Main Roads Western Australia

Perth Darwin National Highway Alignment Definition Study

Maralla Road, Bullsbrook to Great Northern Highway, Muchea

Environmental Impact Assessment and Environmental Management Plan

March 2013

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Executive Summary

GHD has been commissioned by Main Roads Western Australia (Main Roads) to complete an Environmental Impact Assessment (EIA) on a corridor alignment (the Corridor) for the Perth-Darwin National Highway (PDNH) between Maralla Road in the south and Calingiri Road in the north. The investigation for the EIA is part of a larger alignment study of the Corridor to consider all aspects of the proposed PDNH.

An Alignment Selection Study for the future highway between Maralla Road, south of Bullsbrook and Calingiri Road, north of Bindoon started in 1997. The study identified the general Corridor of 500 metres, which was endorsed by the Government in 2002.

As a result of previous planning studies, the Corridor that has been chosen follows a route between Maralla Road, south of Muchea, and the Great Northern Highway at Muchea, including a link to the Brand Highway. (Figure 1). The total length of the highway section is approximately 20 km with the addition of a maximum distance of approximately 3 km for the link to Brand Highway.

The 500 m wide Corridor has been investigated along with any significant aspects which immediately adjoin the Corridor and which may therefore impact upon, or be impacted by, the proposed highway. At the early planning stage, the Corridor included an approximately 100 m wide Refined Alignment, which followed the middle of the Corridor. A Preferred Alignment has now been selected within the Corridor.

The PDNH project is not likely to be commenced until possibly 2020. This document will progress the planning of the project to the stage of an approximately 100 m road reserve alignment which can then be placed on the Metropolitan Region Scheme and Shire of Chittering Town Planning Scheme. This will lead to an understanding of land requirements and land may then be purchased as it becomes available.

The study concentrated on assessing environmental impacts on and near the properties that were intersected by the Corridor and included desktop and the following field investigations:

- Spring biological flora survey;
- Biological fauna survey;
- Dieback survey (observations only, including other diseases or pathogens);
- Noise survey and modelling (4 sites were measured);
- Wetland field assessment;
- Potentially contaminated site assessment; and
- Investigation of other issues identified during the desktop study.

Environmental issues, their impacts and management are summarised in the Key Characteristics Table (Table 12). Potentially significant issues along the Corridor are associated with:

- Conservation Category wetlands along the route and their associated vegetation;
- A Threatened Ecological Community;
- Impacts on Bush Forever sites;
- Impacts on Ellen Brook;

- General vegetation clearing, including potential loss of vegetation types which are very poorly conserved; and
- Potential impacts on listed threatened fauna species that may use the vegetation that will be cleared.

General Environment

The refined PDNH extends from Maralla Rd, Bullsbrook, to the Great Northern Highway in Muchea, and is close to 20 km in length. The alignment traverses areas of gently undulating terrain associated with the Bassendean Dunes and Pinjarra Plain. Minor sections of the alignment cross narrow alluvial streams and low-lying marshlands generally associated with interdunal swales within the Bassendean Dunes.

Conservation Category wetlands

The climate of the study area is Mediterranean, with warm dry summers and cool wet winters. In combination with the landforms, wetlands have formed, and are intersected at a number of locations along the Corridor. The groundwater is characteristically close to the surface on the Swan Coastal Plain, and wetlands are present in interdunal swales on Bassendean Sands and the palusplain of the Pinjarra Plain.

The Corridor intersects three wetlands that are listed as EPP Lakes, as well as five which have been allocated a Conservation management category. Impacts on these wetlands have been reduced during selection of the Preferred Alignment wherever possible.

These listings require that specific approval will be required in order to disturb the wetlands or lakes, including where the PDNH development impacts land within 50 m of the designated wetland boundary. Where possible, wetland areas should be avoided but where that is not possible approval to disturb the areas will require detailed management commitments with regard to vegetation removal, soil movement, hydrological function and pollution.

Bush Forever Sites

The Corridor directly impacts three Bush Forever sites. The three sites are:

- Site 13: Sawpit Road Bushland, Bullsbrook. The eastern section of the Corridor intersects the western section of this site. However, the Preferred Alignment has been designed to avoid the site, running adjacent to the western boundary;
- Site 100: Neaves Road Creek, Bullsbrook. The Corridor crosses the Neaves Road Creek just north of Neaves Road. Other tributaries of Neaves Road Creek are also crossed by the Corridor, although these are not considered in the Bush Forever plan; and
- Site 97: Kirby Road Bushland, Bullsbrook. The Corridor crosses the Kirby Road Bushland site where it juts out eastwards into location 1662. This site is subject to protection under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 and contains a Threatened Ecological Community.

Bush Forever sites have been identified by the State Government as areas which should be protected for conservation purposes and any impacts on these sites are discouraged. The Preferred Alignment has been designed to avoid impacts to Bush Forever Site 13, and reduce impacts on Bush Forever Site 97. The Department of Environment and Conservation and the Western Australian Planning Commission (WAPC) will require detailed consultation and the provision of a land off-set package to replace lost bushland.

Vegetation and Flora

The native vegetation along the Corridor is comprised predominantly of woodland supporting *Corymbia* and Banksia species on the well-drained soils, and Melaleuca woodland, shrublands or heath on low-lying less permeable soils.

The amount of native vegetation that may need to be cleared as a result of the construction of the PDNH is estimated at around 14.0 ha. This is based on a measurement of approximately 2000 m of alignment passing through native vegetation and an indicative clearing width of 70 m. This clearing width could vary in some areas, due to cut and fill requirements, interchanges and retention of roadside vegetation. A permit to clear native vegetation will need to be applied for under regulations associated with the *Environmental Protection Act 1986*. However, if the EPA assesses the project a clearing permit will not be required if the clearing is included as part of the approved activities.

A number of the Declared Rare Flora (DRF) species, *Grevillia curviloba* subp *incurva*, have been recorded along the existing Brand Highway and railway, and are located within the 500m Corridor. There are no known occurrences of DRF or Priority flora species within the footprint of the Preferred Alignment, however given the long lead time, additional surveys will be required closer to the commencement of construction to confirm this position.

A Threatened Ecological Community (TEC) was identified within the Corridor in mid 2008. The Preferred Alignment has been shifted to the east of this TEC to avoid direct impacts on the TEC and its catchment. Further management during the final design and construction stages will be required to ensure that the highway does not have any indirect impacts on this TEC, such as from increased fire risk and weeds.

The alignment appears to intersect vegetation types which are very poorly conserved within Western Australia (less than 10% of the original extent remaining). There is a strong requirement by the DEC to avoid clearing such vegetation and there will likely be a further need to survey the area in detail to verify the vegetation type and condition. Removal of the vegetation could trigger special requirements for vegetation replacement and offset packages.

Fauna habitat

A number of issues in relation to the highway development are risks to fauna and its habitat:

- possible impacts due to changes in water flow and water levels in wetlands;
- potential for impacts resulting from altered flows or water quality within Ellen Brook;
- loss of remnant native vegetation in areas already substantially cleared, particularly in the south of the project area. This could be significant even at the level of single large trees that provide nesting hollows and act as stepping stones for birds moving across paddocks;
- likely disruption of movement of fauna across the highway alignment, especially for terrestrial species such as small mammals and reptiles;
- potential loss of feeding habitat, roosting trees or nesting trees used by Carnaby's Cockatoo; and
- potential for the development of a wildlife corridor through rehabilitation within the road reserve.

These issues can be managed by minimising encroachment on areas of native vegetation when the detailed design is carried out, carrying out detailed investigations closer to the time of construction, and using sensitive highway design.

Other Issues and Impacts

Other issues and impacts identified, which can be managed through sensitive design or standard construction techniques are:

- Acid Sulphate Soils
- Surface Water Hydrology;
- Dust management;
- Air quality;
- Noise and vibration;
- Stormwater disposal; and
- Use of hazardous substances.

Requirements for referral to statutory authorities

The project is likely to require referral under the *Environmental Protection Act 1986* and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act*).

Given the proximity of the proposal to Commonwealth listed TECs ('assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the Swan Coastal Plain'), it is considered likely that the project will require referral to the Department of Environment, Water, Heritage and the Arts (DEWHA) for assessment under the *EPBC Act*. Initial fauna surveys also indicate that the alignment may impact on roosting sites for Carnaby's Cockatoo which is listed as Endangered under the *EPBC Act*.

Detailed site investigations closer to the time of construction, may identify new records of Declared Rare Flora (DRF) or additional impacts on Carnaby's Cockatoo or other threatened species which may be considered significant under the *Act*.

Matters which would require referral under the *Environmental Protection Act 1986* include:

- Impacts on significant wetlands (categorised as Conservation and Resource Enhancement);
- Impacts on Bush Forever sites; and
- Impacts on threatened fauna.

In addition, the size of the project and its impact on landholders would likely require the project to be referred.

The DEWHA has signed a Bilateral Agreement with the WA Environmental Protection Authority (EPA). This agreement gives the EPA the power to assess some projects that would otherwise be assessed by the DEWHA. Projects which trigger the *EPBC Act* must still be referred under that *Act* but there will not be a duplication of assessment at a State and Federal level.

1. Introduction

GHD has been commissioned by Main Roads Western Australia (Main Roads) to complete an Environmental Impact Assessment (EIA) on a corridor alignment (the Corridor) for the Perth-Darwin National Highway (PDNH) between Maralla Road in the south and Calingiri Road in the north. The investigation for the EIA is part of a larger alignment study of the Corridor to consider all aspects of the proposed PDNH.

Studies to examine potential highway alignments between Midland and Muchea began in 1991. These studies resulted in the southern section of the PDNH alignment between Reid Highway and Maralla Road being included in the North-East Corridor Structure Plan (DPUD, 1994) and later included in the Metropolitan Region Scheme (MRS) in December 1994.

An Alignment Selection Study for the future highway between Maralla Road, south of Bullsbrook and Calingiri Road, north of Bindoon, started in 1997. The study identified the general Corridor of 500 metres (the Corridor), which was endorsed by the Government in 2002.

1.1 Project Scope

1.1.1 The Study Area

As a result of previous planning studies, the Corridor was chosen. This Corridor followed a route between Maralla Road, south of Muchea and the Great Northern Highway at the Calingiri Road junction and included three linking options to Brand Highway, and an alternative route over the Brockman River.

This 500 m wide Corridor was investigated along with any significant aspects which immediately adjoin the Corridor and which may therefore impact upon, or be impacted by, the proposed highway. The Corridor included within it an approximately 100 m wide Refined Alignment, which followed the middle of the corridor.

The PDNH Corridor has been divided into two sections: a southern section and a northern section. These two sections were originally delineated by the Metropolitan Regional Scheme boundary, however as the planning study progressed, the boundary was shifted northwards to Muchea. This report deals with the southern section from Maralla Road to Muchea where the PDNH will link into the existing Great Northern Highway, with a connection to Brand Highway. The study area is shown at Figure 1.

The study concentrated on assessing environmental impacts on and near the properties that were intersected by the Corridor and that were shown on the ‘stakeholder maps’ provided by Main Roads, with corresponding property identification numbers, ‘location numbers’. These location numbers are referenced throughout this report and provide a stable point of reference (see Figure 2, Appendix A). General characteristics may also be referenced by chainages.

Figure 1: PDNH Corridor Locality Plan

1.1.2 Scope of the Study

This EIA has built upon the Preliminary Environmental Impact Assessment (PEIA), and includes findings from fieldwork investigations. The fieldwork included:

- Spring biological flora survey;
- Fauna survey;
- Dieback survey (observations only, including other diseases or pathogens);
- Noise survey and modelling (4 sites were measured);
- Wetland field assessments;
- Potentially contaminated site assessment; and
- Other issues identified during the desktop study.

In addition to the information gathered during this fieldwork, this report includes information that was unknown or unavailable at the time the PEIA was prepared. This report has been expanded following the identification of the Preferred Alignment, to determine specific impacts and the management of these impacts.

2. Description of the proposal

2.1 Proponent

The proponent is as follows:

West Australian Planning Commission (WAPC)
Albert Facey House
469 Wellington Street
Perth 6000
Western Australia
Contact: Mohsin Muttaqui

2.2 Justification and Objectives for the Highway

The Perth-Darwin National Highway is an important link in the state and national road network, enhancing transport efficiencies between the Perth metropolitan area, the north west and the Northern Territory. The national highway currently follows the Great Northern Highway alignment starting at Roe Highway in Midland as a two lane road designed to rural standards with limited opportunities for future upgrading to national highway standards.

In the coming years, predicted urban growth and other developments in the north east corridor of the Perth metropolitan area and beyond are expected to increase traffic congestion, reduce social amenity and the serviceability of the existing national highway route.

As a result, advanced planning is required for future improvements including the construction of sections of new road and the provision for future bypasses around the Swan Valley area and rural townsites including Bullsbrook, Muchea and Bindoon.

2.3 Legal framework

The planning and construction of the proposed highway will trigger requirements under a number of State and Federal Government Acts. These are summarised below:

2.3.1 Planning Approvals

The proposed highway route is required to be set in a planning framework that allows future development to progress with the security of knowledge of the alignment and its land requirements. Within the Metropolitan area this is done through the Metropolitan Region Scheme under the *Town Planning and Development Act 1928* and within other areas under the relevant Town Planning scheme. Agreement for the proposed route must be by the Minister for Planning and Infrastructure, through the Western Australian Planning Commission.

2.3.2 Environmental Approvals

The planning and construction of the highway must be approved under the Western Australian *Environmental Protection Act 1986*. A planning proposal is generally assessed by the Environmental Protection Authority under Section 16(e) of Part II of the *Act*, and a construction proposal under Section

38 of Part IV. Due to the probable time lapse between the planning and construction of this project both approval processes may be required.

Where there are environmental issues considered to be of national significance, the project must be referred to the Department of the Environment, Water, Heritage and the Arts under the *Environmental Protection and Biodiversity Conservation Act 1999* for approval.

2.3.3 Aboriginal Heritage Approvals

If Aboriginal sites exist or are identified along the proposed highway route, and will be directly impacted by the project, a Section 18 clearance is required under the *Aboriginal Heritage Act 1972*. Also under the *Act*, it is an offence to damage any sites, known or unknown.

If the highway traverses Crown Land or land that has never been in freehold title, the provisions of the Commonwealth *Native Title Act 1993* apply, such that the proponent must consult with the relevant Native Title claimant group.

Aboriginal heritage assessments and outcomes are addressed in a separate report.

2.4 Design Elements

The PDNH is to be extended northwards from Maralla Road as a 4-lane freeway. The initial study scope proposed diamond interchanges at Maralla Road, Warbrook Road and Neaves Road in Bullsbrook. Subsequent investigations determined that an interchange at Maralla Road could not be justified.

As the planning study progressed, the interchange at Warbrook Road was relocated to Stock Road. An additional interchange was also included to tie the PDNH into the Brand Highway at Muchea.

Provision for a rapid transit system in the highway median is required throughout the length of the alignment, with stations at interchanges. A principal shared path is also required along the highway. There are no major creek or river crossings within this section of the PDNH, however some minor drainage lines, including Ellen Brook will be traversed. At these locations culverts will be required to maintain hydrological flows across the highway.

2.4.1 Design Standards

The following design standards are proposed in accordance with Main Roads requirements, which are based on AustRoads guidelines.

Design Speed	Minimum horizontal curve radius	Maximum grade	Traffic Lane width	Median Width	Shoulder Width	Approximate Road Reserve width
110 km/h	1100 m (to suit rapid transit requirements)	3%	3.5 m	22m (33m at stations)	3m and 2.5 m	100 m nominal

2.5 Preferred Alignment Description

The Preferred Alignment has been designed to maximise the preservation, conservation and enhancement of the existing environment through avoidance of areas of high conservation significance. The alignment has been selected to best incorporate community expectations, to satisfy regulatory stakeholders and to minimise cost. Significant changes to the Refined Alignment which were incorporated into the Preferred Alignment are shown in Figure 3 and are described below.

Stock Road Interchange

Following consultation with the City of Swan and the Department of Environment and Conservation (DEC), the interchange at Warbrook Road was relocated to Stock Road. The DEC indicated a preference for the interchange to be located at Stock Road to avoid any potential impacts on the Twin Swamps Nature Reserve, which is covered by the Environmental Protection (Western Swamp Tortoise Habitat) Policy.

TECs

The Refined Alignment ran between two recorded occurrences of the tumulus springs Threatened Ecological Community (TEC). Hydrological investigations into the tumulus spring indicated that the Refined Alignment would create a barrier between the two springs and potentially impact on the hydrology and water quality. The Preferred Alignment has been shifted to the east of the two tumulus springs to avoid impacts on the TEC catchment.

Department of Defence

At the request of the Department of Defence, alternative alignments were investigated along the eastern boundary of the Department's land. An ecological assessment of the Conservation Category wetland located on either side of Raphael Road in this location and consultation with the DEC indicated that the wetland should be avoided. The Preferred Alignment has been shifted as far east as possible on the Department of Defence land without impacting on the Conservation Category wetland.

2.6 Timing and staging of project

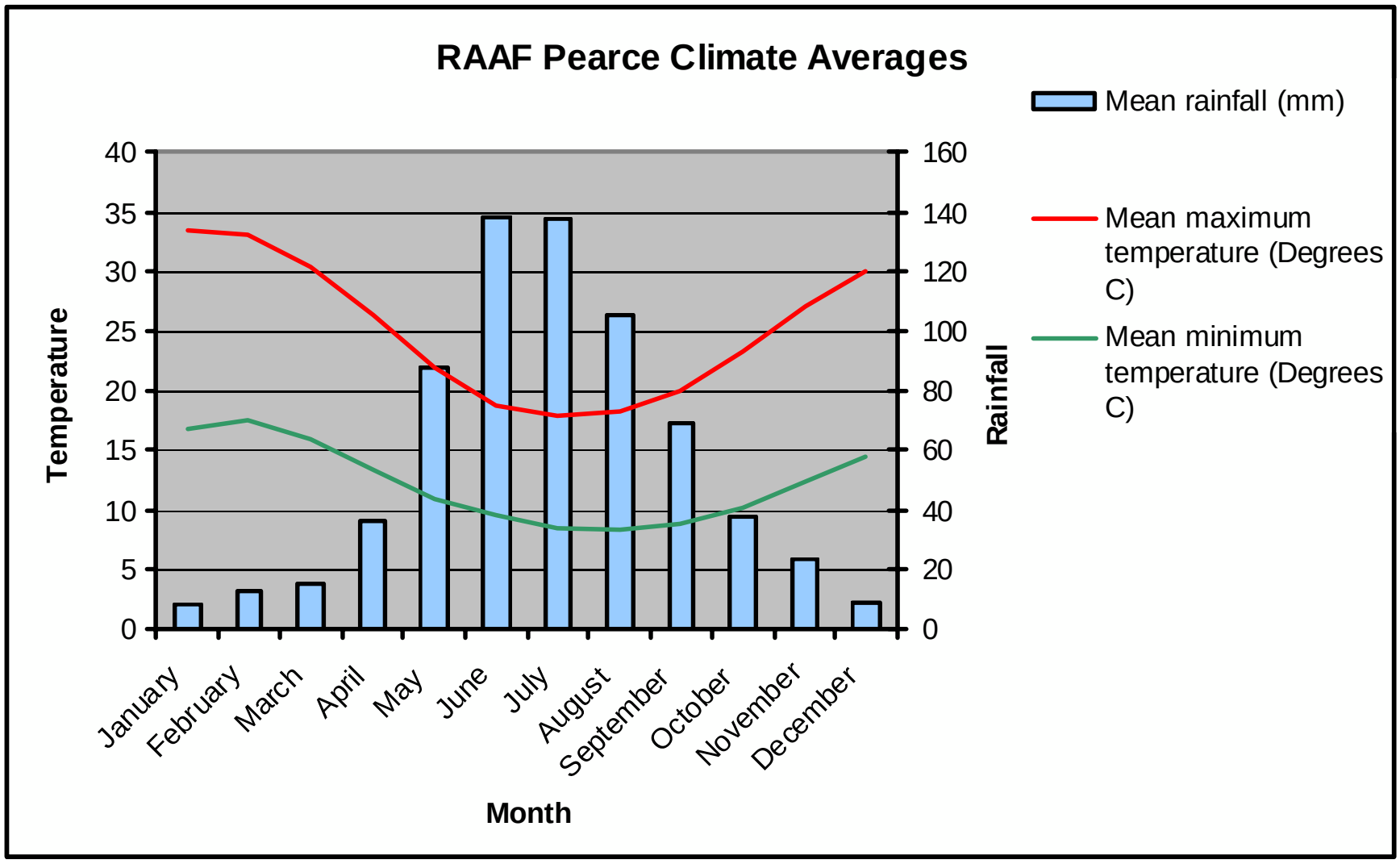
The southern section of the PDNH project is not likely to be commenced until possibly 2020. This document will progress the planning of the project to the stage of an approximately 100 m wide road reserve alignment which can then be placed on the Metropolitan Region Scheme and Shire of Chittering Town Planning Scheme. This will lead to an understanding of land requirements and land may then be purchased as it becomes available.

The highway may be built in stages, depending upon development requirements.

3. Existing Environment

3.1 Climate

The nearest Bureau of Meteorology reporting station to the PDNH Corridor is at the Pearce RAAF Airbase near Bullsbrook. The climate is typically Mediterranean – dry summer and wet winter. The annual rainfall average at Pearce is 685.1 mm. Rainfall in the vicinity of the proposed Perth-Darwin Highway will experience two gradients – a north-south gradient reflecting the increase of rainfall away from the arid zone, and an east-west gradient reflecting the decrease of rainfall away from the coast. The Darling and Gingin Scarps will affect the rainfall patterns topographically, where the rise in land causes a rise in precipitation (Beard, 1979).



Source – Bureau of Meteorology (2009).

3.2 Geology and Soils

The corridor traverses areas of gently undulating terrain associated with the Bassendean Dunes and Pinjarra Plain. Minor sections of the corridor cross narrow alluvial streams and low-lying marshlands generally associated with interdunal swales within the Bassendean Dunes.

3.2.1 Regional Geology

To the southwest of the Gingin Scarp (an erosional feature) along the proposed alignment, the Pinjarra Plain comprises Quaternary to Recent deposits, consisting primarily of aeolian deposits, alluvial fans associated with streams at the base of the scarp and colluvium in the piedmont zone.

The Bassendean Dunes, located to the west of the Pinjarra Plain, generally comprise Quaternary aeolian deposits overlying interbedded alluvial sands and clays associated with the Guildford Formation. Some Recent period swamp deposits, typically located within interdunal swales of the Bassendean Dunes, generally consist of organic sands and clays of lacustrine origin.

A summary of the geology for this section of the Corridor is given in Table 1.

Table 1 Typical Geology along the Preferred Corridor

Material Type	Unit/Origin	Map Symbol		Age
		Env. Geology	1:250,000 Map	
Peaty Sands and Clays	Swamp deposits	Cps	Qhw	RECENT
Silty sands and sands	Aeolian/ Bassendean	S_8	Qpb	RECENT TO QUATERNARY
Clayey sands, sandy clays, gravels and scree	Colluvium	S_5 and S_6	Qm, Qpo and Qrc	
Clayey and sandy soils	Alluvium/ Guildford Formation	Mgs_1	Qa and Qpa	

Source: Geological Survey of Western Australia

3.2.2 Site Geology

The different geological units occurring in the area are described below:

Swamp Deposits (Qhw)

The swamp deposits occur in the southern section of the alignment, in low-lying areas generally between dunes. The swamp deposits typically consists of organic clays and silty sands, containing roots and fibres. These deposits are generally associated with areas of high groundwater and are prone to flooding during the wetter months. The soils are generally expansive (shrink-swell properties) and have low bearing capacities and therefore, poor subgrade properties.

Bassendean Sand (Qpb)

The aeolian Bassendean Sand occurs throughout the entire southern section of the alignment. The sand is generally light grey at the surface, becoming yellow at depth, comprising fine to medium sub-rounded quartz grains. The Bassendean Sand is typically well drained and generally used as an acceptable subgrade material. However, in areas where a thin horizon of wind-blown sand overlies poorly draining soils, perched groundwater may be expected which could result in complications during construction.

Colluvium (Qm, Qpo and Qrc)

An upper horizon of colluvial soil generally overlies the basement rocks, occurring on valley sides upslope of alluvial deposits and rock outcrop. The colluvium varies from poorly graded quartz sand, to an organic, clayey sand to sandy gravel containing abundant rounded laterite pisoliths, sub-rounded quartz and feldspar gravel.

Guildford Formation (Qa and Qpa)

The alluvial Guildford Formation occur in and adjacent to the streams and water courses in the area and generally consists of fine to coarse grained sandy deposits with zones of clayey soils, laterite gravel and coarse rock fragments (i.e. cobbles and boulders) in places.

The Guildford Formation, generally located at the base of the Darling and Gingin Scarp, consist of interbedded silts, sands and gravelly clays, comprising laterite pisoliths, sub-rounded quartz gravel and extremely weathered granite pebbles. The clays and silts associated with the Guildford Formation are typically of low permeability, which can result in locally perched groundwater. Generally the clays and silts are slightly to moderately expansive, but are quite variable depending on the gravel and sand content.

3.2.3 Acid Sulphate Soils

The Western Australian Planning Commission's recent publication in relation to Acid Sulphate Soils, *Planning Bulletin Number 64,* (WAPC 2003*)* identifies many areas of both "High risk of actual acid sulphate soil (AASS) and potential acid sulphate soil (PASS) at <3m depth" and "Moderate to low risk of AASS and PASS occurring generally at depths of >3m" along the proposed Corridor.

Given the above, it is probable that works in some sections of the project area will disturb soils with acid generating potential.

Figure 4 (Appendix A) shows areas of AASS and PASS and their risk categorization. A large percentage of the Corridor in the southern section of the PDNH crosses soils classified as High Risk or Moderate to Low risk. High risk areas often coincide with existing or pre-existing wetlands where waterlogged soils are present. Moderate to low risk AASS and PASS occur over much of the remainder of the Corridor.

3.3 Groundwater

Typically the groundwater within the Bassendean Sand ranges from surface level (interdune areas) to in excess of 30 m deep. The water table fluctuates seasonally.

Where the alignment traverses through areas comprising Guildford clays and sands, the groundwater generally forms a perched water table above the low permeability clays. These areas, in particular between the Midland railway line and Great Northern Highway, are prone to seasonal flooding.

3.3.1 Salinity

Due to the soil types and drainage capacity of much of the area of the Corridor there is little manifestation of dryland salinity. Water tables have possibly risen in some areas due to vegetation clearing but salinity risks appear to be minor.

3.4 Public Drinking Water Source Protection Areas

The Corridor will not cross any public drinking water source areas. The Corridor is to the north and east of the Gnangara Groundwater Mound and does not intersect any of the groundwater protection priority areas.

3.5 Other Water Source Areas

The highway crosses areas of land with high water tables. Landholders draw water from the shallow aquifer for irrigation use and stock use.

The Department of Defence operates a borefield at Location 172, which will be impacted by the proposed PDNH. This borefield includes some 9 bores and presently supplies water to RAAF Base Pearce. One bore, at the eastern end of Location 172, would be directly impacted by the highway at the Neaves Road interchange.

3.6 Surface Hydrology and Wetlands

A significant portion of the Corridor crosses the western edge of a palusplain which is seasonally inundated or which has a high water table. The Corridor crosses a small number of ephemeral watercourses. To the west of the palusplain the drainage is directed into small permanent or seasonal swamps.

The Corridor crosses the permanent channel of Ellen Brook in two locations, to the north and south of the Brand Highway. Information on each of these crossing is included in Section 3.6.3.

Hill *et al*. (1996), suggests that approximately three-quarters of wetlands on the Swan Coastal Plain (SCP) are seasonally waterlogged and are usually interconnected providing an extensive network and mosaic of habitats.

Wetlands in the study area are divided into two groups:

- Sumplands – (seasonally inundated basin), floodplains (seasonally inundated flats); and
- Damplands – (seasonally waterlogged basin) and palusplains (seasonally waterlogged flats).

Lakes, defined as permanently inundated basin, are also present in the study area (Hill *et al*., 1996).

A number of wetlands intersected by the Corridor are protected under the *Environmental Protection Act 1986*. These are discussed below and mapped at Figure 5 in Appendix A.

3.6.1 Environmental Protection Policy Lakes

Certain lakes within the SCP have been classified Environmental Protection Policy (EPP) lakes under the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992.

In excess of fifteen EPP lakes were found to occur within the original SKM (1999) study area ranging in size from 5 km^2 to less than 0.25 km^2. These are mainly located west of the proposed alignment of the PDNH.

3.6.2 Other Wetlands

There are three main management categories of wetlands that have been derived by the Department of Environment and Conservation (DEC). They are:

- Conservation wetlands – which support high levels of attributes and functions;
- Resource Enhancement wetlands – which have been partly modified but still support substantial functions and attributes; and
- Multiple Use wetlands – which have few attributes but still provide important wetland functions.

500m Wide Corridor

The following wetlands mapped by Hill *et al*. (1996) are intersected by the 500 m wide PDNH Corridor. The wetland mapping at Figure 5 provides the most recent wetland classifications.

- Sumpland 206 [Map Sheet 2034 I SE (Muchea SE)] - The western half of the 500 m Corridor crosses this sumpland. Sumpland 206 is a Conservation Category wetland while immediately to the west of Sumpland 206, Sumpland 205 is classified as Resource Enhancement Wetland. Sumpland 205 lies outside the 500 m Corridor of the proposed PDNH alignment.
- Sumpland 204 [Map Sheet 2034 I SE (Muchea SE)] –The eastern part of this wetland is in the western section of the Corridor. This wetland is given a 'conservation' management category;
- Sumpland 214 [Map Sheet 2034 I SE (Muchea SE)] –This wetland is designated a C2* wetland – where more than 95% of its vegetation is categorised as undisturbed. It is a 'conservation' category wetland. The entire wetland falls inside the 500 m Corridor;
- Sumpland 181 [Map Sheet 2034 I SE (Muchea SE)] – This sumpland is entirely included within the 500m Corridor and is given a management category of 'Resource Enhancement';
- Wetland 668 [Map Sheet 2031 I SE (Muchea SE)]- This wetland is given no status in Hill *et al*. (1997) but is indicated as a Conservation Category wetland on digital information received from DEC. This wetland is intersected by the 500 m Corridor;
- Sumpland 195 [Map Sheet 2034 I SE (Muchea SE)] – This wetland is intersected by the Corridor. The management category for this sumpland is given as 'Resource Enhancement';
- Sumpland 202 [Map Sheet 2034 I SE (Muchea SE)] – This wetland is intersected by the Corridor. The management category for this sumpland is given as 'Resource Enhancement';
- Sumpland 198 [Map Sheet 2034 I SE (Muchea SE)] – This sumpland north of Neaves Road is only partly intersected by the 500 m Corridor. It is given a management category of 'conservation';
- Sumpland 196 [Map Sheet 2034 I SE (Muchea SE)] - This sumpland north of Neaves Road is only partly intersected by the 500 m Corridor. It is given a management category of 'Resource Enhancement';
- Sumpland 94 [Map Sheet 2034 I NE (Muchea NE)] – This sumpland is located east of the existing Great Northern Highway and is within the Corridor. The management category for this sumpland is given as 'Resource Enhancement'; and
- Sumpland 98 [Map Sheet 2034 I NE (Muchea NE)] – This sumpland is located south of the proposed eastern link from the interchange at Brand Highway. The sumpland is located within the Corridor. It is given a management category of 'Resource Enhancement'.

Preferred Alignment

Wetlands and watercourses intersected or adjacent to the 100 m wide PDNH Preferred Alignment are summarised below.

- One EPP Lake just north of Maralla Road at Ch 15 000 is intersected by the western boundary of the road reservation.
- Four Conservation Category wetlands (including wetland 668) are intersected by the road reservation in the vicinity of the NeavesRoad Interchange.

- One EPP Lake (associated with Sumpland 221) is intersected by the western side of the road reservation north of the Stock Road Interchange.
- One Resource Enhancement Category wetland is intersected by the preferred alignment at approximate Ch 27 100.
- The alignment crosses Ellen Brook at approximately Ch 31 200 and along the tie-in to the Brand Highway, as well as a number of minor tributaries.

3.6.3 Wetland Field Assessment

An assessment of the wetlands and creeks was undertaken concurrently with the flora survey in spring 2004. This assessment considered all wetlands within or adjoining the 500 m Corridor. A summary of the findings of these investigations is given in Table 2.

Table 2 Wetlands Assessed Along the Corridor in Spring 2004

Location Number	Wetland No. (Hill *et al*.)	Wetland information
4318	204 Conservation Category	Conservation category wetland contains vegetation in pristine to excellent condition.
4318	205/206 Resource Enhancement/ Conservation Category	EPP Lake has vegetation in pristine to excellent condition.
80/81	204 Conservation Category	Conservation category wetland contains vegetation is degraded condition - mostly grass trees.
81	None	Dampland with water table 1-2 metres below surface is located at 0403601, 6488014 (MGA 50 - 6m).
81	206 Conservation Category	EPP Lake has vegetation in condition very good to degraded.
77	204 Conservation Category	Conservation category wetland. The bush was parkland cleared in 1979 when it was bought. It has since re-established, and is not used for grazing since this time. The owner did not wish for the flora survey to take place. He plans to use it for growing melons some time in the future.
109	None	Wetland area dries out 2 months of the year. Soaks are damp all year. Feeds into Ellen Brook, so culverts would be necessary. Birds, frogs, snakes present. Sumpland and dams are waterlogged/ contain standing water all year round.

Location Number	Wetland No. (Hill *et al*.)	Wetland information
510	None	SW corner - Wet until January (ground boggy), no exposed water. NW wetland - boggy at NW corner.
5109,135	221	EPP Lake - cattle graze both of these properties. Remnant of *Astartea fascicularis* heath is in very degraded to good condition. This wetland is on the eastern edge of the Corridor.
3580	None	Waterway flowing and spreading across area during winter. Perennial stream flows during summer. Summer, dry on property but still green.
5202	None	2 wetland areas - both have some water/waterlogged during summer.
169	Eastern Side-none Western Side-south-eastern section of sumpland 195	Permanent creek and dampland within most of vegetated area. Variety of habitats and vegetation types. High conservation value.
167, 996,	195, 202 Resource Enhancement	Bushland, variously affected by dieback. Dieback has altered the vegetation condition, which is excellent in uninfected and resistant areas, and good to degraded in areas that are infected by dieback.
168, 997	195, 202 Resource Enhancement	Degraded parkland.
2703	None	Parkland cleared *Melaleuca* woodland.
994, 991, 990, 992, 4912, 4795, 1011, 1010, 1009, 1007, 348, 347, 342	None	Permanent pools remain in the summer along Ellen Brook. Vegetation is in a degraded condition and consists of Flooded Gum over weed-infested understorey.
4905	94, 98 Resource Enhancement	Wetland has become wet since the Meckering earthquake.

Following consultation with the City of Swan and the DEC, the interchange at Warbrook Road was relocated to Stock Road. The DEC indicated a preference for the interchange to be located at Stock Road to avoid any potential impacts on the Twin Swamps Nature Reserve, which is covered by the Environmental Protection (Western Swamp Tortoise Habitat) Policy. The interchange at Stock Road has been designed to avoid impacts on a number of EPP Lakes and a Resource Enhancement wetland in the vicinity. An assessment of these wetlands was carried out in January 2009 to determine their ecological value (Appendix B). The assessment concluded that the three EPP Lakes have been heavily grazed and are in completely degraded to good condition. The Resource Enhancement wetland to the north-west of the interchange was classified as being in good to degraded condition.

At the request of the Department of Defence, alternative alignments were investigated along the eastern boundary of the Department's land. An ecological assessment of the Conservation Category wetland located on either side of Raphael Road in this location and consultation with the DEC indicated that the wetland should be avoided (Appendix D). The Preferred Alignment was shifted as far east as possible on the Department of Defence land without impacting on the Conservation Category wetland.

3.7 Vegetation and Flora

3.7.1 Vegetation Communities

The vegetation in the study area is located within the South West Botanical Province of the Darling Botanical District. Vegetation communities have been mapped extensively by Beard (1979), updated by Heddle *et al.* (1980) and Mattiske and Havel (1998).

South of the MRS boundary, the proposed 500 m PDNH Corridor crosses portions of the Yanga and Bassendean (North) Complexes on the Swan Coastal Plain (Table 3).

Table 3 Vegetation Complexes in the study area (Heddle *et al.* 1980)

Landform	Vegetation Complex	Landscape Feature	Vegetation Description
Swan Coastal Plain	Bassendean Complex – North	Aeolian deposits on plain	Vegetation ranges from a low open forest and low woodland of *Banksia* spp. *E. todtiana* to low woodland of *Melaleuca* spp., and sedgelands which occupy the moister sites.
	Yanga Complex	Broad fluviatile deposit on plain	Closed scrub of *Melaleuca* species and low open forest of *Casuarina obesa* on the flats subject to inundation in arid zone. On drier sites, the vegetation reflects the adjacent vegetation of the Bassendean and Coonambidgee Complexes

3.7.2 Field Surveys

500 m Wide Corridor

Vegetation types mapped for the study area were investigated by GHD during the Spring survey in October and November 2004. The vegetation observed broadly matched the communities described in Table 3 (Appendix D), and is detailed for each property in Appendix D, and mapped in Figure 6 (Appendix A). As much of the landscape has been modified by its agricultural land use, the condition of the vegetation was also noted, and is provided in these figures and discussed below. The vegetation condition was determined using the condition rating scale given in *Bush Forever Volume 2* (Department of Environment, 2000), and is summarised in Appendix D.

A large majority of the 500 m Corridor reserve south of the MRS boundary crosses land that has been cleared and is used for animal husbandry, hobby farming, turf farming or lies fallow. Those areas of native vegetation which are potential constraints to the final road reserve are described below, ordered from south to north:

1. Maralla Road (Location Numbers: 81, 76, 4318) – The Conservation category wetland on this property is comprised of a woodland of *Melaleuca preissiana* with an understorey dominated by *Pericalymma ellipticum* heath. Woodland of Banksia species (*B. attenuata, B menziesii*) and *Eucalyptus todtiana* is found on the grey sandy hills which surround the wet areas. The vegetation at

location numbers 76 and 4318 is in excellent condition and is part of the Ellenbrook National Estate Area registered on the Australian Heritage Database (ID 18942), while that on 81 is in a generally degraded condition, evidenced by past clearing and invasion of weed species.

2. Sawpit Road (77) – The Conservation category wetland on the property is vegetated with open woodland of *Melaleuca preissiana* and the occasional *Corymbia calophylla*, and has an understorey dominated by heath of *Pericalymma ellipticum*. Communication with the landowner revealed that the vegetation has not been grazed since 1979. It has recovered and is in excellent condition. This property will not intersected by the Preferred Alignment;
3. Raphael Road (5109, 135) – Cattle are grazed on both of these properties which are classified as partially covered by Resource Enhancement floodplain. As a result, the vegetation, which is mostly comprised of *Astartea fascicularis* heath, is in very degraded to good condition. Evidence of disturbance include trampled and broken shrubs and herbs chewed to the ground;
4. Cooper Road (132) – While the aerial photograph suggests that the north eastern corner of the property has good vegetation cover, field survey revealed that the well-drained sandy area has been parkland cleared relatively recently. Trees which remain suggest that it was once woodland of Banksia but, due to clearing, its condition is now degraded. The creekline is fringed by remnant *Melaleuca preissiana* trees growing over grassy weeds. This property will not be intersected by the Preferred Alignment;
5. Gaston Road (169) – The vegetation on this property is part of Bush Forever Protection Area 97. While it is connected to bushland on Bingham Road (167), it is discussed separately as the vegetation is comprised of a mosaic, apparently influenced by the permanent creekline and sumpland areas. It is classified as Resource Enhancement wetland, and is very lightly grazed by a small herd of cattle. Its condition is generally excellent to very good. The permanent creek is lined by a closed tall forest of *Corymbia calophylla* and *Melaleuca preissiana* over a herbaceous carpet. Damp areas either comprise woodland of *Melaleuca preissiana* over myrtaceous heath dominated by *Taxandria linearifolia*, *Astartea fascicularis* and *Kunzea glabrescens*, or medium closed shrubland of *Astartea fascicularis* mixed with *Kunzea glabrescens*. Drier areas are dominated by a similar shrubland, with an overstorey of *Corymbia calophylla*. While the vegetation on this property is comprised generally of species which are dieback resistant, dieback is present upstream on properties 167 and 996; and
6. Bingham Road (167, 996) – The vegetation on these properties is part of Bush Forever Protection Area 97. The area covered by these properties is variously affected by dieback, which appears to have been introduced and spread by machinery used for clearing Bingham Road 5202 to the south, the Corridor for the gas pipeline, and firebreaks on the properties. Dieback has altered the vegetation condition, which is excellent in uninfected and resistant areas, and good to degraded in areas that are infected by dieback. Dieback is further discussed in Section 3.7.7. The vegetation on the sandy ridges is comprised of woodland of *Banksia attenuata* and *B. menziesii*. *Melaleuca preissiana* is growing scattered amongst the Banksia species in the undulations, with *Xanthorrhoea preissii* dominating in the understorey. In areas infected by dieback, Xanthorrhoea dominates, as the trees have been killed by dieback. Three swampy areas are located along the eastern boundary of the properties, and are comprised of medium closed heath dominated by C*alothamnus lateralis, Pericalymma ellipticum, Adenanthos obovatus*, and *Hypocalymma angustifolium*. These properties will not be intersected by the Preferred Alignment;
7. Ellen Brook – The vegetation of Ellen Brook intersected by the Corridor is in a degraded condition. The surrounding lands have been entirely cleared for pasture, and the associated weeds have spread

and dominate the understorey of the fringing vegetation of Ellen Brook. Native species are few, with *Eucalyptus rudis* and *Melaleuca rhaphiophylla* dominating.

8. Muchea East Road (293) – The vegetation in the Corridor is a remnant of Banksia, *Eucalyptus todtiana* and Sheoak woodland in very good condition.
9. Brand Highway/Railway – the Corridor of the connection to the Brand Highway includes the vegetated railway corridor. The connection will be constrained by the Declared Rare Flora species *Grevillea curviloba* subsp *incurva*. The vegetation in which this species is growing is degraded and consists of *Melaleuca preissiana* or *Corymbia calophylla* woodland over scattered native species and aggressive grassy weeds.

Preferred Alignment

Following the identification of the Corridor, the alignment has been shifted to the east to avoid a Threatened Ecological Community on Lot 110 Gaston Road. As a result of this shift, the Preferred Alignment will avoid the majority of impacts on the Bush Forever Site 97, adjacent to Bingham Road. An area of remnant vegetation at 110 Gaston Road, which is included in Bush Forever Site 97, will be intersected by the Preferred Alignment. A flora and fauna assessment was carried out in January 2009 to determine the ecological value of the vegetation at this site, and identify potential impacts associated with the construction of the PDNH in this location (Appendix E).

3.7.3 Regional Vegetation Extent

A vegetation type is considered to be under-represented if there is less than 30 percent of its pre-clearing distribution remaining and 'endangered' if there is less than 10% remaining (EPA, 2000). Table 4 indicates the native vegetation types represented along the Corridor, their regional extent and reservation status in the Swan Coastal Plain IBRA region as drawn from Shepherd *et al.* (2005), based on the vegetation types as observed by Beard (1979), Heddle *et al*. (1980), Gibson *et al*. (1994) and Mattiske and Havel (1998). The area of each vegetation type (in hectares) within the 100 m Preferred Alignment is also included in Table 4. It must be noted that the majority of the Preferred Alignment has previously been cleared, and the estimated area of native vegetation required to be cleared along the alignment is approximately 14 ha.

Vegetation of the eastern Swan Coastal Plain has been extensively cleared and little is conserved in reserves. Many threatened vegetation communities are present within this zone. Vegetation on the Bassendean Dune areas is generally better conserved.

Table 4 Vegetation Type, Extent and Conservation Status in the Swan Coastal Plain IBRA region (after Shepherd et al., 2005)

Vegetation Association Number	Map reference (Beard Code)	Description	Pre-European Extent (Ha)	Current Extent (Ha)	% Remaining	% Current Extent in IUCN Class I-IV Reserves	Area of Mapped Vegetation Types Within Preferred Alignment (ha)
4	e3,5Mi	Medium woodland; marri & wandoo	15930.807	3291.962	20.7	11.7	115.261
949	bLi	Low woodland; banksia	209999.968	122388.368	58.3	49.5	42.629
1018	e2,3Mi/bLi/mLc/c6Li	Mosaic: Medium forest; jarrah-marri / Low woodland; banksia / Low forest; teatree / Low woodland; Casuarina obesa	14060.011	2914.358	20.7	3.0	113.092

3.7.4 Threatened Ecological Communities

Ecological communities are defined as 'naturally occurring biological assemblages that occur in a particular type of habitat' (English and Blythe, 1997). Threatened Ecological Communities (TECs) are ecological communities that have been assessed and assigned to one of four categories related to the status of the threat to the community, i.e. Presumed Totally Destroyed, Critically Endangered, Endangered, and Vulnerable. Some TECs are protected under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. Although TECs are not formally protected under the State *Wildlife Conservation Act 1950,* the loss of, or disturbance to, some TECs triggers the *EPBC Act*. The Environmental Protection Authority's position on TECs states that proposals that result in the direct loss of TECs are likely to be formally assessed.

The Department of Environmental and Conservations (DEC) Threatened Ecological Communities database was searched for TECs in the vicinity of the Corridor. Those recorded are listed below and mapped at Figure 5 in Appendix A.

- Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) – This TEC was previously known within an area of Bush Forever Site 97 outside the PDNH corridor.
- 3a *Corymbia calophylla – Kingia australis* woodlands on heavy soils (critically endangered). These woodlands are found on the eastern coastal plain;
- 7 Herb rich saline shrublands in clay pans (vulnerable). These are found in seasonal wetlands, inundated from winter to mid-summer, and overlie heavy clay soil;
- 8 Herb rich shrublands in clay pans (vulnerable). These are found in seasonal wetlands on clay pan soils;
- 15 Forests and woodlands of deep seasonal wetlands (vulnerable). These are found in seasonal wetlands and overlie alluvial sediments;
- 22 *Banksia ilicifolia* woodlands (listed as "Not evaluated"). Other common trees in this woodland are *B attenuata* and *Melaleuca preissiana*. It is found on soils of the Bassendean dunes in low-lying areas or on lower slopes, and is likely to be seasonally waterlogged;
- 23b Northern *Banksia attenuata – Banksia menziesii* woodlands (listed as "Not evaluated"). *Corymbia calophylla* and *Eucalyptus marginata* are rarely found in this community, which is found on soils of the Bassendean dune system.

Following the 2004 field survey, and discussion with DEC, it was considered that no Threatened Ecological Communities were present within the Corridor in the study area, however, in mid-2007 WWF (World Wide Fund for Nature) Wetland Watch discovered a series of tumulus springs on Lots 88 and 89 Bingham Rd, Bullsbrook, adjacent to the proposed PDNH alignment. DEC assessed the springs and classified them as a Threatened Ecological Community (TEC): "Community of Tumulus Springs (organic

mound springs) of the Swan Coastal Plain". An additional spring was also identified on the neighbouring property, Lot 110 Gaston Road, Bullsbrook.

The habitat of this community is characterised by continuous discharge of groundwater in raised areas of peat. The peat and surrounds provide a stable, permanently moist series of microhabitats. Prior to the discovery of the TEC at Bingham Road, Bullsbrook, intact vegetated tumulus springs were only known at four locations. There is a high level of heterogeneity of invertebrate fauna assemblages between the four previously known sites, but all are associated with a rich, healthy fauna (Department of Conservation and Land Management 2006). During the alignment definition stage (2003-2005) for the proposed PDNH the alignment had been designed to avoid direct impact on the springs (as they contained good wetland vegetation); however, the alignment is still in close proximity to the communities. A hydrological review of the Gaston Road tumulus spring was completed by Groundwater Consulting Services in 2008 (Appendix F).

