APPLICATION OF THE DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF) WETLAND DELINEATION METHOD TO WETLAND SOILS OF THE WESTERN CAPE

Report to the
WATER RESEARCH COMMISSION

as part of the

WESTERN CAPE WETLAND SOILS PROJECT

by

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EXECUTIVE SUMMARY

Wetland delineation

Guidance on how to approach wetland delineation in South Africa is provided in *A practical field procedure for identification and delineation of wetlands and riparian areas* (Department of Water Affairs and Forestry 2005) (hereafter described as the "DWAF delineation manual").

Wetland delineation includes

- confirmation of the **occurrence** of wetland and
- A determination of the **outermost edge** of the wetland.

Identification of wetland presence is important where there is a need to understand how an area functions and its environmental sensitivity, so as to make wise decisions on regulating land use. Accurate identification of the wetland edge is essential when deciding where to commence application of a recommended buffer area adjacent to the wetland, for example for a new building development with a requirement to set back a specified distance from the wetland edge. The wetland ecologist can work with a land surveyor to provide a highly accurate set of surveyed coordinates for use during site planning.

Delineation should be informed by the presence of agreed indicators common to wetlands (see Table 1). Only then should specific management recommendations be made, or broad policy prepared on how to approach development in these areas. For example, large areas of the Cape Flats within the City of Cape Town can be characterised or delineated as seasonal or temporary wetland. This knowledge importantly increases understanding of how that particular piece of land functions, how different land uses would impact the wetland and any associated downstream areas, and how the wetland would affect the desired land use. This should then inform management decisions. Even if subsequent management decisions indicate that it is acceptable to forgo certain wetland area, the decisions can be made in the knowledge that certain extra measures may be needed, not only to protect wetland or catchment functioning but also to have the best outcome for the desired land use and users.

Project aims

The aims of this project were:

- to explore whether the DWAF delineation manual applies to the Western Cape
- to identify new "Specific Cases" i.e. not currently described in the DWAF delineation manual (Appendix A), and that are found specifically in the Western Cape
- to suggest ways to approach the delineation of wetlands occurring on soils of these new "Specific Cases"

"Specific Cases" are situations where the soil is difficult to delineate (i.e. whether it indicates wetland presence or not). They do not show **gleying or mottles**, or other soil wetness indicators.

Project results

This *Western Cape Wetland Soils Project* concludes that:

(a) the principles contained in the DWAF delineation manual, **are applicable to wetlands in the Western Cape**, based on a rapid sampling of sites encompassing the Cape Peninsula, Cape Flats, inland Swartland shales, coastal mountain slopes and sandy coastal plains of the South-Western Cape.

(b) at approximately **65%** of sites, soils exhibit one or more of the main soil wetness indicators described in the DWAF delineation manual. These are gleying and mottles described in Section 3.1 of this report. Soil wetness indicators are "clues" in the soil morphology, indicating that there has been a high water table present for a prolonged period of time, and these "clues" are evident even during times when the water table has dropped (in the summer dry season).

(c) the remaining **35%** of the Western Cape project sites fall within the "Specific Cases" currently described in the DWAF delineation manual (Appendix A). These include sandy soils and low chroma (lack of colour) soils.

The recommended approach to delineation of these soils is to:

- record the presence of a dark, high carbon content, surface layer, and / or
- thoroughly document landscape conditions and any remnant vegetation, soil, hydrology indicators, develop rationale for considering the area to be wetland.

Not all sandy soils are difficult to delineate. Many low chroma or sandy wetland soils visited during the course of the project did exhibit an identifiable soil wetness indicator, namely a high carbon, dark surface layer of varying thickness. Other wetland sites had sandy soils with distinct mottles. However, a sub-set of temporary wetland sites with sandy soils showed no identifiable soil wetness indicators. Specific Cases are described in Section 3.3 of this report.

(d) **no** new "Specific Cases", unique to the Western Cape, were identified during the course of the project.

Project Recommendations

This project has found the DWAF delineation manual to be useful and applicable to the Western Cape and proposes no real departure from what is already contained within the manual. However, it does make several suggestions for expanded explanation, guidance, or added emphasis, including:

1) Provide a list of types of **sites that are difficult to delineate**, and recommend how to approach delineation of these sites.

The DWAF delineation manual currently has guidance within Appendix A with respect to Special Cases / "difficult soils" but a wetland may be difficult to delineate for reasons other than the soil.

Table 1. List of types of site that are difficult to delineate.

Type of "difficult site"	Approach
Some, or all, wetland indicators *are present* but it is a **non-natural wetland** (e.g. some dams, road islands)	- Decide on the relative permanence of the change and whether the area can now be said to be functioning as a wetland. - Time field observations during wet season, when natural hydrology is at its peak, to help to differentiate between naturally-occurring versus human-induced wetland. - Decide appropriate policy / management i.e. can certain land uses be allowed due to "low" wetland functional value, or does wetland perform key function despite being "artificial".
Indicators of soil wetness *are present* but **no longer a functioning wetland** (e.g. wetland has been drained)	- Look for evidence of ditches, canals, dikes, berms, or subsurface drainage tiles. - Decide whether or not the area is currently functioning as a wetland.
Indicators of soil wetness *are present* but **no longer a functioning wetland** (e.g. relict / historical wetland)	- Decide whether indicators were formed in the distant past when conditions were wetter than they are today. - Obtain the assistance of an experienced soil scientist.
Some, or all, wetland indicators *are absent* at **certain times of year** (e.g. annual vegetation or seasonal saturation)	- Thoroughly document soil and landscape conditions, develop rationale for considering the area to be wetland. - Recommend that the site be revisited in the wet season. (In many cases soil wetness indicators are still present.)
Some, or all, wetland indicators *are absent* due to **human disturbance** (e.g. vegetation has been cleared, wetland has been ploughed or filled)	(In the case of ploughing or invasive alien species infestation, soil wetness indicators typically still present.) - Thoroughly document landscape conditions and any remnant vegetation, soil, hydrology indicators, develop rationale for considering the area to be wetland. - Certain cases (illegal fill) may justify that the fill be removed and the wetland rehabilitated.
Indicators of soil wetness *are absent* because soils are **"difficult soils".**	**These situations are the "Specific Cases" already included in Appendix A of the DWAF manual.**

2) Emphasise that defensible delineation requires an interpretation of **all wetland indicators** found on the site (not only soils), taken within the **context** of where the wetland is located.

It is often misunderstood that the DWAF delineation manual methodology requires only looking at soils. Although it is stated that soils are considered to be the most reliable indicator, the DWAF delineation manual presents a set of four indicators (terrain unit, soil form, soil wetness, vegetation) and advocates drawing from all of them on page 16 "combining the indicators". Each indicator supports the **potential** for an area to be wetland, providing a series of "clues" about site conditions.

The recommended approach is for the delineator to draw from all indicators present on the site, together with an interpretation of the influence of the setting and other local conditions, in comparison to adjacent non-wetland areas, so as to build a defense of whether or not an area is a wetland.

3) Record **hydrology** during the site visit.

The DWAF delineation manual states on page 5 that hydrology is currently not used as an indicator, as the presence of water in a wetland varies from day to day, as well as seasonally and annually. However, when it is present, hydrology can be a useful and rapid confirmation of a wetland, and an investigation and recording of depth to saturation / free water within the soil pit at the time of the site visit contributes very useful information about a wetland.

4) Group wetland soils into two broad categories: **organic** and mineral.

It is very useful to make this distinction up front as organic soils (Champagne soil form) are relatively easy to identify and always indicate the presence of wetland.

5) Guide delineators to thoroughly document site conditions through use of a data sheet similar to that prepared for this project.

Among other things, the data sheet prompts the delineator to take measurements within a soil sampling pit of changes in soil colour and texture, and to record the depth at which they occur. In this way, the delineator will be able to describe that the top 2 cm was black, high carbon content, sandy soil and that the next 50 cm were a blue-green gleyed, clay soil, or that there was deep sand, with bright red mottles, or that at 20 cm a dense layer of clay or bedrock was found.

6) Provide an expanded list of indicators of the presence of wetland, in addition to the two most commonly described (gleying and mottles).

Table 2. Wetland indicators described in this report, and the section where they are discussed.

TERRAIN CHARACTERISTICS (*see Section 2.2.1 of this report*)	
Valley bottom	**Slope**
Concave / depression	**Flat**
Presence of an impermeable layer within 50 cm of the soil surface	
WETLAND HYDROLOGY *(see Section 2.2.3 of this report)*	
Permanent water regime	
Visual observation of water within 50 cm of the soil surface (within a soil pit)	
SOIL WETNESS INDICATORS *(see Section 4 of this report)*	
Organic soils (*see Section 2.1 of this report*)	
Sulphur smell (*see Section 3.2 of this report*)	
Gleyed matrix starting within 30-50 cm of the soil surface (*see Section 3.1*)	
Soils with contrasting mottles and low chroma matrix** (*see Section 3.1*)	
High organic matter in the surface horizon* (*see Section 3.3 of this report*)	
Streaking of subsurface horizon* by organic matter (*see Section 3.2*)	
Oxidised root channels (*see Section 3.2 of this report*)	
Soils with low chroma matrix** (*see Section 3.3 of this report*)	
HYDROPHYTIC VEGETATION INDICATOR *(see Section 2.2.2 of this report)*	
New list prepared for DWAF delineation manual update (Hoare, 2007)	

*** Horizon in this context means a layer of the soil**
****Soil matrix is the portion of the soil layer (usually more than 50%) which has the predominant colour.**

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1. INTRODUCTION

1.1 Background and rationale for undertaking the project

"The object of the delineation procedure is to identify the outer edge of the temporary zone. This outer edge marks the boundary between the wetland and adjacent terrestrial areas." (Department of Water Affairs and Forestry 2005)

The most common purpose for undertaking wetland delineation is to confirm the presence of wetland and determine the outermost edge of the wetland. This is crucial when applying a recommended buffer area adjacent to the wetland, for example, to determine where development can occur when a specified distance from the wetland edge is required, or where there is a need to regulate land use within a specific buffer width.

The Department of Water Affairs and Forestry (DWAF) has prepared a guideline manual to "provide authorities with a standardised, auditable and affordable method" to delineate wetlands. The wetland delineation methodology of *A practical field procedure for identification and delineation of wetlands and riparian areas* (DWAF 2005), referred to hereafter as "DWAF delineation manual", is increasingly applied elsewhere in South Africa. The methodology draws from a set of physical "indicators" of the presence of wetland (topographic position, vegetation and soil wetness) that have been extensively researched, documented and applied elsewhere in the world.

However, the DWAF delineation methodology has not yet been taken up or broadly applied in the Western Cape. The difference in wetland soils between those described in the manual and those present in the Western Cape has been cited as a barrier to implementation of the manual.

The stated aim of this WRC-funded K8/718 *Western Cape Wetlands Soils project* was to verify the applicability of the DWAF delineation method to Western Cape wetland soils. Wetland soils encountered during the project that are difficult to delineate and that are not currently described in the DWAF delineation manual would be described and recommendations made on how to approach the delineation of wetlands occurring on these soils.

1.2 Approach

A rapid fieldwork approach was proposed in which wetland soils were sampled across a representative cross-section of Western Cape localities and soil forms. More than fifty sites were visited between September 2006 and July 2007, incorporating the Western Cape summer dry season and extending into the winter rainfall season. To avoid excessive repetition of descriptions, a selection fewer sites, representative of commonly encountered situations, are summarised in Section 6.

1.3 Deliverables

The project had the following deliverables:

1.3.1 List of Western Cape hydromorphic soils

The intention of this deliverable was to explore

- the list of soils described in the DWAF delineation manual as indicating **permanent** wetlands, and
- to explore which soils in the Western Cape always indicate the **occurrence** of a wetland.

The results of this deliverable are further discussed in Section 2.1 of this report.

1.3.2 Field data sheet for wetland delineation

A wetland data sheet to support the recording of findings during a field visit has been adapted for this project from U.S. Army Corps of Engineers (2006) and Washington State Department of Ecology (1997) examples, typically used by wetland delineators in the U.S.A.

The contents of the field data sheet are further explored in Section 3 of this report. A sample data sheet is included in Appendix A of the report.

1.3.3 Western Cape indicators of wetland soils

Wetland soils were sampled, often together with a soil scientist, across a representative cross-section of Western Cape localities, soil forms, in both intact (healthy, natural) and disturbed (impacted) wetlands.

The following table lays out the complete list of indicators which were looked for and encountered during the course of this project:

Table 3. Soil wetness indicators encountered by this project.

Organic soils (*see Section 2.1 of this report*)
Sulphur smell (*see Section 3.2 of this report*)
Gleyed matrix starting within 30-50 cm of the soil surface (*see Section 3.1*)
Soils with contrasting mottles and low chroma matrix (*see Section 3.1*)
High organic matter in the surface horizon* (*see Section 3.3 of this report*)
Streaking of subsurface horizon* by organic matter (*see Section 3.2*)
Oxidised rhizospheres (*see Section 3.2 of this report*)
Soils with low chroma matrix (*see Section 3.3 of this report*)

*** horizon in this context means a layer of the soil**

1.3.4 ARC-WRC joint field site

Concurrent to this Western Cape-focused WRC study, an ARC study, spanning all geographic regions of South Africa, was undertaken to identify signs of wetness indicators not covered in the DWAF delineation document or refine them, if necessary (i.e. to identify and describe further 'Specific Cases').

It was agreed that the projects would overlap within the Western Cape through working together on one collaborative research site within Agulhas National Park on the southern Cape coast. Two joint site visits were undertaken. A joint deliverable was envisaged, in the form of an amended Appendix A of the DWAF delineation document. However, no extensive amendments to the manual were ultimately recommended. Each project instead incorporated their respective results into the project reports. Findings of the ARC site visit have been incorporated into the site description in Section 5.2 of this report.

1.3.5 Report of project findings, including proposed amendment to Appendix A of the DWAF manual

This report documents the findings of the Western Cape Wetland Soils project.

No new “Specific Cases”, unique to the Western Cape and not yet described in the DWAF delineation manual, were identified during the course of the project. Thus no major additions to Appendix A of the DWAF delineation manual have arisen out of this project.

While this project proposes no real departure from what is already contained within the DWAF delineation manual, it does make several suggestions for slight amendments or added emphasis. These suggestions embrace all wetland indicators, not only soils. The suggestions are scattered throughout this report and are also summarised in the Executive Summary and Appendix B.

Specific site descriptions of a representative selection of wetlands that were visited are included Section 5.

2. APPLYING THE DWAF DELINEATION MANUAL

The National Water Act (36 of 1998) refers to the following wetland attributes:

- "*the water table is usually at or near the surface"* i.e. a high water table is present resulting in saturation at or near the surface, leading to anaerobic (lack of oxygen) conditions developing in the top 50 cm of the soil
- "*saturated soils"* i.e. wetland (hydromorphic) soils display characteristics (e.g. gleying or mottles) resulting from prolonged saturation, and
- *"vegetation typically adapted to life in saturated soil"* i.e. plants are present which are adapted to or tolerant of saturated soils (hydrophytes).

The methodology outlined in the DWAF delineation manual is based upon the above characteristics of wetlands, as well as their position in the landscape. Observing evidence (or "indicators") of the presence of each of these features, has become widely accepted as a valid way to identify wetlands and thus to distinguish between wetland areas and dry terrestrial areas.

Field indicators of these four characteristics are outlined in the DWAF delineation manual as follows:

(1) terrain unit indicator (i.e. an area in the landscape where water is likely to collect and a wetland to be present),

(2) soil form indicator (i.e. the soils of South Africa have been grouped into classes / forms according to characteristic diagnostic soil horizons and soil structure),

(3) soil wetness indicator (i.e. characteristics such as gleying or mottles resulting from prolonged saturation), and

(4) vegetation indicator (i.e. presence of plants adapted to or tolerant of saturated soils).

This project draws from a slightly different list of indicators, namely:

(1) terrain characteristics indicator / hydrogeomorphic setting,

(2) ***wetland hydrology as indicated by the presence of water within 50 cm of surface*****,**

(3) soil wetness indicator / hydromorphic soils, and

(4) vegetation indicator / hydrophytic vegetation.

In this amended list, **soil form** is included as a supporting informant to (3) the soil wetness indicator but not used as a primary indicator, and wetland hydrology is added as an indicator. This is discussed further in the following sections, which looks at each of these indicators in turn.

2.1 Soil form indicator

One of the stated deliverables for this report was a list of hydromorphic soils of the Western Cape, based on discussions with local knowledgeable soil scientists.

The intention of this deliverable was to explore

- the list of soils described in the DWAF delineation manual indicating **permanent** wetlands or wetland zones (where permanent means that the soil is permanently saturated to the surface, while the wetland may or may not be inundated), and
- to explore which soils in the Western Cape always indicate the **presence** of a wetland.

As this project sampled only a small set of wetlands, the depth of knowledge and experience of soil scientists of the Western Cape will continue to be the best means to approach this question.

