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City Wetlands Map: Phase 5 - Ground-truthing and map update

Submitted to:
CITY OF CAPE TOWN
Department of Environmental Resource Management

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1 INTRODUCTION

1.1 General Introduction

The development of a comprehensive wetlands map for the City of Cape Town (hereafter referred to as the City) was recognised in 2006 as an urgent requirement both for planning purposes as well as management of the City's wetland resources. In particular, a comprehensive wetlands layer, including information on wetland type, was urgently needed for prioritization of areas to be included in the City's Biodiversity Network. The City's existing GIS coverages pertaining to the various wetlands within its jurisdiction were considered to be incomplete, in terms of wetland location, and inconsistent, in terms of wetland (or waterbody) classification. The City of Cape Town's Department of Environmental Resource Management, therefore initiated a study to consolidate existing GIS wetland covers for the City, as well as to update these spatial data, with additional wetlands identified and mapped from ortho-rectified aerial imagery of the City.

The Freshwater Consulting Group (FCG) (Phases 1, 3 and 4) and Jeffares and Green (Pty) Ltd (Phase 2) completed a desktop spatial wetlands layer for the City of Cape Town, referred to as the City Wetlands Map, in June 2008. The complete wetlands map comprises approximately 8000 polygons classified as wetlands, of which approx. 3500 are classified as known anthropogenic features, while the remaining 4500 wetlands (total area of 8875 hectares (ha)) are considered to be natural or semi-natural. The City Wetlands Map was produced from a largely desktop assessment of aerial photography, with the limited inclusion of information from field assessments completed by FCG and other consultants for separate studies. Where field verification was undertaken, the confidence with which the wetlands were mapped was high, while a low confidence was associated with the desktop mapping of most of the City's wetlands.

In order to increase the confidence with which the wetlands have been mapped, in terms of location, and classified, it was deemed necessary to ground-truth a sub-set of the wetlands included on the Map. This report presents the results of the ground-truthing phase of work.

1.2 Terms of reference for ground-truthing

The terms of reference for the ground-truthing of the City Wetlands Map were as follows:

- Test the accuracy of the City Wetlands Map in terms of wetland presence, and wetland classification;
- Confirm the description of each wetland as "natural and semi-natural" (assigned the descriptor "none" in the "anthropogenic type" attribute field in the wetland database) *versus* the various categories of artificial wetland assigned to the mapped wetlands;
- Propose a wetland typing system. It was proposed that a number of wetlands of each type be visited during ground-truthing. Field verification should also aim to test the appropriateness (in terms of whether the grouping of wetlands into types makes sense, and whether the names assigned to each wetland type adequately describes that type) of the wetland types.
- Devise a desktop method for assessment of wetland condition, sensitivity, importance and level of threat. Wetlands in a range of conditions were required to be visited in the field, thus also allowing verification of the accuracy of the desktop assessment of wetland condition. Highly sensitive, highly threatened and important wetlands should be one of the focuses of field verification;

- Devise a rapid field method for assessment of wetland condition. A rapid method for assessing condition was to be used due to the time constraints for field verification. The field-based assessment of wetland condition was to be used to refine the initial desktop assessment of condition completed prior to ground-truthing, thus allowing greater confidence in the assessment of condition for those wetlands not visited during ground-truthing.
- Develop field verification protocol and manage the process. This was to be developed with a clear understanding of the objectives and spatial extent of the exercise. Datasheets were to be produced and discussed prior to any work being undertaken.

1.3 Definitions

The National Wetland Classification System developed for the National Wetland Inventory defines wetlands as "*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tides does not exceed ten meters"* (Ewart-Smith *et al.* 2006). This is an adaptation of the definition adopted by the Ramsar Convention, which limits marine water to a depth of six meters at low tide (Davis 1994). Accordingly, wetlands are areas where water is the primary factor controlling the environment and therefore, wetlands develop in areas where soils are saturated or inundated with water for varying lengths of time and at different frequencies. Within this classification, three primary systems are identified, namely Marine, Estuarine and Inland. For the purposes of this project, only Estuarine and Inland systems were visited and of the Inland systems, the wetland category "channels" (i.e. river channels) were excluded from the assessment because these have already been included in the City's river centre-line GIS layer. Therefore, wetlands included within the wetland layer generated during this project fall largely within the wetland definition outlined in the South African Water Act (Act 36 of 1998) as "*land which is transitional between terrestrial and aquatic systems, where the water table is usually at, or near the surface, or the land is periodically covered with shallow water and which land in normal circumstances supports, or would support, vegetation adapted to life in saturated soil*". Large vleis / coastal lakes were included in the wetlands addressed.

The use of the word "classification" in this report refers to the process of applying the draft National Wetlands Inventory Classification System of Ewart-Smith *et al.* (2006), while "typing" refers to the grouping of wetlands into types that includes both the NWICS classification and a suitable environmental descriptor.

"Semi-natural" wetlands refers to those systems that are thought to have formed naturally, but which may now appear largely artificial. Given the lack of adequate information on the historical location and extent of wetlands within the City, many of the semi-natural wetlands may indeed be artificial.

1.4 Limitations

The focus of this phase of work was to verify the presence, classification and condition of **natural and semi-natural** wetlands within the City of Cape Town. Data on artificial wetlands were edited where these systems were encountered during field verification, and wetlands originally described as artificial were changed to natural or semi-natural where relevant and *vice versa*, but no new information on artificial wetlands was added. Furthermore, this phase of work did not address the rivers, streams and channels of the City.

This study did not aim to delineate the extent of wetlands, as recommended in the DWAF (2005) wetland delineation protocol. An attempt was made to take at least one GPS point at each wetland visited, however, these data were for accuracy of editing the Wetland Map, and have not been recorded or presented.

Primary data, such as water quality, algae, plants or invertebrates, were not collected from the wetlands visited.

2 GROUND-TRUTHING PROTOCOL

2.1 Objectives of ground-truthing

The objectives of the ground-truthing phase were workshopped at a meeting with the City on 28th October 2008, and were concluded to be verification of the following:

- Wetland presence (based on visual cues such as vegetation, topography and hydrology, i.e. not soils);
- Wetland classification (according to the **draft** National Wetlands Inventory Classification System (NWICS) of Ewart-Smith *et al.* (2006));
- Naturalness – attempts should be made to ascertain whether the wetlands visited in the field are indeed natural or semi-natural features – and transformation – where wetlands have obviously been transformed due to anthropogenic activities;

In addition, the following information would be collected, for inclusion in the City Wetlands database as additional attribute fields:

- Wetland condition;
- Brief description of dominant vegetation and alien vegetation in the wetland;
- Impacts affecting the condition of the wetland, and
- Surrounding land-use within 100m and 1km of the wetland.

2.2 Data format

The projection system used by the city is Transverse Mercator, Lo 19, based on WGS84. All spatial data inputs were therefore projected as WGS84, Lo19.

2.3 Proposed wetland types

In the development of the City Wetlands Map, the primary objectives were the identification and mapping of rough wetland extent of wetlands. A secondary objective was the capture of as much attribute information as possible within the constraints of a visual interpretation of orthophotos, as well as existing, easily available information, and within the constraints of the time and budget allocated to the project. The desktop classification of wetlands was undertaken up to Level 4 of the draft NWICS of Ewart-Smith *et al.* (2006, and see Ewart-Smith *et al.* (2008) for more detail on the NWICS). Briefly, the NWICS is hierarchical, dividing wetlands into increasingly refined categories at four levels. Level 1 of the classification identifies broad categories of Systems, further subdivided into Subsystems (Level 2 of the classification). At the third level in the hierarchy attributes such as landform and setting, which determine the nature of water movement through wetland ecosystems, are used to discriminate additional wetland categories, called Functional Units. Finally at Level 4, discriminators such as dominant cover and life-form define "Structural Units".

One of the objectives of the ground-truthing exercise was to verify the desktop classification of wetlands to a certain extent, within the limitations of using topography and position in the landscape as indicators of the hydrogeomorphic wetland units. The actual application of these classification protocols usually requires field-based evaluation of such aspects as soils, vegetation and seasonality. Furthermore, this classification system is in the development stage and is presently under its second revision during which its application in the field will be tested. Field verification of the wetland classification did, however, allow for increased confidence in the classification included in the database.

Three levels of confidence were provided: a 'High' confidence rating indicates that the mapper and/or ground-truther were certain of the wetland class, whilst a 'Moderate' or 'Low' confidence rating indicates that the classification may change with fine-tuning of the classification system, or that further field verification is required.

In addition to the classification of wetlands according to NWICS, it was proposed that the City's wetlands be grouped into wetland types, which could be based on the classification according to NWICS and an appropriate environmental descriptor. In doing so, the full complement of wetlands in the City can be described in terms of the types of wetlands occurring there. The assumption is that landform shape, and setting (i.e. gradient and position in the landscape) determine the nature of water movement into, through, and out of a wetland, and the functions that the wetland is able to provide. Typing wetlands based on how they function (i.e. the functional units of NWICS), focuses attention on the functions that wetlands of a specific type are most likely to perform, while the landscape and ecosystem factors (such as vegetation group) are most likely to influence how wetlands of that type function. It is useful to identify the geographic areas in which the factors that influence wetland function (i.e. the ecosystem drivers) are similar, in order to ensure that wetlands that respond to these influences in similar ways are grouped together. This allows the preparation of management recommendations that are relevant to a particular type of wetland, and which will aim at ensuring the continued functioning of that type of wetland.

Table 1 The draft National Wetland Classification System (taken from Ewart-Smith *et al.* 2006) for South Africa, showing the classification hierarchy as far as Level 3 (Functional Units).

