Rabie Ridge
Detailed Wetland Assessment and Mitigation Approach

SEF Reference No: 505436

Prepared for:

Roux Property Development Africa
5 Alexander Road
Irene
0062
Tel. No.: (012) 667 2772
Fax No.: (012) 667 2776
E-mail: kgomotso.nakene@nakeneprops.co.za

Prepared by:

Strategic Environmental Focus (Pty) Ltd
P.O. Box 74785
Lynnwood Ridge
0040
Tel. No.: (012) 349-1307
Fax. No.: (012) 349-1229
e-mail: sef@sefsa.co.za

S · E · F

STRATEGIC ENVIRONMENTAL FOCUS

September 2013

Compiled by	Authorised by
Willem Lubbe ***Cand. Sci. Nat.*** Wetland Specialist SACNASP Reg. No. 100064/08 **Rowena Harrison** ***Cand. Sci. Nat.*** Junior Wetland Specialist SACNASP Reg. No 100169/13	**Byron Grant** ***Pr. Sci. Nat.*** Project Manager & Senior Natural Scientist SACNASP Reg. No. 400275/08  Date: 20/09/2013

Declaration of Independence

I, **Willem Lubbe,** in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998);
- Have and will not have vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998);
- Will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not;
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member;
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement; and
- Undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered.

Willem Lubbe *Cand. Sci. Nat.*
Wetland Specialist
SACNASP Reg. No. 100064/08

20/09/2013
Date

Declaration of Independence

I, **Rowena Harrison,** in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Have and will not have vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not;
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member;
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement; and
- Undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered.

____
Rowena Harrison *Cand. Sci. Nat.*
Junior Wetland Specialist
SACNASP Reg. No. 100169/13

___20/09/2013___
Date

EXECUTIVE SUMMARY

Strategic Environmental Focus (Pty) Ltd (SEF) was previously appointed by Roux Property Development Africa to undertake wetland assessments, including wetland delineation and functionality studies, of the areas that will be potentially affected by the proposed development on Rabie Ridge Ext 6 on the Remainder of Allendale 10-IR, Gauteng. The wetlands identified were categorised into three hydrogeomorphic types and included unchannelled valley bottom wetlands, hillslope seepage wetlands connected to a watercourse and isolated hillslope seepage wetlands, located on Halfway House granites. Subsequently, a more detailed assessment of the study area by means of an intensive and extensive augering program was deemed necessary in order to increase the accuracy of the wetland delineation and the accuracy of the developable area on the property. The study was also required to provide potential mitigation measures to protect and improve wetlands. The terms of reference for the current study were as follows:

- Increase the accuracy of the wetland boundaries and extent;
- Provide a detailed soil map; and
- Highlight necessary mitigation measures.

The detailed soil investigation revealed eleven different soil forms including boundary soils, of which seven soil forms were considered to be hydric soils (wetland soils). Wetland areas were delineated based on soil form and identifiable redoximorphic signs. Delineated wetlands included unchannelled valley bottom wetlands, isolated hillslope seepage wetlands and hillslope seepage wetlands connected to a watercourse. The wetlands identified during the current detailed investigation occupied a combined area of 26.84 hectares within the greater study area.

Based on the findings of the investigation, the proposed development within the catchment of the hillslope seepage wetlands and valley bottom wetland would result in significant changes to the hydrology of the catchment, especially in terms of increased peak flows and reduction in subsurface flows supporting these wetlands. In order to mitigate potential negative affects to the watercourse, large scale attenuation and associated diffuse release infrastructure would have to be designed and implemented to mimic the hydrology of a pre-development Halfway House granite landscape. This would require integration of the development layout, inclusion of green spaces and stormwater design to include several attenuation facilities as well as diffuse release infrastructure fringing the hillslope seepage wetlands. It is recommended that both soft and hard engineering principles be utilised to ensure that the most cost effective and aesthetically pleasing mitigation options are implemented. It is important to take cognisance that water moves vertically and horizontally within the soil profile of the catchment and that development within wetland areas may pose a threat to the sustainability of any structures constructed due to serious rising damp, water problems and structural instability.
.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF TABLES

1. INTRODUCTION

With South Africa being a contracting party to the Ramsar Convention on Wetlands, the South African government has taken a keen interest in the conservation, sustainable utilisation and rehabilitation of wetlands in South Africa. This aspect is also reflected in various pieces of legislation controlling development in and around wetlands and other water resources, of which the most prominent may be the National Water Act, 1998 (Act No. 36 of 1998) (NWA).

As South Africa is an arid country, with a mean annual rainfall of only 450mm in relation to the world average of 860mm (DWAF, 2003), water resources and the protection thereof becomes critical to ensure their sustainable utilisation. Wetlands perform various important functions related to water quality, flood attenuation, stream flow augmentation, erosion control, biodiversity, harvesting of natural resources, and others, highlighting their importance as an irreplaceable habitat type. Determining the location and extent of existing wetlands, as well as evaluating the full scope of their ecosystem services, form an essential part in striving towards sustainable development and protection of water resources.

1.1. Project Description and Terms of Reference

Strategic Environmental Focus (Pty) Ltd (SEF), as independent environmental impact practitioners and ecological specialists, was previously appointed by Roux Property Development Africa, to undertake wetland assessments, including wetland delineation and functionality studies, of the areas that will be affected by the proposed development on Rabie Ridge Ext 6 on the Remainder of Allendale 10-IR, Gauteng. Three wetlands located on Halfway House granites were identified on site during the initial study (SEF, 2010). Subsequently a more detailed study of the study area, by means of an intensive and extensive augering program, was deemed necessary in order to increase the accuracy of the wetland delineation and the accuracy of the developable area on the property.

1.2. Assumptions and Limitations

In order to obtain definitive data regarding the biodiversity, hydrology and functioning of particular wetlands, studies should ideally be conducted over a number of seasons and over a number of years. The current study relied on information gained during four days of field surveying conducted during a single season, desktop information for the area, information obtained from previous studies, as well as professional judgement and experience.

Delineations of wetlands were therefore dependent on the extrapolation of data obtained during field surveys and to a limited extend from interpretation of orthophotos and other imagery. Despite the intensive augering program, the potential for errors in delineating boundaries exists, due to the cryptic nature of wetlands associated with Halfway House Granite geology and anthropogenic activities. It is also possible that, small seepage wetlands could have been overseen during the field survey as a result of their cryptic nature, small extend of some isolated seeps and anthropogenic activities in the area.

1.3. Methodology

Field surveys were undertaken during late August and early September 2013. The wetland delineation was based on the methodology as prescribed by the Department of Water Affairs (DWAF, 2005). The survey of the study area entailed intensive soil delineations according to *in situ* observations using a standard hand auger method. Soil types were classified to soil family level according to the South African Soil Classification System (Soil Classification Working Group, 1991).

Soil classification procedure entailed evaluating the following physical soil properties in the field for wetland verification:

- Topography (as % slope gradient);
- Diagnostic horizon sequence;
- Texture (as % clay);
- Effective depth;
- Soil colour; and
- Redoximorphic Features.

The manual hand feel method was used to estimate clay content (texture) and a Munsell colour chart was used to determine soil colour. Thereafter, the soil form and soil family was captured on a hand-held GPS. The GPS points were then used to compile a detailed soil map, where uniform soil patterns were grouped into map units, with respect to observed characteristics.

2. BACKGROUND INFORMATION

2.1. Locality

The study site comprises the remainder of the farm Allendale 10IR and is situated within the jurisdiction of the City of Johannesburg, Gauteng. The site falls within the quarter degree square 2628AA. Modderfontein Road (M38) divides the site into a western and eastern portion, while Dane Road divided the southern portion of the site. Republic Road formed the northern boundary. The study site is situated just west of Rabie Ridge and east of Austin View (Figure 1).

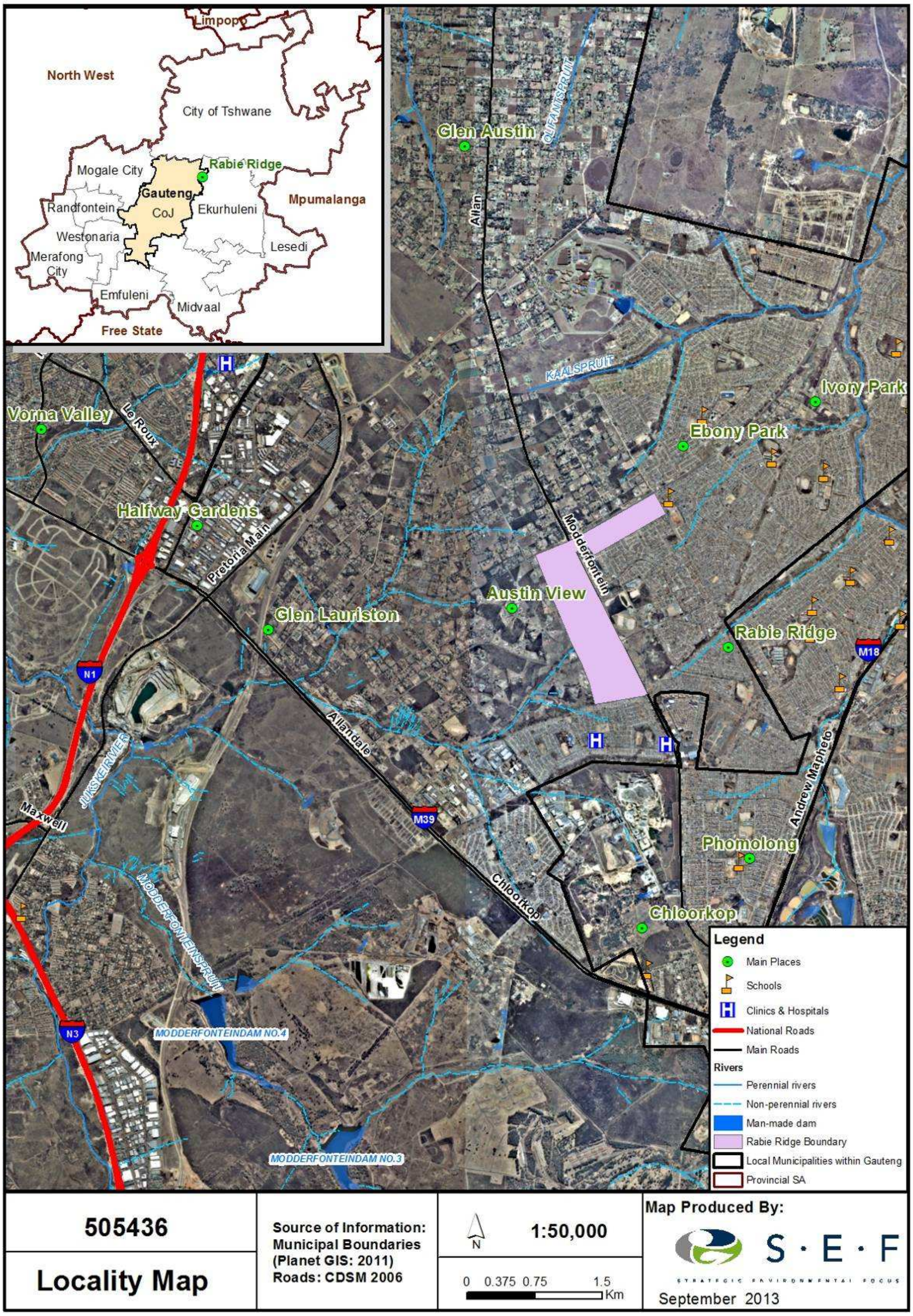


Figure 1: Locality map of the study area

2.2. Biophysical Description

<u>Climate</u>

Midrand is a strongly seasonal summer rainfall region with a mean annual precipitation of 620-800mm. Incidences of frost are very frequent during the winter months. The average monthly midday temperatures for Midrand range from 17.2℃ in June to 26.8℃ in January. The region is the coldest during July when the temperature drops to 1.1℃ on average during th e night (Mucina and Rutherford, 2006).

