Biodiversity Best Practice Guidelines for Potato Production in the Sandveld

A Biodiversity & Business Initiative
Report submitted to **Potato South Africa** and **CapeNature**

By

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**Disclaimer**

This report is the result of a project commissioned by Potatoes South Africa and CapeNature and was funded by Potatoes South Africa, Conservation International, Woolworths, Cape Action for People and the Environment, Critical Ecosystem Partnership Fund, CapeNature and Pick-'n-Pay. The recommendations contained herein are based on earlier scientific work and the knowledge of the specialist consultants. It has been subjected to peer review and is made in good faith. However, Potatoes South Africa, CapeNature, Conservation International, Woolworths, Cape Action for People and the Environment, Critical Ecosystems Partnership Fund, Pick-'n-Pay, members of the Task Team or the specialist consultants do not accept liability for any loss or damage resulting, either directly or indirectly from implementing any or all of the recommendations made in the report.

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"Ons leef in 'n wêreld waar snelle vooruitgang en ontwikkeling meer en meer geneem word teen die negatiewe impak wat dit op die omgewing het. Globale aardverwarming word nou as 'n realiteit beskou. Die sensitiviteit van ons jonger geslag en moderne tendense het die gevolg dat ekonomiese rolspele proaktief en strategies verantwoordelik moet optree.

In Suid-Afrika is daar tekorte aan sekere hulpbronne waarvan water een van die mees kritiese is. Die verantwoordelike gebruik van water sal waarskynlik in die toekoms toenemend onder die vergrootglas geplaas word.

Die Sandveld met sy besondere biodiversiteit, met unieke eienskappe en mense, was vir lank feitlik ongeskonde. Die aartappel industrie in die streek het die afgelope twintig jaar egter vinnig ontwikkel met toenemende druk op ons biodiversiteit.

Daar is landbouers in hierdie gebied wat die natuur wil beskerm, verantwoordelike en volhoubaar wil produseer. Landbou kan nie suksesvol wees sonder die handhawing van 'n gesonde balans met die omgewing waarbinne dit beoefen word nie. Om venootskappe met boere, natuurbewaring, die handel, regerings en nie-regerings organisasies, internasionale befondsers en die verbruiker te vorm, is 'n eerste in sy soort. Dit is vir al hierdie rolspele 'n uitdaging om dit te laat slaag. Ons suksesse tot dusver is die direkte gevolg van ons passie en strewe na 'n meer omgewings vriendelike samelewing.

Aan my mede-produsente wil ek die uitdaging stel - dit is nou die tyd as Sandveld produsente om aan die wêreld te wys hoe belangrik ons omgewing vir ons is. Kom ons gryp die geleentheid aan om hierdie projek te ondersteun, die implementering op ons plase met dringendheid te begin en die beginsels deel te maak van ons langtermyn prosesse en procedures.

Verantwoordelike bestuur in samewerking met alle belangegroepe van dit wat aan ons toevertrou is, is essensieel. Die nageslag moet met trots en waardering kan terug kyk na wat ons huidiglik doen.

Ek wil graag die taakspan, medewerkers, donateurs, wetenskaplikes en almal wat 'n bydrae tot nou toe gemaak het, bedank vir al die tyd en energie wat in hierdie projek geë...
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### Acronyms and abbreviations

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<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AFCASA</td>
<td>Crop Protection and Animal Health Association</td>
</tr>
<tr>
<td>BBPI</td>
<td>Biodiversity Best Practices Initiative</td>
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<td>BWI</td>
<td>Biodiversity and Wine Initiative</td>
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<tr>
<td>C.A.P.E.</td>
<td>Cape Action for People and the Environment</td>
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<td>CARA</td>
<td>Conservation of Agricultural Resources Act</td>
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<td>CI</td>
<td>Conservation International</td>
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<tr>
<td>DEA&amp;DP</td>
<td>Department of Environmental Affairs and Development Planning</td>
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<td>EIA</td>
<td>Environmental Impact Analysis</td>
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<tr>
<td>GCBC</td>
<td>Greater Cederberg Biodiversity Corridor</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>IPM</td>
<td>Integrated Pest Management</td>
</tr>
<tr>
<td>IPW</td>
<td>Integrated Production of Wine</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Environmental Management Act</td>
</tr>
<tr>
<td>NDA</td>
<td>National Department of Agriculture</td>
</tr>
<tr>
<td>PPECB</td>
<td>Perishable Products Export Control Board</td>
</tr>
<tr>
<td>SAKO</td>
<td>Sandveld Aartappel Kwekers Organisasie</td>
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<td>SANS</td>
<td>South African National Standards</td>
</tr>
<tr>
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<td>Water Research Commission</td>
</tr>
<tr>
<td>FPA</td>
<td>Fire Protection Agency</td>
</tr>
<tr>
<td>CMA</td>
<td>Catchment Management Agency</td>
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<td>WUA</td>
<td>Water Users Association</td>
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1 Introduction

Between 6000 and 7000 ha of potatoes are planted annually in the Sandveld.

These guidelines are a joint initiative of Potatoes South Africa and CapeNature, aimed at guiding and promoting responsible farming practices in support of the conservation of the fragile biodiversity of this unique region.

Potato production is the core economic activity in the Sandveld of the Western Cape. In the last three years an average of 6 591 ha was planted annually for the production of seed potatoes, ware potatoes (fresh market) and potatoes for the processing industry (French fries, crisps and frozen products) in an area between the Cederberg mountain range in the east, the Atlantic ocean in the west, the Darling area in the south and Strandfontein in the north. The total turnover for the industry can reach R400m per annum (6500 ha x 40t/ha x R13/10kg), offering job opportunities to some 3 250 workers.

Input costs are high and environmental and other farming conditions often pose great challenges to the farmer in maintaining a viable enterprise. With the exception of the production along the Olifants and Berg Rivers, almost all irrigation depends on groundwater of localised deteriorating quality and still unknown reserve volume. In addition, a number of important biodiversity features are found within the area:

- The core of the production area coincides with an important ecological corridor linking the Greater Cederberg conservation area with the lowlands and the coast.
- The Verlorenvlei is a coastal lake of international conservation significance and is recognised as a RAMSAR site.
- At least 65 rare and threatened plant species and a large number of threatened animal species occur in the Sandveld.
- At least 30 of these threatened plant species are found only in the core Sandveld area (and are thus endemic to the region).
- Recent studies show that six vegetation types are entirely restricted to this area, and a further three are found predominantly in this area. All nine vegetation types are regarded as threatened on a national basis.
- Leipoldtville Sand Fynbos can be regarded as one of the key threatened habitats in the region (about 50% already lost to cultivation) and it supports at least 40 threatened plant species, of which at least 15 are found only in this vegetation type.

Under these circumstances conflict can occur between farmers and conservationists, whilst discerning consumers may also develop resistance to buying Sandveld potatoes, should the farmers take an irresponsible stance. For this very reason Fig. 1: Green dots indicate centre pivot circles used for potato production in the study area. Note that other agriculture is not indicated in this figure.
Potatoes South Africa and CapeNature have joined forces to compile this set of biodiversity best management practice guidelines and to stimulate greater awareness amongst producers in favour of responsible farming practices.

The guidelines aim to limit the impact of potato production on the natural resources, promote ecologically sustainable farming practices and promote conservation of biodiversity.

**Planning principles**

Thorough planning should form the basis of all production, starting with a sound market analysis and complete assessment of the natural resources (including biodiversity) available on the farm. Essentially each farm should be viewed as a single component of a larger environment within which ecosystems needs to function sustainably. At farm level, planning should be focussed at creating a production environment that does not destroy irreplaceable biodiversity, threaten or limit ecological functions, over exploit natural resources, whilst the farming operation itself should be financially viable to ensure sustainability.

**Environmental objectives**

The Cape Action for People and the Environment (C.A.P.E.) is a programme of the South African Government, with support from international donors, to protect the rich biological heritage of the Cape Floristic Region (CFR) of which the potato growing areas of the Sandveld are a part. C.A.P.E. seeks to unleash the economic potential of land and marine resources through focused investment in development of key resources, while conserving nature and ensuring that all people benefit.

The establishment of the Greater Cederberg Biodiversity Corridor (GCBC) is one of the priorities identified in the C.A.P.E. strategy. Given its large size, varied terrain and wilderness nature, the Cederberg Corridor has the potential to conserve not only biological patterns but also...
the ecological and evolutionary processes that sustain these patterns.

One of the main goals of the GCBC initiative is to promote best practice land-uses by:

- Ensuring that all values and traditional land-use practices of the GCBC are recognized and respected.
- Striving to prevent inappropriate land-use practices and provide alternatives.
- Establishing buffer areas and linking provincial with national protected areas.
- Providing opportunities for recreation and tourism that will ensure preservation of the region's essential qualities.

As a first step towards the establishment of important corridors between the inland Cederberg mountain range and the coast, a core area has been identified, where the participation of the majority of land owners has been obtained. Here the remaining fynbos will be set aside for conservation and an encompassing environmental management plan will be followed to ultimately create a coast-to-mountain corridor.

The implementation of this set of best practice farming guidelines on each farm in the Sandveld is strongly endorsed by all conservation agencies operating in the area. However, it cannot be regarded as an all encompassing guideline capable of addressing all current and future issues and therefore it will require revision and amendment from time to time.

**Regulations**

A comprehensive set of legislation and regulations aimed at sustainable development and conservation of resources govern the farming activities in the Sandveld. These include:

- Subdivision of Agricultural Land Act. (Act 70 of 1970)
- CARA: Conservation of Agricultural Resources Act (Act 43 of 1983)
- Environment Conservation Act (Act 73 of 1989) - repealed by NEMA
- National Veld and Forest Act (Act 101 of 1998)
- SANS 10206

These acts and regulations fall under the jurisdiction of the National and Provincial Departments of Agriculture (NDA & PDA), Department of Water Affairs (DWAF) and the Department of Environmental Affairs and Development Planning (DEA&DP) and the National Department of Environmental Affairs and Tourism. Historically, some government agencies have been less vigilant in their enforcement of these laws than others, contributing to a perceived relaxed legal environment exploited by some less sensitive
farmers, often motivated by difficult economic and/or agronomic conditions.

The new Water Act provides for the establishment of Catchment Management Agencies (CMA’s) and Water User’s Associations (WUA’s) who will be responsible for the monitoring and management of water issues on a catchment basis. Self regulation is becoming more important and therefore the Potato Industry – due to its prominent role in the Sandveld - should in future be prepared to take a firm stance in the promotion of principles contained in the various acts.

Industry Footprint

Recent (2003/4) satellite imagery shows a total of 1773 centre pivots in the potato production area of the Sandveld, with a combined area of 30 740 ha. This is about 2 200 ha less than the area required to maintain a 5 year rotation cycle of 6591 ha (average for the last 3 years). This discrepancy is explained by the fact that a large percentage of the recent production took place on “new” land (land not previously used for potato production, but not necessarily virgin soil). Also, some producers only produce for the fresh market (no seed potatoes) and therefore do not always follow a 5 year rotation cycle. An analysis of the expansion trend of expansion in the footprint of the industry shows that, in the core of the production area (Wadrif to Paleisheuwel to Moutonshoek to Elandsbaai) the number of centre pivot fields increased from 599 to 1355 and the area from 12 384 ha to 22 871 ha over the last 10 years. This is an increase of 84 % in area and 126 % in number of circles. The average centre pivot size decreased from 20.7 ha to 16.9 ha. An even higher rate of expansion, although not quantified, was observed in the Aurora to Darling area and along the Jakkals River.

The area planted did not follow this trend and is at present (±6 600 ha) slightly less than 10 years ago (±6 800 ha). The peak of 7 558 ha in 2001 is a reflection of both the profitability of potato production per se and the profitability relative to other crops (i.e. wheat in the Aurora - Hopefield area) at the specific time.

Water use by the potato industry in the Sandveld is conservatively estimated at 46.9 Mm³/a. The annual average recharge has been estimated, based on the Groundwater Recharge Assessment of DWAF in 2005, as 234 Mm³/a. This implies that 20% of the annual recharge is abstracted for potato production. As no safe abstraction limits have been set as yet, it is not possible to evaluate this figure in terms of sustainability.
However, for some catchments the abstraction percentages almost reach 80% which certainly cannot be sustainable. The following table indicates the estimated abstraction rates for each quaternary catchment.

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Abstraction as % of annual recharge</th>
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<tbody>
<tr>
<td>E10G</td>
<td>3%</td>
</tr>
<tr>
<td>E10J</td>
<td>34%</td>
</tr>
<tr>
<td>E10K</td>
<td>7%</td>
</tr>
<tr>
<td>G10K</td>
<td>15%</td>
</tr>
<tr>
<td>G10L</td>
<td>5%</td>
</tr>
<tr>
<td>G10M</td>
<td>2%</td>
</tr>
<tr>
<td>G21D</td>
<td>4%</td>
</tr>
<tr>
<td>G30A</td>
<td>37%</td>
</tr>
<tr>
<td>G30B</td>
<td>3%</td>
</tr>
<tr>
<td>G30C</td>
<td>27%</td>
</tr>
<tr>
<td>G30D</td>
<td>75%</td>
</tr>
<tr>
<td>G30E</td>
<td>77%</td>
</tr>
<tr>
<td>G30F</td>
<td>79%</td>
</tr>
<tr>
<td>G30G</td>
<td>49%</td>
</tr>
</tbody>
</table>

The values were calculated from average planted hectares as recorded by Potatoes South Africa and an irrigation volume of 6 900 m³/ha/a as calculated by the Department of Agriculture from monitoring a representative number of centre pivots.
2 General farming and biodiversity friendly practices

Financial plan

No farming activities should be undertaken without good financial planning. An analysis of the market place is the first step and will indicate if and when opportunities for better prices or larger volumes exist. The financial plan should not only deal with input costs and incomes, but also the cost of capital (interest), replacement costs, owners remuneration, etc.