The tumulus springs TEC was assessed by the State on 21 November 1995 as Critically Endangered. It is also listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The community name as listed under the *EPBC Act* is 'assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the Swan Coastal Plain'.

Under the Commonwealth EPBC Act if proposed works are to have a significant impact on a matter of national environmental significance that is subject to the provisions of the *EPBC Act*, this must be referred to the Commonwealth Minister for the Environment for a decision as to whether a formal Environmental Impact Assessment is required. A bilateral agreement exists between Western Australian and the Commonwealth to minimize duplication in environmental assessment.

3.7.5 Flora

A complete flora survey along the proposed PDNH Corridor was not required at this stage of the planning process. However, significant flora species, which have been previously recorded within, and adjacent to, the study Corridor, were specially considered during vegetation surveys.

Declared Rare and Priority Flora

The Department of Environment and Conservation, DEC (formerly CALM) maintains a list, regularly updated, of significant flora present in Western Australia. These significant flora are allocated a code of conservation significance by DEC, and known records of their locations are maintained in DEC databases. These databases were searched for Declared Rare and Priority Flora previously recorded within the vicinity of the Corridor, and the results are summarised below, with locations of these species shown in Figures 4a and b.

The following significant flora are known to occur or potentially occur along the southern section of the PDNH (Table 5).

Table 5 Significant Flora Species that occur or potentially occur along the Corridor.

Species	Conservation Code CALM/*EPBC Act*	Distribution
Darwinia foetida	Declared Rare Flora, Endangered	Muchea
Grevillea curviloba ssp. *curviloba*	Declared Rare Flora, Endangered	Bullsbrook
Grevillea curviloba ssp. *incurva*	Declared Rare Flora, Endangered	Muchea
Cyathochaeta teretifolia	Priority 3	Whiteman Park, Lake Gnangara, Ellenbrook, Muchea, Denbarker, Yelverton

The spring field survey included a search for Declared Rare and Priority Flora within the Corridor at the locations recorded on DEC's databases. It also included searches for these species in other habitats where they may have been growing. Determining the constraint caused to the final alignment by these taxa was not considered particularly important because of the long lead time to construction of the PDNH. It is highly likely that the status of taxa will change between now and then, and resurvey will be necessary immediately prior to construction.

The Declared Rare Plant, *Grevillea curviloba* subsp *incurva* has been previously recorded within the Corridor near the connection of the PDNH and the Brand Highway. *Grevillea curviloba* subsp *incurva* appears to be a common species with a distribution limited to the highly disturbed vegetation in the railway corridor and Brand Highway reserve to the north of Muchea.

3.7.6 Weeds

The majority of the proposed highway Corridor contains a significant number of introduced and weedy species. Much of the area has been cleared for farming purposes and pasture plants dominate the ground layer. These farming practices have resulted in the spread of Declared Plants and other nuisance plants.

The vegetation survey in October and November 2004 included a recording in the Corridor of Declared Plants listed under the *Agricultural and Related Resources Protection Act 1976*. The species *Moraea flaccida* (One-leaf Cape Tulip) was recorded along Ellen Brook and on a property off Bingham Road (3580). This species has a P1 standard control code throughout the state. P1 requirements prohibit movement of plants or their seeds within the State. This prohibits the movement of contaminated machinery and produce including livestock and fodder. One-leaf Cape Tulip is known to be scattered

along the Ellen Brook and present within some low-lying paddocks. Other Declared species present in the general area and probably in some parts of the Corridor are: *Echium plantaginium* (Patersons Curse), *Rubus fruticosus* (Blackberry) and *Zantedeschia aethiopica* (Arum Lily). All of these plants have the potential to infest other areas along the Corridor and should not be spread.

3.7.7 Dieback and other Disease Risks

Dieback

Dieback disease, caused by the *Phytophthora* fungus species, may be present along parts of the road alignment. Proteaceous species are particularly susceptible to the fungus, especially in poorly drained areas. The areas and vegetation types which would most likely support the dieback fungus include those with sandplain Banksia woodlands, particularly on the Swan Coastal Plain, Jarrah/Banksia woodland on the slopes and valleys of the Darling Range and damplands or depressions on the plain and scarp.

The vegetation survey in Spring 2004 included a visual assessment of the dieback status of the vegetation along the Corridor. This assessment involved recordings of the health of taxa, particularly those plants susceptible to dieback, presence of dieback fronts, and determination of vectors which had spread the dieback. The areas where there was evidence of dieback are:

- Bingham Road (5202) – The sandy ridge to the north of this property is covered with dead Banksia trees, and the landowner reported that when they bought the property approximately 3 years ago, these trees were already dead. This area is possibly dieback infected. The neighbour (169) reported that this area was parkland cleared and then burnt on New Years Eve some years ago. It is possible that the machinery used to clear the property spread the infection, or was contaminated with *Phytophthora*, although dieback is prevalent throughout the Banksia woodland and low-lying damplands to the north of the property (167, 996);
- Bingham Road (167,996) – The vegetation on these properties is part of Bush Forever Protection Area 97. The area covered by these properties is variously affected by dieback, which appears to have been introduced and spread by machinery used for clearing Lot 88 Bingham Road to the south, the Corridor for the gas pipeline, tracks, and firebreaks on the properties. Dieback has altered the vegetation condition, which is Excellent in uninfected and resistant areas, and good to degraded in areas that are infected by dieback. The vegetation on the sandy ridges is comprised of woodland of *Banksia attenuata* and *B. menziesii*. *Melaleuca preissiana* is growing scattered amongst the Banksia species in the depressions, with *Xanthorrhoea preissii* dominating in the understorey. Linear fronts of Banksia death along tracks, firebreaks and the gas pipeline are evidence of dieback infection. Fronts of death are also present in transitional vegetation surrounding the swampy areas. In the south, the species diversity of low-lying depressions is greatly reduced, leaving yellowing plants of *Xanthorrhoea preissii* as the most dominant species. Three swampy areas are located along the eastern boundary of the properties, and support medium closed heath dominated by *Calothamnus lateralis, Pericalymma ellipticum, Adenanthos obovatus*, and *Hypocalymma angustifolium.* While these

species are mostly dieback resistant, their lower position relative to areas infected by dieback infers that they too are likely to be infected by dieback;

- Gaston Road (169) – The vegetation on this property is part of Bush Forever Protection Area 97. While it is connected to bushland on Bingham Road (167), it is discussed separately as the vegetation is comprised of a mosaic of types consisting of dieback resistant species. While many of the species in this vegetation are dieback resistant, the prevalence of dieback on the adjacent property (167) upstream indicates that the fungus, *Phytophora cinnamomi* is highly likely to be present in the soils and water on this property;
- Gaston Road (170) – This property is considered to be dieback infected. The owners report that when they bought the property 23 years ago, the Banksia trees on the sandy ridge to the west were dead or dying; and
- Bingham Road (3580, 4043, 165) and Muchea South Road (172, 171, 168, 997, 998, 32, 33) – These properties have mostly been cleared of native vegetation, or are sparsely vegetated with patches of dieback resistant species. As such, their dieback status could not be determined from visual indicators. However, because of their close proximity to locations 5202, 170, 169, 167 and 996, and their location mostly downstream of these locations, it is inferred that the soils and water on these properties are likely to carry vectors of dieback infection. These properties are therefore classified as dieback uninterpretable.

Other disease

Other pests and diseases, for example, eucalyptus borers, may exist along the Corridor alignment. The roadworks are unlikely to cause the spread of such pests or diseases.

3.8 Fauna

Bamford Consulting Ecologists completed a reconnaissance site survey of the area in early January, 2005. The full report is contained in Appendix G.

Information on the likely presence of particular fauna species as found in WA Museum specimen records (WA Museum on-line database “Faunabase”) and the threatened fauna database maintained by the DEC was correlated with lists of threatened species as indicated by a range of sources as discussed below.

3.8.1 Conservation Significance of Species

The conservation status of fauna species is assessed under Commonwealth and State Acts such as the *EPBC Act* and the Western Australian *Wildlife Conservation Act 1950*. The significance levels for fauna used in the *EPBC Act* are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994). The *Wildlife Conservation Act 1950* uses a set of Schedules but also classifies species using some of the IUCN categories. These categories and Schedules are described in Appendix G.

The *EPBC Act* also has lists of migratory species that are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). Those species listed in JAMBA are also protected under Schedule 3 of the *Wildlife Conservation Act*. In addition, Environment Australia has supported the publication of reports on the conservation status of most vertebrate fauna species e.g. reptiles (Cogger *et al*., 1993), birds (Garnett and Crowley, 2000), monotremes and marsupials (Maxwell *et al.,* 1996), rodents (Lee, 1995), bats (Duncan *et al.,* 1999) and freshwater fish (Wager and Jackson, 1993); while the Threatened Species and Communities Section of Environment Australia has produced a list of Threatened Australian Fauna (Environment Australia, 1999), although this list is effectively a precursor to the list produced under the *EPBC Act*. These publications also use the IUCN categories, although those used by Cogger *et al.* (1993) and Wager and Jackson (1993) differ in some respects as these reports pre-dates Mace and Stuart's review (1994).

In Western Australia, DEC has produced a supplementary list of priority fauna, being species that are not considered threatened under the WA *Environmental Protection Act* but for which the Department feels there is cause for concern. Some priority species, however, are also assigned to the IUCN Conservation Dependent category. Levels of priority are described in Appendix G.

Fauna species included under conservation acts and/or agreements are formally recognised as of conservation significance under State or federal legislation. Species listed only as priority by DEC, or that are included in publications such as Garnett and Crowley (2000) and Cogger *et al*. (1993) but not in State or Commonwealth Acts, are also of recognised conservation significance. In addition, species that are at the limit of their distribution, those that have a very restricted range and those that occur in breeding colonies, such as some waterbirds, can be considered of conservation significance, although this level of significance has no legislative or published recognition and is based on interpretation of distribution information. The WA Department of Environmental Protection (2000) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Perth's Bushplan (now Bush Forever).

On the basis of the above comments, three levels of conservation significance are recognised in this report:

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.

Conservation Significance (CS) 2: Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by DEC.

Conservation Significance (CS) 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

The following species, which may occur in the Corridor area, are listed as being of conservation significance:

Invertebrates

In general, the invertebrate fauna of a region is too species rich and poorly understood for a review to be carried out in the manner that can be conducted for vertebrates. However, DEC's Threatened Fauna Database provides a list of threatened invertebrates of the general region. The only listed species is the Priority 4 South-West Freshwater Mussel *Westralunio carteri* that is considered to be common in freshwater rivers and streams, and permanent, freshwater lakes, in the region. It is probably present in any permanent wetlands along the route. In addition, the Endangered Graceful Sunmoth, *Symenon grantiosa* (Castniidae) has been recorded in the Neerabup area (Dr T. Houston, pers. comm.) and therefore could be present. The habitat requirements of this moth have not been well researched or documented.

Freshwater Fish

The general region of the project area supports 9 native and at least 1 introduced species of freshwater fish. The majority of these freshwater fish rely on permanent water and are therefore confined to rivers and other permanent wetlands, although several species disperse widely when water levels are high and breeding occurs in seasonal wetlands adjacent to permanent sites. Two species, however, the Black-striped Minnow (*Galaxiella nigrostriata*), and possibly the Mud Minnow (*Galaxiella munda*), can survive in seasonal wetlands by sheltering in the burrows of freshwater crayfish (Morgan et al*.,* 1998). These two species are common within a restricted area of the extreme South-West, but small, isolated populations are known from the Muchea to Gingin region. The species are classed as Priority 1 (Black-striped Minnow) and Vulnerable (Mud Minnow) by DEC, but the isolated northern populations are particularly noteworthy.

The population of the Black-striped Minnow is in a wetland in State Forest between Warbrook and Cooper Roads, and therefore west of the highway alignment. The known population of the Mud Minnow is associated with Chandala and Lennard's Brooks near Gingin so is not known within the study area, although the possibility exists that it may be present. Both species are sensitive to changes in water levels.

Frogs

Twelve species of frogs may occur in the project area. None of the frog species are of conservation significance, although the Spotted Burrowing frog (*Helioporus albopunctatus*) is close to the southern limit of its range in the region. Species with aquatic larvae are sensitive to changes in wetland water levels, while the dispersal away from wetlands outside the breeding season that is an important stage in the annual cycle of several species could be affected by road development.

Reptiles

The Study Area is located in a region of high reptile diversity, with a total of 51 species expected. Species of conservation significance are as follows:

Conservation Significance Level 1.

- Short-necked or Western Swamp Tortoise (*Pseudoemydura umbrina*). Classed as Schedule 1 and as Critically Endangered, the natural wild population of this species is confined to Ellenbrook and Twin Swamps Nature Reserves, some 5.3 km and 2.6 km to the south-east and east of the Corridor respectively. Suitable wetlands may have occurred within the project area, but were probably altered during clearing. The species could be sensitive to alterations in groundwater levels, although levels in the wetlands where it survives are maintained artificially; and
- South-West Carpet Python (*Morelia spilota imbricata*). Classed as Schedule 4 and in the area probably confined to large tracts of native vegetation west of the project area, and along the Darling Scarp well to the east.

<u>Conservation Significance Levels 2 and 3.</u>

The Black-striped Snake (*Neelaps calonotos*) is classified as Priority 3. The skink (*Lerista christinae)* are listed by Cogger et al. (1993) but are no longer included in other lists. Both, species, are close to the limit of their distribution in the project area. A further six species are considered to be of Conservation Significance Level 3 because they are at the limit of their distribution in the project area.

Birds

Because of the mobility of birds, almost 200 species could be expected to be recorded in the project area over time, but many of these would be vagrants of little or no significance from a conservation and impact perspective.

Birds of conservation significance are:

<u>Conservation Significant Level 1</u>

- Carnaby's Cockatoo (Calyptorhynchus latirostris). (Endangered under the *EPBC Act, Wildlife Conservation Act 1950* and by Garnett and Crowley, 2000). This species is likely to use the area on a seasonal basis as a food resource, as it feeds on the seeds of eucalypts, banksia and casuarina species. There are recent reports of the species breeding on the Swan Coastal Plain in the Yanchep area (R. Johnstone, pes. comm.). It nests in large tree hollows and formerly bred only in the Wheatbelt where much of its breeding habitat has been cleared. Roosting trees used by Carnaby's Cockatoo have been identified on Lot 110 Gaston Road;
- Baudin's Cockatoo (*Calyptorhynchus baudinii*). (Endangered under the *EPBC Act*, *Wildlife Conservation Act 1950* and by Garnett and Crowley, 2000). This species may utilise the area for food resources, as it feeds primarily on the seeds of eucalypts;
- Australasian Bittern (*Botaurus poiciloptilus*) (Classified as Vulnerable under the WA Wildlife Conservation Act and Garnett and Crowley, 2000). Possibly present in wetlands vegetated with rushes such as occur west of the project area;
- Peregrine Falcon (*Falco peregrinus*). (Other Specially Protected Fauna under the *Wildlife Conservation Act*). This species may forage over the study area and may also utilise available

nesting sites such as old Raven (*Corvus coronoides*)and Wedge-tailed Eagle (*Aquila audax)* nests (Johnstone and Storr, 1998). At least one pair nests in Whiteman Park. Nest sites are important for the species and should be protected when possible; and

- Migratory species under the *EPBC Act*, including the Fork-tailed Swift (*Apus pacificus*), Rainbow Bee-eater (*Merops ornatus*) and all scolopacids. Of these, only the Rainbow Bee-eater is likely to be regularly present. It nests in open areas, often constructing its burrows on sloping paddocks, and is therefore unlikely to be adversely affected by road development.

Conservation Significance Level 2.

- Masked Owl (*Tyto novaehollandiae novalehollandiae*) (southern race classified as Priority 1 by DEC and Near Threatened by Garnett and Crowley, 2000). This species is very infrequently recorded around Perth but is associated with large eucalypts that contain hollows suitable for nesting and roosting. The species may be present in the project area and any trees used for roosting or nesting would be significant;
- Barking Owl (*Ninox connivens connivens*) (classified as Priority 2 by DEC and Near Threatened by Garnett and Crowley, 2000). As with the Masked Owl, the Barking Owl is infrequently recorded around Perth and is associated with large, hollow-bearing eucalypts;
- Crested Bellbird (*Oreoica gutteralis gutturalis*) (Classified as Priority 4 by DEC and Near Threatened by Garnett and Crowley, 2000). The southern race of the Crested Bellbird has declined due to clearing for agriculture and is occasionally reported from the project area, although this appears to be south of its normal range;
- Little Bittern (*Ixobrychus minutus*) (Priority 4 according to DEC). Probably present in wetlands vegetated with rushes such as occur west of the project area; and
- Black Bittern (*Dupetor flavicollis*) (Priority 3 according to DEC). This species has declined greatly in the South-West but was formerly observed in trees overhanging watercourses. There is probably no suitable habitat for it in the project area.

Conservation Significance Level 3

Many of the birds known from the general area are woodland species that are currently recognised as being in decline (Robinson and Traill, 1996), or are listed as significant in the Perth area (Department of Environmental Protection, 2000). These are considered to be of Conservation Significance Level 3. These tend to be species associated with native vegetation that do not disperse readily without corridors of suitable habitat. As noted above, highway development may restrict their movements but could also provide the opportunity to create habitat corridors through agricultural areas.

Mammals

The mammal fauna expected in the project area consists of 24 native and 5 introduced species. Mammal species of conservation significance are as follows:

Conservation Significant Level 1

- Chuditch (*Dasyurus geoffroii*) (Vulnerable under the *EPBC Act*, *Wildlife Conservation Act 1950* and according to Maxwell et al., 1996). A single specimen (a juvenile male) was caught near Ellenbrook in 2001 (M. Bamford, unpubl. data), suggesting that individuals occasionally move onto the coastal plain in this region, probably coming from populations beyond the escarpment where fox-baiting is carried out. This is the only CS1 species likely to occur in the project area, as other species of high conservation significance are regionally extinct; and
- Brush-tailed Phascogale (*Phascogale tapoatafa tapoatafa*) (Vulnerable under the *Wildlife Conservation Act 1950*). Probably locally extinct, but known to occur in Jarrah forests of the nearby escarpment (M. Bamford, pers. obs.);

Conservation Significance Level 2

- Kwoora or Brush Wallaby (*Macropus irma*) (Priority 4 according to DEC and Lower Risk (near threatened) according to Maxwell et al., 1996). This species has been seen regularly in native vegetation west of the project area (M. Bamford unpubl. data) and is abundant in Whiteman Park. Deaths caused by vehicle impacts may increase because of the construction of the highway and this may pose a threat to populations in nearby native vegetation; and
- Quenda or Southern Brown Bandicoot (*Isoodon obesulus fusciventer* (classified as Priority 5 by DEC and Lower Risk (near threatened) according to Maxwell et al., 1996). The Quenda is present in native vegetation west of the project area but this is the northern limit of its range in the region. It favours dense vegetation around wetlands. Without a detailed site inspection of the final alignment, it is not possible to determine if the highway will pass through any existing populations or not. Further fauna investigations will be required in the future, once the final alignment has been defined.

3.9 Landuse

The Corridor for the proposed PDNH is subject to a range of landuses that will be directly or indirectly affected by the highway.

The majority of the properties in this area are used for agriculture, primarily for cattle grazing and hay production. There are some horticultural properties, including a strawberry farm and two nurseries. A few landowners utilise their properties solely as residences and there are some vacant (unused) properties.

Within these broad areas there are specific sites that have particular status or economic values or may be subject to legislative and approval requirements. These are summarised below.

Table 6 Specific Land Uses

Chainages	Description
16 350 – 16 750	Bush Forever site
20 095 – 21 000	Turf farm
21 000 – 25 000	Defence leasehold land (former 3TU and buffer)
24 750 – 25 300	Bush Forever site
24 750 – 25 300	Horticulture- strawberry farm
26 200 – 26 500	Bush Forever site
29 900	Muchea South Road and Midland Railway crossing

3.9.1 Bushland with Conservation Significance

Bush Forever

Bush Forever is a ten year strategic plan (2000-2010) to protect some 51,200 hectares of regionally significant bushland in 287 Bush Forever Sites, representing, where achievable, a target of at least 10% of each of 26 original vegetation complexes of the Swan Coastal Plain portion of the Perth Metropolitan Region.

Three Bush Forever sites were identified as intersecting the 500 m wide PDNH Corridor and are mapped in Figure 7, Appendix A. The sites are listed below from south to north.

Site 13: Sawpit Road Bushland, Bullsbrook

The eastern section of the Corridor intersects the western section of this site. However, the Preferred Alignment does not intersect this site.

Site 100: Neaves Road Creek, Bullsbrook

The Corridor crosses the Neaves Road Creek just north of Neaves Road. Other tributaries of Neaves Road Creek are also crossed by the Corridor, although these are not considered in the Bush Forever plan.

Site 97: Kirby Road Bushland, Bullsbrook

The Corridor crosses the Kirby Road Bushland site where it juts out eastwards into location 1662. This site is subject to protection under the Commonwealth *Environmental Protection and Biodiversity*

Conservation Act 1999 and contains a Threatened Ecological Community. The Preferred Alignment has been shifted to the east of the TEC, therefore reducing impacts on Bush Forever Site 97.

Table 7 Summary of Attributes of Bush Forever Sites Impacted by the Preferred Alignment

Site	Landform and Soil Type	Vegetation	Significant Flora	Wetland	TEC	Specific Detail	National / International Significance
100	Bassendean Sands and over Guildford Formation	Yanga Complex	None recorded	Part Conservation. Category wetland, mostly Multiple Use.	Not determined	Significant Mammal species (Quenda); Contains Plant Community representative of eastern SCP	Not Listed
97	Bassendean Sands and over Guildford Formation, Holocene Swamp Deposits	Yanga Complex, Bassendean (North) Complex	None recorded	Some Conservation Category, Resource Enhance-ment and Multiple Use.	Critically Endangered (Tumulus Springs)	Very Good Vegetation Condition, part of a regionally significant contiguous wetland / bushland	Subject to protection under the Commonwealth *EPBC Act 1999*

3.9.2 System 6 and Other Reserves

System 6 Conservation Reserves covers the area allocated to the Darling System, and was initiated to identify opportunities for setting aside areas of land in the most intensively used part of Western Australia, for the purposes of conservation of natural areas and recreation in natural surroundings. The recommendations made by the System 6 Study predate the Bush Forever programme, but cover a larger area, incorporating a significant amount of the Darling Range and areas well outside the MRS boundary.

The Corridor does not intersect any System 6 Reserves. It may, however, indirectly affect reserves via catchment disturbance. The Corridor will intersect the catchment of two 'A' Class conservation areas:

- Ellen Brook Nature Reserve: A 27620 – 10 km S of Bullsbrook (~5.3 km to the south east of the Corridor); and
- Twin Swamps Wildlife Sanctuary: A 27621 – 6 km S of Bullsbrook (2.6km east of the Corridor).

These two Reserves are known to harbour the Western Swamp (Short-Necked) Tortoise, *Pseudemydura umbrina*¸ one of Australia's most endangered reptiles, protected under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*.

3.10 Potentially Contaminated Sites

The *Contaminated Sites Act 1993* came into effect in December 2006. Under the Act, known or suspected contaminated sites must be reported to the DEC. A search of the DEC's Contaminated Sites Database in February 2009 identified three registered sites within the Bullsbrook-Muchea area. Contamination at these three adjacent sites relates to hydrocarbons present in the groundwater and soil resulting from a fuel dispensing facility on Lots 8 and 9 Brand Highway, Muchea. Various restrictions apply to the access of soil and abstraction of groundwater at these sites. Given the distance of the PDNH Corridor from these sites, it is unlikely that contamination at this site will present a risk to the highway.

In 2004 the Department of Environment and Conservation's 'LEGACI' database was accessed to ascertain potentially contaminated sites within the Corridor (database no longer available/in use). Table 8 provides a summary of potentially contaminated sites identified within the Corridor through the database search.

Table 8 Identified Potentially Contaminated Sites in the Corridor

Location Number	Site ID	Activity	Category	Activity Detail
105	21002479	Piggery	Animal Based Wastes	Up to 150 Pigs

4103	21002481	Piggery	Animal Based Wastes	Up to 150 Pigs
4319	21002483	Piggery	Animal Based Wastes	Up to 150 Pigs

Possible contaminated sites that have not been recorded by the Department of Environment and Conservation were also identified during the field surveys. These sites are listed in Table 9.

Table 9 Possible Contaminated Sites identified During Field Survey

Location Number	Activity	Possible Contaminant
109	Turf farm	Pesticides
4043	Strawberry farm	Pesticides

3.11 Public Risk and Safety

There are few issues along the PDNH Corridor that would pose a threat to the public or to personnel engaged on the construction of the highway. The following potential issues are discussed:

3.11.1 Unexploded Ordinance

Previous studies for the project have not assessed the possibility of unexploded ordinance (UXO) along the Corridor. Due to the proximity of Defence Estate land to the Corridor it was decided to consider this issue.

The Fire and Emergency Services Authority of Western Australia (FESA), was contacted and provided with a map of the Corridor. They have confirmed that the Corridor does not pass through any areas of UXO concern.

3.11.2 Natural Gas Pipeline

The proposed PDNH Corridor does not cross the Dampier-Bunbury Natural Gas pipeline (DBNGP) at any point. It passes approximately one kilometre to the east of it at its closest point near the MRS boundary.

3.11.3 Air and Rail Safety

The proposed PDNH Corridor passes close to the Pearce RAAF air base and under the flight paths of trainer aircraft. There is therefore possibly a slight increase on the average road use risk of impacts from aircraft crashes.

The Corridor crosses the Midlands Railway line at Chainage 29 900. The PDNH will pass over the railway line but there could be a slight increase in the risk of crashes or chemical spills on the railway line impacting road users.

3.12 Visual Quality

3.12.1 General Visual Characters of the Corridor Area

The proposed PDNH crosses a section of the Bassendean Dune system and Guildford Formation on the eastern portion of the Swan Coastal Plain. There is little topographic relief in the area with the only changes in visual quality due to the occurrence of a series of damplands of varying quality, small patches of remnant vegetation and some areas of irrigated pasture and other intensive agriculture. There are however, more distant views to the Darling Scarp

DEC has characterised regions of the State into distinctive landscapes in 'Reading the Remote' (DEC, 1994). DEC has classified various visual quality elements of differing regions broken down into landform, vegetation and waterform. Under their classification the following qualities are likely to be present along the Corridor.

Table 10 Visual Quality Elements Present Along the Corridor

Landform	Vegetation	Waterform
Gently inclined or level areas with distinctive drainage patterns e.g. Pinjarra Plain HIGH SCENIC QUALITY	Scattered remnant vegetation forming an open parkland. HIGH SCENIC QUALITY	All estuaries, wetlands and swamps. HIGH SCENIC QUALITY
	Vegetation patterns found commonly in the surrounding landscape. MODERATE SCENIC QUALITY	Intermittent watercourses with long stretches of unchanging flow characteristics MODERATE SCENIC QUALITY

Most of these characteristics are not present in any great quantity along the proposed Corridor and visual interest is most likely to be gained from land development activities such as irrigated agriculture.

3.12.2 Views from the Highway

The only views of significance are likely to be more distant views to the Darling Scarp.

3.12.3 Views to the Highway

View to the highway from other locations are likely to be only relevant to nearby residents as there are no rises or other viewing places from where views would be impacted.

3.13 Ambient Air Quality

At present there is very little air pollution in the region that the proposed PDNH traverses because the alignment has been set predominantly through rural land. There is little emission produced from traffic or other sources in the region, as there are mostly only minor roads, which carry mainly local traffic, and there are no areas of industry.

No air quality monitoring has been carried out but modelling on the likely air pollution risks are outlined below.

Air Quality Screening Assessment

Methodology

At present in Australia, there is limited detailed data on emissions specifically from motor vehicles, due the absence of a mandatory program of testing vehicles for emissions.

Because of the lack of detailed local data, the emissions data provided by CTEMFAC, a model produced by CalTrans that provides speed based composite emission curves for a pre-defined fleet mix, was used to estimate air emissions for the PDNH. In this case it must be noted that modelling was based on scenarios including very high numbers of trucks (24% to 28%) and a lack of vehicle inspection and maintenance. To provide a level of conservatism in this emissions estimate, modelling also assumed that Western Australia is some 15 years behind the leading edge situation in California and that therefore the appropriate year for entry into the EMFAC model was 2006.

Outputs for the important vehicles mixes are shown in Appendix H and the input parameters are also shown in that appendix.

Modelling was undertaken using Caline4 in a screening configuration where a 1 km section of road was established and a transect of receptors was modelled away from the road. The transect was established perpendicular to the road out to a distance of 100 m.

Meteorological conditions were set up to be worst case with a mixing height of 50m, typical of an early winter morning. The worst case hour of traffic activity was entered by using an extremely conservative 20% of the projected daily traffic. Note that the worst case traffic hour is usually considered to be 0800 to 0900, whereas the worst case meteorological period is usually earlier in the morning. Therefore the model as set up is doubly conservative.

The model was run for carbon monoxide, oxides of nitrogen and particulate matter. Particulate matter models were run with the emissions multiplied by 10 in order to increase model sensitivity to meet National Environmental Protection Measure (NEPM) levels.

Results of Modelling

Carbon Monoxide

Under these worst case traffic and meteorological conditions the level of carbon monoxide did not exceed 1 ppm for the worst case hour even 10m from the road. This is considerably lower than the 9 ppm standard set for the NEPM, which is in any case set for an 8 hour averaging period. It is considered highly unlikely that this section of road would ever produce sufficient carbon monoxide to require any further assessment.

Oxides of Nitrogen

Maximum levels of NOx found at the Neaves to Brand Highway section are 600 parts per billion (ppb). If this were entirely nitrogen dioxide, this would exceed the NEPM standard, however under these meteorological conditions the proportion of nitrogen dioxide present in the NOx would be considerably less than 10%. Even assuming a conservative proportion of 10% this gives a concentration below the NEPM value of 120 ppb for a one hour value.

Particulate Matter

Modelling indicates that the maximum 1 hour contribution from the road would be 30 µg m^{-3} and this compares with a NEPM level of 50µg m^{-3} over an entire day.

Conclusions

This screening model has a number of inadequacies relating to the lack of reliable local data for motor vehicles emissions. However the application of emission factors derived in conservative manner to a model set up in a conservative manner produces modelled concentrations that are considerably below NEPM standards. It is concluded that the relatively small amounts of traffic projected for this road will not impact local air quality to an extent warranting any further assessment.

3.14 Noise

A preliminary, desktop, noise assessment of the receiving environment and a background noise monitoring assessment was carried out by Herring Storer Acoustics. The preliminary study considered the likely characteristics of the proposed highway and its use (seal type, traffic volumes, traffic breakdown etc.) and modelled the noise and its potential effect on noise sensitive premises along the Corridor. From this modelling, a small number of possibly sensitive premises close to the proposed highway were chosen for monitoring. Once the buildings were verified in the field as sensitive (i.e. a residence) they were used as monitoring points. The monitoring points were used to establish the

existing acoustic environment. Monitoring was carried out to determine the noise rating as per the Main Roads Western Australia 'Noise Level Objectives'; to determine the appropriate objective for assessment.

A full report on the noise assessment is attached at Appendix I and the potential noise impacts of the highway are discussed in Section 4.12.

4. Environmental Impacts and their Management

As a result of the desktop assessment of environmental aspects and issues a range of actual and potential impacts on the environment can be identified.

The impacts range in significance, with the most important potentially requiring referral of the project to the Department of the Environment, Water, Heritage and the Arts under the *Environmental Protection and Biodiversity Conservation Act 1999*, others requiring referral to the State Environmental Protection Authority under the *Environmental Protection Act 1986* and less significant impacts requiring detailed management strategies and/or public and community consultation. The discussion below gives details of the potential impacts of the highway on each major issue examined and gives a brief summary of the possible management strategies required to avoid or minimise the impacts. The significant issues, and any further requirements for their investigation, approval and management are summarised in Table 12, at Section 7.

4.1 Acid Sulphate Soils

4.1.1 Potential Impacts

It is probable that works in some sections of the project area will disturb soils with acid generating potential.

Figure 4 (Appendix A) shows areas of AASS and PASS and their risk categorization. The Corridor traverses areas of soil classified as Moderate risk along the majority of its length. Small areas of High-risk soils occur where the Corridor crosses wetlands immediately north of Maralla Road and at Stock Road.

ASS will be an environmental issue for the PDNH where these soils will need to be disturbed in earth-working activities such as footings for bridges and culverts or areas of cut.

4.1.2 Management

In light of the recent emergence of Acid Sulphate Soils (ASS) as a significant and substantial risk to the Western Australian environment, the Department of Environment and Conservation's preferred approach is to characterise ASS materials in situ prior to commencement of development works in order to enable an effective management and treatment plan to be developed before the commencement of earthworks. Works in areas suspected of containing ASS require an acid sulphate soil investigation to be undertaken and a comprehensive acid sulphate soil management plan to be developed and implemented.

As such, a thorough investigation, including sampling and laboratory analysis, would be required in those areas designated as "High" and "Moderate to low" risk prior to commencement of works for the highway

route in order to properly ascertain the potential risk to the surrounding environment and enable appropriate management strategies to be developed. In the southern part of the PDNH, ASS is potentially present as a “High” or “Moderate to low” risk over some 95% of the Corridor. However, of this area, a lesser percentage will be subject to ground disturbance as much of the highway is likely to be built above the existing soil levels.

The DEC has provided a range of guidelines on the investigation, assessment, treatment and management of ASS (Department of Environment, 2004 a, b and c). They have also produced a guideline on the preparation of an acid sulphate soils management plan (ASSMP) (Department of Environment, 2003). These guidelines will be used when developing a plan for the management of ASS and groundwater which will possibly be encountered during construction.

4.2 Groundwater Supplies

There are no public drinking water source protection areas within the vicinity of the PDNH Corridor. However, landowners currently extract water for a range of agricultural and domestic purposes.

The Department of Defence borefield at Location 172, just north of Neaves Road, will be directly impacted by the PDNH. One of the 9 bores would be removed as a result of the highway. Defence (Boyd Wykes, pers. comm.) has indicated that they are currently negotiating with the Water Corporation to obtain water supplies via the reticulation system, which will phase out the requirement for the borefield. However, at this stage, the borefield is still in use.

4.3 Surface Hydrology and Wetlands

4.3.1 Land Drainage

The construction of the PDNH will intersect surface drainage flow in some areas. Where drainage is defined this can be generally managed through flow modelling and culvert design but as the highway will need to be built up considerably in some areas due to seasonal waterlogging, there is potential for alterations to localised sheet flows. This alteration may result in ponding, new areas of waterlogging or changes to water levels in ‘downstream’ swamps and damplands.

4.3.2 Wetlands

Wetlands provide important functions with regard to hydrological function and linkage, water purification, flora biodiversity and fauna habitat.

The Corridor intersects three wetlands that are listed as EPP Lakes, as well as five which have been allocated a Conservation management category.

These listings require that specific approval will be required in order to disturb the wetlands or lakes, including where the PDNH development impacts land within 50 m of the designated wetland boundary.

Where possible, wetland areas should be avoided but where that is not possible approval to disturb the areas will require detailed management commitments with regard to vegetation removal, soil movement, hydrological function and pollution.

4.3.3 Risks of Water Pollution

The construction and operation of the PDNH has the potential to create water runoff and pollution issues in relation to the adjacent wetlands along the Corridor. Extra water runoff from the road surface, collection of the runoff into drains and its diversion into adjacent low points can conflict with the management requirements for the listed and protected wetlands. Apart from the extra water, the runoff may carry pollutants in the form of hydrocarbons, fertilisers and any spills of chemicals. Pollution may also reach wetlands in the form of atmospheric deposition of air-borne pollutants.

Risks of adverse impacts to wetlands will be high when the PDNH runs close to sensitive wetlands, where runoff can flow directly from the road into the wetland and where the wetland is close enough to be subject to atmospheric deposition of pollutants.

Pollutants may change the water quality of the receiving wetlands, which will impact on the organisms that rely on this water. The impact on the plants and animals will range from minor impacts, such as loss of productivity, to major impacts, such as organism mortality and reduction in the biodiversity of the system. If runoff contains fertilisers then the increase of nutrients in the system may lead to algal blooms, eutrophication and subsequent death of many wetland species.

The greatest pollutant risk to wetlands is in the case of accidents on the highway involving chemical spills or the release of other major pollutants, such as fuels. If a road accident leads to the addition of poisonous substances to sensitive wetlands, the consequences could be major and could result in deaths of plants and animals and significant damage to the ecosystem. However, the risk of accidents impacting wetlands will be low if suitable clean-up procedures are put in place following any incident.

Even if the runoff does not contain major pollutants the extra water entering the wetland may result in changes in ecosystem function and could potentially change the species structure of the system. Extra water could result in the waterlogging and death of some plant species and the subsequent dominance of other species that can tolerate greater water levels.

In general, there should be low risk of severe pollution to wetlands, providing suitable management strategies, such as the addition of pollutant traps, are implemented.

4.3.4 Management of Surface Hydrology and Wetlands Impacts

The selection of the highway alignment can minimise the impacts on sensitive wetlands by avoiding them as much as possible. Where the PDNH must pass near significant wetlands a buffer should be retained. The buffer reduces risk of contaminated run-off and atmospheric deposition of contaminants polluting the wetland. The recommended minimum buffer width for development adjoining wetlands on the Swan

Coastal Plain is 50 m with the ideal buffer being at least 200 m. This is particularly important for the EPP lakes at Maralla Road and Warbrook Road.

The Corridor is in close proximity to a number of Conservation Category wetlands at the Neaves Road interchange. One of these wetlands, located on the southern side of Neaves Road, may be directly impacted by the Preferred Alignment. Other Conservation Category wetlands in the vicinity are within the road reservation however are not expected to be significantly impacted by the PDNH alignment, however appropriate management techniques will need to be considered during the design and construction phases to minimise impacts on the hydrology and water quality of these wetlands.

Impacts on wetlands can also be minimised by constructing the highway on already cleared land. Clearing vegetation adjacent to a wetland will impact the basin hydrology of wetlands through increasing runoff and reducing the sediment trapping capacity of the buffer lands.

Further management of impacts on wetlands can be determined at the design stage. This should include:

- Determining environmental risks and water quality objectives;
- Identification of pollutant sources and estimation of pollutant loads;
- Identification of pollutant transport processes;
- Assessment of potential pollutant control devices; and
- Assessment of potential pollutant removal.

Potential management strategies include:

- Use of natural drainage networks such as contours and the natural stormwater system;
- Where it is not possible to utilise existing natural drainage features, artificial ones should be created, such as pipes, culverts and engineered swales;
- Use of natural vegetation to promote filtering and slow run-off;
- Use of structures to manage stormwater quality, such as detention basins, infiltration retention systems, pollutant traps, table drains and buffer strips;
- The drainage system should allow for incorporation of fauna corridors and potential bridging options and culvert modifications to facilitate the movement the fauna; and
- It is important that there be ongoing consultation with DEC for the assessment of impacts on wetlands and the determination of management measures and impacts on Conservation and Resource Enhancement wetlands. The DEC should be consulted with regard to drainage design and their requirements for the protection of specific wetlands.

Further hydrological modelling is required to determine the areas where surface flow may be affected by the PDNH and to design and provide management features or structures. This is particularly important in

the areas of the Corridor alignment where the palusplain is seasonally inundated. The areas that are prone to flooding should have hydrological modelling carried out to determine management systems, such as culverts and drainage lines, to prevent ponding near the road or erosion due to heavy flows through culverts.

The location of the PDNH near creeklines and wetlands will also require management to prevent water-borne pollutants impacting on these sensitive environments. Drainage structures will need to be carefully designed to avoid risks to adjacent wetlands and any high value agricultural land such as that used for horticulture.

As the proposed PDNH will be unkerbed there will be infiltration at the point of source; this must be taken into account when undertaking runoff management.

4.4 Erosion

Erosion of sandy soils on the coastal plain, particularly in relation to drainage lines and creek crossings such as at Neaves Road Creek, is a moderate but manageable risk. Runoff from the road and associated embankments will change local hydrology in that it will increase and concentrate flows in some areas and this may create erosion channels where flows run down towards wetlands and creeks. Again, careful hydrological modelling and drainage design will minimise the risks of erosion from road runoff. Detention basins will be required upslope of sensitive creek and wetland zones and buffer vegetation could be enhanced or re-created.

There is also a small risk of wind erosion of sandy soils on the coastal plain. The Corridor traverses light, erodible soils across much of its length. Construction management measures will be required to minimise the risk of wind erosion, mitigate any effects and provide long-term solutions through rehabilitation and revegetation.

4.5 Vegetation and Flora

Given that much of the vegetation within the Corridor has been previously cleared for agriculture, the remaining vegetation has a relatively greater value due to its rarity. Vegetation communities on the heavier soils on the eastern side of the Swan Coastal Plain have been particularly depleted and any remnants are generally of high value. Loss of vegetation has a number of actual and potential impacts:

- Loss of flora and fauna biodiversity;
- Loss of fauna habitat;
- Changes to drainage;
- Increasing risks of water and wind erosion; and
- Loss of visual appeal.

4.5.1 Vegetation Clearing

The amount of native vegetation that may need to be cleared as a result of the construction of the PDNH is estimated at around 14.0 ha. This is based on a measurement of approximately 2000 m of alignment passing through native vegetation and an indicative clearing width of 70 m. This clearing width could vary in some areas, due to cut and fill requirements, interchanges and retention of roadside vegetation. Usually a Permit to clear native vegetation is required under the *Environmental Protection Act 1986,* to gain approval for any clearing greater than one hectare. However, if the Environmental Protection Authority (EPA) assesses the project a clearing permit will not be required if the clearing is included as part of the approved activities.

4.5.2 Significant Flora and Vegetation Communities

Significant Flora

Disturbance to Declared Rare Flora, either through direct clearing or as a result of changes to its habitat, are breaches of the *Wildlife Conservation Act 1950* and require consent from the Minister if they are to occur without penalty. Populations of *Grevillea curviloba* subsp *incurva* are known to occur within the Corridor. These populations will need to be resurveyed closer to the time of construction to determine the impacts of the Preferred Alignment.

TECs

The Refined Alignment ran between two recorded occurrences of the tumulus springs TEC. Hydrological information on the tumulus springs is limited, however they are believed to be fed by a complicated network of conduits. The top of the Gnangara Mound is located to the west of the springs and water flows in a number of directions from this point, including eastwards, and supplies the groundwater to the springs. It is essential that the level of the watertable in the Gnangara Mound provides an adequate head of pressure to drive the springs. Changes in the level of the water table are likely to influence the hydrology of these wetlands as they are likely to be almost entirely dependent on groundwater for water supply.

It is understood that the capture zone for the spring is aligned west-north-west from the spring, and should incorporate a nominal 30 degree arc to allow for uncertainty and seasonal fluctuations.

Hydrological investigations into the tumulus spring indicated that the Refined Alignment would create a barrier between the two springs and potentially impact on the hydrology and water quality. The Preferred Alignment has been shifted to the east of the two tumulus springs to avoid impacts on the TEC catchment.

The Preferred Alignment to the east of the TEC will minimise the impact on hydrology, and potential changes to water quality, however will require management to ensure environmental risks are reduced as far as possible.

The Corridor appears to intersect vegetation types which are very poorly conserved within Western Australia (less than 10% of the original extent remaining). There is a strong requirement by the DEC to avoid clearing such vegetation and there will likely be a further need to survey the area in detail to verify the vegetation type and condition. Removal of the vegetation could trigger special requirements for vegetation replacement and offset packages.

4.5.3 Management of Vegetation Impacts

The most important option for managing vegetation impacts is to minimise the direct and indirect impacts on vegetation. This can be achieved by minimising encroachment on areas of native vegetation when the detailed design is carried out and ensuring existing surface water flows are maintained through the use of culverts and appropriate drainage.

4.6 Weeds and Dieback

4.6.1 Weeds

The vegetation of the Corridor includes numerous areas of introduced weed species, due to its being cleared for agriculture. Among these weeds are some Declared Plant species and other listed pest plants. Such species have the potential to be spread by the highway construction activities and may threaten nearby creeklines, wetlands and remnant bushland as well as agriculture.

Weeds can be spread through road construction activities, such as earth-works, importation of material and vehicle use. There is a risk of spreading very invasive Declared weeds such as *Zantedeschia aethiopica* (Arum Lily) in one section of the route but this can be managed through careful planning, monitoring and treatment.

There is also potential for the spread of Paterson's Curse (*Echium plantagineum)*, Blackberry *(Rubus ulmifolius)* and Cape Tulip (*Moraea flaccida)*, which are also Declared weeds, and non-declared nuisance weeds to be transported from infested areas and introduced into non-infested areas during the construction process. A weed management plan will need to be developed prior to construction.

4.6.2 Dieback

The dieback disease, caused by the root fungus *Phytophthora*, has the potential to kill a range of native and other plant species. The fungus is quite possibly present in remnant bushland along the Corridor and may be present, but not interpretable, in other areas. The fungus can be spread through human activities such as soil movement, vehicle use and changes in drainage as well as through natural water flows. The construction of the highway has a high potential to spread the dieback fungus, if present, to uninfected areas of bushland and to some horticultural crops.

There are existing areas of dieback within the Corridor and much of the remaining vegetation along the Corridor is susceptible to *Phytophthora* infestation.

4.6.3 Management of Dieback Risk

- A detailed assessment for the presence of the dieback fungus should be undertaken closer to the time of construction;
- Susceptible areas of bushland and horticultural crops, which are within and adjoining the Corridor, should be identified; and
- Following an assessment of the presence of dieback management prior to construction, a management plan would need to be developed in consultation with DEC.

4.7 Fauna

The fauna of the general area has been reasonably well studied and a large list of fauna species which are potentially present, or which use the area of the PDNH at some time, is available. Among the species on the list are a number that are of conservation significance, as a result of either International, National or State assessments. Some, such as a number of waterbirds, are protected under Federal agreements such as JAMBA and CAMBA and some migratory species are protected under the *Environmental Protection and Biodiversity Conservation Act 1999*.

4.7.1 Fauna and Habitat Impacts

A number of issues in relation to the highway development are risks to fauna and its habitat:

- There are possible impacts due to changes in water flow and water levels in wetlands;
- There will be loss of remnant native vegetation in areas already substantially cleared, particularly in the south of the project area. This could be significant even at the level of single large trees that provide nesting hollows and act as stepping stones for birds moving across paddocks;
- There is likely to be disruption of movement of fauna across the highway alignment, especially for terrestrial species such as small mammals and reptiles; and
- There is potential for the development of a wildlife corridor through rehabilitation within the road reserve.

Potential Specific Fauna Impacts

- The critically endangered Western Swamp Tortoise occurs at Twin Swamps and Ellen Brook Nature Reserves some 2.6 km and 5.3 km from the Corridor respectively. There is a very slight risk that changes in drainage due to the construction of the highway could impact these habitats. However, it is considered that with good drainage and pollution control design that this risk will be negligible. In

addition, the water levels at Twin Swamps and Ellen Brook are kept artificially stable so it is unlikely that drainage from the highway could produce significant changes;

- There is a low risk of loss of potential nesting trees for Carnaby's Cockatoo within parts of the Corridor. Carnaby's Cockatoo is listed under the *EPBC Act* but it is unlikely that the impact of the highway would be significant, under the terms of the *Act.* Cockatoo roosting trees have been identified within the Preferred Alignment at 110 Gaston Road, Bullsbrook;
- Baudin's Cockatoo – possibly present in the area but at the northern end of its range. Unlikely that the impacts of the highway would be considered 'significant' under the *EPBC Act*;
- Peregrine Falcon – likely to use the area at some time but impacts not likely to be considered 'significant' under the *EPBC Act*; and
- The southern dampland and wetland bush areas are possible habitat of a range of wetland birds and frogs of conservation significance as well as the Quenda.