<u>Geology</u>

The study area is situated on Halfway House Granite, in which the dominant rock types are Granite and Gneiss.

<u>Regional Vegetation</u>

The study site is situated within the Grassland Biome of South Africa (Rutherford & Westfall, 1994). High summer rainfall and dry winters are characteristic of the Grassland Biome of the Gauteng region. It comprises mainly ‘sweet’ and ‘sour’ grasses and plants with perennial underground storage organs, for example bulbs and tubers, while trees are restricted to specialised habitats such as rocky outcrops or kloofs. The majority of rare and threatened plant species in the summer rainfall regions of South Africa are restricted to high-rainfall grasslands, making this the biome in most urgent need of conservation. It is not generally acknowledged that the majority of plant species in grasslands are non-grassy herbs (forbs), most of which are perennial plants with large underground storage structures (Mucina and Rutherford, 2006).

The Grassland Biome can be divided into smaller units known as vegetation units. The site is situated within Egoli Granite Grassland unit (Mucina and Rutherford, 2006). The Egoli Granite Grassland occurs in the Gauteng Province in the Johannesburg dome and extending toward Centurion in the North, Muldersdrift to the east and Tembisa to the west. The grassland is usually dominated by *Hyparrhenia hirta* with some woody species on rocky-out crops or rock sheets. Only about 3% of this unit is conserved in statutory reserves and private conservation and more than two thirds has already undergone transformations mostly by urbanisation, cultivation or by building of roads. The Egoli Granite Grassland unit is classified as Endangered (Mucina & Rutherford, 2006).

<u>Wetland Vegetation Type</u>

In terms of the Wetland Vegetation Type the study site falls within Mesic Highveld Grassland Group 3 which as a group is regarded as being Critically Endangered (Macfarlane *et al*., 2012)

2.3. Associated Watercourses

The study area falls within the quaternary catchment A21C which is part of the Crocodile (West) and Marico Water Management Area and the Upper Crocodile Sub-Water Management Area. A non-perennial river intersects the study boundary in the western portion of the study site while the most south-western corner also includes a non-perennial drainage line (Chief Directorate: Surveys & Mapping, 1996).

2.4. National Freshwater Ecosystem Priority Areas Status

The National Freshwater Ecosystem Priority Areas project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim uses systematic biodiversity planning to identify priorities for conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development. The second aim comprises a national and sub-national component: The national component aims to align DWA and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems. The sub-national component aims to use three case study areas to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes at a sub-national level. The project further aims to maximize synergies and alignment with other national level initiatives such as the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation.

Based on current outputs of the NFEPA project, no FEPA wetlands or wetland clusters were associated with site.

3. RESULTS

3.1. Soil Forms

According to DWAF (2005), the seasonal and temporary zones of the wetlands will have one or more of the following soil forms present (signs of wetness incorporated at the form level): Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu, as defined by the Soil Classification Working Group (1991). Alternatively, the seasonal and temporary zones will have one or more of the following soil forms present (signs of wetness incorporated at the family level): Inhoek, Tsitsikamma, Houwhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee (DWAF, 2005). Soil types identified during the current study are listed in Table 1, followed by a description of the catena and distribution of soils identified within the landscape.

Table 1: List of soil forms identified within the study area

Soil Form (Map Unit)	Diagnostic Horizon Sequence	Soil Properties	Soil Family
Mispah (Ms)/ Glenrosa (Gs)/ Dresden (Dr)	-A: Orthic -B: Hard rock/ Lithocutanic/ Hard plinthic	Very shallow (<15 cm) sandy loam on hard rock or lithocutanic or hard plinthic B horizon. Characteristic overland flow and recharge of hillslope seeps downstream.	**Ms 2100 – Gulu/ Gs 2111 – Bisho/ Dr 2000 - Hilldrop**
Clovelly (Cv)	-A: Orthic -B: Yellow Brown Apedal	Shallow Orthic A horizon overlaying a moderately deep well drained yellow brown loamy sand. Clay percentage increases with depth.	**2200 – Leiden**
Hutton (Hu)	-A: Orthic -B: Red Apedal	Shallow Orthic A horizon overlaying a moderately deep well drained red loamy sand. Clay percentage increases with depth.	**2200- Suurbekom**
Avalon (Av)	-A: Orthic -B: Yellow Brown Apedal - Soft Plinthic material	Moderately deep and well drained upper solum of loamy sand, overlying a soft plinthic layer below 500mm depth.	**Gc 2200 - Vryheid**
Pinedene (Pn)	-A: Orthic -B1: Yellow-brown apedal -Unspecified material with signs of wetness	Moderately deep and well drained upper solum of yellow brown loamy sand, overlying unconsolidated materials with signs of wetness. Signs of wetness include the presence of mottles and a gleyed matrix.	**Pn 2200 – Reitz**
Longlands (Lo)	-A: Orthic -E: Bleached (grey) -B: Soft Plinthic	Relatively deep mesotrophic sand, with yellow E horizon overlying soft plinthite.	**Lo 2000 - Ermelo**
Westleigh (We)	A: Orthic B: Soft Plinthic	Moderately deep mesotrophic loamy sand topsoil directly overlying soft plinthite.	**We 2000 - Mareetsane**
Cartref (Cf)	-A: Orthic -E: (Bleached) -B: Lithocutanic	Shallow profiles of approximately 200-500mm. A grey A horizon overlies an E horizon, which is situated on lithocutanic features. These appear at approximately 200-300mm depth.	**Cf 1200 - Egolomi**
Katspruit (Ka)	- A: Orthic - G: Gleyed	Moderately deep poorly drained soil with gleyed properties occurring along a channel associated with a leaking pipeline.	**Ka 1000 - Lammermoor**

Plinthic catena

Parts of the traversed catena within the study area resembled a plinthic topo-sequence (Figure 2), comprising of hillslope seepage wetlands connected to a watercourse as well as isolated hillslope seepage wetlands with plinthic (Photograph 1) and hydric soil types. Plinthic soils were also identified within the unchannelled valley bottom wetland. Soils in the hillslope seepage wetland differed to the valley bottom wetland through a distinct increase in clay and organic matter content identified within the A horizon (Photograph 2). Plinthic soils are characterized by their susceptibility to prolonged seasonal wetness due to a fluctuating water table, which creates reducing redox conditions that are expressed as mottles and sometimes Iron (Fe) and Manganese (Mn) concretions. Plinthic soils were also identified as part of isolated hillslope seepage wetlands in the north-eastern area of the study site.

Plinthic soils in which the Orthic A grades directly into a plinthic horizon (e.g. Westleigh (We)) are generally wetter than soils in which the Orthic A grades indirectly through to an E (e.g. Longlands (Lo)) or a yellow-brown apedal B (e.g. Avalon (Av)). Furthermore, the presence of an E horizon on plinthic soils (e.g. Longlands (Lo)) generally indicates greater susceptibility to wetness than those soils with a yellow-brown apedal B horizon, such as Avalon (Av) and Pinedene (Pn) soils.

The Dresden soil form was identified within the hillslope seepage wetlands lower down on the slope. It consists of a hydric A horizon, with signs of mottling in the top few centimeters of soil overlying a hard plinthic layer.

Photograph 1: Plinthic soils located in the hillslope seepage wetlands.

Photograph 2: Plinthic soils with a more clayey A horizon located in the unchannelled valley bottom wetland.

Terrestrial soils

Terrestrial (dry) soils were found on the study site, and included the Hutton, Clovelly, Mispah (Ms), and Glenrosa (Gs) soil forms. The catena sequence from the top of the ridge downslope followed the order Hutton, Clovelly and then Mispah/Glenrosa soil forms for large parts of the study area.

The shallow Mispah and Glenrosa forms were generally located downslope of the Clovelly or Yellow Brown soil forms (including the Pinedene and Avalon soil forms). These soils were found along the convex crest positions of the landscape, comprising of shallow, bleached Orthic A topsoil underlain by some consolidated rock. The consolidated rock could have been any of the hard rock, lithocutanic, or hard plinthite, which would qualify these soils as Mispah, Glenrosa, Dresden, and/or Glencoe respectively.

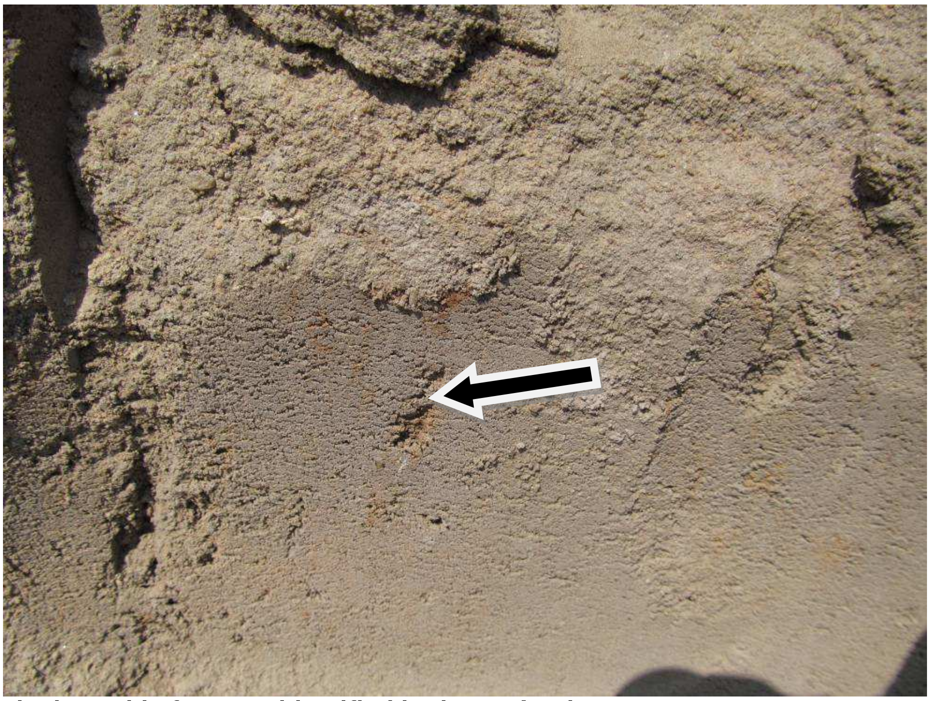
Imperfectly and poorly drained hill-slope seepage soils

These comprised of the Pinedene (Pn 2200), Cartref (Cf 1200) and Katspruit (Kd 1000) soil families. The Pn 2200 soils had a fairly well drained upper solum of *ca*. 300-450mm, although faint signs of wetness were identified at this depth. Below approximately 450mm the signs of wetness became more apparent with greater mottling recorded as well as a gleyed matrix. The Kd 1000 soil form was recorded along an erosion channel that is suspected to have been created as a result of a leaking pipe line (Photograph 3). The gleyed properties of the G horizon associated with the Katspruit form were recorded at a shallow depth of about 100mm. Adjacent to the leaking pipe the Cf 1200 soil form was classified. The presence of an E horizon in this form is indicative of in situ net removal of colloidal material by leaching out through its exposure to water. In some areas the Orthic A horizon has been removed, through cultivation practices and only the E horizon is present, overlying the lithocutanic horizon.