The DWAF delineation manual lists four soil forms indicative of wetland permanent zones, namely Champagne, Katspruit, Willowbrook and Rensburg

The diagnostic features indicating these four soil forms to be hydromorphic are that they are

- **organic** soils (Champagne) or
- mineral soils with a **high organic / carbon surface horizon overlying a gleyed "G" horizon** (Katspruit, Willowbrook and Rensburg)**.**

Of the above four, only Champagne and Katspruit soils were encountered during the course of this project, although Willowbrook and Rensburg soil forms do occur in the Western Cape.

Of all the soil forms encountered, the only two soil forms found by this project to **always** indicate wetland were Katspruit and Champagne.

Only Champagne soils were found to always support **permanent** wetlands or permanent zones within wetland. Katspruit soil forms were found to support both permanent and seasonal wetland / zones within wetland, depending on the site conditions.

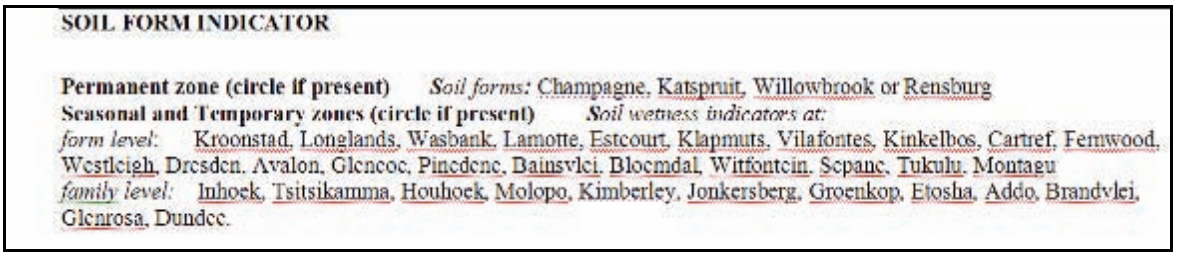
Of the remaining soil forms listed in the DWAF delineation manual, only a small sub-set were encountered by the project, and of these, many exhibited soil wetness indicators (i.e. seasonal or

temporary wetlands were **present**) at certain sites, but the same soil form at other sites did not support wetland. This is discussed further in the following section.

2.1.1 Soil form as a supporting informant to the soil wetness indicator

The soil forms listed in the DWAF delineation manual (see data sheet excerpt below), may all be found in the Western Cape, although a small number are less common.

List of soil forms excerpted from the DWAF delineation manual:



SOIL FORM INDICATOR

Permanent zone (circle if present) *Soil forms:* Champagne, Katspruit, Willowbrook or Rensburg
Seasonal and Temporary zones (circle if present) *Soil wetness indicators at:*
form level: Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu
family level: Inhoek, Tsitsikamma, Houhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee.

Concerns about the use of soil form by wetland delineators were noted from discussions over the course of the project as follows:

(1) Most wetland ecologists are not soil scientists and are not trained in soil diagnostics. It is therefore easier for wetland ecologists to describe the presence of soil wetness indicators than to accurately derive soil form. They will be able to recognise the presence of a dense clay layer but not be able to say whether it is a Katspruit or Kroonstad soil.

(2) This project was not always accompanied by a formal soil survey, however, it was found that many soil forms exhibited soil wetness indicators (i.e. wetlands were **present**) at certain sites, but the same soil form at other sites did not support wetland. For example:

- Most soil forms with a G horizon (gleyed layer) have been included on the list in the DWAF delineation manual as indicating seasonal or temporary wetlands. However, a soil form may have a G horizon that is diagnostic but begins at a lower depth (deeper than 50 cm), thus not supporting a wetland.
- Similarly, most soil forms with a diagnostic E horizon (low chroma / light coloured) were included in the DWAF delineation manual as indicating seasonal or temporary wetlands. Soils that are light coloured (E horizon) and low in iron are commonly encountered in the Western Cape. An E horizon / or leaching may be caused by reasons other than long periods of saturation (see Section 3.3 of this report).

It should be understood that, as with all of the other wetland indicators, use of soil form information should always be taken in context of further information gathered during the field survey.

(3) Soil forms could be grouped into: maybe, possibly, unlikely to be wetland, rather than grouping them according to an indication of permanent, seasonal or temporary wetland. Decisions about whether a particular wetland has permanent, seasonal or temporary wetness should be based on actual conditions found in the field rather than assigning to any particular soil form.

It has been useful and vital as a wetland ecologist to have learnt more about the range of soils of the Western Cape during the course of this project. Where a soil survey has been conducted prior to a wetland field delineation, the information contributes significantly to an informed interpretation of the site. Continued collaboration with soil scientists, and continued learning about the full variety of soils encountered in Western Cape wetlands and their associated uplands and catchments can only enrich our knowledge and understanding of wetland and catchment functioning, and contribute to improved management and land-use decision-making, including appropriate setting of buffers.

Recommendations for DWAF delineation manual
Where it is known, use **soil form** as supporting information (not a primary indicator), taken within the context of further information gathered during the field survey.
Diagnostic features of soils can be drawn into an expanded list of indicators, such as the presence of organic soil or of an impermeable layer within 50 cm of the soil surface.

2.1.2 Organic soil as an additional soil wetness indicator

Soils may be classified into two broad categories: organic and mineral. It is very useful to make this distinction up front as organic (**Champagne soil form**) soils are relatively easy to identify.

As mentioned above, wetland ecologists may not know the name of the soil form but they can recognise that the soil is highly organic. Nevertheless, it is an easy soil form to learn as in South Africa, and in the Western Cape, Champagne is the only organic soil form (MacVicar, 1995).

Organic soils develop under conditions of nearly continuous saturation and/or inundation and so always indicate the presence of permanent wetland.

"*Organic material accumulates in conditions where plant material is produced by an adapted vegetation but decomposition is inhibited by one or more of*

(a) permanent wetness;

(b) low temperatures;

(c) extreme acidity or lack of nutrients and

(d) high concentrations of electrolytes or organic toxins (FAO, 2001), all of which slow down microbially-mediated breakdown of the organic matter "(Fey, 2007).

Organic soils are very dark (black) in colour when wet, and most typically have a Munsell colour of 10YR 2/1. Partially decomposed plant material is often still evident.

"*Organic and mineral soils are separated on the basis that the organic "O" horizon must have at least 10% organic carbon throughout a vertical distance of 200 mm. Many such soils have much greater organic carbon contents and at the extreme would be almost totally organic with only minor inorganic material*" (Fey, 2007; MacVicar *et al.,* 1995).

In contrast to organic soils, a mineral soil consists predominantly of mineral matter usually containing less than 10 percent organic matter. Mineral soils have a wide range of textures (sandy to clayey) and colours (red to grey). Gleying and mottles are features of mineral soils.

In the Western Cape, certain sandy soils within seasonal to permanent wetlands have accumulated a high carbon content, but not enough to be classified as "organic soils". For a non-soil scientist, and without laboratory verification, it is sometimes difficult to distinguish between organic soils and the sandy soils with high carbon content. These situations were commonly encountered by this project (Cape Point, Vermont, Kleinmond) and in these cases the soils were described as having a "high carbon content".

Organic soils are not mentioned in the DWAF delineation manual in the section on soil wetness indicators, yet organic content is relatively easy to recognise, and can tell the delineator straight away that a permanent wetland has been encountered.

Recommendations for DWAF delineation manual
Group wetland soils into two broad categories: **organic** and mineral.
Make **organic soils** an indicator of wetland soils (in addition to gleying and mottles etc)
Similarly, make **dark, high carbon surface layers** an additional indicator of wetlands

2.2 Field data sheet for wetland delineation

Three documents, prepared to assist wetland delineators in the USA to apply the same principles as those incorporated in the DWAF delineation manual, have been drawn from as a framework during this project. The documents have been used in two major ways; firstly, to draw suggestions for including additional interpretive information and guidance on the delineation process in the DWAF delineation manual, and secondly, to see which additional indicators and principles from the USA documents might apply to the South African and Western Cape situation. Further suggestions are also incorporated from the work and meetings of University of Stellenbosch and other South African Soil Surveyors Organisation (SASSO) soil scientists.

The documents are:

Washington State Department of Ecology. 1997. *Washington State Wetlands Identification and Delineation Manual*. Washington State Department of Ecology, Publication No. 96-94.

U.S. Army Corps of Engineers. 2006. *Interim regional supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region.* ed. J. S. Wakeley, R. W. Lichvar, and C. V. Noble. ERDC/EL TR-06-16. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

USDA Natural Resources Conservation Service. 2006. *Field Indicators of Hydric*[1] *Soils in the United States.*

The data sheet prepared for this project was directly adapted from data sheets provided in the Washington State Department of Ecology (1997) manual and the USACOE (2006) manual, as a way to prompt the delineator to collect additional information about the wetland attributes outlined in the DWAF delineation manual. The data sheet was tested and refined during the course of the project.

As mentioned previously, this project has adopted a slightly amended list to the DWAF delineation manual, namely:

(1) hydrogeomorphic setting (terrain characteristics indicator),

(2) hydrophytic vegetation – the presence of plants adapted to or tolerant of saturated soils (vegetation indicator),

[1] The National Technical Committee for Hydric Soils (NTCHS) defines a hydric soil as a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (USDA Soil Conservation Service 1994).

(3) hydromorphic soils – soils that display characteristics resulting from prolonged saturation (soil wetness indicator), and

(4) wetland hydrology – presence of free water within soil pit (soil saturation) or inundation (ponding above soil surface).

The data sheet is laid out according to the above indicators. It is hoped that this will help ensure that delineators examine **all four wetland indicators** and so develop the strongest possible case for whether a wetland is or is not present.

It is anticipated that several data sheets will be filled out per wetland, one for each broadly representative soil and vegetation community, as well as some for non-wetland areas (in order to **help defend the difference between wetland and non-wetland** sampling points on the site).

Importantly, when describing soils, the data sheet prompts the delineator to **closely examine the soil profile** and look carefully at changes in colour and texture, or presence of mottles, and to use a measuring tape to record at what depth each of these features occur. This information helps greatly to describe the difference between wetland and non-wetland, and to draw conclusions about how the wetland functions and its seasonality.

Recommendations for DWAF delineation manual
Guide delineators to thoroughly document site conditions through use of a **data sheet** similar to that prepared for this project.

The contents of the field data sheet are examined in more detail in Section 3 of this report. A sample data sheet is attached in Appendix A.

2.2.1 Hydrogeomorphic setting (terrain characteristics indicator)

Excerpt from data sheet prepared for this project:

TERRAIN CHARACTERISTICS INDICATOR

Position in the landscape
crest (1) ☐ scarp (2) ☐ midslope (3) ☐ footslope (4) ☐ valley bottom (5) ☐ **or a combination** ___
Landform: Slope %: _____ (6) floodplain (7) ☐ flat (8) ☐ concave (9) ☐

In addition to the landscape positions (1-5) currently described by the DWAF delineation manual, the data sheet lists several addition settings likely to collect or concentrate water.

Although possibly self-evident to a more experienced ecologist, the following questions from USACOE (2006) guide a new delineator towards an interpretation of a site, and prompt them to include this type of information in the later report describing the wetland. They ask the delineator to consider the location and setting of the wetland, namely, is it:

(a) located on the **fringe of another wetland or water body***?*

(b) **concave** (e.g. depression), *where water would tend to collect and possibly pond on the soil surface?* (9)

(c) *on a low terrace or* ***floodplain*** *that may be subject to seasonal high-water tables or flooding? (7)*

(d) at the ***toe of a slope*** *(or* ***footslope****) where runoff may tend to collect or groundwater emerge at or near the surface? Are there convergent slopes, where surface or groundwater may be directed toward a central stream or swale?* (6)

(e) a **level or nearly level area** *so that surface water does not run off readily, or is it steeper where surface water would run off from the soil?* (8)

2.2.2 Hydrophytic vegetation – the presence of plants adapted to or tolerant of saturated soils (vegetation indicator)

Excerpt from data sheet prepared for this project:

VEGETATION INDICATOR

	Dominant or indicator plant species within sample plot	OBL/FACW/FAC	% Cover
1.			
2.			
3.			
4.			
5.			
6.			
7.			

Are more than 50% of dominant species (> 50% cover) obligate, facultative wetland or facultative? Yes No

Remarks:

*The "**Remarks**" section allows for recording of on-site observations and preliminary interpretations.

"Indicator" species might not always be dominant but it is known that they have a high chance of occurring in wetlands and thus are a good indicator of wetland occurrence.

This section of the data sheet is in support of pages 14 and 15 of the DWAF delineation manual, the wetland vegetation indicator. The proposed update to the DWAF delineation manual has an

Appendix listing currently known **obligate** plant species for South Africa (Hoare, 2007). Obligate species are those that are mostly found in wetland.

A list of "obligate", "facultative wetland" species (67 to 99 percent chance of occurring in wetland) and "facultative" (34 to 66 percent chance of occurring in wetland) is currently in preparation for the Western Cape as part of the WRC-funded Wetland Health and Integrity project (Corry, in preparation).

The suggested approach is to fill out a data sheet for each representative vegetation community, describing at the same time the associated soils and landscape setting. Data sheet(s) should be filled out for non-wetland areas as well as it is helpful to compare suspected wetland areas with suspected non-wetland areas on site, especially in terms of vegetation.

The DWAF delineation manual describes on page 13 that undisturbed conditions are most useful for applying the wetland vegetation indicator. However, with a bit of deductive work, it is often also possible to draw conclusions in disturbed areas. *"Even for disturbed areas or areas with non-indigenous vegetation, plant responses to wet site conditions are often easily observable, such as stunting in agricultural crops when subjected to long periods of soil saturation in the root zone, or increased abundance or plant vigor when growing on wet sites. This is particularly evident later in the summer when adjacent areas are drying out but moist soils are still present in wetlands"* (USACOE 2006). These types of observations can be briefly recorded on the data sheet under "remarks" to be carried into the delineation report text, towards a defence of why the area was or was not considered wetland.

2.2.3 Wetland hydrology – a high water table that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50 cm of the soil.

Excerpt from data sheet prepared for this project:

HYDROLOGY INDICATORS

☐ Inundated
Depth of Surface Water:_____ cm
☐ Saturated within 50 cm of surface
Depth to Saturated Soil:_____cm
Depth to Free Water in Pit:_____ cm
☐ Sediment Deposits
☐ Salt Crust
☐ Aquatic invertebrates

☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.

☐ Water-Stained Leaves
☐ Water Marks

Remarks:

*The "**Remarks**" section allows for recording of on-site observations and preliminary interpretations.

The data sheet prepared for this project has a place to record depth of inundation (water ponding on the soil surface) during a site visit. This information should be interpreted in relation to the time of year the site visit was conducted.

If there is no surface water / inundation at the sample plot, the data sheet also prompts the delineator to measure the depth to free / standing water within the augured soil pit, or to measure the depth to where soil saturation[2] occurs.

Again, this information should be interpreted in relation to the time of year the site visit was conducted. "*Consider the timing of the site visit in relation to normal seasonal and annual hydrologic variability, and whether the amount of rainfall in the 2-3 months preceding the site visit was normal, above normal, or below normal"* (USACOE 2006). Due to normal seasonal fluctuations, water tables in wetlands often drop below 50 cm during the dry periods. ***Therefore, a dry-season water table below 50 cm does not necessarily indicate that the area is not wetland.***

In some cases, evidence that water sits on the surface for sufficiently long periods can be derived from observation of

- water marks (e.g. darkly stained base of tree trunks),
- drift deposits (debris carried by flooding water),
- salt crust, or
- surface cracks in the soil (due to the soil drying out after being saturated).

These are listed on the data sheet.

As the DWAF delineation manual currently states on page 5, the presence of water in a wetland varies from day to day, as well as seasonally and annually. However, hydrology can be a useful and rapid confirmation of a wetland when present, **particularly if it is found within the upper 50 cm of a soil pit during the dry season, and where the soil is "difficult" but water is present**.

To measure depth to free water within a soil pit: *"Sufficient time must be allowed for water to infiltrate into a newly dug hole and to stabilise at the water-table level. The required time will vary depending upon soil texture / permeability. In some cases, the water table can be determined by*

[2] For wetland delineation purposes, a soil layer is saturated if virtually all pores between soil particles are filled with water (National Research Council 1995, Vepraskas and Sprecher 1997). This definition includes part of the capillary fringe above the water table (i.e., the tension saturated zone) in which soil water content is approximately equal to that below the water table (Freeze and Cherry 1979).

examining the wall of the soil pit and identifying the upper level at which water is seeping into the pit" (USACOE 2006).

Recommendations for DWAF delineation manual
Record **hydrology** during the site visit.
Make use of secondary indicators such as drift deposits etc as supporting information when defending whether an area is wetland.
In some cases, it may be necessary to recommend returning during the wet season.
Record the presence and depth of any restricting layers within 50 cm of the soil surface.

Recording the presence of a restrictive layer (such as bedrock or dense clay) in the soil is a useful additional indictor because the layer will slow or prevent the infiltration of water. This type of wetland is likely a "perched" wetland, receiving water via rainfall or overland runoff, not groundwater.

