WETLAND MAPPING AND CLASSIFICATION

CERVANTES SOUTH

Prepared for:

GOVERNMENT OF WESTERN AUSTRALIA
Department of **Environment and Conservation**
Department of **Water**

Australian Government
National Water Commission

Job No: 09.246

Report No: 10/060

env Australia

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TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

ATTACHMENT

STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report (“the report”) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV .Australia Pty Ltd (ENV) (“scope of services”). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

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The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

EXECUTIVE SUMMARY

This report summarises the methodology and results of the Cervantes South wetland mapping and classification project (Area F). The Geomorphic Wetlands Cervantes South dataset (ENV, 2010) and associated field photographs are presented as two digital attachments. This report and associated dataset was produced by ENV. Australia Pty Ltd (ENV), the project managed by the Wetlands Section, Department of Environment and Conservation (DEC) and funded by the Department of Water through the National Water Commission's Groundwater Action Plan Fund.

The Cervantes South project area (Area F) is within the Midwest region of Western Australia and is located in the vicinity of Cervantes and Cataby in the Shire of Dandaragan. The project area is approximately 100,000 ha and based on the land area encompassed by eight 1:25,000 map sheets. The aim of the project was to identify and delineate geomorphic wetland boundaries and to assign a geomorphic classification according to Semeniuk & Semeniuk (1995) at a 1:25,000 scale. Artificial wetlands (e.g. drains and constructed lakes), tidal wetlands, wetlands on offshore islands and identification of consanguineous suites were not included in the scope of the project.

Desktop mapping was undertaken using a range of both digital and hard copy information sources including satellite imagery, digital orthophotos, hard copy stereoscopic aerial photos, topography, soil types, remnant vegetation and hydrography. To verify the results of the desktop mapping 29 individual wetlands representing 1,517 ha of wetland area was visited and assessed as part of a field survey. The field survey assessed the mapped boundaries of 4% of the total mapped wetlands and 8% of the total mapped wetland area. The field survey also provided a measure of positional accuracy and attribute accuracy that could generally be applied to the dataset. The identification, delineation and classification of wetlands undertaken is considered commensurate with a Stage 2 level of assessment as defined by the Department of Environment and Conservation (DEC, in publication). Evaluation of conservation significance of wetlands was not within the scope of the project.

A total of 770 wetlands were mapped in the project area and comprised 20,221 ha of mapped wetland extent. This represents approximately 20% of total project area. The wetland types mapped (and the relative extent) were Palusplains (52%), Floodplains (27%), Damplands (11%), Creeks (3%), Sumplands (3%), Rivers (0.3%), Barlkarra (2%), and Lakes (1%).

The average positional accuracy of boundaries calculated from groundtruthing at a limited number of wetlands (29) was determined to be approximately 14 m and the classification accuracy was 87%. The temporal resolution of the information used to determine wetland boundaries and classification was 22 years and was biased towards more recent information sources. The mapping may therefore underestimate or overestimate wetland extent or water permanence over a longer climatic period.

This mapping is considered suitable to be used at a scale of 1:25,000. As mapping has been undertaken at 1:25,000 some wetlands present in the project area are not included in the dataset as they are too small in size to be detected as individual entities at this scale. In some cases these wetlands will have been incorporated into a larger wetland polygon and in other cases entirely omitted from the dataset. There is no data to indicate the number of wetlands that have been omitted or represented as part of larger wetland entities due to the 1:25,000 scale or due to other reasons applicable to this largely desktop survey.

1 INTRODUCTION

ENV. Australia Pty Ltd (ENV) was commissioned by the Department of Environment and Conservation (DEC) to undertake mapping and classification of wetlands for the Cervantes South project area (also referred to as “Area F”). The Cervantes South project area is approximately 100,000 ha and located within the Midwest region of Western Australia in the vicinity of Cervantes in the Shire of Dandaragan.

For the purpose of this project the definition of a wetland is consistent with that presented in the *Wetlands Conservation Policy for Western Australia* (Government of Western Australia, 1997) and is adopted from the United Nations Educational Scientific and Cultural Organisation (UNESCO), 1971.

> *“Areas of marsh, fen, peat land 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 tide does not exceed six metres.”* (UNESCO, 1971)

Wetland types included within the scope of this project included terrestrial, natural, and channel type wetlands. This project does not include artificial wetlands, coastal wetlands and those on offshore islands.

Western Australia has significant wetland resources providing a broad range of ecological, hydrological, cultural and economic values. The State’s wetlands are subject to ongoing degradation and loss through direct and indirect impacts of clearing and development including groundwater extraction, and large-scale processes such as salinisation and climate change.

Mapping, classification and evaluation of wetland resources is required to document locations, extents and values of wetlands and to provide a systematic and robust basis for protection and management. Improved knowledge is also required to provide meaningful input to environmental impact assessment and related decision making processes.

1.1 BACKGROUND

The DEC is responsible for coordinating the mapping, classification and evaluation of wetlands around the State. It coordinates the Wetland Status Working Group, a subcommittee of the (State) Wetlands Coordinating Committee, to address wetland mapping, classification, and evaluation and status matters in accordance with the *Wetlands Conservation Policy for Western Australia* (Government of Western Australia, 1997). In this respect, the DEC has prepared a document entitled *Framework for mapping, classification and evaluation of wetlands in Western Australia* (DEC, in publication), in cooperation with the Wetland Status Working Group, which has been endorsed by the Wetlands Coordinating Committee.

Wetland mapping in Western Australia has been an ongoing endeavour. In 1996, the publication of the *Wetlands of the Swan Coastal Plain* (Hill. et al, 1996a) comprised the first mapping effort that considered water permanence, soil and vegetation in wetland mapping in Western Australia. The approach of this original project was highly focused on the use of field work and hard copy stereoscopic aerial photographs to identify the location of wetlands and delineate wetland boundaries. Since then, methods for mapping wetlands in Australia have evolved to include the use of geographic information systems and digital spatial datasets to help streamline the mapping process (Queensland Government, 2007).

1.2 AIMS AND OBJECTIVES

The two overarching aims of this project are to:

1. Produce a digital dataset of geomorphic wetlands suitable for use at a scale of 1:25,000; and
2. Document the methodology that has been applied to produce this digital dataset.

Further objectives of this project are to:

- Compile a spatial dataset of relevant mapped environmental phenomena;
- Undertake desktop mapping of wetland boundaries and geomorphic classification;
- Conduct a preliminary field survey of a wide range of mapped wetlands to assess the adequacy of the desktop mapping methodology;
- Identify wetland boundaries in the field through assessing hydrology, soils and vegetation;
- Assess and refine mapped wetland boundaries based on observations and data collected in the field;
- Provide a measure of positional accuracy for the desktop mapping based on field observations;
- Compile a dataset of mapped wetland boundaries and their classification throughout the project area; and
- Provide a report summarising the methodology and results of the mapping exercise.

1.3 SCOPE OF WORKS

ENV has undertaken this project to be consistent with the requirements for a Stage 2 Assessment according to the *Framework for mapping, classification, and evaluation of wetlands in Western Australia* (DEC, in publication).

The DEC defines a Stage 2 assessment as *"identification of preliminary wetland boundaries, classification of wetlands into geomorphic types and identification of groups of wetlands (consanguineous suites)"* (DEC, in publication). The purpose of a Stage 2 assessment is to provide precise or approximate boundaries and has a requirement for field sampling of a sub-set of wetlands and extrapolation of information (DEC, in publication).

The mapping produced as part of the project is considered suitable for use at a scale of 1:25,000 to be used to facilitate regional decision making and priority setting.

In the tender document the DEC identified that consanguineous suites, artificial wetlands, coastal wetlands (such as tidal flat wetlands) and wetlands on offshore islands are not required as part of this project. Where wetland boundaries intersect the project area boundaries they are truncated to the project boundary edge consistent with the requirements of the tender document.

2 PHYSICAL ENVIRONMENT

2.1 LOCATION

The Cervantes South project area is approximately 100,000 ha and located within the Midwest region of Western Australia (Figure 1). The project area is in the vicinity of Cervantes in the Shire of Dandaragan.

The project area is bound to the west by the Indian Ocean and extends to approximately Brand Highway on the eastern edge. The townsite of Cervantes is the northern most extent whilst the southern boundary is immediately north of Wedge Island. The area is encompassed by the following 1:25,000 map sheets:

- 1936-4 NW;
- 1936-4 NE;
- 1936-1 NW;
- 1936-1 NE;
- 1936-4 SW;
- 1936-4 SE;
- 1936-1 SW; and
- 1936-1 SE.

2.2 EXISTING LAND USE

The Cervantes South project area is predominantly characterised by native bushland consisting of the following conservation reserves: Nambung National Park, Badgingarra National Park, Wongonderrah Nature Reserve and a number of other unnamed conservation reserves. Additionally, some areas are used for agricultural pursuits and the Tiwest mineral sand mine is located near the eastern boundary of the site. An aerial photograph of the project area is provided in Figure 2.

The townsite of Cervantes is within the northwest corner of the project area (Figure 1).

2.3 CLIMATE

The Cervantes South project area is characterised by a Mediterranean climate with cool wet winters and dry hot summers. Rainfall is greater from mid-May to the end of August (Figure 3).

Long-term average annual rainfall in the region from 1968-2010 is 539mm according to Bureau of Meteorology (BOM) recordings from the nearby Jurien Bay station, station number 9131 (BOM, 2010).

2.4 TOPOGRAPHY

The topography for the Cervantes South project area is undulating with the western edge near the Indian Ocean consisting of variable height sand dunes with the remainder of the site predominantly flat. General topography for the site is shown in Figure 4.

Topography generally varies between 0 and 180 mAHD across the project area. See Section 2.5 below for a description of the relationship of topography to geology.

2.5 GEOLOGY AND SOILS

The Cervantes South project area is comprised of a number of geological subsystems as presented in Figure 5. Generally, the project area is composed of sandy soils. A description of the general properties of each geological subsystem within the project area taken from the Department of Agriculture, 2003) soil mapping is described below.

Bassendean Subsystem: Gently undulating sandplains, low dunefields and seasonally wet plains and permanent to semi-permanent swamps consisting predominantly of deep sandy duplexes ranging from dryland rises and semi-wet to wet soils. Varies in origin from unconsolidated sand, aeolian and alluvial.

Nylagarda Subsystem: Relict alluvial plain consisting of grey or yellow/brown sandy duplexes of alluvial origin.

Quindalup Subsystem: Associated primarily with dune formation including interdunal areas, foredune areas, deflation areas, and active and unstable dunes. The Quindalup Subsystem consists of yellow and brown sands derived from Tamala limestone and Holocene calcareous sediments.

Spearwood Subsystem: Gently undulating to undulating rises and limestone outcrops consisting predominantly of yellow/brown sands and bare rock. Sands are derived from Tamala Limestone.

Yerramullah Subsystem: Plateau residuals, colluvial slopes, alluvial plains and closed depressions consisting of shallow loams, pale and yellow deeps sand, pale sandy gravels, and pale deep sands derived from colluvium.

2.6 REGIONAL VEGETATION

The Cervantes South is located in the Drummond Botanical District, in the Southwest Botanical Province of Western Australia. Beard (1978) mapped the project area as comprising the following vegetation associations:

b $^{1}_{2}$Li:	*Banksia* low woodlands on coastal plain white sand;
a$_{26}$m$_{4}$Zc:	*Acacia lasiocarpa* and *Melaleuca acerosa (Melaleuca systena)* Heath;
X$_{9}$SZc:	*Banksia – Calothamnus* association; and
dZc / hSZc:	Mosaic of *Hakea obliqua* scrub – heath on sand and Banksia heath on Laterite.

3 LITERATURE REVIEW

3.1 GEOMORPHIC CLASSIFICATIONS OF WETLANDS

The geomorphic classification of wetlands is based on landform and water permanence attributes of a wetland.

The classification is based on the two key features present in all wetlands in Western Australia; presence of water and type of landform (Semeniuk & Semeniuk, 1995).

The four categories of water permanence that influence the geomorphic type of wetlands are:

- permanent inundation;
- seasonal inundation;
- seasonal waterlogging; and
- intermittent inundation.

The five landform categories that influence the geomorphic wetland type are listed below and depicted in Figure 6:

- basins;
- flats;
- channels;
- slopes; and
- highlands.

The categorisation of the water permanence associated with each wetland landform provides the basis for classification and is presented in Table 1 below:

Table 1: Wetland Types According to the Geomorphic Classification System

	Landform				
Water Permanence	**Basin**	**Flat**	**Slope**	**Channel**	**Highland**
Permanent Inundation	Lake	-	-	River	-
Seasonal Inundation	Sumpland	Floodplain	-	Creek	-
Intermittent Inundation	Playa	Barlkarra	-	Wadi	-
Seasonal Waterlogging	Dampland	Palusplain	Paluslope	Trough	Palusmont

(Semeniuk & Semeniuk, 1995)

3.2 WETLANDS OF THE SWAN COASTAL PLAIN

In 1996, *Wetlands of the Swan Coastal Plain* was published in seven volumes based on the efforts of the (then) Water Authority of Western Australia, Department of Environmental Protection, Water and Rivers Commission and private consultants. The document as a whole provided a comprehensive approach to planning, management and understanding of wetland resources across the Swan Coastal Plain.

Volume 2a of the series, *Wetland Mapping, Classification and Evaluation – Main Report* (Hill *et al*, 1996a) provides information regarding the extent of wetland mapping done on the Swan Coastal Plain up until 1996. This project considered wetlands and their characteristics as being influenced by a number of factors including soil types, vegetation, and landforms whereas previous efforts for wetland mapping focused on wetlands being identified through topographic mapping.

The desktop component of the methodology for wetland mapping is generally described in the document as a process involving the use of hard copy 1:25,000 stereoscopic aerial orthophotographs (herein referred to as stereoscopic aerials). The stereoscopic aerials provided the ability to identify, delineate and classify wetland types at a scale of 1:25,000. Additionally, stereoscopic aerials were a resource for estimating wetland vegetation disturbance, and vegetation cover.

The definition of a wetland boundary within *Wetlands of the Swan Coastal Plain*(Hill *et al,* 1996a) was delineated based on the following three criteria:

1. Water permanence;
2. Vegetation; and
3. Hydric soils.

The wetland boundary is delineated to encompass the extent of all three wetland features listed above (Hill *et al*, 1996a). The above criteria for wetland boundary delineation were adopted for this project.

Volume 2a provides detailed description and justification for the geomorphic classification system which has been adopted for this project. A full description of classifications is given above in Section 3.1.

Volume 2b of *Wetlands of the Swan Coastal Plain – Wetland Atlas* (Hill *et al*, 1996b) is a series of 52, 1:50,000 scale plans showing the boundary, geomorphic type and management category of each mapped wetland. A number of key attributes are also provided in table format for each wetland. Since the original publication of Volume 2b the wetland mapping has been converted into a digital format for use in a geographic information system (the DEC's *Geomorphic Wetlands Swan Coastal Plain* (2010) dataset). This dataset is periodically updated by the DEC.

The evaluation of wetlands is the process used to describe and weigh a wetland's existing values. Management and planning objectives can be derived from wetland evaluation as it provides values, characteristics, function, use and attributes of each wetland. The evaluation of wetlands is not included as part of this project.

3.3 WETLANDS CONSERVATION POLICY FOR WESTERN AUSTRALIA

The *Wetlands Conservation Policy for Western Australia* (Government of WA, 1997) outlines the State's commitment to identifying, maintaining and managing wetland resources.

The Policy consists of five principal objectives with respect to the conservation of wetlands:

1. To prevent further loss or degradation of valuable wetlands and wetland types, and promote wetland conservation, creation and restoration.

2. To include viable representatives of all major wetland types and key wildlife habitats and associated flora and fauna within a Statewide network of appropriately located and managed conservation reserves which ensure the continued survival of species, ecosystems, and ecological functions.

3. To maintain, in viable wild populations, the species and genetic diversity of wetland-dependent flora and fauna.

4. To maintain the abundance of waterbird populations, particularly migratory species.

5. To greatly increase community awareness and appreciation of the many values of wetlands and the importance of sound management of the wetlands and their catchments in the maintenance of those values.

This project is consistent with this policy as it provides wetland boundaries and entities integral for future management, planning and evaluation including contributing to communication and education and providing wetland entities for further classification and evaluation.

3.4 FRAMEWORK FOR MAPPING, CLASSIFICATION AND EVALUATION OF WETLANDS IN WESTERN AUSTRALIA

The DEC has established a draft framework for the mapping, classification and evaluation of wetlands in the State to document wetland resources, identify wetland values, and ensure the preservation and improved management of wetlands in the long-term.

The framework provides information relating to the levels of detail expected at the three stages of assessment. The three stages range from broad to detailed and are described generally below:

- Stage 1 assessment refers to the broad scale identification of the occurrence of wetlands within a project area. The occurrence of a wetland is typically identified by either a point or approximate boundaries;

- Stage 2 assessment includes the identification of preliminary wetland boundaries, classification of wetlands into geomorphic types and identification of groups of wetlands (such as consanguineous suites); and

- Stage 3 assessment involves collection of information on wetland attributes and functions including detailed delineation of wetland boundaries and site specific evaluation.

The mapping and classification done as part of this project is considered commensurate with a Stage 2 assessment as individual wetland boundaries have been mapped at a scale suitable for viewing at 1:25,000, classification of wetlands into geomorphic type and a limited field survey to confirm wetland boundaries has been conducted. In this project, an evaluation of each mapped wetland in the field has not been undertaken, this is generally undertaken in a Stage 3 assessment.

The framework also identifies the system for wetland classification as being the geomorphic classification system described by Semeniuk & Semeniuk (1995), as described above in Section 3.1.

4 METHODOLOGY

The wetland delineation and classification process for this project was developed to be consistent with the methodology used in previous DEC wetland mapping projects and incorporates the use of geographic information systems.

ENV adopted the following general approach to mapping wetland boundaries:

1. Analysis of remotely sensed satellite imagery for preliminary wetland boundaries over the Cervantes South project area.
2. Analysis of associated digital spatial datasets including aerial orthophotos, topography, soil types, remnant vegetation, and hydrography to map preliminary wetland boundaries for approximately 10% of the project area
3. Verification of mapped wetland boundaries with the use of stereoscopic aerials.
4. Preliminary field survey to assess wetland mapping methodology.
5. Revision of desktop mapping methodology based on findings of the field survey.
6. Desktop mapping of remaining wetlands using digital imagery and datasets outlined in steps 1 and 2.
7. Final field survey to assess the methodology undertaken for the desktop mapping and to visit a wide range of identified wetlands in the field.
8. Minor adjustments based on outcomes of final field survey.

4.1 DESKTOP MAPPING

Geographic Information Systems (GIS) are a class of information system that keep track of not only events, activities, and descriptions but also consider **where** these occur. Discrete data stored in a GIS has two main components: the vector data and the attributes. The vector data holds the spatial location of the feature including its extent, boundaries, and geometry whilst the attribute information is stored in tabular format and relates to each shape or spatial feature mapped.

Desktop mapping for this project was undertaken using ESRI ArcGIS Desktop software between December 2009 to April 2010 and was submitted to the DEC as a digital file for review in a compatible GIS format. In this project, all mapping was undertaken by a single operator (Suzanne Smart) establishing consistency and reducing the possibility of handling errors being introduced into the dataset.

All results are presented in Map Grid of Australia (MGA) 1994 Zone 50 coordinates, referenced to the Geocentric Datum of Australia.

Wetland mapping effort in Western Australia has been focused on the digitising of map boundaries at a scale of 1:25,000. The representative fraction, also often known as the scale, is defined for a paper map as the ratio between distance on the map and the corresponding distance on the ground.

Representative fractions associated with standard map series, such as the 1:25,000 topography in Western Australia, have become standard bases for description of maps and map users have become accustomed to the link between representative fraction and the types of features and level of detail shown in maps.

4.1.1 Analysis of Landsat 7 Imagery

Landsat 7 satellite imagery for the project area was analysed to determine preliminary wetland boundaries. Remotely sensed satellite imagery captures both an image of the earth's surface and also captures the electromagnetic energy that is transmitted from the surface. Transmitted electromagnetic energy varies with the material type and condition and allows for analysis and interpretation of the earth's surface (Lillesand & Kiefer, 1994).

The use of indices in satellite imagery compares the difference between two spectral bands to isolate the variation within a given phenomena. Imagery from winter 2005 was used in the index described below.

The Normalised Difference Water Index (NDWI) was applied to the dataset to determine areas where inundation was present. This index enhances water features in the imagery by comparing the green and infrared bands in the electromagnetic spectrum to maximise the reflectance of water bodies. This index is commonly used in baseline wetland mapping in Queensland (Queensland Government, 2007).

It should be noted that the use of Landsat 7 imagery may not capture wetlands that are seasonally waterlogged, have extensive vegetation cover and/or are smaller than 900m^2

4.1.2 Analysis of Spatial Datasets

Spatial datasets were used to verify wetland areas identified using remote sensing and to identify potential omissions, and to verify and refine wetland boundaries.

In a GIS, the ability to overlay spatial datasets allows the user to compare the boundaries of separately occurring phenomena to determine their relationship and influence on wetland areas. Spatial datasets formed a background of detail that could be manipulated, analysed and adjusted to determine wetland boundaries. These datasets can be used to identify wetlands and define their boundaries. Datasets compared include topography, surface water catchments, soils, vegetation and digital aerial orthophotos (herein referred to as orthophotos). A complete list of the spatial datasets is provided in Table 2 (information and metadata supplied by DEC).

The orthophotos represent a raster type dataset where the data values are continuous with no associated attributes or interpretation being provided. The remainder of the datasets represent vector type datasets (as described in Section 4.1.1) which have completed attribute information.