LEVEL 1: SYSTEM	LEVEL 2: SUBSYSTEM	LEVEL 3: FUNCTIONAL UNIT		
		A	B	C
Primary discriminators				
Connectivity to open ocean	*Drainage*	*Landform (shape and/or setting)*		*Tidal regime / Depth class*
MARINE	N/A	Exposed Coast		Subtidal
				Intertidal
				Supratidal
		Sheltered Coast (Embayment)		Subtidal
				Intertidal
				Supratidal
ESTUARINE	Permanently Open	Estuarine Bay		Subtidal
				Intertidal
				Supratidal
		Estuarine Depression		Subtidal
				Intertidal
				Supratidal
		Estuarine Channel		Subtidal
				Intertidal
				Supratidal
		River Mouth		Subtidal
				Intertidal
				Supratidal
	Temporarily Closed	Estuarine Depression		Subtidal (open) / Limnetic (closed)
				Intertidal (open) / Littoral (closed)
				Supratidal
		Estuarine Channel		Subtidal (open) / Limnetic (closed)
				Intertidal (open) / Littoral (closed)
				Supratidal
INLAND	Non-isolated	Channel (river)	Mountain headwater	
			Mountain stream	
			Transitional	
			Upper foothill	
			Lower foothill	
			Lowland stream	
		Valley bottom	With channel	
			Without channel	
		Floodplain	Meander cut-off	
			Floodplain flat	
			Floodplain pan	
		Depression linked to a channel	With channelled outflow	
			Without channelled outflow	
		Seep with channelled outflow	Basin seep	
			Hillslope seep	
	Isolated	Isolated depression		
		Seep without channelled outflow	Basin seep	
			Hillslope seep	

The latest revision of the NWICS proposes that wetlands be classified according to the ecoregion within which they lie. The City's wetlands lie within two ecoregions:

- **Southern folded mountains:** Terrain morphological types consist of plains with low relief (limited), table lands, high mountains with high relief, low mountains with high relief, closed hills with moderate relief and open hills with high relief. Vegetation consists of a variety of fynbos, renosterveld and succulent karoo types.
    - Median annual simulated runoff per quaternary catchment varies widely from <5 mm to > 250 mm. The coefficient of variation for annual simulated runoff per quaternary catchment varies from < 40% to > 160 %.
    - MAP varies from 100 - > 1200 mm, while mean annual temperature varies from 10 to 20 ºC.
    - Altitude varies from 200 – 1750 m.
    - Slopes <5%: <20% but >80% in limited areas
    - Rock types include shale, tillite, sandstone and quartzitic sandstone.

  - Soil texture types include sand-clay-loam, clay-loam, sand-loam, sand-clay.
- **South western coastal belt:** Plains with a moderate to low relief are characteristic of the region, with altitude varying from sea level to 900 mAMSL.
  - Mean annual precipitation: Moderate in a limited area in the south, decreasing to low in the north.
  - Coefficient of variation of annual precipitation: Moderate/high in the north with a restricted area being low in the south.
  - Drainage density: Low.
  - Stream frequency: Low/medium.
  - Slopes <5%: <20% in most areas.
  - Median annual simulated runoff: Very low in the north to moderate/high in the south.
  - Mean annual temperature: Moderate/high.

While the ecoregions provide information on the types of wetlands occurring within them, they are considered too broad to be of use in splitting wetlands into types. Furthermore, the ecoregions have been determined based on the physical, chemical and vegetation characteristics of rivers, so are not necessarily useful for all wetland types.

The typing recommended here adopts the Level 3A classification of the NWICS for inland and estuarine wetlands (see Table 1), combined with the vegetation group (not vegetation unit), according to the City's vegetation map and the South African vegetation map (Rebelo *et al.*, 2006) within which the wetland lies. Rebelo *et al.* (2006) categorised all estuaries in the Western Cape lying south of Lamberts Bay as Cape Estuarine Saltmarsh, and thus the estuarine wetlands of the City fall within 3 wetland types – Cape estuarine channels, Cape estuarine depressions and Cape river mouths. The remaining inland wetlands of the City are divided amongst 33 wetland types (see Results Section and Table 5).

2.4 Functional importance, ecological sensitivity and level of threat

Table 2 presents a proposed list of criteria for the assessment of the functional importance – defined as *the importance of a particular wetland type in maintaining the performance of key ecological functions (important for the persistence of that ecosystem, but also other surrounding ecosystems), and so also providing goods and services to humans* - and ecological sensitivity - defined as *the wetland type's ability to **resist** disturbance (both natural and anthropogenic) and its capability to recover from disturbance once it has occurred (**resilience**)* - of each wetland type. These criteria were developed for the C.A.P.E. fine-scale biodiversity planning project (see Snaddon *et al.*, 2008) and were sourced from the literature and from the ecological importance and sensitivity (EIS) method, which is recommended by DWAF (1999) for the assessment of wetlands.

While these criteria may be useful if applied at the level of the individual wetland, it is difficult to apply these criteria for a whole wetland type. Thus, it is proposed that these criteria rather be used for prioritisation of wetlands (i.e. the next phase of work) for conservation of biodiversity.

In the results section below, an overall functional importance and ecological sensitivity assessment is made for each wetland type, based loosely on the criteria in Table 2, and on the information provided in Nel *et al.* (2006) (see Table 3) for the wetlands of the Olifants-Doring river catchment. This information is based on the ecosystem goods and services provided by each Level 3A functional wetland unit, as defined in the NWICS.

The probable level of threat facing each wetland type was ascertained from the conservation status of the surrounding vegetation type and also the position of the wetlands in the landscape – i.e. wetlands that tend to occur on the lowlands (estuaries, floodplains, lowland valley bottom wetlands, and isolated depressions) are more threatened by development and agriculture, while those occurring on the higher land (seeps, mountain valley bottoms) tend to be less threatened, with many occurring in Protected Areas.

Table 2 A list of relevant criteria for the assessment of functional importance and ecological sensitivity of each wetland type.

Indicator						
Function		**LOW**		**MODERATE**		**HIGH**
Flood storage; energy dissipation		Size < 2 hectares		Size 2 – 5 hectares		Size > 5 hectares
		Riverine or lakeshore wetland		Mid-sloped wetland		Depressions, headwaters, bogs, flats
		Located in lower 1/3 of drainage		Located in middle 1/3 of drainage		Located in upper 1/3 of drainage
Stream flow augmentation ; groundwater storage &/or recharge		Size < 2 hectares		Size 2 – 5 hectares		Size > 5 hectares
		Riverine or lakeshore wetland		Mid-sloped wetland		Depressions, headwaters, bogs, flats
		Located in lower 1/3 of drainage		Located in middle 1/3 of drainage		Located in upper 1/3 of drainage
		Temporarily flooded or saturated		Seasonally or semi-permanently flooded or saturated		Permanently flooded or saturated, or intermittently exposed
		Not important for groundwater recharge		Low importance for groundwater recharge		Moderate to high importance for groundwater recharge
Erosion control; sediment trapping		Sparse grass/herbs or no vegetation along edge		Sparse forest or vegetation along edge		Dense forest or vegetation along edge
		< 50 % vegetation cover		50 - 80% cover		>80% vegetation cover
Water quality improvement		Size < 2 hectares		Size 2 – 5 hectares		Size > 5 hectares
		Rapid flow through site		Moderate flow through site		Slow flow through site
		< 50 % vegetation cover		50 - 80% cover		>80% vegetation cover
		Buffers very disturbed		Buffers slightly disturbed		Buffers not disturbed
		Holds < 25% overland runoff		Holds 35 - 50% overland runoff		Holds > 50% overland runoff

Indicator						
Function		**LOW**		**MODERATE**		**HIGH**
Biological diversity: rare and endangered species; populations of unique species; species/taxon richness		Low taxon diversity		Moderate taxon diversity		High plant diversity
		Buffers very disturbed		Buffers slightly disturbed		Buffers not disturbed
		Isolated from upland habitats		Partially connected to upland		Well connected to upland
		No rare/endangered spp		One rare/endangered sp		More than one rare/endangered sp.
		No unique populations		One unique population		More than one unique population
Habitat diversity; migration, feeding or breeding node; refuge areas (ecological integrity)		Size < 2 hectares		Size 2 – 5 hectares		Size > 5 hectares
		Few habitat features		Some habitat features		Many habitat features
		Not important for feeding		Low importance for feeding		Moderate to high importance for feeding
		Not important for breeding		Low importance for breeding		Moderate to high importance for breeding
		Not important for migration		Low importance for migration		Moderate to high importance for migration
		Not important as refuge		Low importance as refuge area		Moderate to high importance as refuge area
Sensitivity to change in hydrology, water quality		Not sensitive to changes in water quantity / flow regime		Low sensitivity to changes in water quantity / flow regime		Moderate to high sensitivity to changes in water quantity / flow regime
		Not sensitive to changes in water quality		Low sensitivity to changes in water quality		Moderate to high sensitivity to changes in water quality
Food chain support		Size < 2 hectares		Size 2 – 5 hectares		Size > 5 hectares
		Agricultural land, low vegetation structure		Two level vegetation		High vegetation structure
		Seasonal surface water		Permanent surface water		Open water pools through summer
		Low primary productivity		Moderate primary productivity		High primary productivity
		Low organic accumulation		Moderate organic accumulation		High organic accumulation
		Low organic export		Moderate organic export		High organic export

Table 3 A proposed assessment of the functional importance and ecological sensitivity of the functional wetland units of the NWICS. Taken from Nel *et al.* (2006).

Wetland type	Functional importance	Sensitivity	Protection level
Valley bottom (channelled)	Very high	High	High
Valley bottom (unchannelled)	High	High	Moderate
Floodplain	High	Moderate	Moderate
Depression	Moderate	Moderate	Moderate
Seep (channelled)	High	Very High	High
Seep (unchannelled)	Moderate	Very High	Moderate

2.5 Assessment of wetland condition

2.5.1 Desktop assessment

An initial desktop assessment of wetland condition was required prior to ground-truthing, in order to ensure that wetlands in a range of condition were visited. The desktop method of assessment involved the intersection of the natural and semi-natural wetlands with the City's Biodiversity Network spatial layer. Wetlands entirely or mostly within areas of the network categorized as "high" (natural) in terms of habitat condition were thus considered to be "high" in terms of the overall condition of the wetland; "medium" or near natural = "medium"; "low" or restorable = "low"; "transformed" and the remaining area = "transformed" (Table 4). This desktop assessment was then checked against the results of the assessments of condition performed in the field.