4.7.2 Management of Fauna Risks

At the alignment definition stage there is little further that can be done to manage fauna except to avoid as much native vegetation as possible, and to avoid impacts on wetlands and waterways. The following actions can be carried out at the time of preparing the highway masterplan, or at the preliminary design stage:

- A detailed field investigation should be undertaken to assess the presence of fauna species and to consider the risks of the highway on habitats, hydrological changes and movement. This will need to be carried out closer to the time of construction and would include trapping and night-time surveys. Focus areas would include good quality native vegetation, watercourses and wetlands;
- If impacts on Carnaby's Cockatoo are considered to be significant at this time, the highway proposal will need to be referred to the Department of the Environment, Water, Heritage and the Arts under the *EPBC Act*; and
- Design of the highway should consider the areas of specific risk to fauna and may need to include fauna underpasses, reduce the highway footprint and provide corridors for rehabilitation.

4.8 Potentially Contaminated Sites

A small number of potentially contaminated sites are within the Corridor area with only one (Location 4319) being directly crossed by the highway alignment. The risks of disturbance of contaminated soils or water within or adjoining these sites is low, due to the fact that the highway will be built above ground level over much of its length and because the possible contamination levels are likely to be low.

Any potential risks for highway construction are small. They may involve removal of contaminated soil to a more suitable location however, given the nature of the highway use, that is unlikely to be required.

Relocation of contaminated soil is generally only required when the new landuse involves risks to residents or land users through direct contact with the soil or water. Although the construction and use of the highway will open up the land to more users, there is a very low risk of direct contact with the soil and some of the possible contamination would be 'sealed' under the road formation.

4.9 Landuse

4.9.1 Agriculture and Horticulture

The majority landuse over the Corridor area is dryland agriculture, involving pasture for grazing and haymaking. Small areas of intensive agriculture include a turf-farm, piggeries and a strawberry farm. The direct loss of the more intensive agricultural areas has a higher economic impact.

4.9.2 Bushland Conservation Areas

The PDNH Preferred Alignment directly impacts two Bush Forever sites. Bush Forever sites have been identified by the State Government as areas which should be protected for conservation purposes and any impacts on these sites are discouraged. The DEC and WA Planning Commission (WAPC) will require detailed consultation and the provision of a land off-set package to replace lost bushland.

4.9.3 Special Uses

Defence Estate Land

The original Corridor intersects the western edge of a section of the Defence Estate formerly known as 3TU. This area surrounds a former Air Force communications station (now decommissioned) and provides a buffer of land which is leased by Defence to members of the public. The area which is intersected by the Corridor is currently used as dryland pasture. The Department of Defence (DoD) are now planning to use the 3TU buffer land for army training, and have expressed strong opposition to routing the PDNH through this area. In consultation with DoD, the route has been adjusted to an alignment along the eastern boundary of its land, adjacent to Raphael Rd, which is a shift of around 600 m east of the initial Corridor. This alignment minimises impacts on the DoD land.

GHD has investigated the suggested option. This involved site investigations and consultation with the landowners that are located to the west of Raphael Rd, and who may be indirectly impacted by this option. Environmentally there are no major issues with potentially moving the PDNH. Both areas of the Defence land are degraded and weed infested. The greatest potential environmental impacts of the highway in this area will be impacts on wetlands and on the catchment of Ellen Brook. With the alignment is located in the eastern section of the Defence property there may be greater impacts on the wetland areas to the east of Raphael Rd and those just north of Stock Rd West. However, these impacts can be mitigated through drainage works and pollutant controls.

Railway

The PDNH crosses the Midland railway near the northern boundary of the MRS. There is minor potential for contamination within the railway land and risks for construction and operation of the highway over the railway but these can be managed using proven designs and safeguards and should not constrain the project.

4.10 Visual Impact

There are likely to be few significant impacts on visual quality as a result of construction of the highway in this section. The highway will be of most concern to local residents, potentially because of the need to build the road carriageway up in winter-wet palusplain zones. In order to mitigate the impacts to local residents a range of landscaping options may need to be developed.

The visual impact on landowners was determined during the social consultation period and areas of major concern were assessed. There are a number of landowners who expressed concern over the visual impact that the proposed PDNH would have on their residence. Landowner concerns, and possible mitigation strategies, are outlined in the Social Issues Report completed by GHD in December 2004.

Visual impact is affected by loss of vegetation and this aspect is also constrained through requirements to minimise vegetation loss for flora and fauna preservation reasons. Highway design can affect visual impact through batter slopes and design, choice of materials and fittings, bridge and culvert design and allowance for revegetation.

Prior to detailed design and construction, a Landscape and Visual Impact Management Plan should be developed.

4.11 Air Quality

This screening model has a number of inadequacies relating to the lack of reliable local data for motor vehicles emissions. However the application of emission factors derived in a conservative manner to a model set up in a conservative manner produces modelled concentrations that are considerably below NEPM standards. It is concluded that the relatively small amounts of traffic projected for this road will not impact local air quality to an extent warranting any further assessment.

4.12 Operational Noise and Vibration Impact

The desktop noise assessment considered the existing potentially noise sensitive premises along the Corridor and modelled the noise output of the proposed PDNH. Due to a lack of background data, some assumptions were made regarding traffic breakdown and daily traffic spread. The model is also only valid for flat ground at this time and therefore more detailed analysis may alter the outcomes. Of the 46

buildings that were assumed to be noise sensitive premises, all are considered to be in low ambient areas. Of these 46 residences, 12 are calculated to exceed the 63 dB(A) $L_{10(18hour)}$ base objective.

For Main Roads Western Australia 'Noise Level Objectives' criteria, noise received at a residence located adjacent to the proposed PDNH should be designed to meet an L_{Aeq} for the day and night periods of 63 dB (A) and 55 dB(A) respectively. Future environmental investigations should examine where exceedences of these noise levels will occur. Once the areas of exceedence have been determined, noise control strategies, such as noise walls, can be used to manage this issue.

The full noise reports are included in Appendix I.

4.13 Construction Issues

4.13.1 Noise and Vibration

A number of structures within close proximity to the highway may be impacted by noise and vibration as discussed below.

Vibration and low frequency noise impacts are commonly confused because low frequency noise commonly resonates with building components to generate a vibration like effect. However, the two are quite different with the latter unlikely to cause any significant structural damage. Trucks of any size are unlikely to cause significant ground borne vibration and most concerns that are expressed usually relate to resonation impacts.

Ground borne vibration impacts are possible due to road construction activities. Buildings within a zone of 50 m of rock breaking or heavy earthmoving works could be at risk but beyond that distance it is unlikely that vibration impacts would be sufficient to cause damage.

Ground borne vibration caused during construction can lead to structural damage if the particle velocity (mm/sec) exceeds certain limits that are reasonably well understood. The Australian Road Research Board report developed by Tynan (1973) reported the following separation distances for vibrating rollers on behalf of ARRB.

Table 11 Separation Distance for Vibration Risks to Structures

Roller Class	Roller Weight (Static Range) and Centrifugal Force (CF) (Tonnes)	Restriction: Distance to Nearest Building (Metres)
i) Very Light	Maintenance and patching rollers, less than 1.25 (CF 1-2)	Generally not restricted for normal road use
ii) Light	1-2 (CF 2-5)	Generally not restricted for normal road use

Roller Class	Roller Weight (Static Range) and Centrifugal Force (CF) (Tonnes)	Restriction: Distance to Nearest Building (Metres)
iii) Light – Medium	2-4 (CF 5-10) 5+	
iv) Medium – Heavy	4-6	(CF 10-20) Not advised for city and urban streets 10+
v) Heavy	7-11 (CF 20-30)	Restricted. Not advised for built up areas 20+
vi) Very Heavy	12 and over (CF >30)	Restricted, major construction in rural areas away from structures. Blasting

Vibration limits are identified in the German standard as ranging from 2 mm/s for historical buildings to 8 mm/s for structurally sound buildings when the frequency of vibration is less than 80 Hz. By comparison humans can generally feel vibration at a velocity of 1 mm/s.

The type of ground can also affect the range of impact of vibration, with loose sand and materials transmitting vibration to a far lower extent than consolidated or hard rock (e.g. granite). Therefore, more caution should be applied where construction is likely to occur on the areas of hard rock or where nearby buildings are founded on hard rock. This will not be an issue for this section of the PDNH, unless any buildings are found to be on outcropping limestone.

It is important to note that vibration impacts in excess of 50 m from source are quite rare. As a guide it should be noted that GHD commissioned a vibration test on a rock breaker as part of the Water Corporation's Munster Pump Station Upgrade. The purpose of this test was to assess the transmissivity of Tamala Limestone and involved setting up accelerometers on connected rock at distances of 40 m and 70 m and then conducting a series of tests with a rock breaker. These tests indicated that the measured vibration levels were well below levels likely to cause any damage to houses greater than 40 metres from the rock breaker. It is important to note that granite will conduct vibrations more readily than Tamala Limestone and therefore a distance of 40 m is considered to be conservative.

Management of Noise and Vibration Risks

Management of potential vibration and noise impacts should be considered prior to construction, during the design stage. At this stage there will be greater understanding of the specific structures that are at risk and the construction requirements.

- Any buildings which are within 50 m of construction earthworks, should be further considered for vibration risks;

- If a requirement for rock breaking is identified, a separate assessment, which predicts vibration from this activity, may be required; and
- Throughout construction activities the obligations under the Environmental Protection (Noise) Regulations (1997) and Section 6 of AS2436 – 1981 “Guide to Noise Control on Construction, Maintenance and Demolition Sites” will be observed.

4.13.2 Dust

The construction of the PDNH has the potential to produce dust lift which may be a nuisance to nearby residents and which may also impact adjacent wetlands and vegetation. Some of the soil type in the area is loose sand with fine organic matter, which has potential for movement in strong breezes. A Dust Management Plan should be produced prior to construction in order to assess and manage risks to sensitive areas.

4.13.3 Use of Hazardous Substances

The construction of the PDNH is unlikely to require the use of hazardous substances other than fuels and oils for machinery. The storage and use of hazardous substances has the potential to impact wetlands or waterways if not carefully managed. Standard management procedures which minimise the risks at creek crossings and other sensitive areas will be developed prior to construction and provided in a suitable management plan.

5. Agencies and Organisations Consulted

The following organisations have been contacted for advice on issues relating to the location of the PDNH.

Department of Environment and Conservation

- Consulted for information on Declared Rare and Priority flora and TECs.
- Consulted in detail over the mound spring TEC.

Department of Water (Formerly Department of Environment (Water and Rivers Commission)

- Consulted with regard to groundwater source protection zones, Public Drinking Water Source Protection areas and for locations of suspected contaminated sites; and
- Consulted with regard to the constraints posed by Conservation category wetlands along the Corridor.

Department of Defence

- Consulted regarding the use of the 3TU site and buffer lands as well as their borefield at Neaves Road.

6. Public Consultation

There has been ongoing public and landholder consultation since the corridor alignment studies which began in 1997. A range of methods of consultation have been undertaken including letter box drops, public notices, public meetings, direct mail-outs, Community Liaison Group establishment and meetings, and public displays. This consultation is detailed in a separate document, which is part of the alignment definition programme.

As part of this EIA, landholders who are directly affected by the location of the Corridor and who have bushland or other environmental features on their property, have been consulted. This consultation has included phone discussions, mailouts and, in a number of cases visits to the property and site investigation with the landholder. In this way, landholders who have specific knowledge about environmental aspects on their property have passed this information on to the field investigation personnel. Full details of landholder responses to the location of the PDNH within their properties are available in the Social Issues Report (GHD, January 2005) and Community Consultation Report (Carolyn Walker Public Relations, December 2008).

7. Summary of Relevant Issues

7.1 Significant Issues and Impacts

The alignment of the 500 m Corridor for the proposed PDNH potentially creates a number of significant environmental impacts. These are primarily in relation to:

- Conservation Category wetlands along the route and their associated vegetation;
- Impacts on three Bush Forever sites;
- The Threatened Ecological Community "Community of Tumulus Springs (organic mound springs) of the Swan Coastal Plain" on Lots 88 and 89 Bingham Rd, and Lot 110 Gaston Road, Bullsbrook.
- General vegetation clearing, including potential loss of vegetation types which are very poorly conserved; and
- Potential impacts on listed threatened fauna species which may use the vegetation which will be cleared.

The issues and impacts, and the requirements for further investigation are summarised in Table 12 below.

7.2 Other Issues and Impacts

A small number of other actual and potential impacts were identified. These relate primarily to the construction and operation of the PDNH. These impacts can generally be managed using standard strategies and techniques and are not likely to require further investigation or detailed consultation with relevant authorities. The issues are:

- Acid Sulphate Soils;
- Dust management;
- Air quality;
- Noise and vibration;
- Stormwater disposal; and
- Use of hazardous substances.

Table 12 Key Characteristics Table: Relevant Issues and Recommendations

Issue	Relevant Legislation/ Required clearances	Location	Recommendations
Soils			
Acid sulphate soils are present over large sections of the route.	*Environmental Protection Act 1986.* Clearance with DEC.	Various	◗ No further requirements regarding corridor or highway alignment selection. ◗ Carry out field investigations in areas of the proposed highway alignment where acid sulphate soils could be encountered and where there is a likelihood of their being disturbed. ◗ Develop ASS Management Plan prior to construction.
Drainage			
Potential for changes to local surface hydrology and impacts on landuse and wetlands.	*Water and Rivers Commission Act 1995* Clearance with DEC.	Various	◗ No further requirements regarding corridor or highway alignment selection. ◗ Further hydrological modelling should be undertaken to consider the risks of changes to surface drainage and impact on properties and wetlands.
Wetlands And Waterways			
Wetlands 221, 205/06, and 367. After Hill et al. (1996)	EPP Lakes Policy. *Environmental Protection Act 1996*.	Location Number: 76/4318, 4329, 135/5109	◗ Wetlands listed as EPP Lakes or given Conservation or Resource Enhancement management categories should be avoided where possible. ◗ Any activities within 50m of the defined wetland boundary will require approval by DEC prior to commencement.
Wetlands 206, 204, 214, 668 and 198. After Hill et al. (1996)	EPA Bulletin 374. Conservation Category wetlands.	Location Number: 4318/ 80/ 81, 77, 172, 3580/5202	
Water Pollution			

Issue	Relevant Legislation/ Required clearances	Location	Recommendations
Runoff from construction and operation affecting watercourse levels and carrying pollutants.	*Environmental Protection Act 1986*. Approval from DEC and DoW	Various	◗ Undertake ongoing consultation with DEC and DoW with regard to drainage design and their requirements for the protection of specific wetlands.
Vegetation and Flora			
Vegetation clearing. Vegetation significance - if less than 10% of particular vegetation complexes exist, this will trigger regulatory action.	*Environmental Protection Act 1986*	Location Nos. 996,167, 172	◗ Impact on under-conserved vegetation communities triggers formal assessment of projects. ◗ Avoid such vegetation if possible and confirm vegetation type with DEC. ◗ Develop an offsets strategy to compensate for lost vegetation prior to commencement of construction.
Declared Rare and Priority flora.	*Environmental Protection and Biodiversity Conservation Act 1999.* *Wildlife Conservation Act 1950.*	None identified.	◗ Further detailed flora assessment once alignment is finalised and closer to time of construction.
Threatened Ecological Community "Community of Tumulus Springs (organic mound springs) of the Swan Coastal Plain"	*Environmental Protection and Biodiversity Conservation Act 1999.* *Wildlife Conservation Act 1950.* Clearance Permits required from DEC	Lots 88 and 89 Bingham Rd, Bullsbrook; 110 Gaston Rd, Bullsbrook	◗ Avoid TECs by using alignment to the east of the TEC. Manage indirect impacts, such as surface water runoff, weeds etc through appropriate design measures.
Weeds	*Agriculture and Related Resources Protection Act 1976.* Liaison with Department of Agriculture, DEC.	Entire route- particularly where remnant vegetation persists.	◗ Management plans for weed control will be required prior to construction.

Issue	Relevant Legislation/ Required clearances	Location	Recommendations
Dieback and other diseases	Liaison with DEC.	Entire route- particularly where remnant vegetation persists.	◗ A detailed assessment of dieback presence will be required prior to construction. ◗ A Dieback Management Plan will be required prior to construction.
Fauna			
Fauna in the study area may be impacted by: ◗ Changes in water flow and levels in wetlands; ◗ Loss of remnant vegetation; and ◗ Disruption to fauna movement across the highway.	*Wildlife Conservation Act 1950.* *Environmental Protection and Biodiversity Conservation Act 1999.*	Significant habitat areas along the Corridor.	◗ A detailed trapping and night-time survey should be carried out prior to construction. ◗ Impacts on the Carnaby's Cockatoo and other identified threatened fauna should be carried out prior to highway design.
Bush Forever Sites			
Impacts on Bush Forever sites	*Soil and Land Conservation Act 1945/Environmental Protection Act 1986*	Bush Forever Sites 13, 100, 107 on Location Nos. 996, 167, 5202, 172.	◗ Avoid impacts on vegetated areas of Bush Forever sites wherever possible. ◗ If impacts are inevitable, consult with DEC and WAPC with regard to their protection and replacement requirements prior to the commencement of construction.
Contaminated Sites			
Three identified, and two potentially contaminated sites within the Corridor.	*Environmental Protection Act 1986* *Contaminated Sites Act 2003.*	Nos. 4319, 132, 105, 3580, 4043, 165.	◗ Potentially contaminated areas may need soil/water sampling and analysis prior to design and construction.
Other Land Uses			

Issue	Relevant Legislation/ Required clearances	Location	Recommendations
	Various	Various	◗ Confirm future requirements for Defence borefield. ◗ Further consider the railway corridor with regard to soil contamination prior to construction.
Visual Quality			
Potential impacts of the highway when viewed as a user or as a nearby resident or other road user.	None		◗ Consider the exact alignment with regard to potential negative and positive visual quality aspects. ◗ Consider visual impact during design stage. ◗ Consider requirements for landscape screening or other visual impact mitigation during the design stage.
Noise			

Issue	Relevant Legislation/ Required clearances	Location	Recommendations
Noise received at a residence located adjacent to the proposed PDNH should be designed to meet an L_{Aeq} for the day and night periods of 63 dB (A) and 55 dB(A) respectively. Of the 46 buildings that were assumed to be noise sensitive premises, all are considered to be in low ambient areas. Of these 46 residences, 12 are calculated to exceed the 63 dB(A) $L_{10(18hour)}$ base objective.	*Environmental Protection Act 1986*	Various	◗ Management of potential noise impacts should be considered prior to construction, during the design stage. ◗ Throughout construction activities the obligations under the Environmental Protection (Noise) Regulations (1997) and Section 6 of AS2436 – 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites" will be observed.
Vibration			
Vibration impacts are possible on buildings that are within 50m of heavy earthmoving activities.	*Environmental Protection Act 1986*	Various	◗ Any buildings which are within 50m of construction earthworks should be further considered for vibration risks prior to construction.

8. Preferred Alignment Environmental Management Plan

8.1 Management Planning

The following section provides information on the management required to mitigate or minimise impacts associated with the Perth Darwin National Highway, and opportunities to foster positive environmental outcomes during the design of the project.

This section will consider:

- measures requiring particular attention during design;
- specific construction techniques;
- recommended training;
- contractual requirements; and
- prediction of outcomes.

Prior to the commencement of the project, specific Management Plans that address the following issues will be prepared and submitted for approval to the relevant authority.

- Landscape and visual impact;
- Topsoil management and rehabilitation;
- Vegetation and flora;
- Weeds and Dieback;
- Fauna;
- Acid Sulphate Soils;
- Wetlands;
- Surface water and drainage;
- Erosion;
- Dust;
- Noise and vibration; and
- Hazardous materials.

8.1.1 Flora and Vegetation

Clearing of native vegetation will be required for both road construction and material extraction. Material source areas have not yet been identified; separate environmental investigations will be conducted on these areas in the future. Potential impacts on flora and vegetation are not only restricted to loss of native vegetation within the clearing area but also to impacts on the vegetation adjacent to the disturbance, due to edge effects and further fragmentation of the remaining vegetation.

Management of Clearing

- Clearing will be kept to the minimum necessary for the construction works and access tracks;
- Access tracks, vehicle parking and temporary materials storage will be located on existing cleared areas or on grassy sites which incur minimum loss of trees and shrubs; and
- Once material source areas are exhausted, the disturbed areas will be rehabilitated as soon as possible.

Treatment of Cleared Vegetation and Topsoil

Any vegetation or soil removed as part of the works will be treated so as not to damage remaining vegetation or alter surface drainage.

The majority of seeds present within topsoil are held within the top 100 mm of soil. Where vegetation has been cleared (trees and shrubs removed), the top 100 mm of soil from these areas will be stripped and stored in stockpiles no more than 1 m in height. Management of topsoil stockpiles is imperative to maintaining the value of the stored material, as topsoil represents a valuable tool for revegetation and rehabilitation. The storing of topsoil for extended periods of time is also known to decrease the viability of the soil seed reserves, which results in depressed levels of recruitment once the soil is re-spread.

Topsoil should therefore be removed in stages representative of the progress of the road construction. Topsoil should then be re-spread evenly to a depth of 75 to 100 mm over disturbed soil surfaces.

The following management actions will apply:

- Cleared vegetation will be retained on-site for use in site rehabilitation and erosion control;
- Cleared vegetation will not be burnt on-site;
- Stripped topsoil will be retained adjacent to the temporary side tracks, pits, and other disturbed areas for use in rehabilitation;
- Any removed topsoil should be used as soon as possible following works;
- Materials and topsoil stockpiles will be located so as not to restrict or interfere with existing drainage; and
- Any spoil produced will be used to fill pits or spread evenly over cleared or thinly vegetated areas to ensure that sheet flow drainage is not adversely impacted by windrows or stockpiles.

Rehabilitation

Rehabilitation of the PDNH alignment is important to ensure that any visual and environmental impacts of the works are short term. Where required a revegetation plan should be developed. The following rehabilitation procedures will be carried out during and after construction works:

- Areas to be rehabilitated may include temporary works, extraction sites etc.
- Pits will be shaped and contoured to ensure that the likelihood of water ponding is reduced;
- Any compacted ground will be ripped or scarified where revegetation is required;
- Cleared topsoil and vegetation will be respread over disturbed areas;
- If imported soils and materials are required, they will be certified weed free;
- All rubbish, materials heaps or other debris will be removed; and

- Access tracks will be deep ripped and blocked off where possible.

8.1.2 Weed and Dieback Management

The vegetation of the Preferred Alignment includes numerous areas of introduced weed species, due to its being cleared for agriculture. Among these weeds are some Declared Plant species and other listed pest plants. Such species have the potential to be spread by the highway construction activities and may threaten nearby creeklines, wetlands and remnant bushland as well as agriculture.

Weed management

- A specific management plan for weed control will be available to site personnel.
- All vehicles and machinery will be cleaned of plant material and soil before and after entering known weed areas.
- If imported soils and materials are to be used, they will be certified weed free.

Dieback Management

- Dieback mapping will be conducted by an experienced dieback interpreter prior to commencement of construction;
- Dieback boundaries shall be clearly marked by an experienced dieback interpreter;
- All vehicles and machinery will be cleaned of plant material and soil prior to arrival and departure from the project site, when moving from dieback infected to dieback uninfected or uninterpretable areas, or from dieback uninterpretable to dieback uninfected areas; and
- If imported soils and materials are to be used, no untested material shall be used in dieback uninfected areas.

8.1.3 Fauna

A number of issues in relation to the PDNH development are risks to fauna and its habitat. These include possible impacts due to changes in water flow and water levels in wetlands and loss of remnant native vegetation in areas already substantially cleared, particularly in the south of the project area. There is also likely to be disruption of movement of fauna across the highway alignment, especially for terrestrial species such as small mammals and reptiles.

A detailed field investigation should be undertaken to assess the presence of fauna species and to consider the risks of the highway on habitats, hydrological changes and movement. This will need to be carried out closer to the time of construction and would include trapping and night-time surveys. Focus areas would include good quality native vegetation, watercourses and wetlands. Where possible, the detailed design should avoid any impact to priority fauna habitat, cockatoo nesting trees or feeding areas.

During the works in all areas the following management actions should apply:

- No pets, traps or firearms will be allowed on the project site;
- Barriers to native fauna movement will be minimised;
- Any animals disturbed by the works should be allowed to leave the site before further work occurs;

- No native fauna (including venomous snakes) will be impaired or killed by construction personal. Fauna can only be destroyed as a last resort by a designated and trained person;
- Any trenched or open excavations will be checked daily for fauna and any fauna will be removed as soon as possible without damage to the animal; and
- Minimise or restrict movement and use of plant and vehicles at dusk and dawn and during night-time hours.

8.1.4 Alterations to Waterways and Drainage

Drainage impacts during construction works relate to the maintenance of existing surface water flows and water quality. The following impacts have the potential to occur and require management:

- Ponding;
- New areas of waterlogging;
- Changes to water levels in 'downstream' swamps and damplands;
- Obstruction of flow within watercourses;
- Increased turbidity; and
- Contamination of surface water.

The alignment crosses Ellen Brook at approximately Ch 31 200 and along the tie-in to the Brand Highway, as well as a number of minor tributaries. Significant management, including drainage and pollutant controls, will be required to maintain surface water hydrology and water quality within these watercourses.

Material Source Areas have the potential to cause alterations to waterways and drainage through erosion and the creation of temporary pools. The material source areas are unlikely to be local but sourced from across the Swan Coastal Plain. When the location of material source areas is identified environmental investigations will be conducted and impacts managed.

Drainage Management

In order to mitigate any drainage impacts that may occur, the following management measures will be initiated:

- Existing natural drainage paths and drainage channels will not be unnecessarily blocked or restricted; and
- Any material that is found to block drainage will be removed.

Rehabilitation works have the potential to temporarily impact on local drainage flows through scouring and subsequent silt deposition.

The following management will be applied:

- Vegetation and soil disturbance will be minimised around works; and
- Disturbed areas will be compacted and stabilised as soon as possible.

Water Extraction and Waterways Impacts

Where dewatering, obstruction of groundwater or modification of stream banks in major waterways is required for roadworks, Main Roads will need to apply for the relevant permits and licences as indicated below. Application forms are available from the DoW website:

For construction of groundwater bores – 'Application for a 26D Licence to Construct or Alter Wells' (Form A);

For dewatering (including abstraction of groundwater from bores) – 'Application for a 5C Licence to take Groundwater' (Form A); and

For modifying beds and banks – 'Application for a 5C licence to take surface water / Application for a 11/17/21 A permit to modify bed and banks / Application to amend a 11/17/21A permit to modify bed and banks' (Form C).

8.1.5 Construction Issues

A range of construction impacts are predicted or possible. These include:

- Noise and vibration;
- Dust production;
- Pollution through the use of fuels, chemicals or from general construction litter; and
- Traffic management requirements.

The management of these impacts will include the following general actions.

Noise and Vibration

Construction noise will occur due to earth works, road rehabilitation works and vehicle movement along PDNH alignment and access tracks. The potential for noise and vibration related impacts will be minimised through the implementation of the following management principles:

- Adoption of appropriate work practices;
- Design and construction of appropriate noise walls or noise bunds;
- Selection of machinery with lowest practical noise levels; and
- Ongoing communication with nearby affected residents.

Dust Reduction and Mitigation

Dust may be generated from the clearing of vegetation, earthworks, spillage of soil material and vehicle movements along sealed and unsealed roads. The following methods of dust management will be used:

- Water tankers will be available at all times to wet down exposed surfaces on works areas, laydown sites, spoil dumps and topsoil and materials heaps;
- Minimise as far as possible dust generating activities;
- Dust lift will be monitored through visual and other means and all complaints responded to rapidly; and
- Dust from movement of vehicles will be managed at all times. This will include wetting down, road sweeping, and the implementation of suitable speed limits.

Pollution and Litter

There is a minor risk that the construction works will create temporary pollution as a result of fuel or chemical spills or mismanagement of construction materials. This will be managed through the following general actions:

- Any bulk fuel and oil stores will be bunded and managed in accordance with Australian Standards;
- If vehicle or machinery servicing is to occur on site it will occur in designated servicing areas which are supplied with adequate spill trays and spill response equipment; and
- All litter and construction waste will be contained in lidded bins and removed regularly to an approved landfill.

Access and Traffic Management

Increased traffic volumes arising from the movement of construction and transport vehicles may result in some localised short-term adverse impacts on local and regional traffic movements. The following potential impacts have been identified:

- Risk of injury to road users due to construction vehicles operating at the sites;
- Risk to employees and wildlife from fauna deaths (particularly macropods) from fauna road-deaths; and
- Potential damage to roads and spillage of carted materials, particularly sand.

Management strategies to be employed will include:

- The use of appropriate personal safety and traffic management signs;
- Advance notification of construction activities, particularly to local residents;
- Avoid driving to and from site at dawn and dusk; and
- Any significant amounts of material spilled from construction vehicles will be cleaned up on occurrence.

8.1.6 Environmental Management

Inductions and Training

- Construction personnel should be made aware of the issues and actions in this Management Plan so that they do not unnecessarily damage the environment during the works phase.
- Emergency training in relation to fires, chemical spills or other risks shall be carried out early in the construction phase.

Management of Environmental Incidents

The process that will be followed in the event of an environmental incident occurring will include:

- Reporting of the incident in an incident log;
- Time limits for incident reporting and response;
- Assessment of the significance of each incident;
- Discontinuation of the work which gave rise to the incident;

- Reporting incidents to regulatory authorities and stakeholders; and
- Satisfactory and timely remediation/mitigation of impacts.

8.2 Summary of Significant Environmental Issues

A description of each of the significant environmental issues identified within the PDNH corridor and how the Preferred Alignment will impact these issues is detailed in Table 13.

Table 13 Issues associated with the PDNH corridor and the impact the Preferred Alignment has on these issues

Issue	Impact of Preferred Alignment on issue	Outcome
Conservation significant wetlands along the route and their associated vegetation	Preferred Alignment impacts Conservation Category Wetland at Neaves Rd.	Non-Resolved, management required
	Preferred Alignment impacts Resource Enhancement Wetland at Ch 27 100.	Non-Resolved, management required
	Preferred Alignment road reserve intersects 4 Conservation Category Wetlands and one EPP Lake at Stock Rd Interchange.	Non-Resolved, management required
	Refine alignment crossing Ellen Brook at two locations	Non-Resolved, management required
	Preferred Alignment avoids Conservation Category Wetland on Defence land at Raphael Rd	Resolved
Impacts on Bush Forever sites:		
◗ Site 100 Neaves Rd Creek	Preferred Alignment intersects Bush Forever Site	Non-Resolved, management required
◗ Site 13 Sawpit Rd Bushland	Preferred Alignment avoids Bush Forever Site	Resolved
◗ Site 97 Kirkby Rd Bushland	The Preferred Alignment passes through the site but has minimised the impact on the site	Non-resolved management required
"Community of Tumulus Springs (organic mound springs) of the Swan Coastal Plain".	The Preferred Alignment has been designed to avoid direct impact on the springs; however, the alignment is still in close proximity to these communities.	Resolved, management required
General vegetation clearing, including potential loss of vegetation types which are very	The Preferred Alignment will involve general vegetation clearing with the potential for	Non resolved, management required

Issue	Impact of Preferred Alignment on issue	Outcome
poorly conserved	clearing poorly conserved vegetation types	
Potential impacts on listed threatened fauna species which may use the vegetation which will be cleared.	Vegetation that may be utilised by threatened fauna species will be cleared for the Preferred Alignment. The Preferred Alignment will avoid clearing good quality fauna habitat associated with the conservation category wetlands and Bush Forever Site 13.	Non resolved, management required

8.3 Environmental Management Commitments

Environmental management commitments for the Perth Darwin National Highway are summarised in Table 14.

Table 14 PDNH Preferred Alignment Management Commitments

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
ASS	An acid sulphate soil investigation will be undertaken in areas suspected of containing ASS	Determine if ASS are present	Various	Pre-construction	
	A comprehensive acid sulphate soil management plan should be developed in accordance with the DEC's guidelines and the Western Australian Planning Commission's (WAPC) Planning Bulletin No. 64. (if ASS is identified)	Manage impacts of ASS			ASS Management Plan Submit ASS Management Plan to the DEC for approval
	Undertake activities in ASS Management Plan (if prepared)	Manage impacts of ASS		Post Construction	

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
Drainage	Further hydrological modelling should be undertaken to consider the risks of changes to surface drainage and impacts on property	Further identify risks to drainage	Various	Pre-construction	Ongoing consultation with DEC and DoW with regard drainage design and requirements for the protection of specific wetlands
	Use of natural drainage networks such as contours and the natural stormwater system; Where it is not possible to utilise existing natural drainage features, artificial ones should be created, such as pipes, culverts and engineered swales	Minimise disruption to drainage	Various		
	Incorporate use of native vegetation to promote filtering and slow run-off into design		Various		

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
Vegetation and Flora	Avoid under-conserved vegetation communities if possible, confirm vegetation types with DEC. Develop an offsets strategy to compensate for lost vegetation	Reduce impact of vegetation clearing on under-conserved vegetation communities	Various	Pre-construction	Consultation with DEC
	Conduct detailed flora assessment of Preferred Alignment	Assess presence of Declared Rare and Priority Flora			
	Avoid impacts on the hydrology and surface water quality of tumulus spring TECs.	Minimise impact on the TECs	Lots 88 and 89 Bingham Rd, Lot 110 Gaston Rd, Bullsbrook		Consultation with DEC

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
	Detailed consultation should be undertaken with the DEC and WA Planning Commision (WAPC) regarding the protection and replacement requirements of Bush Forever Sites.	Minimise impacts on Bush Forever Sites	Bush Forever Site 100 Neaves Rd Creek Bush Forever Site 97 Kirkby Rd Bushland	Pre-construction	Consultation with DEC and DPI
	Develop and implement a Weed Management Plan	Minimise the potential for introduction and spread of weeds	Various		Weed Management Plan
	Conduct a detailed assessment of dieback presence	Assess the presence of Dieback			
	Develop and implement a Dieback Management Plan	Minimise the potential for introduction and spread of dieback			Dieback Management Plan Consult with DEC

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
	Develop and implement a Revegetation plan	Ensure that vegetation impacts are minimised and define the rehabilitation of remaining areas.	Various	Preconstruction	Revegetation plan
Fauna	Conduct a detailed field investigation including trapping and night time survey	Assess the presence of fauna species, particularly Carnaby's Cockatoo	Various - Significant habitat areas along the Preferred Alignment	Pre-construction	
	Incorporate fauna underpasses and fauna corridors into the design	Minimise impact on fauna species	Various		
	No pets, traps or firearms will be allowed on the project site			Construction	
	Barriers to native fauna movement will be minimised				

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
	Any animals disturbed by the works should be allowed to leave the site before further work occurs				
	No native fauna (including venomous snakes) will be impaired or killed by construction personal. Fauna can only be destroyed as a last resort by a designated and trained person		Various	Construction	
	Any trenched or open excavations will be checked daily for fauna and any fauna will be removed as soon as possible without damage to the animal.				

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
Noise	Design noise mitigating structures such as noise walls or bunds where required	Reduce noise affecting local landowners	Various	Pre-construction	
	Throughout construction activities the contractor should observe all relevant obligations under the *Environmental Protection (Noise) Regulations (1997)* and Section 6 of AS2436 – 1981 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites"*			Construction	*Environmental Protection (Noise) Regulations (1997)* Section 6 of AS2436 – 1981 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites"*

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
	Regularly assess noise emission levels of all critical plant and equipment to ensure compliance with noise limits as defined in AS2436:1981				
	Undertake noise generating activities during times where the impact will be minimised wherever possible				
Vibration	Any buildings which are within 50 m of construction earthworks should be further considered for vibration risks	Assess potential vibration impacts	Buildings within 50m of alignment	Pre-construction	

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
	If a requirement for rock breaking is identified, a separate assessment, which predicts vibration from this activity, may be required		Various		
	Provide adequate and ongoing communications with landowners regarding the timing and type of works and possible times of high impact.	Limit impact of construction vibration on nearby landowners		Construction	
	Ensure that vehicles and equipment are the smallest possible to undertake work				
Dust	A Dust Management Plan should be formulated in order to assess and manage risks to sensitive areas.	Minimise impacts of dust	Various	Pre-construction	Dust Management Plan

Aspect	Action	Objective	Location	Timing	Requirements /Consultation
Visual Impact	A Landscape and Visual Impact Management Plan should be developed	Minimise visual impact	Various	Pre-construction	Landscape and Visual Impact Management Plan
Contaminated Sites	A Preliminary Site Investigation should be carried out for potentially contaminated sites within the alignment footprint	Minimise potential soil or groundwater contamination	Various	Pre-construction	Preliminary Site Investigation
Use of Hazardous substances	Bulk fuel and oil stores will be bunded and managed in accordance with Australian Standards	Minimise risk of spillage to waterways and other sensitive areas	Various	Construction	
	If vehicle or machinery servicing is to occur on site it will occur in designated servicing areas which are supplied with adequate spill trays and spill response equipment				

8.4 Consultation on Preferred Alignment

In October 2008 a formal community consultation program commenced to raise awareness of the study and engage directly affected landowners in the planning process.

The consultation program included:

- direct mail-outs to affected landowners, key stakeholders and the broader Bullsbrook and Muchea community;
- media releases and advertisements;
- public displays; and
- meetings with individual landholders where requested.

A full report on the consultation program including landholder responses is available in the Community Consultation Report (Carolyn Walker Public Relations, December 2008).

The City of Swan and Shire of Chittering have formally endorsed the Preferred Alignment.

9. Environmental Approvals

9.1 Requirements for Referral to Statutory Authorities

9.1.1 Referral to the Department of the Environment, Water, Heritage and the Arts (DEWHA)

Referral to the Commonwealth Department of the Environment, Water, Heritage and the Arts under the *Environment Protection and Biodiversity Conservation Act 1999* (the *EPBC Act*) is triggered by seven major issues. These are:

- World Heritage properties;
- National Heritage places (from 1 January 2004);
- Ramsar wetlands of international significance;
- Nationally listed threatened species and ecological communities;
- Listed migratory species;
- Commonwealth marine areas; and
- Nuclear actions (including uranium mining).

The *EPBC Act* is also triggered if a proposal is likely to have a significant environmental impact on Commonwealth Land.

Given the proximity of the proposal to Commonwealth listed TECs ('assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the Swan Coastal Plain'), it is considered likely that the project will require referral to the DEWHA for assessment under the *EPBC Act*. Initial fauna surveys also indicate that the alignment will impact on a possible roosting site for Carnaby's Cockatoo on Lot 110 Gaston Road, Bullsbrook.

Detailed site investigations during the design stage, may identify new species of Declared Rare Flora (DRF) or additional impacts on Carnaby's Cockatoo or other threatened species which may be considered significant under the *Act*.

9.1.2 Referral to the Environmental Protection Authority

Referral to the Environmental Protection Authority would occur under the *Environmental Protection Act 1986*. Matters which could require referral under this *Act* include:

- Impacts on significant wetlands (EPP listed lakes and other wetlands categorised as for Conservation and Resource Enhancement);
- Impacts on Bush Forever sites; and
- Impacts on threatened fauna.

In addition, the size of the project and its impact on landholders would likely require the project to be referred.

The PDNH Preferred Alignment may impact on a number of Conservation Category wetlands, an EPP Lake and two Bush Forever sites and would therefore require referral to the EPA on those issues.

Formal assessment of the project would preclude the requirement to obtain a separate Clearing Permit. Clearing Permits are required under the *Environmental Protection Act (Clearing of Native Vegetation Regulations) 2004* for any loss of native vegetation. However, if the project is formally assessed, the provisions for a clearing permit would be considered as part of that assessment.

The DEWHA has signed a Bilateral Agreement with the DEC. This agreement gives the DEC the power to assess some projects which would otherwise be assessed by the DEWHA. Projects which trigger the *EPBC Act* must still be referred under that *Act* but there will not be a duplication of assessment at both a State and Federal level.

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Appendix A

Figures

DRAFT

400,000 407,500

6,510,000 6,502,500 6,495,000 6,487,500

BYRNE RD
BRAND HWY
OLD GINGIN RD
WANDENA RD
PATTENS DR
POWDERBARK DR
HARRIS RD
AYRSHIRE LOOP
SANTA GERTRUDIS DR
DEXTER CH
DEVON WY
MORLEY RD
SANDOW RD
ENERGY PL
CHITTERING ST
FENSTER ST
ELLEN ST
PAYNE ST
ARCHIBALD ST
CARL ST
PETERS RD
MUCHEA SOUTH RD
GULLIENTE RD
MUCHEA EAST RD
POLINELLI RD
ROAD A
PIPE LILY WY
GREEN ST
JENKINS RD
Great Northern Hwy
MARTIN RD
BINGHAM RD
ALMERIA PDE
MORLEY RD
MORRISSEY RD
SABRE CL
COVENTRY CRSG
HOAD RD
GASTON RD
SOUNESS RD
APRIL CL
CHITTERING RD
RUTLAND RD
JESS RD
FOX CL
QUINN RD
KIRBY RD
PINE RD
OLD WEST RD
DELLA RD NORTH
WEST RD
NORTH AV
HURD RD
DIRK RD
SMITH RD
NEAVES RD
STRACHAN RD
TURNER RD
DEANHEAD ST
TAYLOR RD
CLARKSON RD
ASHER RD
DELLA RD
UNNAMED RD
GULLY RD
RAILWAY PDE
PAYNE RD
LAGE RD
WARREN RD
COOPER RD
STOCK RD
GREAT NORTHERN HWY
RAPHAEL ST
WISE RD
WARBROOK RD
HALDEN RD
SAWPIT RD
ELLENBROOK RD
WALYUNGA RD
MARALLA RD
BOTANY PDE
CARDINAL DR
VINES AV

343 262 336 4905 342 347 293 345 1007 1009 1010 1011 4795 990 4912 992 991 2703 2704 33 34 998 997 168 169 170 3580 171 4043 165 172 5293 173 6 3627 5377 148 149 150 133 134 132 135 136 109 7 8 9 4329 112 116 114 4319 82 74 77 75 78 79 4318 80 81 1 2 3 4 5

Locality Map
TWO ROCKS
YANCHEP
INDIAN OCEAN
MUNDARING
PERTH

LEGEND

Proposed Highway Alignment - GHD - 200809

Proposed Reservation

Proposed Alignment

Properties Intersecting Road Alignment - GHD - 200412

4318 Location Number

1:75,000 (at A3)

0 750 1,500 2,250 3,000

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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mainroads WESTERN AUSTRALIA

MainRoads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
Date 22 SEP 2009

Potentially Affected Properties

Figure 2

G:\61\14438\gis\mxds\6114438-G138_Rev1.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: GHD: Proposed Highway Alignment - 200809, Potentially Impacted Properties - 200412; Landgate: Cadastre - 200811. Created by: xntan

400,000
407,500
6,510,000
6,502,500
6,495,000
6,487,500

BYRNE RD
BRAND HWY
OLD GINGIN RD
ENERGY PL
CHITTERING ST
FEWSTER ST
ELLEN ST
PAYNE ST
CARR ST
ARCHIBALD ST
ARBUCKLE ST
PETERS RD
HUMPHREYS ST
GULLHENTER RD
MUCHEA EAST RD
WANDENA RD
PATTENS DR
POWDERBARK DR
HARRIS RD
AYRSHIRE LOOP
SANTAGERTRUDIS DR
DEXTER CH
DEVON WY
MORLEY RD
SANDOWN RD
BOLINELLI RD
ROAD A
PIPE LILY WY
JENKINS RD
GREEN ST
MUCHEA SOUTH RD

MARTIN RD
ALMERIA PDE
BINGHAM RD
Great Northern Hwy
MORLEY RD
MORRISSEY RD
SABRE CL
COVENTRY CRSG
HOAD RD
NEAVES RD INTERCHANGE
SOUNESS RD
APRIL CL
CHITTERING RD
JESS RD
FOX CL
QUINN RD
KIRBY RD
PINE RD
DAWSON ST
OLD WEST RD
DELLA RD NORTH
WEST RD
NORTH AV
HURD RD
DIRK RD
SMITH RD
NEAVES RD
STRACHAN RD
RAILWAY PDE
ASHER RD
DELLA RD
UNNAMED RD
GULLY RD
PAYNE RD
CLARKSON RD
TAYLOR RD
LAGE RD
WARREN RD
STOCK RD INTERCHANGE
COOPER RD
STOCK RD
RAPHAEL ST
GREAT NORTHERN HWY
CHITTY RD
WARBROOK RD
WISE RD
WARBROOK RD
ELLENBROOK RD
SAWMILL RD
WALYUNGA RD
MARALLA RD
BOTANY PDE
VINES AV
CARDINAL DR
ALMERIA PDE

Locality Map
TWO ROCKS
YANCHEP
INDIAN OCEAN
MUNDARING
PERTH

LEGEND

Refined Alignment - GHD - 2004
Endorsed 500m Corridor - GHD - 2004

Preferred Highway Alignment - GHD - 200809
Proposed Reservation
Preferred Alignment

Cadastre - Landgate - 200907
Dept. of Defence Land - Landgate - 200907
Indicative Location of TEC - GHD - 20090807

1:75,000 (at A3)
0 750 1,500 2,250 3,000
Meters

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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mainroads WESTERN AUSTRALIA

MainRoads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
Date 21 OCT 2009

Alignment Overview

Figure 3

G:\61\14438\gis\mxds\6114438-G139_Rev1.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: GHD: Preferred Highway Alignment - 200809, Refined Alignment and Endorsed Corridor - 2004, Indicative Location of TEC - 20090807; Landgate: Cadastre - 200907, Metro North 2009 Mosaic - 2009. Created by: xntan

403,000 404,000

6,489,000 6,488,000 6,487,000 6,486,000

Map Index

8 7 6 5 4 3 2 1

16000

15000

ELLEN BROOK: UPPER SWAN

ELLENBROOK NATIONAL ESTATE AREA

MARALLA RD

Great Northern Hwy

LORD STREET 02

BARBERA DR

BRIGALOW BEND

CUBA LINK

ARAMA CTURN

ELMRIDGE PWY

BEECROFT PL

BREWSTER CCT

NEBBOR LINK

ACKWORTH GRA

EASTNOR WY

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges
- Proposed Alignment & Endorsed MRS Reservation

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- Aboriginal Heritage Sites - DIA - 20090715

Register of National Estate - DEH - 2006

- Registered

Acid Sulfate Soils Risk - DEC - 20060807

- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)
- No known ASS disturbance risk (<3m from surface)

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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mainroads WESTERN AUSTRALIA