Note that in some cases a restrictive layer might not indicate wetland. The landscape position and terrain characteristics need to confirm the likely presence of wetland. For example, in the Western Cape many fynbos slopes occur over Mispah soil form, with very shallow soils over bedrock. These areas are freely draining and are not wetland, whereas areas where the terrain is **flat** or **concave / depressional** and a layer of bedrock or dense clay is found close to the surface are almost certain to support wetland.

A note on duration of saturation or inundation

The frequently raised question about how long a location must be wet before it is considered a wetland is beyond the TOR of this project to answer other than to cite from available literature, as follows:

a) "A disturbed or problematic site is wetland when it meets the following standard: the soil is ponded or flooded, or the water table is 30 cm or less from the surface, for 14 or more consecutive days in most years...at a minimum frequency of 5 years in 10 (50 percent or higher probability), unless a different standard has been established for a particular geographic area or wetland type." (U.S. Army Corps of Engineers 2006).

b) "Areas which are inundated and/or saturated to the surface for a consecutive number of days for more than 12.5 percent of the growing season [**45 days or 1.5 months**] **are wetlands**, provided the soil and vegetation parameters are met. Areas inundated or saturated to the surface for a consecutive number of days between 5 percent and 12.5 percent of the growing season* [**18 days**] in most years **may or may not be wetlands**." (WA Department of Ecology 1997)*

*Note: for this definition equivalent numbers of days to replace the concept of "the growing season" have been worked out for SA growing season assuming plants grow year-round in most of South Africa. Percentages as above can be worked out for those areas which do have a distinct growing season.

c) In the Western Cape, a soil wetness classification was developed to describe presence of free water below the soil surface i.e. how wet the area may get and for how long it might remain wet during a typical year.

"*Profile morphology is used to determine the depth of water saturation and the maximum height of signs of hydromorphy / soil wetness indicators is used as the depth limit. Climate, locality, aspect, vegetation and water conditions during the survey, as well as profile morphology, are used to evaluate the duration of water saturation. The expected number of days of saturation during the rainy season in "wet" years is used to determine duration. It is essential for free water to occur in the profile continuously for at least seven (7) days. However, the total number of days with free water need not be continuous*." (Lambrechts *et al*., 2007)

During field surveys, an experienced soil scientist is able to interpret visual soil diagnotistic features, taken in the context of the site and other local conditions, so as to estimate the likely range of depth to free water and its duration at this depth throughout a typical year.

Table 4. Determination of wetness classes (Lambrechts *et al*., 2007)

Depth range of upper boundary of free water surface (mm)	**Wetness symbol**			
0-300	6	7	8	9
300-700	3	6	7	8
700-1 200	2	3	4	5
>1 500	1			
Cumulative number of days with free water	0	30	90	180	365

If a soil survey of this kind has been undertaken on the site, one could then infer that (7-8) may or may not be wetland, (9) will be permanent wetland, where water is present within 30 cm of the surface for more than 180 days in a year. It is suggested that 1-6 are not wetland, where water is present for less than a month. Ongoing wetland-focused research on this subject would increase our understanding of the full range of variability in South African wetlands.

2.2.4 Hydromorphic soils – soils that display characteristics resulting from prolonged saturation (soil wetness indicator)

Excerpt from data sheet prepared for this project:

SOIL WETNESS INDICATORS

Soil Profile Description:

Depth (cm)	Horizon Designation	Matrix Color (Munsell)	Mottle Colors (Munsell)	Mottle Abundance/Contrast	Texture, Concretions, Rhizospheres, etc.

Features present within 50cm of the soil surface:

- ☐ Organic soil
- ☐ High organic content in surface layer
- ☐ Organic streaking
- ☐ Low chroma, supported in remarks
- ☐ Gleyed matrix
- ☐ Mottle / concretions
- ☐ Sulfidic odour
- ☐ Oxidized Root Channels

The DWAF delineation manual currently has a section (Section 5) guiding the approach to a wetland delineation in the field. To help new delineators, it might be useful to expand this section slightly.

Delineators should always be encouraged to dig as deep as necessary in order to fully document and understand the variability in soil properties and hydrologic relationships on the site. *"In general, the hole should be dug to the depth needed to document an indicator or to confirm the absence of indicators.* ***Deeper examination of the soil may be required when field indicators are not easily seen within 50 cm of the surface.*** *Whenever possible, excavate the soil deep enough to determine if there are layers or materials present that* ***might restrict soil drainage****. After a sufficient number of exploratory excavations have been made to understand the soil-hydrologic relationships at the site,* ***subsequent excavations can be limited to the depth needed to identify hydric soil indicators***. (Washington State Department of Ecology 1997)

In mosaic areas with repetitive sequences of wetland / non-wetland, the delineation of individual areas of wetland and non-wetland soils is difficult, extremely time-consuming, and often not cost effective. In such cases it may be better to recommend making a decision based on the **dominant condition**.

For complex or highly contentious sites sampling along a formal grid of transects across the site, or using peizometers to monitor ground water levels may be recommended. The assistance of an experienced soil scientist may also be recommended in difficult cases, to help interpret the site and landscape context.

Pedologists have emphasised during the course of this project that soil indicators should not be looked at in isolation without considering the wider landscape and the complete set of reasons that lead to concluding the occurrence of a wetland.

It is often misunderstood that the DWAF delineation manual requires only looking at soils. Although it is stated that soils are considered to be the most reliable indicator, the DWAF delineation manual presents a set of four indicators and advocates drawing from all of them on page 16 “combining the indicators”. It might be helpful to stress this more robustly, particularly as a recommended approach to difficult sites and difficult soils. A basic recommended approach is to always consider the full set of indicators, and to fully describe the landscape, climatic and local impacts context of a wetland.

Recommendations for DWAF delineation manual
Emphasise that defensible delineation requires an interpretation of **all wetland indicators** (not only soils) found on the site, taken within the **context** of where the wetland is located.
Record **measurements and descriptions of soil profile** during the site visit.
For more complex or contentious sites, prepare a series of transects, use peizometers and / or an experienced soil scientist.
For wetland mosaic sites, it is sometimes expedient to delineate the outer edge of the mosaic, if wetland is the dominant habitat.

3. SOIL WETNESS INDICATORS

As mentioned in the introduction to this report, the difference in wetland soils between those described in the manual and those present in the Western Cape has been cited as a barrier to implementation of the DWAF delineation manual.

The aims of this project were:

1) to identify whether or not the DWAF delineation manual applies to the Western Cape
2) to identify soils in the Western Cape that are new "Specific Cases" i.e. not currently described in the DWAF delineation manual
3) to suggest ways to approach the delineation of wetlands occurring on soils of these new "Specific Cases"

Wetland soils were sampled together with a soil scientist, across a representative cross-section of Western Cape localities, soil forms, in both intact and disturbed (impacted) wetlands.

The findings of this *Western Cape Wetland Soils project* conclude that the principles contained in the DWAF delineation manual as well as the three USA documents **are applicable to wetlands in the Western Cape.**

(a) During the course of this project, it has been found that at approximately 65% of sites, the soils do exhibit one or more of the soil wetness indicators described in the DWAF delineation manual. These indicators have been divided for the purposes of this report into:

Group 1: Directly described in the DWAF delineation manual.

Group 2: Indirectly referred to in the DWAF delineation manual.

(b) The remainder of the sites in the Western Cape, approximately 35%, falls within the "Specific Cases" already described in the DWAF delineation manual. These are placed in **Group 3** for the purposes of this report and are described in Section 3.3 below.

(c) **No new** "Specific Cases", unique to the Western Cape and not yet described in the DWAF delineation manual, were identified during the course of the project.

3.1 Group 1: DWAF delineation manual soil wetness indicators

Most wetland soils exhibit characteristic morphologies that result from repeated periods of saturation or inundation for more than a few days. This is described on page 8 of the DWAF delineation manual in the box 'What are hydromorphic soils?".

The two primary soil wetness indicators described in the DWAF delineation manual are:

(a) gley soil matrix[3] (permanently saturated wetlands / saturated for very long periods)

(b) low chroma soil matrix with mottles (indicating a seasonally fluctuating water table[4] / seasonally or temporarily saturated wetlands)

Both were commonly encountered in Western Cape wetlands by this project. They are dealt with in detail in the DWAF delineation manual and are not discussed further in this report, aside from the following possible additions to the DWAF delineation manual:

Recommendations for DWAF delineation manual
Describe that gley colours can be matched to the gley pages of the Munsell Colour Charts (Munsell Color 1990), and that gley colour is not equal to grey (such as the grey of Fernwood soils which have a low chroma "E" horizon "leached" of colour). True gley is more of a blue/green colour.
Although the DWAF delineation manual lists a range of expected value and chroma for wetland soils sampled in the dry state, for practical purposes, the soil colours for this project were determined in soils that were **moist**, where a matrix chroma of 1 or 2 was considered "low chroma".

3.2 Group 2: DWAF delineation manual additional soil wetness indicators

The table below serves to summarise the full set of soil wetness indicators drawn on by this project. The indicators are listed in order of highest confidence to lowest confidence in indicating the presence of wetland. The two indicators highlighted in grey are the primary indicators currently described in the DWAF delineation manual, while the remaining indicators are either indirectly referred to in the current DWAF delineation manual (such as where Champagne soils are listed but

[3] Soil matrix is the portion of the soil layer (usually more than 50%) which has the predominant colour.

[4] Mineral hydric soils that are saturated for substantial periods of the growing season (but not long enough to produce gleyed soils) will either have high chroma mottles and a low chroma matrix or will lack mottles but have a low chroma matrix. Mottled means "marked with spots of contrasting color."

organic soils are not mentioned), or are referred to as useful indicators for "Special Cases" or "difficult soils" in Appendix A of the manual.

Table 5. Soil wetness indicators described in this report.

Organic soils (*indirectly referred to*)
Sulphidic material (*indirectly referred to*)
Gleyed matrix starting within 30-50 cm of the soil surface (*primary indicator*)
Soils with contrasting mottles and low chroma matrix** (*primary indicator*)
High organic matter in the surface horizon* (*indicator for difficult soils*)
Streaking of subsurface horizon* by organic matter (*indirectly referred to*)
Oxidised rhizospheres (*indirectly referred to*)
Soils with low chroma matrix** (*indicator for difficult soils*)

*** Horizon in this context means a layer of the soil**
****Soil matrix is the portion of the soil layer (usually more than 50%) which has the predominant colour.**

***Soil wetness indicator*: Organic soils**

Organic soils are described in Section 2.1. They indicate the presence of permanent wetlands.

***Soil wetness indicator*: A hydrogen sulfide smell within 30 cm of the soil surface.**

"The presence of hydrogen sulphide gas (producing a rotten egg smell) is a strong indicator of a hydric soil, but this indicator is found only in the wettest (permanent wetland) sites in soils that contain sulphur-bearing compounds." (USACOE 2006).

This indicator was not commonly encountered during this project, probably because the permanent[5] zone of wetlands is easy to identify and doesn't require delineation.

***Soil wetness indicator*: Gleyed soils**

This indicator is fully described in the DWAF delineation manual.

[5] Any time the soil smells of hydrogen sulfide (rotten egg odor), sulfur is currently being reduced and the soil is definitely in an anaerobic state. This indicator is most commonly found in areas that are permanently saturated or inundated. Sulfur is one of the last elements to be reduced by microbes in an anaerobic environment. The microbes convert SO4-2 to H2S, or hydrogen sulfide (USACOE 2006).

***Soil wetness indicator*: Mottles**

This indicator is fully described in the DWAF delineation manual.

***Soil wetness indicator*: High organic matter content in the surface horizon of sandy soils.**
See Section 3.3 below – indicators for difficult soils.

***Soil wetness indicator*: Dark streaking of sandy soils within 15 cm of the soil surface.**

"Look for dark vertical streaks in subsurface horizons. These streaks represent organic matter being moved downward through sand as the water table fluctuates. Thus, the sandy soil appears streaked with darker areas. The stripped areas and translocated oxides and/or organic matter form a faint, diffuse splotchy pattern of two or more colors". (USACOE 2006)

This is a weak indicator and should only be used with substantial other evidence of the presence of wetland.

***Soil wetness indicator*: Oxidized rhizospheres along living roots or linings on soil pores immediately surrounding living roots within 30 cm of the soil surface.**

"Oxidized rhizospheres are the result of oxygen leakage from living roots into the surrounding anoxic soil, causing oxidation of ferrous iron present in the soil solution. They are evidence of saturated and reduced soil conditions during the plant's lifetime. Iron concentrations or plaques may form on the immediate root surface or may coat the soil pore adjacent to the root. In either case, the oxidized iron must be associated with living roots to indicate contemporary wet conditions and to distinguish these features from other pore linings". (USACOE 2006)

Recommendations for DWAF delineation manual
Allow all of the above indicators to be drawn from when delineating a wetland, especially if landscape context and an assessment of vegetation and hydrology are also taken into consideration.

3.3 Group 3: Difficult soils of the Western Cape / "Specific Cases"

No new "Specific Cases" for inclusion in the DWAF delineation manual were encountered in the Western Cape wetland soils project. The difficult soil type most commonly encountered was the Specific Case: "Sandy coastal aquifers". While this project encountered what appeared to be two distinct groups of difficult sandy soils, namely, regic sands over coastal aquifers, and podzol soils on fynbos slopes, only the podzolic soils are described in the DWAF delineation manual.

3.3.1 Podzol soils

"*In South Africa the most extensive area of podzols is along the southern and eastern coast and immediate hinterland of the Western Cape Province, an area largely contiguous with parts of the fynbos biome*. *Such a relatively limited geographic spread highlights the dual importance of climate - cool, moist temperate, and parent material - base-poor and coarse textured, in their formation. Under these conditions only limited types of vegetation can survive such as some deciduous and coniferous trees and plants of the Ericaceae and Proteacae. Because this vegetation grows on base-poor, acid materials the litter returned to the ground surface is similarly low in nutrients and acid. On decomposition this litter produces a large quantity of organic acids that are the major driver for podzolisation - a term that includes an array of subsidiary processes. The most important of these are the mobilisation and eluviation of aluminium and iron from the upper solum and their immobilisation in short-range order complexes with organic matter (and perhaps silica) in the B horizon."* (Fey, 2005)

"One further feature worthy of mention relates to the occurrence of "black water" streams and rivers in areas where podzols predominate, especially if areas are covered by podzols that remain wet for long periods (so-called 'hydromorphic podzols'); where soils are shallow; and/or the parent materials are extremely porous. In such situations substantial amounts of the dissolved organic matter leach from the soils and discolour the drainage water which, however, remains clear since almost no clay is present. Such 'black water' is a common sight along the southern Cape coast." (Fey, 2005)

Fernwood and Lamotte were the soil forms associated with fynbos and podzolisation most commonly encountered during the Western Cape Wetland Soils project. Fernwood soils were

commonly encountered extending into both wetland and non-wetland areas and looking similarly grey in colour for both, thus posing difficulties to delineation.

3.3.2 Regic sands

Deep sandy soils near the coast, in areas with a high water table, were found to differ in degree of difficulty. Most of the sandy coastal aquifer sites sampled by this project either exhibited distinct mottles or extremely low chroma, almost white soils, in contrast to more yellow non-wetland soils. Several of these sites are described in Section 5 of this report. However, some sandy soils of temporary wetland areas were entirely lacking in soil wetness indicators.

Recommended approach to delineate these "difficult" sandy soils:

As with the approach to any delineation, soil and landscape conditions should be documented thoroughly, along with the rationale for considering the area to be wetland. In many cases, vegetation will be present to inform the interpretation of the site. In the most difficult cases it may be necessary to revisit the site during the wet season.

Guidance on how to approach these difficult soils is offered as the same for both podzolic soils and regic sands, and is presented as guidance for how to approach delineation of sandy soils.

The DWAF delineation manual provides detailed guidance on how to approach these difficult soils, including but not limited to:

- identify whether the site is associated with a stream or other landform or landscape position likely to support wetland
- draw on all other wetland indicators
- presence of a dark surface layer, high in organic carbon, even if only 2 or 3 cm thick
- low chroma matrix, in comparison to adjacent non-wetland soils
- revisit in the wet season
- draw upon the expertise of an experienced soil scientist to help interpret the site

***Soil wetness indicator*: Low chroma matrix**

Low chroma matrix is more commonly used as a wetland indicator for non-sandy soils. It is roughly the equivalent of the presence of an "E" horizon (leached of colour). It can sometimes be used for sandy soils, but is a weak indicator, unless it is chroma of 1, and needs to be

- supported by the presence of other indicators, and
- look lighter, less “bright” in comparison to adjacent, non-wetland soil colours.