Table 2: Spatial Information Sources

File Name	File Type	Year of Capture	Accuracy (m)	Resolution (m)	Source
Digital Aerial Orthophotos					
Wedge_Island_1936_Aug_2008_Mosaic	ecw	2008	5	50	Landgate
Wedge_Island_1936_Mar_2004_Mosaic	ecw	2004	5	50	Landgate
HillRiverMoora_98_1p2m_z50	ecw	1998	-	-	Landgate
Jurien_Bay_Marine_Park_Apr_2004_Mosaic (partial coverage)	ecw	2004	-	-	Landgate
Wedge_Island_04-1pm4m_z50	ecw	2004	-	-	Landgate
Miscellaneous Shapefiles					
Soil_subsystems	shp	2001	250	-	DAg[1]
Veg_complexes	shp	1996	-	-	CALM[2]
Drainage_lines	shp	2003	140	-	Geoscience Australia
Waterbodies	shp	-	-	-	-
Catchments	shp	2007	-	-	DoW[3]
Sub_catchments	shp	2007	-	-	DoW
Groundwater_bores	xls	-	-	-	DoW
WEC_CoolWest_Veg_20090311_region	shp	2009	-	-	Tiwest
Topography Statewide 10m Contours					
Contours_10m	shp	-	-	-	Landgate
Contours2009_mga_1	dxf	2009	-	-	Tiwest
Satellite imagery					
Landsat 7 (all bands)	tif	2005	-	30	Landsat
Hard Copy Stereoscopic Aerial Pairs					
Wedge Island (1936)	-	1994	-	1:25000	Landgate
Dandaragan (2036)	-	1994	-	1:25000	Landgate
Wongonderrah Swamp	-	1988	-	1:4500	CALM[2]
Nambung National Park	-	1988	-	1:4500	CALM[2]

1. Department of Agriculture (DAg)
2. Conservation and Land Management (CALM)
3. Department of Water (DoW)

4.1.3 Analysis of Stereoscopic Aerial Pair Photographs

In this project, the use of hard copy stereoscopic pairs has been used as an additional topographic data source and to maintain consistency with previous mapping projects in Western Australia. After the boundaries have been determined using the remote sensing and spatial datasets the area has been reviewed with stereoscopic aerials to potentially uncover any other wetland areas, to modify the boundaries and/or to assess the geomorphic classification given. The stereoscopic aerial pair analysis also provided an indication of the wetland boundaries in 1994 and where applicable in 1988. Additionally, due to the coarse detail of the available digital topography across the site the stereoscopic aerial pairs provided an additional topographic data source.

Stereoscopic aerials analysed for this project were from the Wedge Island (1936) and Dandaragan (2036) map sheets and were represented as 10 flight runs across the project area in an east-west direction consisting of approximately 21 photos within each flight run (Table 2). The flight dates for the stereoscopic aerials were from 19-22 April 1994. These two sets of stereoscopic aerials provide coverage for the entirety of the project area and were captured at a 1:25,000 scale.

An additional two sets of stereoscopic aerial pairs were used in this project to refine wetland boundaries for Wongonderrah Swamp and Nambung National Park which are both DEC managed lands. These images were captured at 1: 4500 scale between 18-28 March 1988 (Table 2).

4.1.4 Identification of Wetland Boundaries

Identification of wetland boundaries was performed in an iterative process involving the use of satellite imagery, spatial datasets and stereoscopic aerials.

The Landsat 7 imagery was able to provide mapping of inundated areas at approximately 30 m spatial resolution (or pixel size). The minimum detectable area of change was 900m^2 for wetland area, which was not considered commensurate with a Stage 2 mapping layer. The Landsat 7 derived wetland boundaries were then overlaid with digital orthophotos, topography, soil mapping, hydrography, catchment mapping and vegetation complex mapping to improve the accuracy of boundaries, the resolution of entities and the inclusiveness of the mapping to be commensurate with a 1:25,000 scale.

The boundary of each wetland was then mapped in the GIS as a polygon feature referenced off digital orthophotos. The use of digital orthophotos in this process provides a georeferenced link to the ground surface where the boundaries of the wetland may occur.

The boundaries of the wetlands were also compared over a number of years as multiple orthophotos taken in different years improved the temporal resolution of the wetland boundaries.

In this project, a conservative approach to wetland delineation was adopted consistent with Semeniuk & Semeniuk (1995) where *“the boundary of (a) wetland is drawn at the outside of the area that has the characteristics of dampness, or hydric soils, or vegetation indicative of wetland conditions*”.

Once the boundaries were digitally mapped on screen, the operator visually checked for consistency with stereoscopic aerial pairs. Stereoscopic aerial pairs were viewed through a stereoscope to enhance the three dimensional appearance of the landscape and compared to the digital mapped boundary on the computer screen. The operator visually compared landscape characteristics (as defined in Section 4.1.5) between the hard copy images and the digital images updating any wetland boundaries when required.

In this project all desktop mapping and the field survey was undertaken by a single operator.

4.1.5 Criteria for Delineating Wetland Boundaries

Wetland boundaries were delineated during the desktop process by using the following three generalised criteria consistent with Hill *et al* (1996):

1. Hydrology;
2. Soil; and
3. Vegetation.

To delineate a boundary of a wetland a minimum of one of the above criteria was used however, two or all three factors can contribute concurrently to the delineation of the boundary. If the criteria show varying extents the most conservative extent encompassing the greatest wetland area was chosen. How each individual criterion was utilised in the desktop mapping is described below.

For each individual wetland the criteria of hydrology, soils and vegetation were considered and ranked in the attribute table associated with the shapefile in terms of which criteria provided the basis for the extent of the boundaries. The attribute table has three columns labelled CRIT 1, CRIT 2 and CRIT 3 which represent primary criteria, secondary criteria and tertiary criteria for identification of wetland boundaries and is populated by the applicable criteria for wetland delineation. In the attribute table 'V' represents vegetation, 'H' represents hydrology and 'S' represents soils. Each wetland has a primary criteria for delineation and may have all three criteria represented. Some wetlands may only have a primary criterion.

For example, if a wetland was delineated solely based on hydrology then the attribute table would list 'H' under 'CRIT 1'. This sole criterion for delineation may indicate that no wetland type vegetation or wetland soils were apparent from the desktop mapping. Another example is if a wetland was largely delineated on the basis of vegetation and to a lesser extent by hydrology then the attribute table would list 'V' under 'CRIT 1' and 'H' under 'CRIT 2'. The intention is to provide clarity in the decision-making process of the wetland mapping for future dataset users. A full description of attributes is included in the Metadata statement, Appendix E to this report.

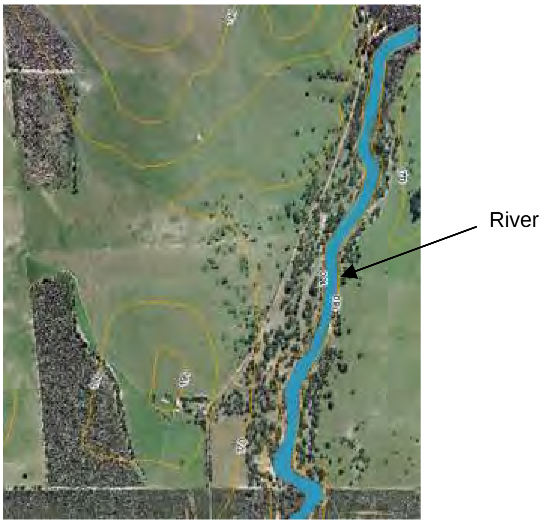
Hydrology

The principle characteristic to identifying the presence of a wetland is determining a degree of water permanence. Delineation of the wetland boundary based on hydrology is determined by differentiating an area characterised by a degree of 'wetness' to a dryland area. Hydrological indicators were usually inferred from the presence and extent of surface water or waterlogging and associated scouring as interpreted from Landsat 7 images, orthophotos and stereoscopic aerials.

Topography provides an indication of the type of landform which governs the local hydrology of the wetland. The physical extent of inundation or waterlogging is generally associated with the surrounding landform. Topography dominates either the depth of inundation or the depth at which wetlands are waterlogged.

For example, in Plate 1 below the boundaries of a river channel from within the project area are shown to be consistent with the 160 mAHD topographic contour.

Plate 1: Topographic Interpretation of River Boundaries



For example, as shown below in Plate 2, the presence of an open water body within the project area in a late summer aerial photo is a clear indication of a wetland governed by the existence of a permanent inundated area. The boundaries of the Lake shown in Plate 2 were determined primarily based on the extent of permanent inundation.

Plate 2: Orthophoto Interpretation of Lake Boundaries

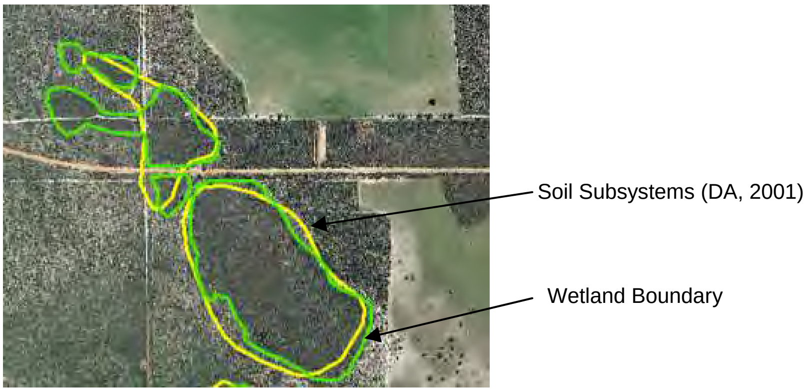
Soil

Identification of wetland soils through desktop mapping was undertaken through the use of both Soil Subsystems mapping from the Department of Agriculture (DA) and through orthophoto interpretation.

Soil mapping for this project area was undertaken by the DA at a 1:100,000 (DA, 2001) scale and was used as a resource for determining potential wetland areas. The soil mapping does not distinguish between hydric and nonhydric soils but does provide an indication of waterlogged, inundated and wetland-type soils (DA, 2001). Soil subsystems that were considered wetland type soils were Bassendean Subsystems 1,4,6,7, and 9 and Yerramullah Subsystem 9 and 10 because the description for these soil subsystems included reference to inundation or waterlogging.

However, the use of general soil mapping assisted in identifying the characteristics and possibly coincident boundaries of wetland soils and wetland boundaries. Plate 3 shows an example of how broadscale mapping of wetland soils is refined to demarcate finer scale wetland boundaries. In this example identification of the wetland soil is from the DA mapping but application of the wetland boundary is coincident with the change in vegetation texture and colour changes in the orthophoto.

Plate 3: Use of Soil Layer



Additionally, orthophoto interpretation can identify areas where soil texture and colour varies and depicts wetland type soils providing an indication of the extent of waterlogged or inundated soils present. For example, wetland areas with high soil salinity are easily identifiable in orthophotos evident as shown in Plate 4. The orthophoto shows a change in colour to a grey-white exposed soil which is likely to be seasonally inundated by saline water as identified during the field survey .

Plate 4: Orthophoto Interpretation of Soil Characteristics

Vegetation

Similar to the methods employed to delineate wetland boundaries based on soil properties, orthophoto interpretation can provide an indication where vegetation boundaries change. Changes in colour and texture delineate where vegetation changes may occur. Assessment of the vegetation during the field survey was undertaken to confirm the desktop analysis of wetland boundary extents and to ensure that variations shown in the orthophotos are reflected in the field. Field survey methodology is presented in Section 4.2.

Plate 5: Orthophoto Interpretation of Vegetation Changes

4.1.6 Classification of Wetlands

Once wetland boundaries were mapped a wetland type was then assigned to the area. The classification of wetlands into types using the geomorphic classification system is dependent on two main factors; landform and water permanence.

To determine the landform of each wetland the topography of the area and how that surrounding topography related to the shape of the wetland was considered. Figure 6 shows in diagrammatic form along with topographic contour line examples, the different landform types that are associated with wetland classification. In this project landform type was determined through the use of digital topography and stereoscopic aerials.

Water permanence was inferred through the use of satellite imagery, orthophotos and stereoscopic aerials. Some of the digital orthophotos used were taken during the summer months, which is when seasonally inundated/waterlogged areas can be distinguished from permanently inundated areas as their drying regime is revealed. Alternatively, extents of inundation were apparent in the August 2008 orthophoto.

In wetlands, the extent of seasonal inundation/waterlogging is often not consistent across the entire wetland area. Therefore classification of wetlands requires an assumption about the extent to which the water permanence can vary. Generally, wetland mapping in this project adopted the 10% cut-off rule proposed by Semeniuk & Semeniuk (1995) to distinguish between water permanences for a particular landform type. That is, the areas' extent of either permanent inundation or seasonal inundation cannot exceed either seasonal inundation or seasonal waterlogging respectively by greater than 10% and still maintain its original classification. The example given in Semeniuk & Semeniuk (1995) is as follows:

> *"If a basin that has a seasonally fluctuating water level dries out such that there is still more than 10% of water by area in the basin at the driest stage, then it is a lake, but if there is less than 10% of water by area in the basin at the driest stage, then it is a sumpland" (p.111).*

4.1.7 Mapping Limitations

Generally in spatial analysis, datasets created are limited by the spatial datasets from which they are derived. In this project, the extent to which Landsat 7 data could be utilised was limited by the coarse spatial resolution of the satellite imagery (30m resolution) and its tendency to underrepresent waterlogged wetlands therefore requiring greater input based on the remaining spatial datasets. Spatial datasets including the topography, soils and vegetation complexes were at a coarser spatial resolution than the required output of this project. In other words, a GIS cannot derive a 1:25,000 dataset from input datasets that are derived at 1:100,000 as is generally the case from remote sensing data. In turn, the resultant boundaries are largely based on the finer resolution of the digital orthophotos and stereoscopic pairs.

The implication of this is that there is a greater emphasis and need for manual processes and operator adjustment and less focus on the information derived from spatial datasets, introducing an element of subjectivity.

A further limitation was imposed by the topographic contours available for the area. Topographic contours provided for the area were at 10m intervals which is suitable for broadscale changes in landform but not localised changes that may occur and influence wetland ecology and therefore may influence the accuracy of classification and delineation.

To overcome the lack of digital topographic information, this project utilised the analysis of stereoscopic aerial pairs for analysis of finer scale topographic changes. The visual analysis of stereoscopic aerial pairs assisted in the delineation of wetlands based on landform. However, topography could not be overlain digitally using the GIS, therefore the ability to directly compare and contrast boundaries between the digital orthophoto and topography could not be undertaken as part of this project.

4.1.8 Mapping Outcomes

Desktop mapping for this project was undertaken from December 2009 to April 2010 and was submitted to the DEC as a digital file for review in a compatible GIS format. In this project, all mapping was undertaken by a single operator providing consistency and reducing the possibility of handling errors being introduced into the dataset.

A number of orthophotos were provided for this project which covered different seasons including winter and summer allowing a more thorough examination of both the extent of water permanence and a clearer understanding of seasonal patterns and in turn more accurate classifications. This improved the ability to classify wetlands and delineate their boundaries by providing a better understanding of the inter-seasonal water permanence of the wetland.

4.2 FIELD SURVEY

Field survey was used in this project to provide an assessment of the applicability of the methodology in the early stages in the mapping process and to provide a measure of accuracy to associate with the finalised mapping dataset.

4.2.1 Site Visits

This project undertook two separate field surveys to assess the desktop mapping methodology.

A preliminary field survey was undertaken by Suzanne Smart (Senior Environmental Scientist) and Ciaran Sgherza (Botanist) from ENV on 21 January 2010 to examine four selected wetlands (a creek, a floodplain, a lake and a sumpland) in the southeast part of the Cervantes South project area (shown in Figure 1 of Appendix A).

A variety of wetlands were chosen for this visit to ground truth the desktop outputs and to gain a practical understanding of the physical environment and the characteristics of the catchment. By the time of this first field visit approximately 10% of the project area had been mapped using the desktop methods.

The wetlands visited during this first field survey represented the range of types present within the project area and varied in their composition including whether their surrounding area had been cleared or consisted of remnant vegetation. ENV field staff examined the soil types, vegetation, hydrological conditions, and landform for wetland characteristics. Wetland boundaries and classifications were assessed to provide feedback into the desktop mapping methodology and contributed to the accuracy statement described below in Section 5.

It should be noted that the mapping methodology remained unchanged after the first field trip but provided a better understanding of the landscape and geomorphology of the project area to be considered as part of the mapping process.

The second field survey was undertaken from 2-5 March 2010 and examined 25 wetlands (including seven creeks, five floodplains, four palusplains, four sumplands, three damplands, and two lakes) representing a wider extent of the project area. The wetlands selected were based on accessibility and diversity of wetland types within the area. The project area is predominantly characterised by native vegetation with few tracks and roads which limited the potential to visit a number of wetlands due to their remote location. For example, ENV were unable to visit any barlkarra type wetlands due to their remote locations with no track access.

A Regulation 4: Authority to Enter CALM Land and/or Waters (No. CE002720) was received for Suzanne Smart and Ciaran Sgherza of ENV to facilitate conducting scientific work in DEC managed lands. All flora specimens for this project were collected by Ciaran Sgherza under the Section 23C Licence for Scientific or Other Prescribed Purposes No. SL008926. Before visiting wetlands on private property, permission to enter was obtained from the landholder.

Field maps showing the wetlands visited are contained in Appendix A and the related photos are provided as the digital Attachment 1 to this project.

For each wetland visited a field sheet was compiled with observations regarding the vegetation, hydrology, soils and landform in the area, how it related to the mapped boundaries of the wetland and its geomorphic classification. The field sheets associated with each wetland visited are found in Appendix B. In addition, a number of photographs were taken at each wetland, an index of the photographs is included as Appendix C with the photos provided digitally in Attachment 1.

During both field surveys large tracts of the survey area was driven. This provided more general interpretation of the landform and more effective interpretation of desktop mapping. A large number of wetlands were surveyed in a brief and informal way as well as large areas surveyed for wetlands missing from the dataset. For example, ENV traversed a large area where no wetlands were mapped at the desktop level to ensure that this was correct.

4.2.2 Delineation of Wetland Boundaries

Delineation of wetland boundaries in the field focused on determining the extent of permanently inundated, seasonally inundated and waterlogged areas based on the hydrology, hydric soils, and wetland vegetation. Identification of the individual characteristics of each wetland is within Section 4.2.3, 4.2.4, and 4.2.5 with the general methodology described below.

To capture the position of the wetland boundary as determined in the field ENV staff were equipped with a handheld global positioning system (GPS) to record coordinate locations. These coordinate locations were then loaded into the GIS on returning to the office and directly compared to the derived desktop boundary. All coordinate locations are transcribed onto the field sheets attached as Appendix B of this report.

When ENV staff were on site they determined where to record coordinates using two methods; a transect and/or a "boundary walk".

For each wetland it was endeavoured to perform one boundary walk, if distinct boundaries were observed. When wetland boundaries were not easily distinguishable 1 or 2 transects were undertaken. Boundaries were determined by either a boundary walk or up to 2 transects per wetland.

Transects were used to determine the boundary of a wetland through analysis of soil and vegetation characteristics. A transect consists of walking in a consistent direction across a clearly wetland zone to a clearly dryland zone (or the reverse) noting changes in characteristics and compositing of vegetation and soil. Transects were used at every wetland to determine soil characteristics (as described in detail in Section 4.2.4) and where used in areas of dense vegetation where visibility was poor (as described in detail in Section 4.2.3).

In areas where a change from wetland to dryland was noted, a GPS coordinate was recorded at the transition point to delineate the wetland boundary.

In this project, a boundary walk refers to walking along the edge of the perceived boundary to a wetland based on identification of wetland vegetation, hydrology, and hydric soils (as specified below). During a boundary walk up to five GPS coordinates were recorded at approximately 10-20m intervals depending on access. A boundary walk was used in this project where there was a clear and distinct transition between wetland and dryland areas.

Described below is how the boundaries were determined based on vegetation, soils, hydrology and landform.

4.2.3 Wetland Boundary Delineation based on Vegetation

During the first field visit where vegetation was present and field identification of plant taxa was not possible, specimens were collected systematically for later identification by a specialised ENV taxonomist.

Based on the literature review using Lyons *et al* (2004) and *FloraBase* (Western Australian Herbarium, 2010) a list was compiled identifying wetland obligate and wetland facultative plant species specific to the project area. For the purposes of this project, species that prefer winter-wet areas, swamp areas, creek lines, waterlogged soils were considered wetland obligate species (i.e. those plants restricted to wetland habitats, DEC 2007a). Facultative species can be common, notably in a variety of habitats such as hills and slopes as well as beside drainage lines, fringing salt marshes (i.e. those species that can occur in wetland and dryland habitats, DEC 2007a).

In addition to the flora specimens collected in the field an ENV Botanist and ENV Taxonomist researched and liaised with the DEC and Department of Water (DoW) to review this list and to consider what additional wetland species would likely be present in the area. Recommended changes and additional species nominated by DEC and DoW were then researched to facilitate identification in the field and improve the delineation of wetland boundaries. All plant specimens were also collected in the field for identification by a specialised ENV Taxonomist to ensure consistency.

Any new flora species not found in the first survey were identified upon return to ENV offices and incorporated in field data. Please note however that this was not a comprehensive flora and vegetation survey as not all species present within the wetland community were recorded.

Species that were considered to be obligate wetland species and facultative wetland species in the project area and that were recorded during the field surveys are listed in Table 3. A complete flora species list and their habitat preferences have been compiled in Appendix D.