Main Roads WA
Perth-Darwin National Highway Planning Study

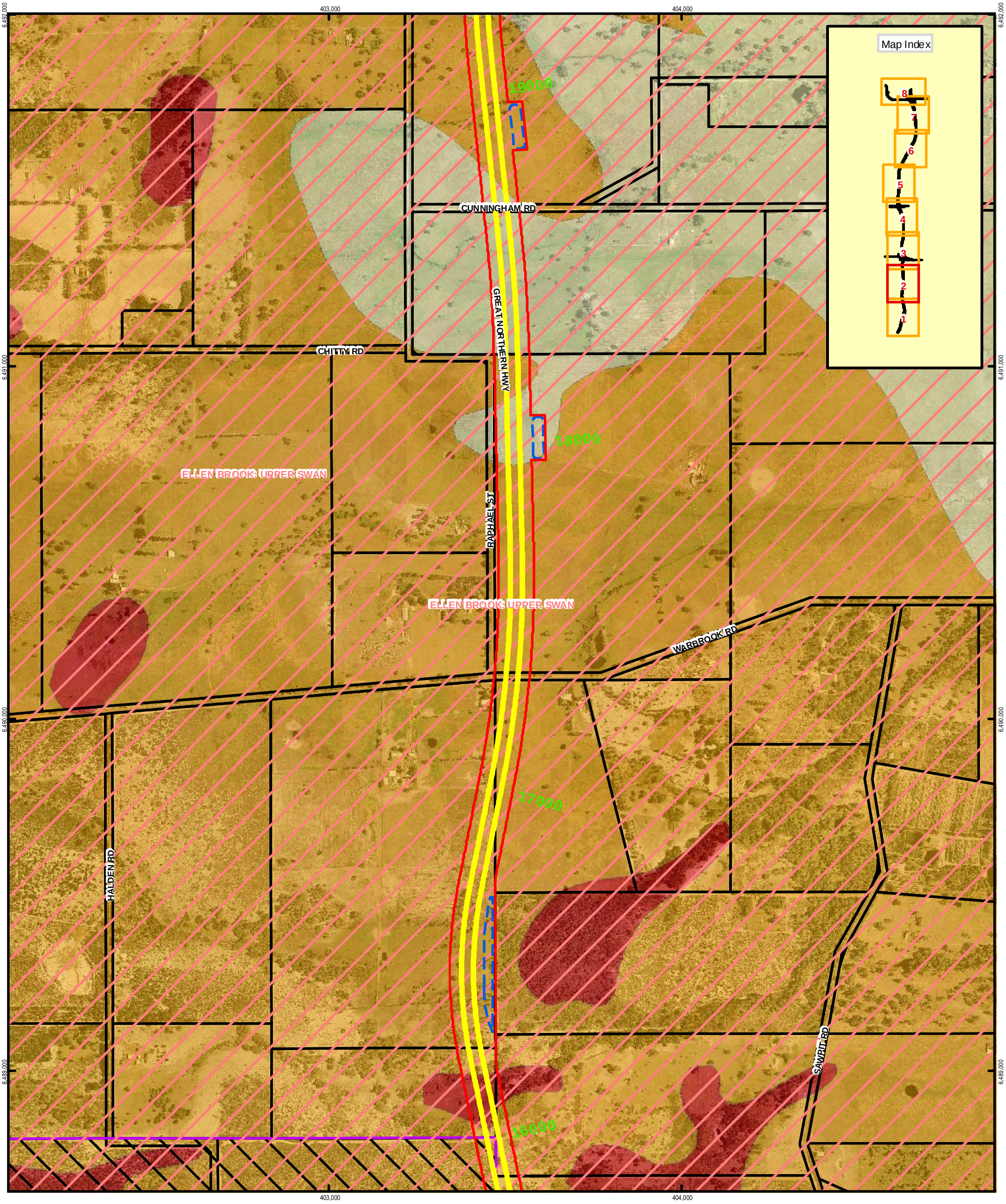
Job Number 61-14438
Revision 1
Date 07 AUG 2009

Environmental Constraints - Geoscientific & Cultural Map Sheet 1 Figure 4

G:\61\14438\gis\mxds\6114438-G134_Rev1.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: GHD: Proposed Highway Alignment & Drainage Outline - Sep 2008; Landgate: Metro North 2009 Mosaic - Dec 2008, Cadastre - 200907; DIA: Aboriginal Heritage Sites - 20090715; DEH: Register of National Estate - 2006; DEC: Acid Sulfate Soil Risks, Swan Coastal Plain - 20060807. Created by: xntan



LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- Aboriginal Heritage Sites - DIA - 20090715

Register of National Estate - DEH - 2006

- Registered

Acid Sulfate Soils Risk - DEC - 20060807

- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)
- No known ASS disturbance risk (<3m from surface)

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

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Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
Date 07 AUG 2009

Environmental Constraints - Geoscientific & Cultural Map Sheet 2

Figure 4

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Map Index
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GULLY RD
RAPHAEL ST
PAYNE RD
ROBINSON RD
ELLEN BROOK UPPER SWAN
GREAT NORTHERN HWY
COOPER RD
STOCK RD

LEGEND

Proposed Highway Alignment - GHD - 200809
- Proposed Carriageway
- Proposed Reservation
- Bridges

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- Aboriginal Heritage Sites - DIA - 20090715

Register of National Estate - DEH - 2006
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Acid Sulfate Soils Risk - DEC - 20060807
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0 50 100 200 300 400
Metres

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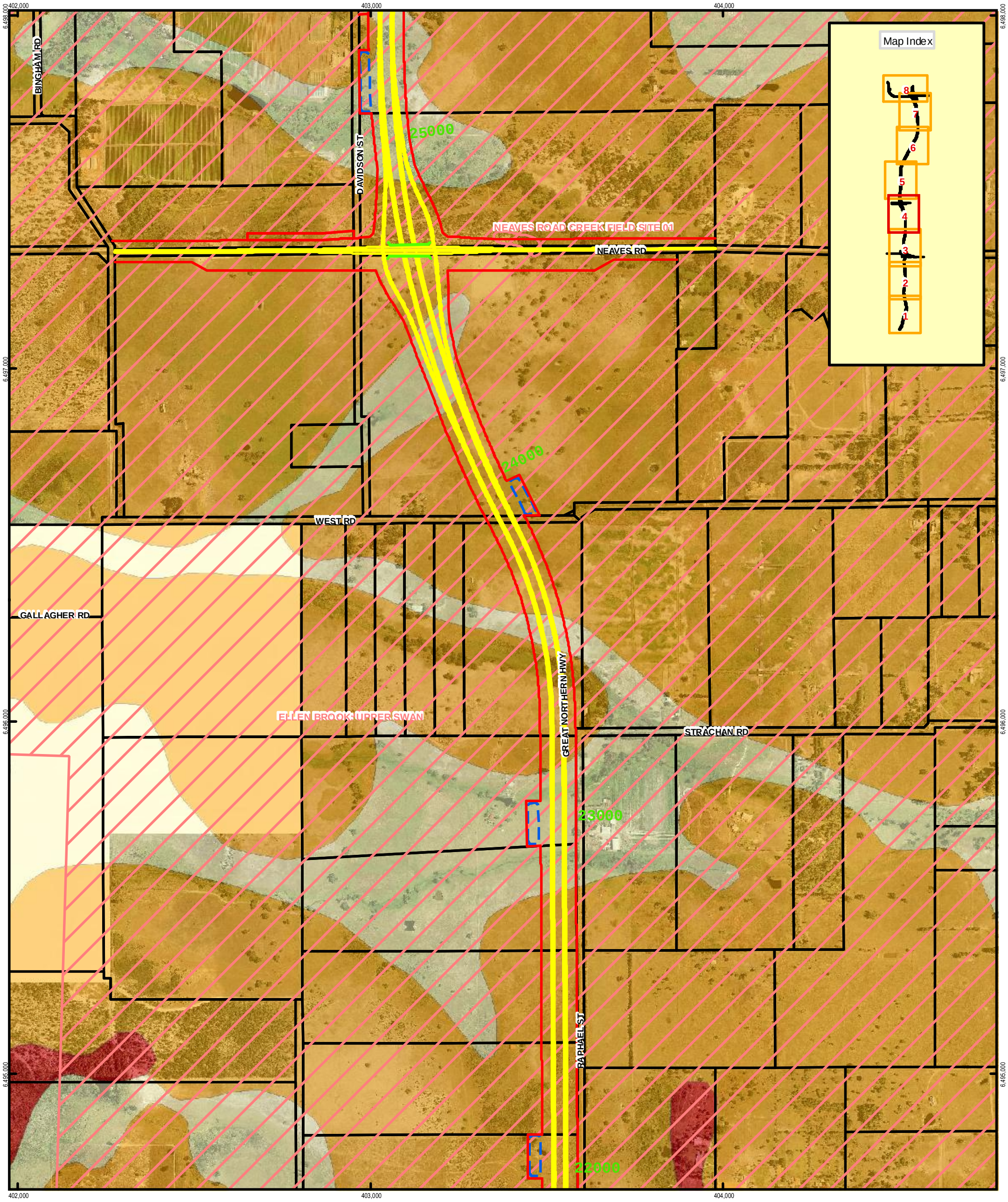

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
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- Proposed Drainage Basin Outline - GHD - 200809
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Environmental Constraints - Geoscientific & Cultural

Map Sheet 4

Figure 4

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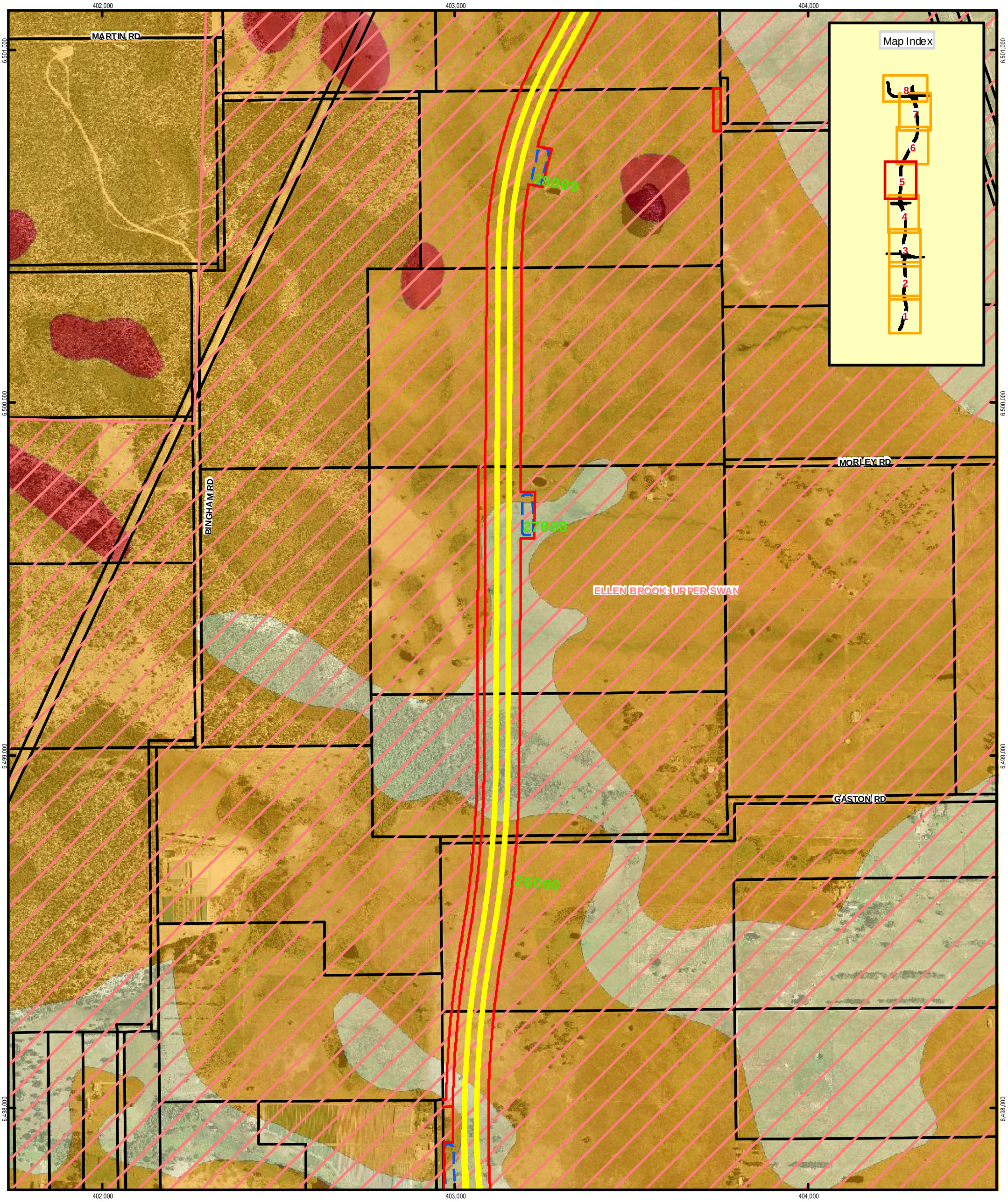

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Proposed Highway Alignment - GHD - 200809

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- Proposed Reservation
- Bridges

- Proposed Drainage Basin Outline - GHD - 200809
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Environmental Constraints - Geoscientific & Cultural

Map Sheet 5

Figure 4

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ALMERIA RDE

MUCHEA SOUTH RD

ELLEN BROOK: UPPER SWAN

31000

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Map Index

1 2 3 4 5 6 7 8

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- Aboriginal Heritage Sites - DIA - 20090715

Register of National Estate - DEH - 2006

- Registered

Acid Sulfate Soils Risk - DEC - 20060807

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0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
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GHD

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mainroads WESTERN AUSTRALIA

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Perth-Darwin National Highway Planning Study

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6,505,000
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GINGIN BROOK WAGGYL SITE
GREAT NORTHERN HWY
CULLIENTE RD
WETLANDS & WATERCOURSES
MOORE RIVER TO BULLSBROOK
BOONANARRING BROOK
WALLERING BROOK
BREERA BROOK
LENNARD BROOK
RED GULLY CREEK
34000
MUCHEA EAST RD
BRAND HWY
CHANDALA BROOK
NULLILLA BROOK
MOORE RIVER WAUGAL
EDWARDS PL
PETERS RD
33000
MUCHEA SOUTH RD
GREAT NORTHERN HWY
ELLEN BROOK: UPPER SWAN
ALMERIA RDE
32000

Map Index
8
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6
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2
1

LEGEND

Proposed Highway Alignment - GHD - 200809
- Proposed Carriageway
- Proposed Reservation
- Bridges
- Future Alternative Alignment

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- Aboriginal Heritage Sites - DIA - 20090715

Register of National Estate - DEH - 2006
- Registered

Acid Sulfate Soils Risk - DEC - 20060807
- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)
- No known ASS disturbance risk (<3m from surface)

1:10,000 (at A3)
0 50 100 200 300 400
Metres

Map Projection: Transverse Mercator
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6,508,000

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BRAND HWY

BYRNE RD

GINGIN BROOK WAGGYL SITE

OLD GINGIN RD

WETLANDS & WATERCOURSES
MOORE RIVER TO BULLSBROOK

WALLERING BROOK

RED GULLY CREEK

NULLILLA BROOK

BREERA BROOK

LENNARD BROOK

CHANDALA BROOK

MOORE RIVER WAUGAL

BOONANARRING BROOK

ELLEN BROOK: UPPER SWAN

GREAT NORTHERN HWY

GREAT NORTHERN HWY

GULLIVER RD

ENERGY PL

Map Index

8 7 6 5 4 3 2 1

Aboriginal Heritage Sites - DIA - 20090715

Cadastre - Landgate - 200907

Acid Sulfate Soils Risk - DEC - 20060807

High to moderate ASS disturbance risk (<3m from surface)

Moderate to low ASS disturbance risk (<3m from surface)

No known ASS disturbance risk (<3m from surface)

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

LEGEND

Proposed Highway Alignment - GHD - 200809

Proposed Carriageway

Proposed Reservation

Bridges

Future Alternative Alignment

Proposed Drainage Basin Outline - GHD - 200809

Cadastre - Landgate - 200907

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Date 07 AUG 2009

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Figure 4

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Data Source: GHD: Proposed Highway Alignment & Drainage Outline - Sep 2008; Landgate: Metro North 2009 Mosaic - Dec 2008, Cadastre - 200907; DIA: Aboriginal Heritage Sites - 20090715; DEC: Acid Sulfate Soils Risk - 20060807. Created by: xntan

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

403,000 404,000

6,489,000 6,488,000 6,487,000 6,486,000

Map Index

8 7 6 5 4 3 2 1

16000

15000

MARALLA RD

GREAT NORTHERN HWY

BARBERA DR

BRIGALOW BEND

CUBA LINK

ARAMAC TURN

BOTANY PDE

ELMRIDGE PWY

BEECROFT L

BREWSTER CCT

NEBBOR LINK

ACKWORTH GRA

EASTNOR WY

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges
- Proposed Alignment & Endorsed MRS Reservation

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- EPP Lakes (1992) - Swan Coastal Plain - DEC - 19921201
- Threatened Ecological Community Buffers - DEC - 20081010

Declared Rare & Priority Species - DEC - 200901*

- (R) Declared Rare Flora - Extant Taxa
- Priority 1 - Poorly Known Taxa
- Priority 2 - Poorly Known Taxa
- Priority 3 - Poorly Known Taxa
- Priority 4 - Rare Taxa

Geomorphic Wetlands - Swan Coastal Plain - DEC - 200809

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

**Note: DRF data includes old WA Herbarium records (Apr 2004)*

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Perth-Darwin National Highway Planning Study

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Environmental Constraints - Ecological Map Sheet 1

Figure 5

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GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

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403,000
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Map Index

CUNNINGHAM RD
CHITTY RD
GREAT NORTHERN HWY
RAPHAEL ST
WARBROOK RD
HALDEN RD
SAWPIT RD

19000
19000
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16000

LEGEND

Proposed Highway Alignment - GHD - 200809
- Proposed Carriageway
- Proposed Reservation
- Bridges

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- EPP Lakes (1992) - Swan Coastal Plain - DEC - 19921201
- Threatened Ecological Community Buffers - DEC - 20081010

Declared Rare & Priority Species - DEC - 200901*
- (R) Declared Rare Flora - Extant Taxa
- Priority 1 - Poorly Known Taxa
- Priority 2 - Poorly Known Taxa
- Priority 3 - Poorly Known Taxa
- Priority 4 - Rare Taxa

Geomorphic Wetlands - Swan Coastal Plain - DEC - 200809
- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

*Note: DRF data includes old WA Herbarium records (Apr 2004)

1:10,000 (at A3)
0 50 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Main Roads WA
Perth-Darwin National Highway Planning Study

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Environmental Constraints - Ecological Map Sheet 2

Figure 5

G:\61\14438\gis\mxds\6114438-G130_Rev1.mxd

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Map Index

8 7 6 5 4 3 2 1

22000 21000 20000 19000

GULLY RD

RAPHAEL ST

PAYNE RD

ROBINSON RD

GREAT NORTHERN HWY

COOPER RD

STOCK RD

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
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Declared Rare & Priority Species - DEC - 200901*

- (R) Declared Rare Flora - Extant Taxa
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Geomorphic Wetlands - Swan Coastal Plain - DEC - 200809

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

**Note: DRF data includes old WA Herbarium records (Apr 2004)*

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
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Figure 5

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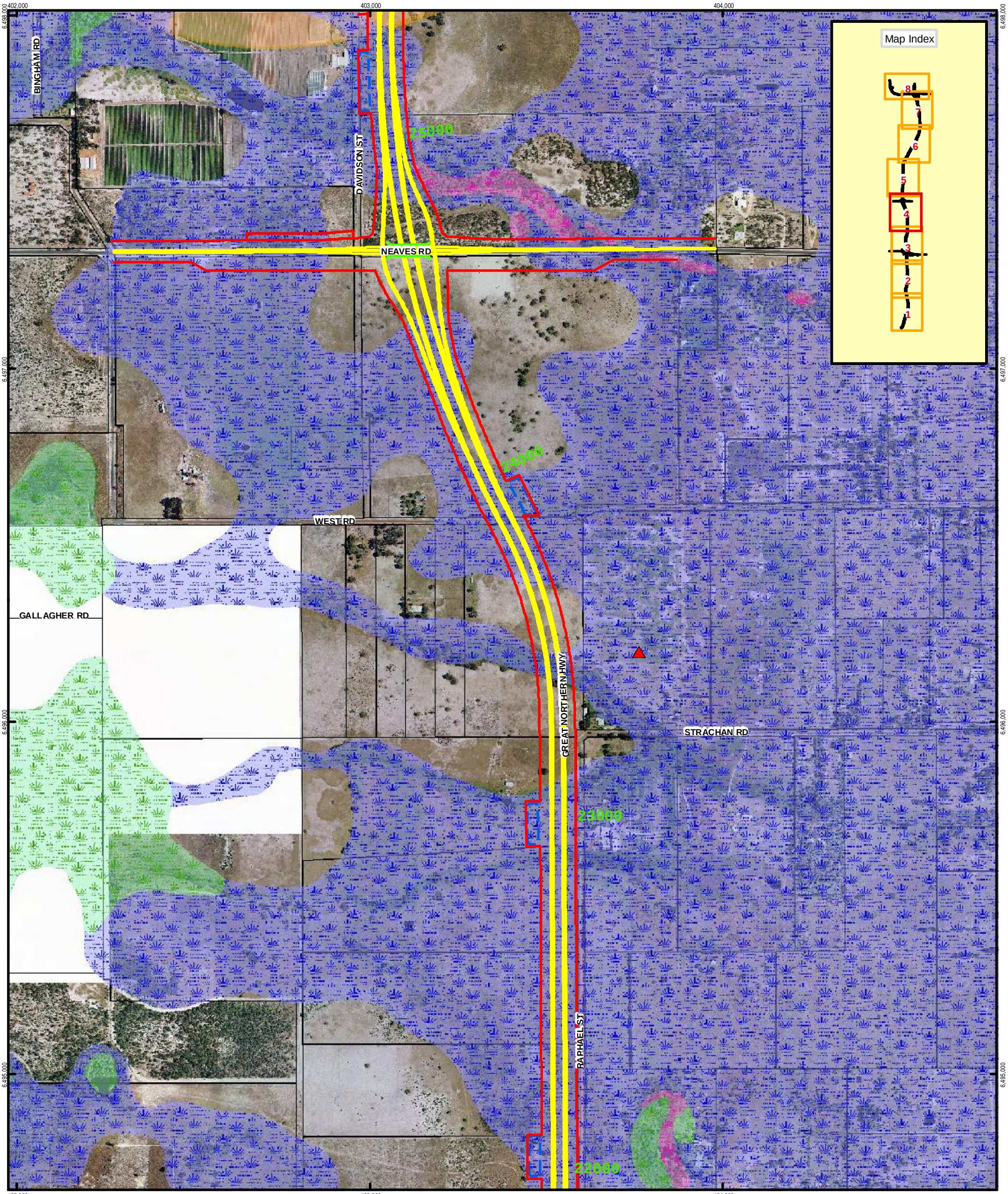

LEGEND

Proposed Highway Alignment - GHD - 200809
- Proposed Carriageway
- Proposed Reservation
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Geomorphic Wetlands - Swan Coastal Plain - DEC - 200809
- Conservation
- Resource Enhancement
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0 50 100 200 300 400

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Environmental Constraints - Ecological Map Sheet 4

Figure 5

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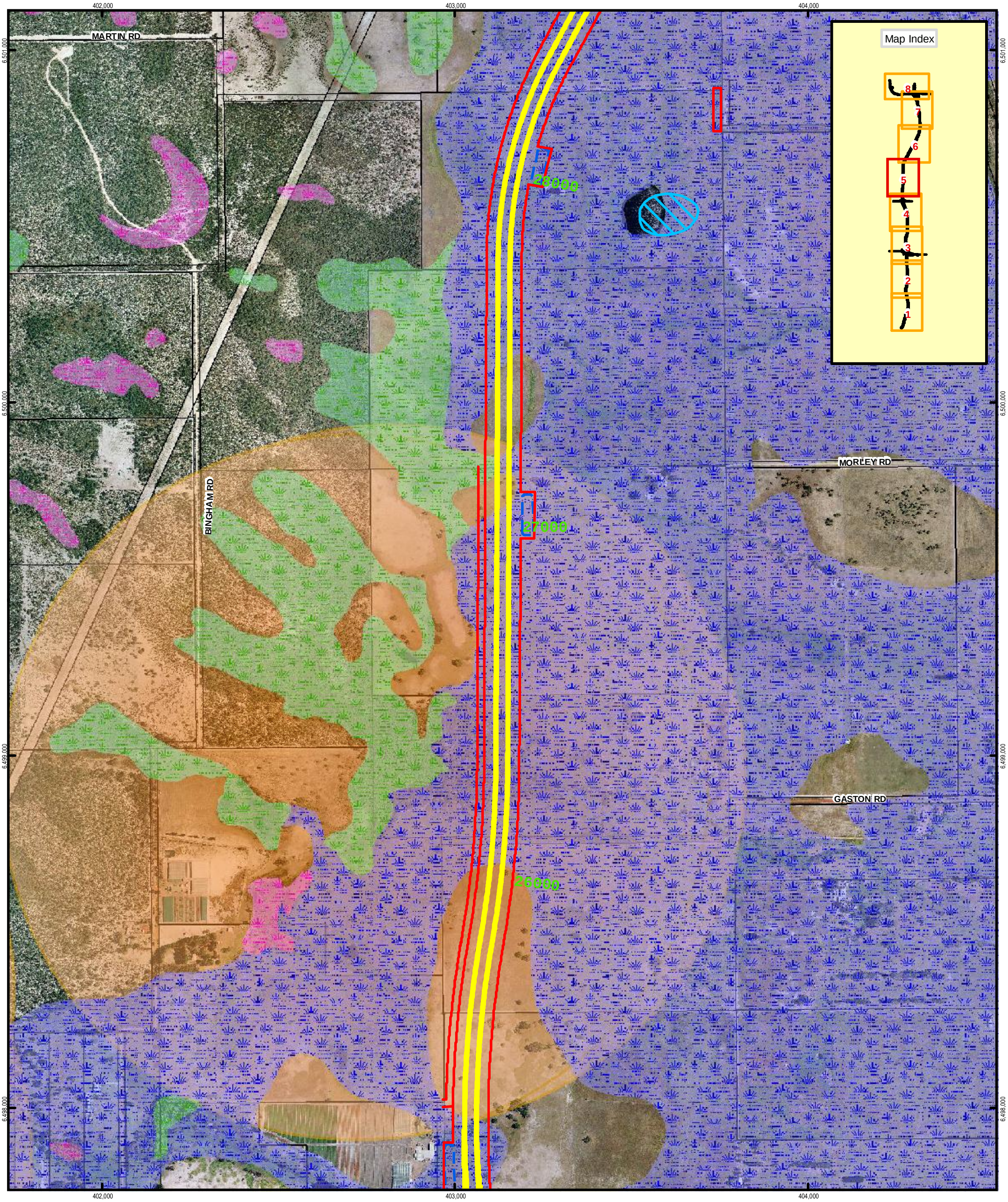

LEGEND

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Geomorphic Wetlands - Swan Coastal Plain - DEC - 200809

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Environmental Constraints - Ecological Map Sheet 5

Figure 5

G:\61\14438\gis\mxds\6114438-G130_Rev1.mxd

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ALMERIA RDE

MUCHEA SOUTH RD

31000

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Map Index

8 7 6 5 4 3 2 1

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
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Geomorphic Wetlands - Swan Coastal Plain - DEC - 200809

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Metres

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Environmental Constraints - Ecological Map Sheet 6

Figure 5

G:\61\14438\gis\mxds\6114438-G130_ Rev1.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: GHD: Proposed Highway Alignment & Drainage Outline - Sep 2008; Landgate: Metro North 2009 Mosaic - Dec 2008, Cadastre - 200907; DEC: Declared Rare Flora - Jan 2009, WA Herbarium Rare Flora - April 2004, TEC - Jan 2009, EPP Lakes - Dec 1992, Geomorphic Wetlands - Sep 2008. Created by: xntan

403,000 404,000 405,000

6,507,000 6,506,000 6,505,000 6,504,000

GREAT NORTHERN HWY

CULLIENTE RD

MUCHEA EAST RD

BRAND HWY

EDWARDS PL

PETERS RD

GREAT NORTHERN HWY

MUCHEA SOUTH RD

ALMERIA PDE

34000

33000

32000

Map Index

8 7 6 5 4 3 2 1

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges
- Future Alternative Alignment

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- EPP Lakes (1992) - Swan Coastal Plain - DEC - 19921201
- Threatened Ecological Community Buffers - DEC - 20081010

Declared Rare & Priority Species - DEC - 200901*

- (R) Declared Rare Flora - Extant Taxa
- Priority 1 - Poorly Known Taxa
- Priority 2 - Poorly Known Taxa
- Priority 3 - Poorly Known Taxa
- Priority 4 - Rare Taxa

Geomorphic Wetlands - Swan Coastal Plain - DEC - 200809

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

*Note: DRF data includes old WA Herbarium records (Apr 2004)

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Main Roads WA
Perth-Darwin National Highway Planning Study

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Environmental Constraints - Ecological Map Sheet 7

Figure 5

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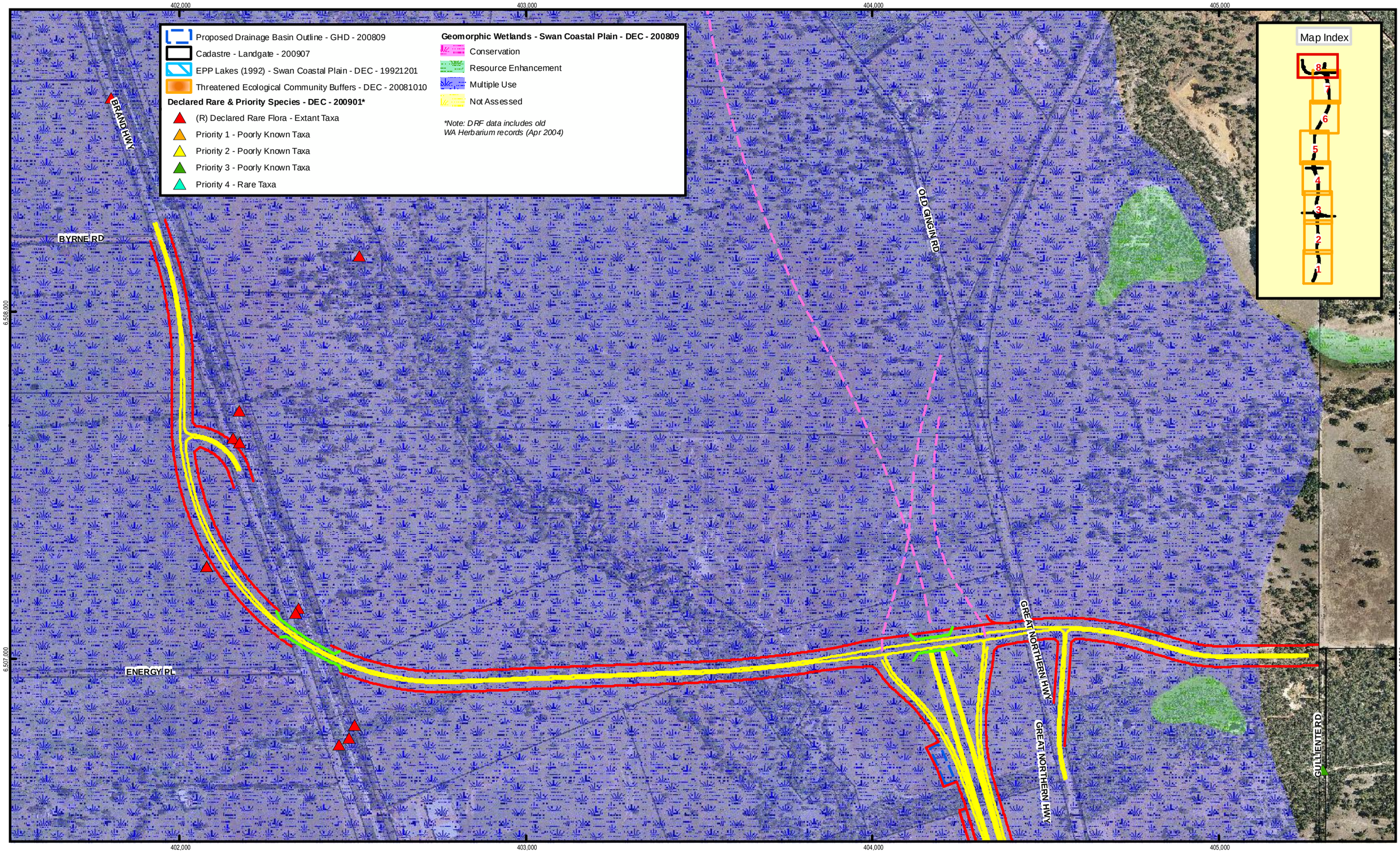

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

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LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges
- Future Alternative Alignment

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Main Roads WA
Perth-Darwin National Highway Planning Study

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Revision	0
Date	07 AUG 2009

Environmental Constraints - Ecological
Map Sheet 8

Figure 5

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Data Source: GHD: Proposed Highway Alignment & Drainage Outline - Sep 2008; Landgate: Metro North 2009 Mosaic - Dec 2008, Cadastre - Jul 2009; DEC: Declared Rare Flora - Jan 2009, WA Herbarium Rare Flora - Apr 2004, TEC - Jan 2009, Geomorphic Wetlands - Sep 2008, EPP Lakes - Dec 1992. Created by: xntan

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6,492,500 6,490,000 6,487,500

PAYNE

ROBINSON RD

COOPER RD

STOCK RD

SAVY CL

GREAT NORTHERN HWY

CHITTY RD

RAPHAEL ST

WARBROOK RD

WISE RD

DELLARD SOUTH

HALDEN RD

SAWPIT RD

RAILWAY PDE

MARALLA RD

ROXBURGHE DR

BRAMLEY CE

VINES AV

BOTANY PDE

CARDINAL DR

MALBEC L

ARAMAC TURN

5 4 3-4 2-3 1-2 2

Map Index

3 2 1

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Reservation
- Proposed Alignment
- Cadastre - Landgate - 200907

Vegetation Types - GHD - 2004

- Medium Marri woodland
- Medium woodland; Marri & Wandoo
- Medium open woodland; Jarrah & Marri, with low woodland; Banksia
- Medium woodland; jarrah & wandoo
- Low woodland; Banksia
- Medium woodland; Wandoo
- Marri woodland/ Banksia low woodland
- Open Eucalypt woodland with Melaleuca low forest
- Shrublands; scrub-heath
- Flooded Gum woodland
- Medium woodland; Jarrah & Marri
- Pine Plantation
- Mosaic; mixed scrub heath, Banksia, Eucalyptus & Melaleuca woodland

Vegetation Condition - GHD - 2004

1 Pristine
2 Excellent
3 Very good
4 Good
5 Degraded
6 Completely Degraded

1:25,000 (at A3)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
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Main Roads WA
Perth-Darwin National Highway Planning Study

Vegetation Community & Condition Map Sheet 1

Job Number 61-14438
Revision 1
Date 07 AUG 2009

Figure 6

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: GHD: Proposed Highway Alignment & Drainage Outline - Sep 2008; Landgate: Metro North 2009 Mosaic - Dec 2008, Cadastre - Jul 2009; GHD: Vegetation Types & Condition - 2004. Created by: xntan

400,000 402,500 405,000

6,500,000 6,497,500 6,495,000

Map Index

3 2 1

MARTIN RD
BINGHAM RD
ALMERIA PDE
MORLEY RD
GASTON RD
MUCHEA SOUTH RD
RUTLAND RD
KIRBY RD
PINE RD
NEAVES RD
OLD WEST RD
WEST RD
GALLAGHER RD
DELLA RD NORTH
STRACHAN RD
RAILWAY PDE
ASHER RD
UNNAMED RD
DELLA RD
RAPHAEL ST
GULLY RD
PAYNE RD

2-3 2-3 2 3-4 4 4 4-5 1-3 5 5 5 2 5

LEGEND

Proposed Highway Alignment - GHD - 200809
- Proposed Reservation
- Proposed Alignment
- Cadastre - Landgate - 200907

Vegetation Types - GHD - 2004
- Medium Marri woodland
- Medium woodland; Marri & Wandoo
- Medium open woodland; Jarrah & Marri, with low woodland; Banksia
- Medium woodland; jarrah & wandoo
- Low woodland; Banksia
- Medium woodland; Wandoo
- Marri woodland/ Banksia low woodland
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- Shrublands; scrub-heath
- Flooded Gum woodland
- Medium woodland; Jarrah & Marri
- Pine Plantation
- Mosaic; mixed scrub heath, Banksia, Eucalyptus & Melaleuca woodland

Vegetation Condition - GHD - 2004
1. Pristine
2. Excellent
3. Very good
4. Good
5. Degraded
6. Completely Degraded

1:25,000 (at A3)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
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Main Roads WA
Perth-Darwin National Highway Planning Study

Vegetation Community & Condition Map Sheet 2

Job Number 61-14438
Revision 1
Date 07 AUG 2009

Figure 6

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GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

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400,000 402,500 405,000

6,510,000 6,507,500 6,505,000 6,502,500

Map Index

3 2 1

RESERVE RD

OLD GINGIN RD

BYRNE RD

ENERGY PL

BRAND HWY

CHITTERING ST

HORTON ST

ELLEN ST

PAYNE ST

PETERS RD

ARBUCKLE ST

HUMPHREYS ST

ALMERIA PDE

GULLIENTE RD

MUCHEA EAST RD

WANDENA RD

5

LEGEND

Proposed Highway Alignment - GHD - 200809
- Proposed Reservation
- Proposed Alignment
- Cadastre - Landgate - 200907

Vegetation Types - GHD - 2004
- Medium Marri woodland
- Medium woodland; Marri & Wandoo
- Medium open woodland; Jarrah & Marri, with low woodland; Banksia
- Medium woodland; jarrah & wandoo
- Low woodland; Banksia
- Medium woodland; Wandoo
- Marri woodland/ Banksia low woodland
- Open Eucalypt woodland with Melaleuca low forest
- Shrublands; scrub-heath
- Flooded Gum woodland
- Medium woodland; Jarrah & Marri
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- Mosaic; mixed scrub heath, Banksia, Eucalyptus & Melaleuca woodland

Vegetation Condition - GHD - 2004
- 1 Pristine
- 2 Excellent
- 3 Very good
- 4 Good
- 5 Degraded
- 6 Completely Degraded

1:25,000 (at A3)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
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Main Roads WA
Perth-Darwin National Highway Planning Study

Vegetation Community & Condition Map Sheet 3

Job Number 61-14438
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Figure 6

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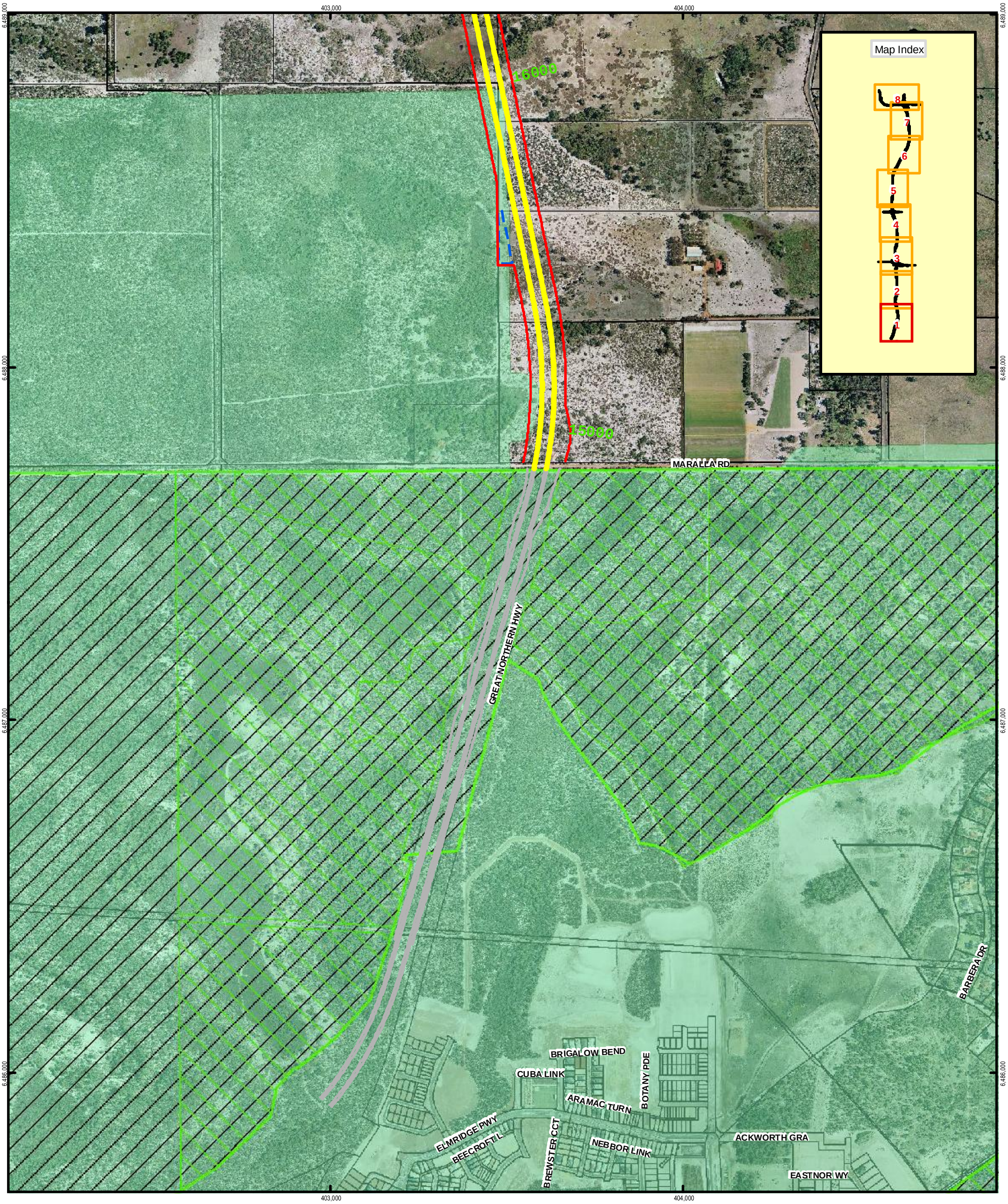

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges
- Proposed Alignment & Endorsed MRS Reservation
- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- DEC Estate - DEC - 200904
- Bush Forever - DPI - 20071203
- Environmentally Sensitive Areas - DEC - 20050530

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

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Main Roads WA
Perth-Darwin National Highway Planning Study

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Revision 1
Date 07 AUG 2009

Environmental Constraints - Administrative Map Sheet 1

Figure 7

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403,000
404,000
6,492,000
6,491,000
6,490,000
6,489,000

CUNNINGHAM RD
CHITTY RD
GREAT NORTHERN HWY
RAPHAEL ST
WARBROOK RD
HALDEN RD
SAWPIT RD

19000
18000
17000
16000

Map Index
1
2
3
4
5
6
7
8

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges
- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- DEC Estate - DEC - 200904
- Bush Forever - DPI - 20071203
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1:10,000 (at A3)
0 50 100 200 300 400
Metres

Map Projection: Transverse Mercator
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CLIENTS | PEOPLE | PERFORMANCE

Main Roads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
Date 07 AUG 2009

Environmental Constraints - Administrative Map Sheet 2

Figure 7

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6,495,000 6,494,000 6,493,000 6,492,000

Map Index

1 2 3 4 5 6 7 8

22000 21000 20000 19000

GULLY RD

RAPHAEL ST

PAYNE RD

ROBINSON RD

GREAT NORTHERN HWY

COOPER RD

STOCK RD

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- DEC Estate - DEC - 200904
- Bush Forever - DPI - 20071203
- Environmentally Sensitive Areas - DEC - 20050530

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

CLIENTS | PEOPLE | PERFORMANCE

Main Roads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
Date 07 AUG 2009

Environmental Constraints - Administrative Map Sheet 3

Figure 7

G:\61\14438\gis\mxds\6114438-G132_Rev1.mxd

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BINGHAM RD

DAVIDSON ST

NEAVES RD

WEST RD

GALLAGHER RD

GREAT NORTHERN HWY

STRACHAN RD

RAPHAEL ST

25000

24000

23000

22000

Map Index

1 2 3 4 5 6 7 8

LEGEND

Proposed Highway Alignment - GHD - 200809

Proposed Carriageway

Proposed Reservation

Bridges

Proposed Drainage Basin Outline - GHD - 200809

Cadastre - Landgate - 200907

DEC Estate - DEC - 200904

Bush Forever - DPI - 20071203

Environmentally Sensitive Areas - DEC - 20050530

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

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CLIENTS|PEOPLE|PERFORMANCE

Main Roads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
Date 07 AUG 2009

Environmental Constraints - Administrative Map Sheet 4

Figure 7

G:\61\14438\gis\mxds\6114438-G132_Rev1.mxd

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402,000 403,000 404,000

6,501,000 6,500,000 6,499,000 6,498,000

MARTIN RD

BINGHAM RD

MORLEY RD

GASTON RD

28000

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Map Index

8 7 6 5 4 3 2 1

LEGEND

Proposed Highway Alignment - GHD - 200809

Proposed Carriageway

Proposed Reservation

Bridges

Proposed Drainage Basin Outline - GHD - 200809

Cadastre - Landgate - 200907

DEC Estate - DEC - 200904

Bush Forever - DPI - 20071203

Environmentally Sensitive Areas - DEC - 20050530

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
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CLIENTS | PEOPLE | PERFORMANCE

Main Roads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
Date 07 AUG 2009

Environmental Constraints - Administrative Map Sheet 5

Figure 7

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ALMERIA PDE

MUCHEA SOUTH RD

31000

30000

29000

Map Index

8 7 6 5 4 3 2 1

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges
- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- DEC Estate - DEC - 200904
- Bush Forever - DPI - 20071203
- Environmentally Sensitive Areas - DEC - 20050530

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0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
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CLIENTS | PEOPLE | PERFORMANCE

Main Roads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
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Environmental Constraints - Administrative Map Sheet 6

Figure 7

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GREAT NORTHERN HWY

CULLENTE RD

MUCHEA EAST RD

BRAND HWY

EDWARDS PL

PETERS RD

GREAT NORTHERN HWY

MUCHEA SOUTH RD

ALMERIA PDE

34000

33000

32000

Map Index

8 7 6 5 4 3 2 1

LEGEND

Proposed Highway Alignment - GHD - 200809

- Proposed Carriageway
- Proposed Reservation
- Bridges
- Future Alternative Alignment

- Proposed Drainage Basin Outline - GHD - 200809
- Cadastre - Landgate - 200907
- DEC Estate - DEC - 200904
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CLIENTS | PEOPLE | PERFORMANCE

Main Roads WA
Perth-Darwin National Highway Planning Study

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Environmental Constraints - Administrative Map Sheet 7

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402,000 403,000 404,000 405,000

6,508,000

6,507,000

BRAND HWY

BYRNE RD

ENERGY PL

OLD GINGIN RD

GREAT NORTHERN HWY

GREAT NORTHERN HWY

GULLIENTER RD

Map Index

8 7 6 5 4 3 2 1

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
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LEGEND

Proposed Highway Alignment - GHD - 200809

Proposed Carriageway

Proposed Reservation

Bridges

Future Alternative Alignment

Proposed Drainage Basin Outline - GHD - 200809

Cadastre - Landgate - 200907

Environmentally Sensitive Areas - DEC - 20050530

CLIENTS|PEOPLE|PERFORMANCE

Main Roads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 1
Date 07 AUG 2009

Environmental Constraints - Administrative
Map Sheet 8

Figure 7

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Appendix B

Stock Road Wetland Assessment

GHD CLIENTS|PEOPLE|PERFORMANCE

MEMORANDUM

4 February 2009

To	Paul Fourie		
Copy to	Paul Fisher (GHD)		
From	Glen Gaikhorst and Erin D'Raine	Tel	6222 8689
Subject	Wetlands assessment along Raphael Road and Stock Road- PDNH alignment	Job no.	61/14438

1 Background

GHD Pty Ltd (GHD) were appointed in December 2003 to undertake an alignment definition study to develop a more precise road reservation within the Government endorsed corridor between Bullsbrook and Bindoon for the Perth Darwin National Highway (PDNH).

Following consultation with the City of Swan and the DEC, the proposed interchange at Warbrook Road was relocated to Stock Road. The DEC indicated a preference for the interchange to be located at Stock Road to avoid any potential impacts on the Twin Swamps Nature Reserve, which is covered by the Environmental Protection (Western Swamp Tortoise Habitat) Policy. The proposed location of the Stock Road interchange is within close proximity to a number of Resource Enhancement category wetlands and wetlands protected under the Environmental Protection Policy – Swan Coastal Plain.