Base map

A good base map of the farm should form the basis of all development planning. Recent aerial or high resolution satellite imagery should ideally be used as a backdrop and infrastructure and production units should be surveyed by GPS or drawn from scale correct imagery. Precision agriculture further requires that this information is available in digital (GIS) format. A geographic information system can also be used as a valuable management tool on the farm.

Land clearing

Removal of natural vegetation for new lands is the single most important activity leading to loss of biodiversity in the Sandveld. Clearing of virgin land should only be considered where no alternative land is available and can only be done after authorisation has been obtained from:


The clearing of New/ Virgin Land is a listed activity in terms of NEMA, requiring a Basic Environmental Assessment (BA) or Scoping and Environmental Impact Assessment (EIA): Activity 12 in GN No. R. 386 of 21 April 2006 and reads as follows:

The transformation or removal of indigenous vegetation of 3 hectares or more or of any size where the transformation or removal would occur within a critically endangered or an endangered ecosystem listed in terms of section 52 of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)

Areas < 20 ha in total (including all areas cleared since 3 July 2006) - (BA)
Areas > 20 ha in total (including all areas cleared since 3 July 2006) - (EIA)

The presence of any plant species listed in Appendix 1 (or any other Red Data Book listed species) strongly suggests that the site is of high biodiversity value and should not be cultivated. The presence or absence of these species should be assessed by a qualified botanical specialist, who should also indicate the likelihood
of such species occurring in the area, identify the vegetation type concerned, make reference to the C.A.P.E. Fine-Scale Biodiversity Plan for the Sandveld (in preparation), and indicate possible mitigation measures.

### Sensitive Botanical Areas
The three vegetation types most impacted by agriculture in the Sandveld, are:
- Leipoldtville Sand Fynbos
- Graafwater Flats Strandveld
- Bergriver Sand Fynbos / Flats Strandveld Mosaic

All three are found only in lowland areas (ie. not in the mountains), and have deep soils, hence their suitability for agriculture.

These three types support about 80% of the Endangered or Critically Endangered plant species in the Sandveld. In these three types 50-60% of the original natural vegetation has already been lost, which means that there is a high concentration of threatened plant species in the remaining areas, and the vegetation types themselves are regarded as Endangered on a national basis (Rouget et al 2004).

To date very little of these vegetation types has been formally conserved (<1%), although the national conservation target is about 29% of the original extent. This means that about half of what remains must be formally conserved in order to reach these national conservation targets.

All old lands that have not been ploughed for more than 10 years are regarded as virgin land and therefore also need a permit before being reworked. Since 3 July 2006 all clearing of natural vegetation of more than 3 ha is subject to a Basic Environmental Assessment. Where more than 20 ha needs to be cleared a full “Scoping” and EIA process is triggered. Phased removal of less than 3 ha of natural vegetation at a time, also requires a permit when the cumulative removal (after 3 July 2006) exceeds 3 ha.

Thus any further applications to cultivate virgin land in these three vegetation types should not be considered, unless a qualified botanist has determined that no threatened species (see Appendix 1 or updated lists) or critical biodiversity features occur or are likely to occur in the application area, AND not unless offset by formal conservation of natural vegetation areas (within the same vegetation type) at least fifteen times as large (ratio in line with provincial guidelines on biodiversity offsets; DEA&DP, 2007). The conservation areas should be signed up as Stewardship Programme sites with CapeNature, which is the recommended way in which the conservation of these privately owned areas can be formalized, and thus help achieve conservation targets.

Applications to cultivate virgin land for potatoes in all other Sandveld vegetation types are still subject to the legally required botanical assessments. It is strongly recommended that any approvals be accompanied by written expressions of willingness by the landowner to engage with the CapeNature Stewardship Programme for the remaining portions of conservation priority land on the subject properties.
Fig. 6: Vegetation map of the Sandveld (compiled from C.A.P.E. Fine-Scale Biodiversity Plan, CapeNature), indicating the sensitivity of each vegetation type towards further transformation:

- Red areas: Leipoldtville Sand Fynbos - Very high sensitivity
- Orange areas: Hopefield Sand Fynbos or Bergriver Sand Fynbos / Flats Strandveld Mosaic or Graafwater Flats Strandveld - High Sensitivity
- Yellow areas: Lambertsbay Strandveld - Moderate sensitivity
- Green areas: Vegetation types not threatened by potato production, but may be highly threatened by other activities including Roobos tea production, Small grain production or urbanisation.
**Irrigation water sources**

The abstraction of water for irrigation, whether from groundwater, a dam or a river requires registration of both the source and the abstraction volumes with the Department of Water Affairs and Forestry (DWAF).

General authorisations for the abstraction of ground- and surface water has been granted and later revised by DWAF for most catchments in South Africa. In many parts of the Sandveld water allocations has been regulated by Subterranean Government Water Control Areas, each with its specific allocations. The present ruling for most of the Sandveld is that no additional water may be abstracted unless a licence has been obtained from DWAF.

All surface water sources (i.e. the Olifants River, Berg River and Verlorenvlei) have been excluded from the general authorisations. All abstraction from these sources also requires an abstraction licence. No potato production should start prior to the acquisition of the necessary water permits and/or licences. The guidelines and involvement of the Water User's Associations will become increasingly important in this regard.

**Buffer Zones**

Cultivated land has an inherent pollution potential, through leaching of applied nutrients, erosion of enriched soil, and spray drift of applied chemicals. Buffer strips between lands and natural water streams, rivers or wetlands are recommended as an attempt to minimise the pollution potential. Normally buffer strips of 30 - 40 m are recommended. In the Sandveld, where the risk of wind erosion, spray drift of agrochemicals and the leaching of nutrients are high, the buffer strips should at least be 50 m wide, although 100 m is preferred.

**Groundwater contamination**

In the Sandveld, the risk of groundwater contamination is high, due to the high permeability of the soil and the shallow depth of the water table. Contamination can happen through point source pollution, such as a leaking liquid fertilizer tank or through leaching of nutrients because of over irrigation and fertilisation. Guidelines to minimise the risk of groundwater contamination will be given under the respective headings below.

**Dams**

Although only a few large farm dams exist in the Sandveld, many smaller lined dams are used as temporary storage facilities for abstracted groundwater, whilst a number of unlined dams are used to access the groundwater in areas where the water table is shallow. In all instances the following guidelines should be followed.
The storage of water in all dams should be registered with DWAF. Dams smaller than 50 000 m³ and with a maximum dam wall height of 5 m (measured on the downstream side) are permitted under a general authorisation. For larger dams a licence is needed. All activities diverting or impeding river flow need DWAF authorisation prior to construction. No dams should be constructed within the course of a river or stream.

Farm dams can contribute to the conservation of rare indigenous fish species. For this purpose the dam should be free of alien fish species, it should provide the fish sufficient cover from birds in the form of underwater structures (logs & rocks) and indigenous water lilies and weeds, and should not be emptied below a set minimum level. Contact CapeNature (Dean Impson) at 021 886 8019 for further advice.

**Roads**

Proper farm planning and responsible use of roads will avoid the unnecessary loss of natural vegetation, associated with an indiscriminate network of farm roads. A permit is also required to remove more than 3 ha of natural vegetation for making farm roads.

![Fig. 7: An indiscriminate network of farm roads can lead to unnecessary destruction of natural vegetation.](image)

Construction of a road may trigger the listed activity in GN 386, Activity 15 in the NEMA regulations and reads as follows:

*The construction of a road that is wider than 4 metres or that has a road reserve wider than 6 metres, excluding roads that fall within the ambit of another listed activity or which are access roads of less than 30 metres long.*

**Alien plants**

Many alien plant species are invasive by nature and negatively impact on the natural vegetation. Dense invasive species also increase the risk and intensity of veld fires, use substantial additional surface and groundwater and increase the risk of erosion. Landowners are under obligation, in terms of the Conservation of Agricultural Resources Act (Act 43 of 1983) to clear their land of listed invasive alien plants, using appropriate DWAF approved methodology.

Very specific strategies should be followed when starting with alien clearing. The following are basic guidelines:

- Realise that alien control is a long term strategy
- Start with a map indicating the distribution, density and species involved
- Begin clearing the lighter infested areas and upstream areas first
- Collaborate with neighbours to implement a wider strategy
Monitor and record all actions for follow-up purposes

The primary invasive species in the area are *Acacia saligna* (Port Jackson), *Acacia cyclops* (rooikrans), *Acacia longifolia* (longleaf wattle), *Eucalyptus* species (gums), and *Arundo donax* (spaanseriet). Consult the Landowner Alien Clearing Manual of CapeNature for a detailed guide on all clearing actions. This guide is available from: [http://www.cederbergcorridor.org.za/library/](http://www.cederbergcorridor.org.za/library/)

**Fire**

Although veld fires are not as common in the Sandveld as in the mountainous areas of the Western Cape, they can have a significant impact on biodiversity and should therefore be discussed here.

In terms of the National Veld and Forest Act (Act 101 of 1998) each landowner is responsible for the prevention and management of all fires that occur on his/her land. Assistance with compliance with the regulations is provided where landowners and their neighbours form a Fire Protection Agency (FPA).

The following guidelines are provided in terms of fire breaks:

- **Every property must have a system of fire breaks in place.** The breaks must be on the boundary of the property unless there is an exemption granted by the Minister or an agreement with the adjoining landowner that the firebreak be located somewhere else within an FPA.
- **Firebreaks must be located strategically to control the spread of wildfires, but mainly serve as an access road from which to fight a fire.** A sensible firebreak width is not wider than 10m in most fynbos and renosterveld vegetation areas and must not be burnt during times when there is a high fire risk.
- **It is often preferable to simply have a “tracer belt” of 2/3m to allow quick access and an opportunity to use a “backburn”.**
- **Owners should ensure that firebreaks are positioned and prepared in such a way as to cause the least disturbance to soil and biodiversity, which will also reduce the risk or erosion and limit the spread of invasive alien plants.** This is achieved by bushcutting (using a bossieslaner, kapmes, or weedeater) rather than ripping or ploughing. Bush cutting should be undertaken in early summer (Nov - Dec).
- **The owner should, if possible, transplant threatened succulents and bulbs that occur within a proposed fire break.** As shrubs usually cannot be transplanted successfully the best alternative is to position the firebreak to avoid threatened species (see Appendix 1 for list of threatened plant species in the Sandveld).

Please note that the making of fire breaks could trigger the listed activity of NEMA in terms of the GN 386, Activity 12 - The transformation or removal of indigenous vegetation of 3 ha or more.

The Greater Cederberg Fire Protection Agency can be contacted at PO Box 277, Citrusdal 7340, whilst an information brochure can be obtained from: [http://www.cederbergcorridor.org.za/library/](http://www.cederbergcorridor.org.za/library/)

The following are general fire management principles:

- **In the drier areas closer to the coast, and on the more alkaline sandy soils, fires are not necessary, and not recommended.** These Strandveld vegetation types often occur up to 8km inland of the coast, and do not require fire.
- **The interval between fires should be determined by the growth rate of the indigenous plants.** No fire should be permitted in fynbos until at least 50% of the population of the slowest-maturing species in an
general farming and biodiversity friendly practices

area (often members of the Protea family, which can also be used to age the veld) have flowered for at least three successive seasons. In the relatively dry Sandveld areas the recommended interval between fires is 15-20 years. External growth nodes on Protea family species can be used to age the veld, and where such species are not present the size of certain shrubs provides a good indication (consult an expert if help is needed).

- Generally, the recommended time for a prescribed burn is March to April, as regeneration is best when followed immediately by the rainy season.
- Intensity is influenced by the fuel load, fuel moisture, relative humidity, gradient and wind speed. The intensity can be manipulated by selecting conditions, point of ignition relative to slope and wind that will lead to the desired type of fire, remembering that the more intense the fire generally the better it is for fynbos, provided that the fuel load has not been increased by alien vegetation.
- It is thus important to remove all alien vegetation from an area before a controlled burn. This should be done using DWAF approved methods.
- It is vital to maintain a mosaic of different vegetation ages within a property (a variety of approved burning practices and veld ages is the best way to maintain species diversity).
- Inform neighbours and local municipality fire officers of your intention to burn at least two weeks prior to the event.
- Ensure fire fighting equipment is maintained and in good working order before the start of each fire season.
- Keep accurate records of fire, using a map of veld age as a basis. Note the date and time of ignition, weather conditions, etc.
- Monitor all extinguished fires for at least two days after a burn.
- Do NOT allow livestock to graze natural areas in the first two years following a fire. All plants are very vulnerable to grazing pressure by domestic stock (especially cattle) in the first 2 years after a fire, and regeneration will be up to 70% better if grazing pressure is removed completely for the key first two years.

Rehabilitation

Biodiversity can greatly benefit from rehabilitation and/or restoration of previously disturbed areas. However, the use of the wrong species for example, can do more harm than good. For this reason specialist advice should be obtained prior to all rehabilitation actions. In all cases it is preferable (and cheaper) to minimise disturbance to natural areas rather than trying to rehabilitate already disturbed areas. Contact CapeNature at 022 931 2900 for assistance.