The version of the Biodiversity Network used for this procedure did not contain the breakdown into various categories of Critical Biodiversity Area, Other Ecological Support Area, etc. This breakdown will be performed during prioritisation of the City wetlands.

Table 4 The location of the City wetland types in relation to the City's Biodiversity Network broad categories of "high", "medium", "low" and "transformed".

			Location in relation to broad Biodiversity categories				
	Wetland type	**Total number of wetlands**	**HIGH**	**MEDIUM**	**LOW**	**TRANS-FORMED**	**NOT IN NETWORK**
1	**Alluvium fynbos depression**	4	-	1	-	-	3
2	**Alluvium fynbos floodplain**	8	1	-	3	1	3
3	**Alluvium fynbos seep**	63	8	-	6	-	49
4	**Alluvium fynbos valley bottom**	7	2	-	2	-	3
5	**Alluvium renosterveld valley bottom**	1	-	-	-	-	1
6	**Dune strandveld depression**	682	277	109	67	8	221
7	**Dune strandveld floodplain**	199	173	4	5	-	17
8	**Dune strandveld seep**	159	62	6	2	1	88
9	**Dune strandveld valley bottom**	26	15	2	4	-	5
10	**Granite fynbos depression**	11	2	-	-	-	9
11	**Granite fynbos floodplain**	29	2	1	-	-	26
12	**Granite fynbos seep**	273	191	11	8	4	59
13	**Granite fynbos valley bottom**	74	20	1	1	2	50
14	**Granite renosterveld depression**	3	1	1	-	-	1
15	**Granite renosterveld floodplain**	1	-	-	-	-	1
16	**Granite renosterveld seep**	32	4	2	-	-	26
17	**Granite renosterveld valley bottom**	19	2	-	-	-	17
18	**Sand fynbos depression**	500	92	24	70	9	305
19	**Sand fynbos floodplain**	256	172	8	4	4	68
20	**Sand fynbos seep**	444	65	13	60	18	288
21	**Sand fynbos valley bottom**	84	11	3	9	1	60
22	**Sandstone fynbos depression**	38	36	-	-	1	1
23	**Sandstone fynbos seep**	839	823	2	4	8	2
24	**Sandstone fynbos valley bottom**	104	97	1	3	2	1
25	**Shale band seep**	5	5	-	-	-	0
26	**Shale fynbos seep**	72	53	8	3	2	6
27	**Shale fynbos valley bottom**	12	6	3	-	1	2
28	**Shale renosterveld depression**	42	-	3	5	2	32
29	**Shale renosterveld floodplain**	32	-	4	-	-	28
30	**Shale renosterveld seep**	204	9	3	4	7	181
31	**Shale renosterveld valley bottom**	68	2	2	5	-	59
32	**Silcrete renosterveld seep**	7	1	-	1	-	5
33	**Silcrete renosterveld valley bottom**	2	-	-	-	-	2
34	**Cape estuarine channel**	10	7	-	-	-	3
35	**Cape estuarine depression**	15	13	-	-	-	2
36	**Cape river mouth**	9	2	1	-	1	5

2.5.2 Field assessment

Subsequently, a rapid method for assessing condition in the field, based on existing methods including WET-Health (MacFarlane *et al.*, 2005) and the Wetland Index of Habitat Integrity (DWAF, 2007), was developed. Although the initial desktop assessment of condition was used to inform the selection of ground-truthing sites, only the results of the field assessment were recorded in the database.

Similar to the WET-Health assessment, the impacts affecting each wetland were divided into four categories – modifications to the **vegetation** in and around (up to 50m) the wetland, **physical** modifications to the wetland (e.g. those affecting the geomorphology or extent of the wetland), and modifications to **water quality** of the wetland and **water quantity** in and / or out of the wetland. Each impact category was given a percentage score – where 0 is no impact and 100% means complete modification of that aspect of wetland condition – which relates to the magnitude of the impact or stressor. The magnitude of the impact is a combination of the extent and intensity of the impact (MacFarlane *et al.*, 2005), as follows:

Rating (%)		Intensity in the impacted area				
		Low	Moderate	High	Serious	Critical
Extent of impacted area	Small	1	2	3	4	5
	Moderate	2	6	7-13	14-19	20-24
	Large	3	7-13	25	26-38	39-50
	Extensive	4	14-19	26-38	51-56	57-75
	Entire	5	20-24	39-50	57-75	75-100

As a guide in the field, the following specific impacts within each category were listed as likely impacts on City wetlands, in increasing order of magnitude (many of these were taken from DWAF's (2007) Wetland Index of Habitat Integrity):

Specific impact within each category	Modifications to wetland condition, listed in order of decreasing magnitude
Modifications to vegetation in and around (50m) the wetland	
Weeds or Invasive plants	Highly invasive spp; excludes indigenous vegetation or covers waterbody
	Competitive invasive spp (including indigenous invasives) inhibits indigenous vegetation or covers part of waterbody
	Invasive spp have little perceptible effect on indigenous vegetation
Vegetation Clearing/Loss/Alteration	Dam
	Cropping - currently ploughed fields OR grassland/shrubland to woodland transition
	Planted pastures
	Historical ploughing OR Heavy grazing
Infilling/Backfilling	Most of wetland filled, affecting vegetation
	Isolated/sporadic infilling; natural vegetation persists
Mining/Excavation	Active Open Cast mining of the wetland
	Deep (>2m) sand mining
	Shallow sand mining

Specific impact within each category	Modifications to wetland condition, listed in order of decreasing magnitude
Physical modifications to wetland	
Presence of roads through/close to wetland	Road through wetland
	Road around perimeter of wetland
	Road affecting flow into or out of wetland
Canalisation / channelisation	Canalisation (concrete)
	Channelisation (i.e. modifications to bed and banks to direct flow)
Hardening of wetland / surrounding area	Loss of wetland through hardening (e.g. buildings, roads, parking lots)
	Hardening around perimeter of wetland
Infilling / excavation of wetland	Bed of wetland
	Banks of wetland
Erosion	Extensive donga formation (>5m deep) and associated threat of erosion across the whole wetland
	Some erosion dongas; or incised main channel (cut/vertical banks on both sides of the channel for more than 80% of the length of the channel), but no other headcuts into the wetland
	Grazing but no erosional dongas/gullies; and/or Ploughing (<50% of the wetland) but no erosional dongas/gullies
Modifications to water quality in wetland	
Stormwater input	From industrial
	From residential only
	From roads only
Effluent input	Mining
	Industrial
	Agricultural
	Residential
Litter	
Increased sediment input	
Modifications to water quantity into or out of wetland	
Connectivity in channeled wetlands (including floodplains) - altered channel width/depth so no overtopping of banks	Channel is so incised that there is no overtopping of banks
	100% change in width/depth of channels
	50% change in width/depth of channels
Changes in flood peaks/frequencies	Large dam upstream with no flow releases OR entirely urbanised catchment
	Numerous small dams OR smallholdings / plots
	One small dam OR heavy grazing
Changes in base flows	Large sewage OR stormwater inflows: probably doubling base flow
	>50% reduction in baseflow
	Moderate levels of irrigation/abstraction OR discharge of indirect flows from upstream hardened areas
Changes in seasonality	Complete switch in seasonality, i.e. seasonal/temporary to permanent
	Moderate shift in seasonality

The magnitude of each specific impact was scored, or where this was difficult to disaggregate, the specific impacts were scored collectively for the category.

In order to summarise the impact scores, the uppermost scores within each cell were summed and averaged, and the total subtracted from 100% (this is the benchmark), in order to place the wetland in a habitat integrity class (or category, see Table 5) (see MacFarlane *et al.*, 2005). The habitat integrity of a wetland is a measure of the degree of intactness of that wetland.

Table 5 Wetland habitat integrity classes (based on Kleynhans, 1996).

CLASS	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

In addition to the field assessment of wetland condition, information was also collected on the dominant vegetation within the wetland (genera or species, where possible), and the dominant alien vegetation (primarily woody aliens, but also including alien grass species).

The surrounding land-use was also recorded, as an indication of the condition of the catchment within which the wetland lies. A list of possible land-uses was provided for selection on the datasheet, and the field worker was encouraged to rate the land-uses in order of dominance.

2.6 Field procedure

Each member of the ground-truthing team went into the field with the field datasheet (see Appendix 1), an A3 full-colour map of the area to be visited (wetlands within an area of approximately 4 – 25 km^2 were the focus for one day of ground-truthing), which included the unique identifier for each wetland, a GPS and a camera. A datasheet was filled in for each wetland, or for each group of similar wetlands, and several photographs taken. GPS readings were taken where there was some doubt as to the location of the wetland, for later verification. Where the outline of the wetland visited was markedly different from that mapped, the outline was amended on the hardcopy map.

The datasheets were returned to Kate Snaddon, who was responsible for entering the data and updating the City Wetlands Map.

3 RESULTS OF GROUND-TRUTHING

3.1 Overview

The updated City Wetlands Map includes 376 wetlands that have been ground-truthed, in terms of wetland location, approximate extent, classification and condition (see Figures 1A and 1B). This represents just over 8% of the total number of natural and semi-natural wetlands included on the City Wetlands Map. The consultant ground-truthing team comprised Kate Snaddon and Dean Ollis of the Freshwater Consulting Group (FCG), Lee Jones of the Independent Vegetation Consultancy (IVC), Nancy Job (independent consultant) and Ross Turner (Ross Turner Botanical Surveys). Ground-truthing was also done by various staff of the City of Cape Town, including Pat Holmes, Ian Cranna and Tumeka Mdlazi.