Photograph 3: Wet channel located within a hillslope seepage wetland, thought to be associated with a leaking pipe.

Redoximorphic features

For an area to be considered a wetland, redoximorphic features must be present within the upper 500mm of the soil profile (Collins, 2005). Redoximorphic features are the result of the reduction, translocation and oxidation (precipitation) of iron and manganese oxides that occur when soils are saturated for sufficiently long periods of time to become anaerobic. Only once soils within 500mm of the surface display these redoximorphic features can the soils be considered to be hydric (wetland) soils. According to the DWAF (2005), soil wetness indicators (i.e. identification of redoximorphic features) are the most important indicator of wetland occurrence due to the fact that soil wetness indicators (redoximorphic features) remain in wetland soils, even if they are degraded or desiccated. It is important to note that the presence or absence of redoximorphic features within the upper 500mm of the soil profile alone is sufficient to identify the soil as being hydric (a wetland soil), or non-hydric (non-wetland soil) (Collins, 2005). Redoximorphic features were therefore utilised as a key factor during the current study to classify soils as terrestrial or hydric since there were several boundary soil forms classified (Photograph 3).



Photograph 4: Redoximorphic features identified in the wetland areas.

Anthropogenic effects on soil properties

The largely disturbed nature of the site, including tillage, cultivation of maize, road and infrastructure development, and dumping of rubble have had a great effect on the soil properties and profile depth located in the study area. Large sections of the hydric soils associated with hillslope seepage wetlands identified were missing as a result of changes to the micro-topography of the area. Wetland soil forms identified, especially those with an E horizon, are more prone to accelerated erosion processes which have been brought about by repeated cultivation and tillage of the land. The presence of the leaking pipe has also resulted in an increase in the annual transportation of soils and further accelerated the erosion processes.

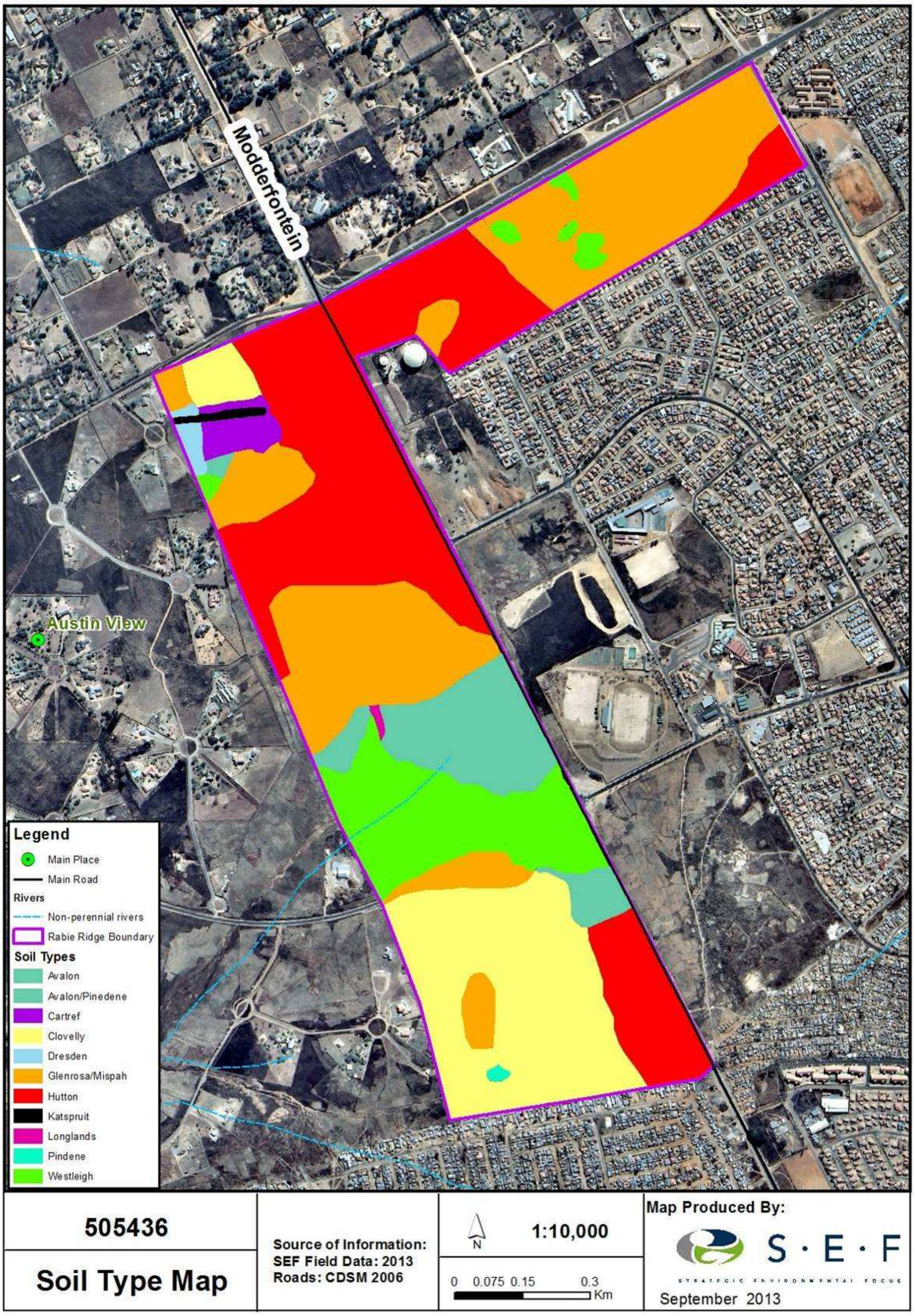


Figure 2: Soil forms identified within the study area

3.2. Wetland Vegetation

According to DWAF (2005), vegetation is regarded as a key component to be used in the delineation procedure for wetlands. Vegetation also forms a central part of the wetland definition in the National Water Act, 1998 (Act No. 36 of 1998) (NWA). Using vegetation as a primary wetland indicator, however, requires undisturbed conditions (DWAF, 2005). A cautionary approach must be taken as vegetation alone cannot be used to delineate a wetland, as several species, while common in wetlands, can occur extensively outside of wetlands. When examining plants within a wetland, a distinction between hydrophilic (vegetation adapted to life in saturated conditions) and upland species must be kept in mind. There is typically a well-defined 'wetness' gradient that occurs from the centre of a wetland to its edge that is characterized by a change in species composition between hydrophilic plants that dominate within the wetland to upland species that dominate on the edges of, and outside of the wetland (DWAF, 2003).

Due to successive years of cultivation of maize and associated ongoing practices such as tilling, the disturbed nature of the vegetation on site did not clearly indicate wetland zonation, especially in the hillslope seepage areas (Photograph 4). The majority of hydrophilic vegetation was located within the valley bottom wetland system, which had permanent, seasonal and temporary zones of wetness. The hillslope seepage wetlands were associated with the temporary zones of wetness. Plant species associated with the permanent zone of wetness within the valley bottom wetland were *Persicaria* species (Knotweed / Snakeroot) and the graminoids *Leersia hexandra, Eragrostis plana* (Tough Love Grass), *Paspalum dilatum* (Dallis Grass), *Agrostis lachnanta* (Bent Grass) and *Setaria pallida-fusca* (Garden Bristle Grass). The permanent and seasonal zones included most of the above mentioned species as well as the graminoid *Sporobulus festivus* (Red Dropseed and indigenous herbaceous plants such as *Senecio serratuloides, S. inaequidens* (Canary weed) and *Lobelia erinus* (Wild lobelia). The hillslope seepage wetlands which were associated with the temporary zones of wetness had no obligate wetland species present.

There were also a large number of alien invasive weeds such as *Tagetes minuata* (Khaki Weed), *Flavernia bidentis* (Smelters Bush) and *Verbena brasiliensis* present within these two zones. Sedges present within the study area, often dominating more towards areas of more prolonged saturation included *Cyperus rupestrs* var. *rupestris*, *Mariscus congestus* and *Schoenoplectus corymbosus* cf. *paludicola.*

Photograph 5: Large parts of the study area cleared of all hydric and non-hydric vegetation for the cultivation of maize.

3.3. Delineated Wetland Areas

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

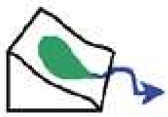
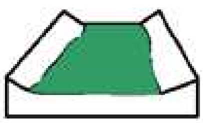
The temporary nature associated with the hillslope seepage wetlands within the Halfway House granite-dominated study area represented a precariously fine line around the definition of the NWA for wetlands and increased the complexity of delineating wetlands. A key component in understanding the delineation process for the study area was recognition of the geohydrology on the granite-dominated geology of the study area. The study area was dominated by very permeable sandy soils situated on top of an impermeable plinthic layer, typically 0.5m to 1m below the soil surface, which in turn resulted in a large component of precipitated water being able to move horizontally through the landscape. Natural slope and changes in micro-topography and effective soil depth will bring water closer or further from the surface, or even cause water to daylight, resulting in redoximorphic conditions and other wetland-associated features to be present. Complicating the matter was various historic and current disturbances and anthropogenic impacts which obscured vegetative indicators, resulted in changes in effective soil depth, removal of soil horizons, redistribution of alluvial material and changes in the micro topography. Reliance during the delineation process was therefore placed on clearly recognisable hydric soil forms, and where soil form boundary issues were noted, more emphasis was placed on redoximorphic features to classify a specific area as hydric or terrestrial.

HGM (hydrogeomorphic) units encompass three key elements (Kotze *et al*, 2005):

(1) Geomorphic setting. This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
(2) Water source. There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
(3) Hydrodynamics, which refers to how water moves through the wetland.

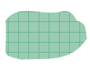
Table 2 describes the characteristics that form the basis for the classification of the HGM units in the study area.

Table 2: Wetland hydro-geomorphic types typically supporting inland wetlands in South Africa (adapted from Kotze *et al.*, 2005)

Hydro-geomorphic types	Description	Source of water maintaining the wetland[1]	
		Surface	Sub-surface
Isolated Hillslope seepage 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel.	*	***
Hillslope seepage connected to a watercourse 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defined stream channel connecting the area directly to a stream channel.	*	***
Unchannelled valley bottom wetland 	Valley bottom areas with no clearly defined stream channel, usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and also from adjacent slopes.	***	*/ ***

1 Precipitation is an important water source and evapotranspiration an important output in all of the above settings

Water source: * Contribution usually small
*** Contribution usually large
*/ *** Contribution may be small or important depending on the local circumstances


Wetland

The unchannelled valley bottom wetland and hillslope seepage wetlands which include isolated hillslope seepage wetlands and hillslope seepages which feed into a watercourse, were divided into HGM units according to hydric soil types in order to afford more accurate description of functional potential and mitigation measures, presented graphically in Figure 3 and Figure 4.