Wetlands

Many significant wetlands are found in the Sandveld. All these areas have a number of important ecological functions. They act as sponges during flood periods, slowly releasing the water after rains whilst recharging the groundwater and protecting downstream riverbanks from erosion. Sediment and pollutants are trapped and they act as natural fire breaks. They further provide a special habitat for many plant and animal species some of which are dependant on wetlands for all or part of their lifecycles. Activities in wetlands are restricted in terms of the Conservation of Agricultural Resources Act the National Water Act (section 21 and 22) and possibly NEMA also.
Activities in wetlands may trigger the listed activity in GN 386 No 4 in the NEMA regulations and reads as follows: The dredging, excavation, infilling, removal or moving of soil, sand or rock exceeding 5 cubic metres from a river, tidal lagoon, tidal river, lake, in-stream dam, floodplain or wetland.

The following guidelines apply:
- Identify and delineate wetlands during winter months. (Some wetlands are not easily identified during the dry summer.) Wetlands are identified by a combination of soil type and plant species.
- Keep natural buffer areas of 50 - 75 m around wetlands free of alien plants and irrigated crops.
- Do not restrict or block the water supply to a wetland.
- Take care not to modify or disturb the catchment of a wetland (e.g. by road construction), as this may lead to increased runoff and possible erosion of the wetland.
- Do not over abstract or divert surface or groundwater feeding into a wetland, which may cause it to dry up. High-yielding boreholes should not be sunk in or near wetlands.
- Dam construction within wetlands transforms the wetland into a permanent water body, resulting in the loss of the important wetland “sponge” habitat. Dams should thus be constructed outside wetlands and stream channels. (DWAF authorisation/registration required.)
- Avoid siting pollution sources like waste disposal sites, domestic effluent, etc. near wetlands.
- Regularly clear wetlands of invasive alien plants, taking care not to disturb the soil (i.e. do not use heavy machinery).
- All modifications of water flow in or through a wetland is illegal. Disturbed wetlands can often be successfully restored by returning the flow to its original state through closing of drainage ditches and trenches.
- Certain wetlands (especially grassy floodplains) can be grazed, provided that no over- grazing occurs, and that it is done in the correct season (December to April).
- Most wetlands should ideally be fenced off and kept free of grazing, and this applies especially to those on acid sands (all those within Leipoldtville Sand Fynbos). Grazing large stock in wetlands in winter and spring can cause severe erosion and loss of biodiversity, and is not recommended.

More information can be obtained from: www.wetland.org.za-pracmanage.htm.

Rivers

Rivers and river banks (riparian zone) support a unique habitat that fulfils several ecological functions. Rivers and streams act as
- act as ecological corridors
- deliver water to downstream areas
- feed groundwater sources
- provide habitat and shelter to numerous plants, animals and micro-organisms that clean and purify the water.
Activities in the river or on the river bed may trigger the following listed activities in GN 386, Activity 1(m) in terms of NEMA and reads as follows:
The construction of facilities or infrastructure, including associated structures or infrastructure, for-
Any purpose in the one in ten year flood line of a river or stream, or within 32 metres from the bank of a river or 
stream where the flood line is unknown, excluding purposes associated with existing residential use, but including -
Canals; Channels; Bridges; Dams; Weirs;
and Activity 4 that reads as follows:
The dredging, excavation, intfilling, removal or moving of soil, sand or rock exceeding 5 cubic metres from a river, tidal 
lagoon, tidal river, lake, in-stream dam, floodplain or wetland.

The following guidelines should be adhered to:
- All water use activities have to be registered/authorised by DWAF. This includes:
  - impeding or diverting river flow,
  - construction of dams,
  - abstraction from a river
  - discharging effluent into a river and
  - altering the beds, banks or course of a river, including erratic streams.
- Control invasive alien plants, including water plants, in rivers and the riparian zone.
- Rehabilitate riparian zones where possible.
- Allow adequate buffer zones (50 - 75 m) between river banks and cultivated lands.
- Maintain an adequate ecological reserve (i.e. minimum river flow to sustain functioning of the river 
  ecosystem). Over abstraction will decrease flow, concentrate pollutants, increase temperature and 
  drastically impact on the health of the river system.

The advice of a freshwater specialist should be consulted wherever rehabilitation is considered or where 
problems occur.

**Corridors and habitat fragmentation**

Removing natural vegetation for cultivation has a fragmenting effect on the remaining natural habitats. Providing buffer strips and significant ecological corridors can positively contribute to maintaining a healthy environment within an agricultural landscape. Many insect species, including important pollinators of rare plants, will not cross large agricultural fields, and others move seasonally from the hills to the flats, and need to move along routes that still have natural vegetation, where they can feed and find shelter. Many pollinators require large, continuous patches of natural vegetation (> 100ha) in order to survive the dry seasons when little is flowering, and will thus disappear from heavily fragmented, agricultural landscapes, leading to a possible failure in seed set for many plants. Natural vegetation corridors also act as windbreaks, and improve the aesthetic and ecotourism appeal of a landscape. The following basic principles will enhance the effectiveness of corridors:
- Conserve pieces of continuous natural habitat.
- Use corridors to link fragments of natural habitat.
- Corridors should be wide enough to allow undisturbed movement of animals and plants, and minimum width is scale dependant, ranging from 50 -1000m. The basic principal is the wider the better.
o Ideally distances between fragments of natural habitat should not be more than 500m and should consist of pollinator friendly terrain (old lands and pastures are more easily crossed by most pollinators than monoculture fields).

o Reduce edge effects by using regularly shaped corridors. Edge effects include spray and fertigation drift from cultivated fields, fertiliser runoff, and invasion of alien weeds, and are more pronounced in irregularly shaped corridors.

More information can be found in the CapeNature Info sheet: “Biodiversity in an Agricultural Landscape” at: http://www.cederbergcorridor.org.za/library/

**Game management**

Two aspects of game management are relevant in terms of these guidelines, namely the introduction or keeping of game on farms and the control of damage causing animals.

When keeping or introducing game on farms care should be taken to ensure that non-indigenous species and high population densities do not damage the remaining natural veld. Merely keeping game on a farm does not necessarily constitute conservation. Carrying capacity, feeding habits (grazers vs browsers) and veld and soil types should be professionally assessed where after species and numbers can be decided upon. Species historically indigenous to the area are strongly recommended as they are adapted to the environment and will have the least impact on the natural veld. A recent study by Dr Ken Coetzee may be helpful in this regard. Contact CapeNature at 022 931 2900 for further guidance.

Control of crop damaging animals is often a problematic issue. Some landowners believe that the additional food source introduced by cultivation leads to escalation in animal numbers (e.g. duikers) and that culling is therefore justified. Whilst this may sometimes be true it often happens that a single stand of potatoes during the dry season attracts individual animals from distant grazing areas with a concentrating effect creating only the perception of an increase in numbers.

Control measures should as far as possible, be based on prevention and deterrence rather than culling. The following guidelines have been successful elsewhere:

**Buck:**
- Fencing off with 1.2 m Bonox fencing has proved the most effective preventative measure.
- Lighting and the playing of radios through the night have also been suggested.

**Baboons:**
- Electric fencing is effective, and this can be solar powered.
- Baboon monitors can be employed to frighten off baboons.
- When hunting baboons never remove an entire troop as other (often more than one) troops will move in to replace the previous troop. Also avoid shooting the alpha male as he plays an important role in troop discipline and keeping it away from human contact. A troop without this guidance can cause even more damage.

**Porcupine:**
- One electric wire in a fence at 25 - 30 cm above ground is an effective preventative measure. It is important not to make the wire lower as it may then kill tortoises.

Landowners are under legal obligation to control and remove the following invasive alien fauna:
o Alien fish species (including bass),
o Mallard ducks and
o Feral pigs, dogs and cats.

**Waste management**

Irresponsible disposal of refuse and other waste products can severely impact on the environment and biodiversity, mainly through pollution effects.


In terms of the law all waste disposal sites need to be registered with DEAT. However, small private non-commercial farm waste disposal sites have been exempted from this requirement on condition that:
o The site is situated outside a water resource and above the 1:50 year floodline,
o The site is adequately fenced to prevent entry of people and animals,
o The site does not overly an area with shallow or emergent water tables,
o The burning of waste does not cause any nuisance conditions to neighbours and
o The waste does not cause any nuisance conditions due to the breeding of flies or other vermin.

Additionally the following guidelines are suggested:
o Locate sites in previously disturbed areas, not in natural vegetation.
o Recycle where possible.
o Educate farm workers and their families on waste management and recycling.

Guidelines for the safe handling and disposal of chemicals and empty containers are covered on page 23 and in the checklist attached as Appendix 3.

**Environmental management plan**

Management of the environment is not an optional activity any more. The National Environmental Management Principles (section 2 of the National Environmental Management Act 107 of 1998) provide mandatory guidelines that

A basic environmental management plan should form part of the operational plan of every farm. This need not be the result of an elaborate and expensive study, but should identify sensitive areas, all vegetation types, wetlands, special habitats, and recommend procedures for maintaining or enhancing the biodiversity of the farm.

The identification of portions of land that could be formally set aside under Cape Nature’s Stewardship Programme is strongly promoted, as this will
contribute towards the establishment of much needed regional corridors, achieving of national conservation targets for the unique Sandveld vegetation types, and ensure conservation of these areas for future generations. Within the scoring system ten bonus points are awarded annually if landowners agree to sign up conservation worthy land under the Stewardship Programme.

Fuel storage

The following guidelines are prescribed by DWAF as their standard to comply with the requirements of the National Water Act (Act No. 36 of 1998), the Water Services Act (Act 108 of 1997) and the National Environmental Management Act (Act No. 107 of 1998):

- Do not locate any fuel depot within the 1:100 year flood line, or within a horizontal distance of 100m (whichever is greater) of a watercourse, drainage line or identified wetland.
- Store all fuel at long term depots within a bunded area, underlain by a concrete slab, sloped towards a sump for spillage removal. The bund must be able to accommodate at least the full volume of one of the containers.
- Provide impervious paving adjacent to fuel tanks, upon which vehicles must park during refuelling. This will help to accommodate fuel spills during refuelling.
- The only permitted method of fuel transfer is by means of a pump, controlled valve, tap, hose and funnel.
- Treat spills within the bund and the contents of the sump as hazardous waste
- In addition these facilities should be built on previously disturbed land, and not in areas of natural vegetation.

The storage of fuel on site may trigger a listed activity requiring a Basic Environmental Assessment (BA) or Scoping and Environmental Impact Assessment (EIA); GN 387, Activity No 1(c) and reads as follows: The construction of facilities or infrastructures, including associated structures or infrastructure, for - The above ground storage of a dangerous good including Fig. 8: Cross section through fuel storage facility as proposed by DWAF standards. (Diagram taken from DWAF Best Practice Specifications.)
3 Soil management

The soils of the Sandveld differ vastly from most other regions, mainly due to the very low clay content which induces:
- Low water retention capacity.
- Low cation exchange capacity and with it a low retention of nutrients.
- High permeability and thus a high leaching potential.
- Low buffer capacity and high acidity.
- Low nitrification potential.
- High wind erosion potential.
- Moderate compaction potential due to a well graded sand fraction.

Add to this list the fact that the main source of irrigation water is the groundwater, often situated only a few meters below the production zone, and a delicate and complex system to manage starts to unfold.

Soil management and agronomic practices should not only be adjusted to suit the character of the soils, but should also be efficiently managed to ensure optimum yields without negative impacts on the environment.

Know your soil

The first step in good soil management is to know your soil. Not all Sandveld soils are exactly the same and different soils respond differently. Knowledge about subsurface layers of gravel or clay is essential and should ideally be assessed by a competent soil scientist.

Soil fertility and plant nutrition

Adequate soil sampling of lands, prior to all production is essential to determine nutrient requirements and data on the pH and salinity of the soil.

Nutrient management should be adjusted to the specific requirements of the crop at each growth stage and the properties of the soil. Excessively high levels of nutrients in the soil solution create a high leaching risk that could lead to contamination of the groundwater and should be avoided.

Erosion control

Water erosion is seldom problematic thanks to the high infiltration rate and permeability of the Sandveld soils. Wind erosion is however a serious problem that contributes to:
- Sandblasting of crops
- Loss of soil
- Loss of nutrients
- Artificial nutrient enrichment of surrounding natural vegetation and/or water bodies
- Wasting of water through attempts to kerb erosion by means of irrigation.

Production practices capable of limiting wind erosion should always be followed. This include avoiding specific sites and soils where extreme wind erosion is prevalent, the use of cover crops, maintenance of natural vegetation buffers and strips, and avoiding planting and harvest times that correspond with strong windy periods.

**Cultivation practices**

Proposed cultivation practices that should be considered and implemented where applicable are:

- Establishment of a good stand of a suitable cover crop after harvest.
- Crop rotation is ideal, but can lead to increased demand for irrigation water and should only be followed where high value crops can be used.
- Deep cultivation should be used wherever compacted layers in the subsoil prevent proper root development.
4 Irrigation practices

Irrigation anywhere has a potentially harmful impact on the ecology through the artificial modification of the environment. In dry areas this impact can be even greater as the natural systems are not adapted to high “rainfall”. In the Sandveld, the volume of water applied through irrigation exceeds the natural rainfall by a factor of between 3 (winter) and 5 (summer). Under-irrigation will induce crop losses, whilst over-irrigation will induce leaching and enrichment of the subsoil and later the aquifer. The importance of efficient and optimised irrigation practices cannot be over emphasised.

