal of this species should be executed with caution.
Acacia mearnsii (Black Wattle)	Black wattle forms dense impenetrable 'jungle thickets' that supresses indigenous vegetation. Reduces water flow when occurring along watercourses.	**Mechanical:** Uproot and sever below junction of roots. Tree felling. **Chemical:** Trees severed above ground should be treated with herbicides, such as 2,4,5-T in diesel oil. Glyphosphate can be used to control seedlings and saplings. • CHOPPER (L3444), HATCHET (L7409). Use 1 l/10 l water. Apply to freshly cut stumps. Apply at least 10 ml per 100 mm of stump diameter. • ACCESS 240 LS (L4920), BROWSER (L7357). Use 150 ml + 50 ml Actipron Super or BP Crop	Do not fell or burn without immediate follow up with herbicides due to rapid resprouting.

[21] Bromiow 2010; Striton 1978; Anon 2005

Species	Plant Invasion Impact	Control methods	Control Caution
		Oil/10 ml water. Apply to the cut surface of low-cut stumps within 3 hours of felling. • LUMBERJACK 360 SL (L7295), TIMBREL 360 SL (L4917). Use 300 ml + 50 ml Acrtipron Super or BP Crop Oil/10l water. Apply to the cut surface of low-cut stumps within 3 hours of felling.	
Acacia melanoxylon (Blackwood)	Grows best in moist and cool situations and is most common in forests, on forest margins and along streams. It competes with indigenous forest and riverine woodland trees. It thrives in shaded areas. This species also spreads vegetatively by suckers from its long surface roots.	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. **Chemical:** Trees severed above ground should be treated with herbicides. • CONFRONT 360 SL (L7314). Use 400 ml + 50 ml Actipron Super/10 l water. Apply to cut surface of low-cut stumps within 3 hours of felling. • TIMBREL 360 SL (4917). Use 600 ml + 50 ml Acrtipron Super/10l water. Apply to the cut surface of low-cut stumps within 3 hours of felling. **Biological:** Use as a long-term programme. Release of seed feeding weevil (*Melanterius maculatus*): attacks seeds of Black Wattle and reduces seed bank.	The wood and ornamental products of this species is highly used. This may cause it to be continuously planted for harvesting reasons. Thus, management of plantation of the species in highly important to prevent possible escape and establishment outside plantation borders.
Acacia saligna (Port Jackson)	Confined to coastal plains with mean annual rainfall of >250 mm. It is able to establish in dry areas as well as in the wetter areas, and the spread is affected by soil moisture, altitude and seed dispersal agents (mainly man and water).	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. **Chemical:** Trees severed above ground should be treated with herbicides. • CONFRONT 360 SL (L7314). Use 250 ml + 50 ml Actipron Super/10 l water. Apply to cut surface of low-cut stumps within 3 hours of felling. • LUMBERJACK 360 SL (L7295), TIMBREL 360 SL (L4917). Use 300 ml + 50 ml Acrtipron Super or BP Crop Oil/10l water. Apply to the cut surface of low-cut stumps within 3 hours of felling.	Port Jacksons reproduce rapidly after fire occurrences. Apply herbicides almost immediately after severing due to rapid resprouting. Port Jackson will rapidly spread to disturbed areas, thus continuous monitoring of disturbed areas are important.

Species	Plant Invasion Impact	Control methods	Control Caution
Acacia pygnantha (Golden Wattle)	Less widely distributed and invasive compared to other wattles. Introduced as stabilizing agent. Replaces indigenous vegetation.	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. **Chemical:** Trees severed above ground should be treated with herbicides. • MOLOPO 500 SC (L5854) (Soil treatment). Use 1,5 l/2,25l water. Apply on the soil at the base of the target plant before or during rainy season. For seedlings use 2 ml /plant; for trees up to 1 m use 2 x 2 ml /tree; for trees 1-2 m use 3-4 x 2 ml /tree; for each additional metre above 2 m use 2 x 2 ml (maximum of 16 ml) • MOLOPO 800 SC (L7043) (Soil treatment). Use 937 g/3,752 l water. Apply on the soil at the base of the target plant. For seedlings use 2 ml /plant; for trees up to 1 m use 2 x 2 ml /tree; for trees 1-2 m use 3-4 x 2 ml /tree; for each additional metre above 2 m use 2 x 2 ml (maximum of 8 doses)	This species requires a combination of mechanical, chemical and cultural techniques when removed.
Eucalyptus grandis (Saligna gum)	Eucalyptus species use a large amount of water, thus reducing stream flow and lowering water supply. Eucalyptus species are able to outcompete indigenous species, threatening local biodiversity.	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. Seedlings can be removed by hand and are also susceptible to fire. **Chemical:** Trees severed above ground should be treated with herbicides. • ROUNDUP MAX (L6790). Use 265 g/10 l water. Apply to cut surface of low-cut stumps within 3 hours of felling. • LUMBERJACK 360 SL (L7295), TIMBREL 360 SL (L4917). Use 300 ml + 50 ml Acrtipron Super or BP Crop Oil/10l water. Apply to the cut surface of low-cut stumps within 3 hours of felling.	Apply herbicides almost immediately after severing due to rapid resprouting.
Paraserianthus lophantha	This species forms monospecific stands and has altered the landscape in many areas where it occurs.	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. **Chemical:** This species does not	Seedfeeding bio-control agents have not been affective. Long-term follow-ups are needed to remove this species.