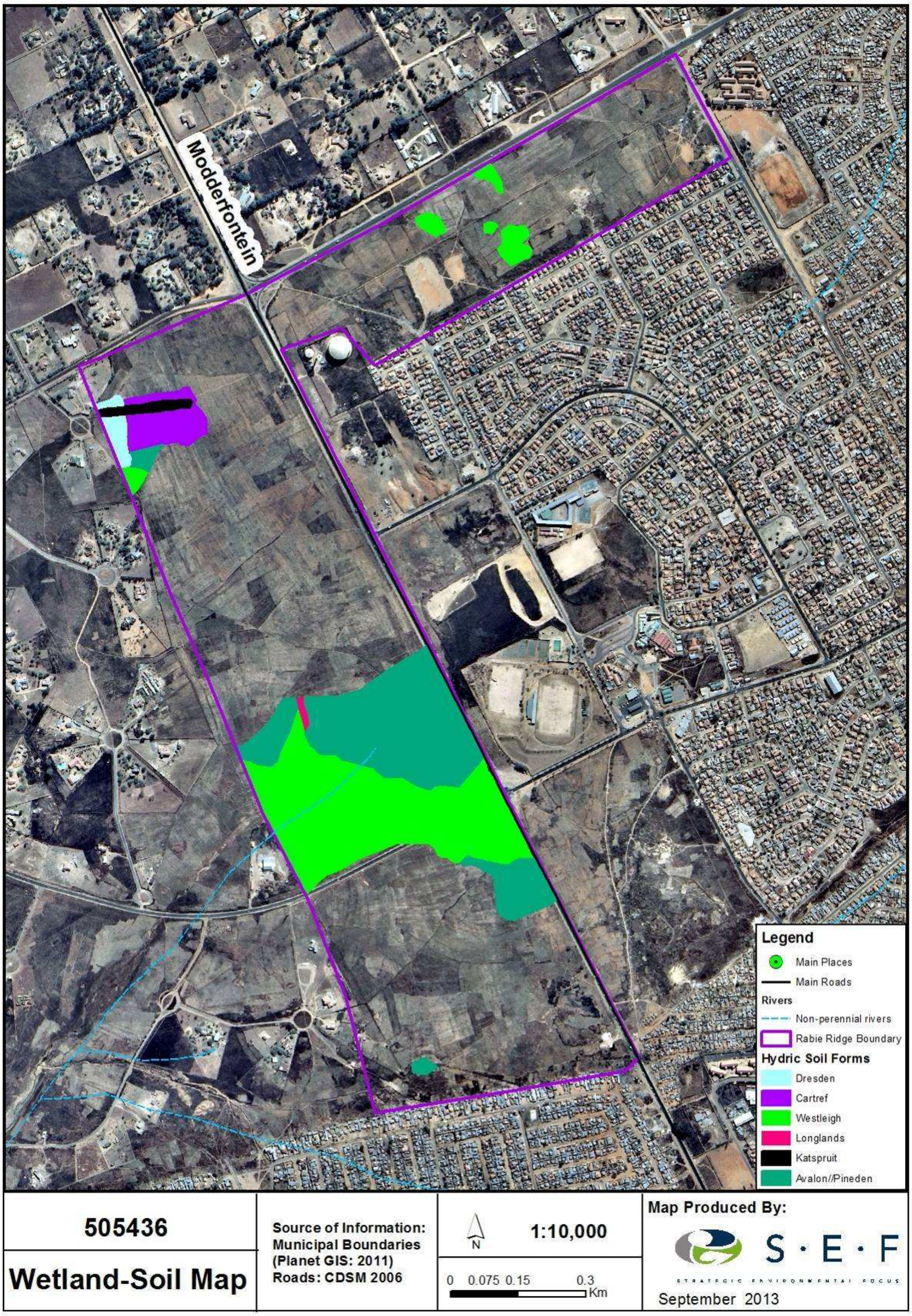


Figure 3: Wetland (hydric) soils identified in the study area

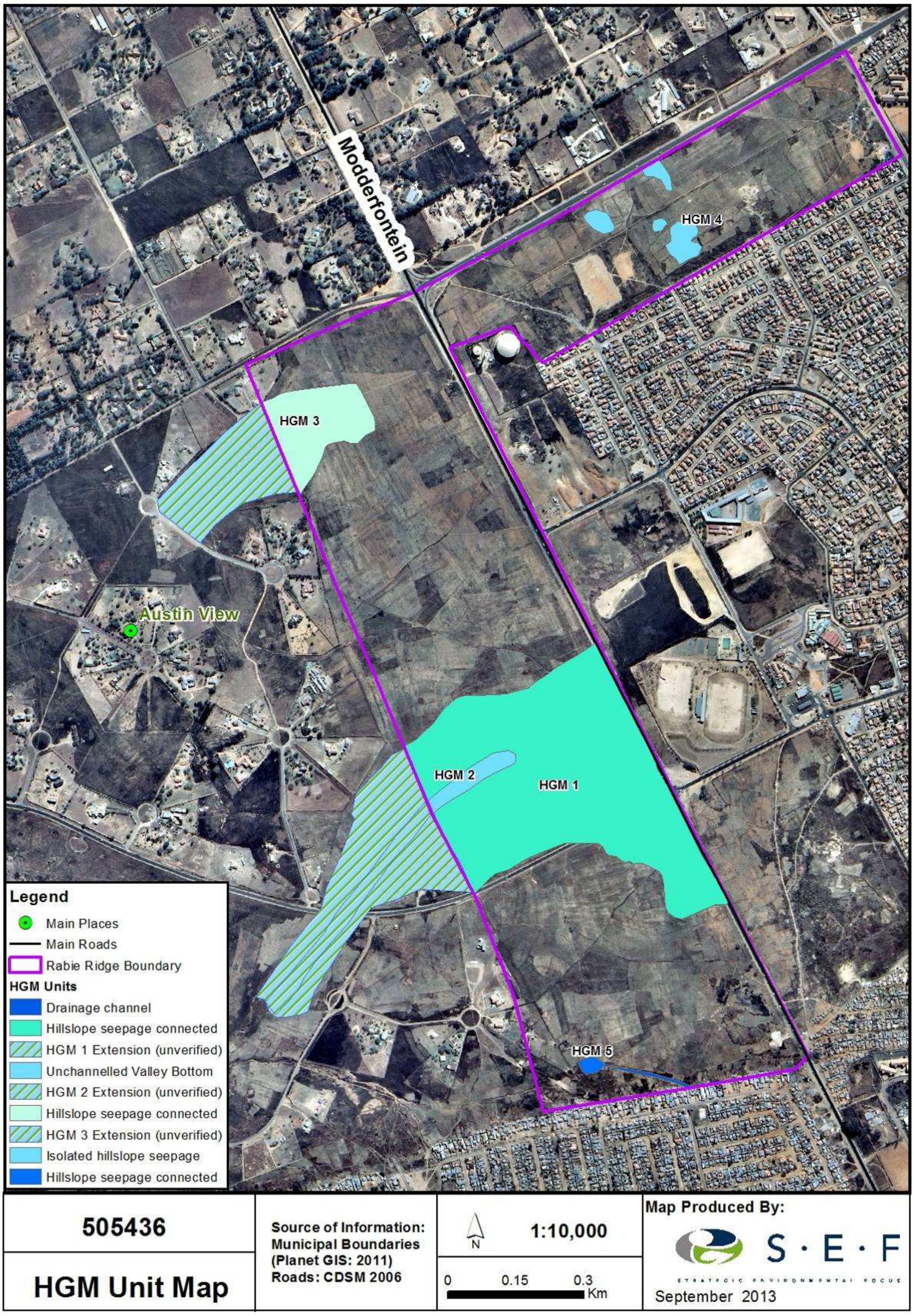


Figure 4: HGM units within the study boundary.

4. PRESENT ECOLOGICAL STATE ASSESSMENT

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increased biodiversity within the transformed study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes (Table 3).

Table 3: Potential wetland services and functions in study area

Function	Aspect
Water balance	Streamflow regulation
	Flood attenuation
	Groundwater recharge
Water purification	Nitrogen removal
	Phosphate removal
	Toxicant removal
	Water quality
Sediment trapping	Particle assimilation
Harvesting of natural resources	Reeds, Hunting, etc.
Livestock usage	Water for livestock
	Grazing for livestock
Crop farming	Irrigation

Hydro-geomorphic units are inherently associated with hydrological characteristics related to their form, structure and particularly their position in the landscape. This, together with the biotic and abiotic character (or biophysical environment) of wetlands in the study area, means that these wetlands are able to contribute better to some ecosystem services than to others (Kotze *et al.* 2005) (Table 4).

Table 4: Preliminary rating of the hydrological benefits likely to be provided by a wetland given its particular hydro-geomorphic type (Kotze *et al*., 2005)

WETLAND HYDRO-GEOMORPHIC TYPE	HYDROLOGICAL BENEFITS POTENTIALLY PROVIDED BY THE WETLAND							
	Flood attenuation		Stream flow regulation	Erosion control	Enhancement of water quality			
	Early wet season	Late wet season			Sediment trapping	Phosphates	Nitrates	Toxicants[2]
1. Valley bottom – unchannelled	+	+	+?	++	++	+	+	++
2. Hillslope seepage connected to a	+	0	+	++	0	0	++	++

watercourse								
3. Isolated hillslope seepage	+	0	0	++	0	0	++	+

[2]Toxicants are taken to include heavy metals and biocides

Rating: 0 Benefit unlikely to be provided to any significant extent
+ Benefit likely to be present at least to some degree
++ Benefit very likely to be present (and often supplied to a high level)

Through the use of a scoring system, the perceived departure of elements of each particular system from the "natural-state" was determined. The following elements were considered in the assessment:

- Hydrologic: Flow modification (has the flow, rates, volume of run-off or the periodicity changed);
- Geomorphic (Canalisation, impounding, topographic alteration and modification of key drivers);
- Biota (Changes in species composition and richness, Invasive plant encroachment, over utilization of biota and land-use modification)

A functional assessment of the wetlands was conducted during the previous study (SEF, 2010) using the Wet-EcoServices method. This method showed that the hillslope seepage wetlands connected to a watercourse and the unchannelled valley bottom wetland do perform a number of functions relating to maintenance of biodiversity, water supply, stream flow regulation, sediment trapping, and toxicant and nitrate removal (Figure 5 and Figure 6). The isolated hillslope seepage wetlands (Figure 7) however received low functional scores due to their severely modified nature as a result of farming practices, and the associated tillage on the land, which is leading to the desiccation of these systems. In order to gauge the Present Ecological Status of the wetlands for this assessment a WET-Health Level 2 field assessment was conducted during this assessment. This method was used to identify the wetlands abilities to contribute to ecosystem services within the study area in relation to a benchmark or reference condition.