Table 3: Cervantes South Project Area Wetland Obligate and Wetland Facultative Flora Species List

FAMILY		TAXA	COMMON NAME	HABITAT PREFERENCE	
				Obligate	Facultative
Anarthriaceae		*Lyginia imberbis*			√
Chenopodiaceae		*Rhagodia preissii subsp. preissii*			√
Chenopodiaceae		*Suaeda australis*	Seablite		√
Chenopodiaceae		*Tecticornia lepidosperma*		√	
Chenopodiaceae		*Tecticornia syncarpa*		√	
Chenopodiaceae		*Tecticornia undulata*		√	
Cyperaceae		*Baumea juncea*	Bare Twigrush	√	
Cyperaceae		*Cyperus gymnocaulos*	Spiny Flat-sedge	√	
Cyperaceae		*Gahnia trifida*	Coast Saw-sedge	√	
Cyperaceae		*Lepidosperma longitudinale*	Pithy Sword-sedge	√	
Cyperaceae		*Schoenus subfascicularis*		√	
Fabaceae		*Acacia cyclops*	Coastal Wattle		√
Fabaceae		*Acacia saligna*	Orange Wattle		√
Fabaceae		*Jacksonia ? sternbergiana*[1]	Stinkwood		√
Fabaceae		*Viminaria juncea*	Swishbush		√
Frankeniaceae		*Frankenia pauciflora*	Seaheath	√	
Goodeniaceae		*Scaevola lanceolata*			√
Juncaceae		*Juncus aridicola*		√	
Juncaceae		*Juncus pallidus*	Pale Rush	√	
Myrtaceae		*Beaufortia elegans*			√
Myrtaceae		*Beaufortia squarrosa*	Sand Bottlebrush		√
Myrtaceae		*Calothamnus quadrifidus*	One-sided Bottlebrush		√
Myrtaceae		*Eucalyptus todtiana*	Coastal Blackbutt		√
Myrtaceae		*Eucalyptus gomphocephala*	Tuart		√
Myrtaceae		*Eucalyptus rudis subsp. rudis*	Flooded Gum	√	
Myrtaceae		*Hypocalymma angustifolium*	White Myrtle		√
Myrtaceae		*Kunzea recurva*			√
Myrtaceae		*Melaleuca brevifolia*		√	

FAMILY		TAXA	COMMON NAME	HABITAT PREFERENCE	
				Obligate	Facultative
Myrtaceae		*Melaleuca cardiophylla*	Tangling Melaleuca		√
Myrtaceae		*Melaleuca lanceolata*	Rottnest Teatree		√
Myrtaceae		*Melaleuca preissiana*	Moonah	√	
Myrtaceae		*Melaleuca rhaphiophylla*	Swamp Paperbark	√	
Myrtaceae		*Melaleuca teretifolia*	Banbar	√	
Myrtaceae		*Pericalymma ellipticum*	Swamp Teatree	√	
Myrtaceae		*Regelia ciliata*			√
Myrtaceae		*Verticordia densiflora var. densiflora*			√
Poaceae	*	*Polypogon monspeliensis*	Annual Beardgrass		√
Polygonaceae		*Muehlenbeckia adpressa*	Climbing Lignum		√
Polygonaceae		*Persicaria prostrata*			√
Proteaceae		*Banksia littoralis*	Swamp Banksia	√	
Proteaceae		*Banksia sphaerocarpa* var. *sphaerocarpa*	Fox Banksia		√
Proteaceae		*Grevillea preissii subsp. preissii*			√
Proteaceae		*Hakea trifurcata*	Two-leaf Hakea		√
Proteaceae		*Hakea varia*	Variable-leaved Hakea	√	
Proteaceae		*Petrophile brevifolia*			√
Restionaceae		*Chaetanthus aristatus*		√	
Restionaceae		*Meeboldina cana*		√	
Restionaceae		*Meeboldina coangustata*		√	
Xanthorrhoeaceae		*Xanthorrhoea preissii*	Grass tree		√

1. Taxonomic identification cannot be confirmed to species level

Abbreviations: sp.: species (singular)
var.: variety
spp.: species (plural) subsp.: subspecies
* denotes introduced species
ms: manuscript name (unpublished)

4.2.4 Wetland Boundary Delineation based on Hydric Soils

Wetland soils are commonly referred to as "Hydric Soils". ENV have applied the definition of hydric soils adopted by DEC in the *Framework for mapping, classification and evaluation of wetlands in Western Australia* which reflects that applied by the United State's Department of Agriculture (DEC, in publication):

> *"Soil that is formed under conditions of saturation, flooding or ponding long enough to develop anaerobic conditions in the* ***upper*** *part. The concept of hydric soils includes soils developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation."*

The following details the field methodology for using hydric soils to delineate the boundary of wetland within the project area.

Hydric Soil Indicators

According to the definition of hydric soils, its properties are observed in the upper part of the soil horizon. Wetland soil indicators generally occur within **0.3 m** of the soil surface (Queensland Government, 2008; Richardson & Vepraska, 2001). The following characteristics are commonly used to identify hydric soils in the field and where encountered are described in the field sheets (Appendix B). The methods applied are considered the most practicable for field identification of hydric soils and their relevance to a wetland boundary.

Organic material An indicator of hydric soils is accumulated organic horizons consisting predominantly of decomposed plant material (Queensland Government, 2008). Organic matter ranges from undecomposed material to completely decomposed.

Gleying Denotes sand or soils that are water saturated and are characterised by being bluish-grey, grey-green or grey (Semeniuk & Semeniuk, 2005; Richardson & Vepraska, 2001; Queensland Government, 2008).

Fibrous Prominent soil structure imparted by plant fibres, roots and decayed stems (Semeniuk & Semeniuk, 2005)

Mottles Richardson & Vapraska (2001)define mottles as small areas which differ in colour from the soil matrix. Semeniuk & Semeniuk (2005) expand this definition to include variation caused by burrows and texture. For the purpose of this project mottles will be considered as any small areas which differ in colour, texture and/or burrows from the soil matrix.

Skeletal Remains Including whole shells, frustules, tests, and skeletons of invertebrate fauna (Semeniuk & Semeniuk, 2005).

Wetland Soil Horizon

Generally, the soil horizon refers to the vertical profile of soil and the associated separation of characteristics and properties. Horizons are generally distinct due to differences in properties such as organics, morphology, mineralogy and chemistry (Richardson & Vepraska, 2005). The soil horizon within a wetland forms through sedimentation over top of the basal facies (parent material), deposition can occur through fluvial influx or aeolian influx and generally forms a distinctive soil profile (Semeniuk & Semeniuk, 2005).

As shown in Figure 7, the soil structure of a wetland profile varies from the central deposits to the marginal deposits of the wetland with both types of sediments underlain by the same parent material (Semeniuk & Semeniuk, 2005).

The central deposits of a wetland are characterised by consistent inundation or waterlogging which in turn show the strongest characteristics of hydric soils and increased organic content. According to Semeniuk & Semeniuk (2005) towards the edges of the wetland the marginal deposits should show characteristics of rising and falling water levels, and mixing of organic matter and skeletal material. It is important to note that underneath both the central and marginal deposits the parent material is the same.

Wetland Boundary Delineation Based on Soils

Semeniuk & Semeniuk (2005) indicate that the limit of hydric soils or wetland sediments delineates the boundary of a wetland. To determine the wetland boundary in the field, ENV performed a single transect commencing within the wetland traversing to the dryland edge examining the soil profile at a number of locations (Figure 7). The upper 30cm of the soil profile was examined using a spade for properties of hydric soils as listed above and described accordingly. Photos of soil profiles are provided in Attachment 1.

The intent of the initial profile is to determine the wetland soil characteristics of each wetland based on the properties of hydric soils listed above. The profile was taken from a location that is clearly defined as occurring within the wetland. The central area of the wetland was determined in the field by consideration of the hydrology, landscape and wetland vegetation. The soil characteristics noted were then analysed along a transect with soil profiles examined to determine at what point the parent material appears at surface. The number of profiles examined was based on the observed characteristics where there is a transition from depositional sediments to parent material.

The wetland boundary was then defined by the profile in which the parent material is observed throughout the full profile such as Profile n in Figure 7. Note that the number of Profile locations was not limited to the 3 shown below but was based on the number of profiles required to reach the conditions exemplified by Profile n (i.e. parental material at surface).

4.2.5 Wetland Boundary Delineation based on Hydrology

Hydrological observations made in the field related primarily to either surface water or groundwater hydrological characteristics. This includes evidence of groundwater rise, surface water inundation or surface water flow across the wetland.

Although a snapshot of the hydrology of a wetland cannot be used to define a wetland boundary it does contribute to either the landform type or the soils present therefore supporting the observations made. More importantly, understanding the hydrology of the wetland is imperative to its geomorphic classification.

Wetland hydrology is largely dependent on the surrounding landform type as it governs the separation distance to groundwater and any surface water flow parameters. Predominant landforms and topographic changes were observed in the field to assist in determining extent of a wetland area and what the dominant local hydrology may be. Additionally, minor changes in relief and landform are evident through field observation but may not be apparent in desktop 10m topographic contour mapping.

4.2.6 Classification of Wetlands

The classification of wetlands in the field was based on two key observations relating to the landform and water permanence.

Observations of landform type in the field were classified according to the landform types presented in Figure 6. A section in the field notes was dedicated to the observation of the landform type and how it related to the desktop mapping. For example, typical observations included identifying low lying or flat areas and basin formations in the landscape.

The water permanence in the field was identified through observations regarding the local hydrology and soils of the wetland. Since the site visit occurred in January and March, and not during a period of peak groundwater and surface water levels, a number of observations were recorded to estimate the extent of waterlogging or inundation that would characterise the wetland. Where waterlogging and surface water flow was observed it was noted in the field notes.

In seasonally dry wetlands, observations regarding soils and hydrology were recorded to make an estimate as to the “water permanence” of the area. Observations regarding erosion or surface water scour in many wetlands were recorded to indicate seasonal inundation.

4.2.7 Survey Limitations

Three main limitations were encountered in the field survey. Firstly, the field survey was undertaken in January and March at the end of summer after a long stretch without significant rainfall. The nearby Jurien Bay weather station had recorded zero rainfall since 20 November, 2009 meaning no rainfall for the preceding three months (BOM, 2010). The long term (1969-2010) average for the December to February period is generally low at 9.3mm which indicates the conditions for the survey were representative for that time period (BOM, 2010).

Estimation of seasonal high groundwater levels or surface water features could not be undertaken due to the timing of the field survey.

Approximately 98% of the wetlands mapped are seasonally inundated, seasonally waterlogged or intermittently inundated. Conclusions made regarding the water permanence of these wetland had to be determined based on vegetation, soil and local hydrology.

Additionally, the field survey was limited to 10 person field days (or 2 people over 5 days) as specified by the DEC tender. As a result approximately 4% of wetlands were visited with an additional 10 person field days (or 2 people over 5 days) estimated to have been required to visit 10% of the wetlands.

Finally, the project area is predominantly characterised by a natural landscape with little formalised road infrastructure. Wetlands visited in the field were selected preferentially based on their proximity to established tracks and existing roads which reduced the spatial distribution of the examined wetlands. For example, two barlkarras were identified in the desktop mapping however access to these wetlands was a significant distance from an established track. Furthermore, this limitation may have implications for the positional accuracy as a limited range of wetlands were visited.

4.2.8 Survey Outcomes

The use of a transect and/or a boundary walk to identify wetland boundaries provided adequate detail to assess the accuracy of boundaries in the GIS.

This project employed the methodology described in Section 4.2.4 which describes how hydric soils can be used to delineate a wetland boundary. The methodology was successful in identifying characteristics of hydric soils within some wetland areas, with most wetlands showing high organic content in the soils.

As mentioned in Section 2.5, the project area is largely characterised by sandy soils. Sandy hydric soils can be problematic in the sense that they have strong drainage properties in which strong characterisation of hydric soil does not occur (Tiner, 1999). In the field survey some hydric soil properties such as gleying and mottling were rarely encountered.

ENV analysed the soil horizon approaching the boundaries of a wetland and generally found that evidence of hydric soils would cease coincident with localised landform changes.

However, it should be noted that in all cases where the wetland areas contained remnant vegetation the limit of hydric soils did not surpass the limit for obligate wetland vegetation, meaning that a boundary based on vegetation resulted in a larger wetland. The field survey determined that in the project area a conservative delineation of wetland boundaries was based on the presence of wetland vegetation.

For the field survey, detailed notes were compiled and have been submitted as Appendix B to this report. All notes refer to the unique feature identifier (UFI) that is contained within the

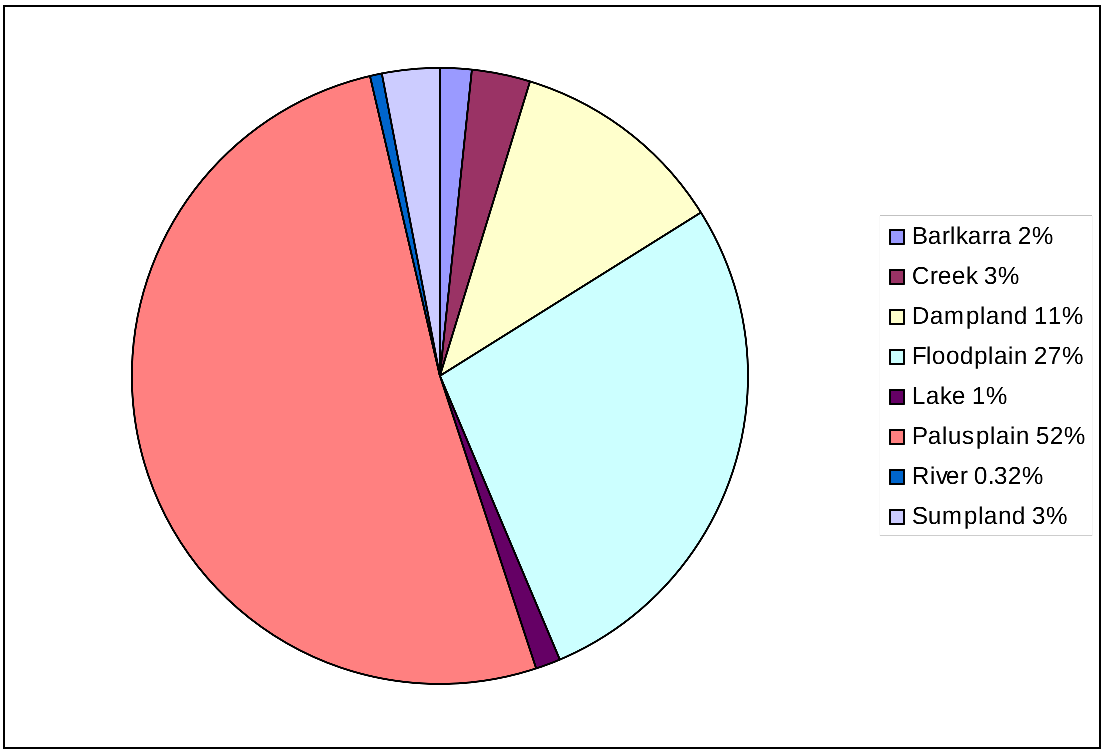
Geomorphic wetlands Cervantes South dataset to link the spatial component of the project to the field component. GPS capture points and key elements of the boundary definition are noted to improve the repeatability of this project. Additionally, photos were taken in the field that identify boundary areas and support the observations documented in the notes.

5 RESULTS

In the Cervantes South project area, 770 wetlands were mapped and classified including sumplands (351), damplands (273), palusplains (66), creeks (33), floodplains (31), lakes (10), rivers (4), and barlkarras (2) using the methods described.

The dataset recognises 20,221 ha of mapped wetlands which represents approximately 20% of the total project area. The smallest mapped wetland is 0.02 ha and the largest mapped wetland is 258 ha. The breakdown of wetland types as a percent of total mapped wetland area is shown in Figure 8 below.

Figure 8: Wetland Type as Percent of Total Wetland Area



The field survey undertaken as part of this project visited 29 wetlands and assessed 1,517 ha of wetland in total making up almost 4% of the number of mapped wetlands and 8% of the mapped wetland area. The boundaries of 29 wetlands were assessed in the field and boundary coordinate locations were captured and used to compile the accuracy statement. Typical accuracy on a handheld GPS is +/- 5m. Based on field observations typical accuracy for the Geomorphic Wetlands Cervantes South dataset was determined as approximately 14 m with a breakdown of accuracies per wetland type provided in Table 4.

Table 4: Average Positional Accuracy for Geomorphic Wetland Types Groundtruthed during the Field Survey

Classification	Number Visited	Positional Accuracy (m)	Range of Distance (m)
Creek	8	15.7	6.0-36.5 (30.5)
Dampland	3	14.7	13.4-17.0 (3.6)
Floodplain	6	14.9	7.2-34.0 (26.8)
Lake	3	7.7	3.4-12.0 (8.4)
Palusplain	4	14.4	6.8-22.0 (15.2)
Sumpland	5	14.6	4.2-33.6 (29.4)
Rivers	0	-	-
Balkarras	0	-	-

Based on the field observations, classification of the wetlands undertaken using desktop techniques was assessed and 4 wetlands from 32 required a change in classification. This suggests an attribute accuracy of approximately 88%. One mapped wetland visited was removed from the dataset because the field visit confirmed it had no characteristics associated with a wetland.

The boundaries of all wetlands have been represented as an ArcGIS shapefile in polygon format. Listed in the attribute table is a unique feature identifier (UFI), the geomorphic classification of each wetland, the criteria that defined the boundary in the desktop process, whether a site visit was conducted and the date of the site visit. The criteria used to define the wetland boundary presented in the attribute table is organised by primary, secondary and tertiary representing vegetation, hydrology and soils described in Appendix E. This has been included in the attribute table to assist the dataset user in understanding how the boundaries were delineated.

Metadata (data about data) has been compiled to describe the content, structure and general features of the Geomorphic Wetlands Cervantes South dataset. The metadata for this dataset is contained in Appendix E. The spatial dataset is the digital Attachment 2 to this report.

6 RECOMMENDATIONS AND DISCUSSION

6.1 DESKTOP MAPPING

This project employed a computer based methodology for desktop mapping and classification of wetlands in the Cervantes South project area. This methodology was undertaken to take advantage of GIS and other spatial information collected in the project area by either the DEC or other State government agencies. The methodology yielded a robust dataset that was ground truthed through field observations at a limited number of wetlands.

6.1.1 ENV Mapping Recommendations

The use of GIS and spatial datasets in wetland mapping is recommended for future wetland mapping projects undertaken by the DEC as it allows the use of a number of different datasets over a range of time periods to assist in identifying boundaries and assigning a geomorphic type. It also allows for the direct digitisation of wetland boundaries and designation of attributes which improves efficiency in production and distribution.

The use of a wide range of information sources over a large time period has increased the reliability of this project's output. ENV would recommend the use of multi-season orthophotos in future projects to assist in classifying wetlands and orthophoto interpretation. In particular, the provision of winter orthophotos improves classification of wetlands as it allows for visual identification regarding the extent of water permanence, particularly for seasonally inundated or seasonally waterlogged wetlands.

ENV also believe there is a significant benefit to having the same operator conduct the desktop interpretation as well as participating in the fieldtrips. The field trip provides the operator with a better sense of the landscape and likely occurrences of vegetation types and landforms correspond to wetland features. This difference can't be quantified but it is likely to have resulted in a more reliable dataset. For example, 40 km of the project area was traversed from west to east from Pinnacles Drive, along the entire length of Wongonderrah Road, to just past Brand Highway which provided a cross section of the landforms, vegetation types and topography which was representative of the total project area. Throughout the 40 km traverse 11 wetlands were assessed using the field survey methods described in Section 4.2 but the physical environment of the region was assessed and any missed wetland would be accounted for.

As mentioned above, this project was limited by the amount of fine scale topographic datasets available and this should be considered a high priority for future wetland mapping projects. The lack of a detailed topographic layer in this project was partially overcome by the use of stereoscopic aerials. Stereoscopic aerials are available in digital form for viewing on a range of different hardware (eg. Planar screen) and although relatively costly, if available would be useful in that this would allow digital overlay of the mapping layer with the stereo image which gives a three dimensional perspective to digital mapping.

The availability and applicability of more detailed satellite imagery or other remote sensing data (such as detailed aerial photography or LIDAR) should be investigated in future, possibly with assistance from Landgate. ENV recommends that 1 m topographic contours would be suitable for establishing wetland boundaries at a 1:25,000 scale.

6.2 FIELD SURVEY

The main goal for the field survey was to visit a wide range of the mapped wetlands within the project area and to identify any wetlands that could potentially have been missed. In total, a two person team visited approximately 4% of wetlands in the project area over 5 days. The field survey provided familiarisation with the catchment which then improved the outcomes in the mapping and provided an estimation of the accuracy in the dataset.

The field survey was an important part of the project as it confirmed that the desktop methodology undertaken to identify, delineate and classify wetlands was appropriate.

Additionally, this project developed and applied a methodology for using hydric soils for delineating wetland boundaries in the field through the use of a soil horizon transect. No clear methodology for determining wetland boundaries based on limits of hydric soils was found as part of the literature review. This project defined the characteristics of hydric soils that could be identified in the field and applied those observations to assist in determining a wetland boundary.

6.2.1 ENV Field Survey Recommendations

A field survey to ground truth results from desktop mapping is an important part of the project and should be included in future projects. As conducted for this project, the vegetation, soils, hydrology, and landforms associated with wetland boundaries that are observed in the field should be identified and described in future projects.

Furthermore, ideally timing of the field survey should be coincident with peak water levels in the catchment. This would improve the understanding of the hydrology of each wetland visited including a determination on whether the wetland is fed by groundwater or surface water. It is understood that these boundaries are still variable year to year but it would at least capture the conditions during a seasonally wet period.

6.3 TEMPORAL RESOLUTION

Temporal resolution refers to the precision of measurement with respect to time (Lillesand & Kiefer, 1994). Wetlands are dynamic systems and the extent and characteristics of wetlands vary over seasons and years due both to climatic changes and physical influences such as the construction of roads and drains. The information used to delineate and classify wetlands in this mapping project included stereoscopic aerials from 1988 and 1994, orthophotos from 1998, 2004 and 2008, Landsat images from 2005 and field survey data from 2010. Therefore the temporal resolution of the Cervantes South dataset is considered to be 22 years (1988 – 2010).

Average monthly rainfall from 1988-2010 compared to the long term climate data from 1969-2010 is shown in Figure 3. Rainfall values over the 22 year period are comparable to the long term average except the slight drying trend in June. The difference in rainfall shown is unlikely to have any significant effect on wetland mapping at a 1:25,000 scale.