Species	Plant Invasion Impact	Control methods	Control Caution
		resprout from burnt or cut stems and does not require herbiced application.	
Pinus pinea (Stone Pine)	This species easily establishes in cool moist areas where they transform the landscape and reduce the carrying capacity of the area as well as increase fire risk.	**Mechanical:** Uprooting young plants (especially in moist soil). Uproot and sever below junction of roots. Tree felling. **Chemical:** Trees severed above ground should be treated with herbicides. • ROUNDUP MAX (L6790). Use 265g/10 l water. Apply to cut surface of low-cut stumps within 3 hours of felling. For seedlings use 2 ml /plant; for trees up to 1 m use 2 x 2 ml /tree; for trees 1-2 m use 3-4 x 2 ml /tree; for each additional metre above 2 m use 2 x 2 ml (maximum of 16 ml) • MOLOPO 800 SC (L7043) (Soil treatment). Use 937g/3,752 l water. Apply on the soil at the base of the target plant. For seedlings use 2 ml /plant; for trees up to 1 m use 2 x 2 ml /tree; for trees 1-2 m use 3-4 x 2 ml /tree; for each additional metre above 2 m use 2 x 2 ml (maximum of 8 doses)	Accumulation of fuel load increases the danger of fire.
Pinus pinaster (Cluster Pine)	Seedlings germinate easily and establish in cool, moist soil. Pine trees reduce carrying capacity of invaded areas such as mountain and lowland fynbos, and thus threaten native biodiversity.	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. Burn approximately 12 to 24 months after clearing to eliminate seedlings. **Chemical:** Trees severed above ground should be treated with herbicides. • ROUNDUP MAX (L6790). Use 265g/10 l water. Apply to cut surface of low-cut stumps within 3 hours of felling. For seedlings use 2 ml /plant; for trees up to 1 m use 2 x 2 ml /tree; for trees 1-2 m use 3-4 x 2 ml /tree; for each additional metre above 2 m use 2 x 2 ml (maximum of 16 ml) • MOLOPO 800 SC (L7043) (Soil treatment). Use 937g/3,752 l water. Apply on the soil at the	Accumulation of fuel load increases the danger of fire.

Species	Plant Invasion Impact	Control methods	Control Caution
		base of the target plant. For seedlings use 2 ml /plant; for trees up to 1 m use 2 x 2 ml /tree; for trees 1-2 m use 3-4 x 2 ml /tree; for each additional metre above 2 m use 2 x 2 ml (maximum of 8 doses)	
Pittosprum undulatum	This species has a fast growth rate and shades out many other plants. Its ability to adapt to higher nutrient soils enables it to out-compete indigenous species. Its seeds are favoured by birds which may, in turn, neglect the seed of indigenous species causing a reduction in seed dispersal.	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. **Chemical:** There is no registered herbicide for this species.	No registered chemical for this species, thus mechanical removal of this species should be executed with caution.
Populus canescens	These trees are found throughout the country on riverbanks and in vleis, where they form dense and uniform stands. They can spread into surrounding veld.	**Mechanical:** Uproot young plants. Uproot and sever below junction of roots. Tree felling. **Chemical:** Trees severed above ground should be treated with herbicides. • CHOPPER (L3444), HATCHET (L7409). Use 500 ml/10 l water. Apply to the cut surface of low-cut stumps. Apply at least 10 ml per 100 mm of stump diameter. • ACCESS 240 SL (L4920), BROWSER (L7357). Use 200 ml + Actipron Super or BP Crop Oil//10 l water. Apply to the cut surface of low-cut stumps within 3 hours of felling. • LUMBERJACK 360 SL (L7295), TIMBREL 360 SL (L4917). Use 600 ml + 50 ml Acrtipron Super or BP Crop Oil/10l water. Apply to the cut surface of low-cut stumps within 3 hours of felling.	This species is difficult to control mechanically as they are able to coppice when cut and regenerates vigorously from root suckers. Herbicides should thus be used when controlling this species.
Robinia pseudoacacia (Black locust)	This species is found on riverbacks and alongside roads. The seeds, inner bark and shoots are poisonous. The flowers compete	**Mechanical:** any attempts to cut down this tree will stimulate sucker production from roots and stumps. Mechanical control is thus non-optional. **Chemical:** This trees species does not	This species is able to resprout even several years after it appears to be killed. Thus, annual monitoring and follow up treatments are important.