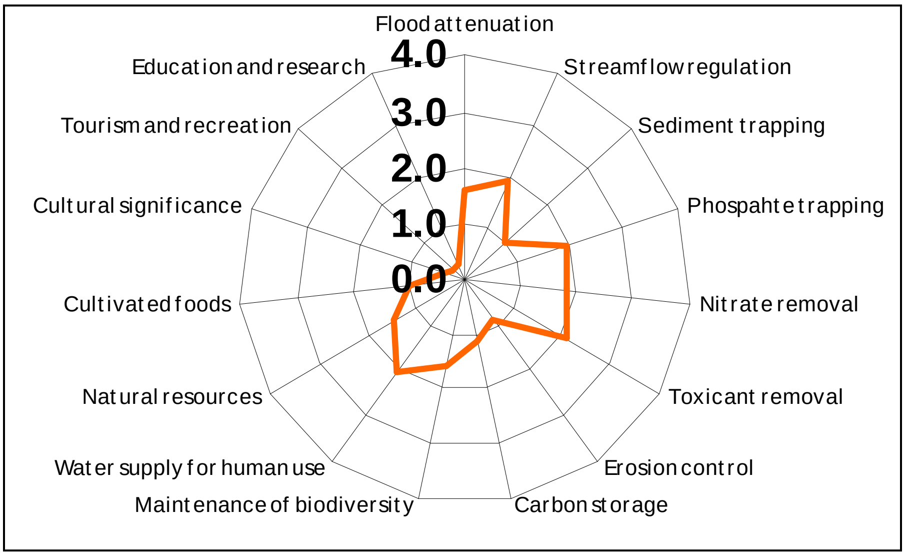


Figure 5: Wetland functionality of the hillslope seepage wetlands connected to a watercourse (SEF, 2010).

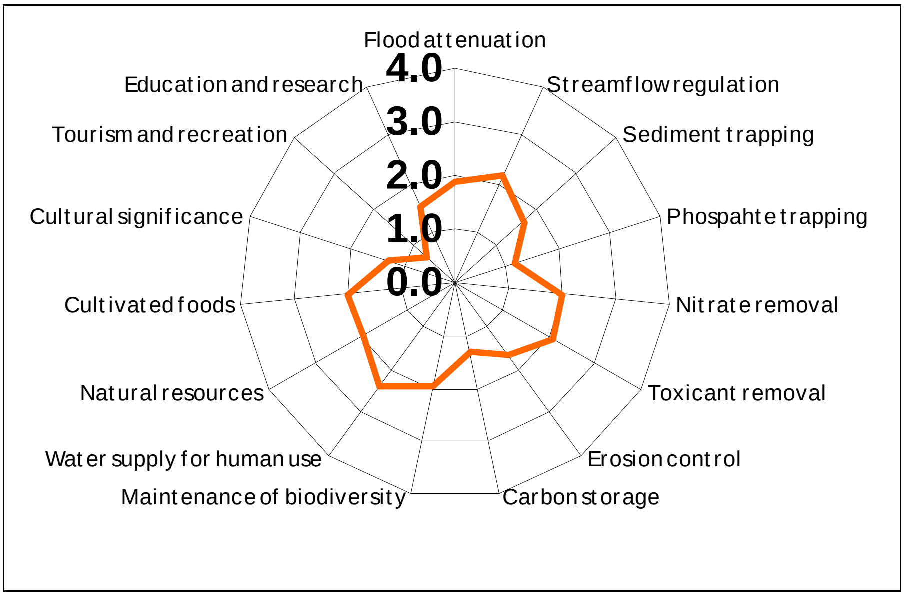


Figure 6: Wetland functionality of the unchannelled valley bottom wetland (SEF, 2010).

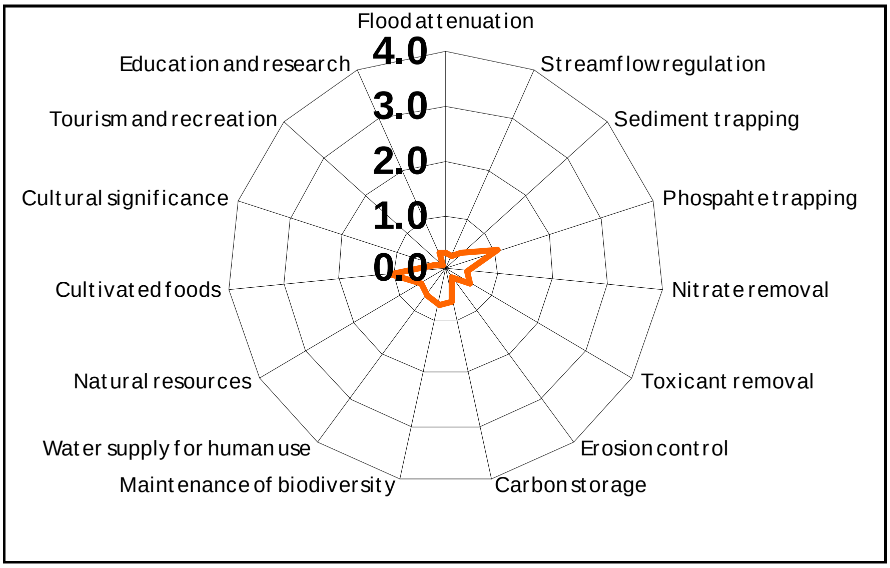


Figure 7: Wetland functionality of the isolated hillslope seepage wetlands (SEF, 2010).

Degradation of wetlands through impacts in catchments or in wetlands themselves has, and continues to result in the reduction and loss of their functional effectiveness and ability to deliver ecosystem services or benefits to humans and the environment (Kotze *et al.,* 2008). The HGM units are discussed in more detail in terms of their functional benefits, their Present Ecological Score and the impacts which affect these. The HGM Units are further displayed in Figure 4.

4.1. HGM 1

HGM 1 was delineated as a hillslope seepage wetland which is connected to a watercourse, and was classified as being largely modified (PES Category D, Table 5) with a large loss of habitat and basic ecosystem processes. Soil types identified within the HGM unit consist of the Westleigh (We), Pinedene (Pn) and Avalon (Av) soil forms. The system is largely modified with a large loss of basic ecosystem processes taking place. Modifications to this system are as a result of the cultivation of the land over many years for the production of Maize. The cultivation has led to a loss in top soil in this area, as sediment has moved downslope; the complete removal of all hydrophytic vegetation; and associated changes to the hydrological functioning of the wetland. Dane Road also dissects the wetland which has caused the formation of erosion channels to form near the road edge. Rubble has also been dumped close to the road, further leading to the degradation of this wetland.

Table 5: Wet-Health scores for HGM 1

Wetland size	Hydrology	Geomorphology	Vegetation	PES Category	Healthy hectare equivalent
21.55 ha	7.5	5.4	4.3	D (5.98)	8.66 ha

4.2. HGM 2

HGM 2 was delineated as an unchannelled valley bottom wetland, and was classified as being largely modified (PES Category D, Table 6). The wetland is associated with the permanent, seasonal and temporary zones of wetness. It consists of the Westleigh soil form, however unlike HGM 1 the accumulation of clay in the A horizon of the soil is of a much greater percentage. The unchannelled valley bottom runs in a southerly direction outside of the study area. Modifications to the system include erosion, overgrazing, the dominance of alien invasive species, and the loss of basal cover and surface roughness. The presence of a permanent and seasonal zone of wetness for this wetland are associated with the wetland providing greater functionality and supporting more functional processes as well as maintaining greater diversity than the surrounding hillslope seepage wetlands.

Table 6: Wet-Health scores for HGM 2

Wetland size	Hydrology	Geomorphology	Vegetation	PES Category	Healthy hectare equivalent
0.78 ha	6.5	4.8	4.0	D (5.30)	0.36 ha

4.3. HGM 3

HGM 3 was delineated as a hillslope seepage wetland which is connected to a watercourse further south of the study area, and was classified as being seriously modified (PES Category E, Table 7). The connection the hillslope seep has to a watercourse has been fragmented through the development of houses within the wetland, which has resulted in the partial desiccation of this wetland. It consists of the Westleigh, Pinedene, Avalon, Dresden and Katspruit soil forms. The presence of a leaking pipe has added to the 'wetness' of this wetland, with some areas experiencing saturated conditions throughout the year. It is thought that a leaking pipeline is situated higher up the slope parallel to the main road. Water from this pipeline is moving horizontally and vertically through the soil profiles and is then expressed at the surface of the soil lower down slope. However, despite the presence of a leaking pipe, the hillslope seep is a natural feature in the landscape as shown by the presence of hydric soil types within this area. The expression of water lower downslope has had an effect on the soil profiles identified on site, especially with regards to the Cartref soil type and its E horizon. E horizons in soils are more susceptible to erosion and there has been a major loss of soil from this area. Soil losses within the wetland could also be as a result of tillage practices and the cultivation of maize. The loss of soil and changes in the micro-topography of the wetland has seriously affected the hydrological and geomorphological processes that govern the wetland's ability to function. Residential housing developments have also been constructed within the wetland's boundary, thereby affecting the wetlands hydrology and resulting in the movement of sediment.

Table 7: Wet-Health scores for HGM 3

Wetland size	Hydrology	Geomorphology	Vegetation	PES Category	Healthy hectare equivalent
3.35 ha	5.0	6.4	8.8	E (6.48)	1.18 ha

4.4. HGM 4

HGM 4 is a combination of four small isolated hillslope seepage wetlands located in the north-eastern portion of the study area. These isolated hillslope seepages are critically modified (PES Category F, Table 8) and the systems have been completely transformed with an almost complete loss of natural habitats. The soil form identified within these small seepage areas was the Westleigh type. The hillslope seepages have been transformed through the cultivation of maize over the majority of this portion of the site as well as anthropogenic activities, including dumping rubble on the site, soil excavations and informal roads.

Table 8: Wet-Health scores for HGM 4

Combined Wetland size	Hydrology	Geomorphology	Vegetation	PES Category	Healthy hectare equivalent
1.01 ha	8.0	8.6	7.5	F (8.02)	0.19 ha

4.5. HGM 5

HGM 5 is a very small hillslope seepage wetland which has formed at the base of an artificial drainage channel. This small wetland has been critically modified (PES Category F, Table 9) and a complete loss of ecosystem functions have resulted. The soil form identified within this small seepage area was the Pinedene form which is the hydric variation of the surrounding terrestrial Clovelly soil type. The hillslope seepages have been transformed through anthropogenic activities, including the dumping of rubble on the site and the removal of natural vegetation. If the artificial channel is removed as part of the development this wetland would become desiccated and lose all functionality.

Table 9: Wet-Health scores for HGM 4

Combined Wetland size	Hydrology	Geomorphology	Vegetation	PES Category	Healthy hectare equivalent
0.15 ha	8.5	8.6	8.0	F (8.17)	0.02 ha

5. ECOLOGICAL IMPORTANCE AND SENSITIVITY

All wetlands, rivers, their flood zones and their riparian areas are protected by law and no development is allowed to negatively impact on rivers and river vegetation. The vegetation in and around rivers and drainage lines play an important role in water catchments, assimilation of phosphates, nitrates and toxins as well as flood attenuation. Quality, quantity and sustainability of water resources are fully dependent on good land management practices within the catchment. All flood lines, riparian zones and wetlands along with corresponding buffer zones must be designated as sensitive.

The Ecological Importance and Sensitivity (EIS) assessment was undertaken to rank water resources in terms of:

- Provision of goods and service or valuable ecosystem functions which benefit people;
- biodiversity support and ecological value; and
- Reliance of subsistence users (especially basic human needs uses).