No significant changes to wetland boundaries were encountered over the project area except for the expansion of the Tiwest Mining operations. The Tiwest expansion area covered some historical wetlands. In these cases the 'prevailing' condition of the wetland as shown in the more recent information sources was used.

7 SUMMARY AND CONCLUSIONS

- This project is consistent with principles and guidelines in the *Framework for mapping, classification, and evaluation of wetlands in Western Australia* (DEC, in publication).

- In a desktop GIS, Landsat 7 data and the spatial datasets were overlayed and compared with each other and stereoscopic aerial photographs to determine what spatial locations were likely to be considered as wetland areas. A total of 770 wetlands were identified.

- Desktop identification of wetland boundaries was performed in an iterative process involving the use of digital spatial datasets and stereoscopic aerials.

- Once wetland boundaries were mapped a geomorphic classification was then assigned to each identified wetland. The classification of a wetland is dependent on two main factors; landform and water permanence. The wetland types identified were rivers, creeks, lakes, sumplands, damplands, floodplains, palusplains, and barlkarras.

- Field survey was used in this project to provide a measure of accuracy of the resultant mapping. Two field surveys were undertaken in this project over the course of 2 separate field trips with a total of 5 days (2 people) in the field visiting approximately 32 wetlands of which 29 had their boundaries scrutinised.

- The accuracy of wetland boundaries determined from the field survey visiting 29 wetlands is +/- 14m.

- The methodology yielded a robust dataset that was ground truthed through field observations and suitable for use at a 1:25,000 scale.

8 REFERENCES

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FIGURES

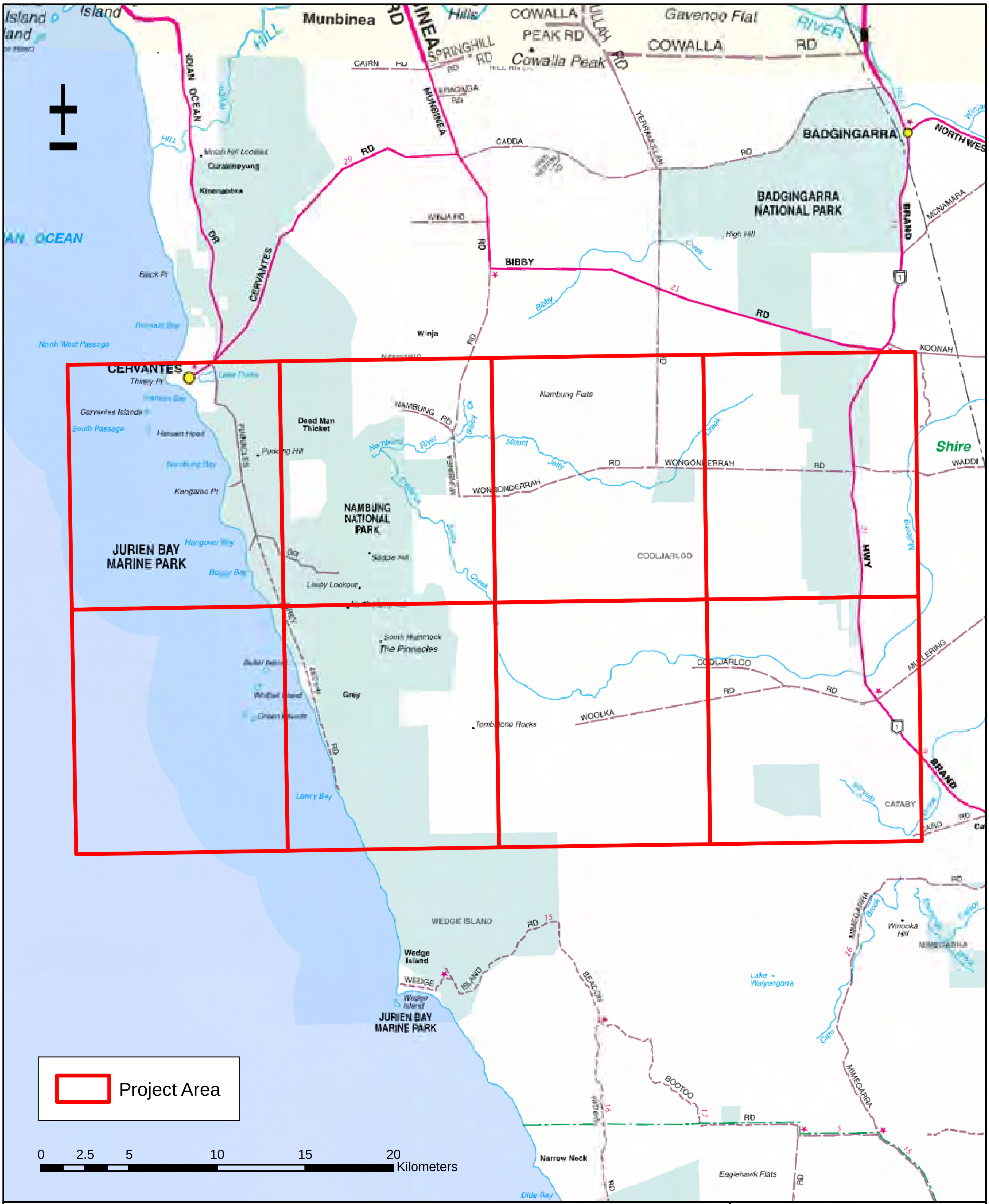


FIGURE 1: Location Plan

CLIENT: Department of Environment and Conservation

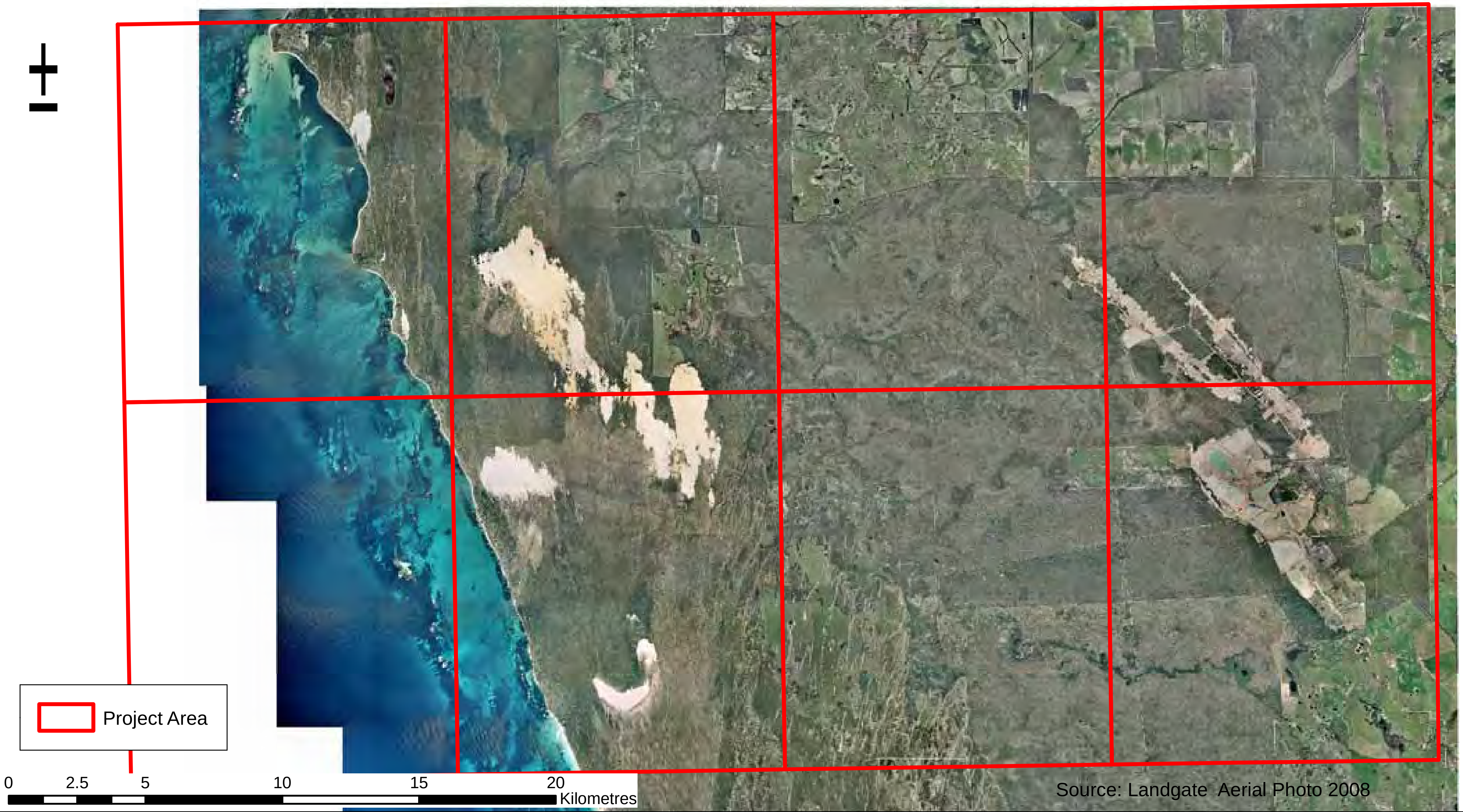
JOB NUMBER: 09.246

SCALE: 1:300,000

DRAWN BY: SS

CHECKED BY: SS

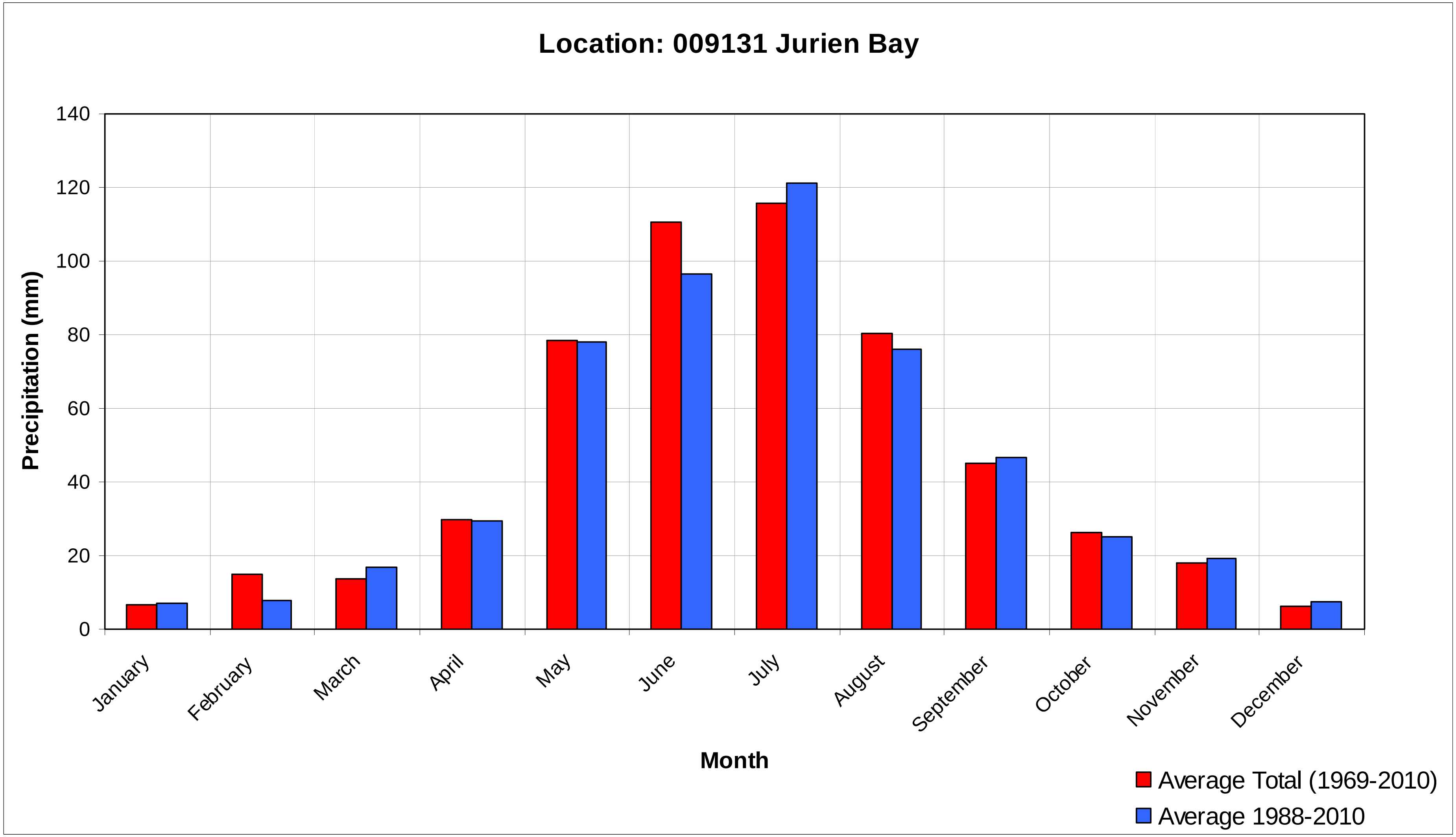
DATE: 9/4/10



Source: Landgate Aerial Photo 2008

FIGURE 2: Aerial Photo	**Job No: 09.246**
	Drawn By: SS
Client: Department of Environment and Conservation	Checked By: SS
Project: Wetland Mapping and Classification: Cervantes South	Scale: 1:200,000 Date: 9/4/10

env Australia



Source: Bureau of Meteorology, 2010

AUTHOR: SS

DRAWN BY: SS

09.246 R001-Fig1

Department of Environment and Conservation
Wetland Mapping and Classification: Cervantes South
Average Rainfall
FIGURE 3

