GEOMORPHIC WETLANDS
SWAN COASTAL PLAIN DATASET
REQUEST FOR MODIFICATION

LOT 123 MORTIMER RD
CASUARINA

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1. INTRODUCTION

1.1. Background

Mr Ivan Yujnovich commissioned Bioscience to undertake an environmental study of his land at Lot 123 Mortimer Rd, Casuarina (32.235ºS, 115.853ºE). The purpose of the work was to make a detailed examination of the hydrology, soil and vegetation, upon which to determine the appropriateness of the Conservation Category Wetland (UFI 6679) classification to the north of the property.

A wetland reclassification request was originally lodged on May 22nd 2006, albeit under different (then) Department of Environment guidance operating at the time. The request was rejected largely due to insufficient long term data and insufficient detail. DEC subsequently issued more detailed guidelines for making requests to modify the geomorphic wetlands dataset.

This report goes well beyond the detail required of current guidelines, and represents 6 years of study and observation at the site.

1.2. Site Description

Lot 123 is located approximately 33 km south of Perth and 9 km east of the coast (Figure 1). The property covers an area of approximately 45 hectares, the vast majority of which is vegetated with *Banksia* open woodland. It lies within the City of Kwinana and is surrounded by a mix of rural and special rural properties to the north, east and west with Mortimer Road defining the southern boundary. Under the Metropolitan Regional Scheme it is zoned Urban Deferred.

The majority of the surrounding land has been cleared of native vegetation, either completely, or parkland cleared.

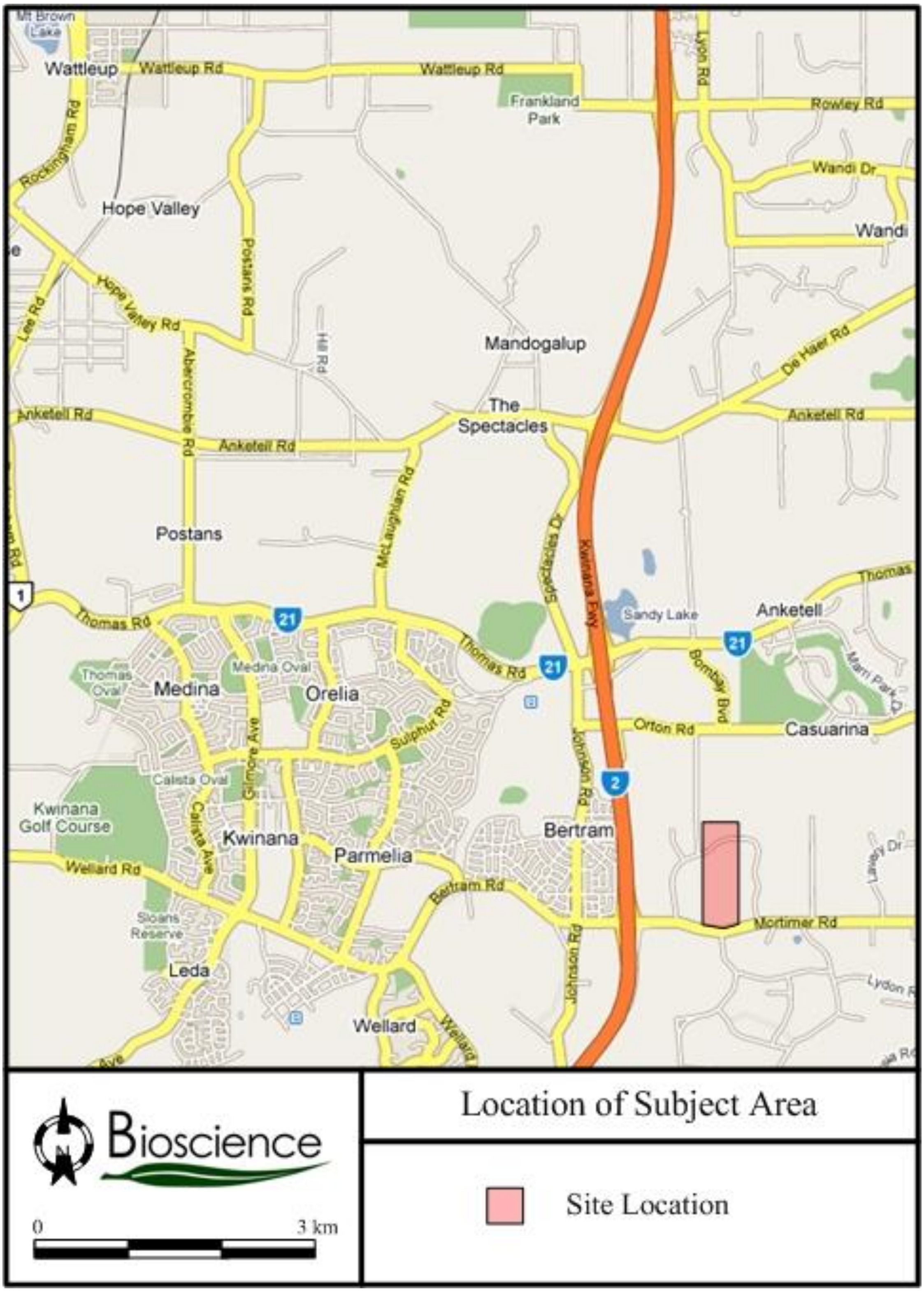


Figure 1: Location of subject site

2. WETLANDS

2.1. Definition

The definition of wetlands of the Swan Coastal Plain as used in the Environmental Protection Act and Regulations is contained in Hill et al (1996). In particular, Chapters 2 and 3 address at length the basis of defining and geomorphically classifying wetlands, considering both internationally accepted definitions and the specific regional setting of the Perth area.

"*Wetlands in Western Australia have been defined locally as: areas of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline, e.g. waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries"* (*ibid*, p.32)

The key words are waterlogged and inundated, and the definition recognises that such conditions may be permanent or intermittent. Unfortunately waterlogged is not a precise technical term and as such is subject to interpretation. Intermittent is also indefinite in that it does not define an appropriate time scale. Hill et al (1996) does provide assistance with interpretation with further description and illustrations.

In particular, Figures 2.2, 2.3 and 2.5 show the authors relate inundation and waterlogging to groundwater levels. Figure 2.2 clearly shows that wetlands extend to the area where there is seasonal saturation of soil by capillary rise of groundwater to the surface. Figure 2.3 clearly shows that the upper extreme of the range of groundwater levels in pertinent to defining wetlands.

"The term 'waterlogged' is equivalent to saturated and is used as distinct from inundated in the following way in this classification:

- *Waterlogged: those soils that are saturated with water, but where the water does not inundate the soil surface*
- *Inundated: those soils that are covered with free standing water, the soil below the surface in these situations is also saturated"* (*ibid*, p. 35)

From the detailed hydrological studies of the Swan Coastal Plain, it is well known that superficial and deeper artesian aquifer interactions influence local water tables, and that local soil conditions (particularly the occurrence of clay and silt particles in surface soil) can create "perched" water tables which lie above local superficial aquifers.

In summary the primary judgement of whether a wetland exists is determined by local groundwater levels, and secondarily by the nature of soils which are connective to a) capillary rise of underlying groundwater creating a saturated state, and b) conditions which create local perching. Accordingly, it is hydrological studies, augmented by soil physical structure which are the major determinants of the presence or absence of wetlands.

2.2. Vegetation and Soil Type

Hill et al (1996) notes the relatedness of vegetation and soil to wetland characteristics:

"Wetland terrains may be distinguished by the occurrence of water, or waterlogged soils, or vegetation typical of water conditions (eg. swamp trees, reed beds) or hydric soil (ie. formed in response prevailing water inundation or waterlogging, and including peats, peaty sands, carbonate muds, etc.)" (p. 32)

The Collins Dictionary defines "distinguished" as: 1. to make, show or recognise a different or differences (between or among): differentiate (between). 2. to be a distinctive feature of; characterise. 3. to make out, perceive. The word distinguish does not mean define, it means show or differentiate.

Semeniuk et al. (1990) proposed a classification of wetland vegetation which can be used to augment the basic geomorphic wetland types." (p. 42) (Hill et al, 1996)

The term "augment" clearly shows the authors do not mean that vegetation defines a wetland, but rather that it assists the classification of wetlands once they are so defined.

This is further elaborated in section 3.5 where the study details the importance of field verification of wetlands

"Wetland vegetation, which is a good indicator of hydro-period needed to be assessed in the field. In many instances aerial photographic work can only reveal a closed forest or a heath, without any indication as to whether water levels or hydro-period, and compositional differences between forest and heath types (eg. Melaleuca preissiana forest and Melaleuca rhaphiophylla forest). These differences in vegetation signal major differences in hydro-period features and cannot be ascertained from aerial photographs." (*ibid,* p. 59)

Note the authors restate vegetation is an indicator, not a definition. The authors also chose to distinguish *M. preissiana* and *rhaphiophylla*, eruditely reflecting Marchant's observations that *M. rhaphiophylla* (Swamp paperbark) occurs in watercourses and permanent swamps, whereas *M. preissiana* (Moonah paperbark) borders watercourses and winter wet depressions.

There are many plants which can survive temporary inundation, and generally need prolonged moist conditions to germinate and grow. These are considered as wetland indicator species. However; almost all can grow outside wetlands, although are most commonly found in areas where the water table varies from between 0.5 and 2 m below the soil surface. Such areas are not wetlands according to the hydrological definition of a wetland adopted by WA regulations or that described by Tiner. The WA Herbarium describes the habitat of such species not at wetlands, but as "winter wet depressions". Accordingly, wetland plants can be a useful indicator of wetlands, but as they are not obliged to live in waterlogged soil, they are not a reliable criterion for identifying wetlands. A far more useful indicator of a wetland is the absence of upland species (i.e. Banksia/Eucalypt) from a wetland area, as their biological limitation prevents their survival in waterlogged/inundated areas.

The point is raised here only to illustrate that should hydrological and soil examination provide equivocal or ambiguous results, vegetation may assist by augmenting the data. In this specific case *M. preissiana* would help define the boundary of a wetland as it occurs along boundaries.

Bioscience notes that DEC's Wetland Program Office has in the more recent past defined wetlands in terms of the presence of "obligate" wetland plants. This is not a term used in Western Australian botany and is not contained in the flora of the Perth Region, nor is it used in the Western Australian Herbarium. We note it is used in the United States Department of Agriculture, where they use the following definitions:

Indicator Code	Wetland Type	Comment
OBL	Obligate Wetland	Occurs almost always (estimated probability 99%) under natural conditions in wetlands.
FACW	Facultative Wetland	Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
FAC	Facultative	Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
FACU	Facultative Upland	Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).
UPL	Obligate Upland	Occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the regions specified. If a species does not occur in wetlands in any region, it is not on the National List.
NA	No agreement	The regional panel was not able to reach a unanimous decision on this species.
NI	No indicator	Insufficient information was available to determine an indicator status.
NO	No occurrence	The species does not occur in that region.

We include this definition to address the status of vegetation across the site.

2.3. Groundwater Levels and Soil Type

Because groundwater is fundamentally important to areas outside environmental science, (e.g. scheme water supply, urban drainage and civil engineering) methods for measuring and monitoring groundwater are well established and an extensive dataset exists for the Swan Coastal Plain covering many decades of records.

Davidson (1995) describes at length the nature and dynamics of the superficial aquifers and notes that the watertable fluctuates seasonally about 1 m in the central sandy areas (Bassendean sands) with the maximum watertable elevation occurring during September/October.

Davidson (1995) also notes in reference to wetlands:

"Many of the swamps are perched above the water table and downward leakage of water is inhibited by peaty swamp deposits and in some areas, particularly south of Perth, by a ferruginous hardpan colloquially called 'coffee rock'." (p. 11)

The term "hydritic soil" refers to chemical changes which occur when soils are permanently or intermittently waterlogged. Because void spaces between soil particles become filled with water, and because gas diffusion is much slower in liquid than in air, such soils become depleted of oxygen. As oxygen has a significant impact on redox potential, such soils become reducing, rather than oxidising. This means organic carbon accumulates and soil sulphur becomes reduced and immobilised as organic and free sulphides. Accordingly, hydritic soils progressively become darker due to accumulation of fine organic humus, and permeability becomes reduced.

Such soils on the Swan Coastal Plain also typically accumulate reduced sulphur and tend to become so-called "acid sulphate soil". Reduced sulfides also interact with free iron forming the ferricrete layer termed "coffee rock".

These characteristics of "swampiness" accurately reflect the extent and duration of inundation and waterlogging. The location of ferruginous layers is also an indicator of the Average Annual Minimum Groundwater Level.

Areas which have prolonged inundation also develop a characteristic sediment layer, with the specific composition of sediment determined by geomorphology and water chemistry during inundation. When sediments include durable materials such as invertebrate parts including shells, or diatom exoskeletons, they can become a very useful indicator of the geological history of inundation.

A further feature of inundated wetland soils relates to the progressive accumulation, under certain circumstances, of precipitated salts to form minerals such as gypsum (calcium sulphate) and limestone (calcium carbonate). These occasionally form where a wetland becomes an evaporitic basin, receiving inflow from surrounding creeks, then the water evaporates of summer months, leading to increases in dissolved salts above their solubility thresholds. In the Perth region, such depositional wetlands are common close to the coast, but occasionally inland wetlands (e.g. Forrestdale Lake) have such deposits.

As a result of many physical and chemical processes which occur in the presence of water, soils develop characters that can be identified for determination of wetland presence and boundaries. Wetland soils can thus be identified using soil morphological indicators such as:

- Accumulation of organic matter
- Sediment layer
- Gleyed soil colours
- Soil mottling
- Iron or manganese aggregations
- Oxidising root channels and soil pore linings
- Reducing of sulfur and carbon (ie Acid Sulfate Soils)
- Precipitated salts

The fundamental basis for defining a wetland is that it is wet. Definitions are somewhat varied, but the key feature is groundwater levels are either above the surface level, as in lakes, or at or very near the surface such that the surface soil is waterlogged or saturated. Given that about 80% of plant roots occupy the top 30 cm of soil and over 95% occupy in the top 65 cm of soil, it is when groundwater approaches this biotic zone near the surface that impacts producing wetland conditions occur.

2.4. The Classification of Wetlands

When a site has been defined as a wetland, in order to classify that area in terms of appropriate management, an assessment is undertaken using the protocols described in EPA Bulletin 686 "*A Guide to Wetland Management in Perth and near Perth Swan*

Coastal Plain area". By using a structured assessment protocol which considers both natural and human use attributes, a wetland is classified into one of three management categories, Conservation Category (CCW), Resource Enhancement (REW), or Multiple Use (MUW). Management decisions in relation to appropriate land use can then be made.

The system of classification is currently under revision, and has been for quite some time. The protocol for proposing modifications to the Geomorphic Wetlands Swan Coastal Plains dataset (2007) states:

"DEC is currently preparing an evaluation method guideline to assign wetland management categories, which will consolidate and replace the evaluation method in Hill et al (1996a), V & C Semeniuk Research Group (1998), and the EPA Bulletin 686 A Guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area (EPA 1993)" (p. 1)

The wetlands re-assessment protocol provides very little by way of further guidance other than to the references previously used, however it requires a far greater amount of work to be undertaken, particularly in relation to definition of vegetation, where comprehensive vegetation surveys are required. The draft is paradoxical in that none of the cited references contained therein require such a detailed assessment of vegetation.

One important reference is Tiner (1999) *Wetland indicators, a guide to wetland identification, delineation, classification and mapping* which refers to wetlands in the US. Most importantly, whereas Hill et al (1996) refers in general terms to distance to watertables, Tiner is quite specific as to how far the watertable must rise and for what duration before an area is classified as a wetland. Tiner (1999) also modifies this definitional benchmark according to soil permeability such that the distance to groundwater is decreased for highly permeable soil, and increased for lower permeability soil.

A further enhancement Tiner brings to wetland classification in WA is a careful and detailed description of hydritic soils (which although mentioned, are not defined by Hill et al).

2.5. Field Verification

Hill et al (1996) state at 3.12 that field verification is important for classifying wetlands for several reasons:

- Climatic variations influence wetlands, and field investigations are needed to determine such changes
- The maximum and minimum water levels in wetlands are required in order to apply geomorphic wetland classification
- Wetlands have to be classified according to the present water regime, as drainage modifies the wetness characteristics of the system.
- Wetlands in unusual or particular settings require field studies to clarify their attributes.
- As previously mentioned, vegetation can provide indicators of hydro period, and these cannot be ascertained from aerial photograph.

3. DESKTOP STUDY

3.1. Climate

The south west of Western Australia is characterised by a Mediterranean climate comprising hot dry summers and cool wet winters. According to the Bureau of Meteorology the average annual rainfall within the vicinity of the site is 827.7mm (Jandakot Aero No. 009172). The monthly distribution of rainfall (Figure 2) indicates approximately 85% of the rainfall occurs during the months of May to October. The potential annual evaporation of the area is 1800 mm, which is significantly more than annual precipitation (Davidson and Yu, 2006). The prevailing wind is from a south-westerly direction, however easterly winds common, particularly in the summer months.