***Soil wetness indicator*: High organic matter content in the surface horizon of sandy soils.**

“Prolonged inundation or saturation creates anaerobic conditions that greatly inhibit decomposition (oxidation) of organic matter and result in a layer of organic material above the mineral surface, or high organic matter content in the surface horizon. It tends to accumulate at the point representing the most commonly occurring depth to the water table. Wet spodosols (formerly called “groundwater podzolic soils”) usually have thick dark surface horizons that are high in organic matter with dull gray E-horizons, and low chroma subsoils. Generally, the nearer to the surface the spodic horizon, the more likely the soil is hydric”. (USACOE 2006). *“If one looks below the spodic horizon the brighter matrix colors often distinguish non-hydric spodosols from hydric ones*” (U.S.D.A. Soil Survey Staff 1975).

High carbon / high organic matter content within the top layer of sandy soils, as described above, was one of the more commonly encountered wetland soils for this project. This high carbon layer was invariably more than 50 cm deep.

However, very thin layers of highly organic substrate, varying from 1 to 2 cm thick, were also encountered at a few sites, overlying sandy soils. These were also used to support the decision to call the area a wetland. This indicator is further described below:

“Muck is highly decomposed organic material. In a dry climate, muck accumulates only where soils are saturated to the surface for long periods each year. Thick muck layers can persist for years after wetland hydrology is effectively removed; therefore, a muck layer greater than 2.5 cm thick does not qualify for this indicator. However, thin muck surfaces disappear quickly or become incorporated into mineral horizons when wetland hydrology is withdrawn. Therefore, the presence of a thin muck layer on the soil surface indicates an active wetland hydrologic regime.” (USACOE 2006)

4. DIFFICULT SITES versus DIFFICULT SOILS

This project investigates the perception that wetland soils in the Western Cape are difficult to delineate and that the DWAF delineation manual therefore does not provide useful guidance on the delineation of Western Cape wetlands.

With respect to wetland soils that are difficult to delineate, the DWAF delineation manual has a section (Appendix A) describing cases across South Africa. This was discussed further in Section 3.3 above.

However, it arose during the project that possibly more delineation challenges are attributed to soil than are due, while, in many cases, there are factors other than the soil which make a site difficult to delineate. These have been called "difficult sites" for this project. **In fact, on many "difficult sites", soil can successfully be relied upon to indicate wetland conditions**.

The following situations in the Western Cape where a wetland may be difficult to delineate because it is a "difficult site" are adapted directly from the *Interim regional supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region.* U.S. Army Corps of Engineers (2006).

The list of potential "difficult sites" includes, but may not be limited to:

- Wetland indicators *are present* but it is a **non-natural wetland**
- Indicators of soil wetness *are present* but **no longer a functioning wetland**
- Wetland indicators *are absent* at **certain times of year**
- Wetland indicators *are absent* due to **human disturbance**
- **Indicators of soil wetness *are absent* because soils are "difficult soils"** (i.e. signs of wetness are absent)**"**

4.1 Indicators are present but it is a non-natural wetland (present due to altered, non-natural circumstances)

"Sometimes hydric soil features have developed, or wetland plants have colonised, in former non-wetland areas due to human activities. For example, road construction may have resulted in impoundment of water in an area that previously was non-wetland. Wetlands may also develop in former non-wetland areas due to diversion of water for irrigation or other uses. In such cases, long term flooding and soil saturation may induce the formation of redoximorphic features and

establishment of hydrophytic vegetation; or may augment previously existing wetlands, raising their water tables and expanding their margins" (USACOE 2006).

The USA term "hydric" has been retained in all citations. It broadly corresponds with the term "hydromorphic" used in the DWAF delineation manual. Similarly, "redoximorphic features" in the USA citations broadly corresponds to "soil wetness indicators" such as mottles, concretions, and oxidized rhizospheres.

To delineate these "difficult sites" (adapted directly from USACOE 2006)***:***

- Decide whether alterations to an area have resulted in changes that are now the "normal circumstances" i.e. decide on the relative permanence of the change and whether the area can now be said to be functioning as a wetland.
- Characterise the naturally occurring hydrology. Time field observations during the wet season, when natural hydrology is at its peak, to help to differentiate between naturally-occurring versus human-induced wetland.

Only a handful of this type of wetland was sampled during this project (excavated wetland / dams and a site where flooding of an area is more extensive than historically due to human activities), and soil wetness indicators were present in the sites visited. These sites maybe less of a delineation issue and more of a policy or management issue i.e. can it be built on, does it have a "low" functional value, and so on.

4.2 Indicators of soil wetness are present but the area is no longer functioning as a wetland due to altered circumstances (the indicators were formed under past conditions).

<u>Drained soils</u>

"A drained wetland soil is one in which sufficient ground or surface water has been removed by artificial means such that the area will no longer support hydrophytic vegetation" (USACOE 2006).

To delineate these "difficult sites":

Look for evidence of:

- *ditches or canals of sufficient depth to lower the water table below the major portion of the root zone of the prevalent vegetation;*
- *dikes, berms, or similar structures that obstruct normal inundation of an area;*

- *subsurface drainage tiles; or*
- *diversion of terrestrial surface runoff from an area.*

Decide whether or not the area is currently functioning as a wetland.

NOTE: "the mere presence of drainage structures in an area is not sufficient basis for concluding that a wetland has been effectively drained; such areas may continue to have wetland hydrology and support hydrophytic vegetation".

Note also that areas that appear to be effectively drained still have the future potential to be rehabilitated if the cultivation ceases and the drain or dike is removed. Theoretically, a drained wetland could return to wetland if drainage structures removed or collapse, or if the farming system changes.

Several partially drained (by drainage ditches) wetlands were visited by this project and soil wetness indicators were present in all cases.

Historic wetlands / relict soils

"Morphological features that do not reflect ***contemporary or recent conditions of saturation and anaerobiosis are called relict features"*** (USACOE 2006).

"Some soils exhibit redoximorphic features / soil wetness indicators that formed in the recent or distant past when conditions may have been wetter than they are today. These features have persisted even though wetland hydrology may no longer be present." (USACOE 2006).

Note that there might be instances where the features may have formed long ago but the wetland might still be subject to wetting. Again, it would be best to approach an experienced soil scientist for interpretation.

To delineate these "difficult sites":

- *"Relict and historic soil wetness indicators may be difficult to distinguish from contemporary features. If indicators of hydrophytic vegetation and wetland hydrology are present, then soil wetness indicators can be assumed to be contemporary. When soil morphology seems*

inconsistent with the landscape, vegetation, or observable hydrology, they are likely to be relict. It may be necessary to obtain the assistance of an experienced soil scientist" (USACOE 2006).

Only one site with relict features was visited during the course of this project. No wetland was present at the site.

4.3 Naturally occurring wetlands that periodically lack wetland indicators / difficult at certain times of the year

Some wetlands can be difficult to identify because wetland indicators may be missing **at times**. Many wetlands have highly seasonal hydrologic conditions due to seasonal variation in precipitation and prolonged summer drought, or experience extremes of normal seasonal or annual variability. An example is **seasonal wetlands that may lack hydrophytic vegetation and/or wetland hydrology during the dry season**.

To delineate these "difficult sites":

- Soils often aren't a problem for these wetlands, unless they are problem soil types for wetland delineation i.e. these are often sites where soil wetness indicators are present.
- Soil and landscape conditions should be documented thoroughly, along with the rationale for considering the area to be wetland. In some cases it may be necessary to revisit the site in the wet season.

Many sites were visited where free water was absent (it was the dry season). Very few sites were visited where vegetation was absent, but the vegetation was mostly "facultative" i.e. it sometimes occurs in wetlands but often occurs outside of wetland as well. More than 50% of the time, soil wetness indicators were present and for the remaining cases wetland presence was deduced based on an interpretation of the site and this was confirmed during the wet season.

4.4 Indicators are absent from a natural wetland due to human disturbance

Human activities that may result in removal or covering of wetland indicators include, but are not limited to:

- alteration (including invasive alien species infestation) or removal of vegetation or surface soil (including ploughing);
- placement of dredged or fill material over wetland soils*"* (USACOE 2006).

To delineate these "difficult sites":

- Soils typically aren't a problem for these wetlands unless they are problem soil types i.e. these are often sites where soil wetness indicators are helpful.

Ploughing, and invasive alien species infestation, were among the most common difficult sites sampled by this project. Soil wetness indicators were present in by far the majority of sites sampled.

4.5 Difficult soils

Some wetlands may permanently lack soil wetness indicators due to the **nature of the soils** on the site. They may or may not be "difficult sites".

The difficult soils most commonly encountered by this project were

- sandy soils and
- soils with low iron content,

and are discussed in Section 3.3 of this document.

Several further "difficult soils" are identified in the USA manuals and also occur in South Africa. These further cases were not encountered by this project, probably due to the relatively small sample size. However, they include:

Soils with high pH – "*Identifiable iron or manganese features do not readily form in saturated soils with high pH. High pH (7.9 or higher) can be caused by many factors. Salt content is a common cause of high soil pH"*.

Soils with red parent materials – *The red colour of the soil masks any mottling, thus these soils are also difficult to delineate soils.*

5. SITES

For the purposes of this project, the Western Cape has been broadly divided regionally and the field site descriptions have been grouped together within these regions as follows:

- Agulhas Plain
- Coastal Overstrand
- Cape Flats and Somerset West
- Cape Peninsula
- Stellenbosch area
- Swartland and Saldahna Peninsula
- West Coast
- Cape Fold Mountains
- Upper Breede Valley
- Little Karoo (not visited by this project)
- Southern Cape

The site visits adapted a rapid fieldwork approach in which wetland soil types were sampled across a representative cross-section of Western Cape localities, soil forms and wetland types (ranging from highly disturbed to pristine). The goal was firstly to identify whether or not the DWAF delineation manual applies to the Western Cape, and then to identify any soils in the Western Cape that are “Specific Cases” (difficult to delineate) either currently described in the manual or to be added.

The format of the site descriptions roughly follows the collection of data prompted by the field data sheet, and is supported by photographs, where available, to illustrate certain points.

In the example below taken from one of the site descriptions, “valley bottom (5)” is in **bold** type to show that the wetland was found in a valley bottom location. Similarly, “bedrock” and “flat” are also in bold to indicate they were found during this site visit.

Setting				
crest (1)	/ scarp (2)	midslope (3)	footslope (4)	**valley bottom (5)**
The setting can also be described as “flats” and “depressional”. The site is found at low altitude on the coastal plain, where there is very little topographic relief over a large area.				
Additional indicators of wetland presence				
Concave				*No*
Bedrock				***In places, between 15-50 cm***
Dense clay				*No*
Flat				***Yes***

AGULHAS PLAIN

Supporting background information on soils and associated vegetation types that occur across the Agulhas Plain has been drawn from Thwaites and Cowling (1988)[6], and Euston-Brown (*in* Cole *et al.,* 2000)[7].

The Thwaites and Cowling (1988) document describes an extensive low-lying coastal plain (6-22 meters above sea level), which is a complex of coastal flats, vleis and pans. This is described as the Moddervlei Land System. According to the report, this system was formed during the Last Interglacial when sea level was 7-9 meters above its present level. Several Moddervlei Land System soils are listed in the report, however, those that are described in association with seasonally and permanently water-logged areas include Fernwood and Katspruit soils. Fernwood soils within the Moddervlei Land System are noted to support restioid fynbos (**RF** in figure below), dominated by *Leucadendron linifolium (***L** in figure below*)* and *Chondropetalum tectorum (* in figure below*)*.

According to the report, footslope soils adjacent to wetlands formed as wetter, colder conditions in the Quaternary gave rise to colluviation[8] in the sandstone uplands resulting in a deep quartz mantle. The medium to coarse texture of the sand together with the woody, sclerophyllous[9] vegetation and sufficient rainfall in the cool winters has led to strong podzolization[10] in these areas under present conditions. These areas support acid sand / proteoid fynbos (**PF** in opposite figure), the most common vegetation type across the Agulhas Plain.

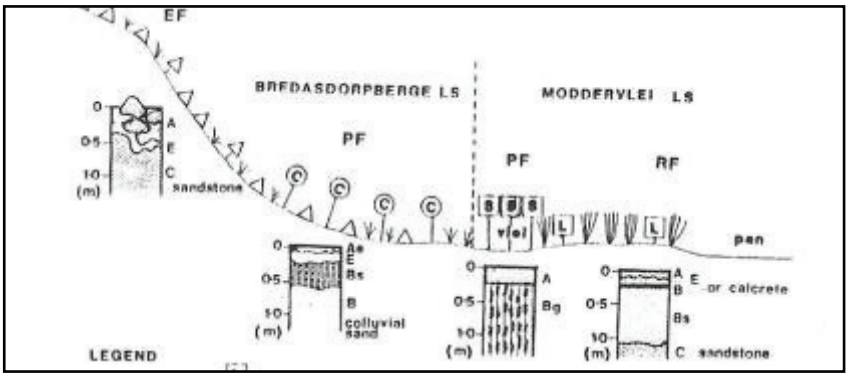


Figure excerpted from Thwaites and Cowling (1998).

Three sites have been described on the Agulhas Plain:

- Ratel River site 1
- Ratel River site 2, and
- Soetendalsvlei.

[6] Thwaites, R.N. and Cowling, R.M. 1988. Soil-vegetation relationships on the Agulhas Plain, South Africa. *In* Catena. Volume 15 pp 333-345. Braunschweig.

[7] Cole, N., Lombard, A.T., Cowling, R.M., Euston-Brown, D., Richardson, D.M. and Heijnis, C.E. 2000. Framework for a conservation plan for the Agulhas Plain, Cape Floristic Region, South Africa. Institute for Plant Conservation, University of Cape Town, Cape Town.

[8] colluvium = a deposit of soil and/or rock fragments accumulated at the base of slopes as a result of gravitational action (MacVicar et al., 1977)

[9] sclerophyllous = hard, tough, leathery-leaved, with short internodes / intervals between leaves along the stem, typical of fynbos

[10] podzolization = the mobilization in and removal from an A horizon of sesquioxides and/or organic matter, so giving rise to a highly leached E horizon. The process takes places typically in quartose parent materials under a …. heath vegetal cover. Lamotte form has an illuvial B horizon enriched with sesquioxides and organic matter. Sesquioxides = a binary compound of a metal and oxygen in the proportion of 2 to 3 (e.g. Al2O3, Fe2O3). Also used generally to describe free iron and aluminium (and, to a lesser extent, manganese) oxides in soils (MacVicar et al., 1977).

5.1 Ratel River site 1 – flats, Agulhas Plain (Agulhas National Park, SANParks)

Altitude 12 m Latitude 34˚ 44’ 30.02” Longitude 19˚ 41’ 00.36”

This is a depressional / flats wetland which appears to support a seasonal zone, and is fed mostly by precipitation.

Do normal circumstances exist on the site?	***Yes***
Is the site significantly disturbed (difficult site)?	***No***
Is the area a Specific Case per Appendix A of the delineation manual?	***No***

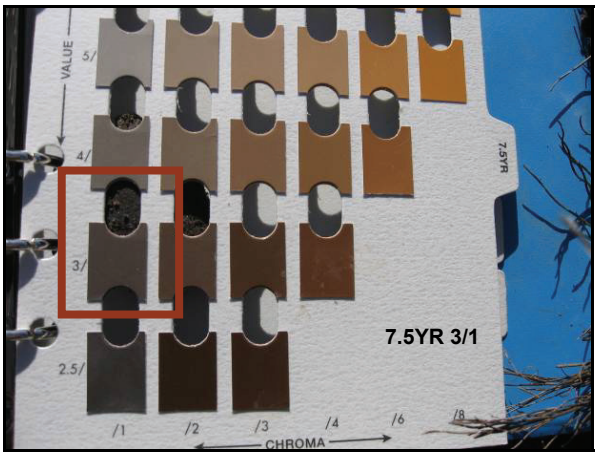
Indicators of soil wetness within 50 cm of soil surface	
Organic soil	*No*
Sulfidic odour	*No*
Gley	***Yes***
Mottles	***Sparse***
Organic streaking or oxidised rhizospheres	*No*
High organic content in surface layer	**Occasional**

Soil sample plots:

Depth	**Texture**	**Matrix colour**	**Mottle colour**	**Mottle abundance**
Wetland (a) seasonal zone				*soil form:* not surveyed
0-10 cm	loamy clay sand	5Y 6/1		
10+ cm	clay	7.5YR 5/1 gley		
Wetland (b) seasonal zone				*soil form:* not surveyed
0-8 cm	sand	high carbon surface layer		
8-15cm	sand		bright, distinct mottles	
15+ cm	sand	gley		
Wetland (c) seasonal zone				*soil form:* not surveyed
0-10 cm	sand	5Y 4/1		
10+ cm	clay	Gley1 5/10Y		


Site (a) Gley clay top 50 cm


(b) Dark surface layer, top 15 cm



Setting				
crest (1) / scarp (2)	midslope (3)	footslope (4)	**valley bottom (5)**

The setting can also be described as “flats” and “depressional”. The site is found at low altitude on the coastal plain, where there is very little topographic relief over a large area.