The ground-truthing teams visited 208 wetlands, of which 40 were not wetlands (and so were deleted), 19 were merged with at least one other wetland polygon (e.g. where previously disconnected wetlands were discovered to be one, continuous system) and 5 were not natural or semi-natural wetlands, but were found to be artificial systems (see Table 6). Twelve wetlands were added, while many were edited in terms of shape, extent and attribute data.

A total of 211 wetlands were ground-truthed during other consultancy projects, primarily by FCG – these assessments did not lead to deletion of wetlands, but rather to an increase in detail in mapping, thus to a higher number of wetland polygons.

In order to gauge the accuracy of the Phase 4 City Wetlands Map, the number of occasions when wetlands visited in the field were not present, or were added, was calculated. The merging, editing or re-definition of wetlands as natural/semi-natural or artificial was not included in the assessment, as these procedures are considered to be a refinement of the database, rather than corrections. Based on the total number of wetlands visited by the ground-truthing team, *versus* those deleted or added, it can be concluded that the Phase 4 Map was approximately 75% accurate in terms of mapping wetland *location*. However, it is more useful to calculate where these deletions/additions occurred, as parts of the Map could be more accurate than others. The sandstone fynbos seeps were the most inaccurate, at 39% mapping accuracy, followed by shale renosterveld depressions at 40%. The mapping of sand fynbos depressions was found to be 86% accurate, while that of dune strandveld depressions was 55% accurate. Granite fynbos seeps were mapped at 63% accuracy. Ignoring those instances where the sample size was very low (e.g. only 2 wetlands were visited), the mapping accuracy for the remaining wetland types was above 80%. These data must be used with caution, however, as only a few wetlands were visited in the case of many of the wetland types.

The deletion of wetlands did not follow a pattern – such as combinations of topography, vegetation type and hydrology that were found not to support wetlands in the field - which could be extrapolated to areas not verified through ground-truthing. The Phase 4 Map was found to be highly accurate in terms of wetland *classification*, with a change in classification being necessary in only 5% of cases.

Wetlands from 26 of the 36 wetland types were visited in the field (Table 6). Most of the ground-truthed wetlands were located in sand fynbos or dune strandveld, which reflects the fact that most of the City lies within these vegetation groups.

The ground-truthed wetlands were found to be vary widely in terms of condition, from Class A through to Class F, with most wetlands being considered to be in Class C – moderately modified. All of the

Class A wetlands were located within the parts of the Network categorised as “high”. Those in the “medium” and “low” categories ranged in condition from Class B downwards but were mostly in a Class C, and those in the “transformed” category were Class C and below. Those wetlands lying outside the Network were in a Class B condition and below, but were mostly in Class C and D. Thus, it is not accurate to assume that all wetlands lying within the “high” category of the Network are in good condition, and those in “transformed” parts of the Network to be all in a poor condition. The results of the field assessment of condition cannot be extrapolated to the remaining wetlands on the Map, in order to prioritise for conservation. Another method of modelling condition must be investigated, which possibly takes into account the condition of the surrounding catchment rather than only the condition of the wetland itself.

Table 6 A list of the types of wetlands within the City, with information on the numbers that were ground-truthed for this project, and the condition in which they were in.

	Wetland type	Total number of wetlands	Number visited by ground-truthing teams	Number deleted	Number added	Total number ground-truthed (incl by other consultants)	Field assessed condition of ground-truthed wetlands
1	**Alluvium fynbos depression**	4	-	-	-	-	-
2	**Alluvium fynbos floodplain**	8	-	-	-	-	-
3	**Alluvium fynbos seep**	63	1	-	-	3	D: 1 E: 2
4	**Alluvium fynbos valley bottom**	7	1	-	-	1	C
5	**Alluvium renosterveld valley bottom**	1	-	-	-	-	-
6	**Dune strandveld depression**	682	56	**23** + 1 (changed to artificial)	**2** + 1 (changed from artificial)	100	A: 8 B: 12 B/C: 20 C: 26 C/D: 2 D: 16 D/E: 2 E: 12 F: 1
7	**Dune strandveld floodplain**	199	2	-	-	14	B: 2 C: 9 C/D: 1 D: 2
8	**Dune strandveld seep**	159	-	-	-	3	B: 1 C: 1 E: 1
9	**Dune strandveld valley bottom**	26	-	-	-	4	C: 4 E: 1
10	**Granite fynbos depression**	11	2	1 (changed to artificial)	-	1	D/E
11	**Granite fynbos floodplain**	29	-	-	-	2	D
12	**Granite fynbos seep**	273	8	1 (changed to artificial)	**3**	18	A: 1 B: 5 C: 3 D: 6 E: 3
13	**Granite fynbos valley**	74	10	2	**1**	12	B: 1

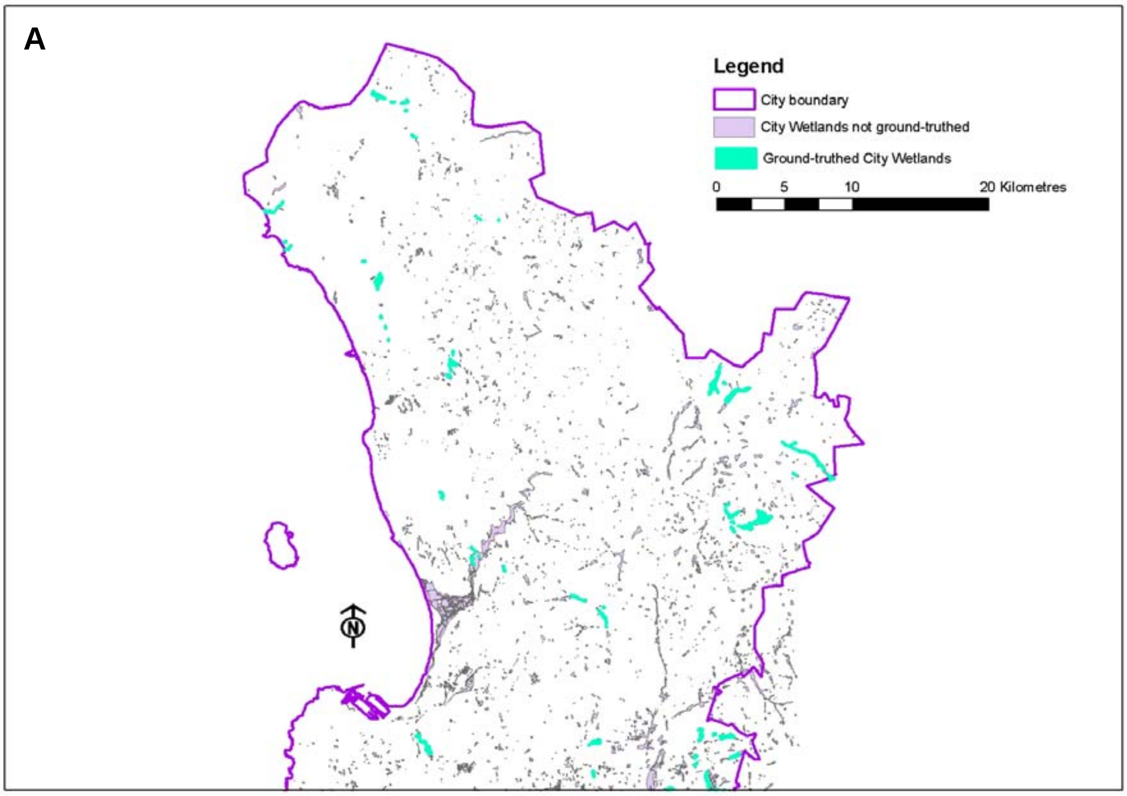
	Wetland type	Total number of wetlands	Number visited by ground-truthing teams	Number deleted	Number added	Total number ground-truthed (incl by other consultants)	Field assessed condition of ground-truthed wetlands
	bottom			(merged)			C: 5 D: 4 E: 2
14	**Granite renosterveld depression**	3	-	-	-	-	-
15	**Granite renosterveld floodplain**	1	-	-	-	-	-
16	**Granite renosterveld seep**	32	1	-	-	1	unknown
17	**Granite renosterveld valley bottom**	19	8	2 (merged)	-	5	C: 2 D: 2 E: 1
18	**Sand fynbos depression**	500	43	**5** + 10 (merged) + 2 (changed to artificial)	**1**	66	A: 2 B: 5 B/C: 1 C: 23 C/D: 2 D: 18 D/E: 4 E: 9
19	**Sand fynbos floodplain**	256	13	-	-	19	C: 13 C/D: 1 E: 4 Unknown: 1
20	**Sand fynbos seep**	444	17	-	-	53	B: 2 B/C: 1 C: 27 D: 6 E: 3 F: 8 Unknown: 6
21	**Sand fynbos valley bottom**	84	4	1 (merge)	-	13	B: 2 C: 4 D: 3 E: 2 Unknown: 2
22	**Sandstone fynbos depression**	38	2	-	-	1	F
23	**Sandstone fynbos seep**	839	18	**6** + 4 (merged)	**5**	19	A: 12 B: 5 C: 2
24	**Sandstone fynbos valley bottom**	104	2	-	-	-	-
25	**Shale band seep**	5	2	**1**	-	4	A: 2 B: 2
26	**Shale fynbos seep**	72	-	-	-	3	D
27	**Shale fynbos valley bottom**	12	2	-	-	2	C
28	**Shale renosterveld depression**	42	5	**3**	-	6	C: 4 D: 1 E: 1
29	**Shale renosterveld floodplain**	32	-	-	-	2	C
30	**Shale renosterveld seep**	204	5	**1**	-	11	C: 1 D: 7 E: 1 F: 2
31	**Shale renosterveld valley bottom**	68	5	**1**	-	10	B: 1 D: 2 D/E: 1

	Wetland type	Total number of wetlands	Number visited by ground-truthing teams	Number deleted	Number added	Total number ground-truthed (incl by other consultants)	Field assessed condition of ground-truthed wetlands
							E: 1 Unknown: 4
32	**Silcrete renosterveld seep**	7	1	-	-	1	F
33	**Silcrete renosterveld valley bottom**	2	-	-	-	-	-
34	**Cape estuarine channel**	10	-	-	-	-	-
35	**Cape estuarine depression**	15	-	-	-	-	-
36	**Cape river mouth**	9	-	-	-	-	-

3.2 Wetland types

The 36 proposed wetland types are presented in Table 7, with information on the vegetation types within which they occur, and the numbers and area of wetland within each type. Also included in Table 7 are notes on the overall condition of each wetland type, and the functional importance and ecological sensitivity of each type, and the level of threat to which each is probably exposed (this is based largely on the conservation status of the vegetation type within which the wetlands occur, but also on the surrounding land-use). The sections that follow provide more detailed information for and photographs of examples of the wetland types, arranged per broader vegetation group.