Fig. 9: An efficient irrigation system is a system that will exactly apply a set amount of irrigation water, evenly distributed, over the total wetted area of the land.

Water quality

Best irrigation practices start with good quality irrigation water. Salinity can be a severe problem in some areas and will either induce a lower yield or - in order to maintain an acceptable yield - the need to over irrigate to induce leaching of salts out of the root zone. This latter practice, although advocated by agronomists and even extension officers cannot be regarded as best practice as subsequent leachings will eventually contaminate the aquifers.

In terms of good agricultural practices the following concentrations of key elements are generally accepted as the maximum levels in irrigation water to ensure optimal yields:

<table>
<thead>
<tr>
<th>Element</th>
<th>Maximum Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity</td>
<td>120 mS/m</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>200 mg/l</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>300 mg/l</td>
</tr>
</tbody>
</table>

In reality these values are often exceeded in the Sandveld, without significant signs of crop stress or yield loss. This is probably due to the very low clay content, high permeability of the soils and the long rotation cycle preventing an accumulation of salts in the rootzone. However, the sustainability of this practice will decrease with an increase in salt content and therefore the following concentrations are proposed as the very maximum levels at which the water should be used at all:

<table>
<thead>
<tr>
<th>Element</th>
<th>Maximum Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity</td>
<td>270 mS/m</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>400 mg/l</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>600 mg/l</td>
</tr>
</tbody>
</table>

**WARNING:** A significant reduction in yield may already occur at these levels!
System design and efficiency

An efficient irrigation system is a system that will deliver a set amount of irrigation water, precisely and evenly distributed, over the total wetted area of the land. Although properly designed centre pivot systems can be highly efficient, they cannot compare with the efficiency of drip irrigation systems over the long run, due to wind effects and evaporation losses. A total conversion to drip irrigation in the Sandveld (although ideal) is not considered possible in the medium term, as it would need a dual system approach: one for prior-to-plant wetting and thereafter the roll out of the drip system. Overhead irrigation is often needed again at the end of the production season, prior to harvesting to prevent the soil from cracking which allows potato moths to access the tubers. Such dual systems have been successfully implemented in other regions and therefore, in this guideline, 5 bonus points are awarded for drip systems of 3 ha or more.

The use of an irrigation system, professionally designed for the land where it is used, is regarded as the minimum required best practice.

Irrigation scheduling

Irrigation scheduling refers to the amount and timing of water application. Applying too little water will induce plant stress and quality and yield reduction. Too much water will leach expensive nutrients from the rootzone and could enrich the groundwater or even surface water systems.

Optimising irrigation scheduling should therefore receive all the effort it deserves. You will need to know the following to support good decisions on irrigation scheduling:

- The application rate of the system
- The water holding capacity of the soil (in the rootzone)
- The water requirement of the potatoes

Determining the application rate of the irrigation system is fairly easy with a centre pivot and can be done by putting out a few rain gauges along radius line of the circle (obviously a good distance ahead of the boom). Set the centre pivot to 100%, let the boom pass the gauges and measure the amount of water in each. From this data the average application rate (at 100%) can be calculated. It will also give a good idea of the distribution uniformity of the system. Ideally all gauges should contain the same amount of water. If the values vary significantly the help of an irrigation specialist should be called upon.

The next step is to determine the water holding capacity of the soil. Most soils in the Sandveld are very sandy by nature (<5% clay) and thus the water retention properties are very low. However, some darker soils (e.g. south of Elands Bay) and duplex soils (in the Aurora - Darling areas) may retain more water and should be treated differently.

As a general guideline the following clay content vs plant available water holding capacity (PAW) can be used to estimate PAW of the soil. This graph shows
that a soil of 5% clay content and a rootzone of 40 cm can store only 20 mm of water. To obtain more accurate values for your soil type soil samples should be submitted for moisture retention determinations at a competent soil testing laboratory. The golden rule is not to exceed the water holding capacity of the soil with any irrigation application.

Finally the water requirement of the potatoes needs to be determined to finalize the irrigation schedule. Potatoes need a varying amount of water during the growing season due to the development of the plant canopy. Weather conditions may increase or decrease the water requirement. One method to determine the water requirement \((E_t)\) is to use a crop factor \((f)\) and evaporation data \((E_o)\).

\[
E_t = E_o \times f
\]

For this method daily A-pan evaporation data is needed, whilst the following crop factors can be used for a medium length cultivar:

<table>
<thead>
<tr>
<th>Weeks after planting</th>
<th>(f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>0.25</td>
</tr>
<tr>
<td>2-4</td>
<td>0.30</td>
</tr>
<tr>
<td>4-6</td>
<td>0.50</td>
</tr>
<tr>
<td>6-8</td>
<td>0.65</td>
</tr>
<tr>
<td>8-10</td>
<td>0.80</td>
</tr>
<tr>
<td>10-12</td>
<td>0.80</td>
</tr>
<tr>
<td>12-14</td>
<td>0.80</td>
</tr>
<tr>
<td>14-16</td>
<td>0.65</td>
</tr>
<tr>
<td>16-18</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Another approach is to use soil moisture measuring devices, such as a neutron moisture probe, diviner, enviroscan, etc. to monitor the moisture content of the soil.

When all the above information is available the amount of water needed to replenish the water used by the crop since the last irrigation can be calculated and the centre pivot (or other system) can be set to apply the required volume. The final step in irrigation scheduling is to record the date and volume of water that was applied.

**Operational procedures**

In terms of the Water Act a water meter must be installed at each abstraction point and pump records be kept on a monthly basis.

A few basic operational principles will ensure higher irrigation efficiencies and thus conserve water, electricity and indirectly also nutrients due to the prevention of leaching:

- Ensure that all sprinklers are fitted with the specified nozzles.
- Regularly measure the pressure of the system at various points, not only at the pump.
- Compare the calculated water application with the meter readings at regular intervals and measure the system application rate and distribution efficiency whenever the figures do not correspond.
- With all overhead (sprinkler) irrigation systems, irrigation should be avoided under moderate to strong wind conditions (>20 km/h). Wind and evaporation is generally lower at night and therefore irrigating then will result in more uniform water distribution, less evaporation, less drift onto adjacent vegetation,
irrigation practices

and possibly help keep animals out of the fields. This practice may however, due to the longer duration of moisture on the leaves, increase disease occurrence and should thus be applied with caution.

- Keep all systems in good working order. Repair leaking hydrants and pipes as soon as possible, regularly clean filters (where applicable) and service pumps.

**Boreholes**

Boreholes provide access to the groundwater contained in aquifers. The following guidelines will ensure the sustainability of the aquifer in terms of its water supply and water quality. Distinction is being made between boreholes providing water for domestic use and irrigation boreholes:

**Domestic use:**
- Protection measures should be placed around boreholes to prevent surface water from flowing back into the borehole
- The borehole should be completely sealed.
- No chemicals, hazardous materials, fuels or oils should be stored within 100 m of the borehole and if they are within this distance they should be in properly constructed storage buildings.

Please note that the present ruling of DWAF for most of the Sandveld is that no additional water may be abstracted unless a licence has been obtained from DWAF. This implies that boreholes may ONLY be made after obtaining an abstraction licence.

**Irrigation boreholes:**
For irrigation boreholes the above guidelines are not as critical, but others become important:
- The National Water Act defines the ownership of water resources as an integrated and shared resource, borehole sitting must therefore take into account neighboring use, “down-stream” users and environmental requirements.
- For the Sandveld area it is proposed that a set-back distance of 250 m from river courses, wetlands, lakes and groundwater dependent ecosystems is applied.
- During the drilling of a borehole there are also best practices that the drilling contractor must adhere to. These have been well documented in a guideline of the Water Research Council. The guideline discusses access routes, site clearing, on-site activities, site rehabilitation etc. The land owner is well advised to take these issues into account during a drilling project.
- Once the borehole is drilled the sustainable yield should be determined by a “step-test” and a constant discharge test while the levels of boreholes in the vicinity are monitored carefully.
- Towards the end of the test a groundwater sample should be taken and the pH should be tested on site as the pH may change significantly before it reaches a laboratory.
- The water chemistry should be analyzed at an accredited laboratory.
- When equipping a borehole it is highly recommend that the following also be installed:
  - A dip meter tube.
  - A sampling tap at the point where the riser main comes out of the ground.
  - A volume meter must also be installed, to enable the measurement of the pumping flow rate and pumped volumes.

The three most important actions in terms of these guidelines remain the measurement and recording of:
- groundwater levels within the borehole,
- groundwater quality and
- monthly volumes of groundwater abstracted.

The National Water Act requires that all measurements be recorded in a log book, that the data be submitted to the Water User’s Association on a yearly basis who, in turn needs to collate the data and thereafter submit it to the Catchment Management Agency or DWAF.
5 Fertilisation practices

Potatoes require high nutrient levels to produce high yields of good quality. The soils of the Sandveld are naturally poor in nutrients and therefore the entire requirement of the crop needs to be supplied artificially.

The indigenous vegetation is not adapted to rapidly increased nutrient levels, and will be negatively affected for up to 20m away from a cultivated field. Invasive alien weeds often replace indigenous vegetation in these fringing areas, as they are better able to deal with the increased nutrient levels. Fertigation by means of pivot irrigation can be particularly problematic if the booms overhang the natural vegetation, or if irrigation is carried out on windy days.

The ability of the soils to retain nutrients, preventing it from leaching out of the rootzone, is also very low due to the low cation exchange capacity (CEC). This necessitates the application of nutrients in smaller quantities that closely match the requirement of the crop at the specific growth stage.

As biodiversity best practice guideline it is recommended that the amount of nutrients applied should be as close as possible to the amount removed by the crop.

The following discussion on the various elements of soil fertility may help to achieve this guideline.

Salinity

High soil salinity impedes the water uptake of plants and can drastically reduce yields. Soil salinity in the Sandveld is caused by high sodiumchloride concentrations (NaCl or table salt). These salts are highly soluble and can relatively easily be leached out of the rootzone, provided that good quality water is used and no subsurface layers (e.g. clay) impedes drainage of the saline water. This practice can however negatively impact on the quality of the groundwater through the addition of salts. Naturally saline soils should therefore not be used for potato production.

Soil pH

The pH indicates whether a soil is acidic or alkaline. The availability of all nutrients and the activity of soil bacteria are pH dependent. A survey in the Sandveld has shown that 60% of the soils have a pH between
fertilisation practices

4.0 and 5.0. At these low pH-levels the availability of applied nitrogen, phosphate, potassium and most other nutrients (excluding iron, manganese, copper and zinc) normally become very low, whilst aluminium toxicity increases. In the Sandveld, with a frequent application of a balanced nutrient programme, the problems with low availability at low pH values are mostly overcome and aluminium toxicity is not prevalent.

Ideally soil pH values should be adjusted to about 5.5 by liming the soil. This would aid the availability of nutrients and stimulate bacterial activity. Common scab (Streptomyces scabies) occurs in soils with a pH range of 5.5 - 7.5. The risk for scab infection is therefore increased by adjusting the pH upwards.

For this reason liming is not a simple decision. However, where the soil pH falls below 4.5 it is recommended to adjust the soil pH to 5.5 by liming after harvest, in a 4 or 5 year rotation, provided that a subsequent irrigated crop is grown on the land.

Nitrogen

Nitrogen (N) is applied as nitrate, ammonium or urea. Most of the uptake is in the nitrate form and therefore the applied ammonium and urea needs to be converted to nitrate by bacteria prior to uptake. In low pH soils (<5.5) this process is very slow and in the sandy soils may lead to low nitrogen use efficiency and leaching of N to the aquifers.

Nitrate is the preferred carrier of nitrogen to be used, although a programme using only nitrate is also not ideal. Urea (although seldom used at present) should only be used on soils with a pH of 5.5 or higher. Ammonium N should not exceed 40% of total N on soils with a pH <5.5.

Phosphorus

Phosphorus (P) is normally regarded as immobile in the soil and therefore most recommendations specify a pre-plant application of all phosphate required by the crop. In the Sandveld, elevated phosphate levels in the subsoil of lands where potatoes have been grown twice or more suggest leaching of phosphate. Local studies by Prof. Vlassak have confirmed this. He found the phosphorus absorption capacity of the sandy soils to be very low and rapidly saturated, whereafter leaching will occur.

Successive leaching events will eventually carry phosphate to the groundwater and surface water systems where it encourages algae growth, and lead to the depletion of oxygen levels and impaired water quality.

Potassium

Like ammonium, potassium (K) is a positive ion and is normally adsorbed to the negative charges of the clay colloids. In the absence of clay, as in most potato soils of the Sandveld, potassium is also subject to leaching and should therefore be applied in small amounts as needed.
**Calcium**

Calcium plays an extremely important role in tuber quality and is normally applied as Gypsum (CaSO4·2H2O) prior to planting. Natural gypsum from nearby sources does have a “slow release” property due to low solubility, does not pose any contamination risk and is recommended. It may sometimes be necessary to apply additional calcium which can be done as calcium nitrate.

**Trace elements**

The need for trace elements should be determined by soil and foliar analysis and applied as necessary. Most trace element deficiencies can be rectified prior to planting with soil applications.

**Fertiliser programme**

The amounts of the various nutrients to apply and the timing of application should be a function of:

- The fertility of the soil prior to fertilisation,
- The requirements of the plant at each growth stage
- The expected yield.

It is therefore essential to:

- have the soil analysed before planting,
- know the requirements of the crop at the various growth stages and
- fertilise for a realistic (and not optimistic) yield.