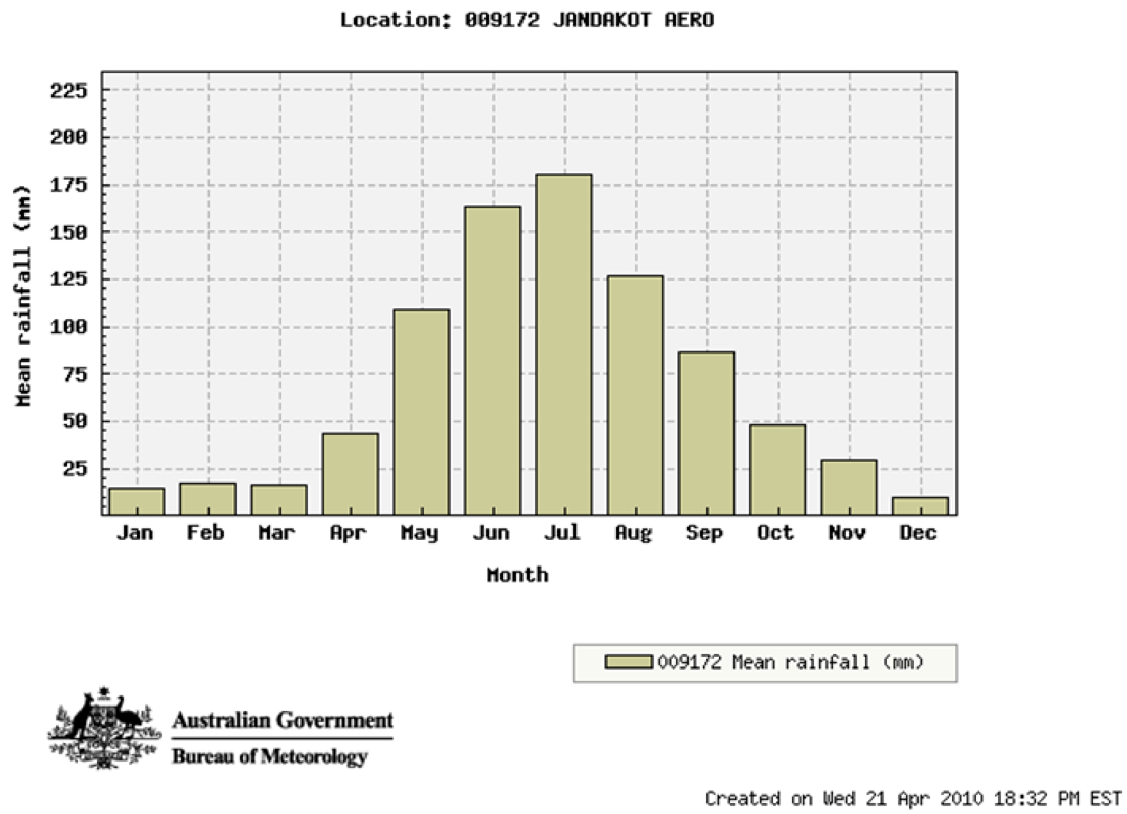
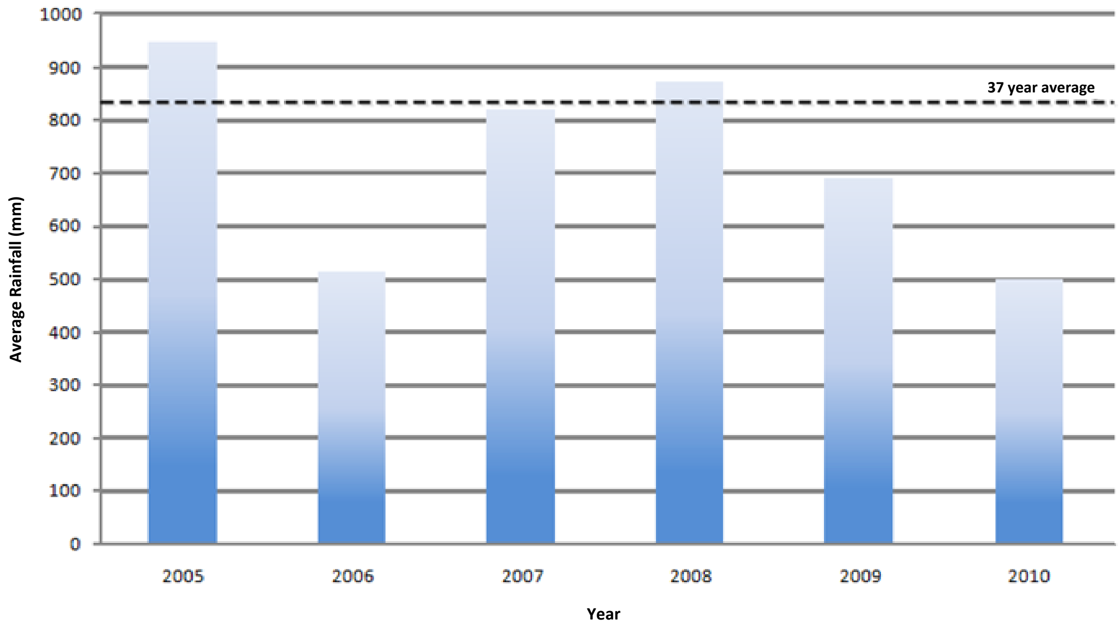


Figure 2: Average Annual Rainfall 1972-2010

The average rainfall over the 6 year study period for this report varied markedly, with some years receiving average or slightly above average rainfall and others with significantly less rainfall than the 37 year average, with 2006 and 2010 receiving nearly half the average amount. However, 2005 recieved 13% more rainfall than the average and 2008 received 5% more rainfall than the average (Figure 3).



Data from Bureau of Meteorology website www.bom.gov.au (Accessed 14/04/11)

Figure 3: Rainfall over the study period

3.1.1. Climate change

Australia is one of the driest continents in the world and the affects of climate change are no more obvious than in south-western Australia. Time series charts such as figure 4 illustrate an excessive decrease in annual rainfall over the past 100 years. Decreasing rainfall and increasing temperatures over south-western Australia has had grim consequences for the Swan Coastal Plain's diverse wetlands. These factors have left many wetlands dry due to decreased groundwater recharge and increased evaporation.

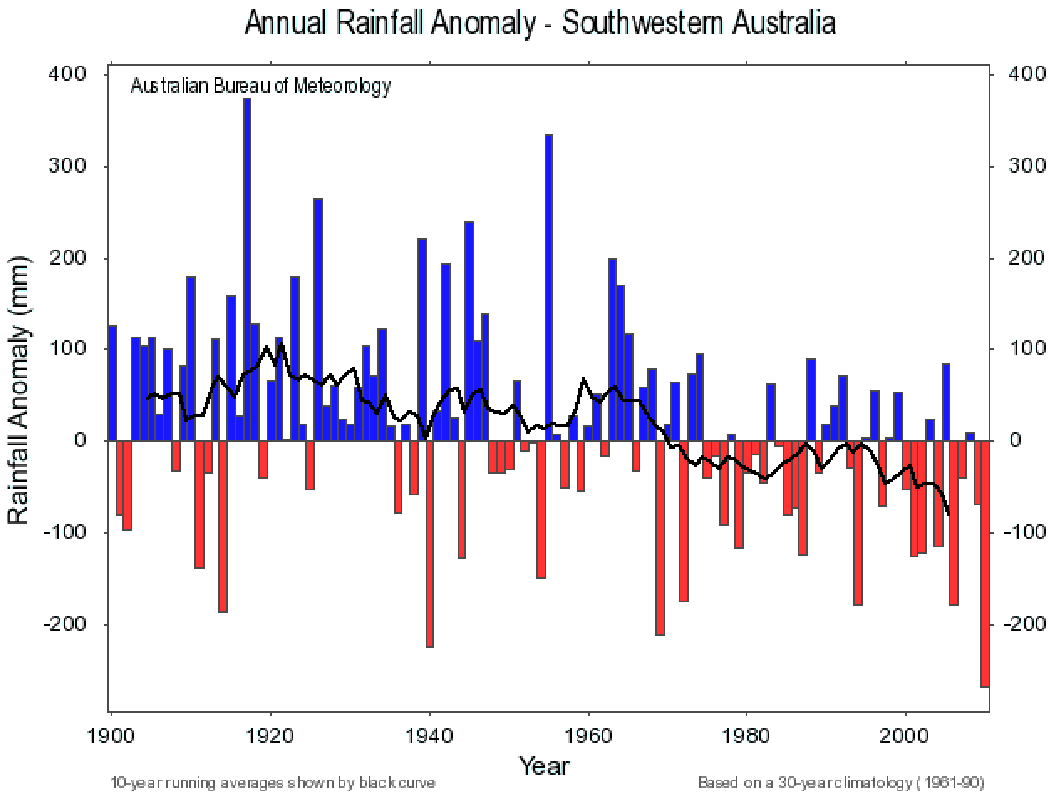


Figure 4: Annual rainfall anomaly for south-western Australia

Climate change predictions indicate that the current trend is likely to continue into the future as a result of human activity. Climate change projections to 2030 in Australia's south-west include an eight percent reduction in average rainfall compared to 1980-99 average rainfall data (DoW, 2009).

3.2. Geomorphic Dataset

The original wetland mapping for the Swan Coastal Plain is contained in Hill et al. (1996) Volume 2b. This was progressively transformed into a digital data set which is now contained within the Western Australian Land Information Service available through the internet (www.walis.wa.gov.au).

In 2002 part of the northern section of the property was classified as Conservation Category Wetland (CCW) under the Department of Environment's Wetland classification guidelines. Four other areas respectively classified as Resource Enhancement Wetlands (REW) also overlap the site (Figure 9).

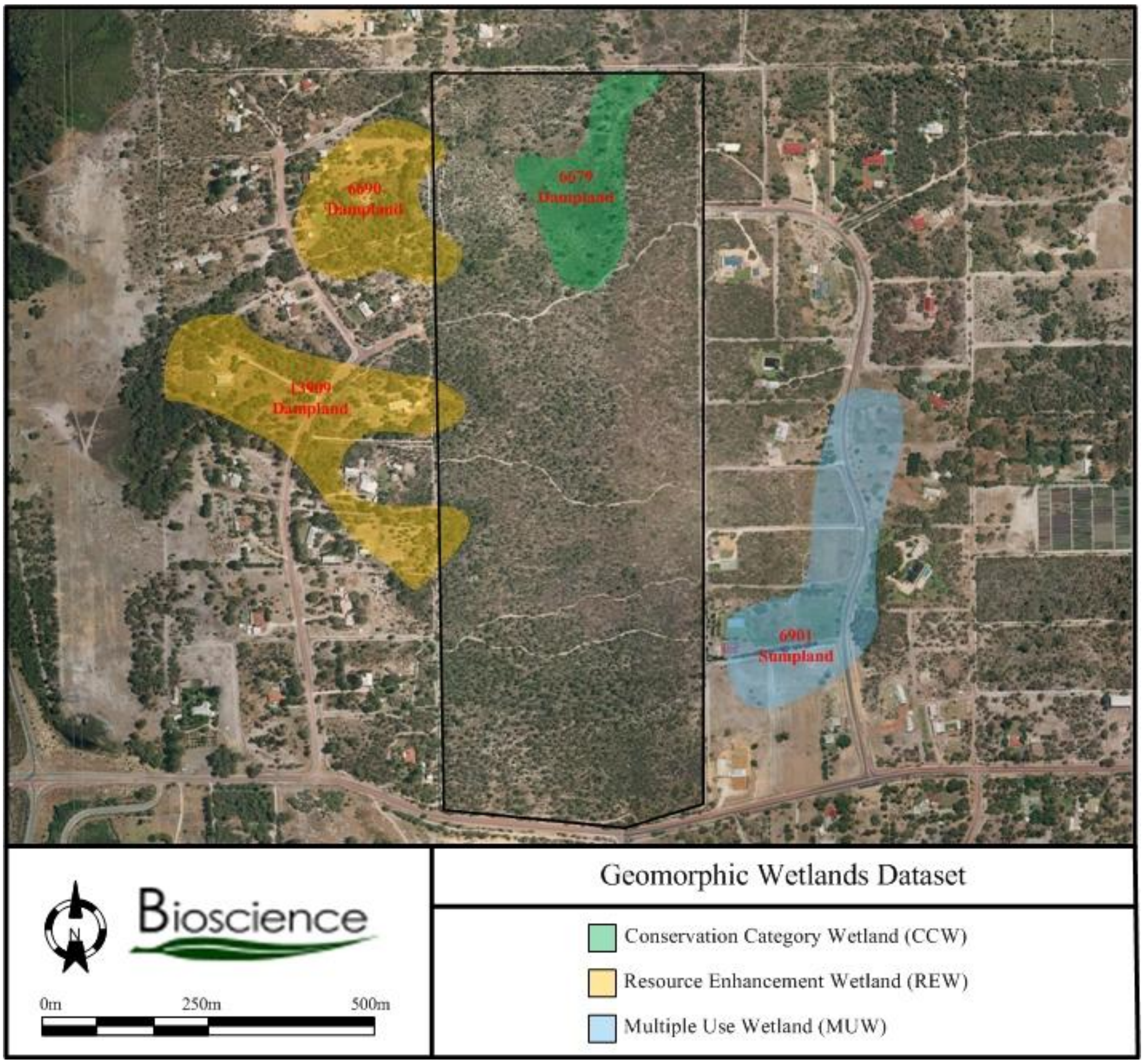


Figure 5: Geomorphic Wetlands Dataset Map

3.3. Topography

The area is undulating and according to the WA Atlas, elevation ranges from 38m AHD in the south eastern corner to 16m AHD in the demarked northern wetland areas and areas along the western boundary. The average height for the area is between 24 to 30m AHD with a general slope from south-east to north-west (Figure 6 contours from WA Atlas).

Bioscience formed the view these elevations were not consistent with other data, so the height was determined in the field using base-corrected differential GPS which is standard surveying equipment and accurate to 2 mm AHD. This work showed the northern demarked wetland had a minimum elevation of 17.605 m AHD and an average of 18.12 m across the relatively flat area. This was subsequently confirmed by the Water

Corporation survey of local drains undertaken in 2009 as part of the Peel Main Drain study for the Department of Water. That study found the wetland area had elevations of 18.40 m at the northern boundary and 18.2 m near the middle of the demarked wetland.

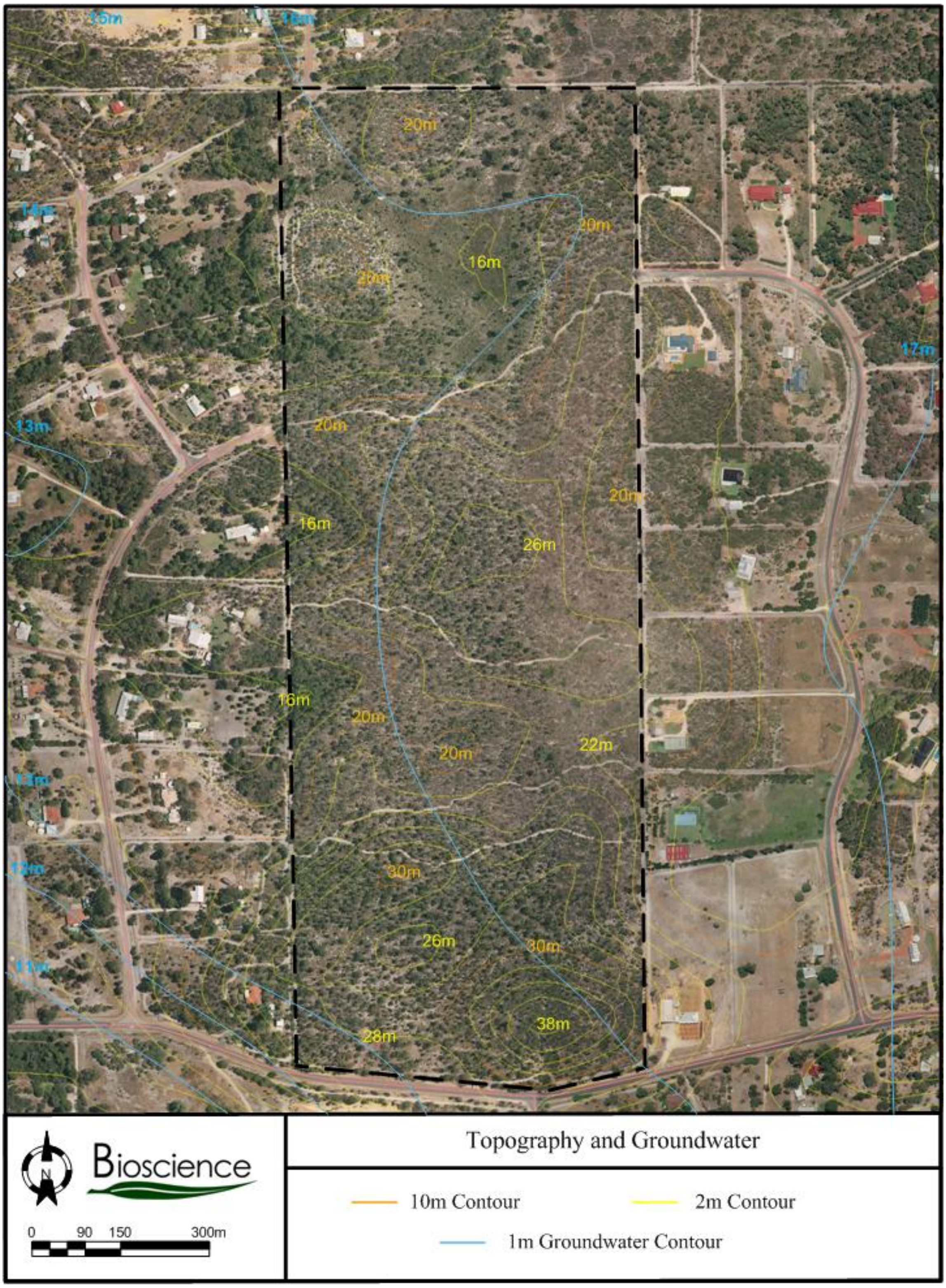


Figure 6: Topography and groundwater contours

3.4. Site Geology and Geomorphology

The subject site is located on the Swan Coastal Plain within the Bassendean dune system, an area characterised by low dunes of siliceous sand interspersed with poorly drained areas or wetlands. Soils tend to be a deep bleached grey colour sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m.

Underlying the Bassendean formation is the Guildford formation. The soils of the Guildford formation are complex, and comprise a successive layering of soils formed from erosion of material from the scarp to the east. Rivers and streams have mostly carried the eroded material, which is deposited from the water as fans of alluvium. The Guildford formation is characterised by poor drainage due to the low permeability of sub-soil clays which prevent the downward infiltration of rainfall, consequently during the winter month's water logging and surface inundation can occur. In addition, the clay fraction of the Guildford formation is known to have highly variable Plasticity Indices (Hillman *et al*., 2003).