Species	Plant Invasion Impact	Control methods	Control Caution
	with native species for pollinators. Dense clonal clusters replace other indigenous vegetation.	respond well to herbicides, though systematic application products are available. • CONFRONT 360 SL (L7314). Use 200ml + 50ml Actipron Super/10l water. Apply as full cover spray to actively growing plants. Plants too high should be slashed and regrowth sprayed. • PLENUM 160 ME (L7702). Use 150ml + 50ml Actipron Super/10l water. Apply as full cover spray to actively growing plants.	
Rubus fruticosus (European Blackberry)	It forms dense stands and the thorny bushes are impenetrable, which restrict the movement of humans and animals.	**Mechanical:** cultivation/removal of the rhizome. **Chemical:** Specialized herbicides are used due to underground runners and are mostly affective in autumn because the sap transports the chemical to the roots. • ROUNDUP MAX (L6790). Use 80g/10l water with knapsack sprayed over 100g/10l water with mist-blower. Apply as full cover. • ROUNDUP TURBO (L7166). Use 240ml/10l water with knapsack sprayed and 320 ml /10l water with mist-blower. • MAMBA MAX 480 SL (L7714). Use 220ml/10l water with knapsack sprayed and 300 ml /10l water with mist-blower. • KILO WSG (L7431). Use 300ml/10l water with knapsack sprayed or 400 ml /10l water with mist-blower. Apply as full cover spray to actively growing plants. Slash growth in winter and apply when new growth is more than 0,5 m high.	Underground runners make this species difficult to eradicate. Specialised herbicides should be used when controlling the species. Herbicides should be applied during autumn when downward sap movement can transport the herbicide to the roots.

13. AUDITING

Control and eradication work performed in terms of this plan must be audited annually. The environment audit to be undertaken is a methodical examination of each site's status in terms of its IAP infestation and to determine the success or impact of the control and eradication measures undertaken.

The environmental audit consists of three stages, namely *pre-audit*, *on-site audit* and *post-audit*. Pre-audit includes the administrative issues associated with planning the audit, selecting the institution to conduct the audit, and preparing the audit protocol. The main purpose of the pre-audit stage will be to develop an audit plan, based on the most recent information and the results of the previous year's audit. The audit plan must also address where the audit is to be conducted, what the scope and objectives of the audit are, how the audit will be conducted (keeping in mind that the results of the audit must be comparable to previous year's audit results), and when the audit is to be conducted.

The on-site audit involves the recording of required information. The audit team gathers information by observation, conducting photographic studies, taking measurements, and conducting tests as was determined during the pre-audit stage. During the on-site audit stage the strength and weaknesses of the methods of information gathering must be evaluated in order to determine whether the process of auditing is effective in achieving its goal. In keeping with the adaptive management approach, the auditing process must also be looking for continual improvement. All the information obtained is recorded and a comprehensive record of the audit and the state of affairs produced.

The audit report is completed during the post-audit stage. Such report will reflect previous, current results, and recommended improvement goals. The audit report will also indicate failures or deficiencies and recommendations for corrective actions.

Table 10: Environmental Indicators for auditing purposes[22].

BIODIVERSITY & NATURAL HERITAGE	
Species Diversity	BD01 – Threatened and extinct species per taxonomic group BD02 – Endemic species per taxonomic group BD03 – Alien (non-indigenous) species per taxonomic group BD04 – Population trends of selected species BD05 – Distribution and abundance of selected alien species
Habitat Change	BD06 – Extent of conserved area BD08 – Disturbance regimes: fire frequency BD09 – Disturbance regimes: flood and drought
Resource Value	BD11 – Contribution to job creation: eradication of alien species
Natural Heritage Resources	NH01 – Status of natural heritage resources NH02 – Investment into natural heritage resources NH03 – Visitors to natural heritage resources
LAND USE	
Land Use	LU01 – Land cover LU02 – Land productivity vs potential
Land Condition	LU03 – Soil loss LU04 – Land degradation

[22] Environmental Indicators for National State of the Environment Reporting, DEAT, 2002

REFERENCES

Allen, T.F.H., and Hoekastra, T.W., (1992). Towards a Unified Ecology. Columbia University Press, New York.

Allen, T.F.H., and Starr, T.B., (1982). Hierarchy: Perspectives for Ecological Complexity. University of Chicago Press, Chicago.