Water resources which have high values for one or more of these criteria may thus be prioritised and managed with greater care due to their ecological importance (for instance, due to biodiversity support for endangered species), hydrological functional importance (where water resources provide critical functions upon which people may be dependent, such as water quality improvement) or their role in providing direct human benefits (Rountree, 2010). Ecological Importance and Sensitivity results for the wetlands identified are listed in Table 10.

Table 10: Ecological Importance and Sensitivity scores for wetland complexes

Wetland Complex	Parameter	Rating (0 -4)	Confidence (1 – 5)
HGM 1 (Hillslope seepage connected to a watercourse)	Ecological Importance & Sensitivity	Low (1.00)	2.33
	Hydrological / Functional Importance	Low (1.75)	2.00
	Direct Human Benefits	Low (1.33)	2.50
HGM 2 (Unchannelled valley bottom wetland)	Ecological Importance & Sensitivity	Moderate (2.00)	2.22
	Hydrological / Functional Importance	Moderate (2.00)	2.50
	Direct Human Benefits	Low (1.00)	2.50
HGM 3 (Hillslope seepage wetland connected to a watercourse)	Ecological Importance & Sensitivity	Low (1.40)	2.02
	Hydrological / Functional Importance	Low (1.87)	2.50
	Direct Human Benefits	Low (1.33)	3.00
HGM 4 (Isolated hillslope seepage wetlands)	Ecological Importance & Sensitivity	Low (1.40)	2.22
	Hydrological / Functional Importance	Low (2.00)	2.00
	Direct Human Benefits	Low (1.33)	3.00
HGM 5 Hillslope seepage wetland	Ecological Importance & Sensitivity	Low (1.40)	2.22
	Hydrological / Functional Importance	Low (1.33)	2.50
	Direct Human Benefits	Low (0.50)	3.00

The wetland areas identified on site were assigned low Ecological Importance and Sensitivity scores owing to current land uses, including the cultivation of maize within the wetlands, the dissection of wetlands by roads, dumping of rubble within the wetlands, the removal of almost all natural wetland vegetation species and the dominance of alien invasive species on site. The wetland vegetation type associated with the study area is categorised as Mesic Highveld Grassland Group 3 which as a group is regarded as being Critically Endangered, and therefore increases the ecological importance of the site. However, due to the low PES scores obtained by all HGM units, these particular wetlands are regarded as having a conservation importance within the wetland vegetation type. The moderate scores received by the valley bottom wetland were as a result of the less disturbed nature of this wetland compared to the hillslope seepage wetlands. The Hydrological Importance and Functionality of the wetlands also scored low as a result in the changes to the hydrological and geomorphological processes which govern the functionality of the wetlands. The movement of soil downslope, the building of houses in the wetlands, and the cultivation of crops in the wetlands have all lead to a reduction in the functionality that the wetlands perform. Direct human benefits were associated with the cultivation of crops in the wetlands and grazing by cattle.

6. MITIGATION MEASURES

The proposed development adjacent to the hillslope seepage wetlands and unchannelled valley bottom wetland would result in a large change to the hydrology of this catchment with increases in peak flows and a decrease in subsurface flow entering and supporting the wetlands. It is important to take cognisance that water moves vertically and horizontally within the soil profile of the catchment and that development within wetland areas may pose a threat to the sustainability of any structures constructed due to serious rising damp, water problems and structural instability.. Residential housing currently built downslope of the study site but within the boundaries of the wetlands are showing signs of water damage. It is therefore recommended that no structures are developed within HGM 1, HGM 2 and HGM 3 wetlands and that a 30m minimum GDARD buffer is placed around these wetlands as a no-go area. Further to this a Water Use License Application (WULA) will have to be submitted to the Department of Water Affairs as per GN 1199 which states that a WULA is needed for any development within 500m of a wetland.

In order to mitigate potential negative affects to the wetland areas and mitigate development within the wetland’s catchment, attenuation and associated diffuse release infrastructure would have to be designed and implemented to mimic the hydrology of a pre-development Halfway House granite landscape. This would require integration of the development layout, inclusion of green spaces, stormwater-infrastructure design to include several attenuation facilities as well as diffuse release infrastructure fringing the hillslope seepage wetlands. It is recommended that both soft and hard engineering principles be utilised to ensure that the most cost effective and aesthetically pleasing mitigation options are implemented.

By restoring the basic ecosystem functions within the seepage wetlands through ‘re-wetting’ wetlands using the below-outlined rehabilitation principles and stormwater attenuation, hillslope seepage wetlands should start to regain lost ecosystem functions through longer water retention periods, re-establishment of obligatory wetland vegetative species and improvement of soil properties, further adding to the ecological status of these wetland areas. In addition, these ecosystem benefits will in turn positively contribute to the ecological functioning of the valley bottom wetland and wetland areas outside of the study boundary. In order to install these systems a WULA will have to be applied for as per GN 1199 which states that a WULA is needed for any development within 500m of a wetland.

Swales and attenuation facilities are to be installed along the outer edge of the buffer area of the hillslope seepage wetlands (HGM 1 and HGM 3). The attenuation facility should retain stormwater runoff and then allow the water to diffuse into the wetland at a slower velocity through diffuse release infrastructure, simulating predevelopment geo-hydrological patterns in the catchment. These should help limit further erosion processes from being initiated along the hillslope seepage wetlands, allow for sediment deposition within the swales, re-distribute water more evenly within the seepage areas and eventually re-wet the desiccated wetlands. The higher moisture regime within these seepage wetlands will also subsequently increase the vegetation cover leading to further ecosystem service benefits. A sketch diagram is shown in Figure 8 and Figure 9 as an example of the attenuation and diffuse release infrastructure proposed to be installed along the hillslope seepage wetlands. The stormwater can enter the swale where it will be attenuated and sediment allowed to be deposited. The water will then flow into an inlet box where it can drain out of the swale and into a channel. This channel needs to be separated to divert the flow of water as shown in Figure 6, to evenly spread the water toward the buffer zone (width to be determined in detailed design phase) and wetland. Adjacent to the wetland buffer zone, a 1-2m trench needs to be dug and filled with rock and pebble material to diffuse the release of water. Once water enters this channel it can then infiltrate into the sandy soil profiles found along the hillslope seepage wetlands. This will facilitate the movement of water evenly through the buffer areas and eventually into the hillslope seeps. It should be noted however that the above description of the diffuse release infrastructure is only conceptual and should be appropriately designed by a suitably qualified engineer in collaboration with a wetland specialist.

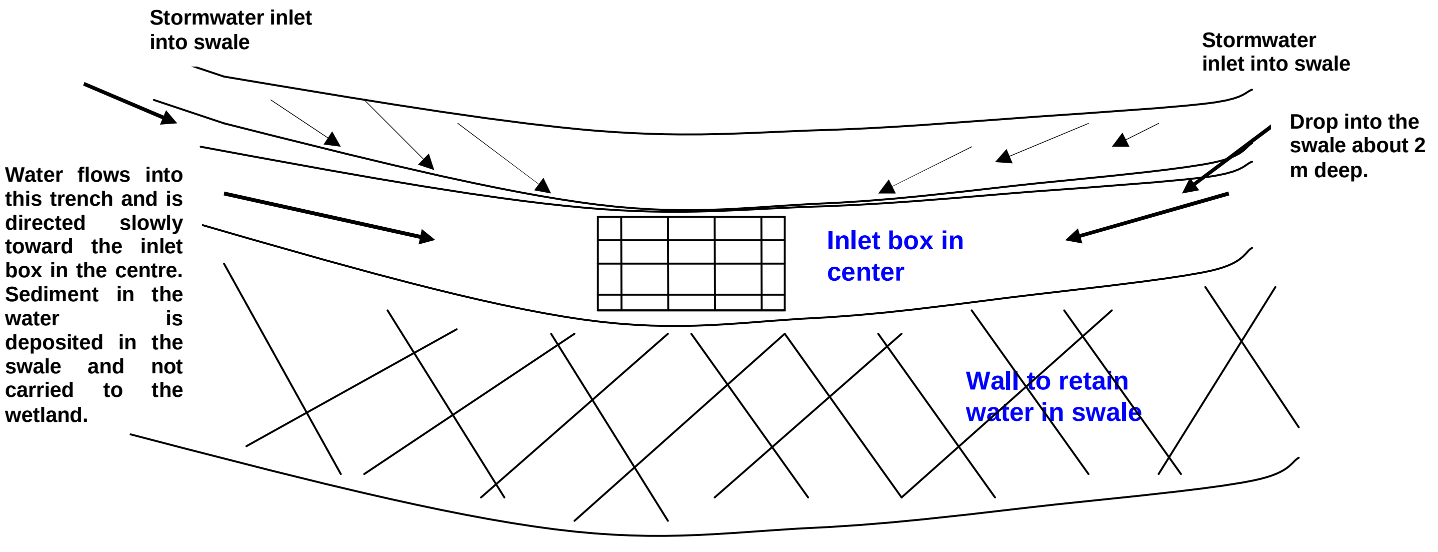


Figure 8: Top view of an example of a swale system.

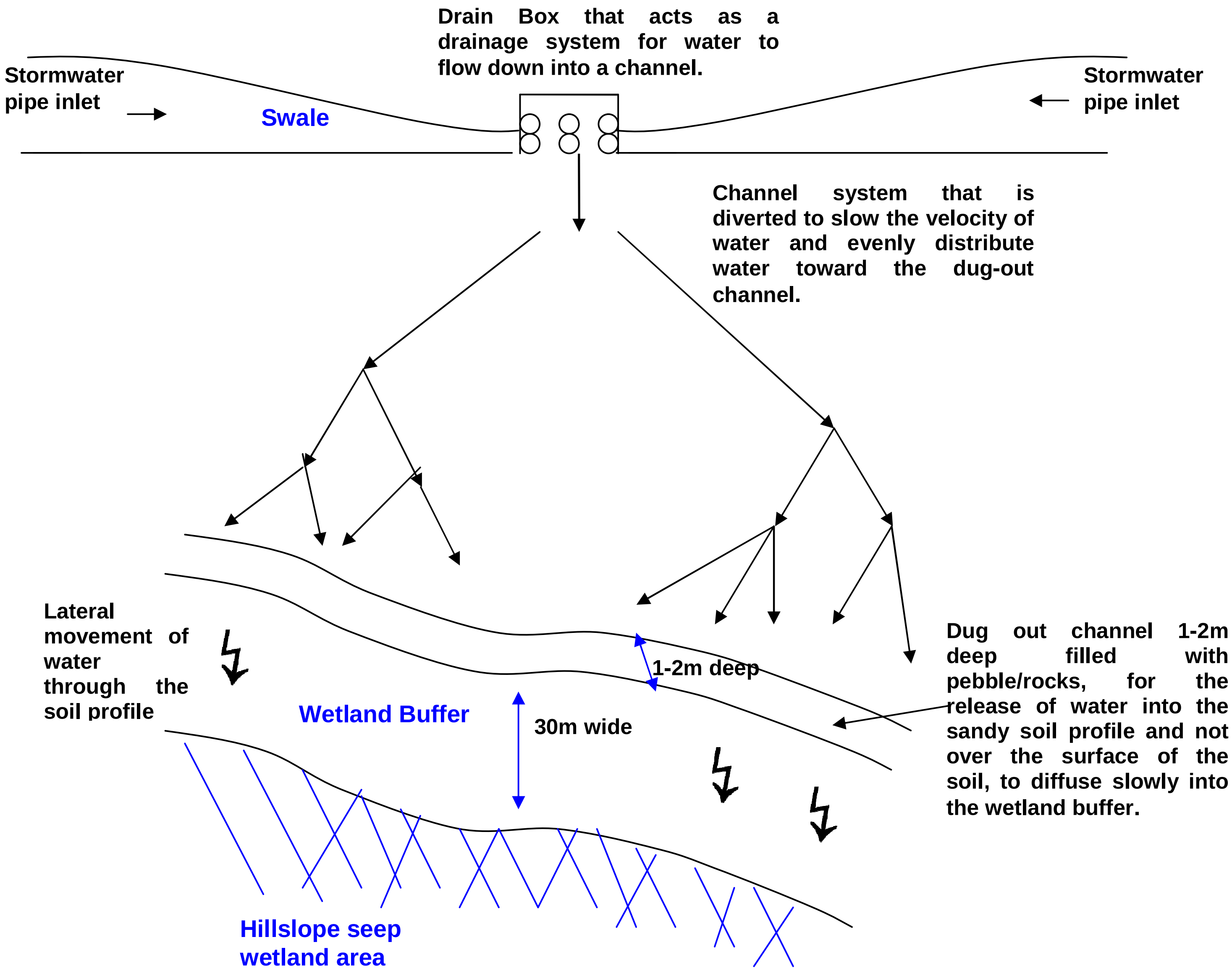


Figure 9: Side view of an example of a swale and associated drainage into wetland buffer.