The geology at the site as per the Geological Survey of Western Australia 1:50000 Environmental Geological Series Fremantle Map part of sheets 2033 I and 2033 IV and Rockingham Map part of sheets 2033 II and 2033 III are either (Figure 6):

- CPS – PEATY CLAY – Dark grey and black, soft, variable organic content, some quartz sand in places, of lacustrine origin
- S8 – SAND – Very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz, moderately well sorted, of eolian origin

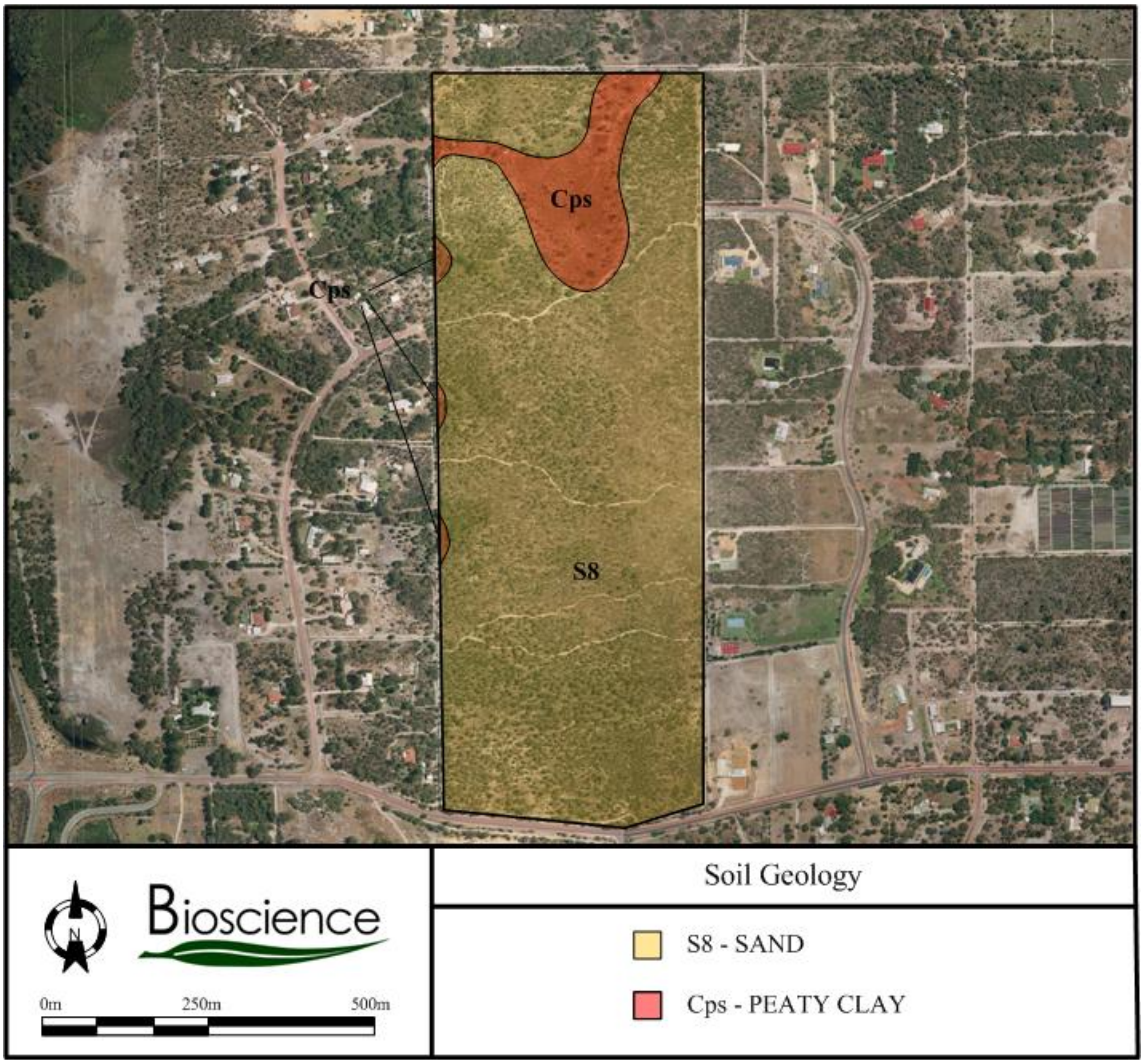


Figure 7: Soil Geology

3.5. Hydrogeology

According to Davidson and Yu (2006) the study area appears to be located within the Jandakot Mound, which is bounded to the north by the Swan and Canning Rivers, to the east by Southern River and Byford superficial aquifer, to the south by the Karnup Drain and to the west by the Ocean. Given this mapping was conducted on a regional scale the actual hydrogeology of the site may be rather complex.

The majority of groundwater recharge like other areas within the Swan Coastal Plain, results from rainfall infiltration, however additional recharge results from rainwater runoff from the Darling Scarp (Davidson and Yu, 2006). An estimated annual recharge of up to 24% is relatively high for the Swan Coastal Plain and due in part to high hydraulic conductivity of the Bassendean sands and the shallow water table.

The Jandakot Mound has a transmissivity ranging from 200 - 1000m^2/day, an average annual fluctuation of approximately 0.64m and ultimately discharges into either the Swan River (15150 m^3/day), Canning River (7000 m^3/day), the Ocean (66450 m^3/day), Karnup Drain (1700 m^3/day), Southern River (3000 m^3/day) or Lake Forrestdale (6200 m^3/day).

WA atlas indicates that the groundwater level is around 16m AHD with the hydraulic gradient moving from east to west and south west (Figure 4).

The Mortimer Road site is part of the Peel main drain system as outlined in the DoWs (2009) *Jandakot drainage and water management plan* (Figure 7). The Peel sub drain O begins at the northern part of the property at its highest point and runs west around 2 km before entering the main drain.

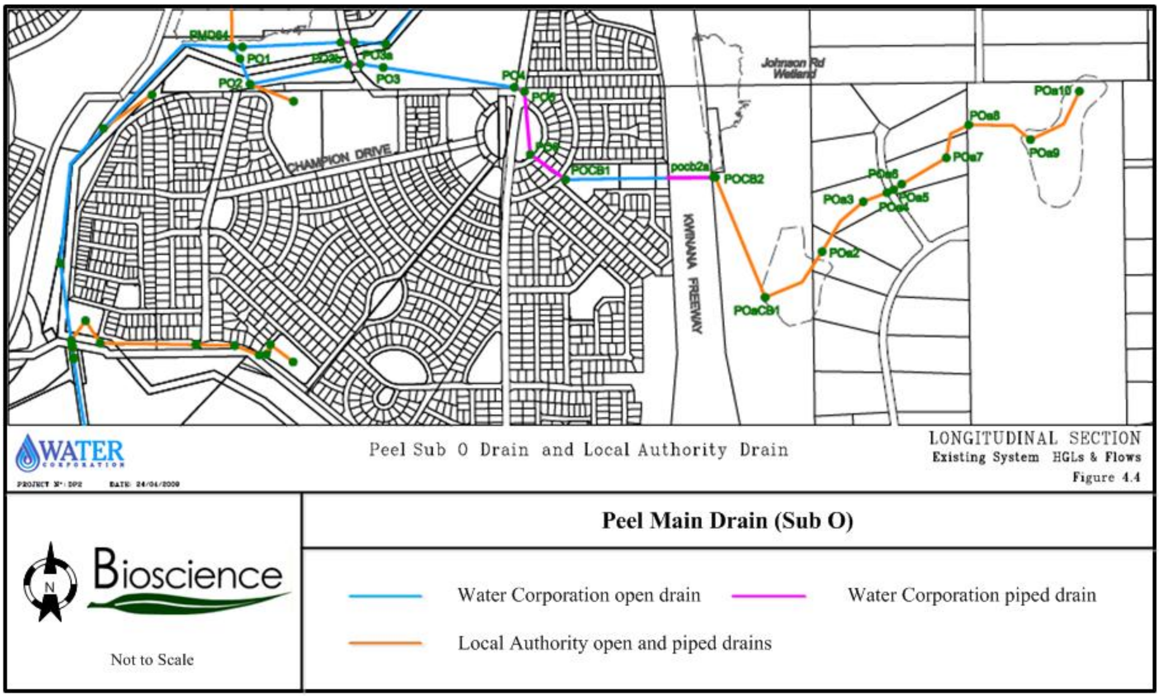


Figure 8: DoW Peel Main Drain – Sub drain O

3.6. Vegetation

The study area is within the Swan Coastal Plain Biogeographic Region of the South-west Botanical Province (Thackway and Cresswell, 1995, Paczkowska and Chapman, 2000), an area that extends from Jurien Bay to the north to Dunsborough to the south, and west of the Darling Scarp.

3.6.1. Vegetation Complexes and Floristic Community Types

The Bush Forever Site Number 273 is located north-east of the study area (Figure 8) and depicts the likely vegetation complexes that reside within the property. According to the *Bush Forever* site description (DEP, 2000) only one complex exists within site number 273; the Bassendean complex (Central and South).

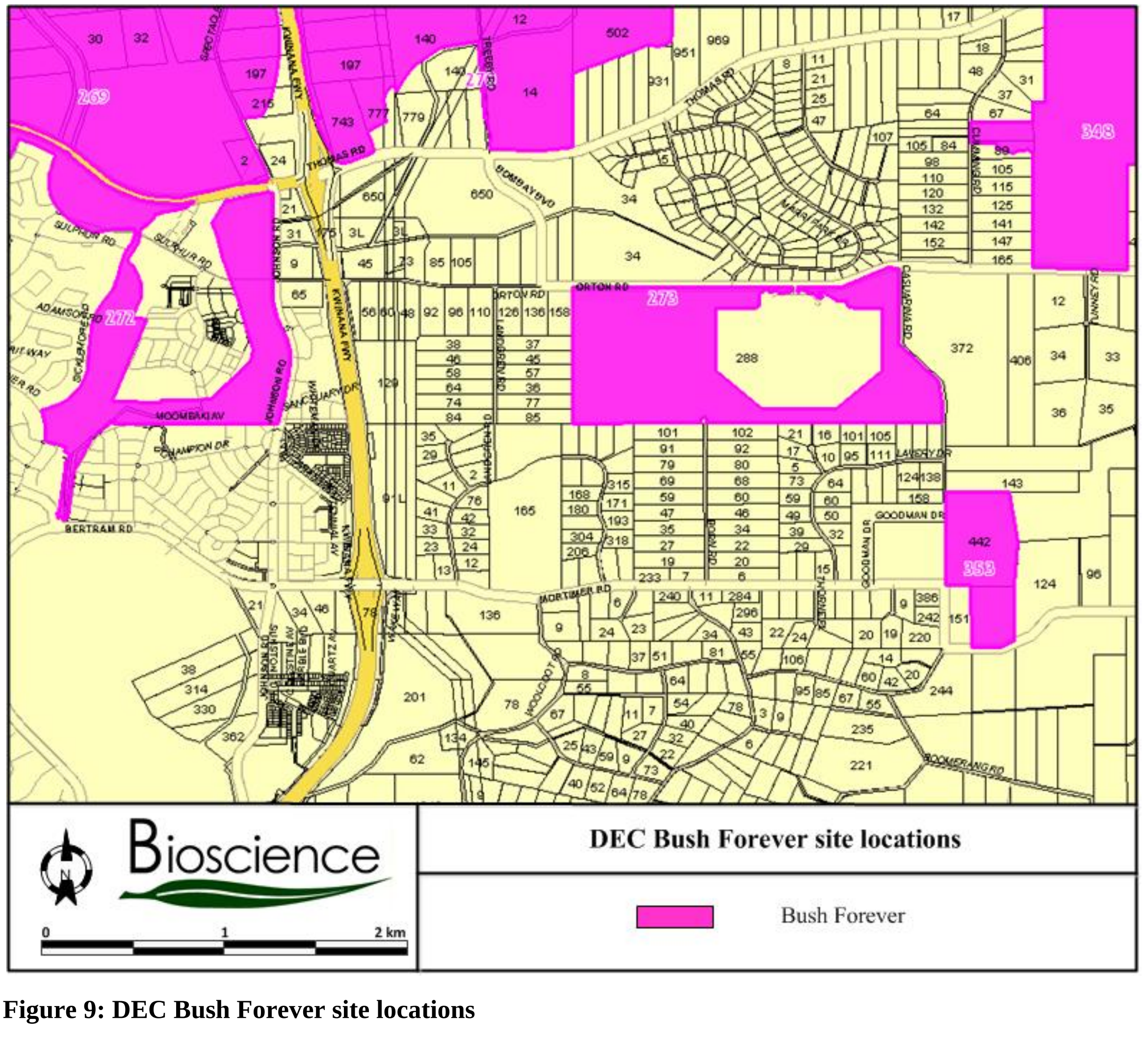


Figure 9: DEC Bush Forever site locations

In addition to the vegetation complex in the *Bush Forever* site description, Gibson *et al*. describes three Floristic Communities Types within two supergroups occur in proximity to the site; including,

Supergroup 2: Seasonal Wetlands

- 4 *Melaleuca preissiana* damplands

Supergroup 3: Uplands centred on Bassendean Dunes and Dandaragan Plateau

- 21a Central *Banksia attenuata* — *Eucalyptus marginata* woodlands
- 23a Central *Banksia attenuata – B. menziesii* woodlands

4. WETLAND ASSESSMENT FIELD WORK

4.1. Hydrology and Soil Investigations

In order to investigate the soil and hydrology of the area classified by DEC as wetland, a drilling program was undertaken in August 2005. An auger-core drill rig equipped with a Geoprobe sampling system was used to dig holes 4m below the surface where core samples were recovered, examined and logged, and sub-samples were taken for laboratory investigation.

Locations were chosen based on geomorphology of the area, and positioned to capture cross sections through the demarked wetland area. Mechanical core augering using a Geoprobe sample collection system is the preferred method over manual core augering as it provides *in situ* representative samples intact and reduces the risk of soil blending within the profile.

After the holes were drilled, piezometers made from 50 mm slotted PVC pipe were inserted below the minimum groundwater level to a depth of 4m (bottom 3m slotted and end capped) with 0.5m above the surface. The annulus around the screened interval was packed with gravel. Piezometer tops were capped and locations were logged by GPS (Figure 10).

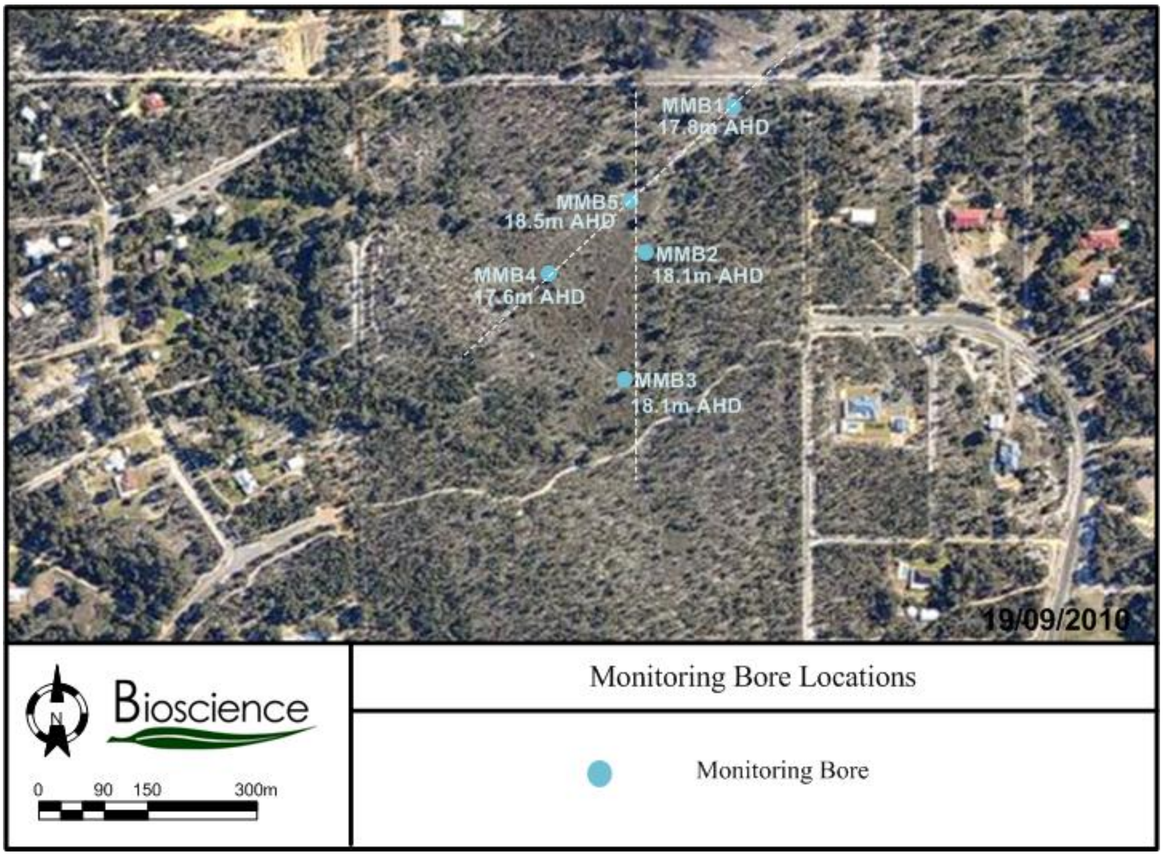


Figure 10: Bore Locations

4.2. Soil Profiles

Each drill hole presented a very similar soil profile consisting of a shallow A horizon (100 – 150mm) of grey sand overlying white medium/coarse grained white sand typically to a depth of about 1m. Sand then became uniform grading coarse yellow to brown sand to 4m (Appendix 1).

A weakly indurated layer 200mm deep was found at one site only (hole 1). This area is outside the boundary of what is currently classified as CCW. There was no evidence in any soils collected of sediment layers, or of organic deposition.

4.3. Hydrological Data

Piezometer water level data was recorded for 6 months in 2005, then monthly from October 2007 until May 2011 (Figure 9). Groundwater levels were closest to the surface during August and began to recede after this time. Groundwater was closest to the surface at MMB4 during 2008 reaching a maximum of 1519mm below the surface.

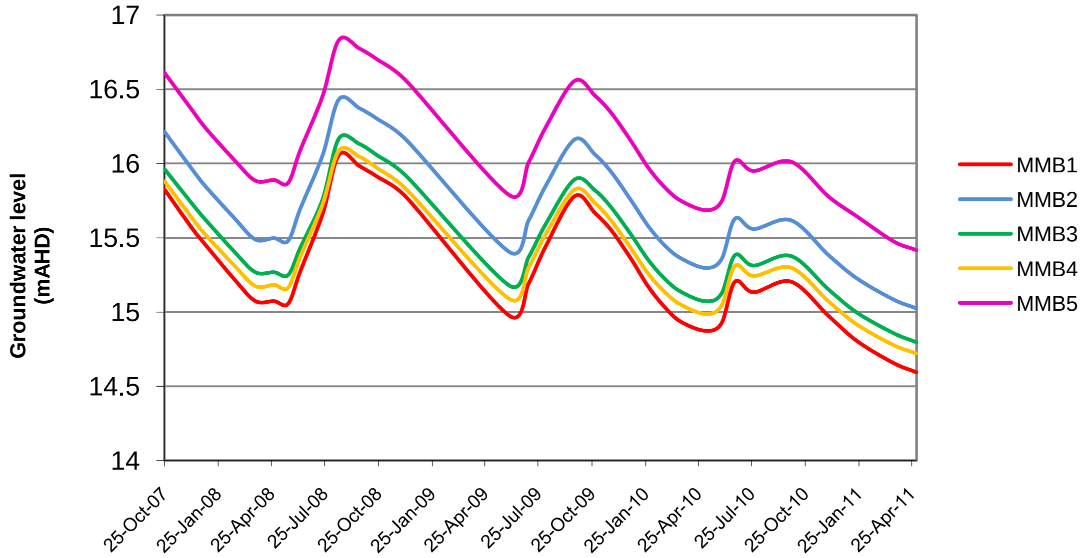


Figure 11: Groundwater levels October 2007-May 2011

This data correlates with local groundwater data of surrounding monitoring bores (DoE, 2005) that suggest levels fluctuate annually about 1m reaching minimum depth around August. However, despite having above average rainfall in 2008 the groundwater reaches no closer than 1519mm below the surface. This is inconsistent with the Hill et al (1996) wetland classification which suggests that in order to be classified as a dampland the soil should become waterlogged through the capillary rise of water or raising of the water table. It is unlikely that capillary action would have an effect of more than 10-20cm in the medium/coarse sands found throughout the area.