2 Scope of work

On 21st January 2009 an assessment was undertaken on three wetland areas (Wetland 221, 224 and 213) along the PDNH alignment on Raphael Road and Stock Road, Muchea. The aim of the assessment was to determine the significance of the wetlands in their current state. The assessment was conducted by Glen Gaikhorst- Senior Zoologist and Erin D'Raine- Ecologist at GHD.

3 Wetland Field Assessment

On 21st January 2009, GHD undertook an assessment of the wetlands adjacent to the proposed Stock Road Interchange near the corner of Raphael Road and Stock Road, Muchea. Details of these wetlands are given in Table 1 and their locations shown in Figure 1.

Table 1 Wetlands that are potentially within the proposed PDNH alignment on Raphael Road and Stock Road.

Lot Number	Wetland No.	Wetland Classification
1610	213	Resource Enhancement Category
1610, 1638	224	EPP Lake
7, 10, 1610	221	EPP Lake

GHD Pty Ltd ABN 39 008 488 373
GHD House 239 Adelaide Terrace Perth WA 6004 PO Box 3106 Perth Adelaide TCE WA 6832 Australia
T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

3.1 Wetland 221 (Hill *et al.* 1996)

This wetland is listed under the Environmental Protection (Swan Coastal Plain Lakes) Policy (1992) and is situated on Lots 10, Lot 7, 1610 and road reserve, Bullsbrook (the road reserve sits between Lot 7 and 10). This wetland has previously been assessed by GHD (2005) and was reported as remnant heath of *Astartea fascicularis* in very degraded to good condition. Its poor state was due to cattle grazing on each of the properties.

In the current assessment it was found to be unchanged, with heavy grazing by cattle impacting on the growth of the vegetation particularly on Lot 10. The small portion of wetland on Lot 7 has been cleared. The road reserve and Lot 1610 have intact stands of good condition *Melaleuca sp.* and *Astartea fascicularis* but have large areas of cleared land surrounding them. The edge of the wetland is denuded of vegetation due to heavy grazing and there is a high proportion of weedy (introduced) flora species. Therefore the north-western portion of the wetland (Lot 1610) although degraded, is in much better condition than the south-eastern portion on Lot 10.

3.2 Wetland 224 (Hill et al 1996)

Wetland 224 is listed under the Environmental Protection (Swan Coastal Plain Lakes) Policy (1992) and is primarily positioned on Lot 1638, and on the edge of Lot 1610, Muchea. This wetland is completely degraded and has been cleared and is denuded of native vegetation. The vegetation present is primarily introduced grasses with scattered reed clumps of *Lepidosperma longitudinale* within agricultural land. Very little fauna habitat persists on this site although seasonal inundation would provide temporary habitat for amphibians and waterbirds. Approximately 150m north-west of wetland 224 is a low-lying area that consists primarily of reeds (*Lepidosperma longitudinale*) within agricultural land. This area would become seasonally inundated but is not recognised as a wetland (Hill *et al.* 1996); it links between wetlands 224 with 213.

3.3 Wetland 213 (Hill et al 1996)

Wetland 213 is listed under the Department of Environment and Conservation Geomorphic Wetlands Database as Resource Enhancement Category. An assessment of this wetland was made from the fence line on Raphael Road and using aerial photography as this property could not be accessed. The vegetation within this wetland appeared to be generally intact and in good to degraded condition. The remnant vegetation is dominated by Myrtaceous species including *Melaleuca preissiana* and *Astartea fascicularis* over reeds and rushes, herbs and grasses. A large proportion of weedy (introduced) flora species is likely to be present within this wetland given that the surrounding vegetation has been cleared for agriculture. This wetland appears to be permanently inundated and would provide good fauna habitat, particularly for amphibians and waterbirds. The vegetation within the wetland may partially be protected from grazing of cattle by fencing.

4 Conclusion

- As a result of large-scale clearing and grazing by cattle the condition of wetland 221 is generally in degraded condition. The vegetation structure of this wetland has been severely impacted by the above disturbances. Improvement of land management practices may improve the regeneration and condition of native vegetation however not without intensive management.

- Wetland 224 has been completely cleared for agricultural land uses and is devoid of native vegetation, and is therefore completely degraded.
- Wetland 213 is categorised as a Resource Enhancement wetland which has partially intact native vegetation that is generally in good to degraded condition. Disturbances to this wetland include large-scale clearing with cow paddocks surrounding the wetland and consequent weed invasion. This wetland can potentially provide good fauna habitat, particularly for amphibians and waterbirds. With appropriate management, the condition of this wetland could be improved, therefore this wetland should be protected were possible.

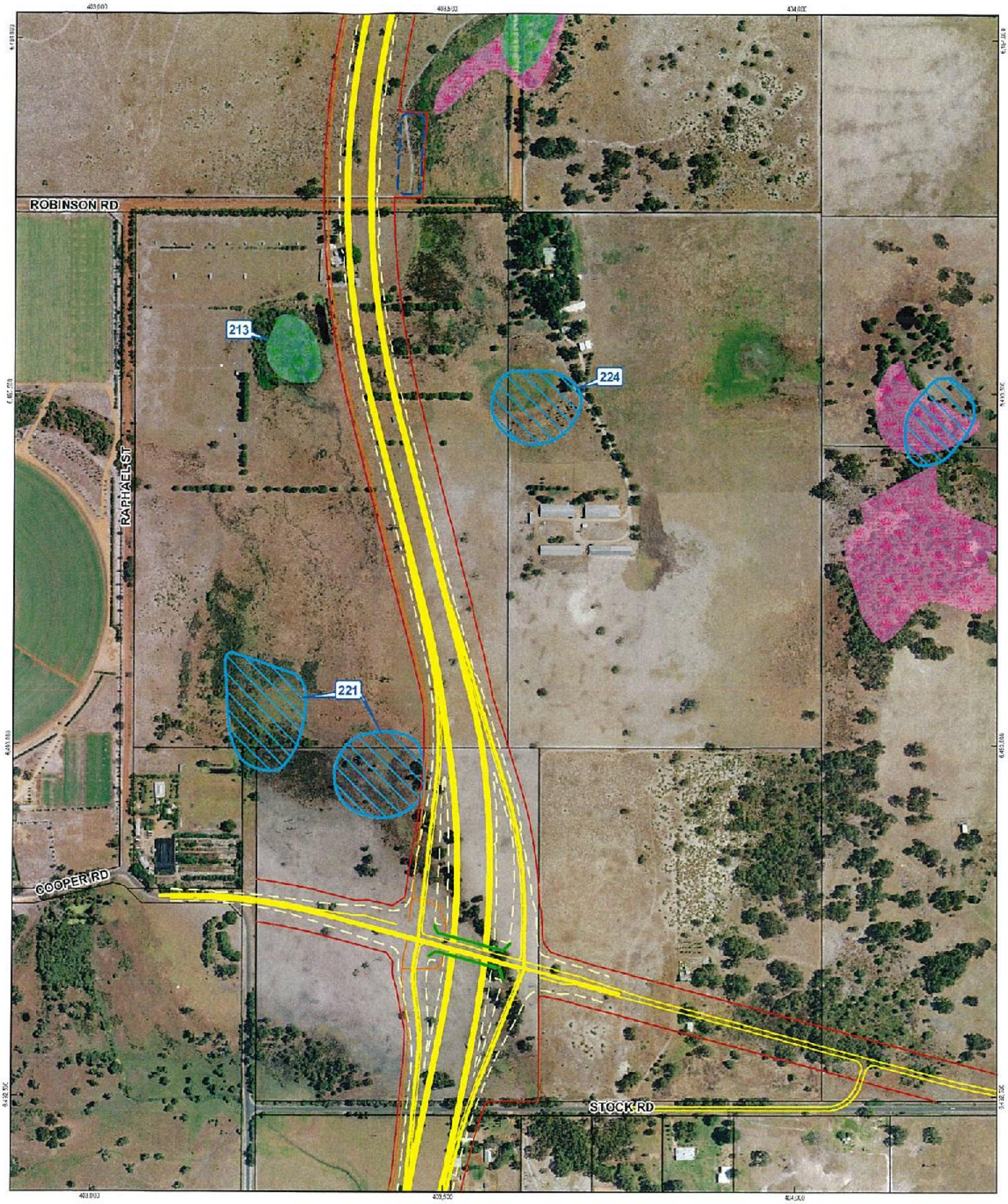
5 References

GHD (2005). Perth-Darwin National Highway Alignment Definition Study; Environmental Impact Assessment Report Southern Section, Perth, Western Australia.

Hill, Al., Semeniuk, CA., Semeniuk, V and Del Marco, A (1996). Wetlands of the Swan Coastal Plain; Volume 2B, Wetland Mapping, Classification and Evaluation, Wetland Atlas.

Environmental Protection Authority (1992) Environmental Protection Policy; Swan Coastal Plain Lakes.

Environmental Protection Authority (EPA) (1993) *Bulletin 686: A Guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area:* An update to EPA Bulletin 374, Report of the EPA, July 1993.



LEGEND

Proposed Highway Alignment

- Future Carriageway
- Future Reservation
- Bridges

- Proposed Drainage Basin Outline
- EPP Lakes (1992) - Swan Coastal Plain
- Cadastre

Geomorphic Wetlands - Swan Coastal Plain

- Conservation
- Resource Enhancement

221 Wetland Numbers (Hill et. al.)

1:5,000 (at A3)

0 25 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Main Roads WA
Perth-Darwin National Highway Planning Study

Geomorphic Wetlands and EPP Lakes

Job Number 61-14438
Revision 0
Date 29 JAN 2009

Figure 1

G:\61\14438\gis\mxds\61144381G129.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data Source: Landgate: Metro North 2006 Mosaic - Dec 2007; Landgate: Cadastre - Nov 2008; GHD: Proposed Highway Alignment and Drainage Outline - Sep 2008; Department of Environment and Conservation: EPP Lakes Policy Area - Dec 1992; Geomorphic Wetlands - Swan Coastal Plain - Mar 2007; Created by: wtse, tedrau

Appendix C

Raphael Road Wetland Assessment

GHD CLIENTS|PEOPLE|PERFORMANCE

MEMORANDUM

15 September 2008

To	Kevin Smith		
Copy to	Lindsay Broadhurst, Paul Fisher (GHD)		
From	Megan Dilly, Paul Fisher	Tel	6222 8973
Subject	PDNH Alignment Definition: Assessment of Raphael Rd Conservation Category Wetland	Job no.	61/14438

1 Background

GHD has been commissioned by Main Roads to undertake alignment definition for the Perth Darwin National Highway (PDNH). One of the issues identified during this process was a Conservation category Wetland near Raphael Road in Bullsbrook (**Figure 1**). Direct impacts on this wetland were avoided in the preliminary design; however, this design had some impact on the holdings of the Department of Defence (DoD). DoD requested that this alignment be revisited and the potential for the alignment to go through the wetland (along the eastern boundary of their land) be investigated, as the wetland is considerably degraded from grazing. A site meeting was held on 6 September 2007 with representatives of the DoD, the Department of Environment and Conservation (DEC), Main Roads and GHD. It was noted that the wetland west of Raphael Road is degraded and has been heavily grazed. However, water flowing through the degraded land also feeds higher quality wetlands east of Raphael Road.

Main Roads requested GHD to undertake an investigation of the wetland to assess the potential to align the highway through the wetland and in preparation for a possible request for modification to the *Geomorphic Wetlands Swan Coastal Plain* dataset. The full wetland assessment is detailed in the report "Raphael Road Conservation Category Wetland Assessment", which covers both the hydrological and ecological aspects of the wetland. The results from this assessment are summarised below. This memo also includes information on the technical aspects of the highway in relation to the wetland.

2 Wetland Mapping

Wetlands not only include lakes with open water but areas of seasonally, intermittently or permanently waterlogged soil. The Raphael Rd wetland has been split into three sections with the Unique Feature Identifiers (UFIs): 8914, 8915 and 8916. The entire area on the eastern side of Raphael Rd was originally identified as Conservation category wetland in Hill et al. (1996) as a result of the area being identified as a vegetated section of wetland, with 100% vegetation cover, and the category explanation of C2 (that is, the wetland is greater than or equal to 95% undisturbed). However, the northern portion (UFIs 8915 and 8916) is currently mapped as Resource Enhancement palusplain on the *Geomorphic Wetlands Swan Coastal Plain* dataset. This modification is the result of the evaluation conducted in 1997 for the Bushplan verification (Alison Beard, DEC Wetlands Branch, *pers comm.*, 31/07/07.). This vegetated wetland is surrounded by an extensive Multiple Use palusplain (UFI 13511).

On the western side of Raphael Rd there is a small portion of the wetland that is Conservation category (UFI 8914) but the majority of the wetland is Multiple Use palusplain (UFI 13511) (**Figure 1**).

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Conservation category wetlands are wetlands that support high levels of attributes and functions. Resource Enhancement wetlands are those that have been partly modified but still support substantial functions and attributes. Multiple Use wetlands are classified as those wetlands with few attributes that still provide important wetland functions.

3 Hydrological Aspects

The study area has a shallow depth to groundwater that is typical of the palusplain that is prevalent in the area. The ground surface of the wetland has intersected the natural groundwater level and therefore becomes a point of groundwater discharge. The wetland is therefore an expression of local groundwater levels and intersects the upper most part of the superficial aquifer. There are other discharge points present in the area that result in various small creeks running in an approximate easterly direction. The source of this groundwater discharge is likely to be the Gnangara Mound located to the west of the site.

At the time of visit the surface water was moving in an easterly direction from the discharge area and pooling in the drainage channel on the western side of Raphael Road. Water was then flowing from the western drainage channel into the eastern drainage channel.

If the new road construction was to take place on the alignment of the western wetland then recharge from surface water flows to the eastern wetland may be adversely affected and engineering controls would need to be employed that safeguard the flow of surface waters from the western wetland to the eastern wetland.

4 Ecological Aspects

The study area has been previously cleared and little of the vegetation structure remains intact. The area surrounding the wetland is a paddock with pasture grasses and introduced species. In the higher, sandy area to the west of the study area there are pasture grasses and weeds and a number of individual Marri trees scattered throughout the paddock. At the site of the spring there is a marshy area of approximately 10 m in diameter. The vegetation surrounding the spring is dominated by rushes and grasses. The section of wetland to the east of Raphael Road retains an intact native overstorey with a number of mature *Melaleuca preissiana* trees. The understorey is similar to the wetland on the western side, supporting rushes and grasses.

The vegetation in the study area has previously been cleared and is highly degraded and dominated by introduced species. Occasional native species, including individual trees (Marris) and shrubs occur throughout the paddock in the dry areas adjacent to the wetland. Within the wetland there are some native species remaining in the under-storey but the majority of the wetland is dominated by introduced grasses and herbs. The wetland condition ranged from *Degraded* (5) to *Completely Degraded* (6).

The western section of the wetland is located within a cleared paddock that has been highly disturbed. However, this wetland still has value as fauna habitat, particularly for frogs and wetland birds.

5 Road Engineering Issues

Engineering implications of placing the road over the springs include the following:

- Water erupting under the pavement would cause damage to the road structure. Accordingly it would be necessary to install extensive (and expensive) subsoil drains to divert the water away. In the event of failure of the subsoil drains, the spring water would cause severe damage to the pavement.

- The weight of the road embankment could cause consolidation of the soil strata, causing the underground flow to change direction with unpredictable results. It is possible that new springs would erupt in the vicinity, again damaging the pavement.

6 Consultation with the Department of Environment and Conservation (DEC)

Realignment of the highway to the east will impact a conservation category wetland. It was therefore proposed to seek reclassification of that part of the wetland west of Raphael Road from conservation category to resource enhancement. Reclassification requires the submission of a written request for assessment and approval by the DEC.

Representatives from the DEC's Wetland Program (Jennifer Higbid) and the Regional office (Michael Roberts) provided feedback on the Raphael Rd wetland and the proposed alignment of the PDNH.

The DEC recognises that the area of conservation category wetland west of Raphael Rd has been degraded by grazing; however the wetland drains into a creekline which passes through the conservation category and resource enhancement wetland areas to the east of Raphael Rd and then discharges into Ellen Brook (Jennifer Higbid *pers comm.*, 2008). The area of Ellen Brook where the creek discharges is located within Bush Forever site 294 "Pearce Aerodrome and Adjacent Bushland, Bullsbrook'.

Feedback from DEC (Jennifer Higbin *pers comm.*, 2008) includes:

The proposal to locate the road alignment through the western wetland area may impact surface flows and drainage patterns which also potentially impacts the existing hydrological regime. Altering the hydrological regime can impact wetland values by:

- *Reducing the vegetation condition*
- *Reducing biodiversity*
- *Impacting fauna habitat*
- *Disrupting fauna life cycles (eg. birds, frogs and invertebrates)*
- *Modifying soil chemical processes (eg. Acid Sulphate Soils)*

In addition, road runoff may introduce pollutants (eg. hydrocarbons) to the wetlands and creek. An increased transport of pollutants has the potential to impact wetland values by:

- *Reducing vegetation condition*
- *Impacting fauna habitat*
- *Impacting water quality*
- *Eutrophication and algal blooms*
- *Fauna mortality*

DEC does not support the modified alignment through the wetland area as it has the potential to impact on Conservation and Resource Enhancement category wetland areas east of Raphael Rd and Ellen Brook.

Given that DEC do not support the proposed realignment of the highway, it is highly unlikely that reclassification of whole or part of the wetland would be approved.

7 Conclusions and Recommendations

The western section of the Conservation category wetland is maintained by groundwater discharge and the wetland on the eastern side of Raphael Road is partly sustained by the groundwater discharge area on the western side. The two areas are currently connected by a single culvert.

The western section of the wetland is very degraded, is mostly devoid of native vegetation and holds low conservation value. However, it does hold some ecological value for its frog and waterbird habitat. Additionally, this wetland is a source of the groundwater discharge that feeds into the eastern section of the wetland through a culvert underneath Raphael Road. The eastern section of the wetland is in better condition and contains remnant *Melaleuca preissiana*.

If the PDNH alignment intersected the western section of the wetland, recharge from surface water flows to the eastern wetland may be adversely affected. If the road alignment passes over the wetland area (and consequently the groundwater discharge area), road construction would require specific engineering controls, such as subsoil drains). This would be necessary both for preventing damage to the road structure and to maintain flows to the wetland on the eastern side of Raphael Road. A subsoil drainage system alone may not prevent pavement failure in future. The consolidation of the soil over time due to the weight of the road embankment may cause underground flow to change direction with unpredictable results. This could damage the road pavement.

Direct impacts on the wetland system at Raphael Road should be avoided by retaining the alignment where it is, in the higher areas to the west of the wetland. This will avoid the need to reclassify the Conservation category wetland and will minimise the impacts on the whole wetland system. The DEC has indicated that moving the alignment will have adverse impacts on the wetland system, as well as Ellen Brook and does not support the modified alignment. Retaining the alignment where it is, outside of the wetland, will also minimise the engineering issues and costs by reducing the need for subsoil drainage.

If the alignment is to be moved to the eastern boundary of the DoD land to pass through the wetland Main Roads will need to demonstrate that it is possible to manage the associated environmental and technical issues, which may be very difficult and costly. Environmental approval to impact on the Conservation category wetland will be required and this may be difficult to obtain as the DEC does not support the alignment through the wetland.

Moving the alignment to the eastern boundary of the DoD land will have additional impacts. The alignment will impact the Environmental Protection Policy wetland (classified under the Environmental Protection Swan Coastal Plain Lakes Policy 1992) to the south. This will likely require referral to the EPA and would not be supported by the DEC. The alignment would affect private property to the south, including impact on a poultry breeding farm on lot 1638. The alignment will affect the Stock Road interchange layout.

The proposed alignment is preferred based on the cumulative engineering, environmental and social impacts outlined above.

Attachments:

Figure 1: Environmental Constraints

Email from DEC Re: Raphael Rd wetland assessment (07/05/08)

"Roberts, Michael" <Michael.Roberts@dec.wa.gov.au>

07/05/2008 09:48 AM

To <MDilly@ghd.com.au>
cc "Lamb, Grant" <Grant.Lamb@dec.wa.gov.au>
bcc
Subject FW: Raphael Rd wetland assessment

Hi Megan,
Apologies for the delay in getting comments back to you. Please find below comments from the DEC Wetlands Program regarding the Raphael Rd wetland assessment. Please contact me if you would like to discuss these comments further.

Regards

Michael Roberts| Land Use Planning Officer

Swan Coastal District

Department of
Environment and Conservation

5 Dundebar Road, Wanneroo 6065 |
Ph: 9405 0755 Fax: 9405 0777 Mob: 0429109085
michael.roberts@dec.wa.gov.au

From: Higbid, Jennifer
Sent: Wednesday, 7 May 2008 9:07 AM
To: Roberts, Michael
Subject: RE: Raphael Rd wetland assessment

Hi Michael,

Please find comments below in regard to the Perth Darwin National Highway and the Raphael Rd Conservation category wetland area. The Wetlands Program also agrees with the conclusions and recommendations presented by GHD and does not support the modified alignment through the western Conservation category wetland area as it has the potential to impact the Conservation and Resource Enhancement category wetland areas east of Raphael Rd and Ellen Brook.

The Conservation category wetland area near Raphael Rd Bullsbrook is identified in the *Geomorphic Wetlands Swan Coastal Plain* dataset as a vegetated portion of an extensive palusplain (i.e. seasonally waterlogged flat). It should be noted that the wetland areas located east and west of Raphael Rd are all part of the same extensive palusplain system.

It is recognised that the area of Conservation category wetland west of Raphael Rd has been degraded by grazing, however, GHD have identified that surface water flows from the western wetland area towards the Conservation and Resource Enhancement category wetland areas located to the east. Wetland mapping from *Wetlands of the Swan Coastal Plain Volume 2B Wetland Mapping Classification and Evaluation, Wetland Atlas* (Hill et al 1996) (Map Sheet 2034 I SE) identifies a creek line that originates in the western wetland area and drains to the east (through the

eastern Conservation and Resource Enhancement category wetland areas) and discharges into Ellen Brook. The area of Ellen Brook where the creek discharges is located within Bush Forever site 294 'Pearce Aerodrome and Adjacent Bushland, Bullsbrook'.

The proposal to locate the road alignment through the western Conservation category wetland area may impact surface flows and drainage patterns, which also potentially impacts the existing hydrological regime. Altering the hydrological regime can impact wetland values by:

- reducing the vegetation condition
- reducing biodiversity
- impacting fauna habitat
- disrupting fauna life cycles (e.g. birds, frogs and invertebrates)
- modifying soil chemical processes (e.g. acid sulphate soils).

In addition, road runoff may introduce pollutants (e.g. hydrocarbons) to the wetlands and creek. An increased transport of pollutants has the potential to impact wetland values by:

- reducing vegetation condition
- impacting fauna habitat
- impacting water quality
- eutrophication and algal blooms
- fauna mortality.

Please let me know if you need any further info or clarification on our comments.

Kind regards,
Jennifer

~~~~~~

Jennifer Higbid
Wetlands Program, Species and Communities Branch
Department of Environment and Conservation

17 Dick Perry Avenue, Technology Park, Kensington WA 6151
Locked Bag 104, Bentley Delivery Centre WA 6983

Ph: 9219 8709 Fax: 9219 8701
Email: jennifer.higbid@dec.wa.gov.au

From: Roberts, Michael
Sent: Tuesday, 22 April 2008 12:15 PM
To: Thorning, Natalie
Subject: FW: Raphael Rd wetland assessment

Hi Natalie,
As discussed briefly yesterday I was wondering if the Wetlands Group would be able to provide comments on the attached Perth-Darwin National Highway alignment study summary relating to the potential impact of the highway on a CCW on Rapheal Rd, Bullsbrook. According to Megan Dilly from GHD she had spoken to someone in the Wetlands Group regarding the proposal so I was just checking to see whether the group would like to make comments on the proposal as detailed in the summary report attached. The amended alignment is not specified on the attached figure (6121533-G7) but it travels north-south where the two quadrats were located in the study. The original alignment was located to the west of the quadrats in an area outside of the wetlands. I have had a brief look and agree with the conclusion that the recharge of the wetland on the east of Raphael rd would probably be impacted if they decided to build the road over the wetland on the west of the road. I was going to send back comments to Megan supporting her conclusions and recommendations but I wanted to get some comments from wetland before I did so.

Regards
~~~~~~

Michael Roberts| Land Use Planning Officer

Swan Coastal District

Department of
Environment and Conservation

5 Dundebar Road, Wanneroo 6065 |
Ph: 9405 0755 Fax: 9405 0777 Mob: 0429109085
michael.roberts@dec.wa.gov.au

From: MDilly@ghd.com.au [mailto:MDilly@ghd.com.au]
Sent: Mon 3/31/2008 12:00 PM
To: Roberts, Michael
Subject: Raphael Rd wetland assessment

Hi Michael,

As discussed, please find attached the draft memo to Main Roads on the Raphael Rd wetland.

Any feedback would be greatly appreciated, if you have any questions please do not hesitate to contact me.

Regards,

Megan Dilly
Ecologist

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D 61 8 6222 8973| F 61 8 6222 8555 | mdilly@ghd.com.au
GHD House 239 Adelaide Terrace Perth WA 6004 | www.ghd.com.au

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Appendix D

Vegetation and Flora Assessment

Vegetation Types

Explanation of Vegetation Condition Rating

Declared Rare and Priority Flora in the vicinity of the PDNH Corridor (source: CALM 2004)

Flora List (dominant and unusual taxa)

Perth Darwin National Highway: Vegetation Types, Maralla Road to Muchea

Nearest Road	Location Number	Name	Location ID	Survey date	Vegetation Type	Trees	Tall Shrubs	Medium Shrubs	Low Shrubs/Herbs	Condition	Soils	Other detail
[illegible] Maralla Road	41	[illegible] Camp	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	51	[illegible] Camp	B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Maralla Road	81	[illegible] Camp	C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	91	[illegible] Camp	D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] York Road	77	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Chittering Road	[illegible]	[illegible] College		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	100	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	[illegible]	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	[illegible]	[illegible]	B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	[illegible]	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	[illegible]	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	39	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	72	[illegible]	B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	[illegible]	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	5426	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	5432	[illegible]	C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Road	[illegible]	[illegible]	C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Gordon Road	89	[illegible]	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Gordon Road	[illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Gordon Road	[illegible]	[illegible]	D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Gordon Road	100	[illegible]	D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Nearest Road	Location Number	Name	Location ID	Survey date	Vegetation Type	Trees	Tall Shrubs	Medium Shrubs	Low Shrubs/Herbs	Condition	Soils	Other detail
2017, 2051 [illegible] Road	197, 9[illegible]	[illegible]	A	5/11/2004	Banksia woodland	Banksia attenuata, Banksia menziesii	[illegible] Jacksonia [illegible]	[illegible]	[illegible]	4-5	well defined white/grey sand	[illegible] of [illegible] species
2017, 2051 [illegible] Road	197, 9[illegible]	[illegible]	B	5/11/2004	Scattered woodland of Melaleuca [illegible]	Melaleuca [illegible]	[illegible]	Hypocalymma angustifolium, [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2017, 2051 [illegible] Road	19[illegible], 9[illegible]	[illegible]	D	5/11/2004	Banksia woodland	[illegible] Banksia [illegible]	[illegible]	[illegible] Acacia pulchella	[illegible]	4	well defined white/grey sand	[illegible]
2017, 2051 [illegible] Road	19[illegible], 9[illegible]	[illegible]	C	5/11/2004	[illegible]	Corymbia calophylla, [illegible]	Jacksonia [illegible]	-	-	2-5	sand	[illegible] Water Corp property. Dieback [illegible]
2017, 2051 [illegible] Road	1[illegible], 9[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Banksia [illegible], Banksia [illegible]	[illegible]	[illegible]	[illegible]	2-4[illegible]	sand	[illegible] Banksia and Acacia pulchella [illegible]
2017, 2051 [illegible] Road	1[illegible], 506	[illegible]	E	5/11/2004	[illegible]	-	[illegible]	[illegible] Hypocalymma angustifolium [illegible]	-	2-3	[illegible]	Dieback [illegible]
2017, 2051 [illegible] Road	1[illegible], 506	[illegible]	F	5/11/2004	[illegible] Banksia woodland	[illegible] Banksia [illegible]	[illegible]	Hypocalymma angustifolium, [illegible]	[illegible]	2 [illegible] 4 [illegible]	[illegible] sand [illegible]	
[illegible] Parade	-	-	A	5/11/2004	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	sand	
[illegible] Parade	-		1	5/11/2004	Melaleuca [illegible]	[illegible] Melaleuca [illegible]	Acacia [illegible]	[illegible]	[illegible]	4[illegible]		
[illegible] Parade	0[illegible]	[illegible]	A	5/11/2004	Artificial wetland vegetation [illegible] Eucalyptus rudis and [illegible]	0	0	0	0	[illegible]		[illegible]
[illegible] Brook	-	-		[illegible] 2004	[illegible]	Eucalyptus rudis, Acacia saligna, [illegible]	-	[illegible]	[illegible]	[illegible]		[illegible]

Explanation of Vegetation Condition Rating (Government of WA, 2000)

Rating	Description	Explanation
1	Pristine	Pristine or nearly so, no obvious signs of disturbance
2	Excellent	Vegetation structure intact, disturbance affecting individual species, and weeds are non-aggressive species
3	Very Good	Vegetation structure altered, obvious signs of disturbance
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance, retains basic vegetation structure or ability to regenerate it
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost without native species

Declared Rare and Priority Flora in the vicinity of the PDNH Corridor (source: CALM 2004)

Plant name	Conservation Category	Description	Habitat/Soils	Family
Acacia anarthros	P3	Erect of prostrate spinose shrub, 0.1-0.5 m high. Fl. Yellow, june- sept.	Lateritic gravely soils, slopes	Mimosaceae
Acacia anomala	R			Mimosaceae
Acacia browniana var.*glaucescens*	P2	Multi-stemmed shrub, 0.2-0.5 m high, spreading by subterranean runners, flowers yellow, Aug,	Lateritic gravely soils	Mimosaceae
Acacia drummondii subsp. *Affinis*	P3	Erect shrub, 0.3- 1 m high, flowers yellow, jul_aug	Lateritic gravely soils	Mimosaceae
Acacia oncinophylla subsp. *Oncinophylla*	P3	Shrub, 0.9–2.5 m high, 'minni-ritchi' bark, phyllodes mostly 8–13 cm long, 1–2 mm wide. Fl. yellow, Aug–Oct.	Granitic soils	Mimosaceae
Acacia puchella var. *reflexa* acuminate bracteole variant (R.J. Cummin)	P3	Shrub, 0.3–1 m high. Fl. yellow, Jul–Sep.	Sandy loam or sandy clay over laterite. Woodland.	Mimosaceae
Adenanthos cygnorum subsp. *chamaephyton*	P3	Prostrate, mat-forming, non-lignotuberous shrub, to 0.3 m high. Fl. white, cream, pink, green, Jul–Jan..	Grey sand, lateritic gravel	Proteaceae
Allocasuarina ramosissima	P3	Dioecious, somewhat divaricate shrub, 0.3–1.2 m high.	Lateritic soils, gravel.	Casuarinaceae
Anigozanthos humilis subsp. *chrysanthus*	P4	Rhizomatous, perennial, herb, 0.2–0.4(–0.8) m high. Fl. yellow, Jul–Oct.	Grey or yellow sand.	Haemodoraceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Anthotium junciforme	P4	Open, erect to prostrate perennial, herb, 0.05–0.4 m high, leaves linear to terete, 0.5–1 mm wide; flowering stems 12–40 cm long. Fl. blue, violet, purple, Nov–Mar.	Sandy clay, clay. Winter-wet depressions, drainage lines.	Goodeniaceae
Asteridea gracilis	P4	Annual, herb, 0.15–0.35 m high. Fl. white, pink, Sep–Dec..	Sand, clay, gravelly soils	Asteraceae
Asterolasia nivea	R	Open, weak, densely branched shrub, 0.3–0.5 m high. Fl. white, Aug–Oct.	Sand or clay with lateritic gravel, saline loam. Breakaway, slopes.	Rutaceae
Astroloma sp. Cataby (E.A. Griffin 1022)	P4	Decumbent, spreading or erect shrub, 0.1–0.35 m high. Fl. cream, yellow, white, Feb–Jul.	Loam or sand over laterite. Lateritic hills & breakaways.	Epacridaceae
Baeckea sp. *Chittering* (R.J.Cranfield 1983	P4	Erect open shrub, ca 0.4 m high. Fl. pink, white, Dec.	Lateritic gravel	Myrtaceae
Banksia chamaephyton	P4	Low, lignotuberous shrub, to 0.4 m high, up to 2 m wide. Fl. cream, brown, Oct–Dec.	Grey or white sand over laterite	Proteaceae
Banksia micrantha	P3	Lignotuberous shrub, 0.3–0.6 m high. Fl. yellow, purple, Jan–May.	Grey or white sand over laterite.	Proteaceae
Billardiera sp. Seabird (G.J.Keighery 1297)	P1	Prostrate, much-branched shrub, to 0.5 m wide. Fl. orange, red, Sep.	White sand over limestone. Sea cliff.	Pittosporaceae
Boronia fenuis	P4	Procumbent or erect & slender shrub, 0.1–0.5 m high. Fl. blue, pink, white, Aug–Nov.	Laterite, stony soils, granite.	Rutaceae
Caladenia arrecta	P4	Tuberous, perennial, herb, 0.12–0.35 m high. Fl. yellow, red, Aug–Oct.	Loam, gravel, laterite. Moist situations.	Orchidaceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Calothamnus pachystachyus	P4	Erect, much-branched, often straggly shrub, (0.3–)0.6–1.7 m high. Fl. red, brown, black, Aug–Oct.	Lateritic soils, often gravelly. Ridges, road verges.	Myrtaceae
Calytrix sylvana	P4	Shrub, 0.4–1 m high. Fl. purple, blue, pink, Aug–Oct	. Lateritic soils, sand. Sandplains, ridges.	Myrtaceae
Centrolepis caespitosa	R	Tufted annual, herb (forming a rounded cushion up to 25 mm across). Fl. Oct–Dec.	White sand, clay. Salt flats, wet areas.	Centrolepidaceae
Chamelaucium lullfitzii	R	Erect, open, straggly shrub, to 2 m high. Fl. white, Sep–Dec.	White or yellow sand, leaf litter. Plains, hilltops, crests and lower slopes of scarp, rises, road verges.	Myrtaceae
Chamelaucium sp. Gingin (N.Marchant s.n. 4/1/88)	R	?		Mytraceae
Chamaescilla gibsonii	P3	Clumped tuberous, herb. Fl. blue, Sep.	Clay to sandy clay. Winter-wet flats, shallow water-filled claypans.	Anthericaceae
Conostephium magnum	P4	Erect, compact, many-stemmed shrub, to 2 m high. Fl. pink, purple, Jul–Sep.	. White-grey sands sometimes associated with laterite gravels. Sand dunes, swampland, disturbed roadside, drainage channels, open woodland	Epacridaceae
Cyathochaeta teretifolia	P3	Rhizomatous, clumped, robust perennial, grass-like or herb (sedge), to 2 m high, to 1.0 m wide. Fl. brown	Grey sand, sandy clay. Swamps, creek edges	Cyperaceae
Darwinia acerosa	R	Spreading, compact shrub, 0.2–0.6 m high. Fl. green, red, purple, Sep–Nov.	Sand, loam, often moist soils. Granite outcrops, road verges.	Myrtaceae
Cyanicula ixiodes subsp. *candida*	P2	Tuberous, perennial, herb, 0.04–0.12 m high. Fl. white, Aug–Oct.	Sand, laterite, gravel.	Orchidaceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Darwinia foetida	R	Tangled, domed shrub, to 0.6 m high. Fl. green, Oct–Nov.	Peaty, sandy clay. Winter-wet flats, swamps.	Myrtaceae
Daviesia epiphyllum	P3	Erect, spreading shrub, 0.3–1.5 m high. Fl. red, Apr–Jul.	Lateritic soils. Breakaways, stony hills.	Papilionaceae
Diplolaena andrewsii	P3	Erect shrub, 0.5–1 m high, inner involucral bracts glabrous, leaves broadly cordate. Fl. red, Jul–Oct.	Loam, clay. Granite outcrops & hillsides.	Rutaceae
Drakaea elastica	R	Tuberous, perennial, herb, 0.12–0.3 m high. Fl. red, green, yellow, Oct–Nov.	White or grey sand. Low-lying situations adjoining winter-wet swamps.	Orchidaceae
Drosera occidentalis	P4	Fibrous-rooted, rosetted perennial, herb, to 0.01 m high. Fl. pink, white, Nov–Dec.	Sandy and clayey soils. Swamps and wet depressions.	Droseraceae
Dryandra kippistiana var. *paenepeccata*	P3	Erect, prickly, lignotuberous shrub, 0.3–1.2 m high. Fl. yellow, cream, Oct–Nov	Lateritic gravelly soils.	Proteaceae
Dryandra mimica	R	Prostrate, lignotuberous shrub, 0.15–0.4 m high. Fl. yellow, brown, Dec–Feb.	White or grey sand over laterite, sandy loam.	Proteaceae
Dryandra platycarpa	P4	Erect, columnar, non-lignotuberous shrub, 0.2–1 m high. Fl. cream, yellow, orange, May–Aug.	White, grey/brown sand, often with gravel & over laterite.	Proteaceae
Dryandra polycephala	P4	Erect, non-lignotuberous shrub, 0.75–4 m high, to 3 m wide. Fl. cream, yellow, Jul–Oct.	Gravelly lateritic soils (sand, loam), laterite.	Proteaceae
Dyrandra pteridifolia subsp. *Vernalis*	P3	Prostrate, lignotuberous shrub, to 0.4 m high. Fl. cream, white, yellow, Sep–Oct.	White/grey sand over laterite.	Proteaceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Eleocharis keigheryi	R	Rhizomatous, clumped perennial, grass-like or herb (sedge), to 0.4 m high. Fl. green, Aug–Nov.	Clay, sandy loam. Emergent in freshwater: creeks, claypans.	Cyperaceae
Eucalyptus exilis	P4	Whipstick mallee, 2–6 m high, bark smooth. Fl. white, Aug–Oct.	Grey sand, gravelly loam. Lateritic ridges.	Myrtaceae
Gastrolobium acutum	P3	Bushy shrub, to 1.5 m high. Fl. yellow, red, Aug–Sep.	Sandy loam, gritty clay, gravel, granite, laterite. Slopes, gravel pits, near boulders.	Papilionaceae
Gastrolobium axillare	P3	?		Papilionaceae
Gastrolobium crispatum	P1	Tall shrub, to 2.5 m high. Fl. yellow, orange, red, Sep–Oct.	Yellow or brown sandy loam, red laterite soils,. Steep gullies, slopes, ridges, breakaways.	Papilionaceae
Gastrolobium nudum	P2	Spreading, twiggy shrub, to 0.8 m high. Fl. orange, red, Feb.	Red-brown clay, brown loam, gravel, laterite, granite. Flats, slopes, hilltops, ridges, valleys, breakaways.	Papilionaceae
Goodenia arthrotricha	P2	Erect perennial, herb, to 0.4 m high. Fl. blue, Oct–Nov.	Gravel. Granite rocks, slopes.	Goodeniaceae
Grevillea althoferorum	R	Compact, rounded, lignotuberous shrub, 0.25–0.5 m high. Fl. yellow, cream, Sep–Nov.	Grey sand with gravel.	Proteaceae
Grevillea candolleana	P2	Spreading shrub, 0.2–0.8 m high. Fl. white, cream, Aug–Sep.	Laterite, lateritic loam Hillsides.	Proteaceae
Grevillea drummondii	R	Spreading to erect shrub, 0.2–2(–2.5) m high. Fl. cream, yellow, red, Jun–Sep.	Lateritic soils (sandy clay, gravel, loam, sand), sand over granite. Rocky hillsides, boulders, granite outcrops.	Proteaceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Grevillea corrugata	P1	Shrub, 1.5–2.5 m high. Fl. white, Aug–Sep.	Gravelly loam. Roadsides.	Proteaceae
Grevillea curviloba subsp. *incurva*	R	Prostrate to erect shrub, 0.1–2.5 m high. Fl. white, cream, Aug–Sep	Sand, sandy loam. Winter-wet heath.	Proteaceae
Grevillea curviloba subsp. *curviloba*	R	Prostrate to erect shrub, 0.1–2.5 m high. Fl. white, cream, Oct.	Grey sand. Winter-wet heath	Proteaceae
Grevillea flexuosa	R	Prostrate to erect shrub, 0.1–2.5 m high. Fl. white, cream, Oct.	Grey sand. Winter-wet heath.	Proteaceae
Grevillea florida	P3	Erect shrub, to 0.9 m high. Fl. cream, yellow, Jul–Sep.	Sand, sandy clay, gravel, laterite. Sandplain, slopes, road verges.	Proteaceae
Grevillea saccata	R	Diffuse scrambling or trailing shrub, 0.25–0.5 m high, 1–2 m wide. Fl. red, Apr–Nov..	Yellow or brown sand, often with lateritic gravel	Proteaceae
Guichenotia tuberculata	P3	Erect, open shrub, (0.25–)0.6–0.9 m high. Fl. purple, pink, Aug–Oct.	Sand clay over laterite, sand.	Sterculiaceae
Halgania corymbosa	P4	Erect shrub, 0.35–1 m high. Fl. blue, purple, Aug–Nov..	Gravelly soils, soils over granite	Boraginaceae
Hibbertia miniata	P4	Decumbent or erect shrub, 0.1–1 m high. Fl. orange, red, Aug–Nov.	Lateritic gravelly soils.	Dilleniaceae
Hibbertia glomerata subsp. *ginginensis*	P1	Erect shrub, to 0.5 m high. Fl. yellow, Jul–Sep	Sand, brown clay, laterite. Near roadsides.	Dilleniaceae
Hydrocotyle lemnoides	P4	Aquatic, floating annual, herb. Fl. purple, Aug–Oct.	Swamps.	Apiaceae
Hypocalymma sylvestre	P1	Spreading shrub. 0.6 m high. Fl. yellow, Aug.	Yellow-brown sandy loam. Woodland on lateritic hilltop.	Myrtaceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Hypolaena robusta	P4	Dioecious rhizomatous, perennial, herb, ca 0.5 m high. Fl. Sep–Oct.	White sand. Sandplains.	Restionaceae
Isopogon drummondii	P3	Erect, lignotuberous shrub, 0.4–1 m high. Fl. yellow, cream, Feb–Jun.	White, grey or yellow sand, often over laterite.	Proteaceae
Lambertia multiflora var. *darlingensis*	P3	Many-stemmed shrub, to 2 m high. Fl. yellow, Jun–Nov.	Deep white-yellow sands or loamy, clayey or gravelly soils, laterite, granite. Flats, gorges, base of scarp, rocky hills, plateaus, roadsides.	Proteaceae
Lasiopetalum exiguum	P1	Shrub. Fl. pink, purple, Sep.		Sterculiaceae
Leucopogon glaucifolius	P3	Erect or spreading shrub, 0.15–0.5 m high. Fl. white, Oct–Jan. swamps.	Grey lateritic or white sand, sandy clay. Flats, sand dunes,	Epacridaceae
Monotoca leucantha	P3	Erect shrub, 0.2–1.2 m high. Fl. white, cream, Jun–Sep.	Quartzitic soils. Breakaways.	Epacridaceae
Myriocephalus appendiculatus	P3	Erect annual, herb, to 0.2 m high. Fl. white, yellow, Sep–Dec.	Sand & clay soils. Moist depressions, swamps, claypans.	Asteraceae
Persoonia rudis	P3	Erect, often spreading shrub, 0.2–1 m high. Fl. yellow, Sep–Jan.	White, grey or yellow sand, often over laterite.	Proteaceae
Persoonia sulcata	P3	Erect, spreading to decumbent shrub, 0.2–1 m high. Fl. yellow, Sep–Nov.	Lateritic or granitic soils.	Proteaceae
Petrophile plumosa	P3	Erect, compact shrub, 0.3–1.3 m high. Fl. yellow, Jul–Nov.	Red/brown laterite, loam. Sandplains, hills.	Proteaceae
Platysace ramosissima	P3	Perennial, herb, to 0.3 m high. Fl. white, cream, Oct–Nov.	Sandy soils.	Apiaceae
Ptychosema pusillum	R	Perennial, herb, mostly 0.05–0.1 m high. Fl. red, brown, yellow, Aug–Oct.	Sand. Rises.	Papilionaceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Rhodanthe pyrethrum	P3	Erect, slender annual, herb, 0.05–0.2 m high. Fl. white, yellow, Oct–Dec.	Clay, sandy clay. Winter-wet depressions, clay pans, swamps	Asteraceae
Schoenus sp. Bullsbrook (J.J. Alford 915)	P2	Grass-like or herb (sedge), ca 0.15 m high. Fl. green, brown.	Grey peaty sand. Low-lying flats.	Cyperaceae
Schoenus capillifolius	P2	Semi-aquatic tufted annual, grass-like or herb (sedge), 0.05 m high. Fl. green, Oct–Nov.	Brown mud. Claypans.	Cyperaceae
Senecio gilbertii	P1	Erect, slender perennial, herb, to 1.5 m high. Fl. yellow, Sep–Nov.	Peaty sand. Swamps, slopes.	Asteraceae
Spirogardnera rubescens	R	Spindly leafless shrub, to 1.6 m high. Fl. white, Aug–Dec.	Laterite, sand over laterite, loam.	Santalaceae
Stylidium ceratum	P2	Fibrous rooted annual, herb, 0.05–0.09 m high, leaves spathulate. Fl. pink, white, Oct–Nov.	Sandy soils. Swamp heathland.	Stylidiaceae
Stylidium cymiferum	P3	Caespitose perennial, herb, 0.1–0.3 m high. Fl. yellow, Oct.	Lateritic soils.	Stylidiaceae
Stylidium glabrifolium	P2	Shortly rhizomatous, rosetted perennial, herb, to 0.4 m high. Fl. yellow, cream, white, Oct..	Clayey sand with granitic alluvial rocks	Stylidiaceae
Stylidium longitubum	P3	Erect annual (ephemeral), herb, 0.05–0.12 m high. Fl. pink, Oct–Dec.	Sandy clay, clay. Seasonal wetlands.	Stylidiaceae
Stylidium nonscandens	P4	Perennial, herb, 0.2–0.45 m high, leaves in whorls. Fl. pink, Sep–Nov.	White/grey lateritic sand.	Stylidiaceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Stylidium semaphorum	P2	Erect perennial, herb, leaves appressed, tile-like, spiral; sepals with apical mucro: corolla with throat appendages. Fl. pink, Sep–Oct.	Lateritic gravelly soils. Hill summit.	Stylidiaceae
Synaphea grandis	P4	Tufted shrub, ca 0.3 m high. Fl. yellow, Oct–Nov.	Laterite.	Proteaceae
Synaphea panhesya	P1	Erect shrub, 0.3–0.6 m high. Fl. yellow, Aug–Sep.	Gravelly loam & sandy gravel.	Proteaceae
Templetonia drummondii	P4	Prostrate or ascending shrub, 0.1–0.4(–0.6) m high. Fl. yellow, brown, purple, Aug–Sep.	Lateritic soils.	Papilionaceae
Thelymitra stellata	R	Tuberous, perennial, herb, 0.15–0.25 m high. Fl. yellow, brown, Oct–Nov.	Sand, gravel, lateritic loam.	Orchidaceae
Trymalium urceolare	P2	Erect, rounded shrub, ca 1 m high. Fl. white, cream. Jul–Sep.	Loamy & clayey soils, often with lateritic gravel.	Rhamnaceae
Verticordia lindleyi subsp. *Lindleyi*	P4	Erect shrub, 0.2–0.75 m high. Fl. pink, May/Nov–Jan.	Sand, sandy clay. Winter-wet depressions.	Myrtaceae
Verticordia paludosa	P4	Erect shrub, 0.3–0.9 m high. Fl. pink, white, Jan–May..	White/grey sand. Winter-wet flats	Myrtaceae
Verticordia plumosa var. *pleiobotrya*	R	Dense shrub, 0.2–1 m high. Fl. pink, Oct–Dec.	Clay, sandy loam. Seasonally inundated swamps, road verges.	Myrtaceae
Verticordia serrata var. *linearis*	P3	Shrub, to 1 m high, differs from other varieties in the linear acuminate leaves 6–20 mm long; cilia to 1.2 mm long. Fl. golden, Sep–Oct.	White sand, gravel. Open woodland.	Myrtaceae

Plant name	Conservation Category	Description	Habitat/Soils	Family
Verticordia serrata var. *udumung* (D. Hunter and B. Yarran 941006)	P2	Shrub. Description unknown.	?	Myrtaceae

Perth Darwin National Highway - Flora Field Sheet - identified and unidentified species

Date: 21 October to 17 November 2004
Conducted by: [illegible]

Location details (numbers refer to 'Vegetation Types' Manila Road to [illegible] Boundary [illegible])

Family	Genus	Species	Common Name	Status
Anthericaceae	[illegible]	[illegible]		
Agavaceae	[illegible]	[illegible]	Rain Lily	[illegible] weed
Asparagaceae	Asparagus	[illegible]	[illegible]	[illegible] weed
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
Dennstaedtiaceae	Pteridium	esculentum	Bracken	
[illegible]	[illegible]	[illegible]	[illegible]	
Goodeniaceae	[illegible]	[illegible]	[illegible]	
Goodeniaceae	Lechenaultia	[illegible]		
Haemodoraceae	Anigozanthos	[illegible]	[illegible] Kangaroo Paw	
Iridaceae	Gladiolus	caryophyllaceus	Wild Gladiolus	weed
Iridaceae	Patersonia	[illegible]		
Iridaceae	Patersonia	occidentalis	Purple Flag	
Iridaceae	Watsonia	[illegible]	Bulbil Watsonia	weed
Juncaceae	Juncus	pallidus	Pale Rush	
Iridaceae	Moraea	flaccida	One-leaf Cape Tulip	weed
Loranthaceae	Nuytsia	floribunda	Christmas Tree	
Mimosaceae	Acacia	pulchella	Prickly Moses	
Mimosaceae	Acacia	saligna	Orange Wattle	
Myrtaceae	Astartea	fascicularis		
Myrtaceae	Calothamnus	[illegible]	[illegible]	
Myrtaceae	Corymbia	calophylla	Marri	
Myrtaceae	[illegible]	[illegible]		
Myrtaceae	Eucalyptus	marginata	Jarrah	
Myrtaceae	Eucalyptus	rudis	Flooded Gum	
Myrtaceae	[illegible]	[illegible]	[illegible]	
Myrtaceae	Hypocalymma	angustifolium	White Myrtle	
Myrtaceae	Kunzea	glabrescens	Spearwood	
Myrtaceae	Melaleuca	preissiana	Moonah	
Myrtaceae	Melaleuca	rhaphiophylla	Swamp Paperbark	
Myrtaceae	Pericalymma	ellipticum		
Myrtaceae	Pericalymma	ellipticum	Swamp Teatree	
Myrtaceae	[illegible]	[illegible]		
Orchidaceae	Microtis	media subsp. media	Common Mignonette Orchid	
Papilionaceae	Bossiaea	eriocarpa	Common Brown Pea	
Papilionaceae	Daviesia	[illegible]		
Papilionaceae	Jacksonia	[illegible]		
Papilionaceae	Jacksonia	[illegible]	Stinkwood	
Papilionaceae	Jacksonia	sternbergiana	Stinkwood	
Papilionaceae	Viminaria	juncea	Swish Bush	
Poaceae	Cynodon	dactylon	Couch	weed
Poaceae	Eragrostis	curvula	African Lovegrass	weed
Poaceae	[illegible]	[illegible]	[illegible] Grass	weed
Poaceae	Lolium	rigidum	Annual Ryegrass	weed
Poaceae	Pennisetum	clandestinum	Kikuyu	weed
Proteaceae	[illegible]	[illegible]	[illegible]	
Proteaceae	Banksia	attenuata	[illegible] Banksia	
Proteaceae	Banksia	ilicifolia	Holly-leaved Banksia	
Proteaceae	Banksia	menziesii	Firewood Banksia	
Proteaceae	[illegible]	[illegible]	[illegible]	
Proteaceae	Stirlingia	latifolia	Blueboy	
Restionaceae	[illegible]	[illegible]		
[illegible]	Pimelea	[illegible]	[illegible]	[illegible]
Typhaceae	Typha	orientalis	Bulrush	[illegible]
Xanthorrhoeaceae	Xanthorrhoea	preissii	Grass Tree	
Zamiaceae	Macrozamia	riedlei	Zamia	

Appendix E

Ecological Survey, 110 Gaston Road

GHD CLIENTS|PEOPLE|PERFORMANCE

MEMORANDUM

5 February 2009

To	Paul Fourie		
Copy to	Paul Fisher (GHD)		
From	Glen Gaikhorst and Erin D'Raine	Tel	6222 8689
Subject	Level 1 Flora and Fauna assessment of 110 Gaston Rd PDNH alignment	Job no.	61/14438

1 Background

GHD Pty Ltd (GHD) were appointed in December 2003 to undertake an alignment definition study to develop a more precise road reservation within the Government endorsed corridor between Bullsbrook and Bindoon for the Perth Darwin National Highway (PDNH).