By not applying more than the crop needs during the next growth stage, the risk of leaching (e.g. due to a sudden high rainfall event) is minimised.

Plant measurements (e.g. petiole sap analysis) can provide very useful information on the nutrient status and requirement of the plant. Bonus points are awarded for implementing this as a standard practice.

Probably the most important recommendation on fertilisation is to use professional advice. Most fertiliser companies will offer such a service. Always make sure to use a knowledgeable advisor with good credibility. Ideally all consultants providing professional advice should be registered with the South African Council for Natural Scientific Professions.

**Foliar sprays**

Foliar sprays are often used to either correct a detected nutrient imbalance in the plant or to perform some “miracle” boost of yield and quality.

Plants were designed with roots as their primary feeding organs and therefore leaf applications will always be a temporary cure and often not the most efficient way of providing plants with their nutrient requirements.

Proper planning and soil analysis prior to planting will eliminate the need for most foliar applications, thereby reducing the possible negative impact of spray drift on the surrounding vegetation.
Fertigation

Fertigation refers to the application of liquid or soluble fertilisers through injection into the irrigation system. This practice, although reasonably established, is still regarded as more advanced technology and does make it possible to “spoonfeed” the plant and to apply nutrients at greater precision, maintaining the optimal concentrations of the various required elements in the soil solution. For this reason fertigation is promoted by this guideline.

However, fertigation also implies that liquid fertiliser is stored, often in large volumes, on the farm. Where storage and handling is not properly planned and managed a serious pollution hazard may arise. To address this hazard the following guidelines, similar to those for storage of fuel are specified:

- Do not locate any liquid fertiliser tanks within the 1:100 year floodline, or within a horizontal distance of 100m (whichever is greater) of a watercourse, drainage line or identified wetland.
- Store all liquid fertiliser within a bunded area, underlain by a concrete slab, sloped towards a sump for spillage removal. The bund must be able to accommodate at least 110% of the full volume of the largest container.
- Provide impervious paving adjacent to liquid fertilizer tanks, upon which vehicles must park during transferring. This will help to accommodate spills during transfer.
- The only permitted method of transfer is by means of a pump, controlled valve, tap, hose and funnel.
- Treat spills within the bund and the contents of the sump as hazardous waste.
- Wherever unsupervised (computerised) dosing of liquid fertiliser is done, the dosing system must be supplied with an automatic cut-off switch triggered by a no-flow condition in the irrigation system.

The use of wetting front detectors in the soil is also highly recommended, as these devices will rapidly indicate when too much water is applied, allowing for corrective measures to be taken and leaching thereby minimised.

Organic approach

The organic carbon content of the Sandveld soils are below 1% and often less then 0.3%. An organically based supply of the nutrient requirements of the crop will thus be ideal, as it will sustain or could slightly elevate the organic carbon content of the soil and also the biological activity and even the water retention properties. Providing a balanced supply of nutrients to the potato plant from organic sources alone, is often
not practical and is sometimes impossible. For this reason most organic nutrition programmes follow a dual approach, using organic compounds supplemented by inorganic sources as needed.

Such practices are favoured above pure inorganic programmes and will be awarded bonus points.

The role of an organic approach in maintaining or enhancing soil health is becoming increasingly important and when used in conjunction with cation balancing formulae as advocated by Albrecht et al could open new doors for potato nutrition in the Sandveld.

Significant experimenting however, still needs to be done prior to wide scale implementation of this approach.
6 Integrated pest management

Pest management in the context of biodiversity best practice, entails a number of basic principals, aimed at reducing the dependency on chemical measures alone. The benefit of these principles often goes beyond biodiversity conservation as it can also offer a more effective, cheaper and sustainable alternative to the producer.

Resistance after prolonged use of chemical control is common amongst weeds, insects and diseases. The adoption of an Integrated Pest Management (IPM) strategy is often the only option in combating resistance. IPM entails a holistic approach, requires knowledge of pest biology and is more management intensive.

IPM is defined as the combination of mutually compatible means of maintaining pest levels below an economic threshold. The management options include cultural, physical, biological and chemical alternatives.

Cultural control

This strategy involves making the crop less attractive to the pest. Planting time, ridging, crop rotation, intercropping, mulching, catch crops and even irrigation practices can all contribute to pest management.

Some species of the Solanum family like Solanum sisymbriifolium are reported to provide good control of nematodes like cyst eelworm, provided that correct cultivation procedures are followed.

One of the main strategies against virus control is to ensure a two month break in production over the mid-summer period.

Physical control

Trapping insects by means of pheromone traps has varying degrees of success. Potato tuber moths can be relatively well managed by this method, whilst thrips can only effectively be controlled this way in greenhouses.

Mechanical removal of weeds is also an example of physical control.

Biological control

Biological control can be very effective and depends on predacious insects and also viruses and fungi that can attack and kill the target insect. These beneficial species can either be artificially introduced or may even occur naturally, especially where significant areas of natural vegetation remain. The use of non-selective chemical measures often restricts the effectiveness of biological control agents.
Chemical control

The application of herbicides, fungicides and insecticides remain the most widely used means of controlling pests. It can be very effective but must be used with caution as it can damage the environment, be harmful to the people working with it, lead to pest resistance and reduce the population of beneficial insects or organisms.

Storage and Safety

The storage and safety aspects of the use of pesticides are regulated by legislation and the SANS 10206 standard. Compliance to all aspects of the legislation are therefore the minimum requirement for this biodiversity best management practice guideline. The checklist in the attached table should be used to test compliance to the standards and regulations concerning the safe storage and handling of pesticides.
7 BBPI - Biodiversity Best Practices Initiative

Rewarding the potato producer for conforming to all (most) recommended best practices is an important aspect in obtaining support for a scheme of this nature, and thus contributing to its sustainability. Although most benefits of the application of best practices may not be clearly visible at this stage, the potentially devastating effect of irresponsible farming (even by a few individuals) on the entire Sandveld Potato Industry, the region's biodiversity and the wider social community is very clear.

Participation

Participation in this scheme, although strongly promoted by SAKO, Potatoes South Africa, CapeNature and other environmental agencies, is on a voluntary basis. Each participant needs to score himself and only submit the final score card to the auditing agent.

Record keeping

Good record keeping is essential and required to support an honest self assessment. This includes records on all inputs and output from each land as well as corresponding dates, properly documented management plans and a log of all relevant activities.

Auditing

Auditing will be done by the auditing officer, appointed by Potatoes South Africa and CapeNature as an extension of this Best Practice Guidelines joint venture. The auditing officer will issue the producer with a certificate upon each successful audit to be done on an annual basis.

Categories

Historic practices in the Sandveld have lead to unpermitted water abstraction and land clearing on many farms. For some of these actions extenuating circumstances may exist and could require prolonged legal actions to determine the final legality thereof. This auditing scheme cannot condone - or reward - illegal practices and points scored for laudable actions should not outweigh gross transgressions. Many of the Best Practices proposed here are in fact prescribed by statutory regulations and laws, and are thus compulsory. On the other hand, if this initiative excludes all producers with historic unlawful practices, its major benefit will be lost. After much deliberation the following three tier system has been proposed as a first attempt to recognise the good work of a Biodiversity Best Practice Producer.

Biodiversity Best Practice Producer - Candidate:
This is the entry level for producers with historic unlawful practices on their farms, but who opted to rectify this situation. Participants in this category will be required to prove that they have declared the unlawful practices to either the Department of Environmental Affairs and Development Planning
or the Department of Water Affairs and Forestry or both where applicable and have embarked on a rectification process that may *inter alia* include permit applications for land that has already been cleared and/or licensing of water abstractions. Candidate participants should assess their operations at the hand of the Best Practice Guidelines and Score Sheet, but will not be audited nor awarded any Biodiversity Best Practise status.

**Biodiversity Best Practice Producer - Gold:**
This category will be awarded to producers achieving 50% in the score sheet AND who have legalised all land clearing and water abstraction by obtaining the necessary permits and/or licenses.

**Biodiversity Best Practice Producer - Platinum:**
This category will be awarded to producers achieving 75% in the score sheet AND who have legalised all land clearing and water abstraction by obtaining the necessary permits and/or licenses AND who have signed a written agreement with CapeNature to conserve unploughed, priority (ie. that could potentially be cultivated) natural veld of more than 100 ha.

**Score sheet**

Points are awarded for all best practices followed by the producer. Higher scores have been assigned to actions considered to be progressive and biodiversity friendly. A minimum score of 50% is required to obtain Biodiversity Best Practice Producer status.

The following score sheet should be used for each farm entered in the Biodiversity Best Practice Initiative.

---

**Qualifying criterion for PLATINUM status**

Have you signed a Conservation Stewardship agreement with CapeNature in which you agree to permanently conserve priority natural vegetation (*ie.* areas that could potentially be cultivated) of greater than 100 ha?

(Award 10 bonus points if the area conserved is more than 50% of property)

Producers not able to respond positively to this criterion will not be eligible for PLATINUM status.

**Further criteria for PLATINUM and qualifying criteria for GOLD status**

Have ploughing permits been obtained for all land cleared on the farm (not only potato fields)?

Is all water abstraction and storage registered with DWAF?

Producers not able to respond positively to these criteria cannot achieve Biodiversity Best Practice status, but are required to formally make use of available procedures to legalise the relevant activities.

**Scoring criteria**

<table>
<thead>
<tr>
<th>Action</th>
<th>Value</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>General farming and biodiversity friendly practices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is &gt;60% of the farm still covered with natural vegetation in good condition?</td>
<td></td>
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<tr>
<td>Is the farm free of alien invasive vegetation?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the size and timing of the plantings based on a financial plan and market analysis?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td></td>
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<tr>
<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Has a scale true base map of the farm been used for proper layout planning?</td>
<td></td>
<td></td>
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<tr>
<td>Has the conservation value of the remaining natural veld of the farm been formally evaluated? (e.g. botanical survey or species list compiled by a specialist)?</td>
<td></td>
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<tr>
<td>Are rare plant species (see Appendix 1) known to occur on the property?</td>
<td></td>
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<tr>
<td>Are buffer strips of 50 m or more allowed between any irrigated field and the natural river systems?</td>
<td></td>
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<tr>
<td>Have the roads on the farm been kept to a minimum and is an out-of-bounds principle followed with respect to natural veld?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has an alien clearing/management plan been compiled?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has alien clearing been undertaken using DWAF approved methods during the past year?</td>
<td></td>
<td></td>
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<tr>
<td>Is a fire control plan in place?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is adequate fire fighting equipment available and in good working order?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have any farm workers received formal fire fighting training?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the farm have an adequate system of fire break in place?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the firebreaks bushcut rather than ripped or ploughed?</td>
<td></td>
<td></td>
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<tr>
<td>Have any rehabilitation works been conducted in the last year? (Where no rehabilitation is required due to good management - also award 2 points)</td>
<td></td>
<td></td>
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<tr>
<td>Have corridors of natural vegetation &gt;20m wide been left between potato fields?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are natural vegetation areas permanently free of livestock, or at least during the period May - October?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Were all problem game control actions in line with the guidelines?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the fuel storage facility properly bunded and controlled?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are all solid waste disposal sites outside water resources, above the 1:50 year floodline and adequately fenced?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has an environmental management plan and policy been compiled for the farm?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Soil management**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have the services of a soil scientist been used for the survey or evaluation of soil properties?</td>
<td></td>
</tr>
<tr>
<td>Have effective cover crops been established on all lands directly after harvest?</td>
<td></td>
</tr>
<tr>
<td>Are deep cultivation (ripping) practices followed at establishment?</td>
<td></td>
</tr>
</tbody>
</table>

**Irrigation practices**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you a member of a Water Users Association?</td>
<td></td>
</tr>
<tr>
<td>Were only irrigation water of suitable quality (EC &lt; 270 mS/m, Na &lt; 400 mg/l, and Cl &lt; 600mg/l) used for irrigation?</td>
<td></td>
</tr>
<tr>
<td>Are all irrigation systems properly designed by a competent specialist?</td>
<td></td>
</tr>
<tr>
<td>Are all pumps fitted with a working water meter and is a monthly pump log being kept?</td>
<td></td>
</tr>
</tbody>
</table>
Were the total volume of water used, within the allocation for the farm?  
Is an irrigation scheduling log being kept?  
Are any soil moisture measuring devices used as an aid for irrigation scheduling?  
Are any climate measuring devices used as an aid for irrigation scheduling?  
Were borehole levels and quality measured and recorded during the past year?  
Were more than 3 ha irrigated by means of a drip irrigation system?  

**Fertilisation practices**  
Are all fertilisation applications based on crop requirements AND soil tests?  
Have the services of a qualified and accredited fertiliser specialist been used in the determination of the amount and timing of fertiliser application?  
Have any lands been fertilised by means of fertigation?  
Where liquid fertiliser is used, is the storage site properly bunded and fenced?  
Have any organic farming principles been followed?  

**Integrated pest management**  
Has a two month break in production been followed?  
Have any insect trapping and/or population monitoring been done?  
Are all chemicals stored and controlled as legally required?  
Have workers been trained properly and is protective gear being used?  
Have empty containers been triple-rinsed, punctured, and safely stored until removal for recycling?  

**TOTAL**
Literature


DWAF 2004, Toolkit for Water Services, Groundwater Monitoring for pump operators. No 6.1 Pretoria


Knight, F.H., 1999. Logingsverliese van makro-elemente op sandgronde. Aartappelkortkursus, LNR Roodeplaat

Knight, F.H., Brink, P.P. & Van Der Walt, C.J., 2000. Effect of ammonium : nitrate ratio in a potato field trial on sandy soils with a low nitrification potential


Summers, R., 2005. The environmental impact of nitrogen and phosphorus fertilisers in high rainfall areas. Western Australia Department of Agriculture.