To determine the influence of the particular season on data collected on site, it was analysed against the closest long term monitoring bores logged by the Department of Environment for at least 35 years. The closest long term monitoring bores are around 1 – 2.5 km away and as such do not give a direct indication of the local hydrology but rather give an overview of regional hydrological change.

Eight monitoring bores within a 4km radius (location in Figure 12)were examined for average annual groundwater level. Results show that there is a general decline from approximately 0.1m to 0.95m in average annual groundwater levels across 5 monitoring bores (3038, 3057, 3069, 3093, and 3094). Three of the eight monitoring bores increased from approximately 0.3m to 0.38m (3044, 3045, and 3070) however, although monitoring bore 3070 has increased in average annual groundwater level, the annual maximum groundwater level has decreased 0.34m in the past 10 years compared with the previous decade.

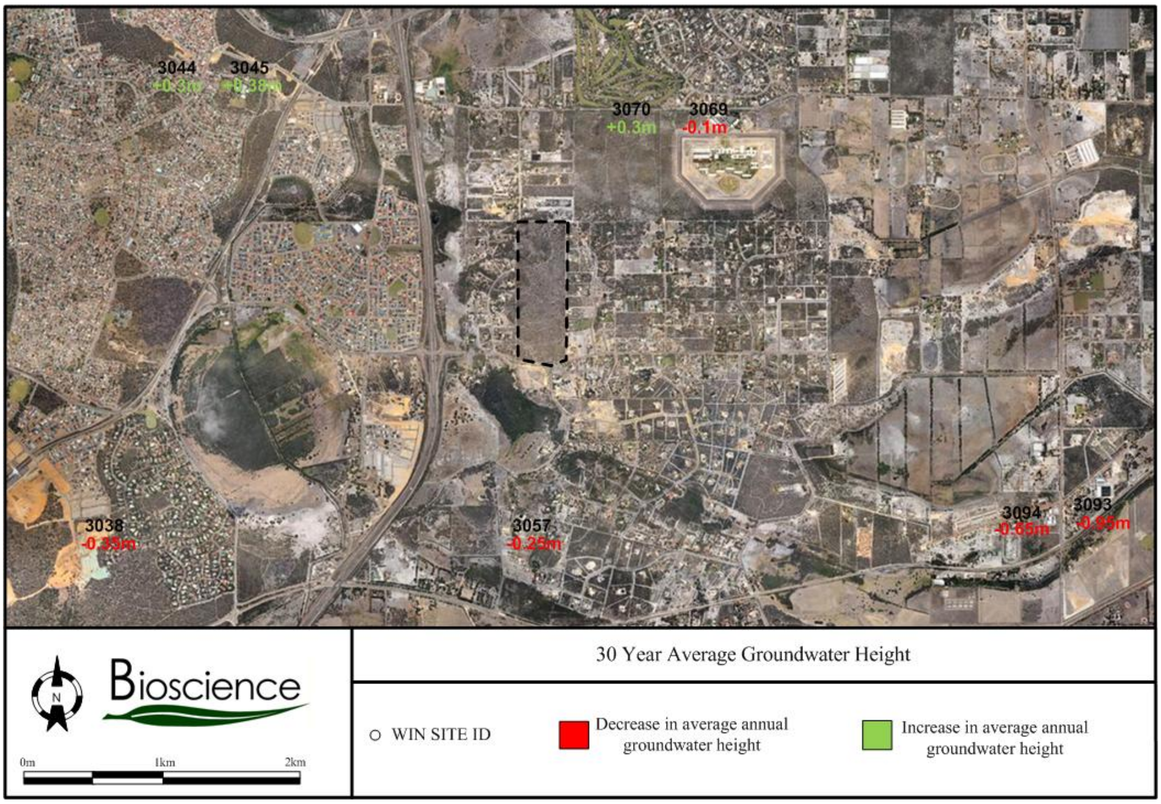


Figure 12: Annual average groundwater levels of surrounding monitoring bores

To determine whether any significant changes to this site have occurred, archived aerial photographs of the site since 1953 were examined. Although the majority of available photographs were taken in summer, there are ample for the wet months of June through September. None of the photographs, including those prior to any substantial clearing in the area, show any evidence that the site has ever been inundated in the last 58 years. It is also worth noting that the wetland area boundary has become much less definitive over time (Appendix 4).

4.4. Soil Data

Soil samples were selected from recovered drilling cores to test for the presence of Actual Acid Sulphate Soils (AASS) and Potential Acid Sulfate Soils (PASS). As the soils were invariably sand with very low organic matter, only those samples which occurred in darker brown horizons were tested except for Hole 1, where the entire profile was tested.

Tests involved measuring field pH and pH after oxidation with peroxide, according to the "Field Test" guidance issued by DEC for assessing Acid Sulfate Soils.

Table 1: Soil pH before and after oxidation with H_2O_2

Sample	pH_{KCl}	pH_{H2O2}	H_2O_2 Reaction
1.2	4.45	4.07	Nil
1.3	4.66	4.28	Nil
1.4	4.84	4.28	Nil
1.5	5.14	4.43	Nil
1.6	5.4	3.89	Nil
1.7	5.64	4.69	Nil
1.8	6.24	5.34	Nil
1.9	6.43	4.74	Nil
2.5	4.91	4.36	Nil
3.6	5.12	4.13	Nil
4.6	5.94	4.36	Nil
5.5	5.42	4.02	Nil

Acid Sulfate Soil is judged by a lowering of pH by more than 2 units after reaction with hydrogen peroxide, and extent of reaction with peroxide. As shown in Table 1, none of the soils tested showed any evidence of acid sulphate conditions.

It is also noteworthy that hole 1 soil shows a progressive rise of soil pH with depth (podzolisation) rather than a sudden rise at a particular point as would be expected from saturated soil, where waterlogging changes redox potential and under anaerobic (reducing) conditions, pH typically shows a sharp rise.

4.5. Vegetation

4.5.1. Detailed Site Investigation

Bioscience undertook a detailed vegetation survey which met the requirements of EPA Guidance 51. Six 10m quadrats were clearly marked out covering each vegetation uni and one 100m transect were studied in detail (Figure 13) (Appendix 2). The demarked CCW was assessed using two quadrats. Quadrat one (MR01) surveyed a 10 x 10 m representative area of the centre of the wetland, whilst quadrat four (MR04) surveyed a 10 x 10 m representative area of the transitional zone between wetland and dry land vegetation along the edge of the wetland boundary. A REW wetland on the western boundary (MR03) was also investigated for comparison.

Survey results show that three vegetation subtypes are represented within lot 123 including;

- 4 *Melaleuca preissiana* damplands
- 21a Central *Banksia attenuata* — *Eucalyptus marginata* woodlands
- 23a Central *Banksia attenuata* – *B. menziesii* woodlands

This is comparable to the bush forever site 273 to the north of the subject area.

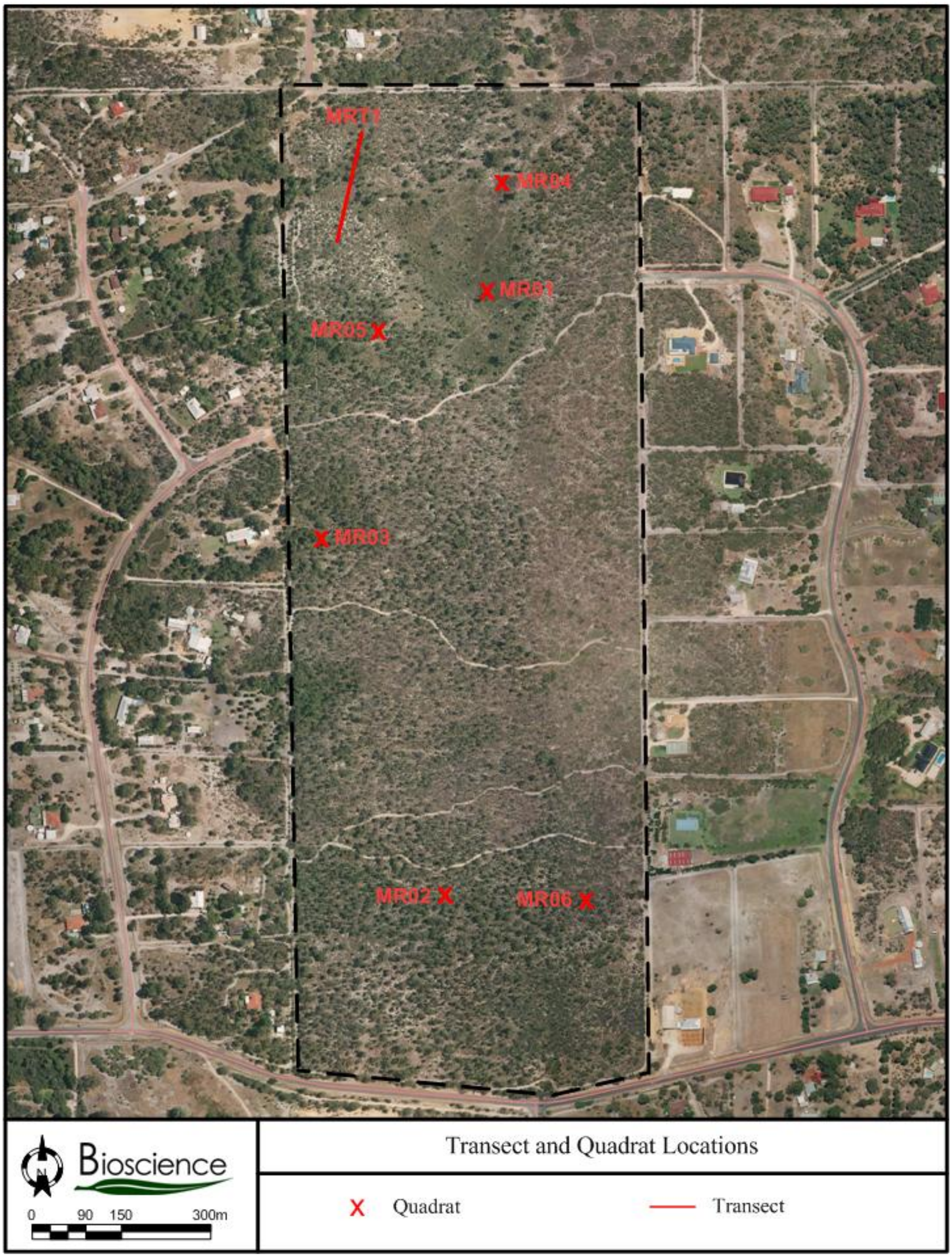


Figure 13: EPA Guidance 51 Quadrat and Transect Locations

Results indicate that some wetland species do exist within the area demarked as CCW. However, this was to be expected as, based on geomorphology (i.e. that the area is flat) it may have had some wetland features over 60 years ago. However; dryland species such as *A. fraseriana* and *C. calophylla* are now well establishing within the area.

Wetlands do not become drylands overnight resulting in a high likelihood that some wetland evidence will remain within the CCW. The only evidence supporting the presence of a wetland is vegetation, which is only one third of the criterion required to satisfy the identification of a wetland. The progression from wetlands to drylands begins with the reduction and eventual absence of water due to altered hydrological regimes, reduced rainfall, and increased evaporation. Once the water is absent from the soil anaerobic conditions turn to aerobic conditions eliminating the presence of hydritic soils. Once the changes in hydrology and soil have occurred the vegetation will begin a succession from wetland vegetation to dryland vegetation, the rate of which is determined by their minimum water requirement and competition with more adapted dryland species. It is worth noting that there have been no studies on vegetation changes over time in wetlands becoming drylands and as a result there is no expected time scale at which the vegetation changes will occur.

4.5.2. Patn Analysis

Statistical pattern analysis (PATN) was used to analyse similarities between each of the community types within the subject area. Bray and Cutis similarity index and nearest neighbour analysis show a distinct dissimilarity between the CCW and REW areas and *Banksia* / *Eucalyptus* areas (Figure 14). However there is still a clear distinction between the REW and the CCW areas. Due to the fact that the REW represents a functioning wetland the dissimilarity between it and the said wetland supports the evidence previously highlighted that the CCW wetland was once a wetland however due to a reduction in water table level is now functioning as a dryland.

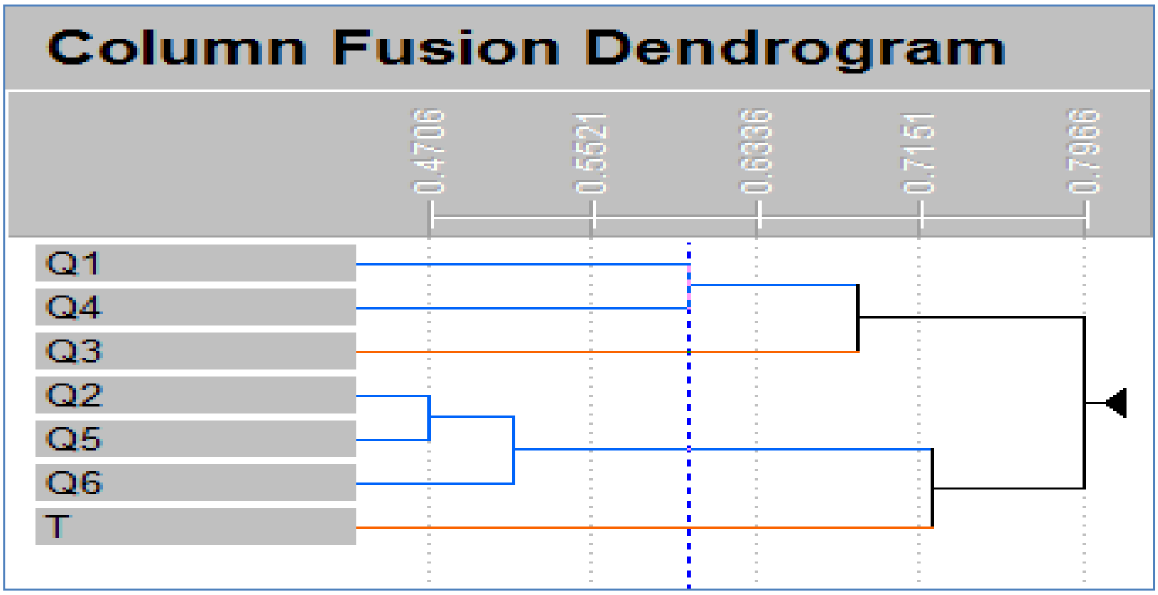


Figure 14: Bray and Curtis nearest neighbour pattern analysis dendrogram

4.5.3. Vegetation Condition

The site appears to be in very good condition with weed incursions largely restricted to the southern end of the property and along the edges of tracks and boundaries. There has also been some disturbance associated with clearing timber (jarrah), the dumping of rubbish and vehicles. According to the Bush Forever condition rating the site is generally very good to pristine with some southern areas in average to poor condition. Fires do not appear to be very regular.

Within the demarked CCW area *M. preissiana* are sparse and older trees appear to be in decline. Little or no regeneration of the species appears to have occurred in the last 20 years. There is evidence of recruitment of *A. fraseriana* and *C. calophylla* encroaching on the area and this suggests there has been a period of prolonged reduction in water table levels.

In 2006, high resolution digital photos were taken facing north, south, east and west from each of the 5 piezometers installed through the CCW area. In 2011, a further set was taken from the same positions (Appended as a CD). These attest to the general decline of wetland species and increasing dominance and general health of upland species.

5. FINDINGS

5.1. Geomorphic Classification

Under the current state legislation the three wetland management categories are:

- Conservation Category Wetlands (CCW) – Wetlands supporting a high level of ecological attributes and functions
- Resource Enhancement Wetlands (REW) – Wetlands which may have been partially modified but still support substantial ecological attributes and functions
- Multiple Use Wetland (MUW) – Wetlands with few important ecological attributes and functions remaining

The subject area is within the Bassendean Soil Complex according to the Western Australian Geological Survey (Gozzard, 1986a & Gozzard, 1986b). Under the Geomorphic Dataset (Hill et al, 1996) the area is classified as a dampland. Under the current classification system, this would suggest the soil experiences intermittent waterlogging either due to the existence of "perched" watertable or the lifting of the watertable to the soil surface.

Soil analysis data from the site is consistent with that of the Bassendean complex. There is little evidence of a confining ferruginous hardpan that would otherwise be expected in the event of a perched watertable (Davidson, 1995). There is no presence of wetland morphological indicators or evidence of hydritic conditions, suggesting that the CCW classification was based purely on vegetation features rather than the soil becoming waterlogged due to watertable rise.

The data collected from monitoring bores on site, and its relatedness to surrounding deep monitoring bores indicates this area is not a wetland due to the fact that that the watertable rose to a maximum of 1519mm below the surface (which occurred during a greater than average rainfall year). Historical data from the closest monitoring bores show that in the wettest years of the 30 year record, the highest groundwater levels recorded are only 300mm above the average maximum which signifies that even in a very heavy rainfall year the groundwater would not rise to greater than 1219mm below the surface.

It is noteworthy that Tiner (1999) states that for an area to be considered a wetland the water table must rise to at least a foot (300mm) from the surface for a minimum of 2 weeks, at least every second year. Groundwater was monitored over a period of six years during which the watertable remained over 1200mm from the level at which is considered to be a wetland.

Accordingly, by the definitions contained in Hill et al (1996) and Tiner (1999), the CCW to the north of the property is not a wetland, therefore classification is not necessary. There are other areas within the site similarly classified as damplands although these have been deemed Resource Enhancement Wetlands (REW) on the western boundary presumably due to the current state of nearby development. These areas are more clearly wetlands as a) water occurs near the surface, b) the soil contains a deeper peaty layer and c) the wetland vegetation, particularly *M. preissiana*, *Pericalymma ellipticum* and *Kunzea sp.* are healthy and regenerating whereas there are no upland species present.

5.2. Purpose and Limitations of Bulletin 686

Bulletin 686 was designed specifically for the Swan Coastal Plain region. It was written *"for a wide range of people including community groups, state and local governments and private landowners"*. It is *"especially useful to developers to assist in their planning and to identify issues that they will have to address to obtain statutory approvals"*.

Bulletin 686 elucidates the reasons why preservation of wetlands is desirable because of their functions and values.