In mid-2007 WWF (World Wide Fund for Nature) Wetland Watch identified a series of tumulus springs on Lots 88 and 89 Bingham Rd, Bullsbrook, adjacent to the proposed PDNH alignment. DEC assessed the springs and classified them as a Threatened Ecological Community (TEC): "Community of Tumulus Springs (organic mound springs) of the Swan Coastal Plain". The TEC was endorsed by the Minister for Environment and is listed as an Endangered TEC under the Commonwealth Environment and Biodiversity Protection Act 1999.

During the alignment definition stage (2003 - 2005) for the proposed PDNH, the alignment had been designed to avoid direct impact on the springs (as they contained good wetland vegetation), however, the alignment is still in close proximity to the communities and it intersects the associated catchment area.

On the 24th July, 2007 GHD met with representatives from WWF – Wetlands Watch and the Department of Environment and Conservation (DEC) Threatened Species and Communities Branch on-site to discuss the newly discovered TECs and the location of the PDNH. At this meeting the DEC representatives strongly expressed the opinion that while the alignment does not directly intersect the TEC it could still have a significant impact on the TEC as it passes through the catchment area.

The road alignment was subsequently shifted to the east of the TEC, outside the TEC catchment. This shift also removed the majority of the PDNH alignment from within a Bush Forever site, and minimised the clearing of native vegetation.

Following a period of community consultation in October 2008, Main Roads commissioned GHD Pty Ltd to undertake a flora and fauna assessment of the refined alignment on Lot 110 Gaston Road, Muchea, to determine the ecological value of remnant bushland at the site, and identify potential impacts associated with construction of the PDNH.

2 Scope of work

On 21st January 2009 a level 1 flora and fauna assessment was undertaken on the PDNH alignment through the property at 110 Gaston Road, Muchea (Figure 1). The assessment was conducted by Glen Gaikhorst - Senior Zoologist and Erin D'Raine - Ecologist of GHD Pty Ltd.

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3 Description of the alignment at 110 Gaston Road.

The refined alignment intersects the property at 110 Gaston Road, Muchea and is positioned approximately 100 metres east of a TEC "Community of Tumulus Springs (organic mound springs) of the Swan Coastal Plain". The area is down stream of the TEC and consists of a drainage and flood plain system that is seasonally inundated. The vegetation within the proposed alignment consists mostly of Mixed Marri (*Corymbia calophylla*) and Flooded Gum (*Eucalyptus rudis*) woodland over an understorey of shrubs, herbs and sedges.

4 Assessment of Flora

The vegetation of the study area was assessed using walking transects of the study area and recording information on the substrate, condition, coverage, species present and the dominant species within the vegetation types.

4.1 Vegetation Description

The study area consists of three vegetation types, including cleared/disturbed vegetation, where clearing or other activities has fundamentally altered the composition of the native vegetation. Approximately one third of the survey area has previously been cleared for agricultural purposes. The vegetation in the middle of the survey area can be described as mixed *Corymbia calophylla* (Marri) and *Eucalyptus rudis* (Flooded Gum) woodland over mixed shrubs, herbs, rushes and sedges. To the north the vegetation merges into *Astartea fascicularis* shrubland mixed with *Kunzea glabrescens* and occasional *Acacia saligna* over herbs, rushes and sedges.

4.2 Vegetation Condition

Developed for Bush Forever, the vegetation Condition Rating is a scale that recognises the intactness of vegetation, which is defined by the following (Government of WA, 2000):

- Completeness of structural levels;
- Extent of weed invasion;
- Historical disturbance from tracks and other clearing or dumping; and
- The potential for natural or assisted regeneration.

The scale therefore consists of six (6) rating levels from pristine, or nearly so, to completely degraded. The Vegetation Condition Rating Scale is outlined in Table 1.

Table 1 Bush Forever (Government of WA, 2000) Vegetation Condition Rating Scale

Vegetation Condition Rating	Vegetation Condition	Description
1	*Pristine or Nearly So.*	No obvious signs of disturbance
2	*Excellent*	Vegetation structure intact, disturbance affecting individual species, and weeds are non-aggressive species.
3	*Very Good*	Vegetation structure altered, obvious signs of disturbance.

Vegetation Condition Rating	Vegetation Condition	Description
4	*Good*	Vegetation structure significantly altered by very obvious signs of multiple disturbances retains basic vegetation structure or ability to regenerate it.
5	*Degraded*	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not in a state approaching good condition without intensive management.
6	*Completely Degraded*	The structure of the vegetation is no longer intact and the area is completely or almost without native species.

The vegetation condition of the study area was rated during the field survey using the Bush Forever scale.

The study area and surrounding areas have a long history of human use and impact. Clearing for agriculture has been extensive in Bullsbrook and surrounding areas. Approximately one third of the study area has been cleared and is dominated by introduced (weedy) species. This area is rated as *Completely Degraded*. Vegetation remaining in the study area has been subject to grazing by cattle, and edge effects, particularly the introduction of weeds. Nonetheless, the remaining vegetation is still relatively intact and is generally in *Excellent* to *Good* condition. There has not been a fire within the study area for over 25 years.

4.3 Flora Species

A total of 26 taxa from 15 families was recorded from the survey area. Of these, 15 taxa were native plant species. A list of flora species collated from the survey is presented in Table 2.

Table 2 Flora species recorded within the survey area – January 2009

Family	Genus	Species	Common Name	Status
Araceae	*Zantedeschia*	*aethiopica*	Arum Lily	*
Asteraceae	*Hypochaeris*	*radicata*	Flatweed	*
Cyperaceae	*Lepidosperma*	*longitudinale*	Pithy Sword-sedge	
Geraniaceae	*Pelargonium*	*capitatum*	Rose Pelargonium	*
Goodeniaceae	*Goodenia*	*pulchella*		
Lobeliaceae	*Lobelia*	*anceps*	Angled Lobelia	
Mimosaceae	*Acacia*	*saligna*	Orange Wattle	
Myrtaceae	*Astartea*	*fascicularis*		
Myrtaceae	*Corymbia*	*calophylla*	Marri	
Myrtaceae	*Eucalyptus*	*rudis*	Flooded Gum	
Myrtaceae	*Kunzea*	*glabrescens*	Spearwood	
Myrtaceae	*Melaleuca*	*preissiana*	Moonah	
Myrtaceae	*Taxandria*	*linearifolia*	Swamp Peppermint	

Family	Genus	Species	Common Name	Status
Orchidaceae	*Microtis*	*media*	Tall Mignonette Orchid	
Papilionaceae	*Eutaxia*	*virgata*		
Papilionaceae	*Kennedia*	*prostrata*	Scarlet Runner	
Papilionaceae	*Medicago*	*polymorpha*	Burr Medic	*
Poaceae	*Briza*	*maxima*	Blowfly Grass	*
Poaceae	*Briza*	*minor*	Shivery Grass	*
Poaceae	*Holcus*	*lanatus*	Yorkshire Fog	*
Poaceae	*Pennisetum*	*clandestinum*	Kikuyu Grass	*
Polygonaceae	*Acetosella*	*vulgaris*	Sheep Sorrel	*
Polygonaceae	*Rumex*	*crispus*	Curled Dock	*
Restionaceae	*Hypolaena*	*exsulca*		
Solanaceae	*Solanum*	*nigrum*	Black Berry Nightshade	*
Stylidiaceae	*Stylidium*	*sp.*		

* Introduced

4.4 Significant Flora Species

No Declared Rare Flora (DRF) or Priority flora species were recorded in the survey area during this survey.

4.5 Introduced Flora Species

A total of 11 introduced species were recorded within the survey area. This represents approximately 42% of the total number of plant species recorded within the survey area. The high proportion of weed species within the study area reflects the area's historical usage, with much of the surrounding land being cleared, or otherwise degraded.

Weeds that are, or may, become a problem to agriculture or the environment can be formally classified as Declared Plants under the *Agriculture and Related Resources Protection Act 1976*. Declarations specify a control class code, or codes, for each plant according to the control strategies or objectives, that are appropriate in a particular place (Table 3).

Table 3 Department of Agriculture Declared Plant Classes (Standard Control Codes)

Priority Class	Description
P1	Prohibits movement of plants or their seeds within the State. This prohibits the movement of contaminated machinery and produce including livestock and fodder.
P2	Eradicate infestation to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery.
P3	Control infestation in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery. Treat to destroy and prevent seed set all plants.

Priority Class	Description
P4	Prevent the spread of infestation from the property on or in livestock, fodder, grain, vehicles and/or machinery. Treat to destroy and prevent seed set on all plants.
P5	Infestations on public lands must be controlled

One Declared Plant taxa was recorded in the survey area: Arum Lily (*Zantedeschia aethiopica*). Arum Lily control codes are P1 and P4 for the whole of the State. Occurrences of Declared Plants should be controlled using recommended methods outlined by the Western Australian Department of Agriculture and Food.

4.6 Phytophthora cinnamomi

No formal *Phytophthora cinnamomi* (Dieback) assessment of the survey area has been undertaken, however, a visual inspection of vegetation for impacts of the pathogen was undertaken during the flora survey.

The plants that were recorded within the survey area are species that are thought not to be sensitive to dieback. In particular, *Melaleuca preissiana* and the sedges recorded within the area are not dieback sensitive. No indicator species for dieback were recorded within the survey area.

4.7 Limitations

A complete flora and vegetation survey can require multiple surveys, at different times of the year, and over a period of a number of years, to enable observation of all species present. Some flora species, such as annuals, are only available for collection at certain times of the year, and other are only identifiable at certain times (such as when they are flowering). Additionally, climatic and stochastic events (such as fire) may affect the presence of plant species. Species that have a very low abundance in the area are more difficult to locate, due to the above factors. Therefore while this flora survey was relatively exhaustive, it was not conducted at a time of year when the majority of the flora species may be present and/or would be able to be identified.

5 Assessment of Fauna

A level 1 fauna assessment was conducted within the PDNH alignment on 110 Gaston Road. The assessment consisted of ground truthing the area, noting all vertebrate species encountered during active inspection. All signs of vertebrates such as scats and diggings were also recorded and identified where possible. In total 19 birds, three reptiles and two mammals were identified from the survey area (Table 4).

Several scratching and claw markings were observed on trunks of *E. rudis* trees which appeared to be Common Brush-tail Possum activity.

Table 4 Fauna species observed within the survey areas – January 2009

Family	Genus	Species	Common Name	Status
Birds				
CORVIDAE	*Corvus*	*coronoides*	Raven	
CRACTICIDAE	*Cracticus*	*tibicen*	Magpie	
CRACTICIDAE	*Cracticus*	*torquatus*	Grey Butcherbird	
ZOSTEROPIDAE	*Zosterops*	*lateralis*	Silver eye	
DICRURIDAE	*Rhipidura*	*leucophrys*	Willie Wagtail	
DICRURIDAE	*Rhipidura*	*fuliginosa*	Grey Fantail	
CAMPEPHAGIDAE	*Coracina*	*novaehollandiae*	Black Faced Cuckoo Shrike	
MEROPIDAE	*Merops*	*ornatus*	Rainbow Bee-eater	Mi
MALURIDAE	*Malurus*	*splendens*	Splendid Fairy-wren	
MELIPHAGIDAE	*Anthochaera*	*carunculata*	Red Wattlebird	
PSITTACIDAE	*Platycercus*	*zonarius*	Twenty eight Parrot	
PSITTACIDAE	*Platycercus*	*spurius*	Red Capped Parrot	
PSITTACIDAE	*Calyptorhynchus*	*latirostris*	Carnaby Black Cockatoo	E, S1
HALCYONIDAE	*Dacelo*	*novaeguineae*	Laughing Kookaburra	
ARTAMIDAE	*Artamus*	*cinereus*	Black-faced Woodswallow	
ACANTHIZIDAE	*Acanthiza*	*apicalis*	Inland Thornbill	
ALCEDINIDAE	*Ocyphaps*	*lophotes*	Crested Pigeon	
FALCONIDAE	*Falco*	*cenchroides*	Australian Kestrel	
ACCIPITRIDAE	*Aquila*	*audax*	Wedge-tailed Eagle	
Reptiles				
Scincidae	*Cryptoblepharus*	*buchananii*	Common Fence skink	
Varanidae	*Varanus*	*gouldii*	Goulds Monitor	
Elapidae	*Notechis*	*scutatus*	Tiger Snake	
Mammals				
Macropodidae	*Macropus*	*fuliginosus*	Western Grey Kangaroo	
Phalangeridae	*Trichosurus*	*vulpecula*	Common Brush-tail Possum	

Mi Migratory (EPBC Act)
Ma Marine (EPBC Act)
E Endangered (EPBC Act)
S1 Schedule 1 (WC Act)

5.1 Significant Fauna Species

Two significant fauna species were recorded, the Rainbow bee-eater which is classified as a Migratory species and Carnaby's Cockatoo which is endangered under the Federal *EPBC Act (1999)* and listed as Schedule 1 under the Western Australian *Wildlife Conservation Act (1950)*. Droppings and feathers of Carnaby's Cockatoo were found under stands of *Eucalyptus rudis* which suggests extended use by the species, either as a rest area between feeding grounds or a roost site overnight. No hollows were observed large enough to support breeding of the species.

5.2 Introduced Fauna Species

Approximately one third of the alignment on the Gaston Rd property consists of paddocks with the remainder unfenced semi-natural habitat. Several pastoral species were observed including cattle and donkeys. The majority of impact appeared to be due to cattle usage. Other species likely to be utilising the bush area would be the red fox and feral cat.

5.3 Limitations

The short nature of this assessment produced few vertebrate species. For a more comprehensive species list further surveys would need to be undertaken in different seasons to capture a more accurate reflection of fauna assemblages. A diverse range of amphibian species would be expected to be present on the property, none of which were recorded during the assessment.

6 Potential Impacts of Flora and Fauna

The majority of the study area has been impacted by historical disturbances such as clearing and grazing of cattle. However the vegetation remaining in the proposed PDNH alignment (survey area) is generally considered being in *Excellent* to *Good* condition.

Potential impacts of the proposed alignment on flora and fauna is outlined below:

1. *Clearing of Native Vegetation*
2. *Introduction and Spread of Weed Species*

Direct impacts to adjacent areas of remnant vegetation, including edge effects and introduction and spread of weed species.

3. *Altered Fire Regimes*

The risk of fire is increased due to road traffic and by the potential increase of grassy weed species in the understorey.

4. *Impacts to the Adjacent TEC (Organic Mound Spring)*

Clearing disturbances in close proximity to the TEC has the potential to increase the risk of additional weed species being introduced and existing weeds spreading. In addition, the increased risk of fire can have a detrimental impact on the TEC. Within the wetlands there is build up of peat. Peat fires can have a devastating effect as they are potentially long burning and difficult to extinguish. An increase in the frequency of fires is likely to pose a significant threat to the wetland-adapted flora and fauna. However the proposed alignment of the PDNH is considered unlikely to pose a significant increased risk to the nearby TEC.

5. *Clearing of Cockatoo roost trees.*

The clearing of roost trees may impact on the habitat usage of Cockatoos in the region. As there are already limited roost sites available on the northern Swan Coastal Plain, the removal of a roost site may impact on the movement and feeding usage of the Carnaby's Cockatoo in the area.

7 Summary and Recommendations

The impacts within the PDNH alignment on the property at 110 Gaston Road are the clearing of the remnant vegetation, the potential impact of fire on the nearby TEC and the loss of roosting trees used by Carnaby's Cockatoos.

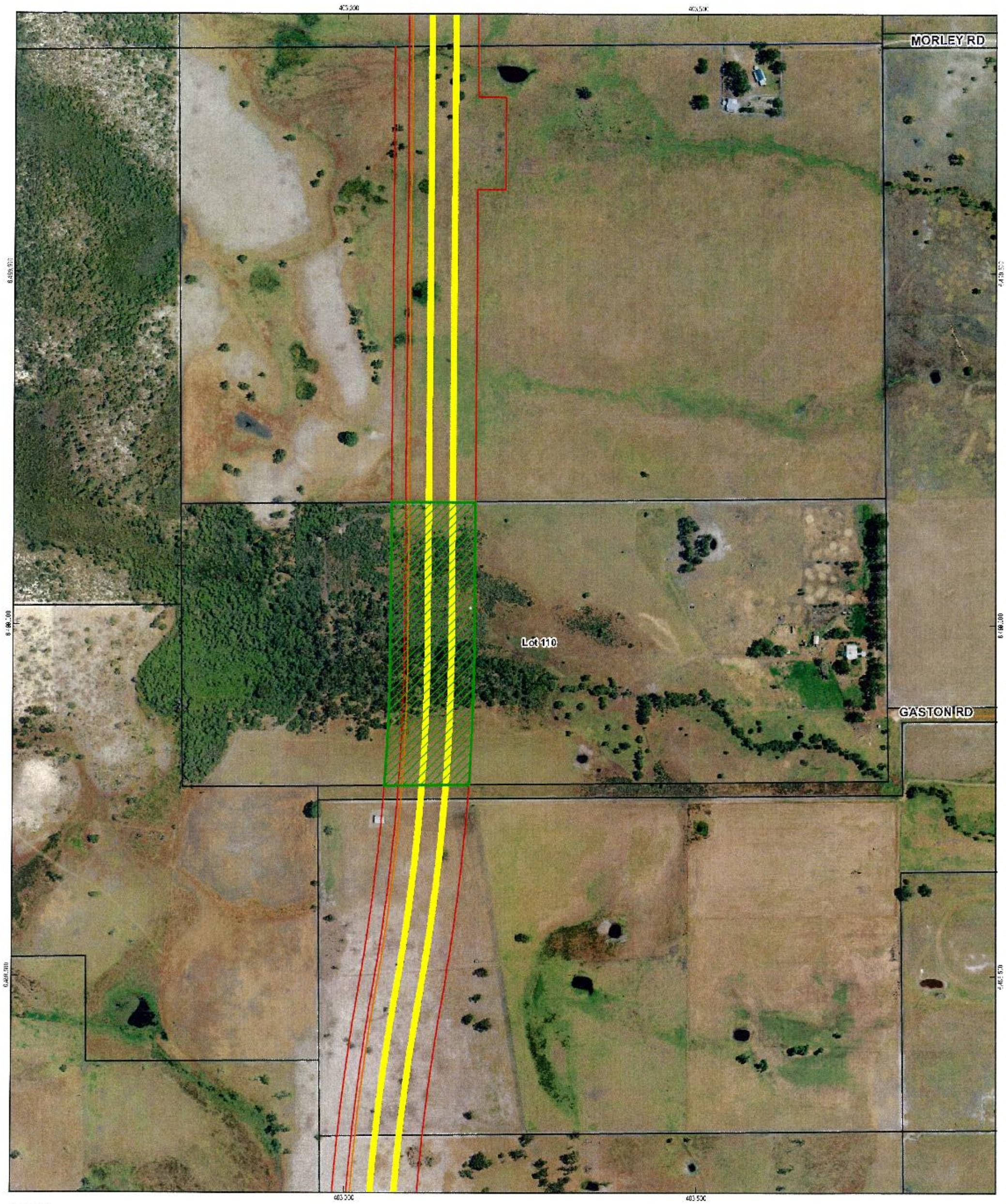
Where the alignment bisects remnant vegetation a minimal clearing approach should be taken to reduce the impact on native areas.

The highway will increase the risk of fire in the area, threatening the TEC (Organic Mound Spring); therefore measures need to be taken to protect the spring and surrounding region. The use of well maintained fire breaks may help mitigate this risk.

The lack of native vegetation in the region (approximately 3% remaining) may localize the usage of bird species to small remnant patches of treed areas such as that in the 110 Gaston Rd property. Therefore, wherever possible, measures should be taken to preserve as much of the vegetation in the area. One option could be to move the refined alignment further east, approximately 100 meters closer to the 110 Gaston Rd homestead. This will protect the remaining remnant vegetation, the Carnaby's Cockatoo roosting area and increase the distance from the TEC.

8 References

Government of WA (2000) *Bush Forever. Volume 1. Policies, Principles and Processes.* Western Australian Planning Commission, Perth.



LEGEND

Proposed Highway Alignment

- Future Carriageway
- Future Reservation
- Ecological Survey Area

1:5,000 (at A3)

0 25 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

CLIENTS | PEOPLE PERFORMANCE

MainRoads WA
Perth-Darwin National Highway Planning Study

Job Number 61-14438
Revision 0
Date 05 FEB 2009

Ecological Survey Area
Lot 110, Gaston Road, Bullsbrook

Figure 1

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Data Source: Landgate Metro North 2008 Mosaic - Dec 2007; Landgate Cadastre - Nov 2008; GHD Proposed Highway Alignment and Drainage Outline - Sep 2008; Department of Environment and Conservation EPP Lakes Policy Area - Dec 1998; Swan Coastal Plain - Mar 2007; GHD Ecological Survey Area - 230001; Cadastre, Lot 110, March 2

Appendix F

Hydrological Review of Gaston Road Spring TEC

GHD Pty Ltd

Brief Hydrogeological Review
Threatened Ecological Community – Gaston Road Spring
Bullsbrook, Western Australia

FINAL

Project Number: GHD001
Report Date: July 2008

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1. INTRODUCTION

GHD Pty Ltd is assisting Main Roads Western Australia to select the alignment for the proposed Perth-Darwin National Highway. The current preferred alignment includes a section that was identified to be near a Threatened Ecological Community. The Threatened Ecological Community occurs on Lot 110 Gaston Road, Bullsbrook (*Figure 1, Appendix A*).

The Department of Environment and Conservation was consulted, and requested a hydrogeological assessment of the springs to provide guidance on the potential impacts of the preferred road alignment. This report documents the assessment.

Groundwater Consulting Services has investigated springs in the northern Perth region over a number of years. These previous investigations provided the basis of the conceptual hydrogeological model for this desktop assessment.

Figure 2 (Appendix A) shows the site with the proposed and alternative highway alignments.

1.1 PREVIOUS WORK

In 2002, Groundwater Consulting Services conducted a preliminary hydrogeological evaluation which assessed the location of the springs (Neaves, Egerton and Muchea) and associated threatened ecological communities, with reference to the hydrogeological environment, and offered possible explanations for their occurrence.

A site investigation was conducted in 2004, including installation of ten shallow groundwater monitoring wells, at the Neaves Road occurrence. Regular groundwater level and quality monitoring was commenced after installation, and was reported by Groundwater Consulting Services (2007). In 2007, three deep monitoring bores (about 20m depth) were installed by Parsons Brinckerhoff Pty Ltd to assess the vertical changes in groundwater pressure/flow and quality (refer DEC document number 07/380-1 223500). The data from the installation of the deep bores, and subsequent monitoring data to December 2007, were reviewed to provide additional background for this assessment.

A site investigation, which included installation, surveying, gauging and water sampling at ten shallow monitoring bores, was conducted at the Bingham Road Threatened Ecological Community, which adjoins the Gaston Road Threatened Ecological Community (Groundwater Consulting Service, 2008). No subsequent groundwater monitoring has been conducted. The detailed on-site information provides valuable local confirmation of the regional hydrogeological model.

1.2 PERCEIVED THREATS

The assessment of the hydrogeology of the springs at Gaston Road is based on the need for useable advice on the risk that the proposed highway may pose to the springs. Only groundwater-related threats are considered, and these comprise (for the purposes of this investigation):

- Changes in water level or spring flow (up or down) due to any changes in the water table elevation;

- Changes in the water quality, due to introduction of contaminants from the road.

As the road is likely to comprise a relatively shallow constructed pavement, it is unlikely to influence groundwater levels. Groundwater level impacts are not considered further.

Contaminants may comprise either spilt products being carried by road (from a catastrophic event such as a truck roll-over or crash) or incremental movement of materials such as residual fuel, oil, grease and metals from vehicle movement, which may be washed into the soil by rainfall and runoff. The ability of any such contaminants to enter and migrate with the groundwater clearly controls the level of risk.

It is important to understand that this study assesses the potential pathways for contaminants to migrate from a proposed alignment to the springs, but does not quantify the risk, and therefore does not recommend a particular alignment or safe buffer distance.

2. SCOPE OF WORK

The following scope of work was conducted.

- Review records of hydrogeological investigations at Neaves road and Bingham road springs, including records of deeper drilling at Neaves Road and water quality records that had not previously been reviewed.

- Receive any information from the DEC on the Gaston road spring, including description of the property and contact details for site access.

- Receive confirmation of proposed (and any alternative) alignments for the highway in the region of the Gaston road occurrence.

- Inspect the site and comment on local landuses, topography and surface drainage, groundwater use and any other pertinent observations.

- Assess the likely groundwater capture zone, based on field observations and review of hydrogeological investigations at other nearby sites.

- Provide a brief report outlining the findings, and providing advice on the land area that is likely to be contributing to groundwater discharge from the spring, including relevant figures and cross-sections.

3. SETTING

The site is located on the central/eastern part of the Swan Coastal Plain, approximately 50km north of Perth, and 4km north-west of Bullsbrook *(Figure 1, Appendix A)*. Historical monthly average rainfall recorded for the RAAF base at Pearce Airport (located 3km south-east of the site) are provided in *Table 3.1*.

Table 3.1 Rainfall

Station	Regional Rainfall Historical Averages (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
RAAF Pearce (10568)	8.2	12.7	15.0	35.7	88.1	138.7	136.3	107.0	69.5	37.4	23.0	9.2	695.0

Data from Bureau of Meteorology http://www.bom.gov.au/climate/averages/tables downloaded on 8 May 2008

Soils to the west of the springs are pale grey quartz sand with high infiltration capacity and characterised by a lack of surface drainages. Soils beneath the low-lying land to the east comprise silt and clay of the Guildford Formation, with a thin cover of Bassendean Sand *(Figure 3, Appendix A)*. Lithological records are only available for some of the recorded bores in the region, however the data support the existence of a sand aquifer to the west, which interfingers with clayey sediments to the east. The nearest detailed lithological log is for bore GN24, located on Bingham road, about 500m west of the site, which shows about 36m of sand from the surface.

Groundwater discharges from most of the vegetated area, both diffused and in some discrete locations. The discharged groundwater then flows overland and merges to form a single stream which flows easterly to the Ellen Brook and subsequently the Swan River. The spring area comprises a melaleuca over-storey with and understorey comprising reeds, sedges and grass. Cattle are free to graze in the spring area, however there is little evidence of damage. The remainder of the property is mostly cleared, and is used to graze cattle and other stock.

The following description of typical vegetation assemblages was taken from English (1999).

> Typical and common native vascular plant species associated with the tumulus springs are the trees *Banksia littoralis*, *Melaleuca preissiana* and *Eucalyptus rudis*, and the shrubs *Agonis linearifolia, Pteridium esculentum, Astartea fascicularis* and *Cyclosorus interruptus*. The following non-vascular plants have also been located on peat mounds associated with the community: *Lycopodium serpentium* (bog clubmoss), *Riccardia aequicellularis*, *Jungermannia inundata*, *Goebelobryum unguiculatum* and *Hyalolepidozia longiscypha*.

Several shallow soaks were excavated on the property, and they intersect the groundwater table near to the surface. A peat layer is exposed in the excavation, immediately below the natural surface.

3.1 GROUNDWATER USE

Local groundwater is used by many landholders for stock and domestic irrigation purposes. Larger scale irrigation of strawberries, vegetables and turf occurs in the region. Details of local groundwater use are provided in Groundwater Consulting Services (2008).

Most local properties are expected to have a shallow bore for domestic garden irrigation purposes, and annual abstraction of about 1,500kL is typically assigned to such bores.

3.2 SITE INSPECTION - SPRING MORPHOLOGY

The spring was inspected on 28 May with the land-owner, as well as an ecologist (Mia Podesta) and hydrogeologist (Ryan Vogwill) from the Department of Environment and Conservation.

The spring area covers approximately four hectares, and the surrounding remnant vegetation covers a total of about ten hectares (including the spring area). An elevated sand dune lies to the west and north of the site, and the ground surface falls easterly towards the springs. The area of the springs and surrounds is relatively flat, with a gentle fall to the east.

The spring area was mostly waterlogged, and peaty underfoot. A peat layer of over 0.3m was observed in an excavated soak nearby, and probing of the ground indicated peat to about 1m thickness. The soils surrounding the spring area were all sandy.

Several discrete springs (or zones of locally enhanced groundwater discharge) were observed indirectly. Discharged groundwater either lay on the surface in stagnant ponds, or drained easterly and formed a single stream that flows to the Ellen Brook. The vegetation is likely to be dependent on groundwater, and is clearly tolerant of seasonal to continuous waterlogging. The presence of saturated peat and standing surface water thoughout the spring area indicates that groundwater is discharging (albeit slowly) through the peat.

A soak, excavated through a peat layer and into the underlying saturated sand, was observed to be full, and water was slowly discharging and infiltrating into the unsaturated sand which overlies the peat.

Anecdotal information from the land-owner indicates that the spring area is saturated all year round, although the flow rate in the stream varies.

Animal and crop production on the adjacent agricultural land upgradient of the springs poses a threat from any inappropriate nutrient or pesticide/herbicide use. The land more distant in the upgradient direction comprises uncleared native vegetation and poses no threat to the groundwater quality.

Selected photographs of the springs and surrounds are provided in *Appendix B*.

3.3 HYDROGEOLOGY

A description of the hydrogeology at Neaves Nature Reserve and Bingham Road Threatened Ecological Community was provided in Groundwater Consulting Services (2002, 2007 and 2008), and a modified summary for the Gaston Road site is provided below.

The superficial aquifer locally comprises about 40m of saturated sand, which interfingers with increasingly clayey units to the east. The gradational change from sand of the Bassendean Sand and the Gnangara Sand to the west, to sand with silt and clay of the Guildford Formation to the east, occurs at about the locations of the springs *(Figure 3, Appendix A).*

Groundwater flows from the Gnangara Mound, which lies to the west and north-west, towards the east-south-east through the area *(Figure 3, Appendix A)*. Depths to groundwater recorded in bores range from nil (water level at surface) to about 5m beneath the larger sand dunes.

Groundwater levels vary seasonally by about 1m, and were nearest the lowest recorded (43 years of records) in superficial aquifer bore GN24, located on Bingham Road in autumn 2008 (refer Groundwater Consulting Services, 2008, for the hydrograph). The reduced groundwater levels since the mid 1980s reflect regional and/or local groundwater use and reduced rainfall.

Groundwater is very fresh, with salinities between 100 and 500mg/L total dissolved solids being common (50 to 290mg/L TDS at Bingham Road). Groundwater salinity up to or exceeding 1,000mg/L TDS can occur in the region, where evaporation from the shallow water table concentrates the dissolved salt. The groundwater pH at Bingham Road was recorded between 4.1 and 5.9.

The superficial aquifer is underlain by the Poison Hill Greensand, which is part of the Mirrabooka Aquifer. The upper aquifers are hydraulically isolated from the deeper Leederville Aquifer by the Kardinya Shale member of the Osborne Formation, a shale unit which effectively prevents groundwater flow.

The vulnerability of groundwater to contamination was mapped by Appleyard (1993). Appleyard ranked groundwater vulnerability to landuse impact by considering the depth to groundwater and the soil type. Sandy soils and shallow depths to water resulted in a higher degree of vulnerability being assigned. Appleyard ranks the areas of the springs "Very High Vulnerability". The catchment areas (west of the springs) are ranked "High Vulnerability", as they have a greater depth to groundwater.

Figure 3 (Appendix A) shows the location of the springs with respect to a regional hydrogeological dataset (including geology, aquifer thickness, groundwater level, and groundwater use).

4. GROUNDWATER INVESTIGATIONS

No on-site groundwater data were collected in relation to the Gaston Road site. The adjacent Bingham Road springs were investigated by installing ten shallow monitoring bores, and local groundwater flow directions, discharge patterns and water quality were observed.

By considering the results of the Bingham Road site investigation with reference to site observations at Gaston Road, a reasonable understanding of the likely hydrogeology was developed.

4.1 REVIEW OF NEAVES MONITORING DATA

Groundwater Consulting Services and others have installed and monitored groundwater levels and quality at the Neaves Nature Reserve (located approximately 2.5km to the south-west). Recently obtained data were reviewed as part of this project, and charts are provided in *Appendix C*, along with logs of the deeper bores and a site plan. Groundwater Consulting Services (2007) contains the logs of the shallow bores.

The data review shows the following pertinent points:

- The nested bores near the springs (NNR3D, I, S) show an upward hydraulic head which clearly supports the shallow groundwater level, and is likely to be responsible for maintaining groundwater pressures. Excessive pumping from the deeper superficial aquifer could reduce spring flows. The bore logs show the presence of clayey materials in NNR9D located further west, where there is less vertical hydraulic gradient. It would be expected that NNR3, with no recorded clay layers, would have a smaller vertical head gradient.

- Lower pH in bores located to the west, and no temporal trend in pH.

- Similar electrical conductivity across the site, and no overall trend.

The recent data support discharge of shallow groundwater from the springs, however it is also clear that the groundwater pressure in the deeper part of the aquifer plays a part in maintaining groundwater levels at the water table.

5. RESULTS

5.1 SPRING DEVELOPMENT AND DISCHARGE MECHANISM

The springs are inferred to result from the east-south-easterly flow of groundwater in the unconfined superficial aquifer. The downgradient flow is impeded by the eastward reduction in aquifer transmissivity, and the water table is exposed at the surface. The area of discharge likely caused erosion of the land surface (draining towards Ellen Brook), and the wetland vegetation thus supported has resulted in stabilisation of the land surface, and accumulation of decomposed vegetation as peat.

As the peat is forming at or below the groundwater level, it locally confines the shallow aquifer. Discharge of groundwater through the peat occurs both through discrete permeable zones, likely from decomposed tree roots and *en masse*, via smaller discontinuities or sandy zones.

5.2 GROUNDWATER QUALITY

The groundwater at the Bingham Road springs is fresh and acidic, and contains elevated nutrients. The implications for the highway alignment are:

- The groundwater has a greater capacity to mobilise and transport heavy metals (such as may be expected from road dust contamination) than neutral or alkaline groundwaters.
- The groundwater is sensitive to landuse impact and the pathway from surface application of fertilisers to the groundwater has been demonstrated locally.

5.3 CATCHMENT

The groundwater table has been mapped on a regional scale and nearby (but not at the site). The local and regional trends are consistent, and show a groundwater flow direction to the east-south-east. Local groundwater flows are likely to be diverted towards the discrete springs.

The unconfined nature of the aquifer upgradient of the springs means that the groundwater is vulnerable to surface contamination sources.

The notional groundwater catchment for the springs is shown in *Figure 4, Appendix A*.

5.3.1 Catchment Orientation

The upgradient direction has been assessed with a reasonable level of confidence. The groundwater flow direction is not considered likely to vary significantly on a seasonal basis. The local abstraction of groundwater from the superficial aquifer is not considered likely to induce any modification of groundwater flow patterns, however this is dependent on the pumping bore depth

and pumping cycles. If pumping at the nursery or other groundwater users to the south did affect groundwater flow directions, it would tend to induce a greater southerly component, and would thus re-orient the catchment area for the springs. This phenomena is not considered to be significant and is ignored for the purposes of this study.

5.3.2 Catchment Width

The springs are about 300m wide, measured perpendicular the the inferred groundwater flow direction. Small-scale groundwater flow dynamics can lead to particle flows that are not aligned with the regional flow-field, and this would result in mixing of a body of water along the flow path, and thus a capture zone is likely to widen with distance from the spring. Some focussing of the groundwater flow towards the springs is likely to occur on a local scale (within 100m of the springs) but this is not likely to affect the overall catchment, as it has been considered in the estimation of the width of the springs.

5.3.3 Catchment Length

The groundwater flow path to the springs could be tracked back to the crest of the Gnangara Mound, is about 5km west of the springs. Any potential contaminants introduced into the groundwater will tend to reduce in concentration with distance downgradient along the flowpath, due to degradation and dispersion processes. The threat of a contaminant is therefore less for locations at a greater distance from the springs.

5.4 IMPLICATIONS ON PROPOSED ALIGNMENT

5.4.1 Upgradient Alignments

Any road alignment to the west of the springs has the potential to introduce contaminants to the local groundwater, through either catastrophic spills or movement of particulate contaminants and oil/grease from the road surface to the groundwater after rainfall. A large spill is the most likely threat to the springs. Increased separation between the springs and the road alignment would allow for not only natural degradation of any contaminants, but also greater time for recovery or remediation of contaminants before impacted groundwater could reach the springs.

An approximate catchment area is identified in *Figure 4 (Appendix A)* and represents the area in which contaminants that are introduced to the ground surface are considered to be a threat to groundwater quality at the springs.

5.4.2 Downgradient Alignments

The potential for impact on the spring from the downgradient direction (ie for road alignments east of the springs) is significantly reduced. As the groundwater flow is easterly, movement of any contaminants in groundwater would be easterly, and away from the spring.

There is potential for the highway to act as a barrier to surface drainage, and as such movement of water away from the springs may be impeded if surface water was impounded by insufficient surface drainage capacity through the road embankment.

Highway alignments east of the spring would need to consider an appropriate buffer distance in the event of, for example, a truck running off the road in the direction of the spring.

Highway alignments downgradient (east) of the springs would be preferred for protection of the groundwater quality at the springs.

This report does not provide advice on management of the risk of groundwater contamination. There may be viable methods such as surface water drainage control that would reduce the threat posed by a highway. If such controls were appropriately implemented, it is considered that the risk of impact on the springs from alignments to the west could be managed to an acceptable level.

The proposed alignment (east of the TEC, refer *Figure 2, Appendix A*) provides for approximately 150m separation in the downgradient direction of the boundary of the TEC, and a greater distance from the zone of groundwater discharge. The separation is considered to be sufficient to protect the TEC from typical water-borne impacts of potential contaminants from the highway use, although it is clear that a catastrophic event has the potential to cause an impact. Enhanced management of surface water and potential contaminants during construction should be considered for this location.

6. CONCLUSIONS

The superficial aquifer hosts the Gnangara Mound, a region of low salinity groundwater with an elevated water table. Groundwater in the superficial aquifer flows in an easterly to south-easterly direction at the site (radially outwards from the mound).

Flow is impeded by lower permeability sediments (Guildford Formation) to the east of the Swan Coastal Plain, and the groundwater table is above ground in low-lying parts of the landscape. Such low-lying parts include the headwaters of the Ellen Brook and the subject springs.

The springs have formed where the water table is exposed at the incised land surface. Peat has accumulated from the denser vegetation and now forms a partial confining layer. Groundwater discharges through the peat, especially where features like decomposed tree roots allow easier vertical flow.

A catchment zone approximately 300 to 500m wide (north-south) and extending 500-1000m to the west is considered to contribute most of the groundwater that discharges to the springs.

The groundwater is vulnerable to land-use impacts and is locally acidic, which would promote the movement of dissolved metals.

Surface spills or movement of contaminants in the groundwater from the catchment may result in reduced groundwater quality at the springs.

Road alignments will probably not affect groundwater levels, unless surface water movement from the site is impeded by an alignment to the east of the springs.

Road alignments downgradient (east) of the springs would be preferred for protection of the groundwater quality at the springs.

The proposed road alignment (east of the TEC) is considered to pose negligible threat to the groundwater quality at the TEC.

On behalf of Groundwater Consulting Services Pty Ltd,

Sam Burton

Director.

7. REFERENCES

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"Explanatory Notes for the Groundwater Vulnerability to Contamination Maps of the Perth Basin". Geological Survey of Western Australia, Department of Minerals and Energy, Report 1993/6

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Groundwater Consulting Services 2007

"Shallow Groundwater Investigation and Monitoring, Northern Perth Springs, Neaves Nature Reserve". Consultants report to Department of Conservation and Land Management, Project No CALM008, June 2006.

Groundwater Consulting Services 2008

"Shallow Hydrogeological Investigation, Bingham Road Threatened Ecological Community, Bullsbrook WA". Consultants report to Department of Environment and Conservation, Project No DEC001, June 2008.

8. LIMITATIONS

Groundwater Consulting Services Pty Ltd has prepared this report for the GHD Pty Ltd, in accordance with generally accepted consulting practice. The specific conditions of the contract and subsequent communications have had a bearing on the depth and breadth of the project and on the confidence in the findings. When client constraints, whether express or implied, have limited the scope of work, a lower than normal confidence may occur.

The confidence in the ability of a groundwater resource to support a nominated withdrawal of groundwater is subject to spatial and temporal variations in the aquifers, climate and landuse that may not be known or predictable. Conservative assumptions will have been used where-ever possible, however, estimates of bore yield or predicted impacts of pumping can be incorrect, especially where conditions on which predictions were made have been changed. Groundwater Consulting Services Pty Ltd's predictions are made on the basis that Groundwater Consulting Services Pty Ltd will be contracted to undertake regular reviews of operational data that may lead to groundwater availability or quality predictions being re-estimated.

Groundwater Consulting Services Pty Ltd does not provide advice on groundwater contaminants, crop water requirements, irrigation schedules, irrigation system design and other non-groundwater related areas. Groundwater Consulting Services Pty Ltd's advice on bore placement and operation must be considered by the proponent with reference to expert advice from other disciplines.

The project for which Groundwater Consulting Services Pty Ltd was contracted was undertaken for the client and its consulting advisers, and for review by regulatory agencies. The report should not be used by other parties without the consent of Groundwater Consulting Services Pty Ltd due to the potential for misunderstandings to occur.