Additional indicators of wetland presence	
Concave	***In places***
Bedrock	***In places, between 15-50 cm***
Dense clay	***Yes***
Flat	***In places***

Hydrology	sampled in May
Seasonal zone	
Depth to saturated soil: *not saturated*	Depth to free water in soil plot: *none*

Soils were moist but not saturated at the May 2007 site visit. It is anticipated that these areas are inundated for one to three months of the year.

Vegetation
Seasonal zone: *Chondropetalum rectum, Sarcocornia pillansii*
Non-wetland: Not recorded

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

5.2 Ratel River site 2 – depression, Agulhas Plain (Agulhas National Park, SANParks) *Joint ARC/WRC research site

Altitude 12 m, Latitude 34˚ 44' 51" Longitude 19˚ 44' 27"

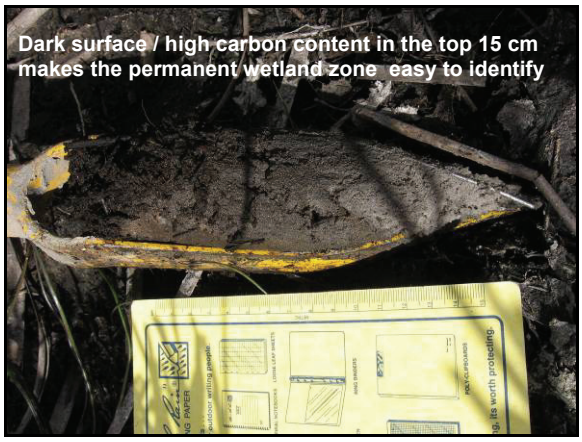
This is a depressional wetland which appears to support a permanent, seasonal and temporary zone, and is fed and drained by the Ratel River. The wetland is part of a much larger complex which is partly farmed (near the original homestead) with drainage ditches and invasive alien vegetation, although there are no major impacts on the surveyed portion.

Do normal circumstances exist on the site?	***Yes***
Is the site significantly disturbed (difficult site)?	***No***
Is the area a Specific Case per Appendix A of the delineation manual?	***Yes***
Sandy, podzol soils	

Indicators of soil wetness within 50 cm of soil surface	
Organic soil	*No*
Sulfidic odour (a slight sulfidic odour was noted in permanent zone)	***Yes***
Gley and low chroma	***Yes***
Mottles or concretions	*No*
Organic streaking	***Yes***
High organic content in surface layer	***Yes***

Soil sample plots:

Depth	Texture	Matrix colour	Mottle colour	Mottle abundance
Wetland (a) permanent zone				*soil form:* Katspruit
0-10 cm	sand with high carbon content	10YR2/1		
10+ cm	sand	gley		
Wetland (b) permanent zone				*soil form:* Fernwood
0-20 cm	sand	10YR2/1		
Wetland (c) seasonal zone				*soil form:* Fernwood
0+ cm	sand	2.5Y 3/1		
Wetland (d) seasonal zone				*soil form:* Fernwood
0-30 cm	sand	black 5Y2.5/1		
30 cm+	sand	grayish brown 2.5Y5/2 low chroma (E horizon)		
Wetland (d) seasonal zone				*soil form:* La Motte
0-20 cm	sand	2.5Y2/1		
20+ cm	sand	10YR5/1 low chroma (E horizon)		
40 cm	clay pan			
Non-wetland				*soil form:* La Motte
	sand	higher chroma colours		
80 cm	clay pan			



Although the permanent wetland zone was easy to identify, this Ratel River site had difficult soils in the seasonal zone. The wetland soils in the seasonal zone are not organic or gleyed, and do not show redoximorphic features. They fit the "Specific Cases" currently described in Appendix A of the DWAF delineation manual as follows:

- "aeolian[11] derived, sandy soils associated with sandy coastal aquifers.

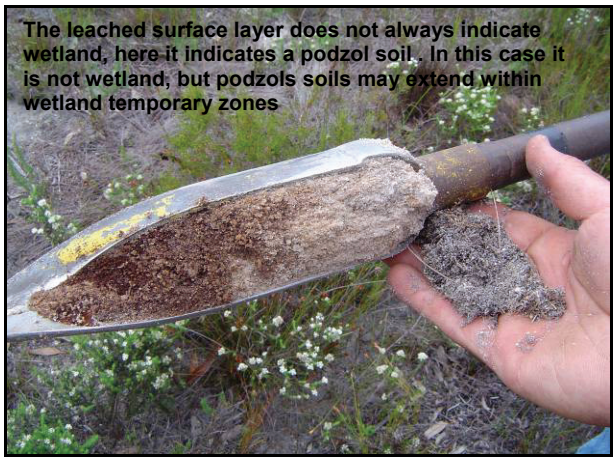
The challenges of identifying wetlands that occur on Lamotte and Fernwood soils include:

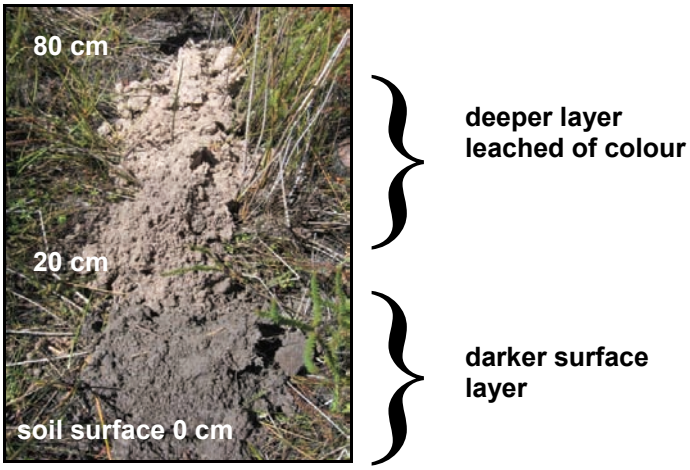
- no redoximorphic features are evident
- the investigator might not dig deep enough and not realise a podzolic soil is present

However, it is still possible to use, as an indicator of wetness for the seasonal zone, the high organic carbon content of the topsoil which gives it a dark colour, as described in Appendix A "Specific Cases":

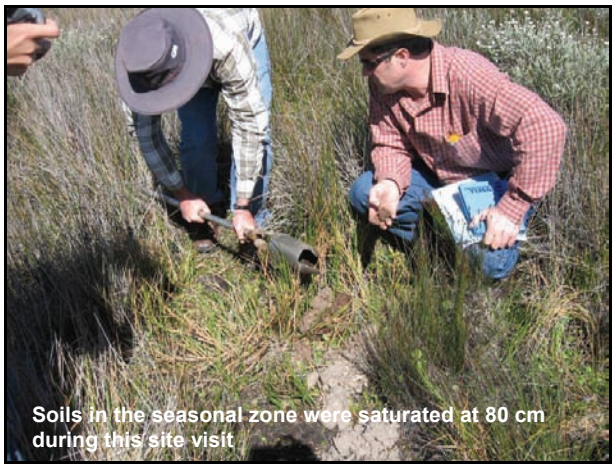
- there is a high carbon content in the topsoil (higher than the adjacent non-wetland soils in the surrounding landscape)
- the organic carbon topsoil content is more than 4-7%
- the topsoil is dark (moist Munsell value of 4 or less and chroma value of 1 or less)

This indicator should be applied together with landscape position and vegetation indicators.

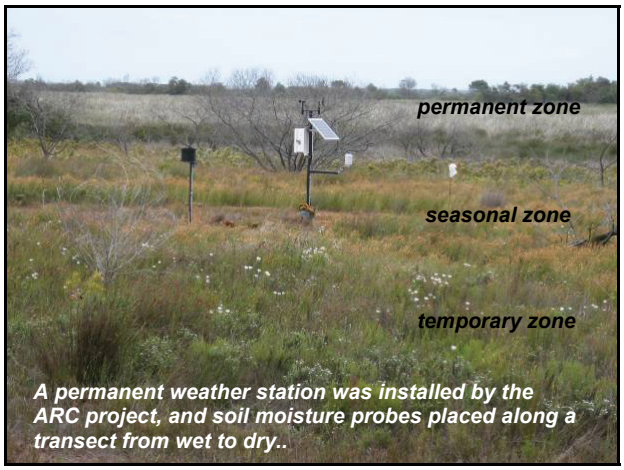




[11] windblown



Soils in the seasonal zone were saturated at 80 cm during this site visit

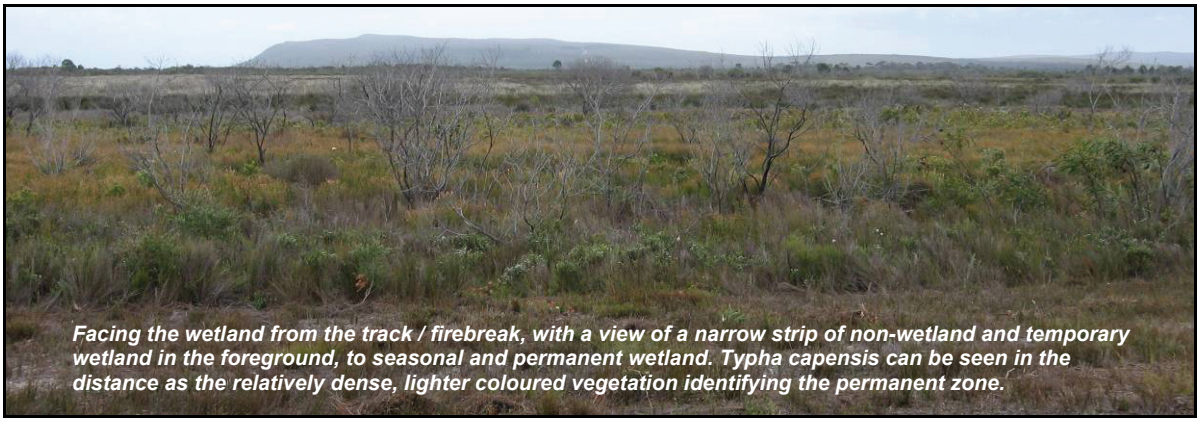


A permanent weather station was installed by the ARC project, and soil moisture probes placed along a transect from wet to dry..

Setting				
crest (1) / scarp (2)		midslope (3)	footslope (4)	**valley bottom (5)**
The available topographic setting for this site in the DWAF delineation manual is valley bottom (5), however, the setting can be described as “depressional”. The site is part of a larger wetland complex, at low altitude on the coastal plain, with very little topographic relief over a large area.				
Additional indicators of wetland presence				
Concave				***Yes***
Bedrock				*No*
Dense clay				*No*
Flat				*No*
Associated with a river				***Yes***

View of both wetlands 5.1 and 5.2. The area is a mosaic of depressional wetlands interspersed with extensive seasonal flats wetland on shallow soils over bedrock and dense clay.

Hydrology	**sampled in March and October**
Permanent zone:	
Inundated: *Yes, in places*	Depth of Surface Water : *0-30 cm*
Depth to saturated soil: *0 cm (surface)*	Depth to free water in soil plot: *0-10 cm*
Surface water was apparent during the March 2007 (dry season) field visit, with a small open water section and about 80% areal coverage of emergent vegetation.	
Seasonal zone	
Depth to saturated soil: *0-40 cm (surface)*	Depth to free water in soil plot: *15-80 cm*
The seasonal zone ranged from being saturated to the surface in areas closest to the permanent zone, to being saturated deeper below the soil surface, but still within 50 cm of the surface during the March field visit.	
Temporary zone	
Saturated within 50 cm of surface	*No*
The temporary zone was moist (not saturated) at the March visit.	



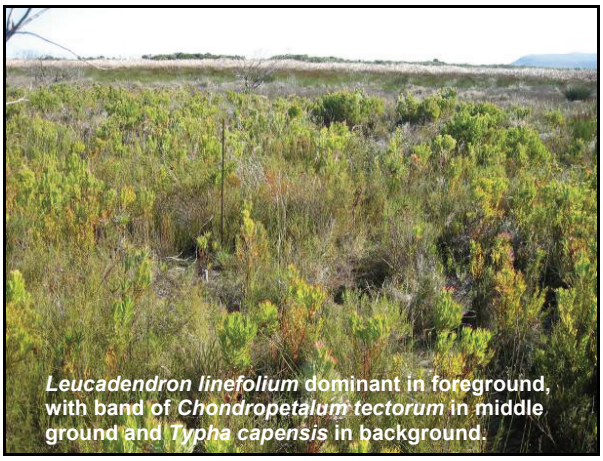
Facing the wetland from the track / firebreak, with a view of a narrow strip of non-wetland and temporary wetland in the foreground, to seasonal and permanent wetland. Typha capensis can be seen in the distance as the relatively dense, lighter coloured vegetation identifying the permanent zone.

Vegetation
Permanent zone: Dominant and commonly recognised indicator plants in this zone include ***Typha capensis*** and ***Triglochin bulbosa***. Other species noted include: ***Isolepis sp., Ficinia sp.***, *Fiurena sp, Chondropetalum elegia, Dodii purpurescens, Plechostachys serpillifolia, Leacodena xanthoconus, Sarcocornia sp.* **Seasonal zone**: The dominant plant indicating this zone is *Chondropetalum tectorum.* Other identified species include: *Laurenbergia repens, Limonium antherocoides, Ischyrolepis paludosa, Hypodiscus willdenowia, Cliffortia ericifolia.* **Temporary zone**: *Leucadendron linifolium* dominates. The entire area is on a very slight slope, presenting a very gradual transition zone where most of the species are present across the gradient, but with *Leucadendron linifolium* being more numerous on the lower temporarily wet slopes and *Elegia filacea* being more numerous as the area transitions upslope. Other identified species include: *Erica subdivaricata, E. lasciva, E. similans, E. sessiliflora, E. imbricata, E. pulchinella, E. muscosa, E. seriphifolia, Erica melanacme, Erica axiliflora, Thamnochortus fruticosus, Penaea mucronata, Leucospermum cordifolium, Serruria nervosa, Metalasia sp. Lachnia densiflora.* **Non-wetland:** Where the *Elegia filacea* assumes dominance, the area was considered non-wetland. Other identified species include: *Staberoha distachyos, Hypodiscus aristatus, Bobartia filiformis, Serruria nervosa, Leucospermum pedunculatum, Penaea mucronata, Metalasia sp.*

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

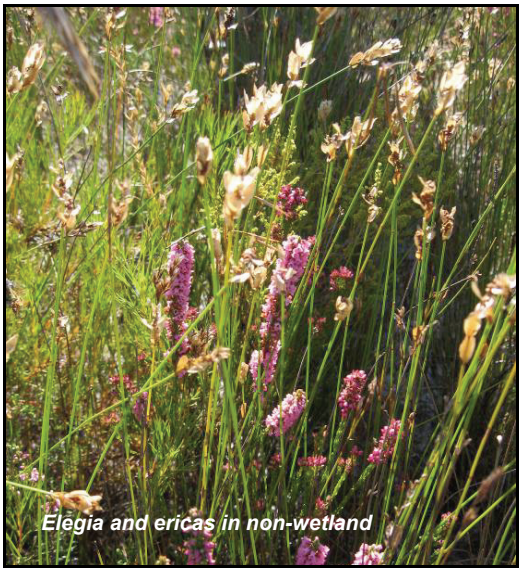
Two site visits were undertaken, 17 October 2006 and 13 March 2007. The assistance of botanist Ross Turner, and Caitlin von Witt and Ismail Ebrahim from the South African National Biodiversity Institute's *Custodians of Rare and Endangered* Wildflowers, and Fynn Corry of UCT Wetland Health and Integrity programme is gratefully acknowledged.

Edge of permant wetland, with Chondropetalum tectorum in foreground



***Leucadendron linefolium* dominant in foreground, with band of *Chondropetalum tectorum* in middle ground and *Typha capensis* in background.**

***Typha capensis* in permanent wetland zone**



***Elegia* and ericas in non-wetland**

Plechostachys serpilifolia

“Custodians of Rare and Endangered Wildlfowers” field visit.

5.3 Soetendalsvlei – coastal depression, Agulhas Plain (Agulhas National Park, SANParks)

Altitude 9 m Latitude 34˚ 43' 07.50" Longitude 19˚ 58' 08.41"

This is a depressional wetland which appears to support a permanent and seasonal zone, and is fed and drained by the Nuwejaars River. The portion studied by this project is predominantly natural and is part of a much larger complex.

Do normal circumstances exist on the site?	***Yes***
Is the site significantly disturbed (difficult site)?	***No***
Is the area a Specific Case per Appendix A of the delineation manual?	***No***

Indicators of soil wetness within 50 cm of soil surface	
Summary:	
Organic soil	*No*
Sulfidic odour (a slight sulfidic odour was noted in permanent zone)	***Yes***
Gley	***Yes***
Mottles	***Yes***
Organic streaking or oxidised rhizospheres	*No*
High organic content in surface layer	***Yes***

Soil sample plots:

Depth	Texture	Matrix colour	Mottle colour	Mottle abundance
Wetland (a) permanent zone				*soil form:* not surveyed
0+ cm	sandy clay	gley		
Wetland (b) seasonal zone				*soil form:* not surveyed
0+ cm	clay	gley	mottles	
Wetland (c) temporary zone				*soil form:* not surveyed
0+ cm	sandy clay	2.5Y 3/1		
Non-wetland				*soil form:* not surveyed
0+ cm	sand	higher chroma		


Very dense clay


Low chroma sandy clay


Gley, with faint mottles, and salt evident on the pan surface


Very dense clay in pan vegetated with sarcocornia sp.