Wetland functions include;

a) Ecological functions:

- Food webs including plants, animals and micro-organisms
- Drought refuges for waterbirds
- Provision of feeding areas for migrating waterbirds
- Habitats for communities considered to be rare or of restricted occurrence
- Limited capacity to assimilate nutrients and pollutants

- An index of environmental quality

b) Hydrological functions

- Compensation basins with a flood control function
- Nutrient, sedimentation and pollution assimilation

c) Social functions

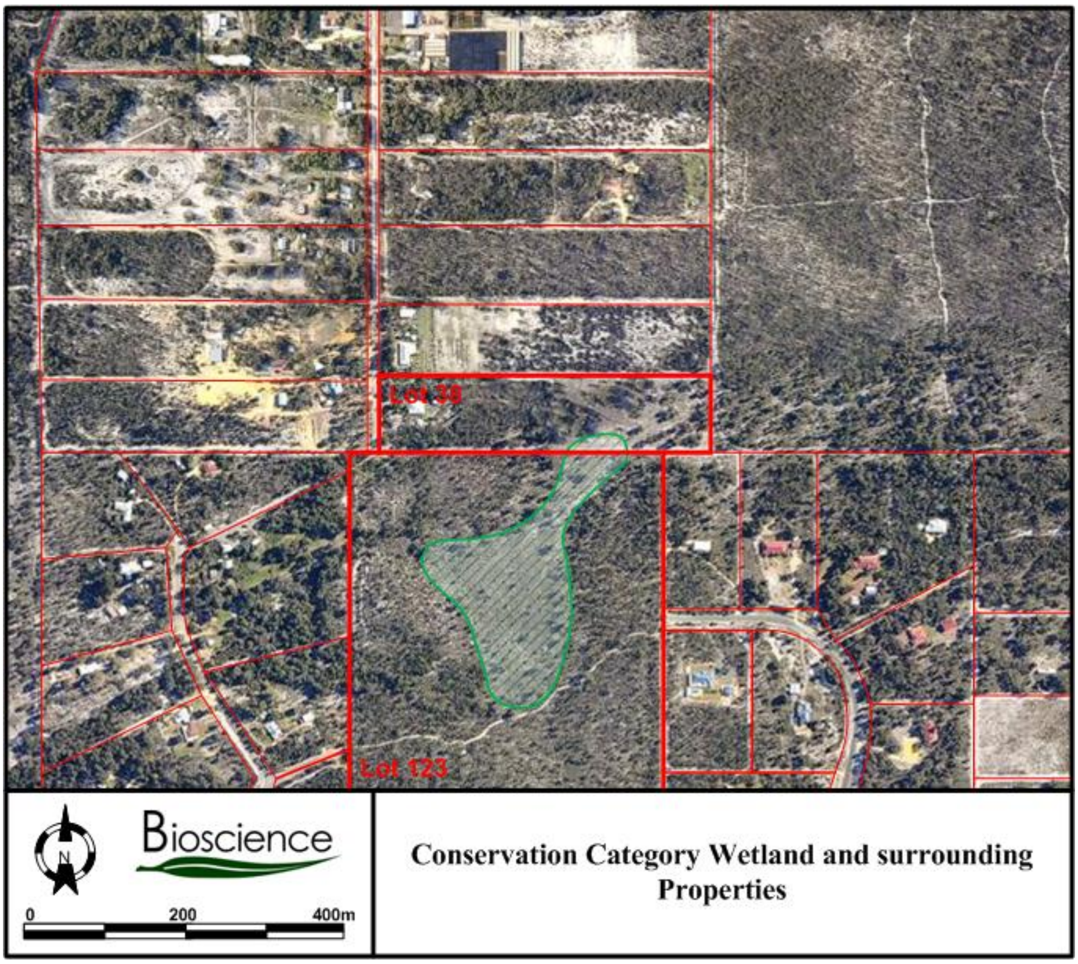
- Historical/archaeological
- Recreation
- Nature study
- Education
- Access to wildlife
- Aesthetic considerations

Wetland values are discussed in Section 3 of Bulletin 686 where it is stated they are important to wildlife as “natural” ecosystems and they are important to people for various human use purposes. The Bulletin is intended to systematically assess wetlands using specific questions and score the totality of answers to distinguish management categories.

5.3. Results of Bulletin 686

Lot 38 Landgren Road, Wellard is one of five privately owned, adjacent properties being considered by the Department of Employment and Training as the potential site of a high school. Development of the site may be affected by the classification of a Conservation Category wetland at the rear of the property.

The site lies adjacent to Lot 123 Mortimer Road, a 45ha bushland remnant also being considered for residential development (Figure 15). A fence, fire break and informal vehicle trail separates the two properties. The wetland has been mapped as overlapping both properties with the vast majority within the Mortimer Road property. The portion of mapped area overlapping the Landgren property consists solely of non-native grasses.



Conservation Category Wetland and surrounding Properties

Figure 15: CCW and surrounding properties

The current owner of the Landgren Road property has advised the eastern half of the property including the said wetland was once cleared for market gardening although it has not been used for this purpose for about 10 years. Native regrowth has largely been limited to areas of lower elevation consisting mostly of *Pericalymma ellipticum*, *Astartea sp.* and sedges (a formal floral assessment has not been undertaken). Sparse *Banksia-Eucalypt* woodland surrounds the wetland with dense populations of non-native grasses (esp. *Ehrharta calycina*) throughout. The western half of the property is characterised by *Banksia-Eucalypt* woodland, part of which has been cleared to accommodate the building envelope.

Local residents suggest that the wetland as a whole has not experienced inundation for at least 10 years. There is some suggestion that this is a result of changes in local drainage to accommodate residential development. A better understanding of this will be obtained in the proposed drainage plan required by the Draft Jandakot Structure Plan.

Results of the Bulletin 686 reveal a conservative score of 11 was recorded for natural attributes. Likewise for human-use, despite being relatively secluded, the wetland has few redeeming features and scored only 7. The area has no value in terms of passive or active recreation (Appendix 3).

Under the Bulletin 686 assessment the combination of these attributes alone would classify the wetland as Multiple Use. This is further strengthened by the fact that past land use and level of disturbance suggest there are no rare and endangered species on the site, there is no significant effect on real estate values and there are no heritage values – there is an Aboriginal Heritage site registered for the south end of the Mortimer Road site, but this has no effect on the wetland in question.

6. DEVELOPMENT POTENTIAL

The Mortimer Road site is currently zoned for Special Rural Development under the Kwinana Town Planning Scheme No. 2 (1992). Under this zoning there is a requirement to limit block sizes to 2-4 hectares with a building envelope of 2000m^2.

Under the Jandakot Structure Plan the land earmarked as future Urban, anticipating housing development for the area surrounding the CCW. Based on present development standards that may mean housing at a rate of about 12 dwellings per hectare for residential land.

Preservation of the CCW would likely require a default allowance of approximately 200m to buffer it from any development. The basis for such a distance is detailed in the t draft publication from WAPC *Guidelines for the Determination of Wetland Buffer Distances* (2005). However, most importantly this guideline unequivocally states the importance of agreeing that wetlands exist as a first step in determining buffer distances.

> "*Acknowledgment of the existence of a wetland is the first step in the determination of a wetland buffer. This step does not require any specific definition of the wetland area. The outcome is agreement that a wetland of some form exists at a particular location.*" (*ibid*, p.7)

The presence of CCWs would have a major impact on development plans. For example housing envelopes or access driveways cannot be placed within the wetlands or buffer zones.

It is noteworthy that the landowner has preserved the bushland on Lot 123 intact for over 50 years with the intention of eventually developing it in a way which maximises the preservation of native vegetation.

7. CONCLUSIONS

The current wetland definitions are clear on wetlands being areas where the soil it wet. The classification system for wetland management categories is inadequate and has been subject to revision for over a decade without any final version being made public. In this site, the primary criterion for defining a dampland (i.e. the soil undergoes intermittent waterlogging) is not satisfied. There is no evidence of hydritic soils being present. Although the area does support a number of key plant species common to low-lying areas and/or wetlands, most are in poor condition and in decline with encroaching and healthy dryland vegetation.

Despite vegetation not being a defining feature under Hill et al (1996) classification, it is our experience that this becomes the defining characteristic that determines the preservation (or otherwise) of land considered wetland, in the absence of clear hydrological and soil data. We have collected and presented such data here. According to the definitions provided by Hill and by Tiner, the data clearly and unequivocally means the area is not a wetland. Because it is not a wetland, Bulletin 686 is not an appropriate mechanism for classifying the areas conservation value; however a Bulletin 686 was conducted for Lot 38 Landgren Road and scored very low making at best a classification of Multiple Use.

The original response received from the DoE (2006) outlines three distinct wetland identifying categories;

“Hill et al (1996) recognises that wetlands are identified by the presence of three wetland indicators: the presence of water/waterlogging, vegetation typical of wet conditions and sediment or hydritic soils”

The Mortimer road wetland has no presence of water/waterlogging, some flora typical of wet conditions (although it also contains obligate upland species), and no sediment or hydritic soils. So by this definition the CCW UFI 6679 does not satisfy the requirements of a wetland.

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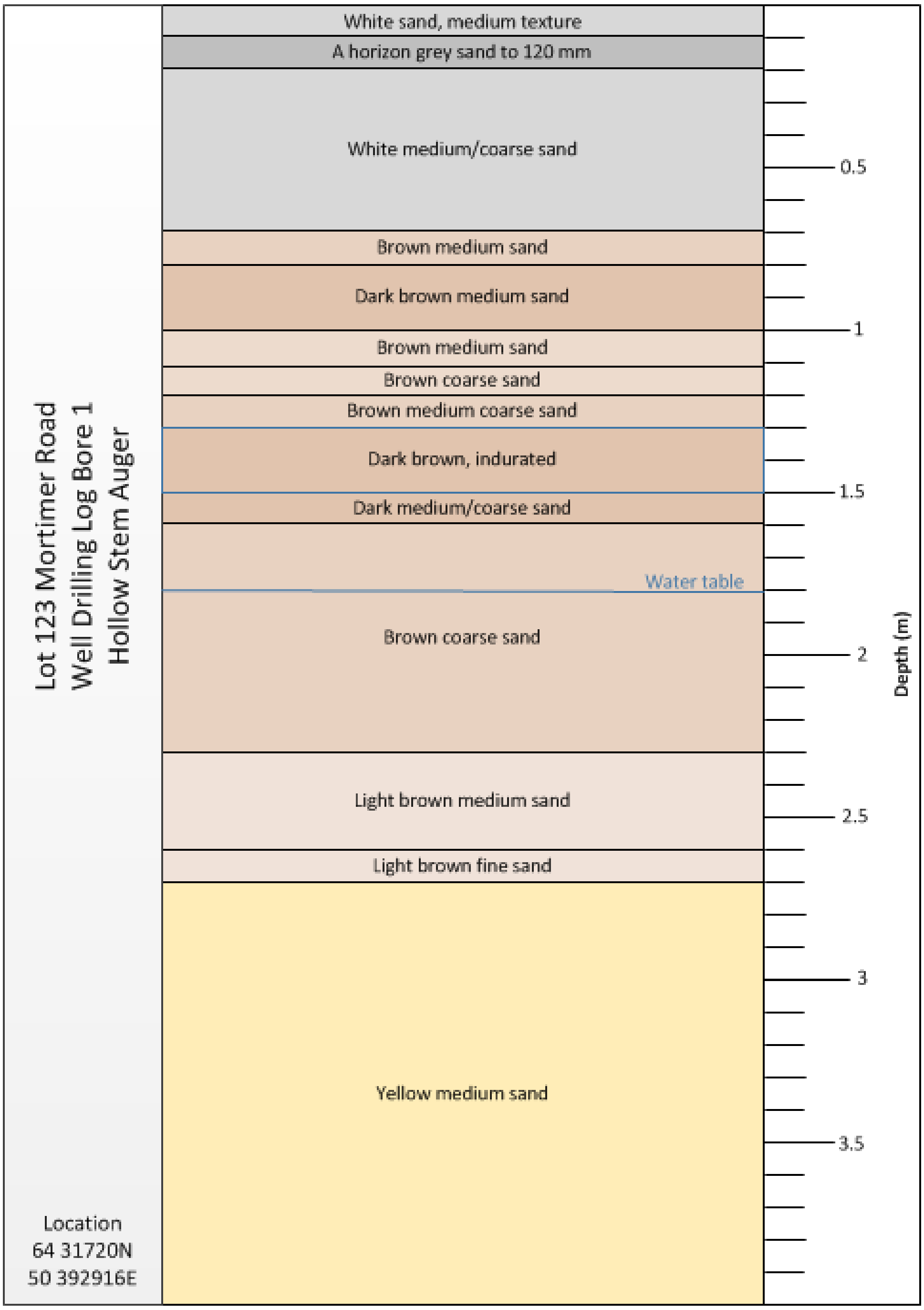
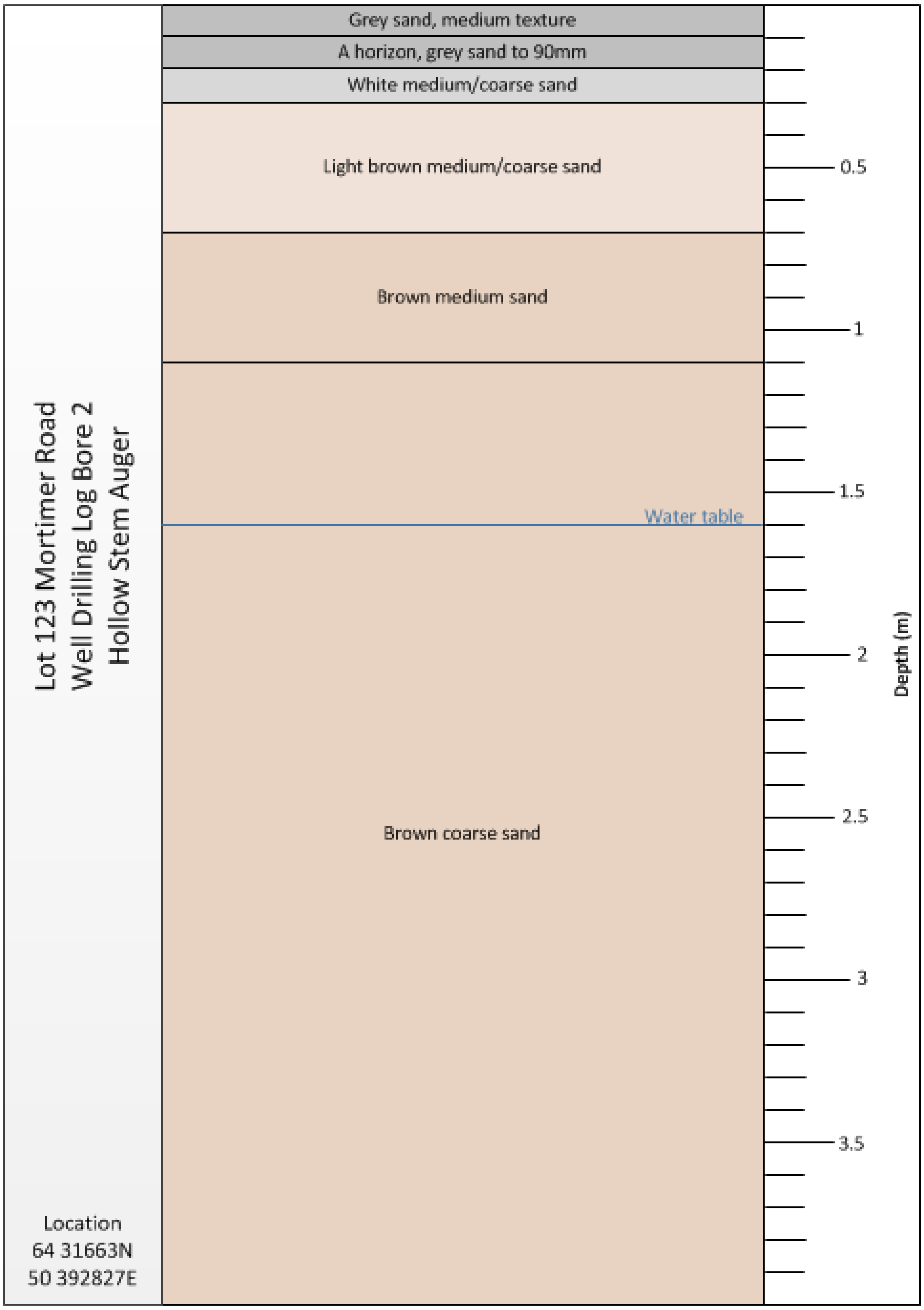
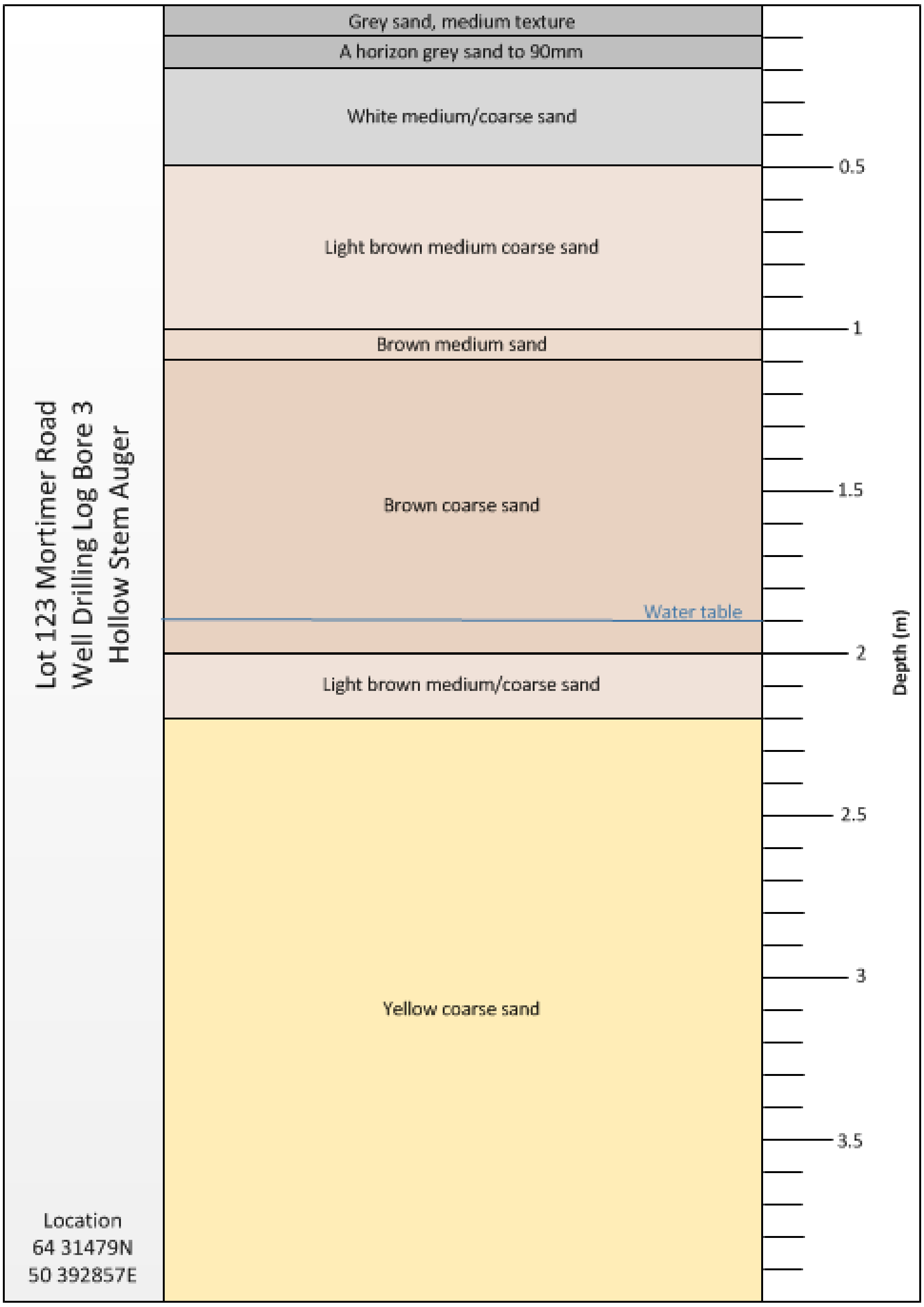
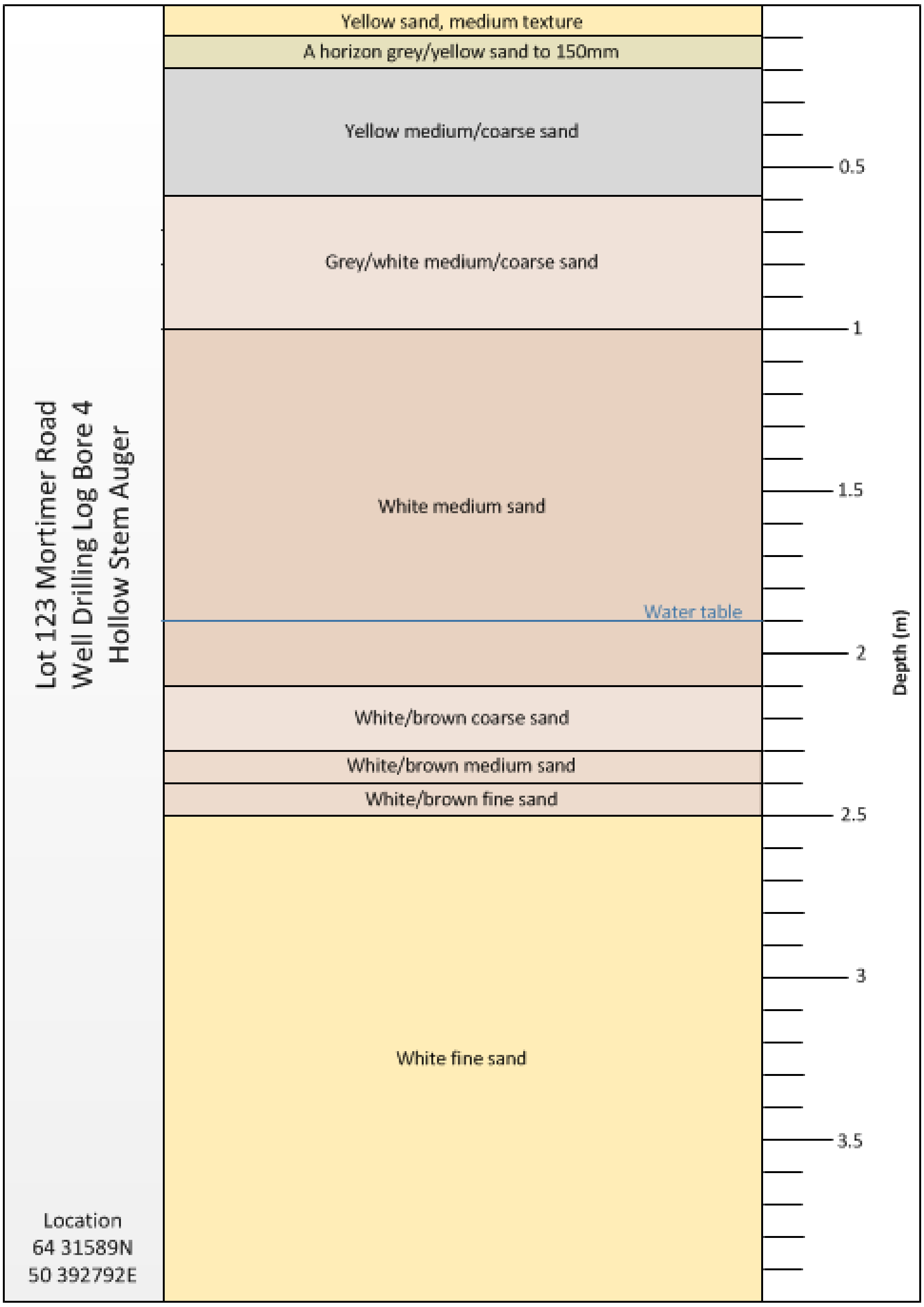
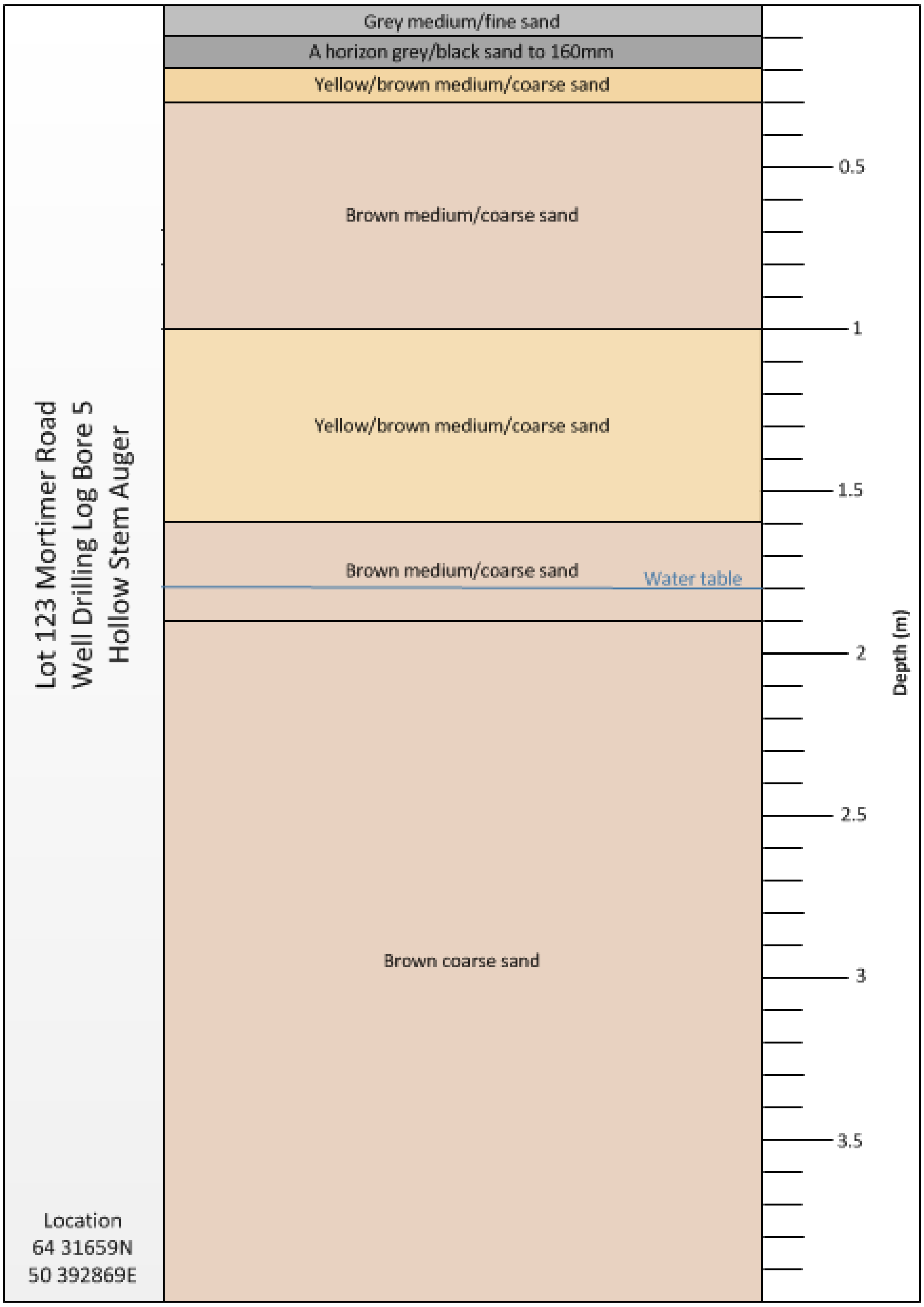
APPENDIX 1: Soil Profiles