NOTE: The vegetation type “Cape Lowland Freshwater Wetlands” was not included as a wetland type on its own, as this is an azonal vegetation unit used for freshwater wetlands in the Western Cape Province in Rebelo *et al.* (2006), embedded predominantly in renosterveld and alluvial fynbos, up to an altitude of 400m. In the City vegetation map, these freshwater wetlands are embedded predominantly in dune strandveld and sand fynbos. For the consistent typing of wetlands, wetlands classified as this vegetation unit were divided amongst the 36 proposed wetland types, according to the vegetation type surrounding more than 50% of the wetland.



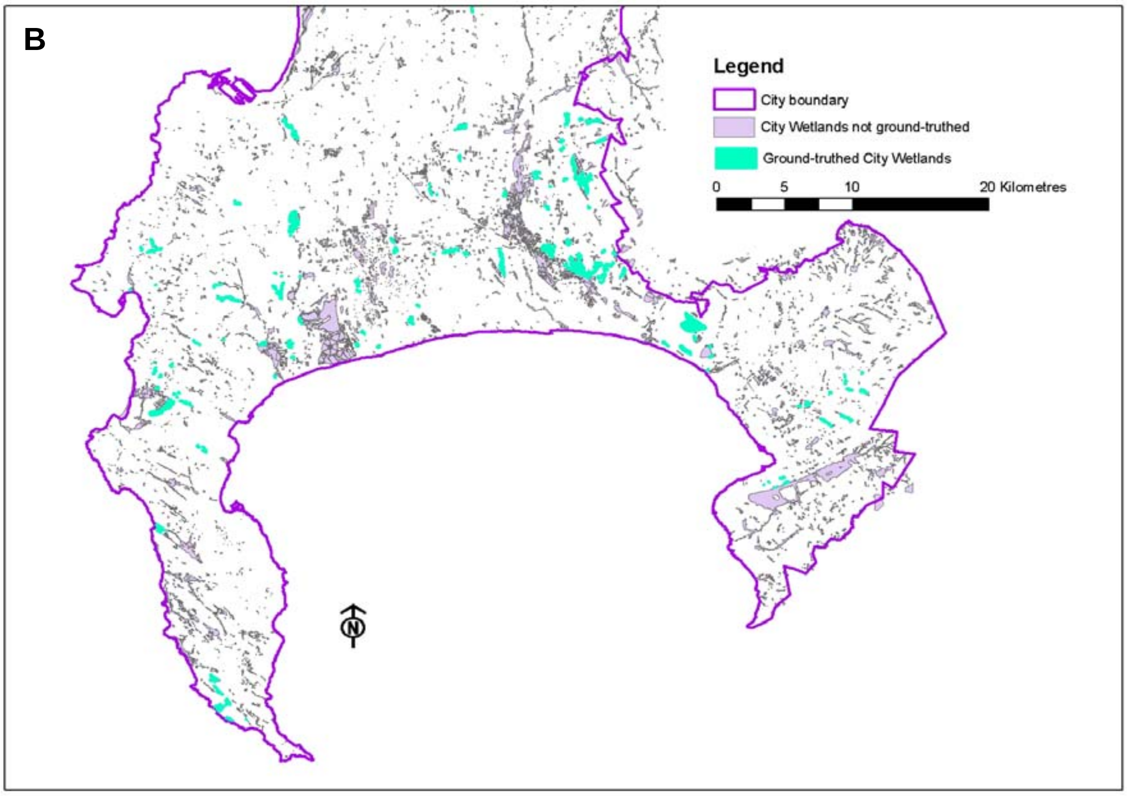


Figure 1 Maps showing the location of the 376 ground-truthed wetlands in the north (A) and south (B) of the City.

Table 7 A list of the 36 proposed wetland types within the City, with information on the number and area of wetlands within each type, and notes on condition, sensitivity, level of threat and conservation importance. CR = critically endangered; EN = endangered; VU = vulnerable; LT = least threatened. See text for details.

	Wetland type	Vegetation group	Number of wetlands	Wetland area (ha) and % of total natural wetland area	Notes on condition	Functional importance and ecological sensitivity	Level of threat
1	**Alluvium fynbos depression**	Alluvium fynbos - mostly Swartland Alluvium Fynbos, but also Lourensford Alluvium Fynbos	4	2 (0.02%)	Vegetation types are all CR. Wetlands are mostly transformed; seeps are in the best condition	MODERATE	VERY HIGH
2	**Alluvium fynbos floodplain**		8	18 (0.2%)		MODERATE to HIGH	VERY HIGH
3	**Alluvium fynbos seep**		63	137 (1.5%)		VERY HIGH	VERY HIGH
4	**Alluvium fynbos valley bottom**		7	44 (0.5%)		HIGH	VERY HIGH
5	**Alluvium renosterveld valley bottom**	Alluvium renosterveld - only Swartland Alluvium Renosterveld	1	0.7 (0.01%)	Vegetation type is vulnerable. One wetland, falls outside of the Network.	HIGH	HIGH
6	**Dune strandveld depression**	Dune strandveld - Cape Flats Dune Strandveld: West Coast and False Bay	682	839 (9.5%)	Both vegetation types are EN. Wetlands are numerous and in a range of condition, in and outside the Network.	MODERATE	VERY HIGH
7	**Dune strandveld floodplain**		199	778 (8.8%)		MODERATE to HIGH	VERY HIGH
8	**Dune strandveld seep**		159	399 (4.5%)		VERY HIGH	HIGH
9	**Dune strandveld valley bottom**		26	61 (0.7%)		HIGH	HIGH
10	**Granite fynbos depression**	Granite fynbos - Boland, and North and South Peninsula Granite Fynbos	11	2 (0.02%)	Vegetation types are all EN. Wetlands are in a range of condition; seeps are generally in good condition.	MODERATE	HIGH
11	**Granite fynbos floodplain**		29	216 (2.4%)		MODERATE to HIGH	HIGH
12	**Granite fynbos seep**		273	439 (4.9%)		VERY HIGH	HIGH
13	**Granite fynbos valley bottom**		74	148 (1.7%)		HIGH	HIGH
14	**Granite renosterveld depression**	Granite renosterveld - Swartland Granite Renosterveld	3	2 (0.02%)	Vegetation type is CR. Some valley bottoms and seeps are in good condition, but most are outside Biodiversity Network.	MODERATE	VERY HIGH
15	**Granite renosterveld floodplain**		1	2 (0.02%)		MODERATE to HIGH	VERY HIGH
16	**Granite renosterveld seep**		32	60 (0.7%)		VERY HIGH	VERY HIGH
17	**Granite renosterveld valley bottom**		19	81 (0.9%)		HIGH	VERY HIGH
18	**Sand fynbos depression**	Sand fynbos - Atlantis, Cape Flats and Hangklip Sand Fynbos	500	1019 (11.5%)	Cape Flats Sand Fynbos is CR, Atlantis and Hangklip Sand	MODERATE	VERY HIGH
19	**Sand fynbos floodplain**		256	776 (8.7%)		MODERATE to HIGH	VERY HIGH

	Wetland type	Vegetation group	Number of wetlands	Wetland area (ha) and % of total natural wetland area	Notes on condition	Functional importance and ecological sensitivity	Level of threat
20	**Sand fynbos seep**		443	878 (9.9%)	Fynbos are VU. Wetlands in the north, and Noordhoek valley are in good condition, others are a mix, but many outside Network.	VERY HIGH	HIGH
21	**Sand fynbos valley bottom**		84	370 (4.2%)		HIGH	HIGH
22	**Sandstone fynbos depression**	Sandstone fynbos - Kogelberg and Peninsula Sandstone Fynbos	38	14 (0.2%)	Both vegetation types are LT. Almost all wetlands are in good condition, and most are in Protected Areas.	MODERATE	HIGH
23	**Sandstone fynbos seep**		839	716 (8.1%)		VERY HIGH	MODERATE
24	**Sandstone fynbos valley bottom**		104	330 (3.7%)		HIGH	MODERATE
25	**Shale band seep**	Shale band vegetation - Western Coastal Shale Band Vegetation	5	17 (0.2%)	Vegetation type is LT. All are seep wetlands, all in good condition in Protected Area (around Steenbras Dam).	VERY HIGH	MODERATE
26	**Shale fynbos seep**	Shale fynbos - Peninsula, Elgin and Cape Winelands Shale Fynbos)	72	89 (1%)	Elgin Shale Fynbos is CR, and Winelands Shale Fynbos is EN. Almost all the wetlands are in a good condition.	VERY HIGH	MODERATE
27	**Shale fynbos valley bottom**		12	21 (0.2%)		HIGH	MODERATE
28	**Shale renosterveld depression**	Shale renosterveld - mostly Swartland Shale Renosterveld, but also Peninsula Shale Renosterveld)	42	40 (0.5%)	Both vegetation types are CR. Wetlands are mostly outside Network, with the exception of wetlands on the slopes of Devil's Peak	MODERATE	VERY HIGH
29	**Shale renosterveld floodplain**		32	183 (2.1%)		MODERATE to HIGH	VERY HIGH
30	**Shale renosterveld seep**		204	380 (4.3%)		VERY HIGH	HIGH
31	**Shale renosterveld valley bottom**		68	262 (3%)		HIGH	VERY HIGH
32	**Silcrete renosterveld seep**	Silcrete renosterveld - Swartland Silcrete Renosterveld	7	4 (0.05%)	Vegetation type is CR. All wetlands are outside Network.	VERY HIGH	VERY HIGH
33	**Silcrete renosterveld valley bottom**		2	3 (0.03%)		HIGH	VERY HIGH
34	**Cape estuarine channel**	Cape Estuarine Saltmarsh	10	102 (1.1%)	All tend to be in poor	VERY HIGH	VERY HIGH