The above mentioned swale designs have been used in other development areas and examples of these are shown in Photograph 6 and Photograph 7. These swales and attenuation facilities could be used in the proximity of the wetlands where soft engineering techniques are favourable (whereas deep vertical basins through hard engineering could be utilised within the development footprint, saving on developable space). Each catchment segment should cater for its own stormwater attenuation generated per area, following a hierarchy of release principles developed according to the attenuation facilities catchment size and its position in the landscape relative to the position of the hillslope seepage wetland in order to ensure the longest possible release period of attenuated water after a precipitation event. Attenuation facilities should potentially be linked, from the top of the catchment towards the valley bottom in order to retain water within the landscape as long as possible.

Photograph 6: Example of a swale being used in another development. This swale has been in operation for approximately 5 years and became vegetated within the first year of operation.

Photograph 7: Example of a drain box used in the swale above. Water drains into this box and then flows out of the swale in a controlled manner. The design of this swale also helps the deposition of sediment out of the stormwater before it enters the wetland system.

Wetland rehabilitation within HGM 3 should be discussed with local authorities as the re-wetting and enhancement of attenuation facilities of this wetland area would cause more water damage to the already developed areas downslope of the wetland. If local authorities are in agreement to re-establish the connectivity of the hillslope seepage with wetland areas downslope of the study area, an integrated rehabilitation plan needs to be developed.

The wetlands associated with HGM 4 are isolated in nature and lack functionality as a result of heavy urbanisation in the area. The development of this portion of the study area will further degrade the wetlands causing an almost complete loss of functionality. It is therefore recommended that if development encroaches onto these wetlands, artificial attenuation facilities are installed that are linked to the stormwater infrastructure to diffusely release stormwater from the new development.

The above mentioned processes would entail a detail design and rehabilitation planning process and implemented under the supervision of an Environmental Control Officer and Wetland Specialist.

7. CONCLUSION

The detailed soil investigation revealed eleven different soil forms (including boundary soils) of which seven soil forms were considered to be hydric soils (wetland soils). Wetland areas were delineated based on soil form and identifiable redoximorphic signs and included isolated hillslope seepage wetlands, hillslope seepage wetlands connected to a watercourse and an unchannelled valley bottom wetland. The wetlands identified during the current detailed investigation occupied a combined area of 26.84 hectares within the study area.

The proposed development within the catchment of the hillslope seepage wetlands and valley bottom wetland would result in critical changes to the hydrology of the catchment, especially in terms of increased peak flows and reduction in subsurface flow supporting wetlands. It is important to realise that water moves horizontally within the soil profile within the catchment and that a lack of mitigation would not only result in further desiccation of wetlands but also pose a threat to the sustainability of structures due to serious damp and water problems. In order to mitigate potential negative affects to the watercourse, large scale attenuation and associated diffuse release infrastructure would have to be designed and implemented to mimic the hydrology of a pre development Halfway House granite landscape. This would require integration of the development layout, inclusion of green spaces, stormwater design to include several attenuation facilities as well as diffuse release infrastructure fringing the hillslope seepage wetlands. It is recommended that both soft and hard engineering principles be utilised to ensure that the most cost effective and aesthetically pleasing mitigation options are implemented. A Water Use License will need to be applied for in order to install these mitigation measures as per GN 1199 which states that a WULA is needed for any development within 500m of a wetland. The above mentioned processes would entail a detail design and rehabilitation planning process and only implemented under the supervision of an Environmental Control Officer and Wetland Specialist.

8. GLOSSARY

Alien species Plant taxa in a given area, whose presence there, is due to the intentional or accidental introduction as a result of human activity.

Biodiversity Biodiversity is the variability among living organisms from all sources including inter alia terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Biome A major biotic unit consisting of plant and animal communities having similarities in form and environmental conditions, but not including the abiotic portion of the environment.

Buffer zone A collar of land that filters edge effects.

Conservation The management of the biosphere so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations. The wise use of natural resources to prevent loss of ecosystems function and integrity.

Critically Endangered A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

Ecosystem Organisms together with their abiotic environment, forming an interacting system, inhabiting an identifiable space.

Ecological Corridors Corridors are roadways of natural habitat providing connectivity of various patches of native habitats along or through which faunal species may travel without any obstructions where other solutions are not feasible.

Edge effect Inappropriate influences from surrounding activities, which physically degrade habitat, endanger resident biota and reduce the functional size of remnant fragments including, for example, the effects of invasive plant and animal species, physical damage and soil compaction caused through trampling and harvesting, abiotic habitat alterations and pollution.

Endangered A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.

Exotic species Plant taxa in a given area, whose presence there, is due to the intentional or accidental introduction as a result of human activity

Fauna The animal life of a region.

Flora The plant life of a region.

Forb A herbaceous plant other than grasses.

Habitat	Type of environment in which plants and animals live.
Indigenous	Any species of plant, shrub or tree that occurs naturally in South Africa.
Invasive species	Naturalised alien plants that have the ability to reproduce, often in large numbers. Aggressive invaders can spread and invade large areas.
Outlier	An observation that is numerically distant from the rest of the data
Primary vegetation	Vegetation state before any disturbances such as cultivation, overgrazing or soil removal
Threatened	Species that have naturally small populations, and species which have been reduced to small (often unsustainable) population by man's activities.
Red data	A list of species, fauna and flora that require environmental protection. Based on the IUCN definitions.
Species diversity	A measure of the number and relative abundance of species.
Species richness	The number of species in an area or habitat.
Vulnerable	A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

9. REFERENCES

Amoros, C. and Bornette, G., (2002). Connectivity and biocomplexity in waterbodies of riverine floodplains. Freshwater Biology 47, 517– 539

Batchelor, A. (2007). Wetland Baseline Assessment: Modderfontein. Wetland Consulting services. Ref 286/2007.

Boto, K G, and Patrick, W H, 1979. Role of wetlands in removal of suspended sediments. In: GREESON P E, CLARK J R, and CLARK J L, (eds.) Wetland functions and values: the state of our understanding. American Water Resources Association, Minneapolis, Minnesota.

Collins, N.B. (2005). Wetlands: The basics and some more. Free State Department of Tourism, Environment and Economic Affairs.

Department of Water Affairs and Forestry (2003) National Water Resource Strategy (Final draft). Department of Water affairs and Forestry. Pretoria. South Africa.

Department of Water Affairs and Forestry. (2005) A practical field procedure for identification and delineation of wetlands and riparian areas. Department of Water Affairs and Forestry. Pretoria. South Africa.

Driver, A., Nel, J.L., Snaddon, K., Murray, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel, J. & Funke, N., (2011). Implementation Manuel for Freshwater Ecosystem Priority Areas. Water Research Commission. Pretoria. South Africa.

Dynesius, M. and Nilsson, C., (1994). Fragmentation and flow regulation of river systems in the northern third of the world. Science 266, 753– 762.

Kotze, D.C., Marneweck G.C., Bachelor, A.L., Lyndley, D.S. & Collins, N.B. (2005). Wet-EcoServices. South African National Botanical Institute. Pretoria. South Africa.

Macfarlane, D., von Hase, A., & Brownlie, S. (2012). Towards a best practice guideline for wetland offsets in South Africa. South African National Biodiversity Institute. Pretoria. South Africa.

Mucina, L. & Rutherford, M.C. (2006): The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Muscutt, A. D., Harris G L, Bailey S W, and Davies D B, (1993). Buffer zones to improve water quality: a review of their potential use in UK agriculture. Agriculture, Ecosystems and Environment 45: 59-77.

Nel, J., Maree, G., Roux, D., Moolman, J., Kleynhans, N., Silberbauer, M. & Driver, A. (2004). South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 2: River Component. CSIR Report Number ENV-S-I-2004-063. Council for Scientific and Industrial Research, Stellenbosch

Palmer, R.W., Turpie, J., Marneweck, G.C. & Batchelor, A.L. (2002). Ecological and economic evaluation of wetlands in the Upper Olifants River catchment, South Africa. WRC Report no. 1162/1/02.

Rutherford, M. C. & Westfall, R. H. (1994). Biomes of Southern Africa: an objective categorisation, Pretoria: National Botanical Institute.

Strategic Environmental Focus, (2010). Remainder Allendale 10-IR Wetland Assessment, SEF Reference Number 503663, Pretoria

Soil Classification Working Group (1991). Soil classification. A taxonomic system for South Africa, Mem. agric. nat. Resour. S. Afr. No. 15. Dept. Agric. Dev., Pretoria.

Thompson N, Marneweck G, Bell S, Kotze D, Muller J, Cox D, and Clark R. (2002). A methodology proposed for a South African national wetland inventory. Division of Water, Environment and Forest Technology, CSIR, Pretoria

WRP (1993). Wetland groundwater processes. WRP Technical Note HY-EV-2.2.

APPENDIX A

Methodology

The report incorporated a desktop study, as well as field surveys, with site visits conducted during late August and early September 2013. Additional data sources that were incorporated into the investigation for further reliability included:

- Google Earth images;
- 1:50 000 cadastral maps; and
- ortho-rectified aerial photographs.

Identified wetland areas were marked digitally using GIS (changes in vegetation composition within wetlands as compared to surrounding non-wetland vegetation show up as a different hue on the orthophotos, thus allowing the identification of wetland areas). These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field surveys.

The wetland delineation methodology used was the same as the one set out by the Department of Water affairs and Forestry (DWAF, 2005) document "*A Practical field procedure for the identification and delineation of wetlands and riparian areas"*.