APPENDIX 1: Threatened Plant Species of the Sandveld

Species in **bold** are those that are regarded as Endangered or Critically Endangered; those not in bold are Near Threatened or Vulnerable. Undescribed species indicated as sp. nov

*Note that this is not a comprehensive list, but merely serves as a basic checklist for botanical assessments in the core Sandveld production area.*

<table>
<thead>
<tr>
<th>FAMILY</th>
<th>SPECIES</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aizoaceae</td>
<td>Lampranthus explanatus</td>
<td>Redelinghuys to Cape Town</td>
</tr>
<tr>
<td>Aizoaceae</td>
<td>Ruschia densiflora</td>
<td>Lamberts - Graafwater</td>
</tr>
<tr>
<td>Amaryllidaceae</td>
<td>Strumaria leipoldtii</td>
<td>Lamberts Bay</td>
</tr>
<tr>
<td>Anthericaceae</td>
<td>Caesia sp. nov.</td>
<td>Redelinghuys - Melkbos</td>
</tr>
<tr>
<td>Apiaceae</td>
<td>Arctopus dregei</td>
<td>Vredenburg to Darling &amp; Malmesbury</td>
</tr>
<tr>
<td>Asphodelaceae</td>
<td>Aloe framesii</td>
<td>Saldanha - Alexander Bay</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Athanasia sertulifera</td>
<td>Paleisheuwel - Aurora</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Cullumia floccosa</td>
<td>currently only Redelinghuys</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Cullumia micracantha</td>
<td>Paleisheuwel - Eendekuil</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Felicia josephiniae</td>
<td>Graafwater - Leipoldtville</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Helichrysum bachmanii</td>
<td>Vredenburg to Hopefield &amp; Velddrif</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Heterorachis sp. nov.</td>
<td>Graafwater</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Steirodiscus capillaceus</td>
<td>Bokkeveld - Piketberg</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Ursinia arenaria (sp. nov.)</td>
<td>Velddrif - Piketberg</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Vellereophyton pulvinatum</td>
<td>Klawer</td>
</tr>
<tr>
<td>Campanulaceae</td>
<td>Wahlenbergia constricta</td>
<td>Olifants R valley, Graafwater, Redelinghuys</td>
</tr>
<tr>
<td>Campanulaceae</td>
<td>Wahlenbergia massonii</td>
<td>Klawer to Het Kruis</td>
</tr>
<tr>
<td>Campanulaceae</td>
<td>Wahlenbergia umbellata</td>
<td>Lamberts Bay coastal sands</td>
</tr>
<tr>
<td>Convallariaceae</td>
<td>Eriospermum arenosum</td>
<td>Redelinghuys - Hondeklipbaai</td>
</tr>
<tr>
<td>Ericaceae</td>
<td>Erica dregei</td>
<td>Bergvallei &amp; Langevlei</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Argyrolobium velutinum</td>
<td>Olifants River - Langebaan</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Amphithalea ericifolia ssp. erecta</td>
<td>Hopefield to Cape Town</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Lebeckia leucocladia</td>
<td>Clanwilliam, Graafwater</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Lotononis bolusii</td>
<td>Hopefield to Olifants R valley</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Lotononis pallens</td>
<td>Clanwilliam</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Otholobium incanum</td>
<td>Vredendal - Lamberts</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Psoralea sp. nov.</td>
<td>Redelinghuys, Aurora, Graafwater</td>
</tr>
<tr>
<td>Geraniaceae</td>
<td>Pelargonium appendiculatum</td>
<td>Leipoldtville</td>
</tr>
<tr>
<td>Geraniaceae</td>
<td>Pelargonium attenuatum</td>
<td>Graafwater &amp; Aurora</td>
</tr>
<tr>
<td>Family</td>
<td>Species</td>
<td>Location</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Geraniaceae</td>
<td><em>Pelargonium fasciculaceum</em></td>
<td>Olifants river valley &amp; Redelinghuys</td>
</tr>
<tr>
<td>Hyacinthaceae</td>
<td><em>Albuca clanwilliamigloria</em></td>
<td>Redelinghuys &amp; Olifants R valley N Clanwilliam</td>
</tr>
<tr>
<td>Iridaceae</td>
<td><em>Babiana toximontana</em></td>
<td>Foot of Gifberg, Klawer</td>
</tr>
<tr>
<td>Iridaceae</td>
<td><em>Geissorhiza barkerae</em></td>
<td>n Swartland and Paleisheuwel</td>
</tr>
<tr>
<td>Iridaceae</td>
<td><em>Geissorhiza louisabolusiae</em></td>
<td>Olifants R valley and Graafwater</td>
</tr>
<tr>
<td>Iridaceae</td>
<td><em>Romulea sinispinosensis</em></td>
<td>Doringbaai to Heerenlogenement and E of Veldrif</td>
</tr>
<tr>
<td>Malvaceae</td>
<td><em>Hermannia ciliaris</em></td>
<td>South and north of Olifants R nr Vredendal</td>
</tr>
<tr>
<td>Oxalidaceae</td>
<td><em>Oxalis suavis</em></td>
<td>Hopefield</td>
</tr>
<tr>
<td>Oxalidaceae</td>
<td><em>Oxalis amblyosepala</em></td>
<td>Clanwilliam</td>
</tr>
<tr>
<td>Oxalidaceae</td>
<td><em>Oxalis aurea</em></td>
<td>Clanwilliam - Citrusdal</td>
</tr>
<tr>
<td>Oxalidaceae</td>
<td><em>Oxalis pillansiana</em></td>
<td>Clanwilliam - Vanrhynsdorp</td>
</tr>
<tr>
<td>Oxalidaceae</td>
<td><em>Oxalis uliginosa</em></td>
<td>Clanwilliam</td>
</tr>
<tr>
<td>Plumbaginaceae</td>
<td><em>Limonium sp. nov</em></td>
<td>Paleisheuwel - Aurora</td>
</tr>
<tr>
<td>Proteaceae</td>
<td><em>Leucadendron brunioides var.</em></td>
<td>Graafwater - Leipoldtville</td>
</tr>
<tr>
<td>Proteaceae</td>
<td><em>Leucadendron loranathifolium</em></td>
<td>Sandveld - Suid Bokkeveld</td>
</tr>
<tr>
<td>Proteaceae</td>
<td><em>Leucadendron procerum</em></td>
<td>Sandveld - Suid Bokkeveld</td>
</tr>
<tr>
<td>Proteaceae</td>
<td><em>Leucospermum arenarium</em></td>
<td>south and east of Redelinghuys</td>
</tr>
<tr>
<td>Proteaceae</td>
<td><em>Leucospermum rodolentum</em></td>
<td>Sandveld</td>
</tr>
<tr>
<td>Proteaceae</td>
<td><em>Serruria decipiens</em></td>
<td>Sandveld</td>
</tr>
<tr>
<td>Proteaceae</td>
<td><em>Serruria fucifolia</em></td>
<td>Sandveld</td>
</tr>
<tr>
<td>Rhamnaceae</td>
<td><em>Phylica cuspidata</em></td>
<td>Graafwater - Aurora</td>
</tr>
<tr>
<td>Rhamnaceae</td>
<td><em>Phylica hirta</em></td>
<td>Olifants R Mts and Nardouwsberg</td>
</tr>
<tr>
<td>Rutaceae</td>
<td><em>Agathosma involucrata</em></td>
<td>Paleisheuwel</td>
</tr>
<tr>
<td>Rutaceae</td>
<td><em>Euchaeatis tricarpellata</em></td>
<td>Paleisheuwel - Piketberg Mt.</td>
</tr>
<tr>
<td>Rutaceae</td>
<td><em>Macrostylis hirta</em></td>
<td>Paleisheuwel &amp; Bergvlei</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Alonsoa unilabiata</em></td>
<td>NE Elands Bay</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Freylinia visseri</em></td>
<td>Berg River nr. Aurora</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Manuela pillansii</em></td>
<td>Lamberts - Clanwilliam</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Manuela psilostoma</em></td>
<td>Graafwater</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Manuela stellata</em></td>
<td>Lamberts - Elands Bay</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Nemesia strumosa</em></td>
<td>Hopefield - Cape Flats</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Phyllopodium mimetes</em></td>
<td>Aurora to Mamre</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Selago heterotricha</em></td>
<td>Graafwater</td>
</tr>
<tr>
<td>Scrophulariaae</td>
<td><em>Selago linearifolia</em></td>
<td>Bulshoek</td>
</tr>
<tr>
<td>Thymelaeaceae</td>
<td><em>Lachnnea capitata</em></td>
<td>Heerenlogenement to Cape Town</td>
</tr>
<tr>
<td>Thymelaeaceae</td>
<td><em>Lachnnea grandiflora</em></td>
<td>Paleisheuwel to Cape Town</td>
</tr>
<tr>
<td>Thymelaeaceae</td>
<td><em>Passerina filiformis ssp.</em></td>
<td>Doringbaai to St Helenabaai</td>
</tr>
</tbody>
</table>
APPENDIX 2: Measurement and monitoring of groundwater levels

Introduction
Am I pumping my borehole at optimum rates? Am I running out of groundwater this season? If so, when can I expect to run out of groundwater? Is my borehole clogging up? Is the groundwater being depleted in the long term? Is there a sudden change in the normal groundwater situation?

To help answer these and other groundwater questions, you need to keep a record of groundwater level in your boreholes. To do this it is necessary to know how to take regular groundwater level measurements.

This document explains what equipment is required to take manual groundwater measurements, and how to use the equipment. By keeping an accurate record of these measurements you will be in possession of valuable data that can help you understand the state of the groundwater resource, and help you manage your supply.

Equipment required for measuring the water level

The following equipment is required to measure water levels:
- Piezometer tube
- Dip meter
- Ruler
- Logbook

The piezometer tube is a small diameter pipe that goes down into the borehole. The water level is measured by lowering the dip meter cable into the piezometer tube. When not being used, the top of the piezometer tube should be closed with an end cap.

<table>
<thead>
<tr>
<th>The piezometer tube</th>
<th>When not In use, the piezometer tube is closed with an end cap</th>
</tr>
</thead>
</table>
We use a dip meter to measure water levels. A dip meter consists of a length of electrical cable rolled onto a spindle, with a weight (also called a probe) on the end of it. It looks like an electric extension cable (but it is not and cannot be used as an extension cable).

The dip meter probe measures the depth in the borehole when it touches the water.

All dip meters have a way of showing when the probe has reached the water. In most cases this is shown by a gauge, but some dip meters use a light or buzzer to tell one when the weight is in the water. Some dip meters also on / off switch.

The dip meter works in the following way:

- When it is switched on, a small electric current becomes active in the cable.
- When the probe is under water, the current flows in the cable and the gauge moves as it records the current.
- When the probe is lifted out of the water, the current stops flowing and the gauge returns to its original zero position.

Therefore, if you lower the probe into the borehole and watch for when the gauge moves, you can measure the depth to the water level in the borehole.

You can try this using a bucket of water. Place the probe into a bucket of water and watch the gauge as the probe touches the water. This is also a good way of checking if your dip meter works.

**Step by step - measuring the water level**

Always take your measurements at the same place. Normally this is the top of the piezometer tube. Measure how far the piezometer tube sticks up above the base plate of the discharge head, and record this measurement in your logbook. This measurement is referred to as the datum height or reference level. If the pump is lifted out of the borehole or the piezometer tube moves for any other reason, measure it again and record the value in your logbook in the comments column.

**Here are the steps to measuring the water level:**

1. Make sure that you have the following:
   - Pen
   - Logbook
   - Dip meter
   - A 1 metre ruler or tape measure
2. Wash your hands before you use the dip meter.
3. Switch the dip meter on, if it has an on / off switch.
4. Remove the end cap from the top of the piezometer tube.
5. Slowly lower the probe into the piezometer tube until the gauge moves.
6. Lift and lower the probe a little, checking the gauge movement, to make sure you have the correct water level.

7. Keep your finger on the correct point on the cable.

8. Pull the cable out of the piezometer tube until a metre mark is visible.
9. Measure from the metre mark on the cable to your finger with the ruler - this will give you the centimetres.

10. Record the metres and centimetres in your logbook.

11. Check the measurement and that you have recorded it correctly.

(In this diagram, the measurement is 14 metres and 7 centimetres or 14.07 metres.

Don't forget to add the zero before the seven when the centimetre reading is less than 10 centimetres. Record the reading in the logbook as 14m 07cm).
Appendix 2

Measuring in a borehole equipped with a pump (WRC, 2005)

When the borehole to be sampled is fitted with a production pump, access to the water level must be open. The pump riser main, the electrical cabling and the safety rope for the pump usually create a tangled mess, and if you try to lower the dip-meter cable inevitably it will get stuck. If this is a borehole that will be sampled on a regular basis then a piezo-tube must be fitted in the borehole. This is a small diameter pipe installed from well-head to some distance below the expected lowest water level in the borehole. The details of the piping have been included earlier in this report.

A water level measuring device that is useful for equipped boreholes which do not have such piezo-tubes fitted, is a sonic water-level meter. This can “see” past the riser-main, cabling and other fittings. Its accuracy is about 0.2% of the depth to the water level, but the readout accuracy is 0.025 m. It is however an expensive item (compared to the dip meter), costing about R10 000.