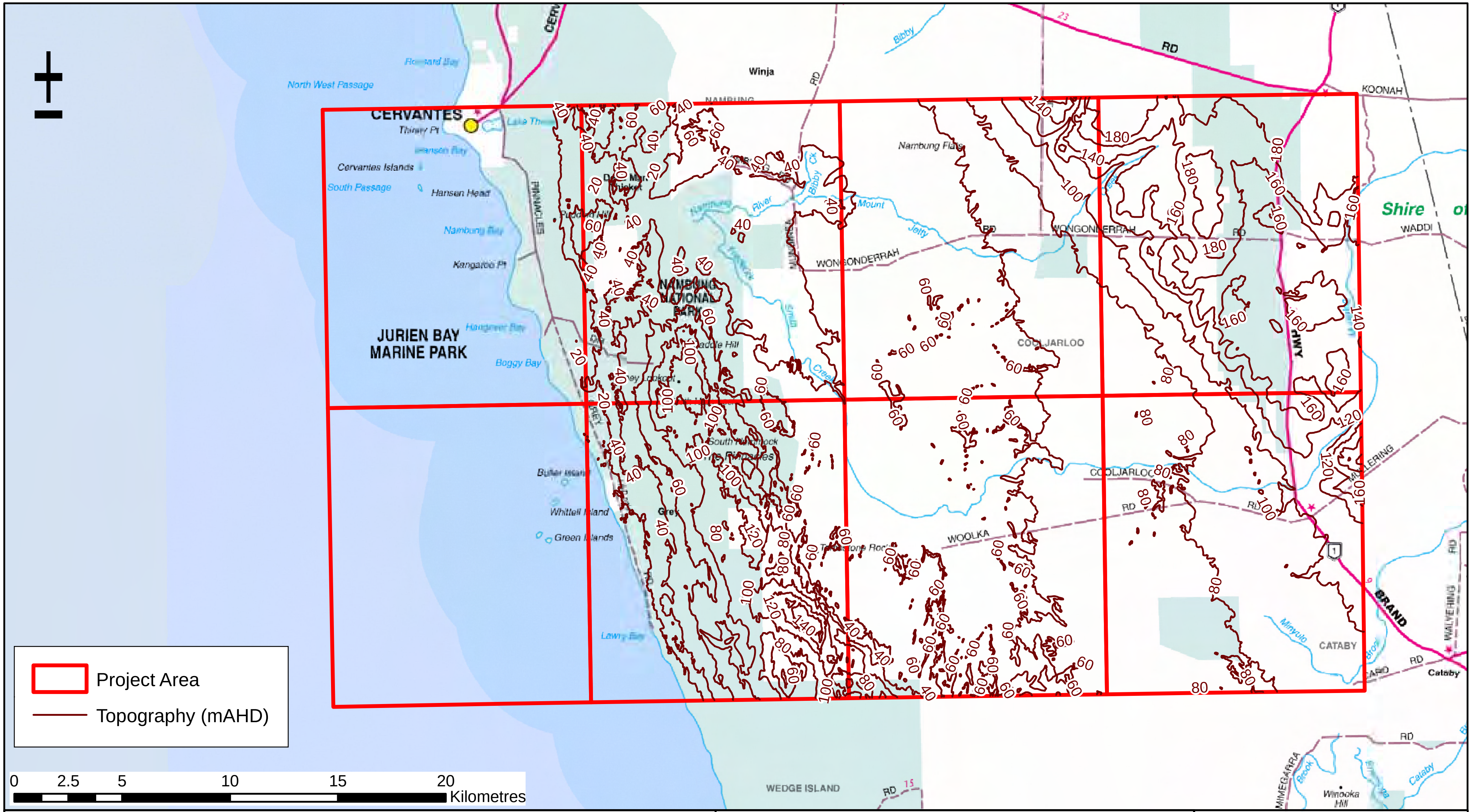


FIGURE 4: Topography

Job No: 09.246

Drawn By: SS

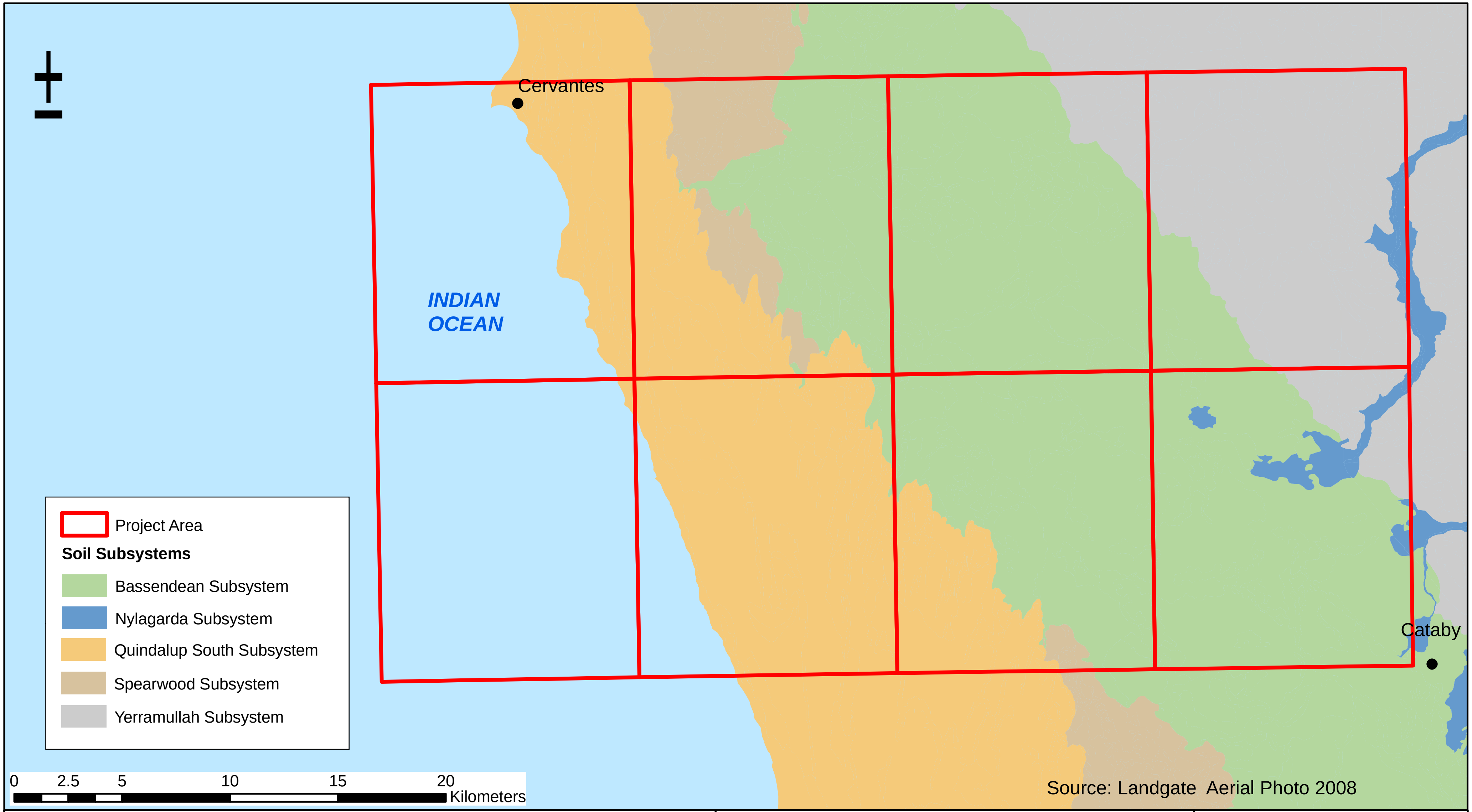
Checked By: SS

Client: Department of Environment and Conservation

Project: Wetland Mapping and Classification: Cervantes South

Scale: 1:250,000

Date: 9/4/10



Source: Landgate Aerial Photo 2008

FIGURE 5: Soil Subsystems

Job No: 09.246

Drawn By: SS

Client: Department of Environment and Conservation

Checked By: SS

Project: Wetland Mapping and Classification: Cervantes South

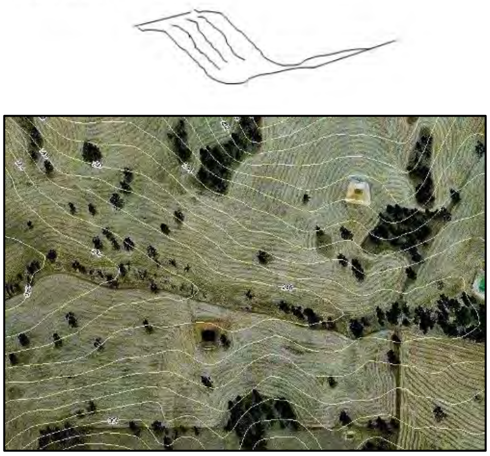
Scale: 1:250,000

Date: 9/4/10

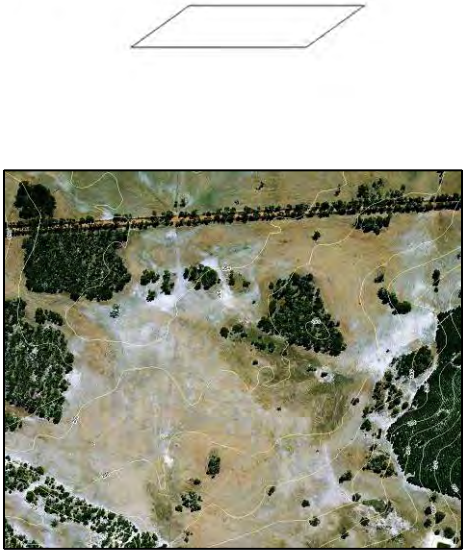
env
Australia

a) Basin

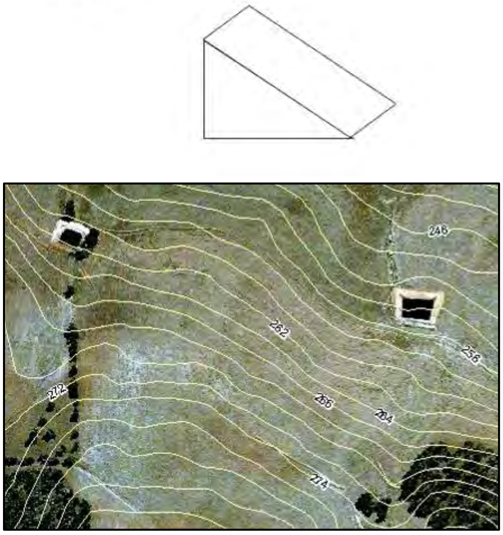
b) Channel



c) Flat



d) Slope



e) Highlands/Hills

Data Source: Semeniuk & Semeniuk 1995

FIGURE 6: Landform Types

CLIENT:Department of Environment and Conservation

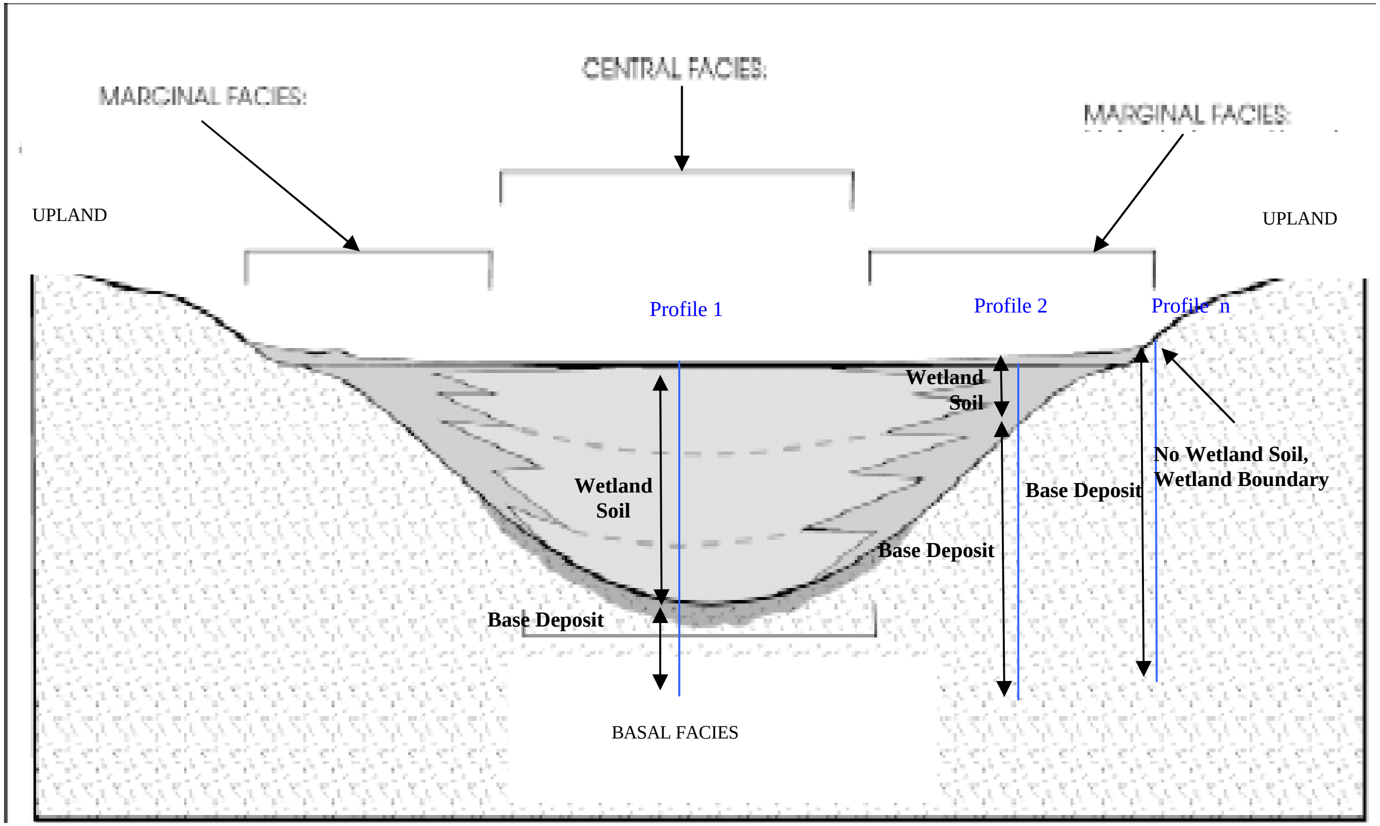
JOB NUMBER:09.246

SCALE: NTS

DRAWN BY: SS

CHECKED BY:TG

DATE: 9/4/10



Source: Adapted from Semeniuk & Semeniuk, 2005

Department of Environment and Conservation
Wetland Mapping and Classification: Cervantes South

Depositional Environment of Basin Wetlands

FIGURE 7

AUTHOR: SS

DRAWN BY: SS

09.246 R001-Fig7

APPENDIX A

FIELD MAPS

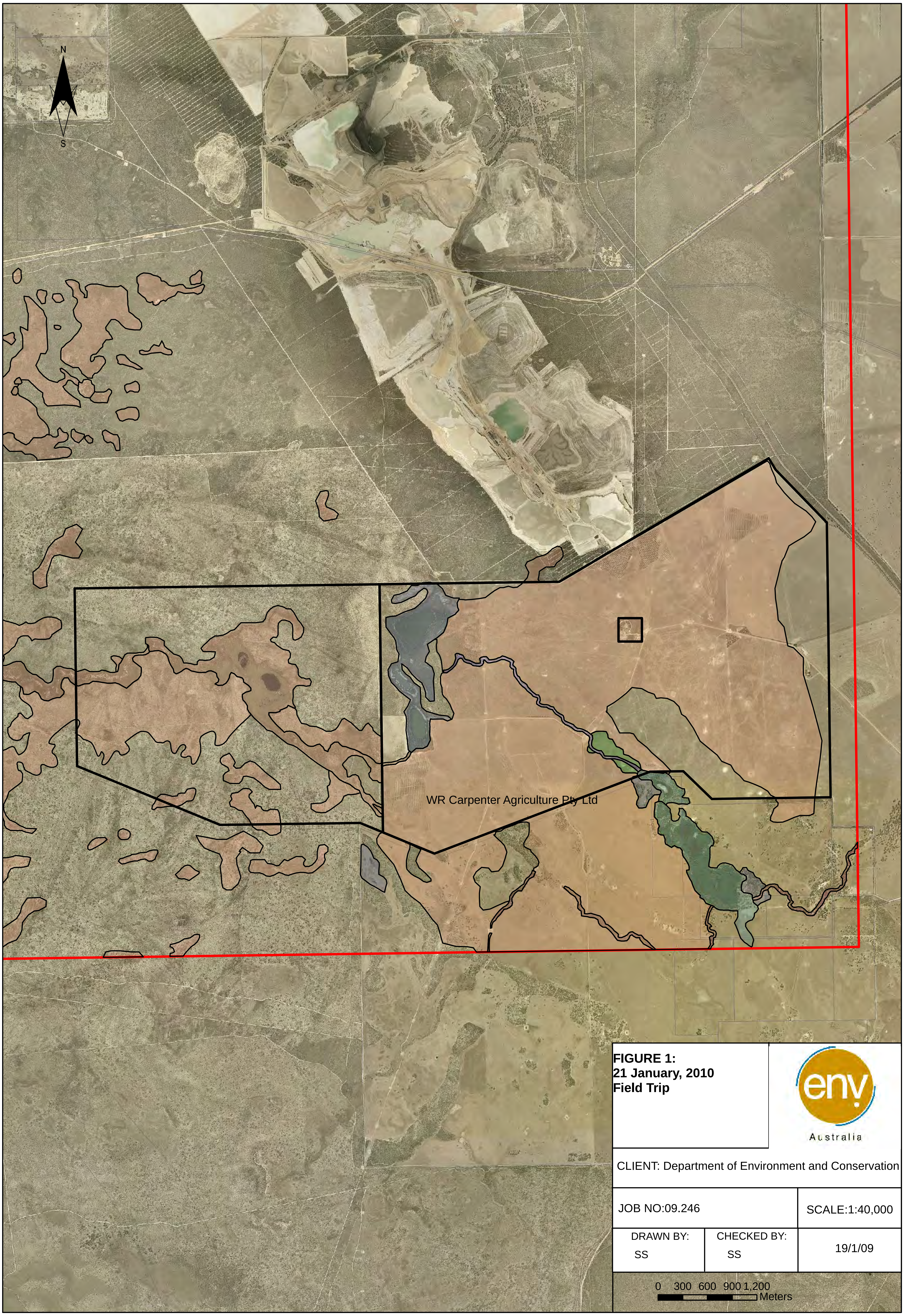


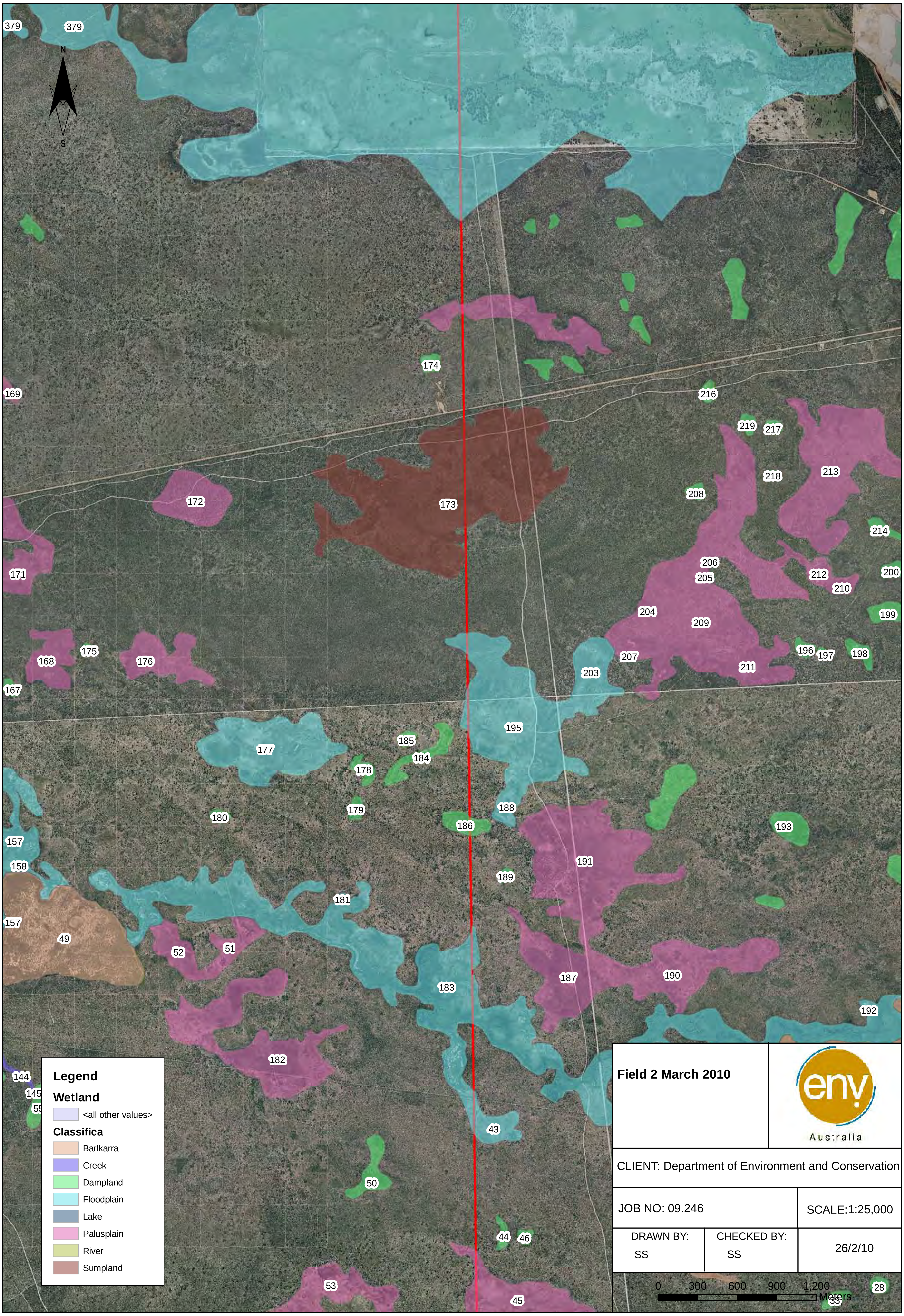
FIGURE 1:
21 January, 2010
Field Trip

CLIENT: Department of Environment and Conservation

JOB NO:09.246	SCALE:1:40,000

DRAWN BY: SS	CHECKED BY: SS	19/1/09

0 300 600 900 1,200
Meters



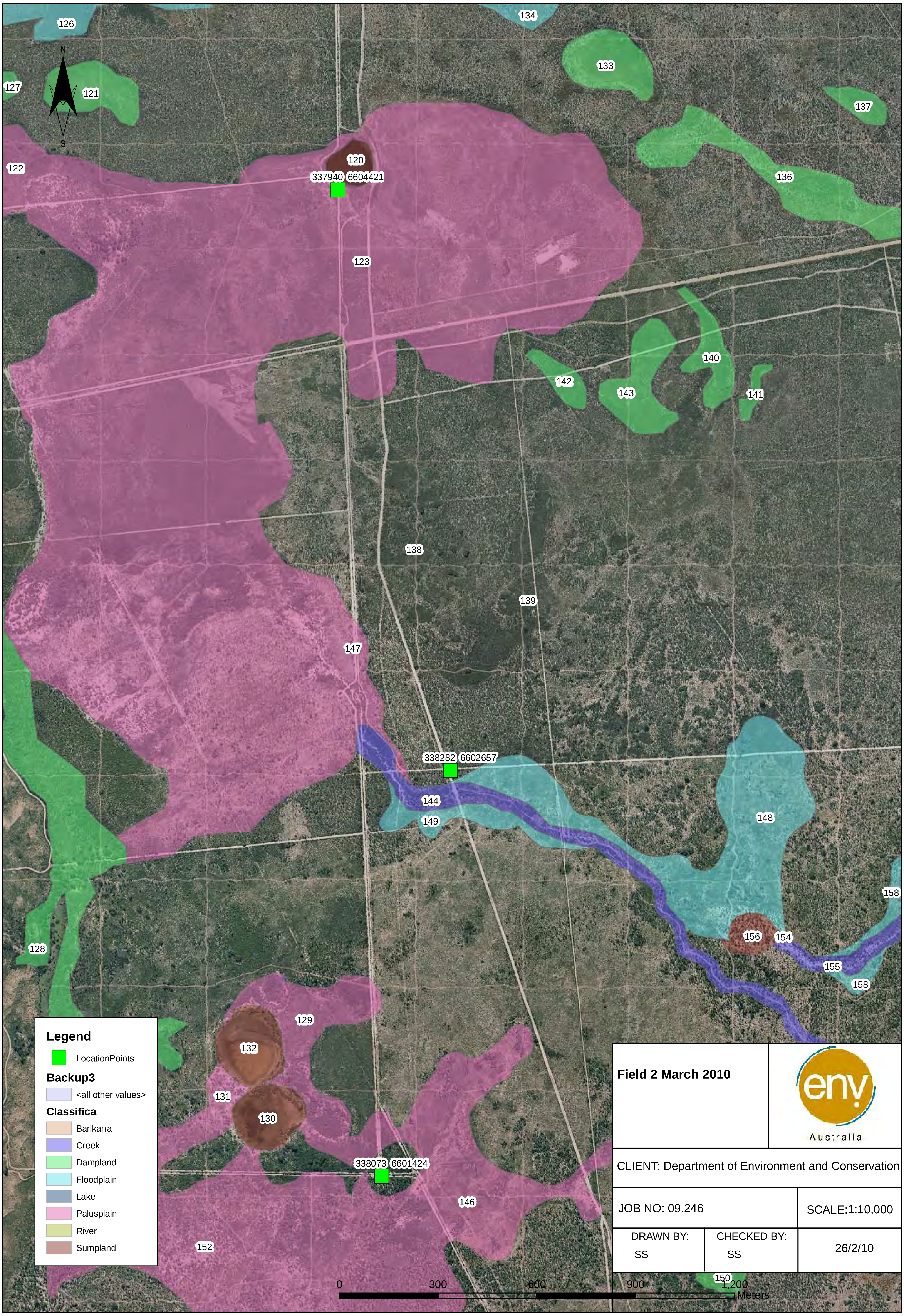
Field 2 March 2010

env Australia

CLIENT: Department of Environment and Conservation

JOB NO: 09.246	SCALE:1:25,000

DRAWN BY: SS	CHECKED BY: SS	26/2/10



Field 2 March 2010

CLIENT: Department of Environment and Conservation

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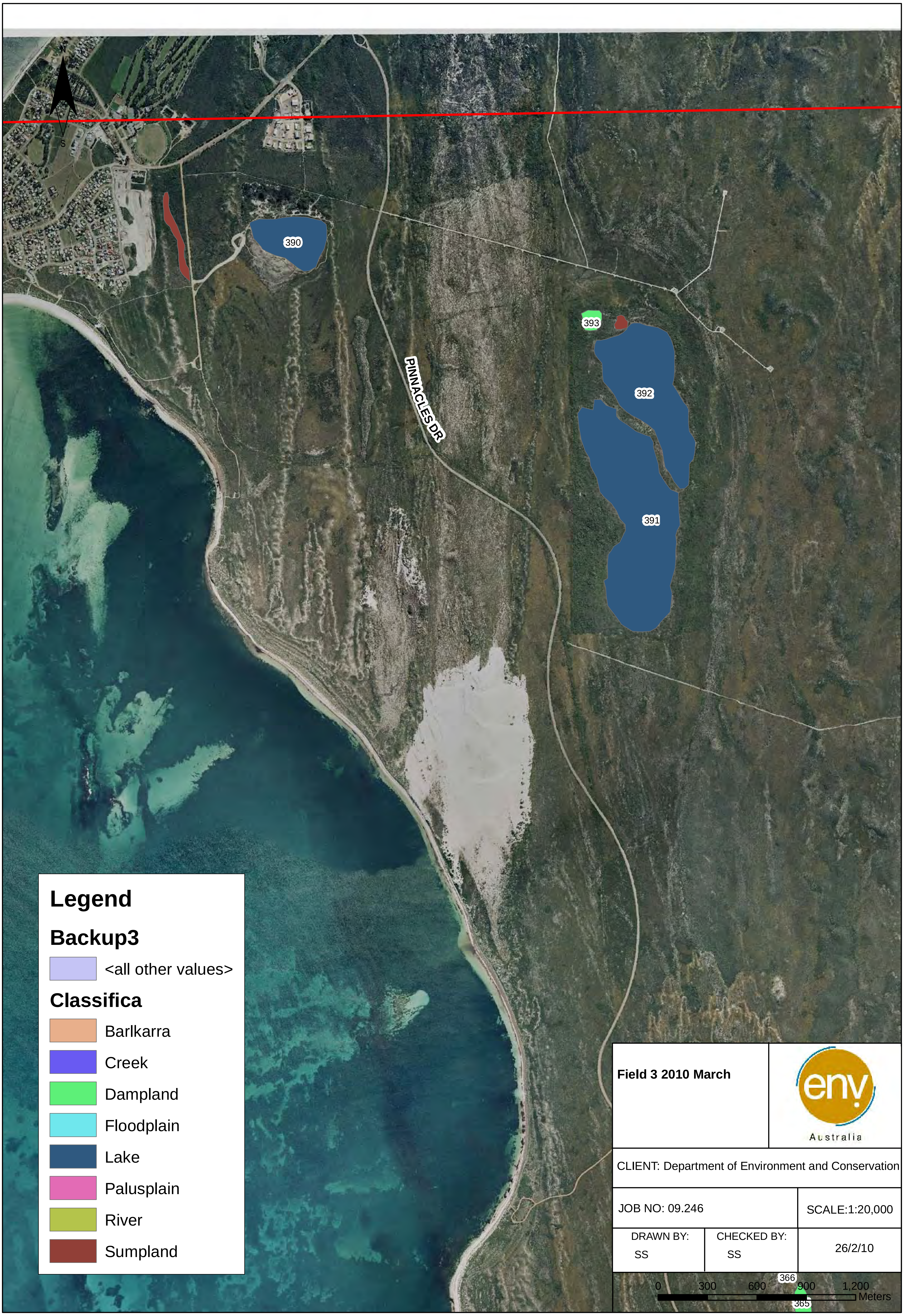