Setting				
crest (1)	/ scarp (2)	midslope (3)	footslope (4)	**valley bottom (5)**
The available topographic setting for this site in the DWAF delineation manual is valley bottom (5), however, the setting can also be described as “coastal flat” and “depressional”. The site is found at low altitude on the coastal plain, where there is very little topographic relief over a large area.				
Additional indicators of wetland presence				
Concave				***Yes***
Bedrock				*No*
Dense clay				***Yes***
Flat				***Yes***
Associated with a river				***Yes***

Hydrology	**sampled in March**
Permanent zone	
Inundated: *Yes, in places*	Depth of Surface Water : *~ 30 cm*
Depth to saturated soil: *0 cm*	Depth to free water in soil plot: *0 cm*
Surface water was apparent throughout the permanent zone during the March 2007 (dry season) field visit, with a small open water section and about 80% areal coverage of emergent vegetation.	
Seasonal zone	
Depth to saturated soil: *range 0-50 cm*	Depth to free water in soil plot: *none*
The seasonal zone ranged from being saturated to the surface in areas closest to the permanent zone, to being saturated deeper below the soil surface, but still within 50 cm of the surface during the March 2007 (dry season) field visit.	
Temporary zone	**None noted**

Vegetation
Permanent zone: ***Schoenoplectus* sp**., ***Bulboschoenus maritimus, Ficinia nodosa***
Seasonal zone: ***Cotula coronopifolia,*** *Sporobolus virginica, Sarcocornia sp*
Non-wetland: *Not surveyed*

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

COASTAL OVERSTRAND

Much of Betty's Bay development has encroached into wetland. Betty's Bay supports several depressional wetlands, and extensive wetlands with high carbon soils on deep sands, however this figure shows multiple small temporary wetlands on shallow soils over bedrock.

5.4 Betty's Bay site 1 – coastal depression (Overstrand municipality)

Altitude 8 m Latitude 34˚ 21' 36.89" Longitude 18˚ 53' 35.62"

The wetland is a depression located at the foot of coastal mountains. It has been encroached upon by development, with some houses built within wetland area. Wetland hydrology is also affected by multiple residential roads and culverts, however, the central depressional area is relatively intact.

Do normal circumstances exist on the site?	***No***
Is the site significantly disturbed (difficult site)?	***Yes***
Is the area a Specific Case per Appendix A of the delineation manual?	***No***

Indicators of soil wetness within 50 cm of soil surface				
Summary:				
Organic soil				*No*
Sulfidic odour				*No*
Soil sample plots:				
Depth	**Texture**	**Matrix colour**	**Mottle colour**	**Mottle abundance**
Wetland (a) permanent zone				*soil form:* not surveyed
0+ cm	high organic content	10YR 2/1		
Wetland (b) permanent zone				*soil form:* not surveyed
0+ cm	high organic content	10YR3/2		

Setting				
crest (1)	/ scarp (2)	midslope (3)	**footslope (4)**	valley bottom (5)
The available topographic setting for this site in the DWAF delineation manual is footslope (4), although, the dominant landform describing the wetland is "depressional".				
Additional indicators of wetland presence				
Concave				***Yes***
Bedrock				*No*
Dense clay				*No*
Flat				*No*
Associated with a river				*No*

Hydrology	**sampled in March**
Permanent zone:	
Inundated: *Yes*	Depth of Surface Water : *not measured*
Seasonal zone	
Depth to saturated soil: *0 cm*	Depth to free water in soil plot: *10 cm*

Vegetation

Permanent zone: ***Typha capensis***

Seasonal zone: *Chondropetalum tectorum,* ***Wachendorfia thyrsifolia***

Non-wetland: *Not recorded*

5.5 Betty's Bay site 2 – coastal depression, (Overstrand municipality)

Altitude 6 m Latitude 34˚ 21' 59.67" Longitude 18˚ 53' 20.40"

This is a small, perched depression, fed by precipitation and surface runoff, and located within a developed neighbourhood of Betty's Bay.

Do normal circumstances exist on the site?	***Yes***
Is the site significantly disturbed (difficult site)?	***No***
Is the area a Specific Case per Appendix A of the delineation manual?	***No***

Indicators of soil wetness within 50 cm of soil surface		
Sulfidic odour		*No*
Organic soil		*No*
Mineral soil texture		**clay sand**
Mineral soils with the following signs of wetness:		
Gley		***Yes***
Mottles		***Sparse***
Organic streaking or oxidised rhizospheres		*No*
High organic content in surface layer		**Occasional**
Seasonal zone	*Non-wetland*	
gley, moist	Not sampled	
Soil form		**Not surveyed**

Setting			
crest (1) / scarp (2)	midslope (3)	**footslope (4)**	valley bottom (5)
The available topographic setting for this site in the DWAF delineation manual is footslope (4), although, strictly, it is not right at the footslope. The landform is "depressional". The site is found at low altitude in close proximity to the ocean.			
Additional indicators of wetland presence			
Concave			***Yes***
Bedrock			***Yes***
Dense clay			***Yes***
Flat			*No*
Associated with a river			*No*

Hydrology		
Permanent zone:		**Not observed**
Seasonal zone		
Depth to saturated soil: *0 cm*	Depth to free water in soil plot: *none*	
Temporary zone		**Not observed**

Vegetation
Seasonal zone: *Chondropetalum nudum, Sarcocornia pillansii*
Non-wetland: *Not recorded*

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

5.6 Vermont site 1 – depression, Onrus (private and municipal land)

Altitude 29 m Latitude -34˚24'33.88" Longitude 19˚09'34.30"

Vermont Pan has both inundated and saturated wetland habitats. This wetland is hydrologically connected to an adjacent wetland (5.7 below) by subsurface groundwater seepage. Three seep areas and a spring to the north also contribute freshwater to the pan. Landscaping has encroached within wetland, vegetation has been cleared and fill placed within wetland in some places.

Do normal circumstances exist on the site?	***No***
Is the site significantly disturbed (difficult site)?	***Yes***
Is the area a Specific Case per Appendix A of the delineation manual?	***No***

Indicators of soil wetness within 50 cm of soil surface		
Sulfidic odour		*No*
Organic soil		*No*
Mineral soil texture:		**sand / loamy clay sand**
Mineral soils with the following signs of wetness:		
Gley		***Yes***
Mottles		***Sparse***
Organic streaking or oxidised rhizospheres		*No*
High organic content in surface layer		**Yes**
Seasonal zone	*Non-wetland*	
(a) black silty sand (10 YR 2/1) (b) silty sand (10 Y 6/1 Gley) over very dark gray (N 3/ Gley)	(a) dark grey (10YR 5/1) sandy loam with few yellowish brown (10YR 5/6) mottles (not considered hydric due to infrequency and pale colour). Dry, July 2006. (b) sandy dune, white (2.5Y 8/1) sand, dry during the July 2006 field visit (within milkwoods) (c) 5 cm layer of light grey (10YR 7/1) loamy sand over black (10YR 2/1) silty sand (beneath invasive alien species)	
Soil form		**Not surveyed**

Setting				
crest (1) / scarp (2)	midslope (3)	**footslope (4)**	valley bottom (5)	
The available topographic setting for this site in the DWAF delineation manual is footslope (4). The wetland is a pan / depressional wetland.				
Additional indicators of wetland presence				
Concave				***Yes***
B edrock				***Yes***
Impermeable clay				*No*
Flat				*No*
Associated with a river				*No*

Hydrology	**sampled in July**
Permanent zone	
Inundated: *Yes, in places*	Depth of surface water : *~ 50 cm*
Depth to saturated soil: *0 cm*	Depth to free water in soil plot: *0 cm*
Central section is seasonally inundated. Much of this shoreline has been filled-in, creating a rapid drop off in ground level at the edge of the wetland.	

Seasonal zone	
Depth to saturated soil: 0-20 *cm*	Depth to free water in soil plot: 0-30 *cm*
This wetland receives water from surface runoff and rainfall, but also apparently from the spring and a series of seeps as groundwater daylights where the slope flattens out and geology changes from sandstone to unconsolidated alluvial soils.	
Temporary zone	**none noted**

Vegetation
Permanent zone: ***Typha capensis***.
Seasonal zone: *Chrysanthemoides monilifera*, *Stenotaphrum secundatum*, ***Juncus* cf. *krausii***, ***Bulboschoenus maritimus***, *Sarcocornia* cf. *littoralis*, ***Ficinia nodosus***, *Cotula coronopifolia*, *Zantedishia aethiopica, Psoralea pinnata,* ***Phragmites australis***, ***Cyperus textilis***, *Chondropetalum tectorum*, *Senecio halmifolius*, *Pittosporum undulatum*, *Plecostachys serpilifolia*, *Chasmanthe aethiopica*, *Gnidia squamosa, Briza maxima*, *Pteridium aquilinum*, and invasive alien species *Acacia cyclops*, *A. saligna*, *Eucalyptus sp*., *Sesbania punicea*, *Solanum nigrum*, *Pinus radiata*.
Non-wetland: *(a) Chrysantehmoides monilifera, Leptospermum laevigatum, Passerina corymbosa*, *Metalasia muricata*, *Carpobrotus edulis, Plecostachys serpilifolia, Stenatophrum secondatum, Eucalyptus* spp.*, Acacia saligna and Acacia Cyclops*, *Diospyros glabra*, *Phylica plumosa*. (b) *Agathosma ciliaris, Rhus glauca, Passerina corymbosa, Androcimbium eucamoides, Oxalis obtusa, Senecio halmifolius, Pittosporum undulatum, Trachyandra ciliate, Acacia cyclops, A. saligna, Pelargonium capitata, Chrysantehmoides monilifera, Carpobrotus edulis, Oxalis pes-caprae* and *Tetragonia fruticosa*. (c) mowed lawns dominated by *Pennisetum clandestinum* and other non-indigenous landscaping. (d) *Sideroxylon inerme*, *Rhus crenata*, *Manotoka sp., Carpobrotus edulis, Chrysantehmoides monilifera* and *Osyris crenata*. (e, fynbos) *Erica subdivaricata, Leucadendron linifolium, Satyrium odorum, Oxalis versicolor,* and *Pseudognaphalium undulatum, Disa halackii*

Note: Species list prepared by Ross Turner. Species in ***bold*** *are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

5.7 Vermont site 2 – coastal depression, Onrus (private and municipal land)

Altitude 29 m Latitude -34˚24'26.81" Longitude 19˚08'56.46"

This wetland is located to the west of, and hydrologically connected to, Vermont site 1 (5.6 above). This wetland also receives water from surface runoff and rainfall. The wetland is impacted by invasive alien vegetation, landscaping, and buildings encroaching within wetland.

Do normal circumstances exist on the site?	***No***
Is the site significantly disturbed (difficult site)?	***Yes***
Is the area a Specific Case per Appendix A of the delineation manual?	***No***

Indicators of wetness within 50 cm of soil surface		
Sulfidic odour		*No*
Organic soil		***Yes***
Mineral soil texture:		**sandy clay loam**
Mineral soils with the following signs of wetness:		
Gley		*No*
Mottles		*No*
Organic streaking or oxidised rhizospheres		*No*
High organic content in surface layer		***Yes***
Permanent zone	*Non-wetland*	
(a) black mucky loam (10YR 2/1) over sandy loam (b) black mucky loam (10YR 2/1) throughout	(a) dark grey (5YR 4/1) loamy sand to dark gray (5Y 4/1) sand, dry (b) black (10YR 2/1) silty sand north, dry	
Soil form		**Not formally surveyed**

Setting				
crest (1) / scarp (2)	midslope (3)	**footslope (4)**	valley bottom (5)	
The available topographic setting for this site in the DWAF delineation manual is footslope (4), and its landform is depressional.				
Additional indicators of wetland presence				
Concave				***Yes***
Bedrock				*No*
Impermeable clay				*No*
Flat				*No*
Associated with a river				*No*

Hydrology	**sampled in July**
Permanent zone	
Inundated: *Yes, in places*	Depth of Surface Water : *~ 30 cm*
Depth to saturated soil: *0 cm*	Depth to free water in soil plot: *o cm*
Seasonal zone	
Depth to saturated soil: *0-15 cm*	Depth to free water in soil plot: *30-50 cm*
Temporary zone	**none noted**

Vegetation
Permanent zone: *Juncus* cf. *krausii*, *Isolepis* sp
Seasonal zone: *Chrysanthemoides monilifera*,*Stenotaphrum secundatum*, ***Juncus* cf. *krausii*** and *Bulboschoenus maritimus*, *Sarcocornia* cf. *littoralis*, ***Ficinia nodosa***, ***Cotula coronopifolia*, *Zantedishia aethiopica,*** *Psoralea pinnata, Chasmanthe aethiopica*, ***Phragmites australis****,* ***Cyperus textilis*****,** *Chondropetalum tectorum*, *Briza maxima* and *Pteridium aquilinum*, and invasive alien species *Acacia cyclops*, *A. saligna*, *Eucalyptus sp*., *Sesbania punicea*, *Solanum nigrum*, *Pinus radiata*. e *Senecio halmifolius*, *Pittosporum undulatum*, *Zantedishia aethiopica*, *Plecostachys serpilifolia*, *Chasmanthe aethiopica* and *Gnidia squamosa* **Non-wetland:** *(a) Agathosma ciliaris, Rhus glauca, Passerina corymbosa, Androcimbium eucamoides, Oxalis obtusa, Senecio halmifolius, Pittosporum undulatum, Trachyandra ciliate, Acacia cyclops, A. saligna, Pelargonium capitata, Chrysantehmoides monilifera, Carpobrotus edulis, Oxalis pes-caprae* and *Tetragonia fruticosa*. (b) mowed lawns dominated by *Pennisetum clandestinum* and other non-indigenous landscaping. (c) *Erica subdivaricata, Leucadendron linifolium, Satyrium odorum, Oxalis versicolor,* and *Pseudognaphalium undulatum, Disa halackii*

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list*

5.8 Kleinmond – slope (private land)

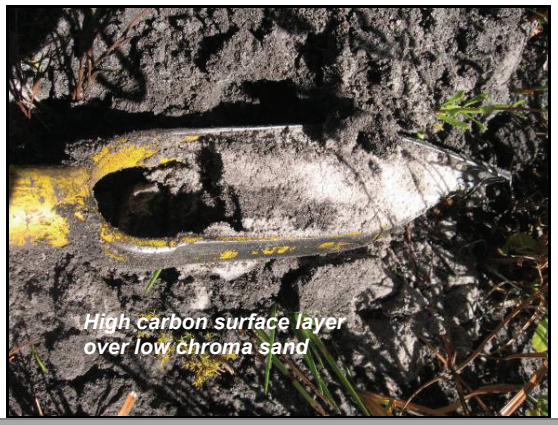
Altitude 20-23 m Latitude 34˚19'58.60" Longitude 19˚03'28.88"

This hillslope seep wetland is part of a much larger wetland. It appears to continue downslope until it reaches Kleinmond estuary.

Do normal circumstances exist on the site?	***No***
Is the site significantly disturbed (difficult site)?	***No***
Is the area a Specific Case per Appendix A of the delineation manual?	***Yes***

Sandy, podzol soils

Indicators of wetness within 50 cm of soil surface			
Sulfidic odour (a slight sulfidic odour was noted in permanent zone)			***Yes***
Organic soil			*No*
Mineral soil texture:			**sand**
Mineral soils with the following signs of wetness:			
Gley or low chroma			*No*
Mottles or concretions			*No*
Organic streaking			***Yes***
High organic content in surface layer			***Yes***
Permanent zone	*Seasonal zone*	*Temporary zone*	*Non-wetland*
black (10YR2/1) high carbon surface layer	dark surface layer 10YR 2/1 to 15 cm over white (Gley1 7N)	dark grey (10YR 5/1) sandy loam	not surveyed
Soil form			**not surveyed**



Setting				
crest (1) / scarp (2)	midslope (3)	**footslope (4)**	valley bottom (5)	
Additional indicators of wetland presence				
Concave				*No*
Bedrock				*No*
Impermeable clay				*No*
Flat				*No*
Associated with a river				*No*

Hydrology Permanent zone:	**sampled in February**
Inundated: *No*	Depth of Surface Water : n/a
Depth to saturated soil: *0 cm*	Depth to free water in soil plot: 3*0 cm*
Seasonal zone	
Depth to saturated soil: *10-30 cm*	Depth to free water in soil plot: *none*
Temporary zone	
Saturated within 50 cm of surface	*No*

Vegetation
Permanent zone: The wetland is dominated by *Elegia mucronata* in the wettest areas. Other easily recognised wetland indicator species include *Psoralea sp, Berzelia languinosa,* a single ***Prionium serratum*** plant*, Watsonia meriana, Witsenia maura.*
Seasonal zone: *Berzelia languinosa, Watsonia meriana,* ***Fuirena hirsuta***
Transitional / non-wetland zone: *Pteridium aquilinum, Ischyrolepis sp. Leucadendron salignum., Serruria sp.*

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*


Witsenia maura


Berzelia languinosa


Chondropetalum mucronatum

CAPE FLATS AND SOMERSET WEST

5.9 Vergenoegd – flat, weak slope / cape flats (private land)

Altitude 10-15 m Latitude 34˚02'12.09" Long 18˚43'54.90"

On-site wetlands appear hydrologically isolated within the broader landscape, however their proximity to each other indicates interconnectedness within the mosaic of habitats.