Water Quality measurement (WRC, 2005)

A borehole must first be purged to remove stagnant water from the borehole so that the groundwater sample subsequently collected is representative of the in situ groundwater. Stagnation modifies groundwater chemistry to the extent that samples may be totally unrepresentative of the formation water.

Purging of the borehole in practice involves the removal of sufficient water so that the field chemistry parameters (pH, EC, DO, Eh, temperature, and turbidity) are stable. For most cases, this involves the removal of three to five times the volume of the standing water in the borehole. We suggest that for most cases as soon as pH, temp, EC and either Eh or DO are stable, sampling can start.

FIELD PROCEDURE

1. Measure the water level.
2. Measure the borehole depth.
3. Thus height of water column = borehole depth - depth to water level.
4. Calculate the standing volume of water in litres by substituting in the following formula.

\[
\text{Volume of standing water in litres} = \frac{(\text{radius of borehole})^2 \times \text{Height of water column in metres} \times 1000}{\text{in metres}}
\]

5. Install pump with inlet close to static water level for a high yielding borehole.
6. Set up the EC meter and the pH meter.
7. Start pumping.
8. Measure pumping rate in L/sec.
9. Using the calculated well volume of step 4, calculate the pumping time needed to remove 3 volumes.

10. Take continuous readings of pH, temperature and EC.

11. If the field chemistry stabilizes before three volumes are pumped, use the time for three volumes as the purge time at that pumping rate.

12. If the field parameters have not stabilized (this is uncommon), continue pumping until they stabilize. This will be the purge time at that pumping rate.

13. Note that subsequent sampling runs should not measure the depth of the borehole described in step 2. By measuring the depth you tend to disturb material settled in the sump, and this will add to the turbidity. Seeing as the purging volume has been established and recorded the depth should only be checked once sampling of the borehole is complete.

14. Once the borehole has been purged, with the pump still pumping, lower the pump a short distance, about 0.5 m, and collect the water sample. This is done so that contamination from the stagnant water which is above the pump inlet does not occur.

15. Record the pH and EC and collect the required groundwater samples.

ELECTRICAL CONDUCTIVITY

INTRODUCTION

Conductivity is the ability of an aqueous solution to conduct an electric current.

This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on the temperature of measurement.

Practical meters and electrodes measure and record the "conductivity" of the water sample. The International System of Unit (SI), which is used by South Africa and most other countries, reports conductivity in millisiemens per metre (mS/m). Some instruments have various scales of sensitivity and unfortunately have named these scales in various fashions such as millisiemens per centimetre or microsiemens per centimetre. All measurements must be reported in mS/m. It is not unusual to read a set of chemistry results that appear to be incorrect, only to discover that the EC has been reported as shown on the meter read-out face and thus with the incorrect units.

Conversion table for units used to record EC

<table>
<thead>
<tr>
<th>Convert from</th>
<th>Conversion factor</th>
<th>To</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Siemen per cm</td>
<td>x 100 000</td>
<td>=</td>
<td>1 millisiemen per metre</td>
</tr>
<tr>
<td>1 Millisiemen per cm</td>
<td>x 100</td>
<td>=</td>
<td>1 millisiemen per metre</td>
</tr>
<tr>
<td>1 Microsiemen per cm</td>
<td>x 0.1</td>
<td>=</td>
<td>1 millisiemen per metre</td>
</tr>
<tr>
<td>1 Micromho per cm</td>
<td>x 0.1</td>
<td>=</td>
<td>1 millisiemen per metre</td>
</tr>
</tbody>
</table>
There are several reasons for determining the EC of a sample in the field at the time of collection rather than waiting for a laboratory measurement. The field determination can be used as an aid in evaluating whether a sample is representative of water in the aquifer.

**EC AND TDS (TOTAL DISSOLVED SOLIDS)**

TDS is a measure of the mass of dissolved salts in a given mass of solution. EC is rapid and cheap and gives a good indication of TDS. The relationship between TDS and EC for most groundwaters is linear and $TDS = A \times EC$. The factor $A$ is between 5.5 and 9, with the most commonly used conversion factor being 6.4. Of course, if a full analysis of the major and minor constituents is made then TDS can be calculated by summation of the ions.

**APPARATUS**

1. EC meter
2. EC electrode
3. Thermometer graduated in 0.2°C
4. 1000 mL plastic beaker
5. Flow-through cell (optional)

**FIELD PROCEDURE**

1. Read the manufacturer’s instructions for specific procedures for the instrument.
2. Calibrate the instrument, either in the field or in the laboratory before leaving for the field, with a standard EC water. Note: make sure the EC meter you purchase can be calibrated, otherwise it is a waste of money.
3. Start pumping the borehole.
4. Measure the water temperature.
5. Set the temperature dial to the observed groundwater temperature.
6. Immerse the electrode in flowing water for a few minutes to equalize the temperature of the electrode and the water. Move up and down a few times to remove any air bubbles.
7. Take the reading, make sure it is in mS/m and record.
8. Rinse the cell with distilled water and pack away wet.

Note: Possible errors in reading can be made if the electrode is either not fully immersed or air bubbles are on the platinum electrodes.

**pH**

**INTRODUCTION**

pH is a measurement of the concentration of hydrogen ions in solution. By definition, the symbol $pH$ represents the negative base-10 logarithm of the effective concentration (activity) of the hydrogen ion ($H^+$) in moles per litre. Concentrations in natural waters are generally very low, which makes them more convenient to report on a logarithm scale, rather than as absolute concentrations.
pH is one of the most important parameters affecting the chemical composition of groundwater. Anything that changes the pH of a sample will likely affect other constituents as well. Aeration, oxidation, mineral precipitation, temperature changes and degassing of a sample can significantly alter its pH.

For example, during a water sampling project in the Western Cape of South Africa, it was observed that CO\textsubscript{2} degassing from low TDS groundwater from Table Mountain Group quartzite caused the measured pH to change from 4.9 to 7.1. In practical terms highly corrosive water became mildly corrosive. If the pH had been measured in the laboratory, and not on site, pipeline design precautions might not have been taken.

**METHOD OF pH MEASUREMENT**

pH can be determined by electrometric or colorimetric methods. Electrometric methods use either a glass electrode or an ion sensitive field effect transistor (ISFET), which is sensitive to the hydrogen ion. Colorimetric methods use pH indicators (e.g. litmus paper), which change colour with a change in pH. Colorimetric methods are only suitable for rough pH estimates and are not recommended for field measurements during groundwater sampling.

**pH MEASURING EQUIPMENT AND SUPPLIES**

An electrometric pH measuring system consists of:
- the pH meter (potentiometer)
- the measuring electrode
- the reference electrode
- pH buffer solutions

The measuring electrode and reference electrode are typically combined into one combination probe. A temperature measuring device is also commonly included and many pH instruments offer the option of automatic temperature compensation. Many pH meters are capable of reading pH and millivolts. The millivolt scale is an important feature as this same meter using a different electrode is used for measuring Eh in mV.

**NOTE:** There are numerous pH meters on the market, many with slightly different features and operating procedures to those described in this manual. It is very important to read the manufacturer's instructions on the correct calibration, operation and maintenance procedures for your particular instrument. Some of the equipment and procedures described here may be out of date. If the equipment being used incorporates more recent technology, follow the manufacturer's instructions.
**pH METER**

For routine work, use a pH meter accurate and reproducible to 0.1 pH unit with a range of at least 2 to 12 pH. The instrument should preferably be equipped with a temperature-compensation adjustment and should operate over a temperature range of at least 0 to 45°C. The pH meter for field measurements should be portable - a lightweight, battery-powered unit is recommended - and come in a robust casing. Waterproof models are highly recommended, particularly for work in humid areas. Many instruments have fully automated calibration routines. This can improve their ease of use, but can also restrict the choice of buffer solutions for calibration in some cases.

The pH meter should be tested before each sampling trip and properly cleaned and stored after use. Check batteries for leakage every two months. pH meters, even the field models, are sophisticated electronic equipment that require care in handling and operation. Try to keep the instrument clean and dry by using a groundsheet and portable shelter for field work. Make sure it is stored in a clean, dry place away from temperature extremes. The pH meter is usually supplied in a waterproof transport case. Do not store the pH meter in this case with the lid closed, as condensation may occur and damage the meter. Avoid unnecessary jostling or sudden impacts, which can damage fragile components or dislodge electronic connections.

**ELECTRODES**

Two electrodes are needed to measure pH:

1. the measuring electrode (either glass electrode or ISFET sensor)
2. the reference electrode, which provides an independent, constant potential against which to measure the unknown pH.

For general field use, a combination electrode is recommended, as it is much easier to handle a single electrode than two electrodes. The combination electrode incorporates the measuring electrode and reference electrode into a single probe. The glass electrode system is preferred over the ISFET for high accuracy applications. The advantages of ISFET sensors for environmental applications are their small dimensions, rapid response times and robustness.

**pH BUFFERS**

pH buffer solutions are used to calibrate the pH meter readings. During calibration, the electrodes are immersed in a buffer solution and the instrument adjusted according to the manufacturer’s instructions, so that the meter reads the correct pH value for that buffer.

Some instruments offer one-, two- or three point calibration, using up to three buffer solutions. At least two buffers should be used for routine pH measurement work. Single point calibration can be used to check that the instrument has not drifted between readings. For two point calibration, buffers should be selected that bracket the expected pH range of the samples to be measured, usually with pH 7.0 buffer as one end of the bracketed range.
The pH of groundwater from quartzites is usually between 5 and 6, so select buffers pH 4 and pH 7 to calibrate the meter. Limestone or dolomite aquifers typically have groundwaters of pH greater than 7 and buffers of pH 7 and pH 10 should be used for calibration.

Poor quality, old or contaminated buffers will give at best inaccurate and at worst completely wrong pH readings.

EQUIPMENT CHECKLIST

1. pH meter
2. pH combination electrode
3. pH buffer solutions of pH 4, pH 7 and pH 10 (500 mL each)
4. 3 x 100 mL glass or plastic beakers to hold buffer solutions when calibrating the pH meter. Use plastic beakers if using a glass pH electrode in order to reduce breakage
5. Filling solution for electrode, plus syringe
6. Bucket to immerse buffer solution in order that the buffer solution and the groundwater are within 1°C
7. Thermometer, if pH meter does not have automatic compensation
8. Deionised water plus squeeze wash bottle
9. Soft tissue to dry electrode
10. Table or flat working surface

FIELD PROCEDURE FOR pH MEASUREMENT

Read the manufacturer's instructions for your specific instrument.

Many pH meters have autocalibration functions and automatic temperature compensation. To use an autocalibration routine, follow the instructions in the manufacturer's handbook.

pH measurement

Always use a calibrated pH meter to measure the pH of a groundwater sample. The pH measurement should be taken as follows:

1. After calibration, rinse a clean beaker several times with the water to be tested and collect a fresh subsample from as close to the borehole outlet as possible. Do not use a bailed sample. Try to minimise aeration by using a low flow rate. Do not shake or stir vigorously and do not leave the sample standing in the sun. Take the measurement as soon as possible.
2. Rinse the pH electrode with deionised water and gently blot dry.
3. Insert the electrode into the beaker and stir gently while waiting for the reading to stabilise.
4. Record the pH to the nearest 0.1 units.
5. Rinse the electrode, blot dry and switch off.
TROUBLE-SHOOTING

- Do not let the glass electrode dry out, cover with the cap or rubber sleeve supplied with the electrode with a few drops of storage solution.
- Ensure the liquid-filled glass electrode is filled with solution and contains no trapped air bubbles.
- Ensure electrode is clean. If not, clean glass electrodes by alternately immersing three times each in 0.1N NaOH and 0.1N HCl. Clean ISFET electrodes with a toothbrush and mild detergent.
- Use buffer solutions before their expiry date and decant a fresh portion for each calibration.
Measuring the Amount or Volume of Water Pumped: Taking a Flow-meter Measurement

Water meter and water meter dial

The numbers on the flow-meter are the number of kilolitres that have been pumped.

One kilolitre is the same as 1 m³ (one cubic metre), which is the same as 1000 litres. The smaller clock-like dials on the water meter show smaller amounts.

- X 0.1 measures 100 litre intervals and a full revolution of the clock is 1 kilolitre.
- X 0.01 measures 10 litre intervals and a full revolution of the clock equals 100 litres.
- X 0.001 measures 1 litre intervals and a full revolution of the clock equals 10 litres.

For recording the abstraction in your logbook, just record the number of kilolitres pumped, as in the following examples:

```
0026458
```

Record 26458 in the water meter column of your logbook.

The dials of water meters from different manufacturers are different. Sometimes the last one or two numbers are in a different colour. This means that the number in a different colour is measuring a part of a kilolitre. On these meters, only record the kilolitres (the figures in black and white numbers, on our examples). If you are not sure of the readings on your water meter, ask your supervisor for advice.
Record 7223 kilolitres in the water column of your logbook.

Record 950 kilolitres in the water meter column of your logbook.

**Recording Readings in Your Logbook**

There are two types of pump motors commonly used for rural water supplies, manual and automatic. For each one, the operator would record measurements differently.

- **Manual pumps** are switched on and off by the operator and include all diesel powered pumps and manually operated electric powered pumps.
- **Automatic pump motors** are electric powered pumps, that automatically switch on and off with a timer or another switch.

With manual pumps, it is recommended that the operator measures the water level before starting to pump and just before the pump is switched off. If it is dangerous to measure the water level while the pump is running, measure the water level five minutes after switching off the pump.