Anon, (2005). Control of unwanted plants. Xact Information Ltd.

Bromilow, C., (2010). Problem Plants and Alien Weeds of South Africa. Briza Publications, Pretoria, South Africa.

Dennis Moss Partnership, (2011). Papegaaiberg Nature Reserve Environmental Management Plan. Consultative Draft.

Denny, P., (1992). An approach to the development of environmentally sensitive action plans for river floodplain management in central and Eastern Europe. In: Finlayson M. (ed.), Integrated Management and Conservation of Wetlands in Agricultural and Forested Landscapes. pp. 46-49. IWEB Special Publication, Number 22, Slimbridge, Gloucester, England.

Edwards, K.R., (1998). A critique of the general approach to invasive plant species. In: Starfinger, U.,

Edwards, K., Kowarik, I., and Williamson, M. (ed.), Ecological Mechanisms and Human Responses. pp. 85-94. Backhuys Publishers, Leiden, The Netherlands.

Enright, W. D. (2000). The effect of terrestrial invasive alien plants on water scarcity in South Africa. Phys. Chem. (B), Vol 25, No 3, 237-242.

Koen, L. (2013). A Management Plan for Alien Invasive Plants on Municipal Land in Stellenbosch Municipality. Faculty of Entomology and Conservation, University of Stellenbosch.

Le Maitre, D. C., van Wilgen, B. W., Gelderblom, C. M., Baily, C., Chapman, R. A., and Nel, J. A. (2002). Invasive alien trees and water resources in South Africa: case studies of the costs and benefits of management. Forest Ecology and Management 160, 143-159.

Le Maitre., D. and Versfeld, D., (1994). Field Manual for mapping populations of invasive plants for the use with the catchment management system. CSIR Division of Forest Science and Technology.

Macdonald, I. A. W., Jarman, M. L. (1985). Invasive alien plants in the terrestrial ecosystems of Natal, South Africa. CSIR Foundation for Research Development, Council for Scientific and Industrial Research, Pretoria.

Macdonald, I. A. W., Jarman, M. L. and Beeston, P., (1985). Management of invasive alien plants in the Fynbos Biome. CSIR Foundation for Research Development, Council for Scientific and Industrial Research, Pretoria.

Margerum, R.D., and Born, S.M., (1995). Integrated environmental management: Moving from theory to practice. J. Environ. Plan. Manag. 28: 371-391.

Richardson, D., (1989). The ecology of invasions by Pinus (Pinaceae) and Hakea (Proteaceae) species, with special emphasis on pattern, processes and consequences of invasion in mountain fynbos of the southwestern Cape Province, South Africa. Doctoral thesis. Cape Town: University of Cape Town.

Richardson, D.M., Macdonald, I.A.W., and Forsyth, G.G., (1989). Reduction in plant species richness under stands of alien trees and shrubs in the fynbos biomass. Far-off 149:1-8.

Richardson, D. and Brown, P., (1986). Invasion of mesic mountain fynbos by Pinus radiate. South African Journal of Botany 52, 6:529-536.

Richard, D. M., Pysek, P., Rejmanek, M., Barbour, M. G., Panetta, F. D., and West, C. J. (2000). Naturalization and invasion of alien plants: concepts and definition. Diversity and Distributions 6, 93-107.

SANBI (2009). Threatened Ecosystems in South Africa: Description and Maps. South African Biodiversity Institute, Department of Environmental Affairs and Tourism

Schonegeval, L., (2001). Modelling alien vegetation invasions and clearing strategies. Master's Thesis. Stellenbosch: University of Stellenbosch.

Tsoar, A., Shohami, D., and Nathan, R., (2011). A movement ecology approach to study seed dispersal and plant invasion: an overview and application of seed dispersal by fruit bats. In: Richardson, D.M., (2011). Fifty years of invasion ecology: the legend of Charles Elton. Blackwell publishing. Garsington Road. Oxford. UK. P. 103-119.

Tucker, K. C., and Richardson, D. M. (1995). An Expert System for Screening Potentially Invasive Alien Plants in South African Fynbos. Journal of Environmental Management 44, 309-338.

Van Wilgen, B. W., Forsyth, G. G., Le Maitre, D. C., Wannenburgh, A., Kotzé, J. D., and van den Berg, E., (2012). An assessment of the effectiveness of a large, national-scale invasive alien plant control strategy in South Africa. Biological Conservation 148, 28-38.

Versfeld, D.B., Le Maitre D.C., Chapman R.A., (1998). Alien invading plants and water resources in South Africa: A preliminary assessment. Pretoria: Water Research Commission.

Vitousek, P.M., Mooney, H., Lubchenco, J., and Melillo, J.M., (1997). Human domination of Earth's ecosystems. *Science*, 277. P. 494-499.