Lot 123 Mortimer Road
Well Drilling Log Bore 2
Hollow Stem Auger
Location
64 31663N
50 392827E
Grey sand, medium texture
A horizon, grey sand to 90mm
White medium/coarse sand
Light brown medium/coarse sand
Brown medium sand
Water table
Brown coarse sand
0.5
1
1.5
2
2.5
3
3.5
Depth (m)


Lot 123 Mortimer Road
Well Drilling Log Bore 3
Hollow Stem Auger
Location
64 31479N
50 392857E
Grey sand, medium texture
A horizon grey sand to 90mm
White medium/coarse sand
Light brown medium coarse sand
Brown medium sand
Brown coarse sand
Water table
Light brown medium/coarse sand
Yellow coarse sand
0.5
1
1.5
2
2.5
3
3.5
Depth (m)


Lot 123 Mortimer Road
Well Drilling Log Bore 4
Hollow Stem Auger
Location
64 31589N
50 392792E
Yellow sand, medium texture
A horizon grey/yellow sand to 150mm
Yellow medium/coarse sand
Grey/white medium/coarse sand
White medium sand
Water table
White/brown coarse sand
White/brown medium sand
White/brown fine sand
White fine sand
0.5
1
1.5
2
2.5
3
3.5
Depth (m)


Lot 123 Mortimer Road
Well Drilling Log Bore 5
Hollow Stem Auger
Location
64 31659N
50 392869E
Grey medium/fine sand
A horizon grey/black sand to 160mm
Yellow/brown medium/coarse sand
Brown medium/coarse sand
Yellow/brown medium/coarse sand
Brown medium/coarse sand
Water table
Brown coarse sand
0.5
1
1.5
2
2.5
3
3.5
Depth (m)

APPENDIX 2: Guidance 51 Survey Results

Species	Site						
	Q1	Q2	Q3	Q4	Q5	Q6	T1
Chamaescilla corymbosa var. corymbosa		+		+	+		
Laxmannia squarrosa		OQ				+	
Sowerbaea laxiflora		+				+	
Thysanotus patersonii		OQ					
Thysanotus sparteus				OQ			
Trachymene pilosa	+	+		+			
Hypochaeris glabra**						+	
Lagenophora huegelii						+	
Podolepis gracilis		+			+	2%	
Podotheca chrysantha						+	
Rhodanthe floribunda	OQ			+			
Ursinia anthemoides		+				+	
Allocasuarina fraseriana			5%				
Allocasuarina humilis						OQ	
Burchardia congesta		+			+	+	
Crassula colorata var. colorata	OQ						
Lepidosperma squamatum					+		
Mesomelaena pseudostygia		5%				+	
Mesomelaena tetragona				OQ			
Schoenus curvifolius				OQ			
Calectasia narragara						OQ	
Dasypogon bromeliifolius	+		+	+	+		
Lomandra hermaphrodita		+					
Lomandra sericea					+		
Hibbertia hypericoides		5%				1%	
Hibbertia racemosa		5%	OQ		+	+	
Hibbertia vaginata	+			+			
Drosera erythrorhiza subsp. erythrorhiza		+			+	+	
Drosera menziesii subsp. penicillaris		+			+		
Drosera porrecta		+				2%	
Conostephium pendulum		1%				10%	
Leucopogon australis			1%				
Leucopogon conostephioides			+		5%	40%	
Lysinema ciliatum				OQ		OQ	
Monotaxis occidentalis			+				
Dampiera linearis			+		+	+	+
Goodenia pulchella subsp. Coastal Plain A (M. Hislop 634)				OQ			
Lechenaultia floribunda			OQ				
Anigozanthos humilis subsp. humilis						OQ	
Conostylis aculeata subsp. aculeata		1%			2%	+	+
Conostylis juncea				+			
Conostylis setigera subsp. setigera						OQ	
Phlebocarya ciliata	4%	+	+	35%			
Patersonia occidentalis var. occidentalis				OQ	+		
Hemiandra pungens					+	OQ	
Cassytha sp.			1%				
Lobelia tenuior						OQ	
Phyllangium paradoxum	+						
Acacia applanata		+			+		
Acacia huegelii					+	OQ	
Acacia insolita subsp. insolita			+				
Astartea affinis			+				
Astartea sp. Gingalup (N. Gibson & M. Lyons 119)	30%		+				
Calytrix angulata		+				+	
Calytrix flavescens						+	
Calytrix fraseri				OQ			
Corymbia calophylla			+	4%			
Eremaea asterocarpa subsp. asterocarpa		1%				OQ	
Eremaea pauciflora			OQ				
Eucalyptus marginata						30%	
Hypocalymma angustifolium	15%		8%	+			
Hypocalymma robustum					+		

Kunzea glabrescens							+
Melaleuca preissiana	1%						
Melaleuca rhaphiophylla			20%				
Pericalymma ellipticum var. floridum	25%			35%			
Scholtzia involucrata				+			
Caladenia discoidea				+			
Caladenia flava						+	
Caladenia flava subsp. flava		+		+			
Diuris magnifica						+	
Elythranthera brunonis		+					
Pterostylis sanguinea				+			
Pyrorchis nigricans		+			+		
Thelymitra sp.			OQ				
Aotus gracillima			1%				
Bossiaea eriocarpa		1%			5%	+	+
Daviesia incrassata subsp. incrassata						OQ	+
Euchilopsis linearis	30%			3%			
Gompholobium tomentosum				+	+		
Hovea trisperma var. trisperma						OQ	
Isotropis cuneifolia subsp. cuneifolia						+	
Jacksonia furcellata				+			
Jacksonia sericea				+			
Jacksonia sternbergiana						OQ	
Amphipogon turbinatus		40%		OQ			
Ehrharta calycina**						+	
Thyridolepis multiculmis				+			
Adenanthos obovatus					OQ		+
Banksia attenuata		15%	+		25%	2%	
Banksia ilicifolia					5%		+
Banksia menziesii		20%			5%	10%	
Conospermum capitatum subsp. glabratum				2%			
Persoonia saccata						3%	
Petrophile linearis		1%			+	+	
Stirlingia latifolia					1%		
Synaphea spinulosa subsp. spinulosa						OQ	
Desmocladus flexuosus		+			5%	+	
Dielsia stenostachya			40%				
Hypolaena exsulca	+		5%	+			+
Lyginia imberbis	+	+		OQ	+		
Boronia crenulata subsp. viminea					1%		
Philotheca spicata			OQ		+		+
Leptomeria pauciflora	5%						
Stylidium aff. androsaceum				+			
Stylidium guttatum				+			
Stylidium piliferum	OQ	OQ			+		
Stylidium repens	+	+		+	+		
Stylidium scariosum			+				
Stylidium schoenoides		+			+		
Pimelea rosea subsp. rosea						OQ	
Xanthorrhoea preissii	1%		5%	4%			
Macrozamia riedlei					2%		

** Weed Species
OQ Outside Quadrat
+ Only 1 individual present

APPENDIX 3: Bulletin 686

Bulletin 686 Assessment for Lot 38 Landgren Road, Wellard.

Part I - presence of rare species

Is the wetland a habitat for Gazetted rare species of flora or fauna?

Answer: No

Part IIB: Seasonal and episodic wetlands with poorly defined boundaries

Introduction - "zoning" the wetlands

As described in Section 2.4, these "extensive" wetlands cannot be treated as single units. Zone the wetland as described in Section 4.2, Step 6. Each section should be the subject of a separate assessment using the following questionnaire. Where the word "wetland" is used it should be interpreted to mean "wetland section".

i Environmental geology classification

Does the wetland occur on the Quindalup Dunes or on a geological unit confined to a river/estuary floodplain?

Answer: No. The property is Bassendean sand at approximately 20m AHD.

Score[1]

ii Adjacent wetlands

Are there wetlands within a 2km radius?

Answer: Yes. The property lies adjacent to Lot 123 Mortimer Road which contains the vast majority of the wetland proper with a better representation of the endemic flora.

Score[0]

iii Habitat diversity

Is the composition and structure of the vegetation significantly different to that found at nearby wetlands?

Answer: No. The adjacent property contains a better representation of the endemic flora and has suffered less disturbance.

Score[1]

iv Habitat type

Using the list below score one for each habitat type represented (maximum score 10).

a) Vegetation over 0.1 hectare (1000m ^{2}) in area.

- large paperbarks (>2.5m tall) in dense clumps [-]
- low thickets (ie <2.5m tall). These are often *Melaleuca*, *Astartea* or *Kunzea* spp [-]
- paperbark fringe [-]
- fringing rushes and sedges (often *Baumea*, *Juncea* spp) [-]
- fringing *Typha* (bulrush) [-]
- samphire or salt marsh [-]
- extensive inlake beds of *Typha* or other rushes [-]
- scattered dense clumps of rushes or sedges [-]

b) Other habitats

- flooded grassland in winter/spring [-]
- mud flats or seasonally dry open water [-]
- islands — natural or human made [-]
- fringing woodland or heath (eg eucalyptus nodes or non-wetland species) [1]
- permanent shallow open water < 50cm deep [-]
- permanent deep open water > 50cm deep [-]

Score $1/2$ point for

- scattered paperbarks [1]
- scattered rushes [1]

Score[3]

Notes: The wetland has been previously cleared. Regrowth of native vegetation has occurred at lower elevation mainly consisting of *Pericalymma ellipticum* and sedges, with only occasional *Melaleuca preissii*, *Allocasuaina fraseriana* and *Corymbia calophylla*. The boundary is densely populated with non-native grass species (*Ehrharta calycina* etc.).

v Drainage

Are there drains directing water into or out of the wetland?

Answer: No

Score[5]

vi Area of wetland modified

What proportion of the wetland has been modified by clearing of vegetation (including undergrowth) landfill, paving, cultivated gardens/playing fields, irrigated agriculture, grazing, weed invasion, mining etc?