Do normal circumstances exist on the site?	***Yes***
Is the site significantly disturbed (difficult site)?	***No***

Areas of the site have been cleared, ditched, ploughed, and overgrown with invasive alien plants.

Is the area a Specific Case per Appendix A of the delineation manual?	***Yes***

Not in terms of soils, but mosaic is a difficult to delineate site.

Indicators of wetness within 50 cm of soil surface			
Sulfidic odour			*No*
Organic soil			*No*
Mineral soil texture			**clay sand**
Gley or low chroma			***Yes***
Mottles or concretions			***Yes***
Organic streaking or oxidised rhizospheres			*No*
High organic content in surface layer			***Yes***
Seasonal zone		*Temporary zone*	*Non-wetland*
high carbon in A horizon, low chroma colours, moist (a) 0-10 cm light reddish brown 2.5 YR 6/4 and weak red 2.5 YR 5/2 sandy clay 10+ cm clay, same colours as above with brown 7.5 YR 4/4 faint, common mottles. (b) 0-25 cm dark grey 2.5 Y 4/1 sandy clay dark red 2.5 YR 3/6 and brownish yellow 10 YR 6/6 fine, very common mottles 25+ cm very fine /dense clay layer olive yellow 2.5Y 6/6 and light olive brown 2.5Y 5/3. (c) 0-20 cm grayish brown 10 YR 5/2 with dark yellowish brown 10 YR 4/6 distinct, common mottles 20+ cm dark gray 10 YR 4/1 and pale yellow 2.5 Y 7/4 (c) 0-40 cm thin surface layer high in organic material over a brown 10 YR 5/3 fine sand with brown 7.5 YR 4/4 faint, common mottles. 40+ cm dense clay layer (d) 0-20 cm brown 7.5 YR 4/2 sand with distinct, yellowish red 5YR 4/6 mottles 20+ cm brown 7.5 YR 5/2 sandy clay		low chroma colours, mottles, moist (a) 0-x cm light reddish brown 2.5 YR 6/3 and weak red 2.5 YR 4/2 and red 2.5 YR 5/8 dense loamy clay x-x cm very dense clay (b) 0-80 cm reddish grey 5 YR 5/2 deep sand with 5 YR 4/6 mottles 80+ cm dense clay (c) 0-20 cm grayish brown 10 YR 5/2 moist clay sand with faint, common mottles 20+ cm gray 7.5 YR 5/1 and pale yellow 2.5 Y 7/4 sandy clay below 20 cm	dry, higher chroma (a) brown 7.5YR4/4 loamy sand, dense clay from 40+ cm, bright, dry (b) brown 7.5 YR 4/2 sandy clay, very dense clay at 50+ cm. dry
Soil form			
Permanent zone	*Seasonal zone*	*Temporary zone*	*Non-wetland*
Katspruit	Kroonstad	Kroonstad, Estcourt	Estcourt and Sepane

Two broad soil suites are present at Vergenoegd: Katspruit and Kroonstad forms with a distinctive gleyed (G) horizon, which is associated with associated with intermittent to continuous wetness), and Estcourt and Sepane forms, with a distinct clay B horizon relatively close to the surface, which can impede water movement) (Shloms *et al.,* 2006). All of the soil forms found on site may support wetlands. In soils where the G horizon is close to the surface (Katspruit form) soil is typically wet throughout most of the year. On this site, these areas were described as seasonal wetlands. In the Kroonstad form, the deeper G horizon beneath an E implies that the upper part of the profile will exhibit saturation only intermittently (Fey, 2006). Estcourt and Sepane forms may also hold water intermittently due to their dense clay B horizon (seasonal to temporary wetland, or non-wetland).

Dense clay soils. Indicating were saturation begins.

Delineation tools: auger, munsell book and data sheet

Setting				
crest (1) / scarp (2)	midslope (3)	footslope (4)	**valley bottom (5)**	
The available topographic setting for this site in the DWAF delineation manual is valley bottom (5), but more specifically it is located on lowland coastal flats.				
Additional indicators of wetland presence				
Concave				*No*
Bedrock				*No*
Impermeable clay				***Yes***
Flat				***Yes***
Associated with a river				*No*

Hydrology	**sampled in September**
Seasonal zone	
Depth to saturated soil: *0-30 cm*	Depth to free water in soil plot: *50 cm*
Temporary zone	**Not observed**
Depth to saturated soil: *0 cm*	Depth to free water in soil plot: *none*

Soil data plots within the study area did not find evidence of a high water table, suggesting that the wetlands are maintained predominantly via precipitation, as well as some overland runoff during rain events.

Vegetation
Seasonal zone *(soils saturated to the surface)*: *Ficinia indica, Chondropetalum nudum,* ***Bolboschoenus maritimus, Eleocharis limosa, Juncus oxycarpus, Triglochin bulbosa.***

Temporary zone: *Watsonia meriana*, *Zantedeschia aethiopica*, *Elegia nudum, Muraltia macropetala, Arctotheca calendula, Athanasia trifurcate, Dimorphotheca pluvialis, Felicia tenella, Senecio littoreus, Senecio pterophorus Crassula natans, Erepsia bracteata, Gnidia cf. laxa, Brunsvigia orientalis, Aponogeton cf. angustifolius, Baeometra uniflora, Isolepis antarctica, Isolepis cernua, Isolepis diabolica, Isolepis marginata, Isolepis cf. striata, Isolepis trachysperma, Tetraria cuspidate, Ornithogalum thyrsoides, Babiana angustifolia, Geissorhiza imbricate, Romulea rosea, Sparaxis bulbifera, Juncus cephalotes, Disa bracteata, Cynodon dactylon, Ehrharta calycina, Eragrostis capensis, Elegia recta.*

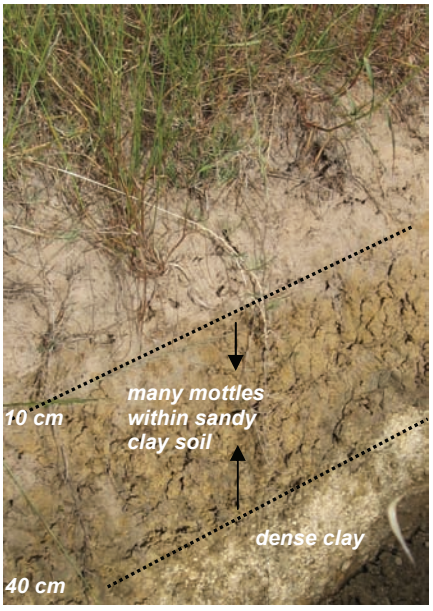
*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

Barrie Low (Coastec)and Fynn Corrie (UCT) are gratefully acknowledged for plant species lists.


Watsonia meriana


Dense and extensive stand of Watsonia meriana


many mottles within sandy clay soil



5.10 ACSA – depression, cape flats (private land)

Altitude 49/50 m Latitude 33˚58'34.31" Longitude 18˚37'41.47"

Do normal circumstances exist on the site?	***No***
Is the site significantly disturbed (difficult site)?	***Yes***

The wetland has been cleared, natural vegetation has been mostly replaced by invasive alien woody species and there has been a recent fire.

Is the area a Specific Case per Appendix A of the delineation manual?	***Yes***

A difficult site where indigenous plants have been replaced by invasive alien species

A difficult site where indigenous plants have been recently burnt or replaced by invasive

Indicators of soil wetness within 50 cm of soil surface		
Sulfidic odour		*No*
Organic soil		*No*
Mineral soil texture		**sand**
Mineral soils with the following signs of wetness:		
Gley / low chroma		***Yes***
Mottles		***Sparse***
Organic streaking and oxidised rhizospheres		**Occasional**
High organic content in surface layer		**Occasional**
Seasonal zone	*Non-wetland*	
low chroma, moist, mottles, organic streaking	dry, higher chroma	
Soil form		**Not formally surveyed**


Distinctive mottles in sandy soils


Gley sand within 50 cm of the soil surface.

Setting				
crest (1) / scarp (2)	midslope (3)	footslope (4)	**valley bottom (5)**	
The available topographic setting for this site in the DWAF delineation manual is valley bottom (5), however, the setting can also be described as "coastal depression".				
Additional indicators of wetland presence				
Concave				***Yes***
Bedrock				*No*
Dense clay				*No*
Flat				*No*
Associated with a river				*No*

Hydrology	**surveyed in May**
Permanent zone:	
Inundated: small, central area	Depth of Surface Water : *~5-10 cm*
Seasonal zone	
Depth to saturated soil: *40 cm*	Depth to free water in soil plot: *none noted*

Vegetation
Seasonal zone: ***Typha capensis*, *Phragmites australis***, *Pennisetum macrourum,* ***Cladium mariscus* subsp*. jamaicanse,*** *Chondropetalum tectorum* **Non-wetland:** *Not recorded*

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*


Chondropetalum tectorum

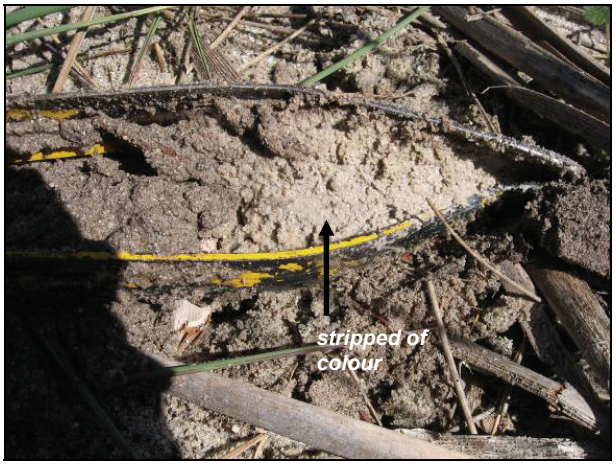

Cladium mariscus subsp *jamaicense*

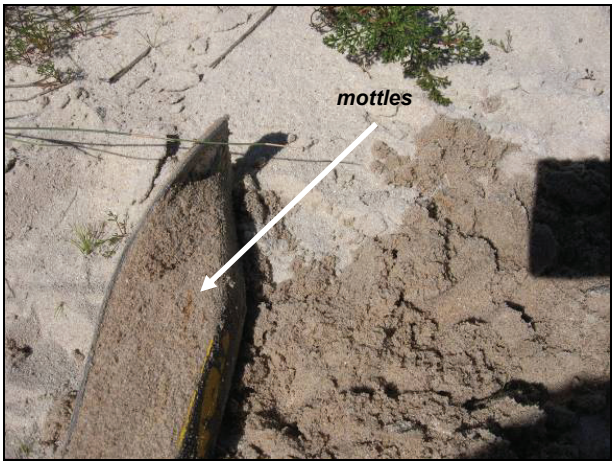
5.11 Philippi – depression, cape flats (private land)

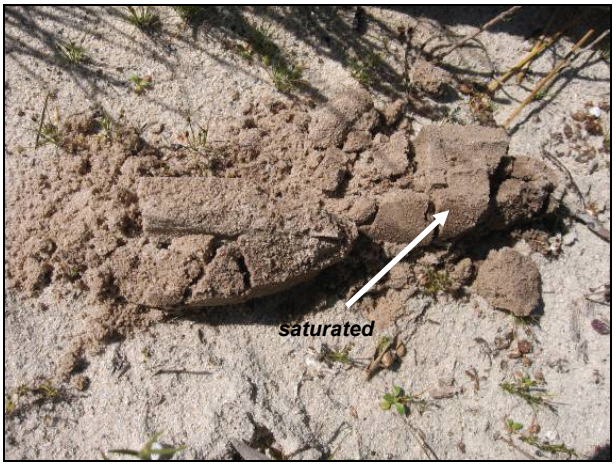
Altitude 20 m Latitude 34˚04'54.65" Longitude 18˚46'52.70"

Do normal circumstances exist on the site?	***No***
Is the site significantly disturbed (difficult site)?	***Yes***
Soil mining area – top of dunes mostly removed, some excavation.	
Is the area a Specific Case per Appendix A of the delineation manual?	***Yes***
Sandy soils coastal aquifer	

Indicators of wetness within 50 cm of soil surface		
Sulfidic odour		***No***
Organic soil		***No***
Mineral soil texture		**sand**
Gley		***No***
Mottles / concretions		***Yes***
Organic streaking / oxidised rhizospheres		***Yes***
High organic content in surface layer		***Yes***
Seasonal zone	***Temporary zone***	***Non-wetland***
high carbon in A horizon, low chroma colours, moist	**low chroma colours, moist**	**invariably brighter (more red in colour), with no mottles, no surface organic layer and dry**
(a) 0-12 cm light reddish grey (2.5YR 7/1) sand 12-30 cm light reddish grey (2.5YR 7/1) and dark reddish grey (2.5YR 3/1) sand 30+ cm light grey (Gley1 7N) (b) 1 cm high carbon / dark organic surface layer 1-40 cm light reddish grey (2.5YR 7/1) sand 40+ cm light grey (Gley1 7N) sand (c) light reddish grey (2.5YR 7/1) sandy soils with strong brown (7.5YR 5/8) distinct mottles	**grey (10YR 6/1) sand with strong brown (7.5YR 5/8) few, fine mottles**	**change to light grey in colour but only at 80+ cm**
Soil form		**Not formally surveyed**







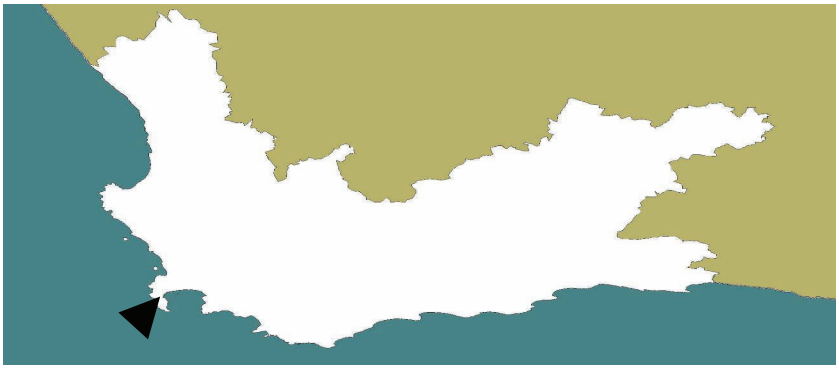
Setting				
crest (1) / scarp (2)	midslope (3)	footslope (4)	valley bottom (5)	
The available topographic setting for this site in the DWAF delineation manual is valley bottom (5), however, the wetlands occur within depressional areas, fed primarily by groundwater. The site is found at low altitude within sandy coastal dunes on the Cape flats.				
Additional indicators of wetland presence				
Concave				*Yes*
Bedrock				*No*
Impermeable clay				*No*
Flat				*No*
Associated with a river				*No*

Hydrology	
Permanent zone	
Inundated: *Yes, in places*	Depth of Surface Water : ~ *50-150 cm*
Seasonal zone	
Depth to saturated soil: 8-*15 cm*	Depth to free water in soil plot: 10-*20 cm*
Temporary zone	
Saturated within 50 cm of surface	*Yes*
The temporary zone was saturated at 40 cm during the field visit.	

Free water in the soil pit at 8 cm

Inundated

CAPE PENINSULA



View of Olifantsbos wetlands (arrows indicate wetland areas) – Cape Point.

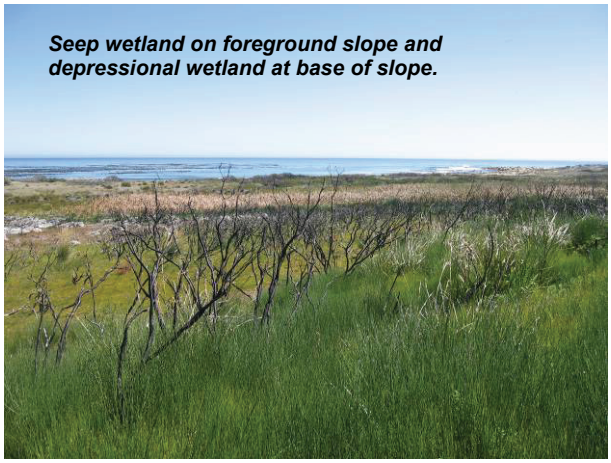
5.12 Olifantsbos - depression, flats and slope (SANParks, Table Mountain National Park)

Altitude 17 m Latitude 34˚18'17.83" Longitude 18˚25'11.12"

Do normal circumstances exist on the site?	***Yes***
Is the site significantly disturbed (difficult site)?	***No***
Is the area a Specific Case per Appendix A of the delineation manual?	***Yes***
Sandy soils	

Indicators of wetness within 50 cm of soil surface			
Sulfidic odour			***No***
Organic soil			***No***
Mineral soil texture:			**sand**
Mineral soils with the following signs of wetness:			
Gley			***No***
Mottles / concretions			***No***
Organic streaking / oxidised rhizospheres			***No***
High organic content in surface layer			***Yes***
Permanent zone	***Seasonal zone***	***Temporary zone***	***Non-wetland***
high carbon in surface layer, saturated to surface		**none noted**	**dry, higher chroma**
Soil form			**Not formally surveyed**

High carbon, black soils saturated to the surface. Pencil shows change from sand to clay sand.