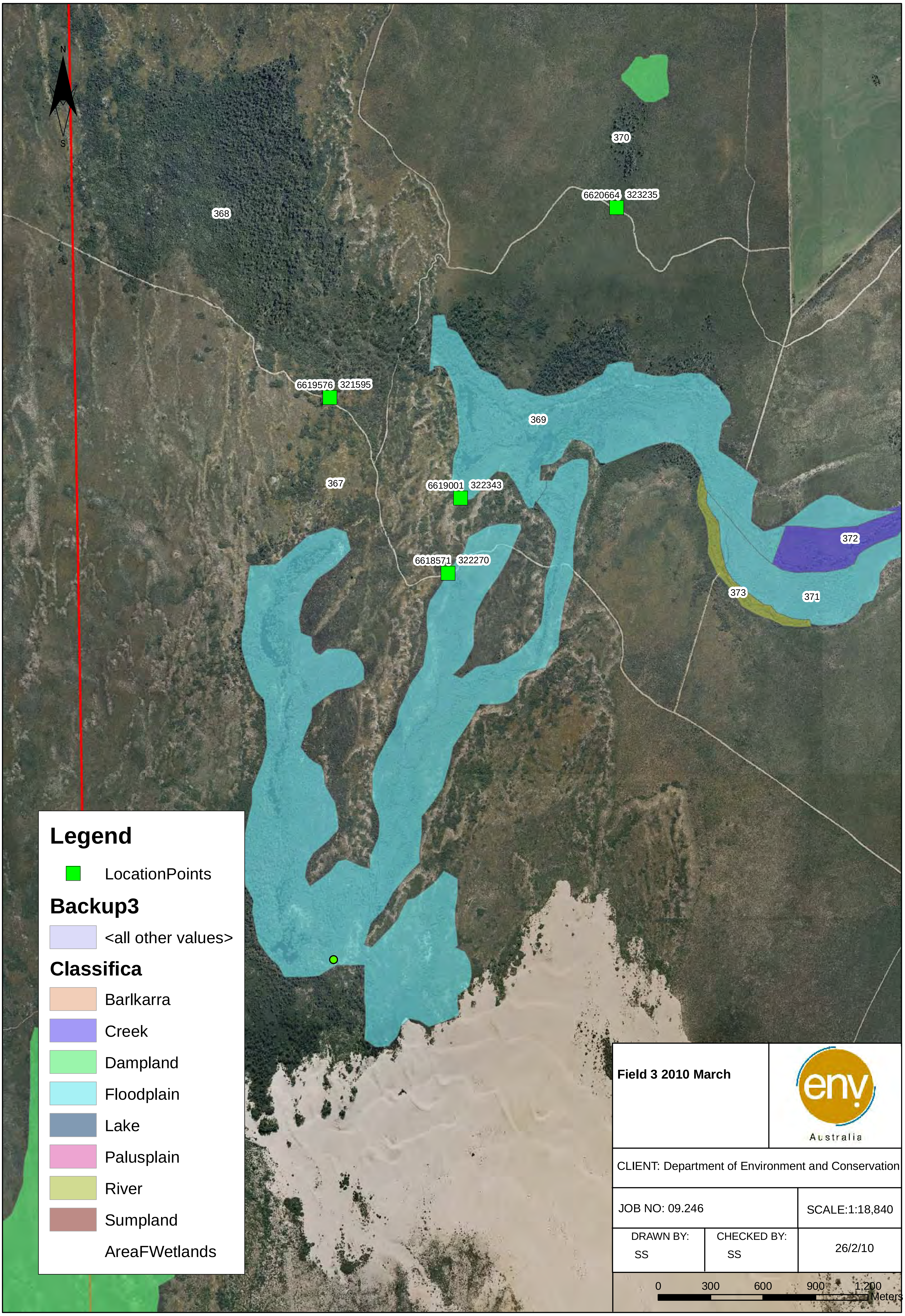
Field 3 2010 March

env Australia

CLIENT: Department of Environment and Conservation

JOB NO: 09.246	SCALE:1:20,000

DRAWN BY: SS	CHECKED BY: SS	26/2/10



Field 3 2010 March

env
Australia

CLIENT: Department of Environment and Conservation

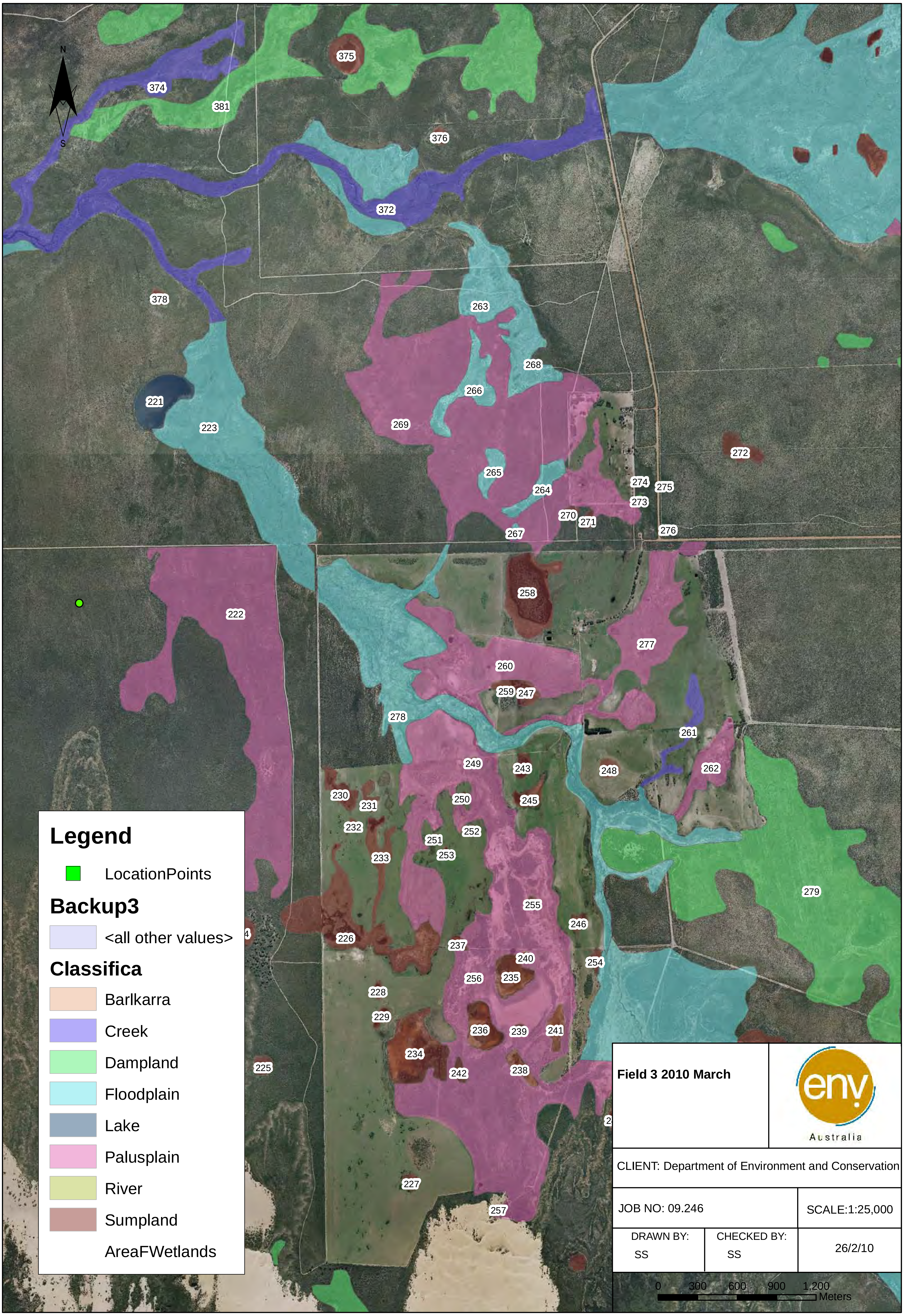
JOB NO: 09.246

SCALE:1:18,840

DRAWN BY:
SS

CHECKED BY:
SS

26/2/10



Field 3 2010 March

env Australia

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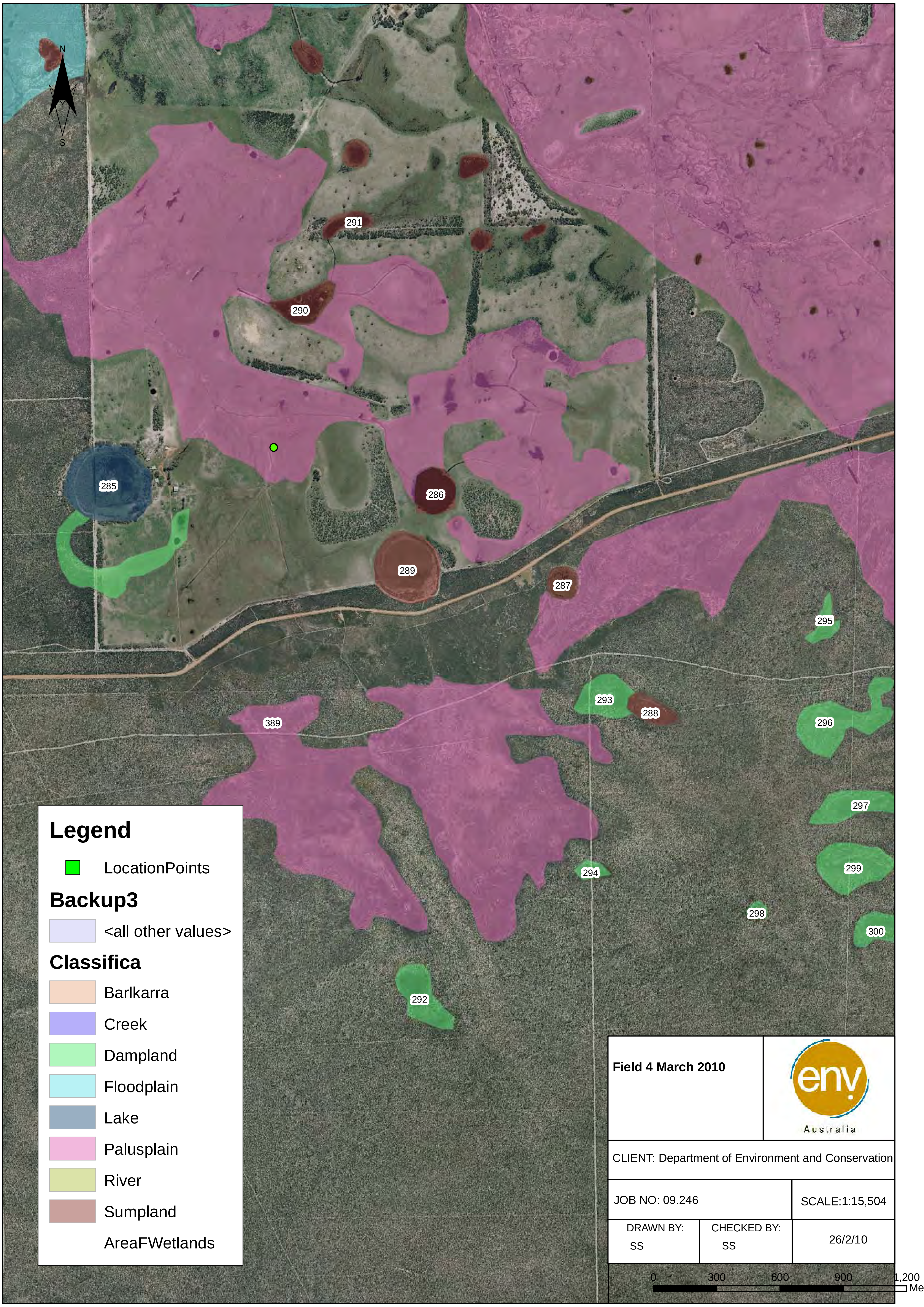
26/2/10



Legend

🟩 LocationPoints

Backup3

▨ <all other values>

Classifica

▨ Barlkarra

▨ Creek

▨ Dampland

▨ Floodplain

▨ Lake

▨ Palusplain

▨ River

▨ Sumpland

AreaFWetlands

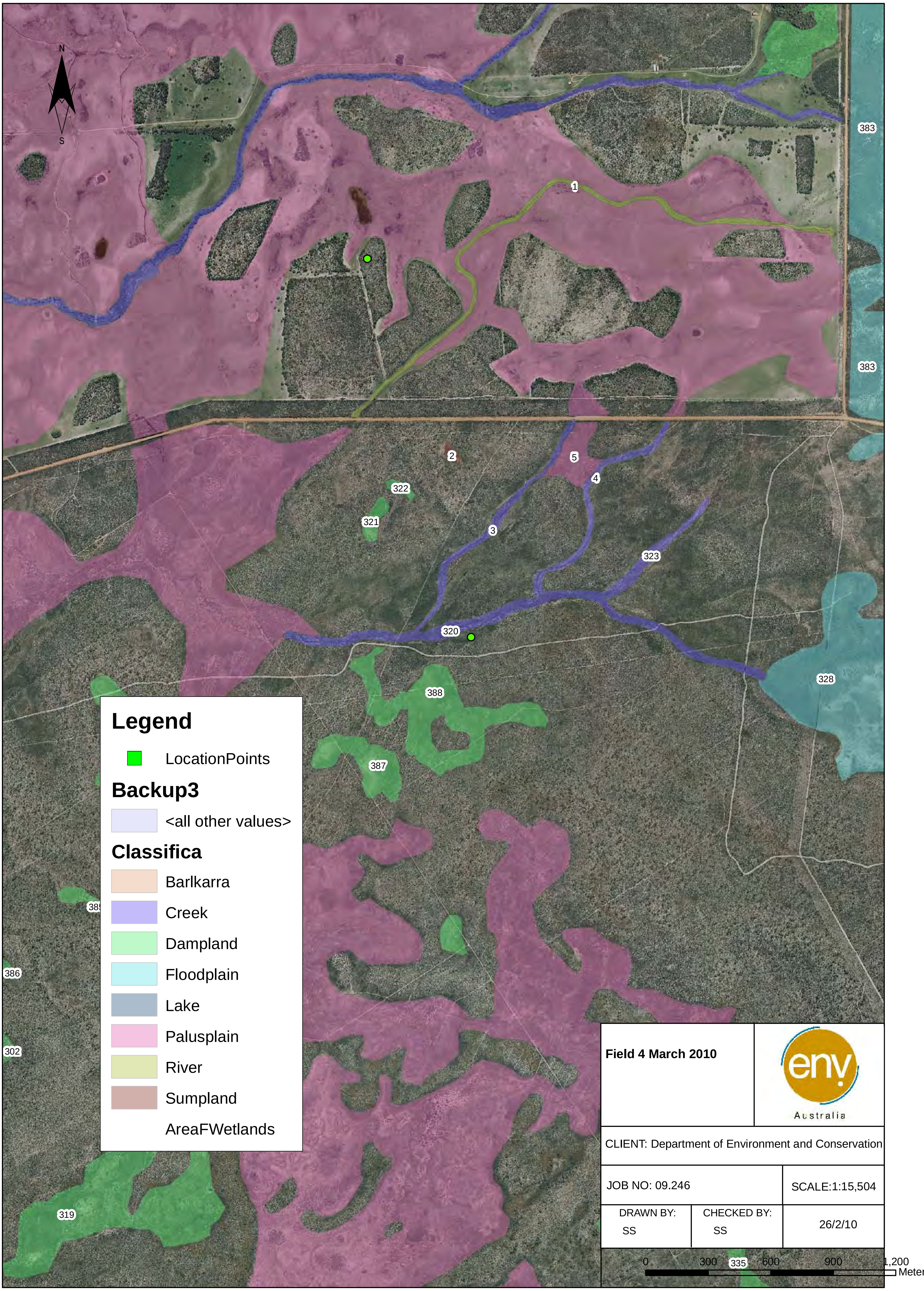
Field 4 March 2010

env Australia

CLIENT: Department of Environment and Conservation

JOB NO: 09.246	SCALE:1:15,504

DRAWN BY: SS	CHECKED BY: SS	26/2/10



Field 4 March 2010

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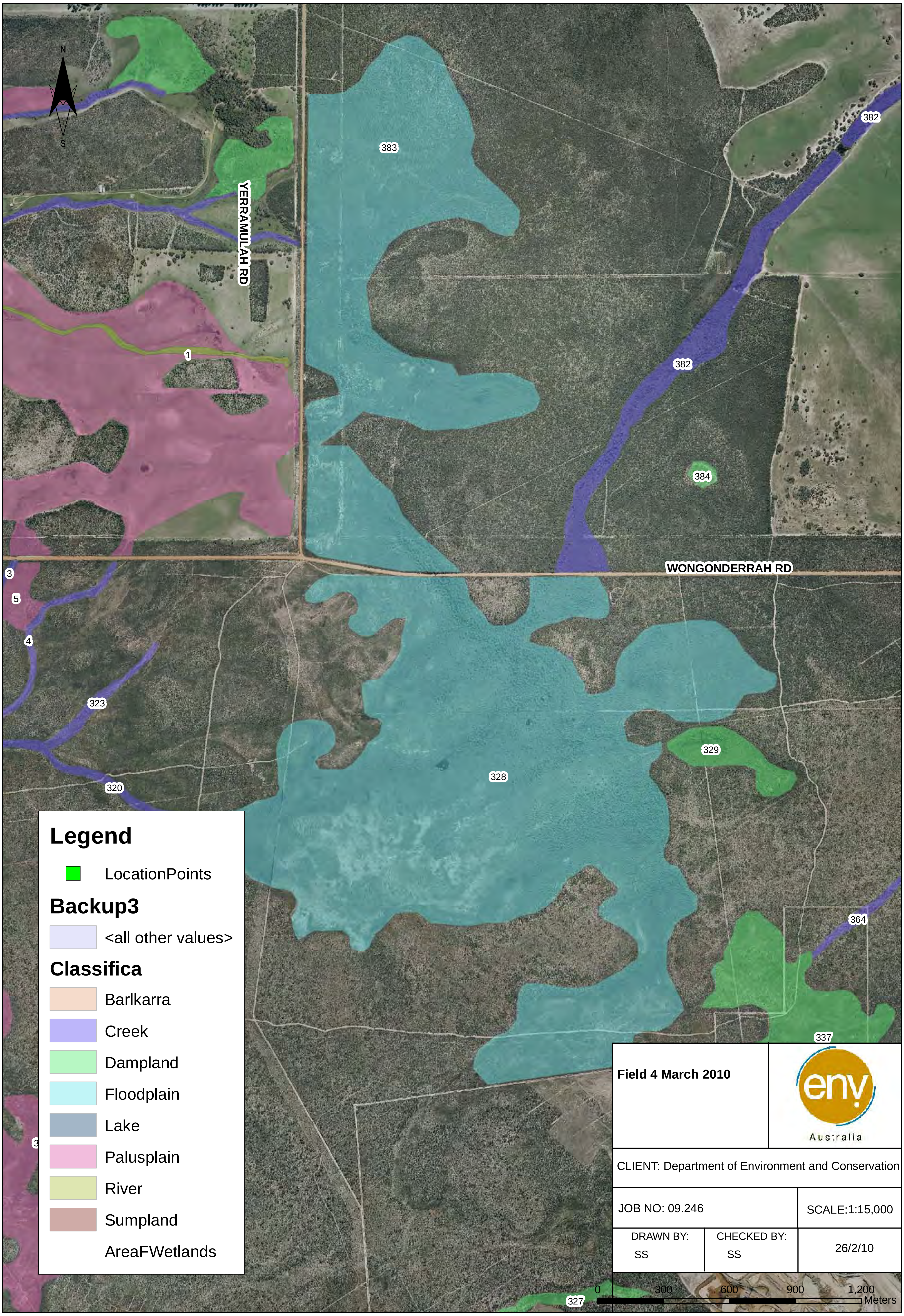
26/2/10