Answer: Current owner advised land was cleared for market gardening, but has not been used for this purpose for approximately 10 years. Only lowest elevations have experienced native regrowth.

Score[1]

vii wetland size

Section of wetland on Lot <10ha.

Score[1]

TOTAL SCORE [11]

Part III - Human-use questionnaire

i Aesthetics

Does the wetland possess any of the following attributes? (score appropriately and add score at the end)

Little, if any, artificial noise	Score	2	[2]
Understorey mostly intact	Score	2	[-]
Few, or no, roads or buildings obvious from wetland	Score	2	[2]
Steep ridge visible as part of the scenery	Score	1	[-]
Ridge accessible giving view of wetland	Score	1	[-]
Wetland is a lake and open water easy to view	Score	1	[-]
A section of wetland exists where few people visit	Score	1	[1]

Score[5]

ii Historical and archaeological features

Does the wetland have any of the following historical or archaeological features?

- registered Aboriginal relics or sacred sites[3] .
- pioneer relics/operations
- National Estate/Trust listings

Note: An Aboriginal site is registered on Mortimer Road to the south but does not affect this property.

Score[0]

iii Security of wetland

What is the current vesting of the land containing the wetland? Score according to the following table.

Answer: Privately owned

Score[1]

iv Protection groups

Does the wetland have active community protection groups?

One or more	Score	5
No groups	Score	0

Score[0]

v Passive recreation

Is the wetland used for any of the following passive recreation activities?

If yes, score 1 for each

- nature study/bird watching [-]
- education (school or other educational interest within 500m) [-]
- picnic and /or barbecue facilities [-]
- conservation of flora (refer to maps) [-]
- conservation of fauna (refer to maps) [-]
- protection and preservation of other attributes [-]
- recognised research site

— biological

— archaeological

— other [-]

• recognised tourist venue [-]

Score[0]

Note: Previous disturbance events have resulted in reduced biodiversity and degraded vegetation. Non-native species are prevalent.

vi Active recreation

Is the wetland used for any of the following active recreational activities? If yes, score 1 for each.

- walking/jogging or cycling [-]
- horse riding [-]
- trail bike riding [-]
- playground [-]
- sports grounds [-]
- model boats [-]
- golf course [-]
- canoeing/rowing [-]
- power boating/skiing [-]
- swimming [-]

Score[0]

vii Other human-uses

Is the wetland used for any of the following purposes? (Score 1 for each)

- agricultural activities (grazing, horticulture etc) [-]
- mining (check for mining leases) [-]
- existing/proposed service corridors (SECWA, roads, etc) [-]
- water supply [-]
- proposed urban/housing use [1]
- private purposes other than described above [-]

Score[1]

Note: The wetland is situated at the rear of a property currently classified as 'special rural'.

TOTAL SCORE [7]

Part IV - Supplementary questions

i Species rarity

Are rare (and not gazetted) species of animals or plants present or are there communities represented which have a limited distribution?

Answer: No

ii Effect on land values

Does the wetland significantly enhance real estate values and land rates around it? ie, does the wetland add more than 10% to the value of nearby houses?

Answer: No. In its current state the wetland has low biodiversity and significant weed infestation.

iii Human use

Do more than 100 people visit the wetland each week?

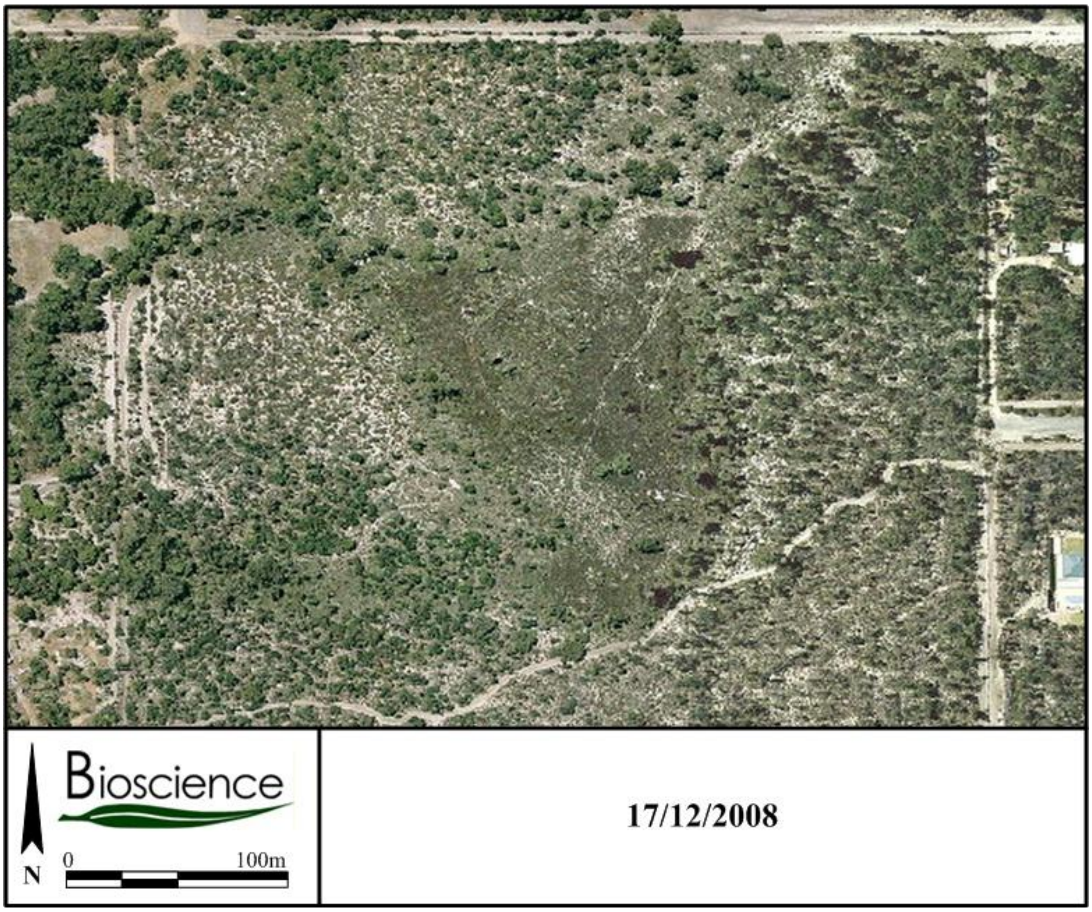
Answer: No

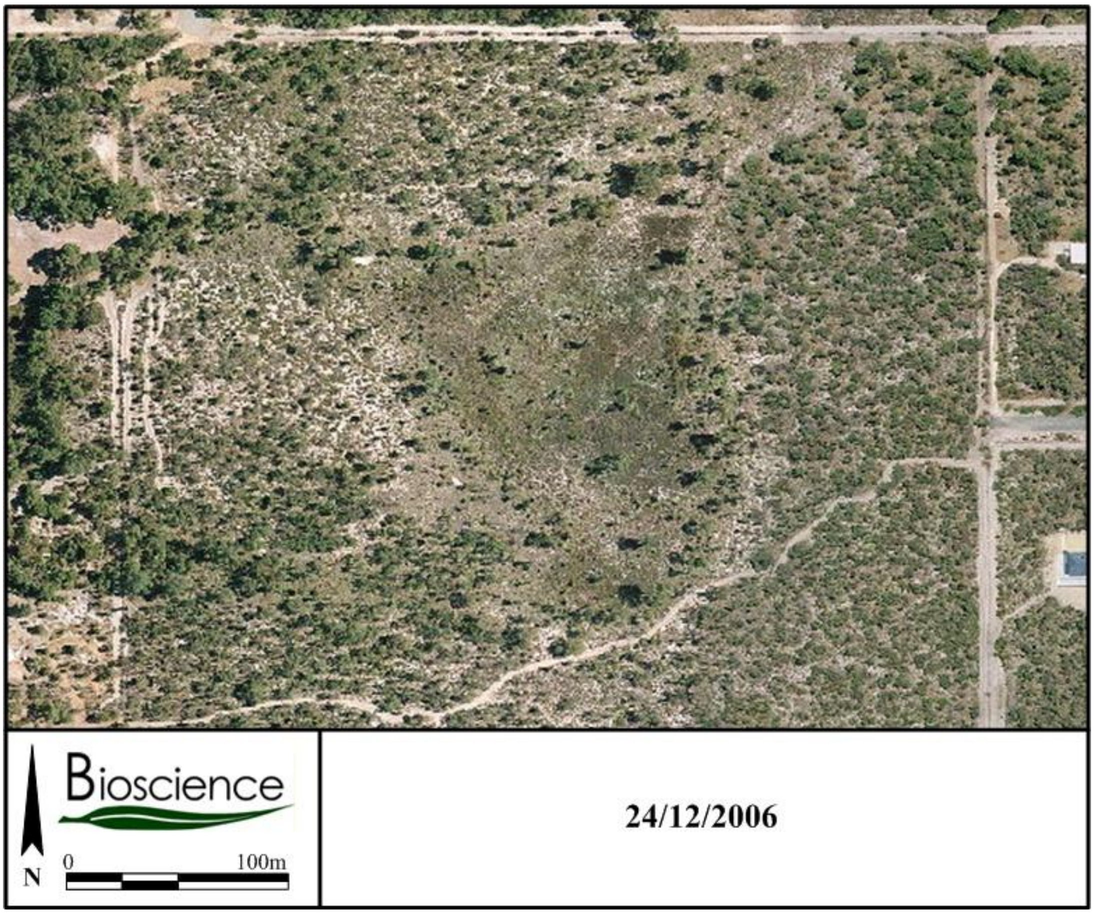
iv) private human-use value

Where there is evidence of private use of the wetland (stock grazing, views of wetland from house or private recreation) ask owner how important the wetland is as a private resource. Does the owner rate it highly?

Answer: No

APPENDIX 4: Historical aerial photographs

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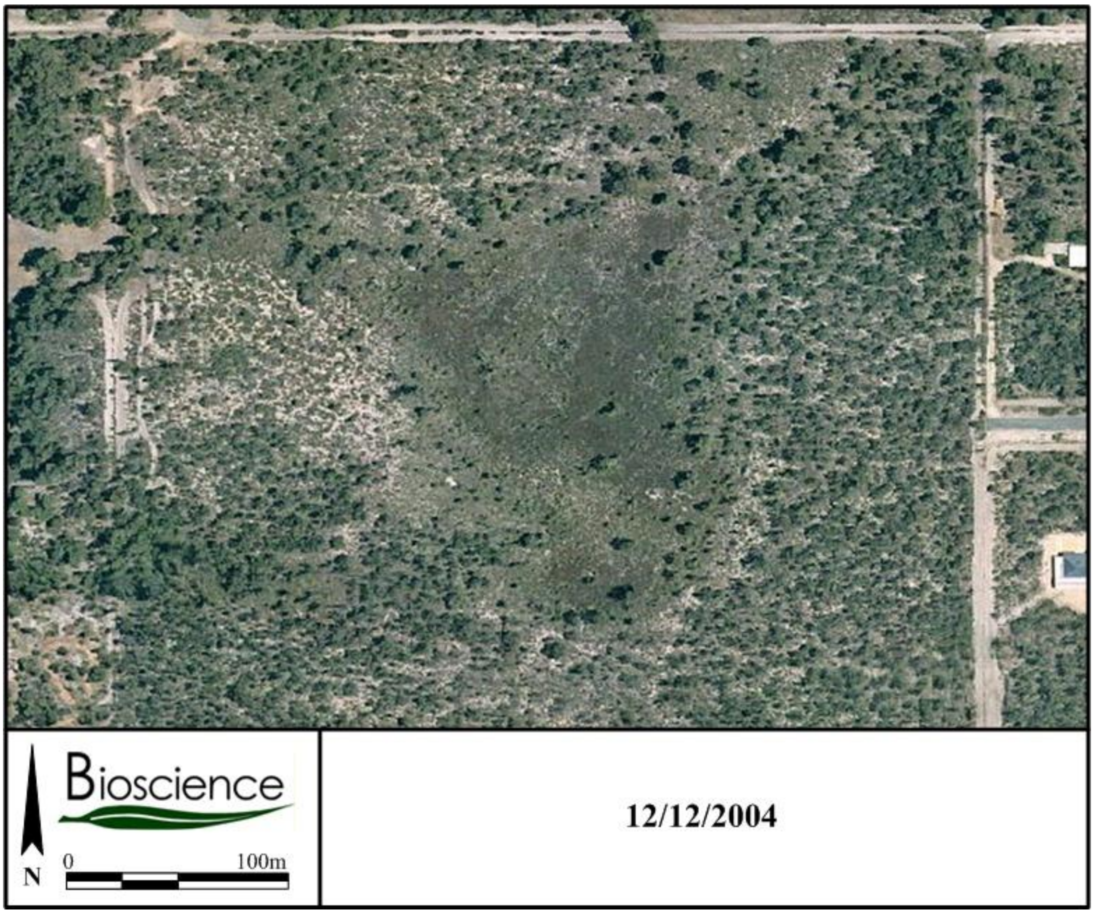
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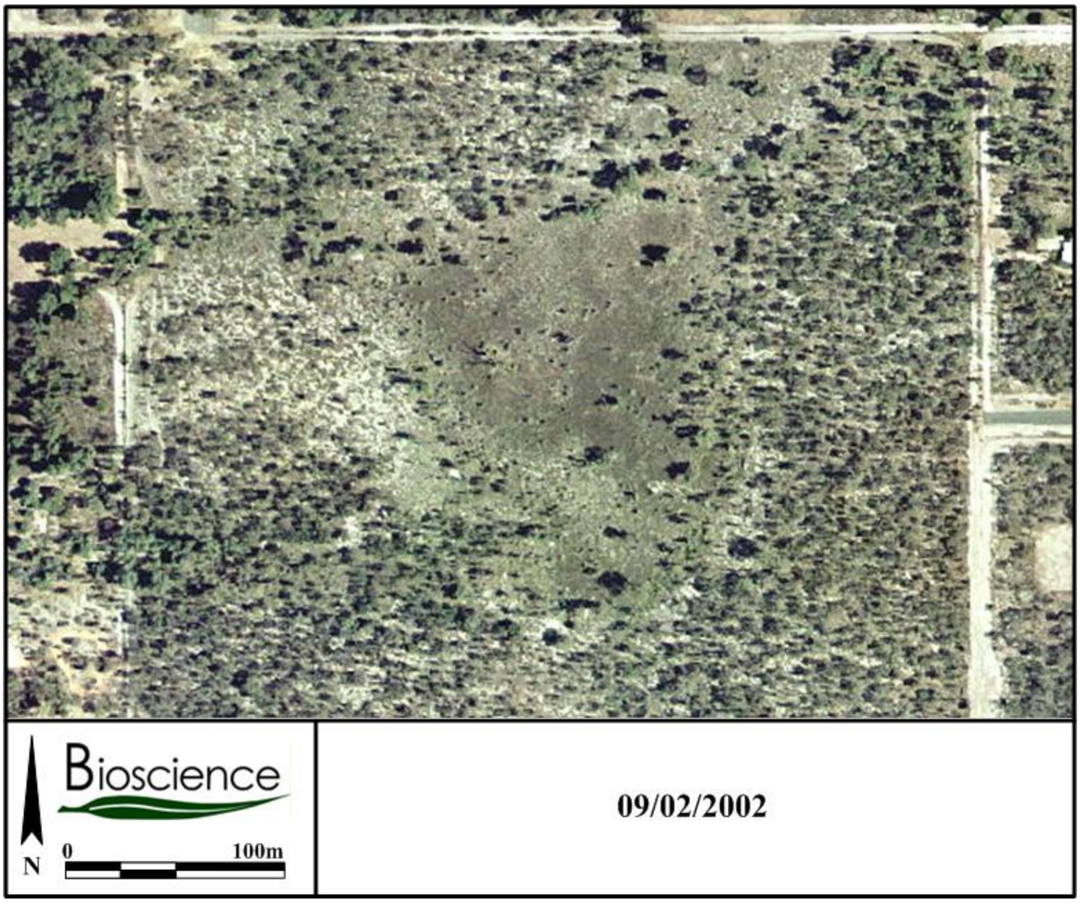
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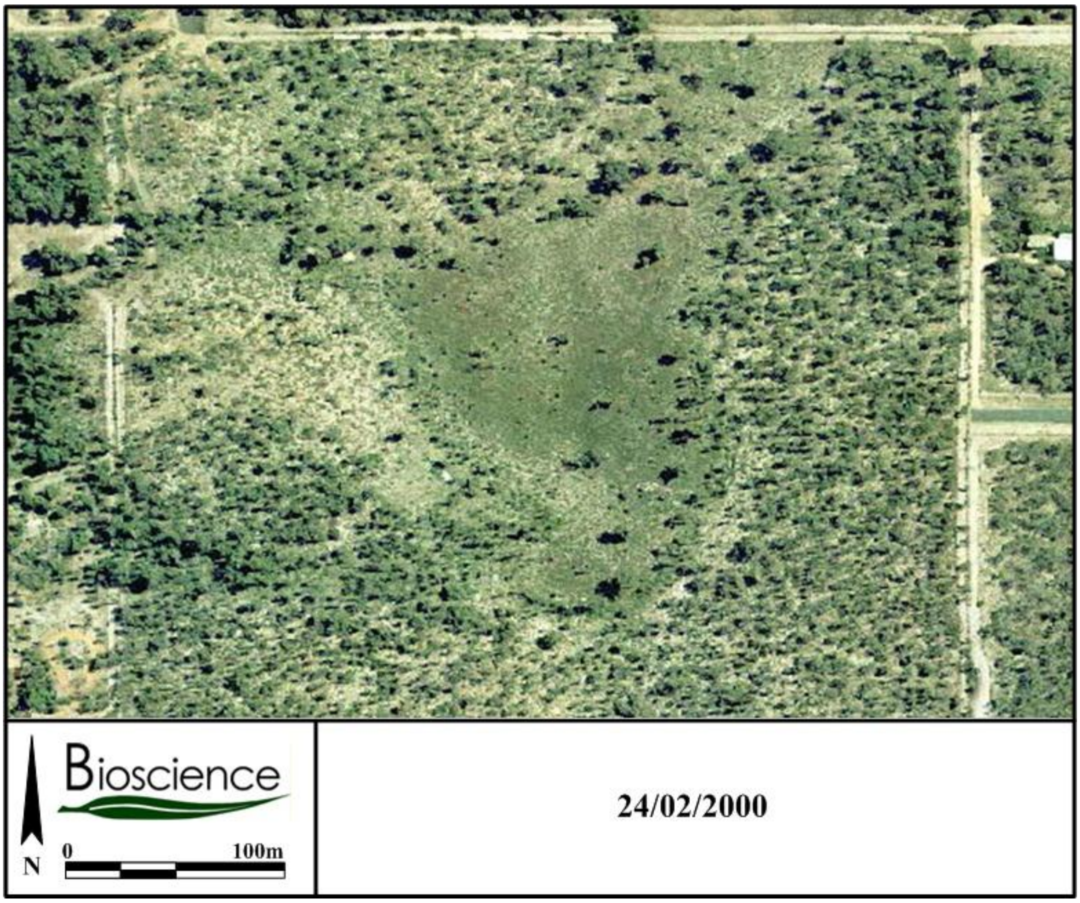
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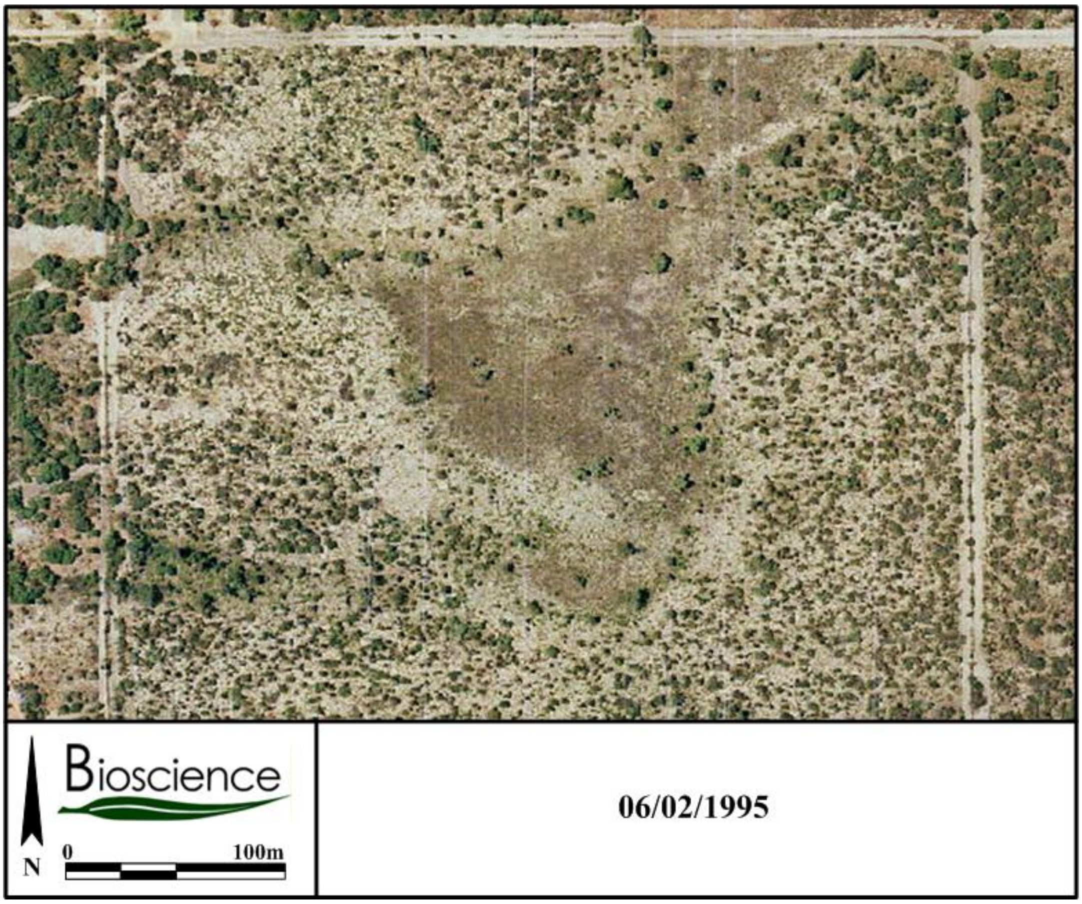