Seep wetland on foreground slope and depressional wetland at base of slope.

Setting				
crest (1) / scarp (2)	**midslope (3)**	**footslope (4)**	**valley bottom (5)**	
Additional indicators of wetland presence				
Concave				***No***
Bedrock				***No***
Dense clay				***No***
Flat				***No***
Associated with a river (small stream)				***Yes***

5.13 Slangkop – slope (SANParks, Table Mountain National Park)

Altitude 80 m Latitude 34˚09'52.30" Longitude 18˚20'34.07"

Do normal circumstances exist on the site?	***Yes***
Is the site significantly disturbed (difficult site)?	***No***
Is the area a Specific Case per Appendix A of the delineation manual?	***Yes***
Sandy soils	

Indicators of wetness within 50 cm of soil surface			
Sulfidic odour			***No***
Organic soil			***No***
Mineral soil texture			**sand**
Mineral soils with the following signs of wetness:			
Gley			***No***
Mottles / concretions			***No***
Organic streaking / oxidised rhizospheres ***No***			
High organic content in surface layer			***Yes***
Permanent zone	***Seasonal zone***	***Temporary zone***	***Non-wetland***
high carbon in 2-5 cm surface layer, saturated to surface	**high carbon in 2-5 cm surface layer, saturated to surface**	**none noted**	**dry, higher chroma**
Soil form			**Not formally surveyed**

Setting				
crest (1) / scarp (2)	**midslope (3)**	**footslope (4)**	**valley bottom (5)**	
The available topographic setting for this site in the DWAF delineation manual is valley bottom (5), although it is also midslope (3)(5).				
Additional indicators of wetland presence				
Concave				***No***
Bedrock				***No***
Dense clay				***No***
Flat				***No***
Associated with a river (small stream)				***Yes***

Kniphofia in flower after a fire.

Hydrology **Seasonal zone**	
Depth to saturated soil: *0 cm* ***5cm***	**Depth to free water in soil plot:**
Temporary zone	**not observed**

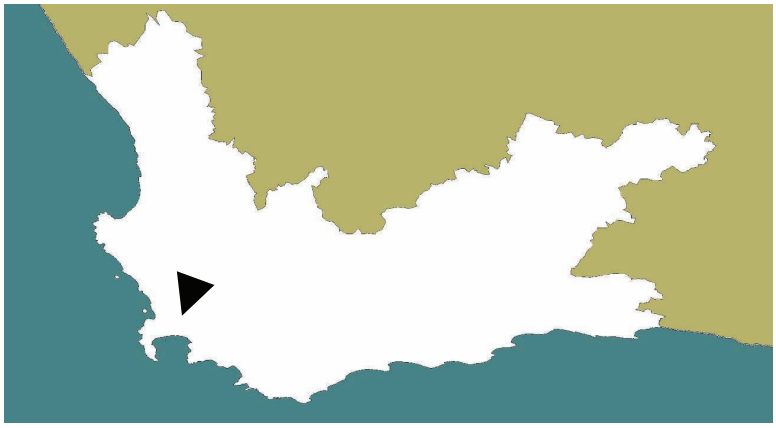
Vegetation

Seasonal zone: *Kniphofia, Ischyrolepis, Cyperus*

Non-wetland: *Not recorded*

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

STELLENBOSCH AREA



5.14 Rustenberg – slope and depression, Stellenbosch (private land)

Do normal circumstances exist on the site?	***No***
Is the site significantly disturbed (difficult site)?	***Yes***
Wetland cleared of indigenous vegetation in areas and pastures planted with kikuyu.	
Is the area a Specific Case per Appendix A of the delineation manual?	***No***

Indicators of soil wetness within 50 cm of soil surface		
Sulfidic odour		***No***
Organic soil		***No***
Mineral soil texture		**loamy clay sand**
Mineral soils with the following signs of wetness:		
Gley		***Yes***
Mottles / concretions		***Sparse***
Organic streaking / oxidised rhizospheres		***No***
High organic content in surface layer		**Occasional**
Seasonal zone	***Non-wetland***	
mottles, moist	**dry, higher chroma**	
Soil form		**Not formally surveyed**


The same soil in a wet and dry state.


Saturated to the surface.


Mottles


Mottles

Setting				
crest (1) / scarp (2)	**midslope (3)**	**footslope (4)**	**valley bottom (5)**	
Additional indicators of wetland presence				
Concave				***In places***
Impermeable bedrock				***No***
Impermeable clay				***No***
Flat				***No***
Associated with a river				***No***

Setting
Permanent zone: ***Typha capensis, Juncus sp., Isolepis prolifera.***
Seasonal zone: ***Pennisetum macruorum, Stenatophrum secundatum.***
Temporary zone: ***Not recorded***
Non-wetland: ***Not recorded***

*Note: species in **bold** are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

Pennisetum macruorum

A "difficult site" without indigenous plants

5.15 Spier - floodplain, depression, flats and slope (private land)

Altitude 21-50m Latitude 33˚58'33.77" Longitude 18˚47'01.45"

Do normal circumstances exist on the site?	***No***
Is the site significantly disturbed (difficult site)?	***Yes***
Impacted as a result of development of the site for past agricultural activities, multiple ditches criss-cross the wetland.	
Is the area a Specific Case per Appendix A of the delineation manual?	***No***

Indicators of soil wetness within 50 cm of soil surface	
Sulfidic odour ***No*** **Organic soil** ***No***	
Mineral soil texture	**sand / loamy clay sand**
Gley	***Yes***
Mottles	***Sparse***
Organic streaking / oxidised rhizospheres ***No***	
High organic content in surface layer	**Occasional**
Seasonal zone	***Non-wetland***
gley, moist	**dry, higher chroma**
(a) 0-25 cm dark grey (2.5Y 4/1) sandy clay with dark red (2.5YR 3/6) and brownish yellow (10YR 6/6) very common, fine, mottles **25-50 cm olive yellow (2.5Y 6/6) and light olive brown (2.5Y 5/3) fine clay** **(b) 0-25 cm brown (7.5YR 4/4) sand with yellowish red (5YR 4/6) distinct mottles** **25-50 cm brown (7.5Y 5/3) sandy clay** **50+ cm strong brown (7.5YR 5/6) clay** **(c) black sandy loam (10YR 2/1) over very dark gray (N3/ Gley)** **(d) 0-10 cm black mucky loam (10YR 2/1)** **10+ cm very dark gray (N 3/ Gley) silty sand** **(e) very dark gray sand (N 3/ Gley)** **(f) very dark grey (10YR 3/1) loamy sand with sparse yellowish red (5YR 5/8) mottles.**	**(a) dark grey (10YR 5/1) sandy loam. Dry September 2007** **(b) yellowish brown (10YR 5/1) sand, dry September 2007**
Soil form	**not formally surveyed**

October 2007 dark surface layer, high carbon.

Dark grey from 10 cm with sparse mottles.

Mottles.

Mottles, surrounded by low chroma matrix.

Free water 2 cm from the soil surface at the time of the site visit..

Hydrology **Permanent zone:**	
Inundated: ***Yes***	**Depth of Surface Water : ~ 10 cm**
Seasonal zone	
Depth to saturated soil: ***2-15 cm***	**Depth to free water in soil plot:** ***30-40 cm***
Temporary zone	**not observed**

Vegetation
Permanent zone: ***Typha*** **capensis,** ***Phragmites*** **australis** **Seasonal zone:** ***Pennisetum macrourum*****,** ***Typha capensis*****,** ***Phragmites australis*****,*****Juncus krausii, Zantedischia aethiopica*****,** ***Triglochin bulbosa, Spiloxene aquatica, Sparaxis sp., Watsonia meriana, Eleocharis limosa. Pennisetum clandestinum*****,** ***Plecostachys serpilifolia, Cyperus textilis, Drosera sp. Ficinia sp.*** **Non-wetland zone:** ***Briza major, Rumex sp. Plantago major, lupine, Elytropapus rinoceratus, Pennisetum clandestinum, Cynodon dactylon*** **and other non-indigenous grasses.**

Note: species in ***bold*** *are species included on the Hoare 2007 obligate wetland species list prepared for the DWAF delineation manual.*

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APPENDIX A: DATA SHEET

WETLAND DELINEATION DATA SHEET

Project/Site: _____ **Sample Plot #:** _____

Co-ordinates: _____ **Date:** _____

Investigator: _____

Do normal circumstances exist on the site? Yes No

Is the site a difficult site (significantly disturbed / naturally difficult)? Yes No

Is the area a Specific Case per Appendix A of the delineation manual? Yes No

Remarks:

TERRAIN CHARACTERISTICS INDICATOR

Position in the landscape
crest (1) ☐ scarp (2) ☐ midslope (3) ☐ footslope (4) ☐ valley bottom (5) ☐ **or a combination** ___
Landform: Slope %: _____ (6) floodplain (7) ☐ flat (8) ☐ concave (9) ☐

VEGETATION INDICATOR

	Dominant or indicator plant species within sample plot	OBL/FACW/FAC	% Cover
1.			
2.			
3.			
4.			
5.			
6.			
7.			

Are more than 50% of dominant species (> 50% cover) obligate, facultative wetland or facultative? Yes No

Remarks:

SOIL FORM INDICATOR

Permanent zone (circle if present) ***S****oil forms:* Champagne, Katspruit, Willowbrook or Rensburg
Seasonal and Temporary zones (circle if present) ***S****oil wetness indicators at:*
form level: Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu
family level: Inhoek, Tsitsikamma, Houhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee.

Project/Site: _____ **Date:** _____ **Sample Plot #:** _____

SOIL WETNESS INDICATORS

Soil Profile Description:

Depth (cm)	Horizon Designation	Matrix Color (Munsell)	Mottle Colors (Munsell)	Mottle Abundance/Contrast	Texture, Concretions, Rhizospheres, etc.

Features present within 50 cm of the soil surface:

- ☐ Organic soil
- ☐ High organic content in surface layer
- ☐ Organic streaking
- ☐ Low chroma, supported in remarks
- ☐ Gleyed matrix
- ☐ Mottle / concretions
- ☐ Sulfidic odour
- ☐ Oxidized Root Channels

HYDROLOGY INDICATORS

- ☐ Inundated
  Depth of Surface Water:_____ cm
- ☐ Saturated within 50 cm of surface
  Depth to Saturated Soil:_____cm
  Depth to Free Water in Pit:_____ cm
- ☐ Sediment Deposits
- ☐ Salt Crust
- ☐ Aquatic invertebrates
- ☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.
- ☐ Water-Stained Leaves
- ☐ Water Marks

Remarks:

WETLAND DETERMINATION

Terrain indicators present? Yes No
Vegetation indicators present? Yes No
Soil form or other supporting information? Yes No
Is this sampling plot within wetland?
Remarks (include a sketch of the site):

Soil wetness indicators present? Yes No
Hydrology indicators present? Yes No

Yes No

APPENDIX B:

RECOMMENDATIONS FOR INCLUSION IN DWAF DELINEATION MANUAL UPDATE

Table B-1. Recommendations for DWAF delineation manual update

1	Where it is known, use **soil form** as supporting information (not a primary indicator), taken within the context of further information gathered during the field survey.
2	Diagnostic features of soils can be drawn into an expanded list of indicators, such as the presence of organic soil or of an impermeable layer within 50 cm of the soil surface.
3	Group wetland soils into two broad categories: **organic** and mineral.
4	Make **organic soils** an indicator of wetland soils (in addition to gleying, mottles and other indicators)
5	Similarly, make **dark, high carbon surface layers** an additional indicator of wetlands
6	Guide delineators to thoroughly document site conditions through use of a **data sheet** similar to that prepared for this project.
7	Record **hydrology** during the site visit.
8	Make use of secondary indicators such as drift deposits etc as supporting information when defending whether an area is wetland.
9	In some cases, it may be necessary to recommend returning during the wet season.
10	Record the presence and depth of any restricting layers within 50 cm of the soil surface.
11	Emphasise that defensible delineation requires an interpretation of **all wetland indicators** (not only soils) found on the site, taken within the **context** of where the wetland is located.
12	Record **measurements and descriptions of soil profile** during the site visit.
13	For more complex or contentious sites, prepare a series of transects, use peizometers and / or an experienced soil scientist.
14	For wetland mosaic sites, it is sometimes expedient to delineate the outer edge of the mosaic, if wetland is the dominant condition.
15	Describe that gley colours can be matched to the gley pages of the Munsell Colour Charts (Munsell Color 1990), and that gley colour is not equal to grey (such as the grey of Fernwood soils which have a low chroma “E” horizon “leached” of colour). True gley is more of a blue/green colour.
16	Although the DWAF delineation manual lists a range of expected value and chroma for wetland soils sampled in the dry state, for practical purposes, the soil colours for this project were determined in soils that were **moist**, where a matrix chroma of 1 or 2 was considered “low chroma”.
17	Allow all of the above indicators to be drawn from when delineating a wetland, especially if a precautionary approach is advocated, where landscape context and an assessment of vegetation and hydrology is also taken into consideration.

Table B-2. Wetland indicators described in this report, and the section where they are discussed.

TERRAIN CHARACTERISTICS (*see Section 2.2.1 of this report*)	
Valley bottom	**Slope**
Concave / depression	**Flat**
Presence of an impermeable layer within 50 cm of the soil surface	
WETLAND HYDROLOGY *(see Section 2.2.3 of this report)*	
Permanent water regime	
Visual observation of water within 50 cm of the soil surface (within a soil pit)	
SOIL WETNESS INDICATORS *(see Section 4 of this report)*	
Organic soils (*see Section 2.1 of this report*)	
Sulphur smell (*see Section 3.2 of this report*)	
Gleyed matrix starting within 30-50 cm of the soil surface (*see Section 3.1*)	
Soils with contrasting mottles and low chroma matrix** (*see Section 3.1*)	
High organic matter in the surface horizon (*see Section 3.3 of this report*)	
Streaking of subsurface horizon by organic matter (*see Section 3.2*)	
Oxidised root channels (*see Section 3.2 of this report*)	
Soils with low chroma matrix** (*see Section 3.3 of this report*)	
HYDROPHYTIC VEGETATION INDICATOR *(see Section 2.2.2 of this report)*	
New list prepared for DWAF delineation manual update	

*** Horizon in this context means a layer of the soil**
****Soil matrix is the portion of the soil layer (usually more than 50%) which has the predominant colour.**

Table B-3. List of types of site that are difficult to delineate.

Type of "difficult site"	**Approach**
Some, or all, wetland indicators *are present* but it is a **non-natural wetland** (e.g. some dams, road islands)	- Decide on the relative permanence of the change and whether the area can now be said to be functioning as a wetland. - Time field observations during wet season, when natural hydrology is at its peak, to help to differentiate between naturally-occurring versus human-induced wetland. - Decide appropriate policy / management i.e. can certain land uses be allowed due to "low" wetland functional value, or does wetland perform key function despite being "artificial".
Indicators of soil wetness *are present* but **no longer a functioning wetland** (e.g. wetland has been drained)	- Look for evidence of ditches, canals, dikes, berms, or subsurface drainage tiles. - Decide whether or not the area is currently functioning as a wetland.
Indicators of soil wetness *are present* but **no longer a functioning wetland** (e.g. relict / historical wetland)	- Decide whether indicators were formed in the distant past when conditions were wetter than they are today. - Obtain the assistance of an experienced soil scientist.
Some, or all, wetland indicators *are absent* at **certain times of year** (e.g. annual vegetation or seasonal saturation)	- Thoroughly document soil and landscape conditions, develop rationale for considering the area to be wetland. - Recommend that the site be revisited in the wet season. (In many cases soil wetness indicators are still present.)
Some, or all, wetland indicators *are absent* due to **human disturbance** (e.g. vegetation has been cleared, wetland has been ploughed or filled)	(In the case of ploughing or invasive alien species infestation, soil wetness indicators typically still present.) - Thoroughly document landscape conditions and any remnant vegetation, soil, hydrology indicators, develop rationale for considering the area to be wetland. - Certain cases (illegal fill) may justify that the fill be removed and the wetland rehabilitated.
Indicators of soil wetness *are absent* because soils are **"difficult soils".**	**These situations are the "Specific Cases" already included in Appendix A of the DWAF manual.**