Field 4 March 2010

env Australia

CLIENT: Department of Environment and Conservation

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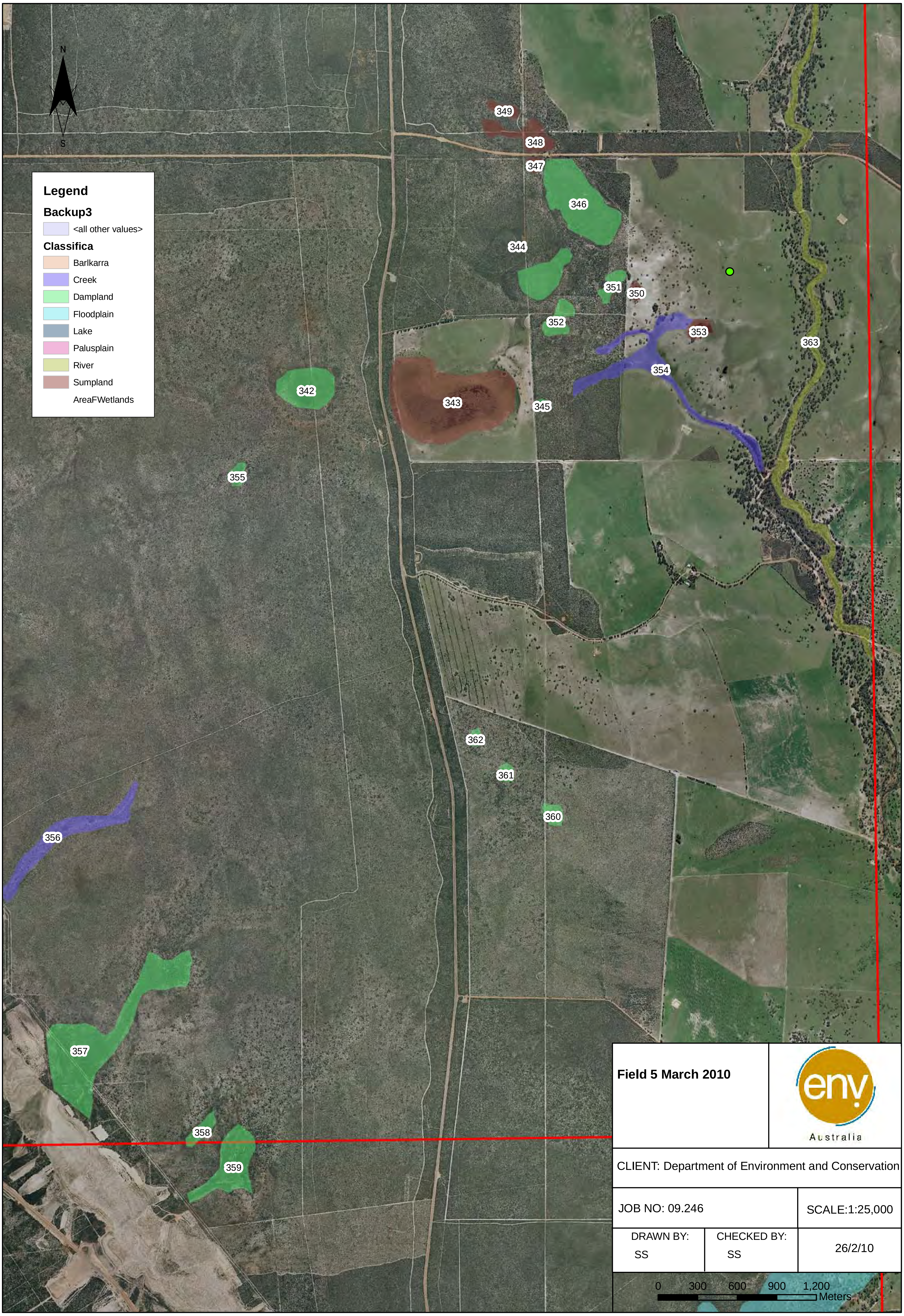


Field 5 March 2010

env Australia

CLIENT: Department of Environment and Conservation

JOB NO: 09.246		SCALE:1:25,000
DRAWN BY: SS	CHECKED BY: SS	26/2/10

APPENDIX B

FIELD SHEETS

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 21/11/01
Time: 1200
Wetland UFI: 40 Floodplain
Easting: 30350638 Northing: 6598533

Vegetation Assessment

No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
350638	6598533	
350588	6598766	
350585	6598776	
350581	6598800	
350562	6598823	

Vegetation Notes:

Mel. rhaph. Hakea tri. Cyperus gymnocaulos Juncus pallidus
A. saligna Beaufortia Melaleuca lance Banksia sphaerocarpa
Pigweed Melaleuca teretifolia Pericalymma ellip
Fire age Young - between 2-5 years

Soil Assessment

white sand @ 0.7 m depth, some organics

Hydrology

Green grass at surface, likely to be inundated in winter

Topography

Site Elevation:
Landform Notes:
Flat, slight change in topo

Notes:
W3-1 soil at boundary 3402
3403
3404

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 21/11/10
Time: 1030
Wetland UFI: 830 Sumpland

Easting: 50/351 229 Northing: 6598276

Vegetation Assessment

No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
351269	6598248	
351292	6598228	
351342	6598184	
351400	6598215	
351392	6598250	

Vegetation Notes:

Scattered juncus sp. Mel priessii Mel raph. Beaufortia elegans Mel sp.
degraded condition - Hakea on boundary
Banksia littoralis - Juncus sp
Viminaria juncea Euc tod
Green grasses in summer

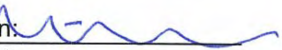
Soil Assessment

Very sandy, grey

Hydrology

Groundwater at surface with depression. Nearby water hole shows groundwater ~~[illegible]~~ 1m below surface.

Topography

Site Elevation: 

Landform Notes:

Basin shape

Notes: Boundary based on vegetation
Soil photo 3394 & 3395
3393 Boundary

~~[illegible]~~ 3391 Boundary
3392 water hole

393

env Australia

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 21/11/01
Time: 120
Wetland UFI: 881

Easting: ____ Northing: ____

Vegetation Assessment

No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
350606	6599354	
350591	6599358	
350581	6599397	
350547	6599413	

Vegetation Notes:

Mela raph, cyperus + african love grass, Mel prei
Persoonia ful

Soil Assessment

Sandy at 40cm depth, white medium, dry

Hydrology

Creek, seldomly running, no evidence of water marks

2m deep

Topography

Site Elevation: ____

Landform Notes:

Creek - channel

Notes: 3406
3405

Soil - white sand at boundary.

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 2/11/09
Time: 1115
Wetland UFI: 20 Emu Lake

Easting: 351168 Northing: 6599819

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
351194	6599820	
351200	6599788	
351196	6599763	
351208	6599730	
351232	6599699	

Vegetation Notes:
Lepidosperma longi. Mel pressiana, Mel rash ∞
Banksia attenuata cassytha, Euc rudis
Banksia littoralis, Acacia cyclops
Xanthorrea, - Restio, Nuysta
Schoenus subfascic

Soil Assessment
Very wet soils from inside wetland. High organic content in top layer. Sandy at depth. Soil transect taken

Hydrology
Open water, clear inundation at edges due to brown, mulic & dead plants

Topography
Site Elevation:
Landform Notes:
Clear basin formation, depressed into landscape

Notes:
Lots of ducks enjoying the open water
3398 - core 3401 - boundary
3397 - open water
open water 3396
3399 - 3340 - Euc

W2-1 - soil sample within lake
- moist through entire profile, consistent medium sand depth
- small amount organic matter

W2-3 - 0-40 sand at

W2-2 - 10cm - organic top layer
~~10-20~~ 10-40 cm - sand - slightly moist

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: [illegible] 2/3/10
Time: 12:45
Wetland UFI: 123 Palusplain
Easting: 338058 Northing: 6604694

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
338058	6604694	57
338079	6604698	
338095	6604701	
338108	6604701	
338121	6604701	

Vegetation Notes:
Mostly facultative species including Calothamnus sp. (WIZOCS?) Verticordia melaleuca laneedolok, Some sedges indicating seasonal wetness. Xanthorreas', Acacia pulchella, Viminaria juncea Hakea trifurcata. Banksia sphaerocarpa - At boundary, mix of upland species

Soil Assessment
X Organic Mtl
_Gleying
_Fibrous
_Skeletal
_ Mottles

waterlogging evidence in surface crusts, organic material at surface. All sandy. Transect done at wetland, determined parent material as sandy quartz.

Hydrology
No surface water features, ground water rise evident

Topography
Site Elevation: 57
Landform Notes:
Very flat, gentle rise on northern boundary.

Notes: Boundary taken as where organic soils finished in upper 30cm or 10cm, and where upland species present

63[illegible]0 - looking across wetland
[illegible]
631 - boundary

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Australia

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 2/3/10
Time: 12:40
Wetland UFI: 120 Sumpland
Easting: 337940 Northing: 660442

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

	Easting	Northing	Alt
A	337993	6604429	52
B	337975	6604427	
C	337948	6604449	
D	337921	6604476	
	337912	6604505	

Vegetation Notes:
Scattered samphire - W120 - Tecticornia undulata
Edges - melaleuca lanceolata, 1.5m high

Nearby record of W120-CS02 338027, 6604367
Verticordia x25

Soil Assessment
✓Organic Mtl Inundation obvious, organic content at surface, crusting occurring
_Gleying
_Fibrous
_Skeletal
_ Mottles

Hydrology
Groundwater rise, no surface inflows

Topography
Site Elevation:
Landform Notes:
Basin formation within greater wetland, 0.5 m lower than surrounding landscape

Notes:

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 2/3/10
Time:
Wetland UFI: 149

Easting: 338234 Northing: 6602520

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt

Vegetation Notes:
Mix of facultative + upland, Verticordia, calothamnus, quadrifidus
Xanthorea preissii, Acacia cyclops, Acacia salinga, Regelia ciliata

Soil Assessment
_Organic Mtl
_Gleying
_Fibrous
_Skeletal
_ Mottles

Hydrology

No evidence of waterlogging or inundation

Topography
Site Elevation:
Landform Notes: "high" ground, 1m above

Notes:

Not a wetland

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 2/3/10
Time: 2:00
Wetland UFI: 144 Creek

Easting: ________ Northing: ________

Vegetation Assessment

No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
338384	6602544	54
338370	6602547	
338355	6602560	
338329	6602568	
338313	6602551	

Vegetation Notes:

Melaleuca rhaphiophylla, and Mell presstana within wetland. Melaleuca lanceolata at boundaries. Hakea varia and Lepidosperma longitudinale. Regelia ciliata at boundaries (Beaufortia) elegans

Soil Assessment

✓ Organic Mtl High organic content surface, mosses, crusting. Orange at surface
_Gleying
_Fibrous
_Skeletal
_ Mottles

Hydrology

Moss growing at surface; waterlogging through. Surface water innundation

Topography

Site Elevation: 54

Landform Notes:

No clear channel, slight trough formation.

Notes: Boundary formed by limit of inundated soils to water logged soils. Boundary between classification

s

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 2/3/10
Time: 330
Wetland UFI: 138 Paluspla1n

Easting: 338469 Northing: 6603381

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
338484	6603409	53
338473	6603398	
338469	6603381	
338466	6603366	
338474	6603355	

Vegetation Notes:
All facultative species - Hakea trifurcata, Banksia sphaerocarpa - Beaufortia squarrosa - Melaleuca brevifolia - Melaleuca lanceolata

Soil Assessment
_Organic Mtl
_Gleying
_Fibrous
_Skeletal
_ Mottles

No hydric soils, grey sand at depth within wetland. White sand at boundary

Hydrology

No obvious hydrological features - surface or waterlogging

Topography
Site Elevation: 53
Landform Notes:
Flat - low lying, waterlogging at depth.

Notes:
Boundary formed by dryland species.

3639 - Boundary Photo

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 2·3·10
Time: 4:15pm
Wetland UFI: 171 Dampland
Easting: ____ Northing: ____

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

	Easting	Northing	Alt
A	340910	6604453	58
B	340906	6604466	
C	340903	6604480	
D	340876	6604473	
E	340861	6604479	

Vegetation Notes:
Mostly facultative species throughout. Clear distinction at boundary between facultative and dryland some WO - Hakea varia, Pericalymma ellipticum (WO) Banksia sphaerocarpa, Beaufortia squarrosa - verticordia & Melaleuca lanceolata Hakea trifurcata

Soil Assessment
_Organic Mtl
_Gleying
_Fibrous
_Skeletal
_ Mottles

No hydric soil properties, grey quartz sand at surface

Hydrology
Waterlogging likely, no signs of water ponding

Topography
Site Elevation: ____
Landform Notes:
Low basin formation risen on all sides by approx 1m.

Notes:
Photo 3640 - Across wetland

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 3/3/10
Time:
Wetland UFI: 390 Lake Thetis

Easting: Northing:

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

	Easting	Northing	Alt
A	315671	6623623	0
B	315686	6623621	
C	315700	6623619	
D	315728	6623624	
E	315750	6623623	

Vegetation Notes:
Gahnia trifida .. Baumea juncea Euc gompho
Suaeda australis Tecticornia leptosp. Melaleuca brevifolia
Frankenia pauciflora .

Soil Assessment
_Organic Mtl - low organic content, some cracking at
_Gleying surface no other indicators of hydric soils
_Fibrous
_Skeletal
_ Mottles

Hydrology
Open water present.

Topography
Site Elevation:
Landform Notes:
Basin Formation

Notes:
3641 - Boundary photo
3642 = across water
3643 & 44 - soil profile of Adjacent wetland (not mapped as artifical - old quarry)

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FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 3/12/10
Time: 3 00
Wetland UFI: 289 Sumpland

Easting: Northing:

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
344193	6617188	46
334217	6617186	
334242	6617190	
334273	6617171	
334296	6617176	

Vegetation Notes:
CS83, Chenopod, Mel rhaph around edges and Schoenus subfasci), Hakea varia + Chaetanthus aristatus

Soil Assessment
X Organic Mtl
X Gleying
_ Fibrous
_ Skeletal
_ Mottles

OM at surface, and gleying, cracked white clay sand at surface

Hydrology

Dry at time of visit. Likely filled with water seasonally due to extent of anoxy

Topography
Site Elevation: 46
Landform Notes:
Basin Formation

Notes:
3672 - looking across wetland

Boundary based on extent of gleying.

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 3/3/10
Time:
Wetland UFI: 367 Floodplain
Easting: 322282 Northing: 6618504

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt	
322280 ~~[illegible]~~	6618504	30	~~[illegible]~~
322279	6618511		
322277	6618522		
322284	6618536		
322291	6618549		

Vegetation Notes:
Obligates present Melaleuca rhaphiophylla, Euc. rudis, Acacia saligna, Mel lanceolata, ~~now~~ No ground plants likely due to inundation.

Change in density.

Soil Assessment
_Organic Mtl low organic content, some surface crusting.
_Gleying No clear hydric soil indicator
_Fibrous
_Skeletal
_ Mottles

Hydrology
Waterlogging likely and evident.

Topography
Site Elevation:
Landform Notes:
Flat in landscape, ~~gla~~ gentle rise ≈ 0.5m at boundary

Notes:
3645 - boundary photo - dominance change
3646 - boundary at last point in boundary walk

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FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 3/3/10
Time: 100
Wetland UFI: 267 Floodplain
Easting: 329110 Northing: 6616849

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
329110	6616849	38
392100	6616859	
329093	6616874	
392090	6616890	
392080	6616903	

Vegetation Notes:
Hakea varia, (Melaleuca brevifolia), Schoenus subfascicul
tecticornia undul, Regelia ciliata:, Tecticornia syncarpa, Ficinia nodosa

Orange lily

Soil Assessment
✓Organic Mtl - at surface water anoxity
_Gleying
_Fibrous
_Skeletal
_ Mottles

Hydrology

Inundation ~~proven~~ likely annually due to low cover of plants

Topography
Site Elevation: 38
Landform Notes:
Basin formation, flat bottomed, wide

Notes:
3650 - Boundary photo
3651 - Across wetland

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 3/3/10
Time:
Wetland UFI: 263

Easting: 329013 Northing: 6616847

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
329013	6616847	37
329022	6616838	
329025	6616818	
329028	6616801	
329035	6616768	

Vegetation Notes:
Mostly facultative species Lepidosperma longi
+ Regelia ciliata, Banksia sphaerocarpa.

Soil Assessment
☒ Organic Mtl crusting of organics occuring at surface w evidence of red sandy
_Gleying
_Fibrous
_Skeletal
_ Mottles

Hydrology
Salt ~~p~~ evident through die off of plant.
Soils would be innundated in winter but
dry at time of visit

Topography
Site Elevation: 37
Landform Notes:
Low lying and flat

Notes:
3652
3653 > bom of boundary

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 3·3·10
Time: 15:30
Wetland UFI: 827 Creek

Easting: Northing:

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

	Easting	Northing	Alt
A	329603	6620239	3660
B	329593	6620206	
C	329604	6620192	
D	329618	6620164	
E	329598	6620154	

Vegetation Notes:
Gahnia tri Mel lanceolata Callitris preissii ??
Banksia sphaerocarpa · Hakea trifurcata, Beaufortia elegans
Hakea varia, Regelia ciliata, Tecticornia undulata,
Suaeda australis, Tectornia syncarpa

Soil Assessment
Organic Mtl Surface crusting evident throughout, not at boundaries
Gleying Little OM
Fibrous
Skeletal
Mottles

Hydrology
Floodway over road, dry at time of visit
Floodplain - River

Topography
Site Elevation:
Landform Notes: Flat and Low in landscape.

Notes: 3660 - Boundary.

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 3/3/10
Time: 300
Wetland UFI: 277

Easting: 330165 Northing: 6616674

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt

- no boundary
- no access

Vegetation Notes:
Saltbush, Gahnia trifida present. Area predominated
Schoenus subfascicularis

Soil Assessment
_Organic Mtl no soil assessment
_Gleying
_Fibrous
_Skeletal
_ Mottles

Hydrology

Topography
Site Elevation:
Landform Notes: flat

Notes:
Photos - 3659

is a wetland

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 3·3·10
Time: 16·17
Wetland UFI: 263 Floodplain
Easting:
Northing:

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

	Easting	Northing	Alt
A	329036	6618796	32
B	~~329036~~	~~66187~~	
C	329057	6618750	
D	329052	6618723	
E	329108	6618712	

329043 6618779

Vegetation Notes:
~~Aw~~ Chenopods, Gahnia trifida Mel lanceolata,
Banksia sphaerocarpa, Juncus pallidus. ✓
Callitris on Boundary - drying trend.

Soil Assessment
_Organic Mtl Little OM, Hummocking crust on surface.
_Gleying
_Fibrous
_Skeletal
_ Mottles

Hydrology
Seasonal inundation, floodplain.

Topography
Site Elevation:
Landform Notes: flat w slight rise. douseplain / floodplain

Notes: 3662 - Boundary
3661 Across wetland.

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 4/3/10
Time: 900
Wetland UFI: 389 Palusplain

Easting: 332703 Northing: 6617314

Vegetation Assessment

No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
332703	6617314	38
332682	6617324	↓
332664	6617324	
332638	6617339	
332625	6617358	

Vegetation Notes:

Melaleuca rhap (×3m) Gahnia tri, ~~[illegible]~~ Rhagodia, Banksia sphaero, Regelia cilidata, scattered Callitris preissii, Nuytsia floria Hakea trifurda

★ Mel rhap used as boundary marker.

Soil Assessment

_Organic Mtl
_Gleying
_Fibrous
_Skeletal
_ Mottles

No organic material, coarse sand, brown and white (ID 389). No hydric soil indicators.

Hydrology

No evidence of surface innundation. Waterlogging likely at depth

Topography

Site Elevation: 38

Landform Notes:

Flat, marginal rise at one boundary

Notes:

Pictures - boundary 3666
across 3667
soil 3664, 3665
3668 - melaleuca, wooly bush + bancsia growing close together

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FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 4/3/10
Time: 930
Wetland UFI: 285 Sumpland

Easting: 332663 Northing: 6617563

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
332663	6617563	37m
332683	6617558	↓
332695	6617586	
332707	6617555	
332719	6617551	

Vegetation Notes:
Melaleuca rhaphiophylla, Lepidosperma long Heavily grazed area by kangaroos.

Soil Assessment
✓Organic Mtl low organic content, grey sand, fine.
_Gleying Crusting at surface
_Fibrous
_Skeletal
_ Mottles

Hydrology
Aerial photo shows partial inundation likely due to small bunds created through firebreak maintenance

Topography
Site Elevation: 37
Landform Notes:
Basin formation, rises on all sides. Low point in landscape

Notes:
3669+3670 - gecko!
3671 - boundary photo

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FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 4/3/10
Time: 345
Wetland UFI: 287 Sumpland
Easting: 334883 Northing: 6617254

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
334883	6617254	47
334888	6617265	
334890	6617280	
334898	6617293	
334907	6617304	

Vegetation Notes:
Mel rhaph, Lepidosperma + Restio (same as UFI 289)
Mel teretifolia, obligates within ~~wet~~ area. Sedges.
Facultative towards edge, Hakea varia

Soil Assessment
✓Organic Mtl Grey sandy soil some organics and
_Gleying crusting at surface
_Fibrous
_Skeletal
_Mottles

Hydrology
Groundwater rise noted by crusty soils,
inundation likely

Topography
Site Elevation: 47
Landform Notes:
Low in landscape basin formation,

Notes: Boundary defined as end of obligates and landscape change. Wetland within wetland. Boundary based on landform and hydrological change

3675 - across wetlan
3674 - boundary

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 4/3/10
Time:
Wetland UFI: # 1 Creek
Easting: 338996 Northing: 6618485

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
338996	6618485	56
339004	6618493	
339014	6618601	
339023	6618508	
339038	6618529	

Vegetation Notes:
Mel rhaphdophylla, Banksia sphaerocarpa.
Tecticornia undulata, Hakea varia, Mesomelaena pseud
Lepidosperm long Schoenus subfascicularis -

Soil Assessment
_Organic Mtl Heavily compacted, grey sands
_Gleying
_Fibrous Depositional soils in channel
_Skeletal
_Mottles

Hydrology
Culvert under rd. Surface water flow evident in channel, Dry at time of visit Cleared debris from flow

Topography
Site Elevation: 56
Landform Notes:
channel, poorly defined.