9. APPENDICES

Appendix A – Figures

Appendix B – Plates

Appendix C – Neaves Road Data

Appendix A

Figures

Tue 20 May 08

N

0 2.5 5 7.5 10km

SCALE 1 : 250 000 at A4 (MGA)

SITE LOCATION

MUCHEA

BULLSBROOK

JOONDALUP

STIRLING

MORLEY

MIDLAND

PARKERVILLE

PERTH

FREMANTLE

CANNINGTON

City of Wanneroo

City of Joondalup

City of Swan

City of Stirling

Shire of Gingin

WA Location

Indian Ocean

Derby

Broome

Port Hedland

Karratha

WESTERN AUSTRALIA

Geraldton

Kalgoorlie

PERTH

Bunbury

Albany

GHD001-f01.dgn

PINPOINT CARTOGRAPHICS (08) 9277 7763

GCS Groundwater Consulting Services Pty Ltd

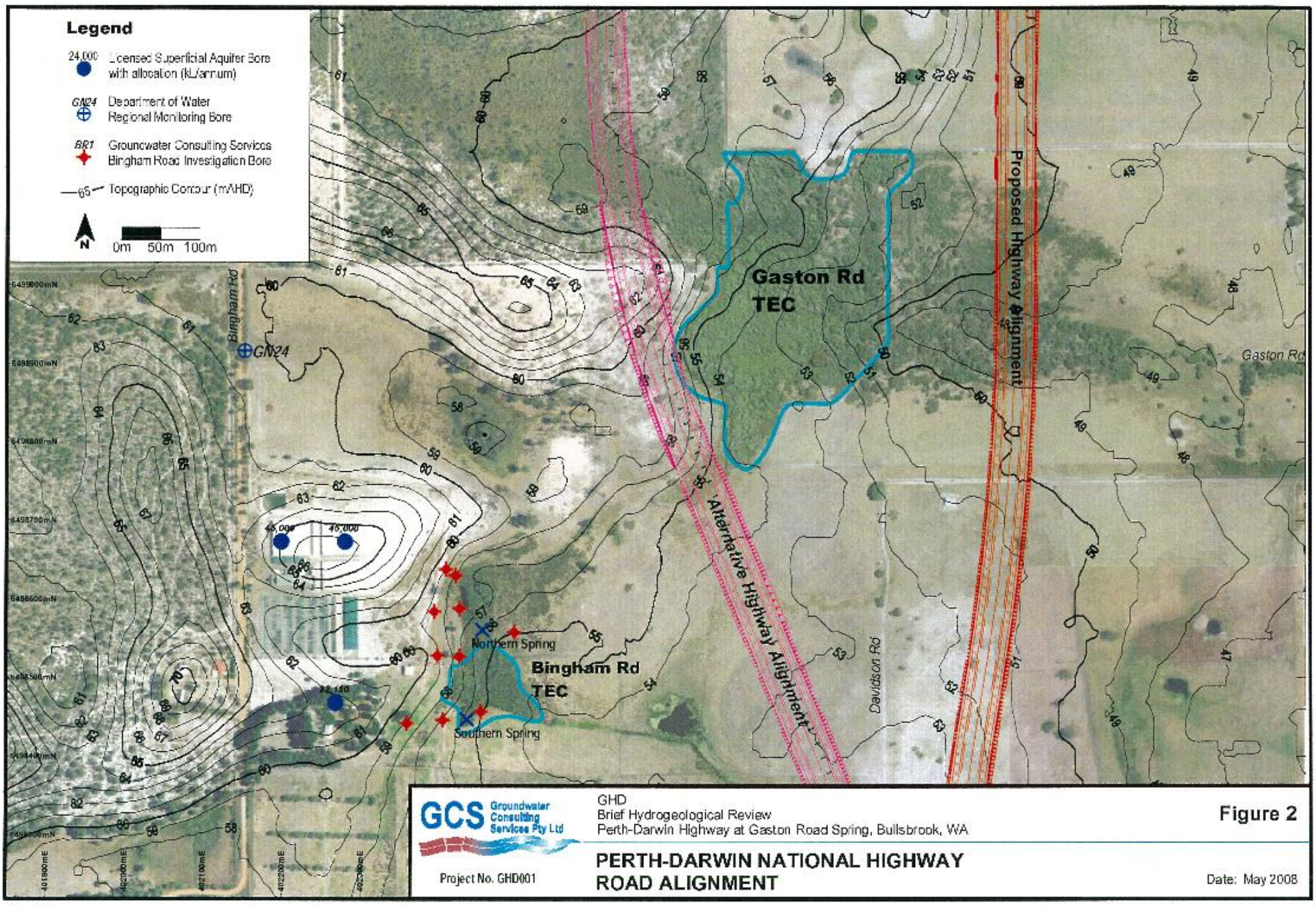
Project No. GHD001

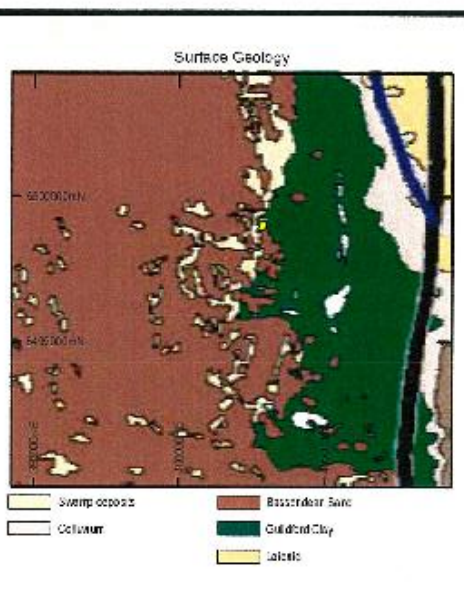
GHD Pty Ltd
GASTON ROAD SPRINGS
HYDROGEOLOGICAL ASSESSMENT

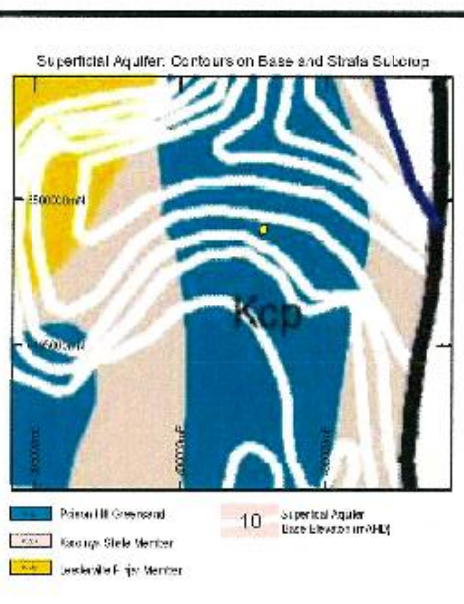
Figure 1

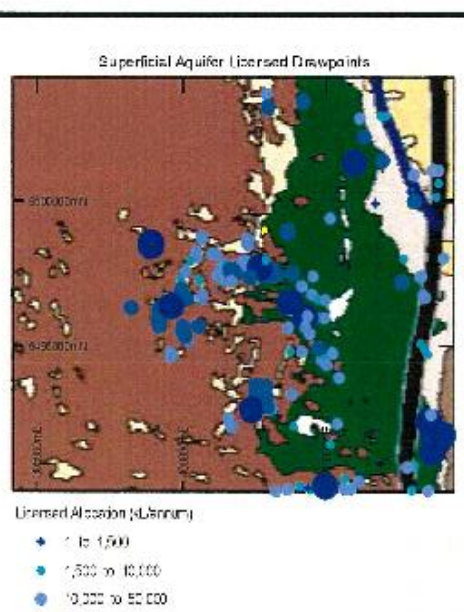
SITE LOCATION

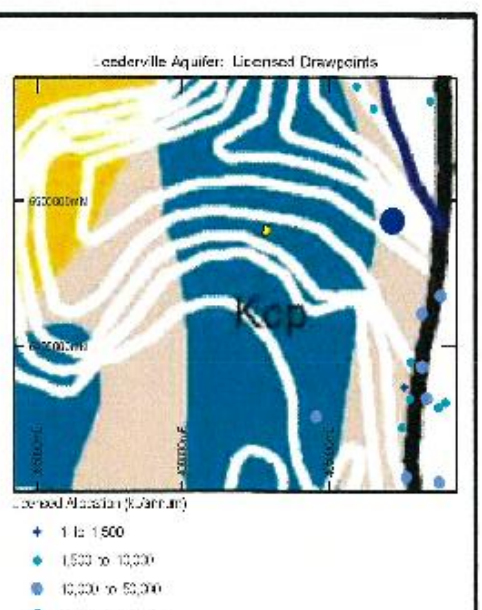
Drawn: S. Burton
Date: 20 May 2008

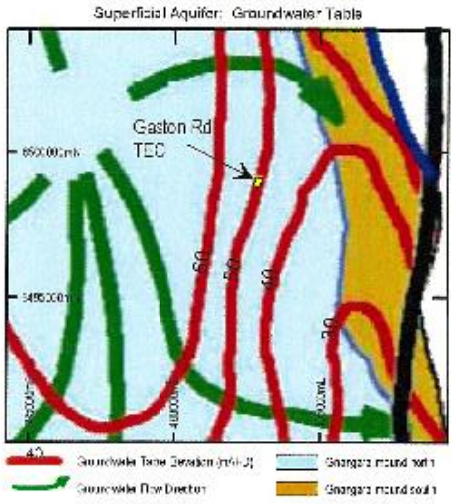

Legend
24,000 Licensed Superficial Aquifer Bore with allocation (kL/annum)
GN24 Department of Water Regional Monitoring Bore
BR1 Groundwater Consulting Services Bingham Road Investigation Bore
65 Topographic Contour (mAHD)
N
0m 50m 100m
Bingham Rd
GN24
Gaston Rd TEC
Proposed Highway Alignment
Gaston Rd
Alternative Highway Alignment
Davidson Rd
Northern Spring
Bingham Rd TEC
Southern Spring
45,000
45,000
22,150
GCS Groundwater Consulting Services Pty Ltd
GHD
Brief Hydrogeological Review
Perth-Darwin Highway at Gaston Road Spring, Bullsbrook, WA
Figure 2
PERTH-DARWIN NATIONAL HIGHWAY
ROAD ALIGNMENT
Project No. GHD001
Date: May 2008

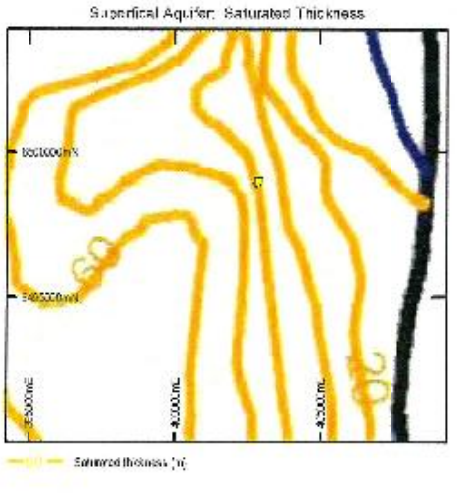


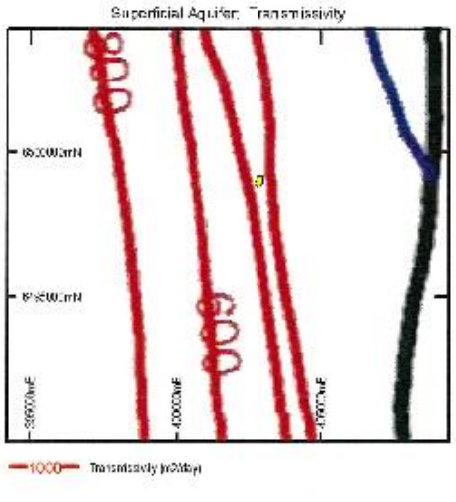












Gaston Road
Threatened Ecological Community

Note: Hydrogeological base-data (Gordon & Co, 2003)

GCS Groundwater Consulting Services Pty Ltd

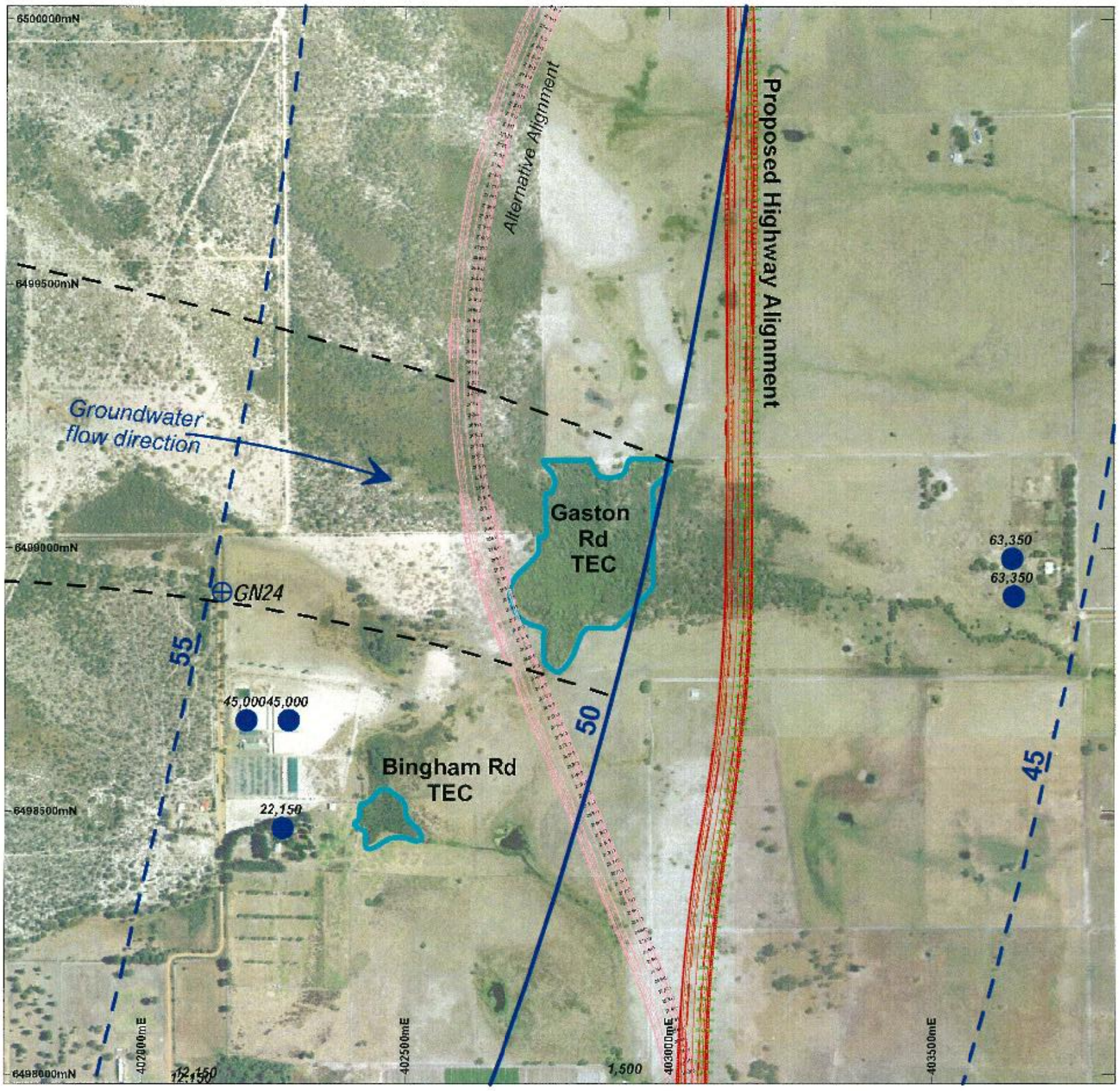
GHD
Brief Hydrogeological Review
Perth-Darwin Highway at Gaston Road Spring, Bullsbrook, WA

Figure 3

Project No. DEC001

REGIONAL HYDROGEOLOGICAL SETTING

Date: May 2008



Legend

- 24,000 — Licensed Superficial Aquifer Bore with allocation (kL/annum)
- GN24 — Department of Water Regional Monitoring Bore
- Approximate Groundwater Catchment for Gaston Rd TEC
- Groundwater Level Contour (mAHD) Superficial Aquifer
- (Interpolated)

N

0m 250m 500m

Note: Groundwater contours adapted from Davidson & Xu (2006)

GCS Groundwater Consulting Services Pty Ltd

GHD
Brief Hydrogeological Review
Perth-Darwin Highway at Gaston Road Spring, Bullsbrook, WA

Figure 4

CATCHMENT AREA

Project No. GHD001

Date: July 2008

Appendix B

Plates

Plate 1a: Typical view of spring area.

Plate 1b: Typical view of spring area.

Plate 3:

Excavated soak showing peat layer.

Plate 4:

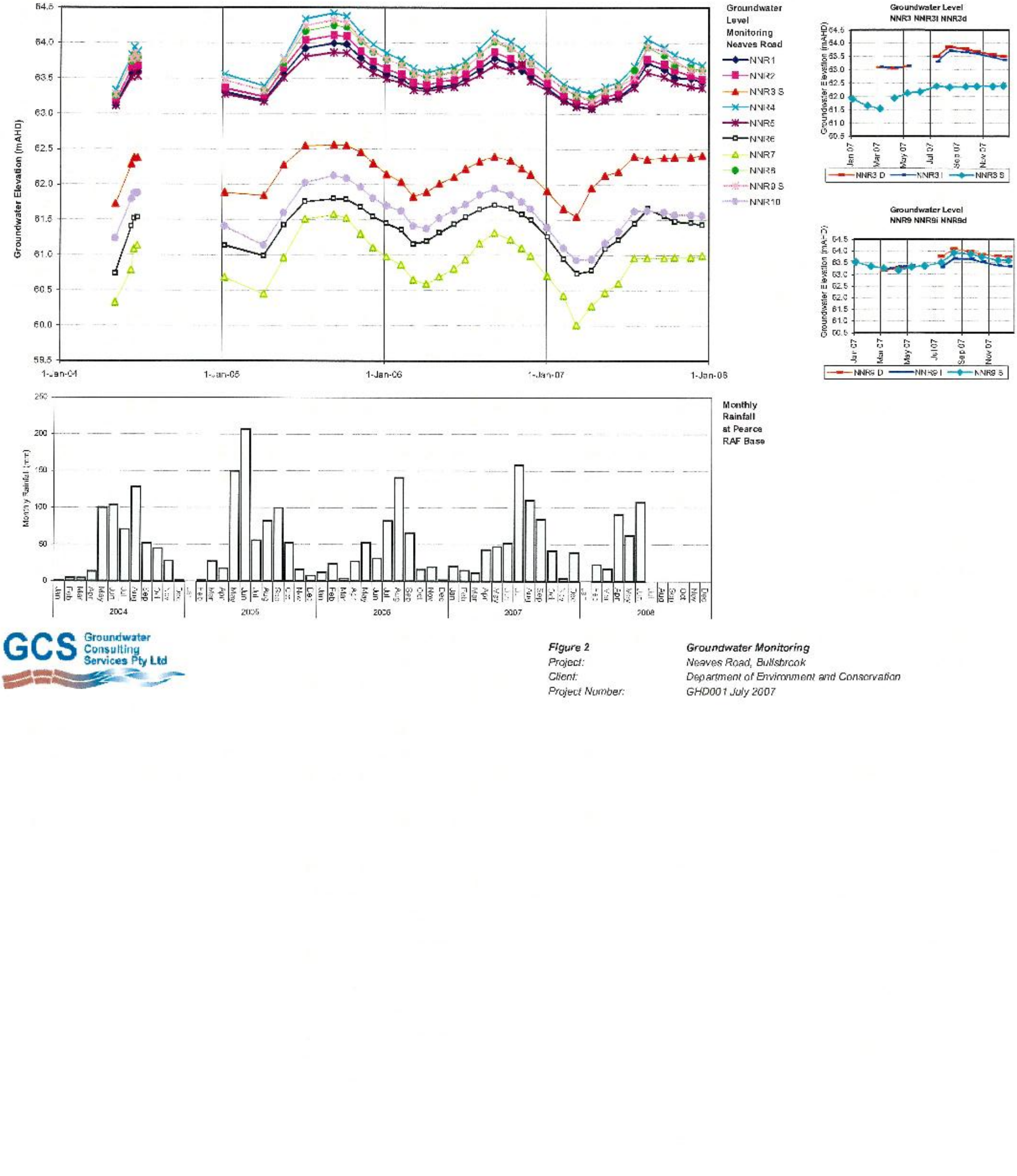
Excavated soak showing elevated water level.

Plate 5:

Excavated soak east of springs showing peat layer and water level below ground.

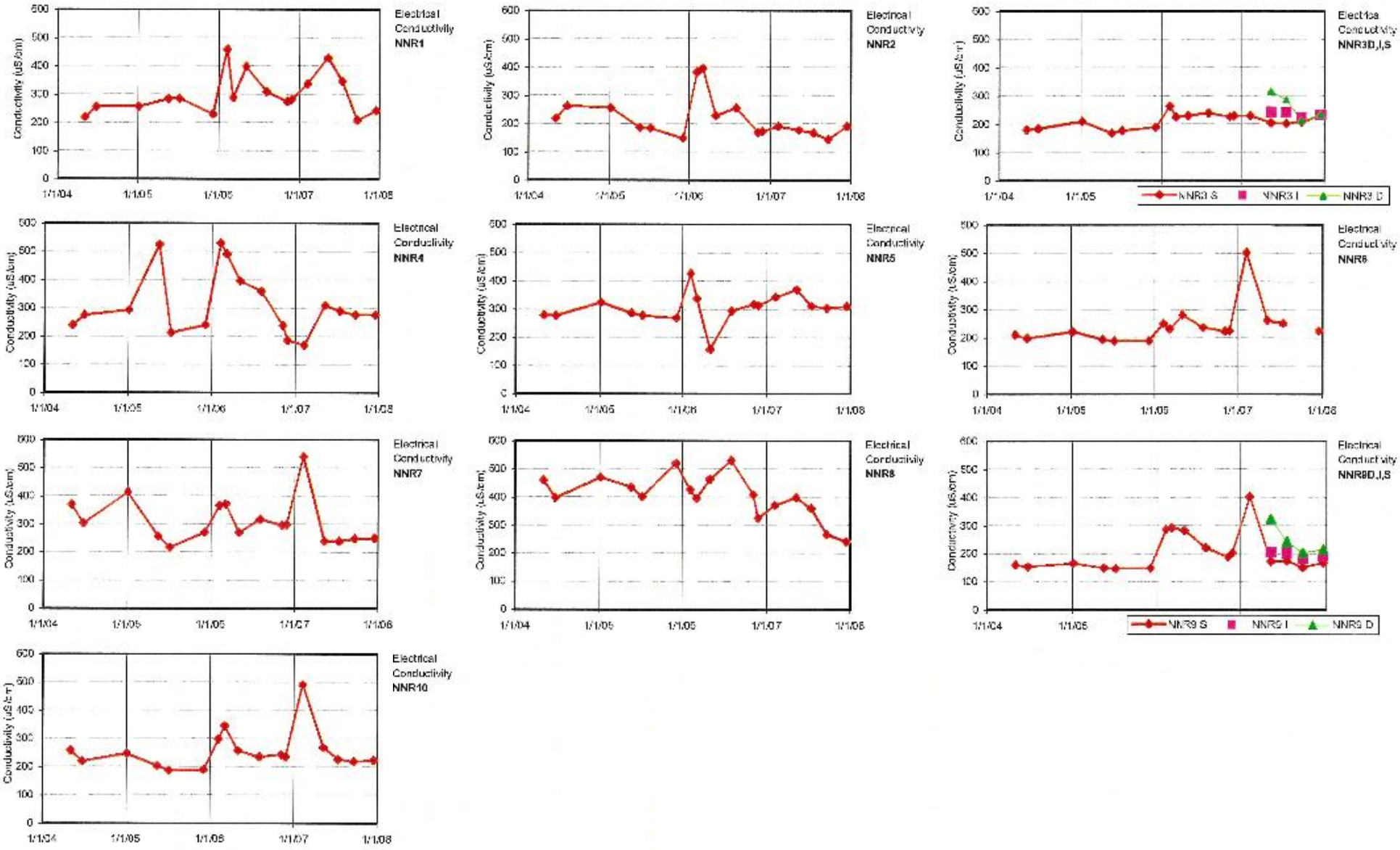
Appendix C

Neaves Road Data



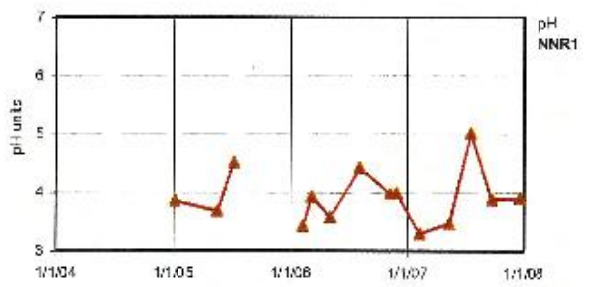
GCS Groundwater Consulting Services Pty Ltd

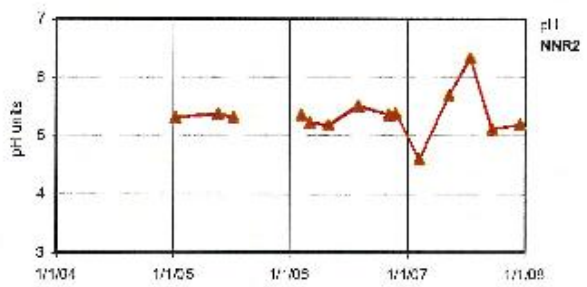
Figure 2	***Groundwater Monitoring***
Project:	*Neaves Road, Bullsbrook*
Client:	*Department of Environment and Conservation*
Project Number:	*GHD001 July 2007*

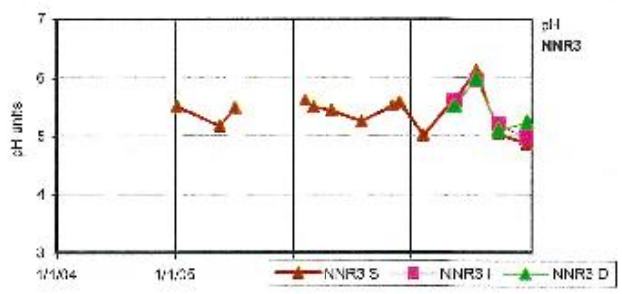


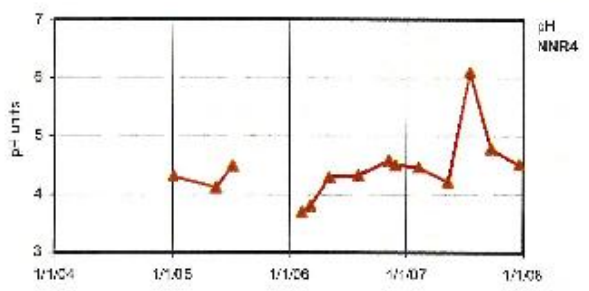
GCS Groundwater Consulting Services Pty Ltd

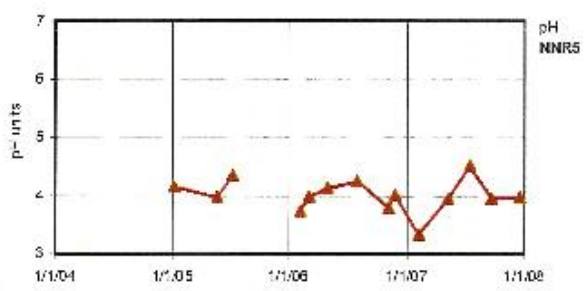
Figure 3 ***Electrical Conductivity Monitoring***
Project: *Neaves Road, Bullsbrook*
Client: *Department of Environment and Conservation*
Project Number: *GHD001 July 2007*

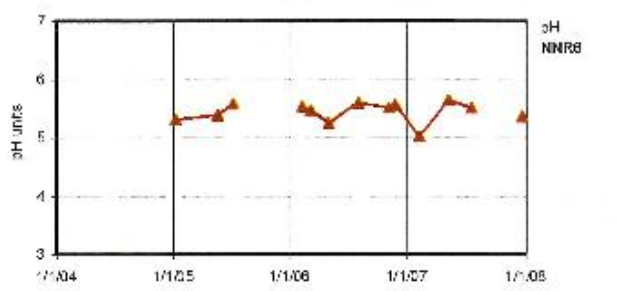


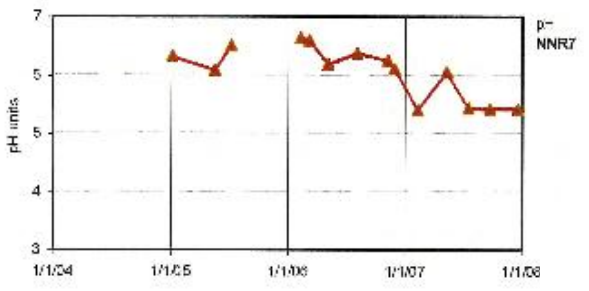


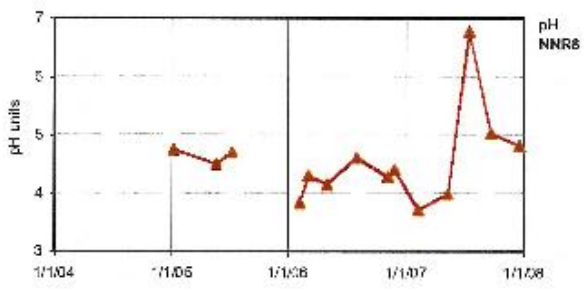


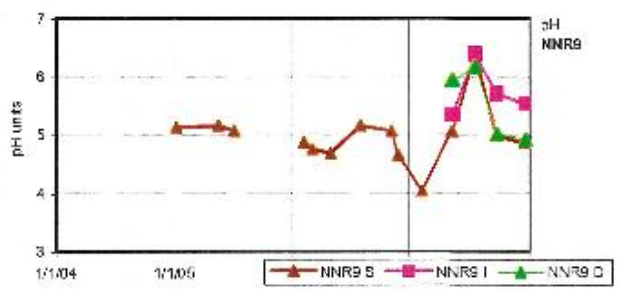












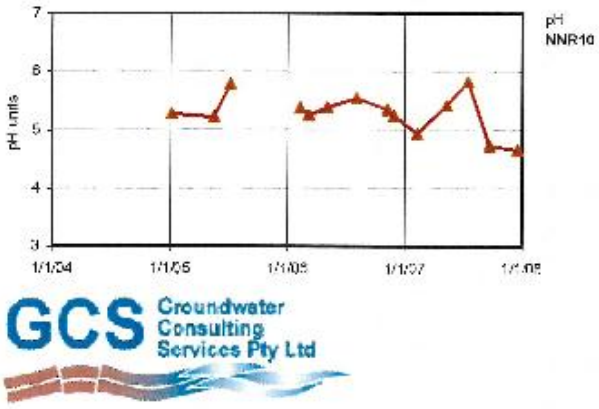


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Figure 4 ***pH Monitoring***
Project: *Neaves Road, Bullsbrook*
Client: *Department of Environment and Conservation*
Project Number: *GHD001 July 2007*

BOREHOLE ENVIRONMENTAL LOG

BOREHOLE NO.

NNR3D

SHEET 1 OF 1

Client:	CALM	Date Commenced:	29/3/07
Project:	Bore installation at Neaves Nature Reserve	Date Completed:	29/3/07
Borehole Location:	Bullsbrook	Recorded By:	JS
Project Number:	2146393A	Log Checked By:	EB

Drill Model/Mounting: **Hollow Stem** Driller: **GS Drilling** Surface RL: **62.92 m**

Borehole Diameter: **150 mm** Driller Lic No: Co-ords: **E 400742.34 N 6497802.31**

Borehole Information | **Field Material Description**

1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS, S, FB, VL, L, MD, St, VSt, D, H, VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
			PVC top cap; PVC upstand	62 / 0					PEAT: Black, fine grained (silty), moist, high organic content, low plasticity			
			PVC with sand infill; Bentonite Seal	61 / 1					SAND: Grey sand, fine to medium gerained, subangular, moderately sorted			
			PVC with sand infill	60 / 2								
				59 / 3								
				58 / 4								
				57 / 5								
				56 / 6								
				55 / 7								
				54 / 8								
				53 / 9								
				52 / 10								
				51 / 11								
				50 / 12								
				49 / 13								
				48 / 14								
				47 / 15								
				46 / 16								
			Slotted PVC with filter pack	45 / 17								
				44 / 18								
				43 / 19								
				42 / 20								
			PVC bottom cap	41 / 21					END OF BOREHOLE AT 21.05 m			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

BOREHOLE ENVIRONMENTAL LOG

BOREHOLE NO.

NNR3I

SHEET 1 OF 1

Client:	CALM	Date Commenced:	29/3/07
Project:	Bore Installation at Neaves Nature Reserve	Date Completed:	29/3/07
Borehole Location:	Bullsbrook	Recorded By:	JS
Project Number:	2146393A	Log Checked By:	EB

Drill Model/Mounting:	Hollow Stem	Driller:	GS Drilling	Surface RL:	62.85 m
Borehole Diameter:	150 mm	Driller Lic No:		Co-ords:	E 400743.65 N 6497600.28

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m)	DEPTH(m)	FIELD TEST	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			PVC top cap PVC upstand PVC with sand infill Bentonite Seal PVC with sand infill Slotted PVC with filter pack PVC bottom cap	62 61 60 59 58 57 56 55 54 53 52	0 1 2 3 4 5 6 7 8 9 10				PEAT: Black, fine grained (silty), moist, high organic content, low plasticity SAND: Grey sand, fine to medium garained, subangular, moderately sorted END OF BOREHOLE AT 10.05 m		FB VL L MD D VD VS S F St VSt H	

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

BOREHOLE ENVIRONMENTAL LOG

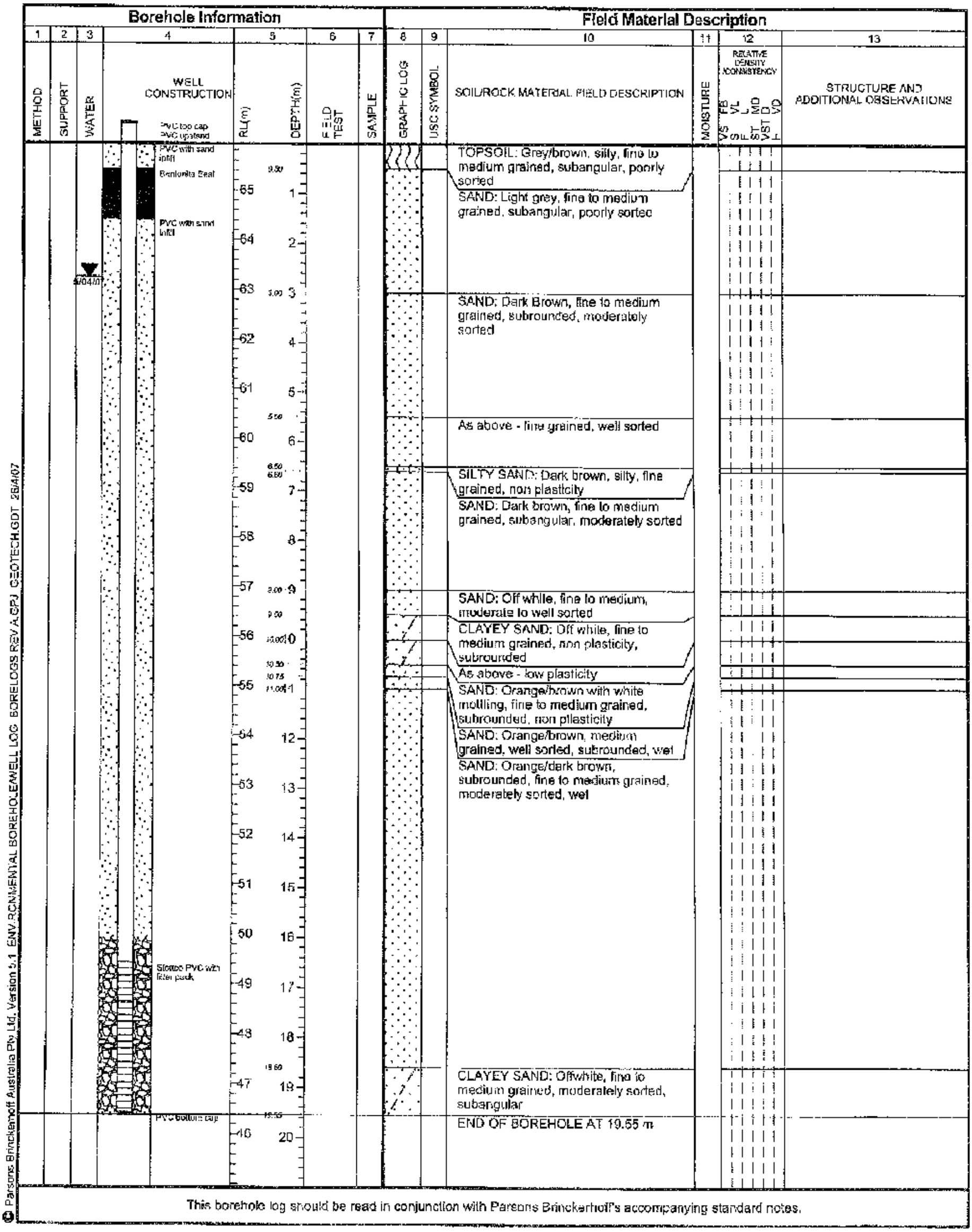
BOREHOLE NO.

NNR9D

SHEET 1 OF 1

Client:	**CALM**	Date Commenced:	**30/3/07**
Project:	**Bore installation at Neaves Nature Reserve**	Date Completed:	**30/3/07**
Borehole Location:	**Bullsbrook**	Recorded By:	**JS**
Project Number:	**2146393A**	Log Checked By:	**EB**

Drill Model/Mounting:	**Hollow Stem**	Driller:	**GS Drilling**	Surface RL:	**65.93 m**
Borehole Diameter:	**150 mm**	Driller Lic No:		Co-ords:	**E 400615.43 N 6497801.09**



This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

BOREHOLE ENVIRONMENTAL LOG

BOREHOLE NO.

NNR9I

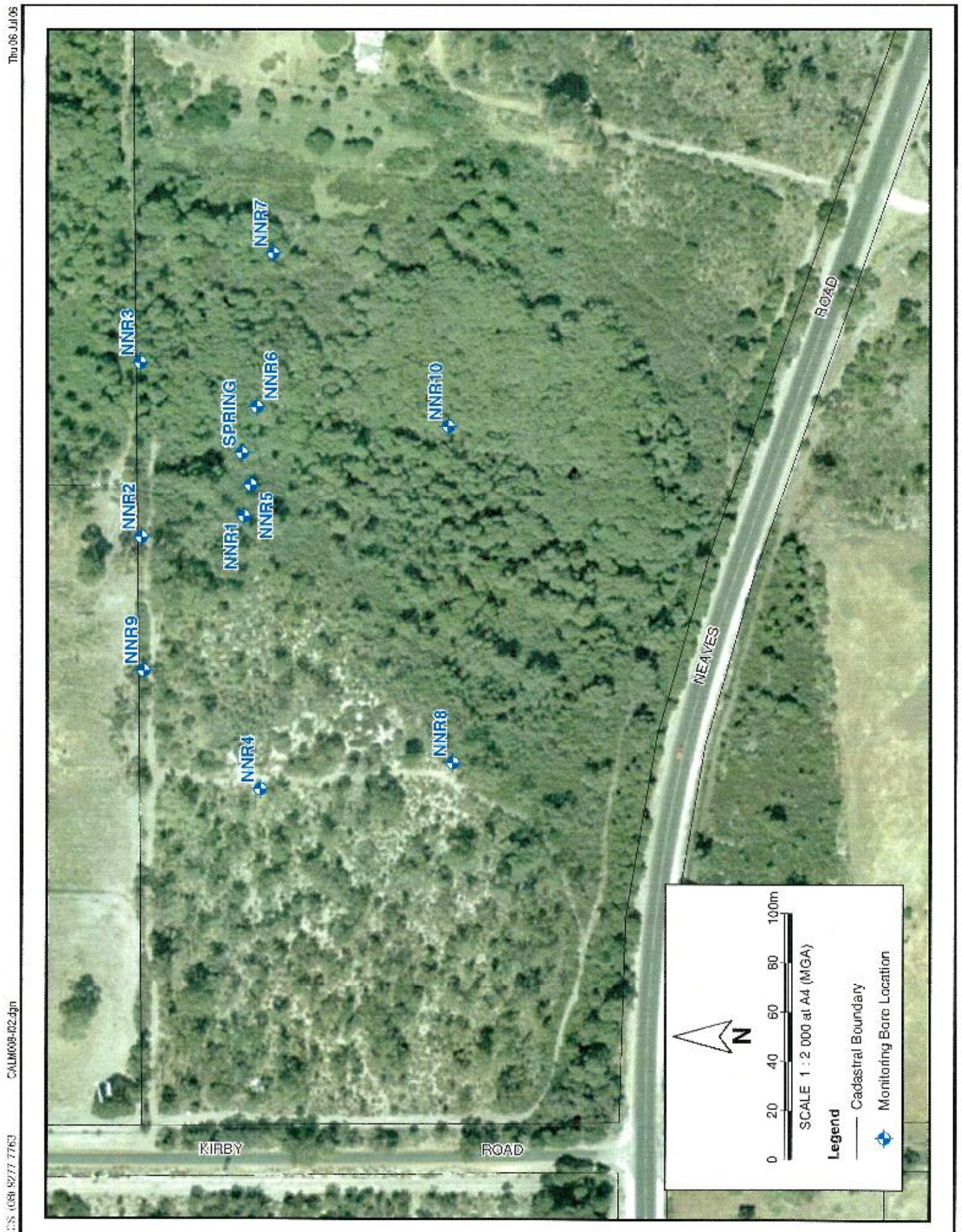
SHEET 1 OF 1

Client:	CALM	Date Commenced:	30/3/07
Project:	Bore installation at Neaves Nature Reserve	Date Completed:	30/3/07
Borehole Location:	Bullsbrook	Recorded By:	JS
Project Number:	2146393A	Log Checked By:	EB

Drill Model/Mounting:	Hollow Stem	Driller:	GS Drilling	Surface RL:	65.93 m
Borehole Diameter:	150 mm	Driller Lic No:		Co-ords:	E 400816.38 N 6497801.52

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS S/L L MD D VD / VS F St VSt H)	STRUCTURE AND ADDITIONAL OBSERVATIONS
			PVC top cap; PVC upstand									
			PVC with sand infill						TOPSOIL: Grey/brown, silty, fine to medium grained, subangular, poorly sorted			
			Bentonite Seal	65 / 1					SAND: Light grey, fine to medium grained, subangular, poorly sorted			
			PVC with sand infill	64 / 2								
		▼ 5/04/07		63 / 3					SAND: Dark Brown, fine to medium grained, subrounded, moderately sorted			
				62 / 4								
				61 / 5					As above - fine grained, well sorted			
				60 / 6					SILTY SAND: Dark brown, silty, fine grained, non plasticity			
				59 / 7					SAND: Dark brown, fine to medium grained, subangular, moderately sorted			
			Slotted PVC with filter pack	58 / 8								
				57 / 9					SAND: Off white, fine to medium, moderate to well sorted			
				56 / 10					CLAYEY SAND: Off white, fine to medium grained, non plasticity, subrounded			
									As above - low plasticity			
			PVC bottom cap	55 / 11					END OF BOREHOLE AT 10.55 m			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.



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GCS Groundwater Consulting Services Pty Ltd

Project No. CALM008

Conservation and Land Management
NORTHERN PERTH SPRINGS

MONITORING BORES (2004)

Figure 2

Drawn: S. Burton
Date: 23 May 2006

Appendix G

Fauna Assessment

Bamford Consulting Ecologists

PERTH-DARWIN HIGHWAY
Maralla Road to Calingiri Road

FAUNA VALUES: desktop review and site inspection

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10th January 2005

INTRODUCTION

As part of the determination of environmental constraints for the Perth to Darwin Highway from Maralla Road, Bullsbrook, to the intersection of the Great Northern Highway and Calingiri Road, Bamford Consulting Ecologists was commissioned to undertake an assessment of the fauna values of the preferred route. This was initially carried out as a desktop study, with the results presented separately for north and south of the Metropolitan Region Scheme (MRS) boundary (Bamford 2004 a & b). The present report expands upon the desktop studies and incorporates the results of a site inspection. The aims of this report are to:

- Present a list of species known to be present or expected to occur in an approximately 500m wide corridor and in the footprint of the preferred option for the Perth-Darwin Highway;
- Discuss issues associated with species of conservation significance known or expected to occur in the project area;
- Identify locations along the preferred option where impacts upon species of conservation significance, or upon other fauna, may constitute environmental constraints.
- Discuss management issues and options for impact minimisation with respect to fauna.

METHODS

Personnel

The desktop review, site inspection and report preparation were carried out by Dr Mike Bamford (*B.Sc.Biol., Hons.Biol., Ph.D. Biol.*). Mr Josh Foster of GHD provided logistical support for the site inspection.

Site inspection

The site inspection was carried out on 6th and 7th January 2005 by Dr Mike Bamford and Mr Josh Foster. The purpose of the site visit was essentially to familiarise the consultant with the environment (principally vegetation and soils) along the proposed development corridor so that constraints with respect to fauna known from the region can be identified. This report is classified as a Level 1 survey (a background research or 'desk-top' study and a reconnaissance survey) according to the EPA Guidance Statement No.56 (Environmental Protection Authority 2004).

The site inspection involved visiting as many locations as possible along the development corridor, with attention focussed on areas of native vegetation. In addition, landowners who had been contacted previously and had agreed to meet with us were visited. Some of these landowners had fauna records of interest or were able to show us habitats of potential significance.

Sources of information

Major sources of information for the desktop review were personal records from studies conducted at Ellenbrook, Lexia, Chandala (north of Muchea) and between Gingin and Bindoon. This includes a 3 year study near Mooliabeenee at a site through which the preferred highway alignment passes (Bamford 1986). Other sources of information included Storr *et al.* (1978), Storr and Johnstone (1988), Bush *et al*. (1995), Johnstone and Storr (1998), the Birds Australia Atlas Database (available through the website of Birds Australia, see also Barrett *et al*. 2003), W.A. Museum specimen records (WA Museum on-line database "Faunabase") and the threatened fauna database maintained by the Department of Conservation and Land Management (CALM). The EPBC database was also examined. Information from databases was taken from the area bounded approximately by 31 00' to 31 45'S, and 115 45' to 116 15'E. Species lists presented in Perth's Bush Forever (Government of Western Australia 2000) were also examined. Note that the site inspection also provided the opportunity to make some fauna observations.

These sources of information were used to create lists of species expected to occur in the project area. Expected species are those that are likely to utilise the project area, and such lists exclude species that have been recorded in the general region as vagrants or for which suitable habitat is absent. Particularly among the birds, for example, vagrants can be recorded almost anywhere.

Taxonomy and nomenclature for fauna species used in this report generally follow Aplin and Smith (2001) for amphibians and reptiles, How *et al.* (2001) for mammals and Johnstone (2001) for birds. Alternative names, including common names recommended for national and international use by Christidis and Boles (1994) for birds, are also given.

Assessment of conservation significance

The conservation status of fauna species is assessed under Commonwealth and State Acts such as the *Commonwealth Environment Protection and Biodiversity Conservation Act* (EPBC Act) 1999 and the *Western Australian Wildlife Conservation Act* 1950. The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2001). The *WA Wildlife Conservation Act* 1950 uses a set of Schedules but also classifies species using some of the IUCN categories. These categories and Schedules are described in Appendix 1.

The EPBC Act also has lists of migratory species that are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The list of migratory species under the EPBC Act has been revised to include species only, thus excluding family listings (DEH, pers comm.). Those species listed in JAMBA are also protected under Schedule 3 of the *WA Wildlife Conservation Act*. There is a separate list

of marine species under the EPBC Act, but this only applies to land and waters under commonwealth management.

The Department of the Environment and Heritage (DEH, formerly Environment Australia) has also supported the publication of reports on the conservation status of most vertebrate fauna species: reptiles (Cogger *et al.* 1993), birds (Garnett and Crowley 2000), monotremes and marsupials (Maxwell *et al.* 1996), rodents (Lee 1995) and bats (Duncan *et al.* 1999). The Threatened Species and Communities Section of Environment Australia has also produced a list of Threatened Australian Fauna (Environment Australia 1999), although this list is effectively a precursor to the list produced under the EPBC Act. These publications also use the IUCN categories, although those used by Cogger *et al.* (1993) differ in some respects because this report pre-dates categories reviewed by Mace and Stuart (1994) and revisited since by IUCN (2001).