The Department of Water affairs and Forestry (DWAF) wetland delineation guide makes use of indirect indicators of prolonged saturation by water, namely wetland plants (hydrophytes) and (hydromorphic) soils. The presence of these two indicators is indicative of an area that has sufficient saturation to classify the area as a wetland. Hydrophytes were recorded during the site visit and hydromorphic soils in the top 0.5 m of the profile were identified by taking cored soil samples with a bucket soil auger and Dutch clay auger (photographs of the soils were taken). Each auger point was marked with a handheld Global Positioning System (GPS) device. All cored samples were analysed for signs of wetness that indicate wetland associated conditions. Areas denuded of primary vegetation often corresponded to areas that have been tilled, making vegetation and soil profiles poor wetland indicators.

Soil classification procedure entailed evaluating the following physical soil properties in the field for wetland verification:

- Topography (as %slope gradient)
- Diagnostic horizon sequence
- Texture (as %clay);
- Effective depth;
- Soil colour; and
- Redoximorphic Features.

The manual hand feel method was used to estimate clay content (texture) and a Munsell colour chart was used to determine soil colour. These features were used to identify soils to their family level. Thereafter the soil form and soil family was assigned based on the given criteria, and location captured on a hand-held GPS. The GPS points were then used to compile a detailed soil map, where uniform soil patterns were grouped into map units, with respect to observed characteristics. Augering points made during the current study are shown in Figure 10.

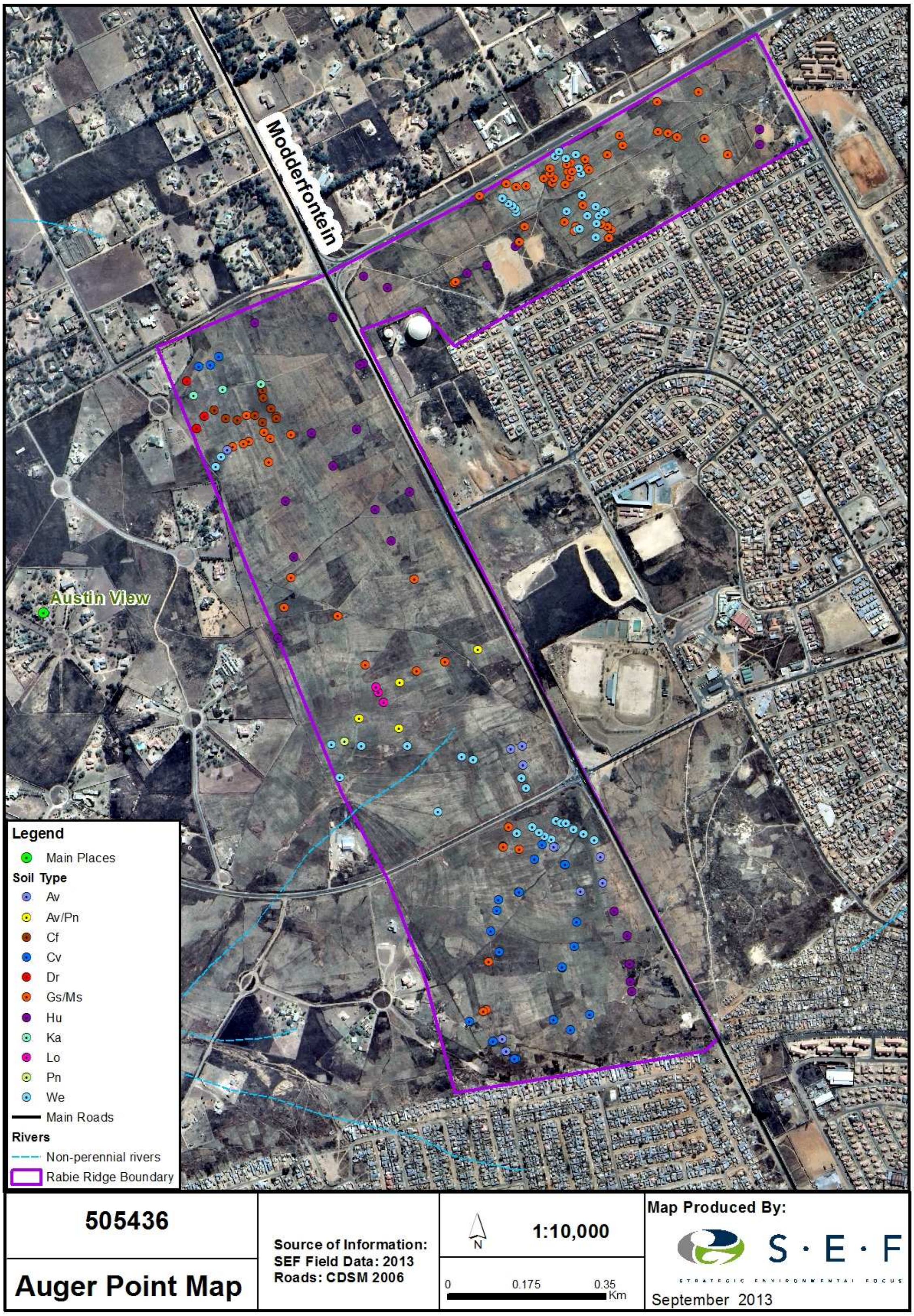


Figure 10: Auger points used to identify soil types.

In order to gauge the Present Ecological State of various wetlands within the study area, a level 2 Wet-Health assessment was applied in order to assign PES categories to certain wetlands. Wet-Health (Macfarlane *et al., 2*009) is a tool which guides the rapid assessment of a wetland's environmental condition based on a site visit. This involves scoring a number of attributes connected to the geomorphology, hydrology and vegetation, and devising an overall score which gives a rating of environmental condition.

Wet-Health is useful when making decisions regarding wetland rehabilitation, as it identifies whether the wetland is beyond repair, whether rehabilitation would be beneficial, or whether intervention is unnecessary, as the wetland's functionality is still intact. Through this method, the cause of any wetland degradation is also identified, and this facilitates effective remediation of wetland damage. There is wide scope for the application of Wet-Health as it can also be used in assessing the Present Ecological State of wetlands and thereby assist in determining the Ecological Reserve as laid out under the National Water Act. Wet-Health offers two levels of assessment, one more rapid than the other.

For the assessments, an impact and indicator system is used. The wetland is first categorized into the different hydrogeomorphic (HGM) units and their associated catchments, and these are then assessed individually in terms of their hydrological, geomorphologic and vegetation health by examining the extent, intensity and magnitude of impacts, of activities such as grazing or draining. The extent of the impact is measured by estimating the proportion the wetland that is affected. The intensity of the impact is determined by looking at the amount of alteration that occurs in the wetland due to various activities. The magnitude is then calculated as the combination of the intensity and the extent of the impact and is translated into an impact score. This is rated on a scale of 1 to 10, which can be translated into six health classes (A to F – compatible with the ecostatus categories used by DWAF, Table 11). Threats to the wetland and its overall vulnerability can also be assessed and expressed as a likely Trajectory of Change.

Table 11: Interpretation of scores for determining present ecological status (Kleynhans 1999)

Rating of Present Ecological State Category (PES Category)
CATEGORY A Score: 0-0.9; Unmodified, or approximates natural condition.
CATEGORY B Score: 1-1.9; Largely natural with few modifications, but with some loss of natural habitats.
CATEGORY C Score: 2 – 3.9; Moderately modified, but with some loss of natural habitats.
CATEGORY D Score: 4 – 5.9; Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E Score: 6 -7.9; Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
CATEGORY F Score: 8 - 10; Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

* If any of the attributes are rated <2, then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean

Determination of Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments (DWAF, 1999), and the work conducted by Kotze *et al* (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree, 2010). An example of the scoring sheet is attached as Table 12. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 13.

Table 12: Example of scoring sheet for Ecological Importance and sensitivity

Ecological Importance	Score (0-4)	*Confidence (1-5)*	**Motivation**
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rarity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland	**1.00**		
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			

Table 13: Category of score for the Ecological Importance and Sensitivity

Rating	**Explanation**
Very low (0-1)	Rarely sensitive to changes in water quality/hydrological regime.
Low (1-2)	One or a few elements sensitive to changes in water quality/hydrological regime.
Moderate (2-3)	Some elements sensitive to changes in water quality/hydrological regime.
High (3-3.5)	Many elements sensitive to changes in water quality/ hydrological regime.
Very high (+3.5)	Very many elements sensitive to changes in water quality/ hydrological regime.

APPENDIX B

Re-vegetation of disturbed areas must be undertaken with site indigenous species and in accordance with the instructions issued by a wetland specialist. The following species should be utilised in each of the different wetland zones for rehabilitation:

- Temporary hillslope seeps: *Aristida junciformis; Conyza ulmifolia; Eriocaulon dregei; Fingerhuthia sesleriiformis; Gunnera perpensa; Helichrysum mundii; Imperata cylindrica; Miscanthus capensis; Miscanthus junceus; Paspalum scrobiculatum; Pennisetum macrourum; Pennisetum sphacelatum; Ranunculus meyeri; Ranunculus multifidus* and *Setaria sphacelata*.
- Seasonal wetlands: *Andropogon appendiculatus; Arundinella nepalensis; Carex acutiformis; Carex cognata; Cladium mariscus; Cyperus digitatus; Cyperus latifolius; Cyperus longus; Eriocaulon dregei; Fimbristylis complanata; Fimbristylis dichotoma; Fingerhuthia sesleriiformis; Gunnera perpensa; Helichrysum mundii; Isolepis costata; Juncus dregeanus; Juncus exsertus; Juncus oxycarpus; Juncus punctorius; Kniphofia linearifolia; Limosella longiflora; Ludwigia palustris; Paspalum scrobiculatum; Pennisetum macrourum; Pycreus mundii; Pycreus nitidus; Ranunculus meyeri; Ranunculus multifidus; Sacciolepis chevalieri; Schoenoplectus decipiens; Scleria welwitschii; Setaria sphacelata; Xyris capensis; Agrosits lachnanta* and *Xyris congensis*.
- Permanent zone: *Agrostis lachnanta; Arundinella nepalensis; Carex acutiformis; Carex cognata; Cladium mariscus; Cyperus digitatus; Cyperus latifolius; Fimbristylis dichotoma; Gunnera perpensa; Isolepis costata; Juncus dregeanus; Juncus exsertus; Juncus oxycarpus; Juncus punctorius; Kniphofia linearifolia; Limosella longiflora; Ludwigia palustris; Phragmites australis; Leersia hexandra, Typha capensis; Pycreus mundii; Pycreus nitidus; Ranunculus meyeri; Ranunculus multifidus; Sacciolepis chevalieri; Schoenoplectus decipiens* and *Scleria welwitschii*.
- Buffer zone (Terrestrial species): *Aristida aequiglumis*; *A. congesta*; *A. junciformis* subsp. *galpinii*; *Brachiaria serrata*; *Cynodon dactylon*; *Digitaria monodactyla*; *D. tricholaenoides*; *Elionurus muticus; Eragrostis chloromelas*; *E. curvula*; *E. plana; E. racemosa; Loudetia simplex; Monocymbium ceresiiforme; Setaria sphacelata; Themeda triandra; Trachypogon spicatus; Tristachya leucothrix; Tristachya rehmanni; Alloteropsis semialata* subsp. *eckloniana; Ctenium concinnum; Diheterpogon amplectans; Harpochloa falx; Panicum natalense* and *Schizachyrium sangiuneum* (Mucina & Rutherford, 2006).