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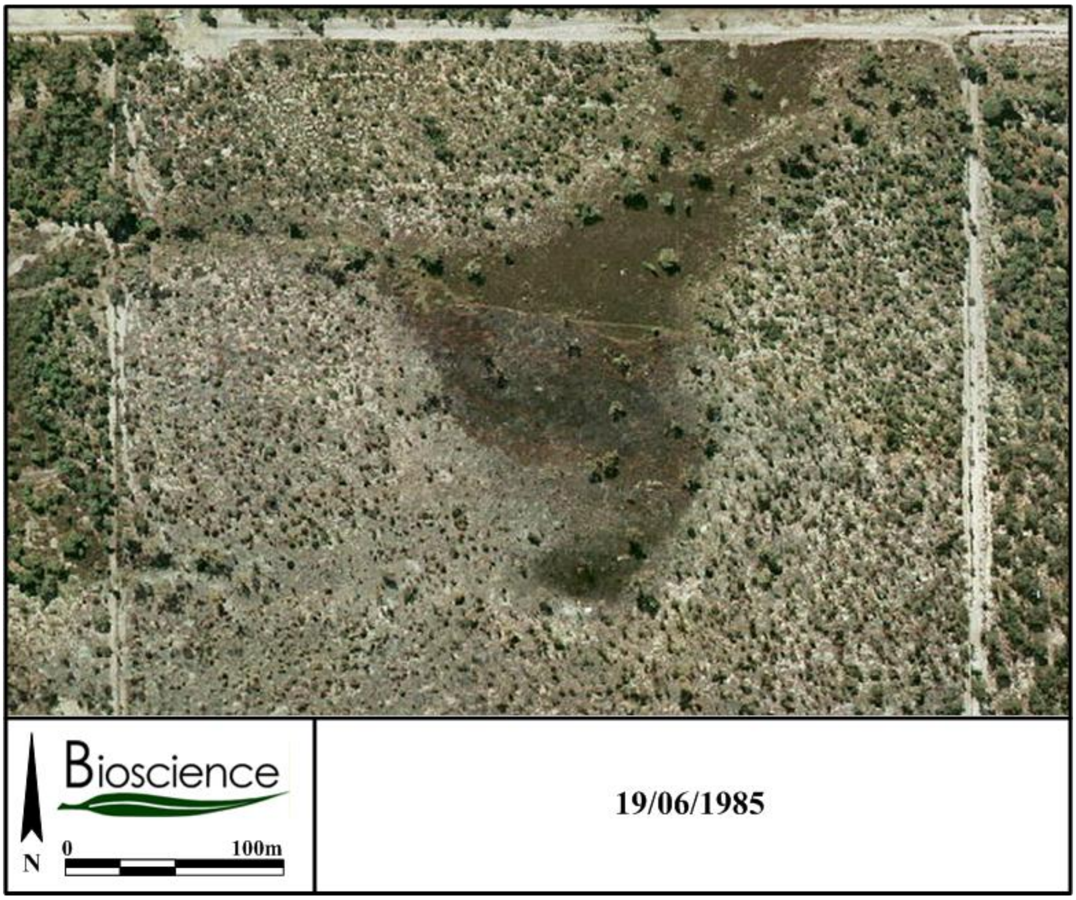
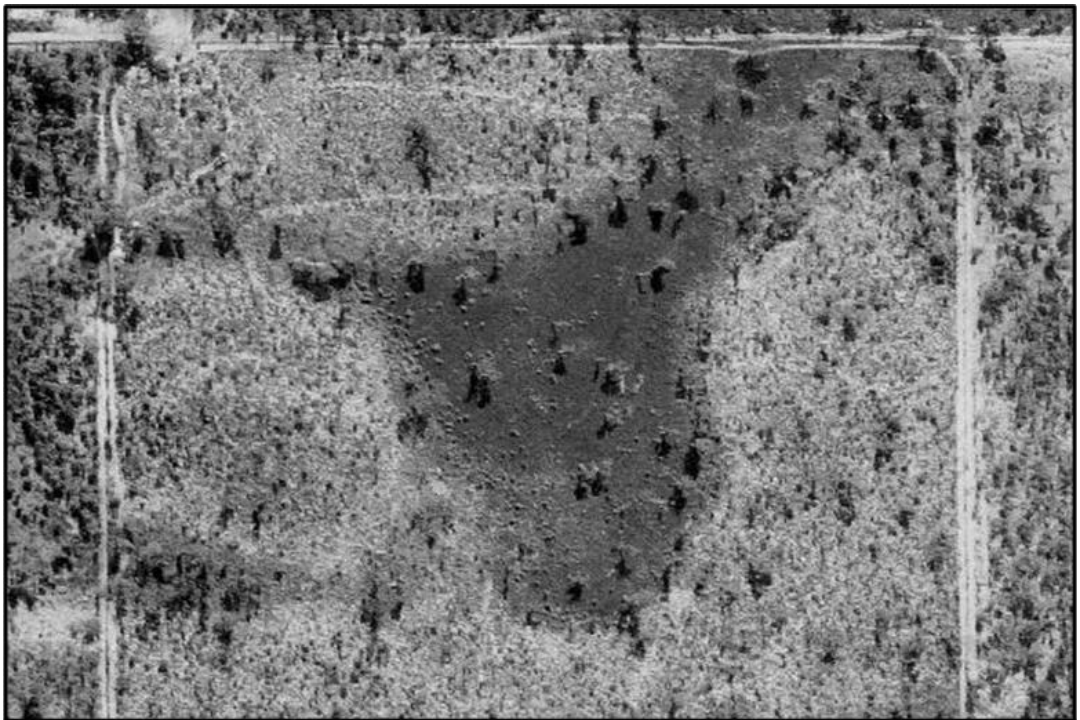


19/06/1985

30/08/1981



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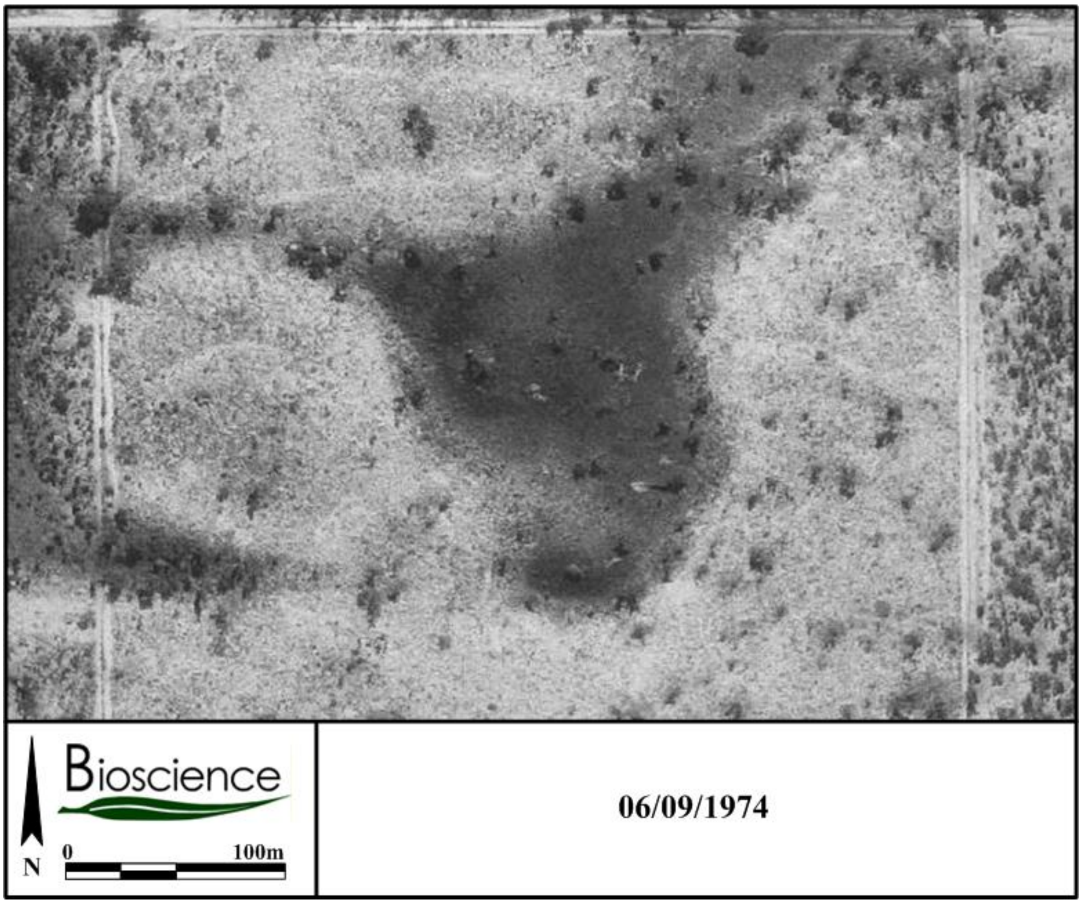

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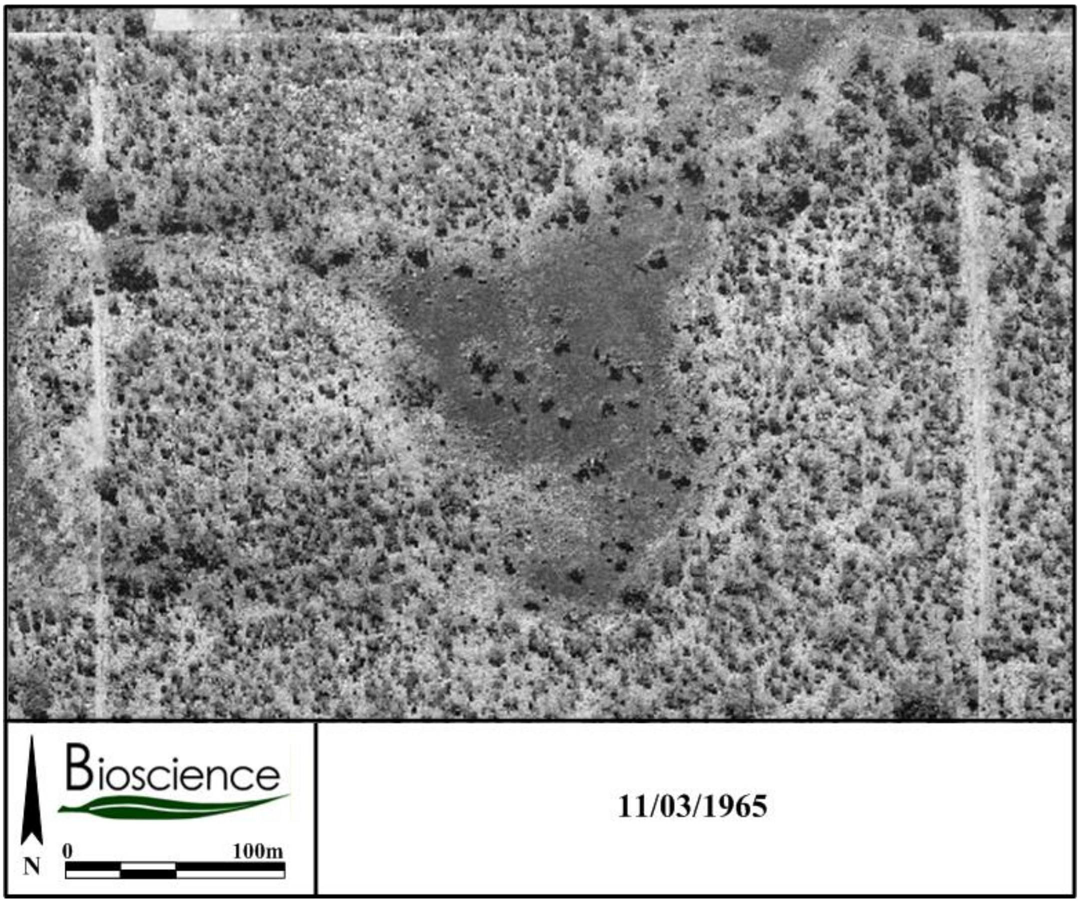

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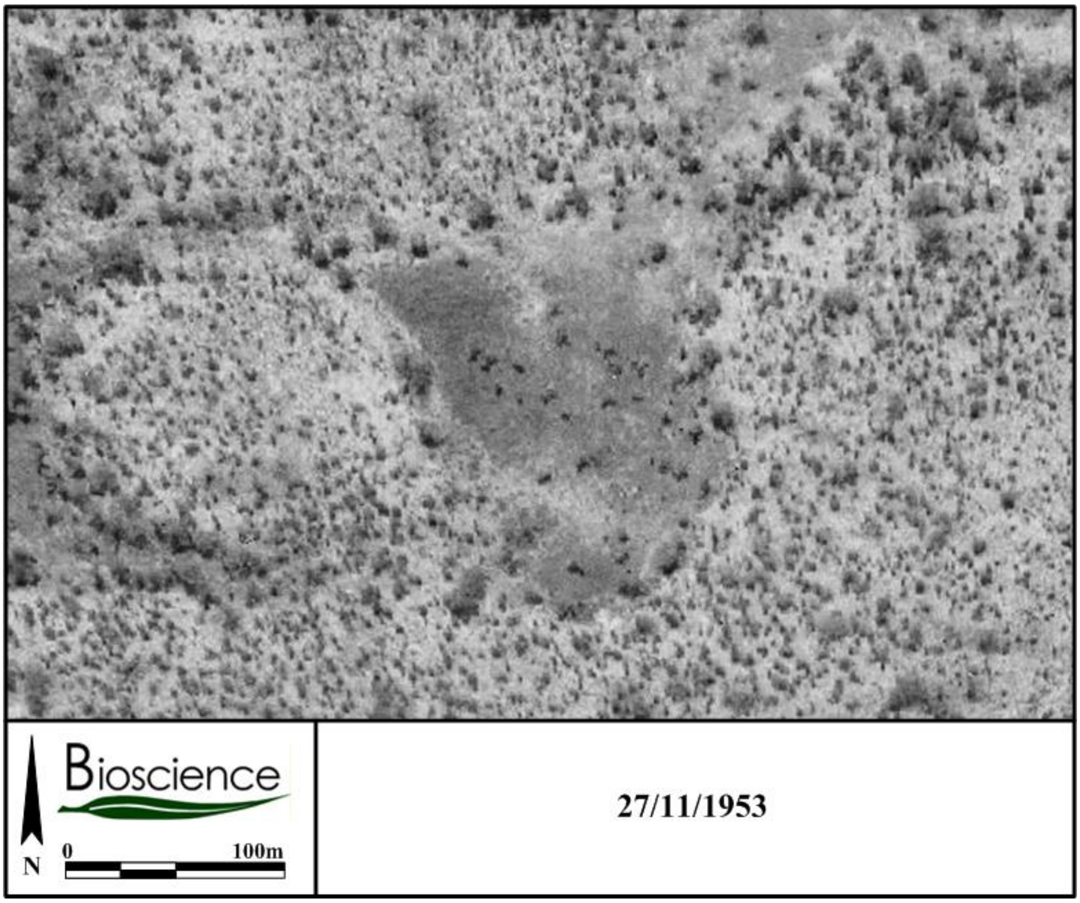

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