	Wetland type	Vegetation group	Number of wetlands	Wetland area (ha) and % of total natural wetland area	Notes on condition	Functional importance and ecological sensitivity	Level of threat
					condition.		
35	**Cape estuarine depression**	Cape Estuarine Saltmarsh	15	71 (0.8%)	Tend to be in poor condition, with the exception of the Krom River estuary in the Table Mountain National Park.	VERY HIGH	VERY HIGH
36	**Cape river mouth**	Cape Estuarine Saltmarsh	9	23 (0.3%)	In poor condition.	VERY HIGH	VERY HIGH

3.2.1 Alluvium fynbos wetlands

The alluvium fynbos wetlands are situated predominantly in the Lourens River catchment in the Somerset West area, lying within the Lourensford alluvium fynbos vegetation unit. The wetlands are dominated by non-isolated hillslope and basin seeps, which occupy the lower-lying slopes (below approximately 200mAMSL) of the catchment. The soils tend to be silty soils, often over granite, Malmesbury Group metasediments, or sandstones – the soils often are embedded with cobbles, pebbles and gravel (Rebelo *et al.*, 2006). The wetlands are vegetated with sedges, such as *Bolboschoenus maritimus*, rushes, such as *Juncus kraussi* and grasses, such as *Pennisetum macrourum* and *Cynodon dactylon*. The halophytic *Sarcocornia* sp. (possibly *natalensis*) is also found in the wetland depressions and valley bottom wetlands.

The wetlands that were ground-truthed (4 wetlands) were found to be in a poor condition – ranging from a Class C to Class E. The Lourens River catchment has been farmed for centuries, and so the soils and ecosystems have been heavily modified through grazing, ploughing, frequent fires and, more recently, industrial and residential development.

Alluvium fynbos seeps are considered to be of high sensitivity, and the depressions, floodplain and valley bottom wetlands of moderate sensitivity. All of the alluvium fynbos wetlands are subject to a high level of threat, and are likely to be of high conservation importance, due to the low level of present preservation of land within this vegetation unit.

Photo 1 An alluvium fynbos hillslope seep (KS0298), dominated by *Pennisetum macrourum*.

3.2.2 Alluvium renosterveld wetlands

Only one alluvium renosterveld was mapped – an alluvium renosterveld valley bottom wetland, associated with the middle reaches of the Diep River. The wetland occurs in Swartland Alluvium Renosterveld, which is a vulnerable vegetation type. This wetland was not ground-truthed, and very little information is known about this wetland type. The soils underlying the vegetation type are predominantly fine silty and sandy alluvial sediments, derived mainly from granite (Rebelo *et al.*, 2006). The wetland lies outside of the Biodiversity Network, on land that has been severely modified by agricultural activities such as ploughing.

3.2.3 Dune strandveld wetlands

Dune strandveld wetlands comprise mostly depressions – many of which are typical duneslack wetlands – followed by floodplains and seeps, and a few valley bottom wetlands. These wetlands are located primarily on the Cape Flats, in a triangle that extends from the False Bay coast between Muizenberg and Gordons Bay, up to Bellville. Others are scattered between dunes along the west coast of the Peninsula, within the Table Mountain National Park. The Cape Flats Dune Strandveld vegetation types occupy the low-lying parts of the City (generally 0 – 80mAMSL), and grow in soils that are calcareous sands of marine origin. The dune strandveld wetlands that are in the best condition are mostly the isolated depressions, or duneslack wetlands, which typically support a good mix of wetland grasses (such as *Imperata cylindrical*), sedges (such as *Ficinia* spp.), asteraceous shrubs (such as *Senecio halimifolius*) and restios. The undisturbed floodplain and valley bottom wetlands are vegetated with sedges, restios, *Berzelia* spp. and *Leucadendron* spp.

These wetlands are highly threatened by infilling for development, stormwater discharge, alien invasion, and fragmentation through road construction.

Together, the dune strandveld wetlands make up 23.5% of the total area of natural and semi-natural wetlands in the City of Cape Town. 121 wetlands of this type were visited in the field.

Photo 2 Cape Flats dune strandveld depressional wetland (KS1874), dominated by *Imperata cylindrica*.

Photo 3 Dune strandveld depression (JES1569) near Strandfontein, showing *Juncus kraussi* and *Imperata cylindrica*.

3.2.4 Granite fynbos wetlands

Granite fynbos wetlands are mostly hillslope and basin seeps, occurring on the slopes of the Helderberg Mountains near Somerset West and Stellenbosch, and the lower slopes of the Peninsula. Boland and Peninsula (North and South) granite fynbos occurs on the lower slopes of the City's mountains, below the upper sandstone slopes, on deep, loamy, granite-derived sandy soils. The less disturbed wetlands are inhabited by wetland grasses (primarily *Cynodon dactylon*), restios and some sedges and rushes (*Juncus kraussii*). Many of these wetlands have been impacted by infilling and excavation, alien invasion (especially kikuyu), input of stormwater and the loss of natural wetland vegetation.

Granite fynbos wetlands account for 9% of the City's natural and semi-natural wetlands. Thirty-three of these wetlands were ground-truthed.

Photo 4 A granite fynbos seep on the lower slopes of Hout Bay valley (KS0739).

3.2.5 Granite renosterveld wetlands

Granite renosterveld wetlands occur in the Swartland Granite Renosterveld vegetation type, which is critically endangered. The wetlands, mainly seeps and valley bottom wetlands associated with river channels, are located in four separate areas – in the far north of the City, associated with the Louwskloof River, in the Joostenberg area around the R312, around the middle reaches of the Bottelary River, and the upper reaches of the Eerste/Kuils catchment. All occur on coarse sandy to loamy granite-derived soils, which tend to retain moisture during the wet months (Rebelo *et al.*, 2006).

All of the 6 granite renosterveld wetlands visited during ground-truthing were in poor condition (less than or in a Class C), mainly as a result of agricultural activities such as ploughing and grazing. Most of them were found to support stands of reeds and bulrush, with few other wetland sedges and grasses. Many were invaded by woody aliens such as poplars, pines and oaks.

3.2.6 Sand fynbos wetlands

Sand fynbos wetlands are predominantly depressions and seeps, followed closely by floodplain wetlands. These wetland types account for the highest proportion of wetlands in the City - over 34%. They are found on low-lying (below 200m) lands, on deep, acid sands throughout the City. Cape Flats Sand Fynbos is critically endangered, while Hangklip and Atlantis Sand Fynbos are vulnerable.

These wetlands tend to be dominated by restios and sedges, but are often invaded by reeds and bulrush. They are threatened by impacts such as stormwater discharge, fragmentation through the construction of roads and bridges, invasion of aliens and invasives, and other impacts associated with urban areas. 151 sand fynbos wetlands were ground-truthed.

Photo 5 Sand fynbos depression, at Kenilworth Racecourse (VRG0317).

Photo 6 Sand fynbos depression (KS1838) at Wynberg Sports Precinct, surrounded by roads and heavily invaded by kikuyu.

3.2.7 Sandstone fynbos wetlands

Sandstone fynbos wetlands comprise depressions, seeps (which are the most numerous) and valley bottom wetlands. Together, these wetlands account for 12% of the total area of natural and semi-natural wetlands in the City. They are located on gentle to steep slopes in the Peninsula mountains and the mountains around Steenbras Dam, and so are largely conserved in Protected Areas. As a result, the vegetation types in which these wetlands occur are considered to be least threatened by land transformation (the conservation status of these vegetation types will be changed in the 2008 NEMBA to endangered for Peninsula Sandstone Fynbos and critically endangered for Kogelberg Sandstone Fynbos, due to the high concentrations of Red Data List plant species in these types). The soils are acidic and sandstone-derived.

Twenty-three of the sandstone fynbos wetlands were ground-truthed, most of which were in an A or B Class, in terms of wetland condition. These wetlands are dominated by *Berzelia* spp. and *Leucadendron* spp., with several species of *Ericas* and restios. A common plant inhabitant is *Psoralea pinnata*.

Photo 7 A burnt shale band hillslope seep above Steenbras Dam (DO0609), showing *Berzelia lanuginosa*-dominated community.

Photo 8 Mixed *Berzelia* and *Leucadendron* plant community in a sandstone fynbos hillslope seep.

3.2.8 Shale band wetlands

There are five shale band seeps in the City – all of these occur above Steenbras Dam, so, like the sandstone fynbos wetlands, these are protected. The wetlands occur on clayey soils, derived from shale, and are dominated by *Berzelia* spp. and *Leucadendron* spp. and various indigenous grasses. Four of these wetlands were ground-truthed and were found to be in good condition – either an A or B Class.

Photo 9 A burnt sandstone fynbos hillslope seep above Steenbras Dam (JES2992), showing *Berzelia lanuginosa*-dominated community.

3.2.9 Shale fynbos wetlands

Shale fynbos wetlands comprise only seeps and valley bottom wetlands, but mostly hillslope seeps, which occur on the high-lying slopes of mountains in the City – such as Devil's Peak, and the Steenbras Mountains. Shale fynbos vegetation types – these are Peninsula, Elgin and Winelands Shale Fynbos – occur on well-leached soils derived from shale. They appear to be dominated by grasses and sedges.

Five shale fynbos wetlands were visited in the field, but all were in a poor condition, largely as a result of agricultural activities in the area and heavy alien infestation.