**Manual operated pumps**

An example of a logbook for a manual pump would look like this:

<table>
<thead>
<tr>
<th>Date</th>
<th>Before pumping</th>
<th>Time pumping starts</th>
<th>Pumping water level (m)</th>
<th>Time pumping stops</th>
<th>Flow meter after pumping (kl or m³)</th>
<th>Total hours pumped</th>
<th>Volume pumped (kl or m³)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow meter after pumping (kl or m³)</td>
<td>Water level below datum (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F₁</td>
<td>T₁</td>
<td>T₂</td>
<td>F₂</td>
<td></td>
<td>T₂ – T₁</td>
<td>F₂–F₁</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Before starting the pump, write down the date, the flow-meter reading, the water level reading and the time in the columns. When the pump is switched off, write down the water level reading, the time and the flow-meter reading. It is best to take the water level reading just before the pump is switched off.

**Automatic pumps**

With automatic pumps, the operator must take a water level reading each time the pump is inspected. This should be done once a week if possible, but will normally have to fit in with the scheduled visits of the operator.

For example, if an operator is responsible for ten boreholes and visits each one routinely every two weeks, then they will measure and record water levels every two weeks.

With an automatic pump the following must be recorded:

- Date
- Time of reading
- Water level
- Water meter reading
- Hour-meter reading
- Whether the pump is on or off at the time of measurement

The hour-meter can be found on the electrical control box.

An example of a logbook for an automatic pump would look like this:
The above logbook sheets can be modified to include groundwater levels measurements and field measurements of groundwater quality (pH and EC) or they can be noted in the comments column.
# Appendix 3: Checklist for Storage, Handling and Disposal of Pesticides on Farms

**SANS Standard 10206 of 2005**

## Pesticide Store

<table>
<thead>
<tr>
<th>Authorisation</th>
<th>Permission from local authority to erect anew store &amp; certificate of occupancy obtained.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certificate of occupancy</td>
<td>obtained from local authority for existing store.</td>
</tr>
<tr>
<td>Location of store</td>
<td>Above 50 year flood line, preferably above 100 year flood line.</td>
</tr>
<tr>
<td></td>
<td>Out of reach of rock falls, falling trees and veld fires.</td>
</tr>
<tr>
<td></td>
<td>• Preferably in separate building, at least 10 m from house, stables and stores for animal feed, fuel and flammable material.</td>
</tr>
<tr>
<td></td>
<td>• If part of a complex, store to be totally sealed off, i.e. no free movement of air between store area and rest of building. Approved firewall if flammable products are stored.</td>
</tr>
<tr>
<td></td>
<td>Away from rivers, dams, boreholes &amp; areas likely to be flooded. Spills and flooding should no contaminate water sources, crops or pastures.</td>
</tr>
<tr>
<td></td>
<td>Situated where it can be supervised.</td>
</tr>
<tr>
<td></td>
<td>Easy access for delivery or dispatch.</td>
</tr>
<tr>
<td></td>
<td>In case of fire: easy access for fire fighting, vegetation within 5m of building cleared.</td>
</tr>
<tr>
<td>Construction</td>
<td>Walls, roof &amp; floor should be made of non-combustible materials.</td>
</tr>
<tr>
<td>Floor</td>
<td>• Smooth, screeded concrete required. Soil, wood, bitumen, PVC, linoleum, unscreeded, disintegrating or cracked concrete not acceptable.</td>
</tr>
<tr>
<td></td>
<td>• Must be impenetrable to split chemicals.</td>
</tr>
<tr>
<td></td>
<td>• Wall-to-floor joints must be watertight.</td>
</tr>
<tr>
<td>Walls</td>
<td>Must be brick or concrete.</td>
</tr>
<tr>
<td>Roof</td>
<td>• Leak-free and insulated with non-combustible material to maintain temperature at a reasonable level.</td>
</tr>
<tr>
<td></td>
<td>• Vents in roof will allow hot air to escape.</td>
</tr>
<tr>
<td>Doors</td>
<td>• Preferably steel with effective locks.</td>
</tr>
<tr>
<td></td>
<td>• All doors must have security gates to reduce risk of forced entry.</td>
</tr>
<tr>
<td></td>
<td>• Exit door(s) must open to the outside.</td>
</tr>
<tr>
<td>Windows</td>
<td>• Must allow in sufficient light to read labels, otherwise install electric light.</td>
</tr>
<tr>
<td></td>
<td>• All windows must have burglar bars.</td>
</tr>
<tr>
<td></td>
<td>• Window frames must be steel.</td>
</tr>
<tr>
<td></td>
<td>• Windows must be fitted with wired glass, minimum 8 mm thickness.</td>
</tr>
<tr>
<td></td>
<td>• Window panels maximum size 450 x 450 mm.</td>
</tr>
<tr>
<td></td>
<td>• No windows shall be capable of being opened.</td>
</tr>
<tr>
<td>Retention of contamination</td>
<td>• Seal all joints in floor.</td>
</tr>
<tr>
<td></td>
<td>• Ridge or retention wall 20 cm high at door (to prevent environmental contamination &amp; to keep out floodwater).</td>
</tr>
<tr>
<td>Ventilation</td>
<td>• Natural ventilation: airbricks (min. 140 x 215 mm), provided with non-corrodible gauze wire, in at least 3 external walls, to provide min. 5 total air</td>
</tr>
</tbody>
</table>

Biodiversity Best Practice Guidelines for Potato Production in the Sandveld
<table>
<thead>
<tr>
<th><strong>Lightning protection</strong></th>
<th>Protect store against lightning strike in regions where required.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Run-off water</strong></td>
<td>Contaminated water from fire or clean-up of spillage must be contained and disposed of in accordance with requirements of local authority.</td>
</tr>
</tbody>
</table>
| **Security**            | • Only authorized and trained personnel shall have access to keys and store.  
                          | • Area around store secured against unauthorized entry by a wall/fence at least 1,8 m high, with lockable gate & clear strip 1 m wide along inner perimeter. |
| **Placement of products in store** | Only plant protection and/or animal health products in store – no feedstuffs. |
|                         | Herbicides and phenoxy compounds separated from other pesticides by a division made of wire mesh, metal bars or wall and with another gate/door to prevent accidental application of herbicides to crop foliage (GAP). |
|                         | Separate, fenced & lockable area to be provided for all Danger Group I products. |
|                         | Special requirements for flammable products to be met, where applicable. |
| **Shelving**            | • Shelves must be non-absorbent, impervious and chemically resistant to stored products – wooden shelves covered with thick plastic or with non-combustible trays can be used.  
                          | • Large containers should not be stored directly on cement floor – place on wooden pallets covered with thick plastic or on plastic pallets.  
                          | • Products in solid, powder or granular form must be stored above liquid formulations (less damage during accidental leakage).  
                          | • Keep open bags with powder formulations in large plastic bins with lids to contain fumes, protect against contamination and prevent unnecessary spillage onto floor (GAP). |
|                         | All products must be stored in original containers with labels in tact. |
| **Working area**        | • Separate bunded working area for weighing, measuring & mixing of chemicals.  
                          | • An eye wash bottle & washbasin with running water to wash equipment without polluting the environment must be provided in the working area.  
                          | • Shower facilities should be available in or near above working area. |
| **Spillage**            | • Broom, spade and bucket of sand available to clean up spillage.  
                          | • Large, open containers available for removal of contaminated material and to place leaking containers in. |
| **Warning notices**      | **outside store**  
                          | • Warning signs at entrance and on surrounding fence: “Storage of Pesticides” and “Unauthorized Entry Prohibited” in red letters (≥75 mm) on white background.  
                          | • At entrance: No Smoking; No Naked Flames; No Fires; Position and types of fire related equipment (signs at least 290 x 290 mm). |
|                         | **inside store**  
                          | • All areas clearly demarcated and relevant hazard class diamonds (e.g. toxic, flammable, corrosive) displayed (size at least 250 x 250 mm).  
                          | • No Smoking; No Naked Flames; No Fires (signs at least 290 x 290 mm).  
                          | • Location of First Aid Station.  
                          | • Position and types of fire related equipment. |
### Responsible persons
- Person responsible for managing pesticide store (farmer/ literate farm worker) must be trained in pesticide handling & understand implications of incorrect handling.
- The responsible person shall check every container on delivery for correct content and to ensure that container does not leak.
- The responsible person shall ensure that oldest stock is used first (label date of manufacture or mark container with date of delivery in waterproof ink).

### Emergency Procedure
- Emergency telephone numbers to be available at nearest telephone: nearest poison centre, doctor, hospital, fire brigade and ambulance service.
- Responsible personnel must have immediate access to a telephone and emergency numbers, even in absence of employer.
- At least one farm worker to be trained in basic first aid. Information on relevant first-aid procedures for all pesticides in the store must be available in a prominent place.
- An Emergency Procedure which clearly outlines actions to be taken in an emergency must be available in the store and responsible personnel must be familiar with it.

### Fire fighting
- Portable fire extinguishers (carbon dioxide, dry chemical or foam type) of minimum 9 kg or 9 L to be available.
- Ratio: 1 extinguisher to every 100 m² storage, unless more deemed necessary by local fire authority.
- Fire hose mounted outside store and connected to a water supply.
- For stores larger 9 m³ a sprinkler system is recommended.
- Fire extinguishers shall be inspected and maintained annually by a registered person (SANS 10105-1, SANS 10105-2, SANS 1475-1, SANS 1475-2).

### Record keeping
- A complete and up-to-date record (inventory) of all products received, used and the balance of products in the store must be kept by the person responsible for the store.
- Keep records away from storage area. A copy can also be kept in store.
- Records to be available at all times for inspection by national, provincial or local authorities.

### HANDLING AND APPLICATION OF PESTICIDES

#### Filling points
The mixing and filling area for spray tanks must be:
- well away from any water sources
- the floor must be non-porous (e.g. cement with damp coursing)
- the floor must be bunded (retaining wall)
- rinse liquid from measuring vessels must be added to the spray tank
- run-off and spillage may not contaminate the ground or water sources (construct non-permeable evaporation pit, fill with stones & add lime to increase pH, or install a tank that can be emptied by Wastech).

#### Worker health
- For work involving exposure to pesticides, only operators who have been declared medically fit may be employed.
- Operators handling pesticides should undergo annual medical examinations to test for signs of pesticide exposure.
- Medical records and records of pesticide exposure must be kept for every worker exposed to pesticides. Work-exposure records must be kept for at least 30 years or be sent to regional labour representative if farming operations cease.

#### Training
- Every farm worker working with pesticides shall be trained in the meaning of the symbols on labels and interpretation of written instructions.
- Spray operators must receive practical training in the safe handling and
### Protective clothing & equipment
- Keep protective clothing separate from personal clothing (different lockers)
- All protective garments to be thoroughly washed with soap/detergent and water after each application/spray operation before being worn again.
- Contaminated protective clothing not to be removed from storage area – not to be washed at home!

#### Overall
- Must be impervious to pesticide formulations.
- Must give splash and droplet protection.
- Must be durable, light-weight, comfortable & affordable.
- Two-piece garment (jacket with hood & trousers) or one-piece garment with hood can be used.
- Hood must close around gas mask.
- Sleeves must close at wrists with elasticized cuffs.
- Trousers must have elasticized closures around waist and ankles.
- Jacket of two-piece suit should seal on the hips (e.g. Velcro).
- Overalls should preferably be light in colour - contamination with pesticides visible.

#### Eye and face protection
- A face shield made of clear transparent material, which is impervious to solvent and pesticide vapours and which provides full face protection should be worn as indicated on the product label when preparing and applying spray mixtures.
- Safety goggles are an acceptable alternative to a face shield.

#### Gloves
- Gloves made of nitrile rubber, PVC, neoprene and butyl rubber are suitable.
- Should be light in colour (contamination with pesticides visible) and non-slippery.
- Lined gloves not recommended – pesticide can accumulate in lining material.
- Gloves must be long enough to cover minimum of 90 mm above the wrist.
- Contaminated gloves must be washed with soap & water before being removed from hands and again after removal (inside out).

#### Boots
- Rubber boots, unlined and at least calf-high are to be used. Trousers shall be worn outside boots to prevent pesticide entering boots.
- Boots shall be washed inside & outside at the end of each day’s spraying.

#### Head coverings
- For protection against spray drift, a cotton hat with brim can be used.
- Overhead spraying: a waterproof hat and cape shall be worn.
- When applying irritant powders (e.g. sulphur), a hood to cover head, neck and shoulders for total skin protection shall be worn.
- Respirators should be worn when indicated. Must comply with SANS 10220.

### NOTE
Tractors with closed canopies and air conditioning are recommended for maximum safety and comfort during application – improves productivity and quality of application & coverage (GAP).

### Ablution facilities
- Each operator shall wash or shower at the end of each spray operation or shift.
- Contaminated washing water shall not be disposed of into any water source, including rivers, ground water sources and sewerage systems.

### DISPOSAL OF EMPTY CONTAINERS AND OBSOLETE PESTICIDES
**Pesticides**
Obsolete or unwanted pesticide formulations must be disposed of at a registered hazardous waste landfill site.
| Empty containers | • Empty containers shall be triple-rinsed and rendered unserviceable (puncture or cut up).
• Containers should then be stored until removal for recycling or disposal at a hazardous waste disposal site. Ensure that the person/company removing containers is registered to dispose of containers legally.
• Combustible containers may not be burned on the farm – this is illegal. |

* GAP = not a legal requirement, but recommended as a good agricultural practice to enhance safe handling, application & storage.