Notes:
Photos
36,78 - across wetland
3677 - boundary

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FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 4/3/10
Time: 445
Wetland UFI: 3 Creek

Easting: 340005 Northing: 6618390

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start	~~340005~~					
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
340005	6618390	64
340010	6618409	
340071	6618408	
340034	6618424	
340037	6618425	

Vegetation Notes:
Obligate - Hakea varia, Baumea juncea, Banksia spharocarpa
Facultative - Hakea trifurcata, Juncus aridicola
- Melaleuca lancelota

Soil Assessment
_Organic Mtl Brown sand, caking at edges,
_Gleying
_Fibrous
_Skeletal
_ Mottles

Hydrology
Creek, culvert under road, surface water flow

Topography
Site Elevation: 64
Landform Notes:
poorly defined channel with little veg growing within

Notes:
photo - boundaries 3679, 3680
- bank of creek defined as boundary

eny Australia

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 4/4/10
Time: 530
Wetland UFI: 383 Floodplain
Easting: 341991 Northing: 6418404

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change	341972	6618427	76	341967	6618440	76

Boundary Walks (Y/N)

Easting	Northing	Alt

Vegetation Notes:

Obligates - Pericalymma ~~[illegible]~~ ellipticum, Melaleuca pressiana
Banksia littoralis
Facultative. Euc todtiana, Hypocalymma angustifolia, Regelia ciliata -

Thick vegetati

Soil Assessment
_Organic Mtl High organics in top layer of soil. grey sand
_Gleying at depth Peaty top layer
_Fibrous
_Skeletal
_ Mottles

Hydrology

High soil moisture content

Topography
Site Elevation:
Landform Notes:
Flat

Notes:

3693
3694 } boundary photos

Near by to Wongonderrah Swamp

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 5/3/10
Time: 730
Wetland UFI: 328 Palusplain

Easting: ________ Northing: ________

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start			81			
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
342408	6618360	81
342408	6618343	81
342206	6618321	79
342406	6618308	80
342403	6618292	80

Vegetation Notes:
Banksia littoris, Melaleuca preissiana, pericalymma elli, Lepidosperma longitud. Lots of facultative veg within wetland along obligates including Xanthorrhoea preissii, Jacksonia, Hypocalymma angustifolium. Pristine condition

Soil Assessment
_Organic Mtl
_Gleying
_Fibrous
_Skeletal
_ Mottles

Fine clayey sand grey. Low organic content within wetland some hummocking present. At boundary grey medium grained sand at depth ~0.3m no change in soil profile

Hydrology
No signs of surface water ponding, likely to be water logged as some cracking occurring

Topography
Site Elevation: 81
Landform Notes:
Flat, gentle rise on western side

Notes:
3700 soil profile. red colouring is plant root.
3701 - soil profile at boundary
3702 - boundary photo

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 5·3·10
Time: 9:00
Wetland UFI: 382   Creek
Easting: 342555   Northing: 6618473

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

	Easting	Northing	Alt
A	342555	6618473	82
B	342556	6618458	79
C	342552	6618446	79
D	342552	6618435	↓
E	342546	6618425	↓

Vegetation Notes:
Melaleuca preissiana   Pericalymma elli, Kunzea recurva
Banksia littoralis Hypocalymma angustifolium
Lepidosperma longitudinale.

Soil Assessment
_Organic Mtl   Grey clayey sand at surface - fine - within wetland low organics
_Gleying   At boundary grey medium sand from surface, low
_Fibrous   organic content.
_Skeletal
_ Mottles

Hydrology
Area impacted by road, surface water flows
being diverted in to road drainage. Evidence of flow
at time of visit through moved debris, but dry

Topography
Site Elevation: 82
Landform Notes:
Flat area, no banked sides - considered flat at
this point but channel seems to form further away

Notes: Photo 3705 - boundary
3704 - soil at boundary
3703 - soil within wetland

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 5·3·10
Time: 10·00
Wetland UFI: 329 Sumpland
Easting: 343139 Northing: 6617713

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y]/N)

Easting	Northing	Alt
343139	6617713	73
343148	6617713	73
343162	6617717	76
343175	6617717	"
343194	6617720	"

Vegetation Notes:
Banksia littoris, Lepidosperma long, Melaleuca preissiana,
, Viminaria juncea , Hakea varia, Pericalymma ellipticum .
Hypocalymma angustifolium Melaleuca lanceolata

Dominant sedges within core of wetland.

Soil Assessment
_Organic Mtl Within wetland, white (gleyed) fine cracked clay.
_Gleying Towards boundary & transitioning to a medium
_Fibrous grained grey sand with no hydric soil
_Skeletal properties.
_Mottles

Hydrology
Area dry at time of visit. Innundation seasonally
apparent through cracking and debris movement

Topography
Site Elevation: 73
Landform Notes:
Shallow basin, 0.5 m rise on edges

Notes:
3706 - soil within wetland
3707 - soil at boundary
3708 - across wetland
3710 - looking across wetland to Melaleuca woodland

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 5/3/10
Time: 10:00
Wetland UFI: 337 Dampland

Easting: ____ Northing: ____

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks ([✓ Y] N)

Easting	Northing	Alt
343332	6616600	78
343344	6616601	
343353	6616587	
343362	6616579	
343366	6616565	

Vegetation Notes:
Regelia ciliata, Banksia sphae, Hypocalymma angust.
Beaufortia squarrosa, Xanthorrhoea, Hakea trifurcata
Young Banksia prionotes scattered within from edge -
Possible drying trend. ~~Approx~~ 98% facultative - 2% barens

Soil Assessment
_Organic Mtl within wetland - 10cm grey sand >10cm fine white sand.
_Gleying ~~Kp~~ Some fine organic content in upper layer
_Fibrous Within wetland
_Skeletal on Boundary - sand to surface.
_Mottles

Hydrology
Groundwater rise

Topography
Site Elevation: 75 in bottom
Landform Notes:
within basin

Notes: soil profile - 3711 within wetland.
3712 - soil profile on boundary.
3713 - Xcross wetland
3714 - Boundary

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 5/3/10
Time: 1030
Wetland UFI: 3564 Creek

Easting: ____________ Northing: ____________

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
343958	6616863	82
343972	6616872	↓
343991	6616888	
344012	6616911	
344023	6616926	

Vegetation Notes:
Sparse wetland obligates within channel Mel rhaph, Schoenus
Lepidosperma
Facultative veg up to bank including Banksia ilicifolia, Lyginia imberbis
Very narrow formation

Soil Assessment
✓ Organic Mtl Low organic material, medium grey sand at depth
_Gleying
_Fibrous
_Skeletal
_Mottles

Hydrology
Evidence of flow through debris on sides of channel although dry at time of visit

Topography
Site Elevation: 82
Landform Notes:
Clear channel although gradual banks - very narrow area of innundation

Notes:
3715 - soil profile within channel
3716 - across wetland

Boundary based on landform and extent of innundation

env Australia

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 5/3/10
Time: 11:00
Wetland UFI: 640

Dampland

Easting: 346542 Northing: 6618432

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
346542	6618432	115
346529	6618449	
346530	6618460	
346530	6618476	
346530	6618488	↓

Vegetation Notes:
Hakea varia, Mel preissiana Banksia littoralis Lepidosperma long.
Melaleuca cardiophylla, Hypocalymma angustifolium, Xanthorrhea preissii.
Banksia sphaerocarpa / Hakea trifurcata

Soil Assessment
_Organic Mtl Within wetland significant hummocking of
_Gleying grasses. At boundary brown medium sand
_Fibrous
_Skeletal
_ Mottles

Hydrology
Ha No evidence of surface flow. Dry at time of visit

Topography
Site Elevation: Low in landscape
Landform Notes:
Forms basin between two gentle rises

Notes:

3717 - hummocking.
3718 - boundary

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: ~~348~~ 5.3.10
Time: 12:30
Wetland UFI: 348 Sumpland
Easting: 353797 Northing:

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
353706	6618450	48
353725	6618457	
353762	6618472	
353778	6618477	
353797	6618481	

Vegetation Notes:
Hakea trifurcata, Kunzea recurva, Hypocalymma, Jacksonia
Regilia cilata.

Euc rudis, Mel preissi, Mel rhaph (<1m)

Soil Assessment
✓Organic Mtl White fine clay at surface within wetland
✓Gleying grey sand at boundary
_Fibrous
_Skeletal
_Mottles

Hydrology
Area would be inundated seasonally shown through debris

Topography
Site Elevation: [illegible]
Landform Notes:
Basin formation topographic rise on all sides
Sharp topo change.

Notes: Boundary at sharp topo change

3719 - across wetland
3720 - boundary showing topo change
3721 - within wetland

FIELD SHEET
09.246 Wetland Mapping of Area F

Date: 5.3.10
Time: 130
Wetland UFI: 3863 Creek

Easting: 355601 Northing: 6618467

Vegetation Assessment
No. Transects:

	Transect 1			Transect 2		
	Easting	Northing	Alt	Easting	Northing	Alt
Start						
Finish						
Veg Change						

Boundary Walks (Y/N)

Easting	Northing	Alt
355601	6618467	155
355605	6618478	
355621	6618487	
355635	6618510	
355652	6618533	

Vegetation Notes:
Mel rhaph, euc rudis, Meeboldina coangustata

Soil Assessment
_Organic Mtl Cracking clay on surface of channel
_Gleying
_Fibrous
_Skeletal
_Mottles

Hydrology
Dry at the time of visit but evident that water present annually because of cracking clays

Topography
Site Elevation: 155
Landform Notes:
Clearly defined

Notes:
cracking clay 3724 - 3723
Channel - 3725
Boundary - 3726

3722 - channel

APPENDIX C

PHOTO INDEX

Appendix C: Photo Index

PHOTO NO#	UFI	DESCRIPTION
3715	364	Soil profile within channel
3716	364	Across wetland
3711	337	Within wetland
3712	337	Soil profile on boundary
3713	337	Across wetland
3714	337	Boundary
3706	329	Soil within wetland
3707	329	Soil at boundary
3708	329	Across wetland
3710	329	Looking across wetland to melaleuca woodland
3705	382	Boundary
3704	382	Soil at boundary
3703	382	Soil within wetland
3700	328	Soil profile, red colouring is plant root
3701	328	Soil profile at boundary
3702	328	Boundary photo
3717	640	Hummocking
3718	640	Boundary
3719	348	Across wetland
3720	348	Boundary showing topo change
3721	348	Within wetland
3722	363	Channel
3723	363	Cracking Clay
3724	363	Cracking Clay
3725	363	Channel
3726	363	Boundary
3639	138	Boundary
3640	171	Across Wetland
3662	268	Boundary
3661	268	Across Wetland
3660	372	Boundary
3659	277	
3652	263	Both of boundary
3653	263	Both of boundary
3650	267	Boundary photo
3651	267	Across Wetland
3645	367	Boundary photo-dominance change
3646	367	Boundary at last point in boundary walk
3641	390	Boundary photo
3642	390	Across water
3643	390	44 soil profile of adjacent wetland (not mapped as

Appendix C: Photo Index

PHOTO NO#	UFI	DESCRIPTION
		artificial –old quarry)
3693	383	Boundary photo (Near by Wongondeuah Swamp)
3694	383	Boundary photo (Near by Wongondeuah Swamp)
3679-3680	3	Bank of creek defined as boundary
3678	1	Across wetland
3677	1	Boundary
3675	287	Across wetland
3674	287	boundary
3672	289	Looking across wetland
3671	285	Boundary photo
3669-3670	285	Gecko
3666	389	Boundary
3667	389	Across
3664,3665	389	Soil
3668	389	Melaleuca, wooly bush & banksias growing close together
3394,3395	830	Soil photo
3393	830	Boundary
3391	830	Boundary
3392	830	Water hole
3398	20	Core
3397	20	Open water
3396	20	Open water
3399	20	EUC
3401	20	Boundary
3402,3403, 3404	40	Soil at Boundary
3406	831	Soil- white sand at boundary
3405	831	Soil- white sand at boundary

APPENDIX D

COMPLETE FLORA LIST

APPENDIX D: COMPLETE FLORA LIST

* denotes foreign introduced species

Abbreviations:

subsp.: subspecies var.: variety

Source: Western Australian Herbarium (2010)

FAMILY	TAXA	COMMON NAME	HABITAT PREFERENCE		
			Obligate	Facultative	Dryland
Anarthriaceae	*Lyginia imberbis*			√	
Asparagaceae	*Lomandra preissii*				√
Chenopodiaceae	*Rhagodia preissii subsp. preissii*			√	
Chenopodiaceae	*Suaeda australis*	Seablite		√	
Chenopodiaceae	*Tecticornia lepidosperma*		√		
Chenopodiaceae	*Tecticornia syncarpa*		√		
Chenopodiaceae	*Tecticornia undulata*		√		
Cyperaceae	*Baumea juncea*	Bare Twigrush	√		
Cyperaceae	*Cyperus gymnocaulos*	Spiny Flat-sedge	√		
Cyperaceae	*Gahnia trifida*	Coast Saw-sedge	√		
Cyperaceae	*Lepidosperma longitudinale*	Pithy Sword-sedge	√		
Cyperaceae	*Mesomelaena pseudostygia*				√
Cyperaceae	*Schoenus subfascicularis*		√		
Fabaceae	*Acacia cyclops*	Coastal Wattle		√	
Fabaceae	*Acacia saligna*	Orange Wattle		√	
Fabaceae	*Jacksonia? sternbergiana*	Stinkwood		√	
Fabaceae	*Viminaria juncea*	Swishbush		√	
Frankeniaceae	*Frankenia pauciflora*	Seaheath	√		
Goodeniaceae	*Scaevola lanceolata*			√	
Hemerocallidaceae	*Corynotheca micrantha* var. *micrantha*				√
Juncaceae	*Juncus aridicola*		√		
Juncaceae	*Juncus pallidus*	Pale Rush	√		
Lauraceae	*Cassytha racemosa forma racemosa*				√

FAMILY		TAXA	COMMON NAME	HABITAT PREFERENCE		
				Obligate	**Facultative**	**Dryland**
Myrtaceae		*Astartea scoparia*				√
Myrtaceae		*Beaufortia elegans*			√	
Myrtaceae		*Beaufortia squarrosa*	Sand Bottlebrush		√	
Myrtaceae		*Calothamnus quadrifidus*	One-sided Bottlebrush		√	
Myrtaceae		*Eucalyptus todtiana*	Coastal Blackbutt		√	
Myrtaceae		*Eucalytpus gomphocephala*	Tuart		√	
Myrtaceae		*Eucalytpus rudis subsp. rudis*	Flooded Gum	√		
Myrtaceae		*Hypocalymma angustifolium*	White Myrtle		√	
Myrtaceae		*Kunzea recurva*			√	
Myrtaceae		*Melaleuca brevifolia*		√		
Myrtaceae		*Melaleuca cardiophylla*	Tangling Melaleuca		√	
Myrtaceae		*Melaleuca lanceolata*	Rottnest Teatree		√	
Myrtaceae		*Melaleuca preissiana*	Moonah	√		
Myrtaceae		*Melaleuca rhaphiophylla*	Swamp Paperbark	√		
Myrtaceae		*Melaleuca teretifolia*	Banbar	√		
Myrtaceae		*Pericalymma ellipticum*	Swamp Teatree	√		
Myrtaceae		*Regelia ciliata*			√	
Myrtaceae		*Verticordia densiflora var. densiflora*			√	
Myrtaceae		*Verticordia pennigera*				√
Poaceae	*	*Polypogon monspeliensis*	Annual Beardgrass		√	
Polygonaceae		*Muehlenbeckia adpressa*	Climbing Lignum		√	
Polygonaceae		*Persicaria prostrata*			√	
Proteaceae		*Banksia attenuata*	Slender Banksia			√
Proteaceae		*Banksia littoralis*	Swamp Banksia	√		
Proteaceae		*Banksia sphaerocarpa* var. *sphaerocarpa*	Fox Banksia		√	
Proteaceae		*Grevillea preissii subsp. preissii*			√	
Proteaceae		*Hakea trifurcata*	Two-leaf Hakea		√	
Proteaceae		*Hakea varia*	Variable-leaved Hakea	√		
Proteaceae		*Petrophile brevifolia*			√	
Restionaceae		*Chaetanthus aristatus*		√		
Restionaceae		*Meeboldina cana*		√		
Restionaceae		*Meeboldina coangustata*		√		
Xanthorrhoeaceae		*Xanthorrhoea preissii*	Grass tree		√	

APPENDIX E

METADATA STATEMENT

Geomorphic Wetlands Cervantes South dataset

Citation

Title:	Geomorphic Wetlands Cervantes South
Custodian:	**Department of Environment and Conservation, Wetlands Section**
Scientific Custodian	
Technical Custodian	

Description

Abstract:

The Geomorphic Wetlands Cervantes South dataset displays the location, boundary and geomorphic classification of wetlands. Wetlands in this dataset have been classified into types according to the geomorphic wetland classification system (Semeniuk & Semeniuk 1995 and unpublished report to the Department of Environment and Conservation (DEC 2007; VCSRG 2006a)). This classification system defines wetlands based on their landform and water permanence. Artificial wetlands, coastal wetlands, wetlands on offshore islands and identification of consanguineous suites were not included in the scope of the project.

Detailed methodology and results are described in the report *Wetland Mapping and Classification: Cervantes South* (ENV 2010).

The Cervantes South wetland mapping project area is located in the vicinity of Cervantes and Cataby in the Shire of Dandaragan within the Midwest region of Western Australia. The project area is approximately 100,000ha and is based on the land area encompassed by eight 1:25,000 map sheets. Wetland extent was identified and geomorphic types identified and classified using a range of information sources including Landsat, orthophotos, hard copy stereoscopic aerial photographs, topography, soil types, remnant vegetation and hydrography. Approximately 4% of wetlands were visited in the field to

groundtruth desktop outputs and to provide positional accuracy data.

A total of 770 wetlands were mapped in the project area and comprised approximately 20,000 ha of mapped wetland extent (20% of total project area).

References:

Department of Environment and Conservation, 2007. Framework for mapping, classification and evaluation of wetlands in Western Australia, Department of Environment and Conservation.

ENV Australia Pty Ltd, 2010. *Wetland mapping and classification: Cervantes South*, prepared for the Department of Environment and Conservation, Department of Environment and Conservation, Western Australia.

Semeniuk, C A & Semeniuk, V., 1995. “A Geomorphic Approach to Global Classification for Inland Wetlands”, *Vegetatio* 118:103-124.

V & C Semeniuk Research Group, 2006. Wetlands mapping, classification and evaluation - southwest region. Unpublished Report to the Department of Environment and Conservation. Western Australia

Search words: wetlands, wetland mapping, wetland classification, geomorphic classification, Western Australia, Midwest, Shire of Dandaragan, Cervantes, Cataby.

Geographic extent:

Description: Cervantes South wetland mapping project area is approximately 100,000 hectares of the Midwest region, primarily within the Shire of Dandaragan, in the vicinity of Cervantes and Cataby.

Geographical Bounding Box

North:	6624107
South:	6597142
East:	356420
West:	308059

Data Currency and Status

Beginning Date:	December 2010
Ending Date:	In progress
Progress:	Final
Maintenance/Update:	Updates to be conducted as required
History:	4th June 2010 v1
Current version:	4th June 2010 v1

Access

Stored Data Format:	vector digital data, as ArcGIS Shapefile set.
Coordinate System:	GCS_GDA_1994
Access Constraints:	Government access for purposes of internal use only to be supplied with no charge. Non-government access to be granted upon approval. Non-government use of this information is to be strictly in accordance with licence conditions. Charges for non-government access may apply.

Data Quality

Lineage: Wetland extent was identified and geomorphic types identified and classified using a range of information sources including Landsat, orthophotos, hard copy stereoscopic aerial photographs, topography, soil types, remnant vegetation and hydrography. Approximately 4% of wetlands were visited in the field to groundtruth desktop outputs and to assess positional accuracy.

Statement of limitations:

- The project sought to map all natural wetland types within the project area (including channel type wetlands) however artificial wetlands were not within the scope of the mapping and are not included in the dataset.
- This mapping is to be used at a scale of 1:25,000. As mapping has been undertaken at 1:25,000 some wetlands have not been included in the dataset as they are too small in size to be detected. In some cases these wetlands will have been incorporated into a larger wetland polygon and in other cases entirely missed from the dataset. There is no data to indicate the number of wetlands that have been missed due to the 1:25,000 scale or due to other

reasons applicable to this largely desktop survey.

- No Granite rocks were identified in this project area. If granite rocks are identified in the area they should be individually assessed for their potential to support wetlands.
- The boundaries are considered approximate and the positional accuracy statement provides only an indication of boundary accuracy.
- The temporal resolution of the information used to determine wetland boundaries and classification was 20 years and was biased towards more recent information sources. The mapping may therefore underestimate or overestimate wetland extent or water permanence over a longer climatic period.
- Wetlands were classified according to the prevailing hydrological conditions at the time. This classification may need to be re-examined if hydrological conditions are altered by irreversible anthropological effects or by cyclic climatic variability.

Positional Accuracy: Boundaries of wetlands are approximate and to be used at a scale of 1:25,000. Positional accuracy for a sample of wetlands is provided for guidance only and boundary accuracy across the whole dataset may be larger or smaller than those sampled.

Groundtruthing was conducted for portions of boundaries at 29 of the 770 wetlands (4%) and indicated average positional accuracy per site was 14m (Range: 1m – 44m). GPS accuracy of field recorded locations was ≤5 m and may result in an underestimate or overestimate of the accuracy measure calculated.

Attribute Accuracy: Groundtruthing at a limited number of wetlands found high accuracy in classification.

Logical Consistency: All polygons representing wetland areas are closed with no overlapping polygons.

Completeness: All natural geomorphic wetland types were mapped. Artificial wetlands were not mapped. No Granite outcrops were identified in this project.

Inclusiveness: No data is available on the inclusiveness of wetlands within the scope of the project. Limited groundtruthing indicated high level of inclusiveness. Wetlands may have been missed due to scale or other reasons. These may be missed entirely or combined with other wetland polygons. Small and waterlogged wetlands are more likely to be underrepresented.

Attributes List:

Name	Description
ID	Internal feature number.
Class	Wetland type based on Geomorphic classification
CRIT 1	Primary criteria used in desktop delineation. S:V:H = Soil: Vegetation: Hydrology
CRIT 2	Secondary criteria used in desktop delineation. S:V:H = Soil: Vegetation: Hydrology
CRIT 3	Tertiary criteria used in desktop delineation. S:V:H = Soil: Vegetation: Hydrology
UFI	Dataset unique feature identifier of wetland
Site visit	site visit identifier Yes / No:
Date	Date of Site visit (DD/MM/YEAR)
Area_m2	Area of wetland in square metres

Contact Information

Contact Organisation:	Department of Environment and Conservation
Contact Position:	Principal Coordinator, Wetlands Section
Mail Address:	Locked Bag 104, Bentley Delivery Centre
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Metadata Information

Metadata History:	**4th June 2010 v1**
This version	**4th June 2010 v1**

Additional Metadata

Additional Metadata:	**Detailed methodology and results are described in the report *Wetland mapping and classification: Cervantes South* (ENV 2010).**