Photo 10 Shale fynbos hillslope seep (KS1776) below the N2 at Sir Lowry's Pass, dominated by sedges and grasses.

3.2.10 Shale renosterveld wetlands

Shale renosterveld wetlands include depressions, floodplain wetlands, seeps (the majority) and valley bottom wetlands. The two vegetation types in which they occur are both critically endangered, and most of the wetlands are located outside of the City's Biodiversity Network. These vegetation types are located on clayey soils derived from shales.

Only one of the 27 shale renosterveld wetlands that were ground-truthed was found to be in good condition – this wetland supported a good mix of wetland plants including sedges such as *Bolboschoenus maritimus*, restios such as *Chondropetalum rectum*, and rushes and grasses. Most of the wetlands visited were heavily impacted by farming practices, fragmentation, channelisation, and alien invasion (especially kikuyu and poplars). Many are now dominated by reeds and bulrushes.

Photo 11 A shale renosterveld seep (NJ0491) invaded by poplars.

3.2.11 Silcrete renosterveld wetlands

Only 9 scattered silcrete renosterveld wetlands were mapped – 7 are seeps and 2 are valley bottom wetlands. These wetlands occur on remnant silcrete layers on shales and granites (Rebelo *et al.*, 2006). Only one of these wetlands was visited in the field, and was found to be in a very poor state (F Class), as a result of ploughing.

Photo 12 The remnants of a silcrete renosterveld seep (KS0243).

3.2.12 Cape estuaries

The City Wetlands Map includes Cape estuarine channels, depressions and river mouths, as defined in the NWICS (Ewart-Smith *et al.*, 2006). These have been mapped at the estuaries of the Diep, Sand, Krom, Schusters, Soet, Bokramspruit, Eerste, Lourens, Hout Bay and Sout Rivers.

None of the estuaries were ground-truthed. They tend to be systems that are a mix of vegetated depressions and flats, and sandy channels. The vegetated areas should naturally be covered with salt-tolerant estuarine species such as *Sarcocornia* spp. and *Salicornia* spp., grasses such as *Cynodon dactylon*, the rush *Juncus kraussii*, and other shrubs and herbs such as *Cotula* spp., *Triglochin* spp. and *Plantago* spp.

Many of the estuaries in the City have been heavily impacted by activities in their catchments. These coastal systems receive polluted water from upstream, with discharge regimes that are not natural. As a result, the City's estuaries are in poor condition, and tend to be dominated by stands of the common reed, *Phragmites australis*, which thrives in these altered conditions.

Estuaries are all considered to be of very high functional importance and ecological sensitivity, and are subject to a very high level of threat, due to their position in the catchment.

3.3 Update of the City Wetlands Map

The City Wetlands Map was updated to record all new information collected during ground-truthing, and wetland polygons were edited or deleted where relevant. Table 8 provides a description of the attribute fields that are linked to the ground-truthed City Wetlands Map.

Table 8 Attributes captured for the updated City Wetlands Map (both for natural/semi-natural and for artificial wetlands), developed during Phases 1 to 4, and finalised during Phase 5 (ground-truthing). Attributes that have changed in or been added during Phase 5 are marked with an asterisk. The information added during ground-truthing is relevant only to the natural/semi-natural wetlands.

Abbreviation	Heading in full	Explanation	Attribute table entry code	Attribute explanation
WET_ID	Wetland identity	Unique identifier code / number for each wetland polygon for this project	various e.g. GR001	code is based on the initials of the mapper, plus numeric identifier for reference
WET_NAME	Wetland name	Name of wetland where it exists on topo map, existing GIS data or elsewhere	various e.g. Kuils R fldpl	gap or unknown represents unknown name, some abbreviations
MAP_SOURCE*	Information source for mapping and classification of a wetland	Main source of information used in the mapping and classification of the wetland	CCT pond 2003	based on CCT 2003 ponds layer
			CCT pond 2005	based on CCT 2005 ponds layer
			orthophotos	based on visual examination of orthophotos
			field assessment	based on field-assessment or study
			CCT waterbodies	based on description in CCT “waterbodies” layer
Confid_MAP	Confidence level – wetland mapping	Indicator of the confidence of the mapper in whether the polygon represents wetland habitat	high	reasonable certainty based on ground-truthing, field assessment or good visual cues
			low	mapper uncertain and the presence of wetland requires field verification
Transform*	Transformed wetlands	Description of the type of impact that has led to the probable transformation of most (more than 75%) or all of the natural or semi-natural wetland; all artificial wetlands are described as “artificial”	mowed	urban modification of wetland areas e.g. sports fields
			partially drained	wetlands retaining natural function but associated with drainage ditches
			farmed	range of modifications as a result of farming practices, e.g. ploughing
			afforested	wetlands transformed by plantations of woody exotic vegetation
			excavated	Wetlands have clearly been significantly altered through excavation
			stormwater	wetlands have been modified through input of stormwater, from residential, industrial or agricultural areas
			developed	hard development (i.e. housing, roads, parking lots etc) have significantly reduced the extent and nature of the wetlands
			grazed	grazing has significantly altered the vegetation growing in the wetlands

Abbreviation	Heading in full	Explanation	Attribute table entry code	Attribute explanation
			cleared	natural wetland vegetation has been cleared, but not necessarily replaced by crops (see "farmed")
			effluent	effluent from a waste water treatment plant has significantly altered the wetland characteristics
			unknown	wetland may be transformed but transformation unknown
Artif_typ*	Type of artificial waterbody	Identification of one of a number of categories that define a range of artificial wetlands, and which are based on the descriptions in the source data, namely the City "waterbodies" or 2005 ponds update GIS covers	open reservoir	concrete water reservoir
			dam	specific category off CCT waterbodies layer
			quarry	specific category off CCT waterbodies layer
			irrigation pond	specific category off CCT waterbodies layer, separate function to stormwater ponds
			WWTW pond	includes irrigation and sludge ponds, no ecological value
			WWTW effluent pond	larger, shallower effluent ponds, may have ecological function
			stormwater pond	general name given to stormwater, detention, retention and attenuation ponds in the CCT 2005 ponds update and CCT "waterbodies" layers
			stormwater depression	open areas identified from orthophotos during this project – i.e. that are not registered in the existing City's GIS cover but appear to be artificial
			marina	describes waterbodies created for marinas
			none	wetlands categorised as natural or semi-natural, generally retaining natural function, although may be impacted (i.e. not pristine)
WetCLASS_1	Wetland Classification Level 1: SYSTEM	Level 1 of the National Wetland Classification: major systems	estuarine	as described in the National Wetland Classification System
			inland	
WetCLASS_2	Wetland Classification Level 2: SUB-SYSTEM	Based on tidal exchange (estuaries) or hydrological connectivity (inland systems)	permanently open	as described in the National Wetland Classification System ; not all wetland types were encountered in this project phase
			temporarily closed	
			isolated	
			non-isolated	
WetCLAS_3a	Wetland Classification Level 3a: FUNCTIONAL	Based on landform features that determine hydrological and	N/A	as described in the National Wetland Classification System ; not all wetland types were encountered in this project phase
			river mouth	

Abbreviation	Heading in full	Explanation	Attribute table entry code	Attribute explanation
	UNIT	geomorphological processes.	estuarine depression	N/A = not applicable
			estuarine channel	
			depression linked channel	
			floodplain	
			valley bottom	
			seep, channeled outflow	
			seep, no outflow	
			isolated depression	
WetCLAS_3b	Wetland Classification Level 3b: Functional Sub-unit		N/A	as described in the National Wetland Classification System ; not all wetland types were encountered in this project phase N/A = not applicable
			with channel	
			without channel	
			meander cutoff	
			floodplain flat	
			floodplain pan	
			with channeled outflow	
			without channeled outflow	
			basin seep	
			hillslope seep	
			unknown	
WetCLAS_4a	Wetland Classification Level 4b: Structural Unit	depth class	N/A	As described in the National Wetland Classification System N/A = not applicable Some systems were allocated more than one attribute category
			limnetic	
			limnetic & littoral	
			littoral	
			subtidal	
			supratidal	
			unknown	
WetCLAS_4b	Wetland Classification Level 4b: Structural Sub-	Dominant cover type	N/A	As described in the National Wetland Classification System ; not all wetland types were encountered in this project phase
			rocky/unconsolidated	

Abbreviation	Heading in full	Explanation	Attribute table entry code	Attribute explanation
	unit		open water open water & emerg veg surface/subsurface veg emerg veg unknown	N/A = not applicable Some systems were allocated more than one attribute category (e.g. both open water plus emergent vegetation in parts of a wetland)
WetCLAS_4c	Wetland Classification Level 4c: Structural Sub-unit	Dominant substratum type or dominant life-form	N/A none floating rooted herbaceous mixed scrub-shrub sand silt/mud unknown	Types as described in the National Wetland Classification System; not all wetland types were encountered in this project phase N/A = not applicable
DOM_VEG	Dominant vegetation	Provides a list of genera or species, or plant growth form, dominating the wetland	various e.g. Bolboschoenus maritimus	
ALIEN_VEG	Alien vegetation	Provides a list of dominant alien genera or species, generally woody but also grasses	various e.g. A. saligna	
HydroPerio	Hydroperiod	Describes the frequency and level of inundation or saturation	perm inundated perm saturated seas inundated seas saturated not permanent	data only captured where available; data sparse abbreviations: perm = permanent, seas = seasonal
Salinity				data not captured – field included for future use
pH				data not captured – field included for future use
CONF_CLASS	Confidence level - wetland classification	Confidence in the classification of the wetland, according to NWICS (Ewart-	low moderate	

Abbreviation	Heading in full	Explanation	Attribute table entry code	Attribute explanation
		Smith *et al.*, 2006)	high	
COMMENTS	Comments	Any additional comments or observations	various	Includes the reference, if wetland was ground-truthed or assessed during a consultancy project (see References for full citations)
Area_M2	Area (m^2)	GIS-generated information		Area in m^2
Area_ha	Area (ha)	GIS-generated information		Area in hectares
PHASE*	City Wetlands Map Project phase	The project phase during which the wetland was added to the database	1	Phase 1 Mapping and classification
			2	Phase 2 Mapping and classification
			3	Phase 3 Mapping and classification
			4	Phase 4 Mapping and classification
			5	Phase 5 Ground-truthing
GR_TRUTHED*	Ground-truthed?	Records whether a wetland was ground-truthed, either during Phase 5, or during other consultancy projects	Y	Yes; gap means the wetland was not ground-truthed
GRTRUTH_BY*	Ground-truthed by	Name of the individual who ground-truthed the wetland	various, names of ground-truthers	Name and organisation
GRTRUTH_DAT*	Ground-truthing date	Date on which the wetland was visited	various, e.g. 11/12/2008	
WET_COND	Wetland condition	Wetland condition Class in which ground-truthed wetland has been placed	A, B, C, D, E, F	Class assigned according to DWAF (1999) protocol
CONF_COND	Condition confidence	Confidence with which wetland condition has been assessed	High, moderate, low	Confidence will be lower if upstream impacts are unknown.
IMPACTS*	Impacts	Impacts affecting wetland condition, but not necessarily leading to transformation of the wetland	various, e.g. grazing	
LANDUSE100*	Land-use within 100m of the wetland	Land-use within 100m of the wetland, listed in order of dominance	various, from field datasheet (see Appendix 1)	
LANDUSE1km*	Land-use within 1km of the wetland	Land-use within 1km of the wetland, listed in order of dominance	various, from field datasheet (see Appendix 1)	
VEG_GROUP	Vegetation group	Vegetation group within which the wetland lies	As provided on the City vegetation map	

4 CONCLUSIONS AND RECOMMENDATIONS

- The updated Phase 5 City Wetlands Map includes 377 natural and semi-natural wetlands that have been ground-truthed, in terms of wetland location, approximate extent, classification and condition. This represents just over 8% of the total number of natural and semi-natural wetlands included on the City Wetlands Map. The ground-truthing team visited 208 wetlands, of which 40 were deleted. Twelve wetlands were added, while many were edited. The consultant ground-truthing team comprised Kate Snaddon and Dean Ollis of the Freshwater Consulting Group (FCG), Lee Jones of the Independent Vegetation Consultancy (IVC), Nancy Job (independent consultant) and Ross Turner (Ross Turner Botanical Surveys). Further ground-truthing was performed by Pat Holmes, Ian Cranna and Tumeka Mdlazi.
- A total of 211 wetlands were ground-truthed during other consultancy projects, primarily by FCG – these assessments did not lead to deletion of wetlands, but rather to an increase in detail in mapping, thus to a higher number of wetland polygons.
- The Phase 4 City Wetlands Map was found to be approximately 75% accurate overall, in terms of mapping wetland presence, and approximately 95% accurate in wetland classification. The accuracy of mapping of the various wetland types ranged widely from 100% down to 39%.
- Wetlands from 26 of the 36 proposed wetland types were visited in the field. The condition of these wetlands ranged widely, from Class A through to Class F.
- The desktop assessment of wetland condition done prior to ground-truthing for this project was useful, as it allowed the team to ensure that wetlands in a range of conditions were visited. However, the desktop assessment did not always reflect the actual condition of wetlands, and so this is not an ideal method for extrapolating the assessment of condition to those wetlands not visited in the field. It is recommended that wetland condition be modeled (as % natural vegetation occurring both within and around the wetland) across the City, using the most recent land-use data, at the highest resolution, in order to compare this result for wetlands against the City's Biodiversity Network. The condition of the surrounding catchment is almost more important for the assessment of condition, than the presence of natural vegetation within the wetland.
- Thirty six wetland types are proposed, which describe each wetland type in terms of the vegetation group within which it occurs, and the Level 3A functional wetland unit, as described in the draft National Wetland Inventory Classification System (Ewart-Smith *et al.*, 2006). These wetland types include three estuarine types, and 33 inland wetland types.
- The wetland types were found to be a useful way of dividing the wetlands of the City into meaningful groups. However, degradation of wetlands across the City does lead to a "homegenising" of wetland characteristics. Degraded wetlands tend to be dominated by the same aliens and invasive plant species.
- An attempt was made to propose functional importance and ecological sensitivity for each wetland type. This was difficult to do at the level of the wetland type, and it is recommended that the approaches recommended in this document be developed and applied to individual wetlands during the next phase of work – prioritisation for the conservation of biodiversity.

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APPENDIX 1 FIELD DATASHEET FOR GROUND-TRUTHING

Ground-truthing of City Wetlands Map

Field datasheet

Name(s): ______________________ Photos: __________

Date: ______________________

Wetland ID (name if there is one) - you can group similar wetlands together: __________

Part of a wetland mosaic? ______________________

GPS co-ordinates (if any): ______________________

Describe location point at which GPS points were taken (i.e. where in relation to the wetland):

____

1. WETLAND LOCATION (NB this is not wetland extent)

Has the location of the wetland been correctly mapped? ______________ New wetland? ______

Confidence in mapping (H, M, L)? ______________________

DRAW LOCATION AND APPROX EXTENT ON AERIAL PHOTO IF DIFFERENT FROM MAPPED

DRAW NEW WETLANDS ONTO AERIAL, AND FILL IN DATASHEET

2. WETLAND TYPING (see definitions)

SYSTEM	SUB-SYSTEM	FUNCTIONAL TYPE	FUNCTIONAL SUB-TYPE
LEVEL 1	LEVEL 2	LEVEL 3	
ESTUARINE	Permanently open	Estuarine bay	
		Estuarine depression	
		Estuarine channel	
		River mouth	
	Temporarily closed	Estuarine depression	
		Estuarine channel	
INLAND	Non-isolated	Valley bottom	With channel
			Without channel
		Floodplain	Meander cutoff
			Floodplain flat
			Floodplain pan
		Depression linked to a channel	With channeled outflow
			Without channeled outflow
		Seep with channeled outflow	Basin seep
			Hillslope seep
	Isolated	Isolated depression	
		Seep without channeled outflow	Basin seep
			Hillslope seep

Tidal regime (for estuaries):

subtidal	intertidal	supra-tidal

Depth class (for depressions):

littoral	limnetic

NOTE: can be both!

Dominant cover and substratum:

rocky/unconsolidated substratum								
sand	silt/mud	mixed	salt crust	pebbles/ gravel	peat	bedrock	boulders	cobbles

surface/subsurface vegetation	
floating	rooted

emergent vegetation		
herbaceous	scrub-shrub	forested

open water

Describe dominant plant community: ______________________

Describe dominant woody aliens and aquatic aliens: ______________________

Ground-truthing of City Wetlands Map

Field datasheet

3. WETLAND CONDITION

Is this a natural or semi-natural wetland? **Or artificial:**

Type of artificial wetland:									

Give reasons to support whether natural or artificial:

Rate the intensity/extent of each individual impact in the relevant matrix below - e.g. rate alien plant invasion AND vegetation clearing in the "vegetation impacts" matrix

MODIFICATIONS TO VEGETATION IN AND AROUND (up to 50m) WETLAND

Rating (%)		Intensity in the impacted area					Description of impacts on vegetation (ranked 1, 2, 3):
		Low	Moderate	High	Serious	Critical	
Extent of impacted area	Small	1	2	3	4	5	
	Moderate	2	6	7-13	14-19	20-24	
	Large	3	7-13	25	26-38	39-50	
	Extensive	4	14-19	26-38	51-56	57-75	
	Entire	5	20-24	39-50	57-75	75-100	

PHYSICAL MODIFICATIONS WITHIN WETLAND

Rating (%)		Intensity in the impacted area					Description of physical impacts (ranked 1, 2, 3):
		Low	Moderate	High	Serious	Critical	
Extent of impacted area	Small	1	2	3	4	5	
	Moderate	2	6	7-13	14-19	20-24	
	Large	3	7-13	25	26-38	39-50	
	Extensive	4	14-19	26-38	51-56	57-75	
	Entire	5	20-24	39-50	57-75	75-100	

MODIFICATIONS TO WATER QUALITY OF WETLAND

Rating (%)		Intensity in the impacted area					Description of impacts on water quality (ranked 1, 2, 3):
		Low	Moderate	High	Serious	Critical	
Extent of impacted area	Small	1	2	3	4	5	
	Moderate	2	6	7-13	14-19	20-24	
	Large	3	7-13	25	26-38	39-50	
	Extensive	4	14-19	26-38	51-56	57-75	
	Entire	5	20-24	39-50	57-75	75-100	

MODIFICATIONS TO WATER QUANTITY IN/TO WETLAND

Rating (%)		Intensity in the impacted area					Description of impacts on water quantity (ranked 1, 2, 3):
		Low	Moderate	High	Serious	Critical	
Extent of impacted area	Small	1	2	3	4	5	
	Moderate	2	6	7-13	14-19	20-24	
	Large	3	7-13	25	26-38	39-50	
	Extensive	4	14-19	26-38	51-56	57-75	
	Entire	5	20-24	39-50	57-75	75-100	

Ground-truthing of City Wetlands Map

Field datasheet

Surrounding landuse (rank, at least 1, 2, 3):

	within 100m of wetland	within 1km of wetland
Afforestation		
Agriculture – crops		
Agriculture – livestock		
Roads / other infrastructure		
Rural development		
Urban development		
Industrial		
Informal settlement		
Alien invasive vegetation		
Alien invasive fauna		
Mining		
Recreational		
Nature Conservation		
Sewage disposal		
Solid waste disposal (including dumping and litter)		
Harvesting of flora or fauna		
Erosion		
Construction / Infilling		
Physical modifications (e.g. bulldozing, sandmining, weirs, gabions)		
Loss of riparian vegetation		

Other (please specify): ____________________