In Western Australia, the Department of Conservation and Land Management (CALM) has produced a supplementary list of Priority Fauna, being species that are not considered Threatened under the WA Act but for which the Department feels there is cause for concern. Some Priority species, however, are also assigned to the IUCN Conservation Dependent category. Levels of Priority are described in Appendix 1.

Fauna species included under conservation acts and/or agreements are formally recognised as of conservation significance under state or federal legislation. Species listed only as Priority by CALM, or that are included in publications such as Garnett and Crowley (2000) and Cogger *et al.* (1993), but not in State or Commonwealth Acts, are also of recognised conservation significance. In addition, species that are at the limit of their distribution, those that have a very restricted range and those that occur in breeding colonies, such as some waterbirds, can be considered of conservation significance, although this level of significance has no legislative or published recognition and is based on interpretation of distribution information. The WA Department of Environmental Protection (2000) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Perth Bushplan (DEP 2000).

On the basis of the above comments, three levels of conservation significance are recognised in this report:

- *Conservation Significance (CS) 1*: Species listed under State or Commonwealth Acts.
- *Conservation Significance (CS) 2*: Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by CALM.
- *Conservation Significance (CS) 3*: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

OBSERVATIONS

Fauna of the development corridor

Invertebrates

In general, the invertebrate fauna of a region is too species rich and poorly understood for a review to be carried out in the manner that can be conducted for vertebrates. However, CALM's Threatened Fauna Database provides a list of threatened invertebrates of the general region. These species are discussed below.

Conservation Significance level 1

- Graceful Sunmoth *Symenon grantiosa* (Castniidae). Schedule 1 (Endangered). Known from the Neerabup area to the west. Possibly present in banksia woodlands of the study area.
- native bee *Leioproctus douglasiellus*. Schedule 1. Known only from Lake Forrestdale, south of Perth, and from the Pearce area which is close to the southern end of the development corridor. All records are from flowers of *Goodenia filiformis* but it is not known if this species is present in the project area.

Conservation Significance level 2

- trapdoor spider *Arbanitis inornatus*. Priority 1. Restricted to the Darling Scarp with some coastal plain populations between the Brockman and Serpentine Rivers. Considered to be under threat from land clearing. The development corridor passes through the northern part of this species' range so any area of native vegetation may be important. Note that there may be other species of mygalomorph spiders of conservation interest in the project area, especially in heavy soils, such as where laterites are close to the surface, or where the soil is a grey or red loam. Mygalomorph spiders tend to have disjunct distributions and to include short range endemic species that may be undescribed and therefore cannot be listed under wildlife conservation acts.
- cricket *Austrosaga spinifer*. Priority 3. Recorded from heathlands between Perth and Cervantes. May be limited to near-coastal areas, but there are heathlands along the development corridor, notably on shallow sand over laterite south of Ioppolo Road.
- Mogumber Bush Cricket *Throscodectes xederoides*. Priority 3. Found only between New Norcia and Mogumber, and therefore just north of the development corridor, but the species would only have to occur slightly south of its known range to be affected. Records are from heaths and grasslands.
- native bee *Hyaleus globuliferus*. Priority 3. Forages on the flowers of Woollybush *Adenanthos cygnorum* and some other species, and recorded from Melaleuca Conservation Park, which lies just to the west of the southern end of the development corridor. Woollybush is widespread on sandy soils and occurs in disturbed areas.

- native bee *Leioproctus contrarius*. Priority 3. Apparently dependent upon flowers of Goodeniaceae and known from Bullsbrook and Gnangara, so almost certainly present in native vegetation towards the southern end of the development corridor.
- South-West Freshwater Mussel *Westralunio carteri*. Priority 4. At the extreme northern limit of its range in the region, and only likely in more or less permanent freshwater wetlands. May be present in Ellen Brook in the south of the development corridor.

Freshwater Fish

The general region of the project area supports 9 native and 2 introduced species of freshwater fish (Table 1). Six species, the Western Minnow, Mud Minnow, Pygmy Perch, Swan River Goby, Mosquitofish and Goldfish, are known from Lake Chandala (M. Bamford unpubl. data). During the site inspection, only the Mosquitofish was observed, in a permanent soak on the Emu Springs property. The Ellen and Chandala Brook system (including Yal Yal Brook that is crossed by the development corridor) is probably richest in species, as the Brockman River is brackish which adversely affects most freshwater fish.

The majority of these freshwater fish rely on permanent water and are therefore confined to rivers and other permanent wetlands, although several species disperse widely when water levels are high and breeding occurs in seasonal wetlands adjacent to permanent sites. Two species, however, the Black-striped Minnow, and possibly the Mud Minnow, can survive in seasonal wetlands by sheltering in the burrows of freshwater crayfish (Morgan *et al.* 1998). These two species are common within a restricted area of the extreme South-West, but small, isolated populations are known from the Muchea to Gingin region. The species are classed as Priority 3 (Black-striped Minnow) and Priority 4 (Mud Minnow) by CALM, but the isolated northern populations are particularly noteworthy.

The population of the Black-striped Minnow is in a wetland in State Forest between Warbrook and Cooper Roads, and therefore west of the highway alignment. It probably previously occurred in areas that are now cleared. The population of the Mud Minnow is associated with Lake Chandala, and Chandala and Lennard's Brooks near Gingin. It may be present in Yal Yal Brook that is crossed by the development corridor. Both species are sensitive to changes in water levels so could be affected by hydrological impacts of the development.

Frogs

Thirteen species of frogs may occur in the project area (Table 2). With the exception of the Turtle Frog that breeds terrestrially and lives in woodland or heathland with sandy soil (Roberts 1981), all species rely on wetlands for breeding. Some of the frog species remain around wetlands as adults, but several are known to move long distances into

terrestrial habitats outside the breeding season. For example, the Moaning Frog and Pobblebonk occupy woodland several kilometres from the wetlands where they breed (Bamford 1992).

Two of the frog species, the Quacking Frog and Glauert's Froglet, are at the northern limit of their range around Gingin, so are of Conservation Significance Level 3. The Spotted Burrowing Frog and Humming Frog are of the same significance as it is at the southern limit of its range in the region. The region around Muchea and Bullsbrook is of significance as a hybrid zone between *Crinia insignifera* and *Crinia insignifera*.

Species with aquatic larvae are sensitive to changes in wetland water levels, while the dispersal away from wetlands outside the breeding season that is an important stage in the annual cycle of several species could be affected by road development. Sections of the development corridor close to wetlands are therefore likely to be important with respect to impacts upon frogs. These include locations near wetlands and watercourses between Maralla Road and the Brand Highway, particularly Lot 1662 Gaston Road, the route near Lake Chandala, the route near an un-named wetland close to Mooliabeenee Road, and where the route crosses the Brockman River and its tributaries.

Reptiles

The Study Area is located in a region of high reptile diversity, and is particularly rich because of the transition from the Coastal Plain through to the Darling and Gingin Escarpments, and across to the western Wheatbelt. There are species restricted to particular soil types, with sandy soils probably supporting the greatest species richness. A total of 62 species is expected (Table 3), with 39 recorded at a single site by Bamford (1986) and 47 definitely recorded within the development area if observations and reports from landowners are included. Other records are for within the search area as defined in the Methods.

In general, reptiles persist in areas of native vegetation, even in fragmented landscapes, while a few species will survive in cleared areas. Reptile species of conservation significance are as follows:

Conservation Significance Level 1.

- Short-necked Tortoise. Classed as Schedule 1 and as Critically Endangered under the WA Wildlife Conservation Act, and as Endangered under the EPBC Act. The extant natural wild population of this species is confined to Ellenbrook and Twin Swamps Nature Reserves, to the south-east and east of the southern end of the development corridor respectively. Suitable wetlands may have occurred within the project area, particularly between Maralla Road and Brand Highway, but were probably altered during clearing. The species could be sensitive to alterations in groundwater levels, although levels in the wetlands where it survives are maintained artificially and the species is not present within the development corridor.
- South-West Carpet Python. (Schedule 4 according to CALM). May be present throughout the study area where native vegetation has been retained. Reported by landowners at properties adjacent to Udumung Nature Reserve and by four landowners contacted in the vicinity of Cook Road. As the Cook Road area is close to Bamford's (1986) study site, where the species was not recorded, it may be that Carpet Pythons are concentrated in regions of exposed laterite and eucalypt woodland and are scarce in banksia woodlands, where Bamford worked. Carpet Pythons are particularly sensitive to being killed on roads as they are large and slow-moving. As they are also predators and occur at low population densities, they are prone to local extinction in fragmented landscapes; particularly with additional mortality from roadkill.

Conservation Significance Level 2.

The Salmon Gum Gecko, skink *Lerista christinae* and the Black-striped Snake are listed by Cogger *et al.* (1993), and the snake is also listed as Priority 3 by CALM. All, however, are close to the limit of their distribution in the project area. *L. christinae* and the Black-striped Snake are associated with sandy soils and *L. christinae* was found to be particularly common by Bamford (1986). How and Shine (1999) have suggested that the Black-striped Snake is particularly vulnerable to habitat fragmentation and may require areas >2000 ha for long-term persistence. This would make it sensitive to impacts of the

proposed development in the large tracts of native vegetation that would be divided south of Ioppolo Road and Brennan Road. The Salmon Gum Gecko is of interest, as a specimen was found on the Emu Springs property during the site inspection, but the next known records are along the Great Northern Highway. Emu Springs may support an isolated population of this species in the small area of Wandoo woodland.

Conservation Significance Level 3.

Thirteen reptile species are considered to be of some significance because they are at the limit of their distribution in the project area. For example, the skink *Acritoscincus trilineata* is that the northern limit of its range near Gingin, has been recorded in the Chandala area but was not recorded at Mooliabeenee. Other species at the northern limit of their range in the area are the Mourning Skink, Crowned Snake, Tiger Snake, Dugite and *P. nigriceps*. *A. trilineata*, the Mourning Skink, Crowned Snake and Tiger Snake are associated with mesic environments and will therefore be dependent upon wetlands in the area. Other CS3 species tend to be associated with more xeric environments.

Reptiles will be affected by loss and fragmentation of habitat which, in conjunction with increased mortality, may be particularly important for the Carpet Python. Fragmentation may also be important for some of the fossorial snakes, notably the fossorial Black-striped Snake. Habitats that are restricted in area, such as Wandoo woodland on Emu Springs, may support small, isolated populations of some species and such small populations would be particularly vulnerable.

Birds

Because of the mobility of birds, almost 200 species could be expected to be recorded in the project area over time, but many of these would be vagrants of little or no significance from a conservation and impact perspective. Therefore, Table 4 lists only species that are expected to make regular use of the project area, but does include species of conservation significance as by their very nature these may be infrequently observed. A total of 158 bird species are expected to be present. Bamford (1986) recorded 84 bird species at Mooliabeenee over three years, but the site had no wetlands so very few waterbirds were present.

Many of the bird species are waterbirds that would use flooded pastures as well as natural wetlands, while there is a suite of birds that use farmland. A large proportion of the avifauna, however, will be mostly restricted to native vegetation.

Bird species of conservation significance are as follows:

Conservation Significant Level 1

- Malleefowl. (Vulnerable under the EPBC Act, WA Wildlife Conservation Act and by Garnett and Crowley 2000). This species is listed for the area under the EPBC database and while it may have been present historically in the north of the development corridor, it is almost certainly locally extinct due to habitat loss.

Therefore, there is no likelihood of the project having a significant impact upon the Malleefowl.

- Australasian Bittern (Vulnerable under the WA Wildlife Conservation Act and according to Garnett and Crowley 2000). Probably present in wetlands vegetated with rushes in the general region. A wetland just east of the development corridor, adjacent to Mooliabeenee Road, appeared to be very suitable for this species. Potential impacts of the proposed development upon this species are slight.
- Short billed (Carnaby's) Black-Cockatoo. (Endangered under the EPBC Act, WA Wildlife Conservation Act and by Garnett and Crowley 2000). This species is likely to use the area on a seasonal basis as a food resource, as it feeds on the seeds of eucalypts, banksia and casuarina species. It also feeds in pine plantations. Therefore, there are extensive foraging areas south and north of Ioppolo Road, south of Brennan Road and along Cullala Road. In addition, the development corridor passes close to large tracts of native vegetation near Maralla Road, north and south of Gray Road and along Hay Flat Road. There is the potential for some loss of foraging habitat, but in all areas where the birds feed, there is also the potential for roadkill to be an issue, as the cockatoos often fly low between trees, particularly when foraging in banksia woodland. The cockatoos may also nest in parts of the project area, with confirmed breeding on two properties near Cook Road/Cullala Road, and on one property on Hay Flat Road. One nest that was examined contained an old egg and a chick was reported to have fledged before Christmas 2004. The nest that was visited was in a Wandoo, and the Hay Flat Road nest was also in a Wandoo, but breeding on a property south of Cook Road would be in Marri, as Wandoo is absent at that site. Although all nesting records are in the north of the development corridor, there has been a recent trend for the species to breed further south and closer to the coast than it did historically (R. Johnstone, pes. comm.), and therefore breeding may occur wherever there are tree hollows of suitable size. Because of the extent of the development corridor and the presence of both foraging and breeding sites, the impact of the development should be considered potentially significant under the EPBC Act.
- Baudin's Black-Cockatoo. (Vulnerable under the EPBC Act, WA Wildlife Conservation Act and by Garnett and Crowley 2000). This species is listed for the project area in the EPBC database, but the region is on the northern edge of its generally recognised distribution (Johnstone and Storr 1998). Therefore, it may only be an infrequent visitor, perhaps to the eucalypt woodlands south of Ioppolo Road. Baudin's Black-Cockatoo feeds primarily on the seeds of eucalypts. Because the development corridor is marginal habitat for the species, the impact of the development is probably not significant under the EPBC Act.
- Peregrine Falcon. (Other Specially Protected Fauna under the WA Wildlife Conservation Act). This species may forage over the study area and may also utilise available nesting sites such as old Raven *Corvus coronoides* and Wedge-tailed Eagle *Aquila audax* nests (Johnstone and Storr 1998). It also nests in large, horizontally-aligned tree hollows and on cliffs, although the latter are not present in the study area. A pair is regularly observed at Tiwest's Chandala operations

(M. Bamford pers. obs) and probably nests in the region. The nest site could be in the large tract of woodland south of Ioppolo Road but the species potentially could nest in any large tree with a suitable nest-site along the development corridor. Nest sites are important for the species and should be protected when possible. Loss of a nest site would be the main potential impact of the proposal upon this species.

- Migratory species under the EPBC Act, including the Fork-tailed Swift, Rainbow Bee-eater and all scolopacids. Of these, only the Rainbow Bee-eater is likely to be regularly present. It nests in open areas, often constructing its burrows on sloping paddocks, and is therefore unlikely to be adversely affected by road development. The EPBC database includes a number of other migratory species for the region, but these are marine, such as the White-bellied Sea-Eagle, and have therefore been excluded on the basis of lack of suitable habitat.
- Marine species under the EPBC Act. Most marine species are not present in the study area, but the Great Egret occurs in wetlands in the region and is listed as marine under the EPBC Act. However, a marine listing is only significant on Commonwealth managed lands and waters, so impacts on the Great Egret would only be of concern under the EPBC Act in areas such as Defence Department land, which are adjacent to parts of the development corridor near Neaves Road, in the south.

<u>Conservation Significance Level 2.</u>

- Black Bittern (Priority 2 according to CALM). This species has declined greatly in the South-West but was formerly observed in trees overhanging watercourses. Parts of the Brockman River may have provided suitable habitat but the species is considered extinct in the region now (Johnstone and Storr 1998).
- Little Bittern (Priority 4 according to CALM). Probably present in wetlands vegetated with rushes in the general region. A wetland just east of the development corridor, adjacent to Mooliabeenee Road, appeared to be very suitable for this species. Potential impacts of the proposed development upon this species are slight.
- Red-tailed Black-Cockatoo (forest race) (Priority 3 according to CALM). Although considered to occur as far north as Gingin, and formerly as far north as Dandaragan (Johnstone and Storr 1998), this species was not recorded in Bamford's (1986) three year study at Mooliabeenee, so is probably only a vagrant in the study area. If it is present regularly, it would occur in the eucalypt woodlands south of Ioppolo Road. In this area, it would be expected to forage on eucalypts.
- Barking Owl (southern race) (classified as Priority 2 by CALM and Near Threatened by Garnett and Crowley 2000). The Barking Owl is infrequently recorded around Perth and is associated with large, hollow-bearing eucalypts. There is potential for it to be present wherever there are large trees, including in parkland-cleared paddocks.
- Masked Owl (southern race classified as Priority 3 by CALM and Near Threatened by Garnett and Crowley 2000). This species is very infrequently recorded around Perth but is associated with large eucalypts that contain hollows

suitable for nesting and roosting. The species may be present in the project area and any trees used for roosting or nesting would be significant.

- Crested Bellbird (*O. g. gutturalis* is listed as Near Threatened by Garnett and Crowley 2000 and as P4 by CALM). The southern race of the Crested Bellbird has declined due to clearing for agriculture and was recorded regularly at Mooliabeenee (Bamford 1986). It is probably resident in large areas of native vegetation along the development corridor.

Conservation Significance level 3

Many of the birds known from the general area are woodland species that are currently recognised as being in decline (Robinson and Traill 1996), or are listed as significant in the Perth area (Department of Environmental Protection 2000). These are considered to be of Conservation Significance Level 3. These tend to be species associated with native vegetation. To some extent, the criteria used to identify these species at risk in agricultural and urban areas do not apply to the development corridor, since there are at least moderate amounts of native vegetation remaining. However, the proposed development will lead to some habitat loss and fragmentation which are the factors that have led to the decline of these species elsewhere. There are 46 species of CS3, accounting for 18% of the avifauna. Among these species, a few have specific habitat requirements worthy of note. The Red-winged Fairy-wren is represented in the region by an isolated population in dense vegetation along Gingin Brook. It probably does not occur as far east as the development corridor but is generally dependent upon dense vegetation around watercourses and other wetlands. The Southern Emu-wren is more likely to be present along the development corridor, and tends to occur in areas of heath, such as were observed on shallow soil over laterite south of Ioppolo Road. Several of the CS3 birds are waterbirds that utilise undisturbed freshwater wetlands. While there are few such wetlands in the vicinity of the development corridor, potential effects on these need to be considered.

The major impact upon birds would be through loss and fragmentation of habitat, with nest sites for species such as Carnaby's Black-Cockatoo and the Peregrine Falcon being of particular significance. Fragmentation may be of importance especially in areas where the habitat is already substantially fragmented, such as near Gray Road.

Mammals

The mammal fauna expected in the project area consists of 26 native and 5 introduced species (Table 5). A number of other native species are regionally extinct (Table 6) as part of a massive loss of mammal species across much of mainland Australia that has been attributed to changes in fire regime, habitat loss and predation by Foxes and Cats (Burbidge and McKenzie 1989, Paton 1991).

With the exception of the Grey Kangaroo and some of the bat species, the native mammal species will be mostly confined to the large tracts of native vegetation. The area to the south of Ioppolo Road may be of particular significance because of its size and location. Mammal species of conservation significance are as follows:

Conservation Significant Level 1

- Chuditch (Vulnerable under the EPBC Act, WA Wildlife Conservation Act and according to Maxwell *et al.* 1996). A single specimen (a juvenile male) was caught near Ellenbrook in 2001 (M. Bamford, unpubl. data), suggesting that individuals occasionally move onto the coastal plain in this region, probably coming from populations beyond the escarpment where fox-baiting is carried out. This is the only CS1 species likely to occur in the project area, as other species of high conservation significance are regionally extinct (Table 6). The large tract of native vegetation south of Ioppolo Road may support this species and fragmentation of this area of habitat would be a concern.

Conservation Significance Level 2

- Brush-tailed Phascogale (Priority 3 according to CALM). Probably locally extinct, but known to occur in Jarrah forests of the nearby escarpment (M. Bamford, pers. obs.).
- Kwoora or Brush Wallaby (Priority 4 according to CALM and Lower Risk (near threatened) according to Maxwell *et al.* 1996). This species is probably present in large tracts of native vegetation right along the development corridor. It was recorded at Mooliabeenee (Bamford 1986) and was reported by landowners just south of Cook Road. It is prone to being killed on roads so roadkill may pose a threat to populations.
- Quenda or Southern Brown Bandicoot (Priority 5 according to CALM and Lower Risk (near threatened) according to Maxwell *et al.* 1996). The species is common in the Lexia wetlands just south-west of Maralla Road and is reported by landowners between Maralla Road and Brand Highway. It has not been recorded in the Chandala area, but Bamford (1986) observed the species north of Mooliabeenee Road (a single observation in 1985) and one landowner just south of Cook Road reported Quendas, although the observation is best considered unconfirmed. There may be an outlying population in this area. Quendas are associated with dense vegetation, often around wetlands, and in areas where populations occur close to major roads, underpasses have been provided to prevent fragmentation and reduce roadkill. Where the alignment passes between a wetland and woodland near Gaston Road would be one such location.
- Rakali or Water Rat (classified as Priority 4 by CALM and although Lee (1995) does not give the species a formal status under the IUCN categories, he admits that the population in south-western Western Australia has experienced a substantial decline as a result of increased salinity and general degradation of rivers in the region). The Rakali is probably present along Ellen/Chandala Brook and the Brockman River, including tributaries, and was reported in the Mooliabeenee region by landowners in the mid 1980s (M. Bamford unpubl. data). It may visit seasonal wetlands such as Lake Chandala. Although semi-aquatic, the Rakali regularly moves between wetlands and is a fairly common roadkill close to suitable habitat (M. Bamford pers. obs.). This may be a concern wherever the development corridor passes close to wetlands.

- Western False Pipistrelle (classified as Priority 4 by CALM and Lower Risk (near threatened) by Duncan *et al.* 1999). The species is endemic to south-western Australia, with a preference for areas of forest and tall woodlands (Strahan 1995), but it has been recorded in banksia woodland south of Perth (Hosken and O'Shea 1994). While the accepted distribution of the species does not extend north of Perth, woodland south of Ioppolo Road appeared to be suitable habitat and the distribution of bats is poorly understood. The main threat to this species is habitat loss through logging/land-clearing (Duncan *et al*. 1999), and the proposed development could result in some habitat loss.

Conservation Significance Level 3

Nine of the mammal species expected in the project area (Table 5) are considered to be of local significance, mainly because they have restricted distributions in the region. For example, the Mardo would be at the northern limit of its range but might be present in woodland south of Ioppolo Road, while the three dunnart species and the Noodji may be at the southern limit of their range in the same area. Habitat loss and fragmentation would be a concern for these species, although Bamford's (1986) study demonstrated a rich fauna of small mammals in a fragmented, partly agricultural landscape, leading to the suggestion that the fragmentation had prevented any single wildfire from impacting upon all woodland areas.

As with other fauna groups, habitat loss and fragmentation are a concern for mammals, but roadkill is also a concern for the larger species such as Quenda, Rakali and Brush Wallaby. With small and possibly isolated populations, roadkill can lead to localised decline and even extinction.

CONCLUSIONS

The development corridor passes through a complex landscape of varying vegetation types and soils, with extensive remnants of natural habitat in some areas. As a result, the fauna is rich and a number of key issues with respect to fauna and impacts from the proposed development can be identified.

Fauna habitats and fauna impacts in the development corridor

Much of the development corridor supports cleared or parkland-cleared agricultural land, but there were a number of locations of interest. Features, habitats and issues with respect to fauna within sections of the development corridor, from south to north, are summarised below.

Maralla Road to Brand Highway.

Mostly parkland-cleared with the landscape low-lying and much of it seasonally damp or inundated. There are minor drainage lines flowing towards Ellen Brook and the route crosses Ellen Brook at one point. These drainage lines and the crossing point at Ellen Brook support some remnant vegetation, mostly trees with badly degraded understorey.

Immediately north of Maralla Road the route passes close to wetlands and native vegetation (eg. lot 5 Sawpit Road). On Lot 1662 Gaston Road, the route passes close to a large, more or less permanent wetland that is currently linked to extensive upland vegetation of mostly banksia woodland.

Major issues for fauna in this sector would be:

- Fragmentation of remnant habitat, mainly a concern on lot 1662 Gaston Road where there may be impacts on frogs and the Quenda. Associated with fragmentation would be an increase in roadkill of medium sized and large mammals and reptiles.
- Disruption of movement of terrestrial fauna along linear habitats, such as watercourses.
- Disruption of surface and sub-surface hydrology. Even degraded wetlands in the region are important for waterbirds and frogs. A conservation significant reptile (Short-necked tortoise) and fish (Black-striped Minnow) depend upon seasonal wetlands just outside the study area.
- Loss of habitat patches trees in agricultural areas. In extensively cleared areas, even single trees may be significant for fauna.
- Some potential benefits exist because verge planting can create linear habitats in an otherwise substantially degraded landscape.

<u>Brand Highway to Ioppolo Road.</u>

In the south of this sector, as far north as Yal Yal Road, the route passes through mostly cleared agricultural land. From just north of Yal Yal Road, however, the route passes through an extensive area of native vegetation in good condition. This includes banksia woodland on sand and eucalypt woodland where lateritic gravels are at or close to the surface. In some areas of very shallow soil, the vegetation is a *Xanthorrhoea* dominated heath. At the northern end of this sector, alongside Ioppolo Road, there is a grove of particularly large eucalypts (mostly Marri *Corymbia calophylla*). The woodland south of Ioppolo Road is particularly significant for fauna because it is extensive and may support populations of species at the northern or southern extreme of their distribution.

Major issues for fauna in this sector would be:

- Loss and degradation of habitat in the large area of native vegetation.
- Disruption of movement of terrestrial fauna, particularly in the large area of native vegetation. This may be important for frogs that breed in nearby Lake Chandala, and for other terrestrial fauna.
- Possible loss of habitat trees, including nest trees, also of greatest concern in the large area of native vegetation. There may be a Peregrine Falcon nest in the area.
- Potential groundwater impacts that could influence Chandala Lake Nature Reserve.

Ioppolo Road to Mooliabeenee Road.

Through most of this sector, the route passes through parkland-cleared agricultural land and has been chosen to avoid remnant native vegetation in paddocks where possible. It does, however, pass through native vegetation and pine plantations immediately north of Ioppolo Road, and through a large tract of native vegetation (mostly banksia woodland on sand) at the southern end of Brennan Road. North and south of Gray Road, the route passes through mostly private property with a lot of remnant native vegetation, including a large block of vegetation on Lots 20 and 21 Gray Road.

Major issues for fauna in this sector would be:

- Loss and degradation of habitat in areas of native vegetation.
- Disruption of movement of terrestrial fauna. This would be an issue where the route passes through native vegetation, such as south of Brennan Road and south of Gray Road, but would also be an issue where there is extensive remnant native vegetation north of Gray Road, even though the route largely avoids the native vegetation itself. In such an already fragmented landscape, an additional barrier may be more significant than it would be in an otherwise intact landscape. Roadkill would also be a concern in this area.
- Possible loss of habitat trees, including nest trees, in native vegetation and parkland-cleared agricultural areas.

Mooliabeenee Road to Moora Road.

In the south of this sector, the route passes through properties where Bamford (1986) undertook a 3-year fauna study (M2059, M1465 and a property west of Cullala Road, opposite M2082). The route passes through native vegetation adjacent to Cullala Road on M2059, M1465, Lot 20 Barn Road, and around Cook Road. From north of Emu Springs (Lot 21 Cook Road) to Moora Road, the route passes through substantially cleared agricultural land and crosses the Brockman River at a point where little native vegetation remains. Vegetation on M2059 and M1465 consists largely of banksia woodland, but around Cook road the vegetation includes eucalypt woodlands where lateritic gravels lie close to the surface, and on Emu Springs is an apparently isolated area of Wandoo *Eucalyptus wandoo* woodland on gravelly loam soils associated with a low breakaway. There are several small wetlands on the Emu Springs property, including one permanent soak. Fauna of interest in this area include nesting Carnaby's Black-Cockatoo, outlying populations of lizard species associated with a small patch of Wandoo woodland, the presence of Carpet Pythons and the possible presence of an outlying population of the Quenda.

Major issues for fauna in this sector would be:

- Loss and degradation of habitat in areas of native vegetation.
- Disruption of movement of terrestrial fauna. This would be an issue where the route passes through large tracts of native vegetation, and would also be a concern along the Midland Railway where it passes through farmland, as the development would probably result in the loss of remnant vegetation along the railway.
- Possible loss of habitat trees, including nest trees, in native vegetation and parkland-cleared agricultural areas. The small area of Wandoo woodland on the

Emu Springs property may be of particular significance in this respect (Carnaby's Black-Cockatoo, reptiles).
- Hydrological impacts on the Emu Springs property and along the Brockman River.
- Roadkill would be a concern as several vulnerable species are present in this sector.

Moora Road to Great Northern Highway.

Most of this sector passes through agricultural land with only scattered trees, and remnant native vegetation is largely avoided. Exceptions are on Lot 2448 Kangaroo Gully Road, where the route passes through an area of open eucalypt woodland over heath, at Head Road, where the route passes through Wandoo woodland over *Dryandra polycephala* thickets, along Hay Flat Road where it passes through riparian vegetation along a branch of the Brockman River, and at the north-eastern corner of Udumung Nature Reserve, where the route passes through Wandoo woodland. Wandoos are associated with red loam soils and breakaways in this sector. Significant fauna include nesting Carnaby's Black-Cockatoo and Carpet Pythons.

Major issues for fauna in this sector would be:
- Loss and degradation of habitat in areas of native vegetation. This would be particularly significant as little native vegetation remains in this sector.
- Disruption of movement of terrestrial fauna. This would be an issue where the route passes through native vegetation, and would be important where the route crosses the Brockman River alongside Hay Flat Road. The route would also divide Udumung Nature Reserve from some good tracts of native vegetation on private property to the north and west.
- Possible loss of habitat trees, including nest trees, in native vegetation and parkland-cleared agricultural areas.
- Hydrological impacts where the route crosses the Brockman River alongside Hay Flat Road. The route also crosses a watercourse that runs alongside Kangaroo Gully Road.

Further studies

This preliminary assessment has identified a number of areas that require further investigation.
- Nests of rare birds (Carnaby's Black-Cockatoo, Peregrine Falcon, possible Masked and Barking Owls) should be located.
- An outlying population of the Quenda may be present on private property near Cook Road and this should be confirmed.
- The fauna of the bushland south of Ioppolo Road may be of particular interest and should be investigated, with a focus on small mammals.

Table One. Freshwater fish of the study area. Conservation significance is indicated as described in Methods.

Species	Conservation significance
Plotosidae (eel-tailed catfish)	
Freshwater Cobbler *Tandanus bostocki*	
Galaxiidae (Australian minnows)	
Western Minnow *Galaxias occidentalis*	
Mud Minnow *Galaxiella munda*	CS2
Black-striped Minnow *Galaxiella nigrostriata*	CS2
Percichthyidae (Australian perches)	
Nightfish *Bostockia porosa*	
Nannopercidae (pygmy-perches)	
Western Pygmy-perch *Edelia vittata*	
Atherinidae (hardyheads)	
Western Hardyhead *Leptatherina wallacei*	
Gobiidae (gobies)	
Swan River Goby *Pseudogobius olorum*	
Big-headed Goby *Afurcagobius suppositus*	
Poeciliidae (live-bearing tooth-carps)	
Mosquito Fish *Gambusia holbrooki*	Introduced
Cyprinidae (carp and allies)	
Goldfish *Carassius auratus*	Introduced

Table Two. Frogs of the study area. Conservation significance is indicated as described in Methods. Species recorded along the route either by Bamford (1986) at Mooliabeenee (Mool), or in the Chandala area (Chan) by Bamford (unpubl. data) are indicated.

Species	Conservation significance	Records
Myobatrachidae (ground frogs)		
Quacking Frog *Crinia georgiana*	CS3	Mool, Chan
Glauert's Froglet *Crinia glauerti*	CS3	Mool, Chan
Sandplain Froglet *Crinia insignifera*		Mool, Chan
Granite Froglet *Crinia pseudinsignifera*		Chan
Moaning Frog *Heleioporus eyrei*		Mool, Chan
Spotted Burrowing Frog *Heleioporus albopunctatus*	CS3	
Heleioporus psammophilus		
Pobblebonk *Limnodynastes dorsalis*		Mool, Chan
Turtle Frog *Myobatrachus gouldii*		Mool
Humming Frog *Neobatrachus pelobatoides*	CS3	
Guenther's Toadlet *Pseudophryne guentheri*		Mool, Chan
Hylidae (tree frogs)		
Slender Tree Frog *Litoria adelaidensis*		Mool, Chan
Motorbike Frog *Litoria moorei*		Chan

Table Three. Reptiles of the project area. Conservation significance is indicated as described in Methods. Species recorded along the route either by Bamford (1986) at Mooliabeenee (Mool), or in the Chandala area (Chan) by Bamford (unpubl. data) are indicated. Observations during the site inspection (obs), including reports from landowners, are also shown.

Species		Conservation significance	Records
Chelidae (side-neck tortoises)			
Short-necked Tortoise	*Pseudemydura umbrina*	CS1	
Long-necked Tortoise	*Chelodina oblonga*		Chan, Obs
Gekkonidae (geckoes)			
Clawless Gecko	*Crenadactylus ocellatus*	CS3	
	Diplodactylus alboguttatus		
	Diplodactylus granariensis	CS3	
	Diplodactylus polyophthalmus		Mool
Spiny-tailed Gecko	*Diplodactylus spinigerus*		Mool
Marbled Gecko	*Christinus (Phyllodactylus) marmoratus*		Mool
Tree Dtella	*Gehyra variegata*	CS3	
Salmon Gum Gecko	*Oedura reticulata*	CS2	Obs
Barking Gecko	*Underwoodisaurus milii*		Mool
Pygopodidae (legless lizards)			
Sandplain Worm Lizard	*Aprasia repens*		Mool
	Aclys concinna		
Fraser's Legless Lizard	*Delma fraseri*		Mool
	Delma grayii		Mool
Burton's Legless Lizard	*Lialis burtonis*		Mool
	Pletholax gracilis		Mool
Common Scaleyfoot	*Pygopus lepidopodus*		Mool
Agamidae (dragon lizards)			
Western Bearded Dragon	*Pogona minor*		Mool, Chan
Sandhill Dragon	*Rankinia(Tympanocryptis) adelaidensis*		Mool
Varanidae (monitors or goannas)			
Gould's Sand Goanna	*Varanus gouldii*		Mool, Chan
Black-tailed Tree Goanna	*Varanus tristis*		Mool, Obs
Scincidae (skink lizards)			
	Acritoscincus (Bassiana) trilineata	CS3	Chan
Fence Skink	*Cryptoblepharus plagiocephalus*		Mool, Chan, Obs
	Ctenotus australis		Mool
	Ctenotus fallens		Mool
	Ctenotus gemmula		
	Ctenotus impar		Mool
	Ctenotus schomburgkii		Mool

Table 3 (cont.)

Species		Conservation significance	Records
King's Skink	*Egernia kingii*		
Mourning Skink	*Egernia luctuosa*	CS3	
	Egernia multiscutata		Mool
Salmon-bellied Skink	*Egernia napoleonis*		Mool
Broad-banded Sand-swimmer	*Eremiascincus richardsoni*		Obs
	Hemiergis quadrilineata		
	Lerista christinae	CS2	Mool
	Lerista distinguenda		
	Lerista elegans		Mool
	Lerista praepedita		Mool
Dwarf Skink	*Menetia greyii*		Mool, Chan
Spotted Morethia	*Morethia lineoocellata*		Mool
Dusky Morethia	*Morethia obscura*		Mool
Western Bluetongue	*Tiliqua occipitalis*		Mool
Bobtail	*Tiliqua rugosa*		Mool, Chan, Obs
Typhlopidae (blind snakes)			
	Ramphotyphlops australis		Mool
	Ramphotyphlops waitii		
Boidae (pythons)			
Carpet Python	*Morelia spilota imbricata*	CS1	Obs
Stimson's Python	*Antaresia stimsoni*	CS3	Obs
Elapidae (front-fanged snakes)			
Yellow-faced Whip-Snake	*Demansia psammophis*		Mool
Crowned Snake	*Drysdalia coronata*	CS3	
Bardick	*Echiopsis curta*		Mool
Tiger Snake	*Notechis scutatus*	CS3	Chan
Mulga Snake	*Pseudechis australis*	CS3	Obs
Dugite	*Pseudonaja affinis*	CS3	Obs
Gwardar	*Pseudonaja nuchalis*	CS3	Mool
Gould's Snake	*Parasuta gouldii*		Mool, Chan
	Parasuta nigriceps	CS3	
Jan's Bandy-Bandy	*Simoselaps bertholdi*		Mool
Black-naped Snake	*Neelaps bimaculata*		Mool
Black-striped Snake	*Neelaps calonotos*	CS2	Mool
Half-ringed Snake	*Brachyurophis semifasciata*		Mool
Narrow Banded Snake	*Brachyurophis fasciolata*		

Table Four. Birds of the project area. Conservation significance is indicated as described in Methods. Species recorded along the route either by Bamford (1986) at Mooliabeenee (Ml), or in the Chandala area (Ch) by Bamford (unpubl. data) are indicated. Observations during the site inspection (obs), including reports from landowners, are also shown.

Species		Cons. sign.	Records
Dromaiidae (emus)			
Emu	*Dromaius novaehollandiae*	CS3	ml, obs
Megapodiidae (mound-builders)			
Malleefowl	*Leipoa ocellata*	CS1	
Phasianidae (pheasants and quails)			
Stubble Quail	*Coturnix pectoralis*		ml
Anatidae (ducks, geese and swans)			
Freckled Duck	*Stictonetta naevosa*	CS3	
Black Swan	*Cygnus atratus*		ch
Australian Shelduck	*Tadorna tadornoides*		ml, ch
Pacific Black Duck	*Anas superciliosus*		ml, ch
Grey Teal	*Anas gibberifrons*		ch
Australasian Shoveler	*Anas rhynchotis*	CS3	ch
Pink-eared Duck	*Malacorhynchus membranaceus*	CS3	ch
Hardhead (White-eyed Duck)	*Aythya australis*	CS3	ch
Australian Wood Duck	*Chenonetta jubata*		ml, ch
Musk Duck	*Biziura lobata*	CS3	ch
Blue-billed Duck	*Oxyura australis*	CS3	ch
Podicepididae (grebes)			
Great Crested Grebe	*Podiceps cristatus*		
Hoary-headed Grebe	*Poliocephalus poliocephalus*		ch
Australasian Grebe	*Tachybaptus novaehollandiae*		ch
Phalacrocoracidae (cormorants)			
Great Cormorant	*Phalacrocorax carbo*		obs
Little Black Cormorant	*Phalacrocorax sulcirostris*		ch
Little Pied Cormorant	*Phalacrocorax melanoleucos*		ch
Ardeidae (herons and egrets)			
White-faced Heron	*Egretta novaehollandiae*		ml, ch
Little Egret	*Egretta garzetta*		
White-necked Heron	*Ardea pacifica*		ch
Great Egret	*Egretta alba*	CS1 (marine)	ch
Nankeen Night Heron	*Nycticorax caledonicus*	CS3	ml
Black Bittern	*Dupetor flavicollis*	CS2	
Little Bittern	*Ixobrychus minutus*	CS2	
Australasian Bittern	*Botaurus poiciloptilus*	CS2	

Table 4 (cont.)

Species		Cons. sign.	Records
Plataleidae (ibis and spoonbills)			
Glossy Ibis	*Plegadis falcinellus*		ch
Australian White Ibis	*Threskiornis molucca*		ch
Straw-necked Ibis	*Threskiornis spinicollis*		ml, ch
Yellow-billed Spoonbill	*Platalea flavipes*		ch
Accipitridae (kites, hawks and eagles)			
Black-shouldered Kite	*Elanus notatus*		ml, ch
Square-tailed Kite	*Lophoictinia isura*	CS3	
Whistling Kite	*Haliastur sphenurus*	CS3	ch
Spotted Harrier	*Circus assimilis*		
Swamp Harrier	*Circus approximans*		ch
Brown Goshawk	*Accipiter fasciatus*	CS3	ml
Collared Sparrowhawk	*Accipiter cirrhocephalus*	CS3	ml
Wedge-tailed Eagle	*Aquila audax*	CS3	ch
Little Eagle	*Hieraaetus morphnoides*	CS3	ml
Falconidae (falcons)			
Peregrine Falcon	*Falco peregrinus*	CS1	ch
Australian Hobby	*Falco longipennis*		ml
Brown Falcon	*Falco berigora*	CS3	ml
Nankeen Kestrel	*Falco cenchroides*		ml, ch, obs
Rallidae (crakes and rails)			
Buff-banded Rail	*Rallus philippensis*		
Baillon's Crake	*Porzana pusilla*		ch
Australian Spotted Crake	*Porzana fluminea*		
Spotless Crake	*Porzana tabuensis*		
Black-tailed Native-hen	*Gallinula ventralis*		ch
Purple Swamphen	*Porphyrio porphyrio*		ch
Dusky Moorhen	*Gallinula tenebrosa*	CS3	
Eurasian Coot	*Fulica atra*		ch
Scolopacidae (sandpipers)			
Marsh Sandpiper	*Tringa stagnatalis*	CS1 (mig)	
Common Greenshank	*Tringa nebularia*	CS1 (mig)	
Wood Sandpiper	*Tringa glareola*	CS1 (mig)	
Common Sandpiper	*Tringa hypoleucos*	CS1 (mig)	ch
Red-necked Stint	*Calidris ruficollis*	CS1 (mig)	
Sharp-tailed Sandpiper	*Calidris acuminata*	CS1 (mig)	
Curlew Sandpiper	*Calidris ferruginea*	CS1 (mig)	
Recurvirostridae (stilts and avocets)			
Black-winged Stilt	*Himantopus himantopus*		ch
Banded Stilt	*Cladorhynchus leucocephalus*		
Red-necked Avocet	*Recurvirostra novaehollandiae*		

Table 4 (cont.)

Species		Cons. sign.	Records
Charadriidae (lapwings and plovers)			
Banded Lapwing	*Vanellus tricolor*		ml
Red-capped Plover	*Charadrius ruficapillus*		
Black-fronted Dotterel	*Elseyornis melanops*		ch
Red-kneed Dotterel	*Erythrogonys cinctus*		
Turnicidae (button-quails)			
Painted Button-quail	*Turnix varia*	CS3	ml
Little Button-quail	*Turnix velox*		ml
Columbidae (pigeons and doves)			
Laughing Turtle-Dove	*Streptopelia senegalensis*	Introduced	ml
Spotted Turtle-Dove	*Streptopelia chinensis*	Introduced	
Common Bronzewing	*Phaps chalcoptera*	CS3	ml, ch, obs
Brush Bronzewing	*Phaps elegans*	CS3	
Crested Pigeon	*Ocyphaps lophotes*		ml, ch, obs
Cacatuidae (cockatoos)			
Baudin's Black-Cockatoo	*Calyptorhynchus baundinii*	CS1	
Short-billed Black-Cockatoo	*Calyptorhynchus latirostris*	CS1	ml, ch, obs
Red-tailed black-Cockatoo	*Calyptorhynchus banksii naso*	CS2	
Galah	*Cacatua roseicapilla*		ml, ch, obs
Western Corella	*Cacatua pastinator*		ml
Psittacidae (lorikeets and parrots)			
Rainbow Lorikeet	*Trichoglossus haematodus*	Introduced	
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*		ml
Regent Parrot	*Polytelis anthopeplus*		ml
Red-capped Parrot	*Purpureicephalus spurius*		ml, ch, obs
Western Rosella	*Platycercus icterotis*	CS3	ml
Australian Ringneck	*Barnardius zonarius*		ml, ch, obs
Elegant Parrot	*Neophema elegans*		ml
Cuculidae (cuckoos)			
Pallid Cuckoo	*Cuculus pallidus*		ml
Fan-tailed Cuckoo	*Cuculus pyrrhophanus*		ml
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		ml
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		ml
Strigidae (hawk-owls)			
Southern Boobook Owl	*Ninox novaeseelandiae*		ml
Barking Owl (southern race)	*Ninox connivens connivens*	CS2	
Tytonidae (barn owls)			
Masked Owl	*Tyto novaehollandiae novaehollandiae*	CS2	
Barn Owl	*Tyto alba*		ml
Podargidae (frogmouths)			
Tawny Frogmouth	*Podargus strigoides*		ml
Podargidae (nightjars)			
Spotted Nightjar	*Eurostopodus argus*		ml

Table 4 (cont).

Species		Cons. sign.	Records
Aegothelidae (owlet-nightjars)			
Austraian Owlet-nightjar	*Aegotheles cristatus*		
Apodidae (swifts)			
Fork-tailed Swift	*Apus pacificus*	CS1 mig	
Halcyonidae (forest kingfishers)			
Laughing Kookaburra	*Dacelo novaeguineae*	Introduced	ml, ch, obs
Sacred Kingfisher	*Todiramphus sanctus*		ml
Meropidae (bee-eaters)			
Rainbow Bee-eater	*Merops ornatus*	CS1 mig	ml, ch
Maluridae (fairy-wrens)			
Red-winged Fairy-wren	*Malurus elegans*	CS3	
Splendid Fairy-wren	*Malurus splendens*	CS3	ml, ch, obs
Variegated Fairy-wren	*Malurus lamberti*	CS3	
White-winged Fairy-wren	*Malurus leucopterus*	CS3	ml
Southern Emu-wren	*Stipiturus malachurus*	CS3	
Pardalotidae (pardalotes)			
Spotted Pardalote	*Pardalotus punctatus*		
Striated Pardalote	*Pardalotus striatus*		ml, ch, obs
White-browed Scrubwren	*Sericornis frontalis*	CS3	
Weebill	*Smicrornis brevirostris*	CS3	ch, obs
Western Gerygone	*Gerygone fusca*		ml, ch, obs
Inland Thornbill	*Acanthiza apicalis*	CS3	
Western Thornbill	*Acanthiza inornata*	CS3	ml, ch
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	CS3	ml, ch, obs
Meliphagidae (honeyeaters)			
Red Wattlebird	*Anthochaera carunculata*		ml, ch, obs
Western Wattlebird	*Anthochaera lunullata*	CS3	ml, ch, obs
Yellow-throated Miner	*Manorina flavigula*	CS3	ml
Singing Honeyeater	*Lichenostomus virescens*		ml, ch, obs
Brown-headed Honeyeater	*Melithreptus brevirostris*		ml
White-naped Honeyeater	*Melithreptus lunatus*	CS3	
Brown Honeyeater	*Lichmera indistincta*		ml, ch, obs
New Holland Honeyeater	*Phylidonyris novaehollandiae*	CS3	ml
White-cheeked Honeyeater	*Phylidonyris nigra*	CS3	
Tawny-crowned Honeyeater	*Phylidonyris melanops*	CS3	ml
Western Spinebill	*Acanthorhynchus superciliosus*		ml
Crimson Chat	*Epthianura tricolor*		ml
White-fronted Chat	*Epthianura albifrons*		ml
Petroicidae (Australian robins)			
Scarlet Robin	*Petroica multicolor*	CS3	ml, obs
Red-capped Robin	*Petroica goodenovii*		ml
Hooded Robin	*Melanodryas cucullata*	CS3	ml
Western Yellow Robin	*Eopsaltria griseogularis*	CS3	

Table 4 (cont.)

Species		Cons. sign.	Records
Neosittidae (sittellas)			
Varied Sittella	*Daphoenositta chrysoptera*	CS3	ml
Pachycephalidae (whistlers)			
Crested Bellbird	*Oreoica gutturalis gutturalis*	CS2	ml
Golden Whistler	*Pachycephala pectoralis*	CS3	
Rufous Whistler	*Pachycephala rufiventris*		ml, ch, obs
Grey Shrike-thrush	*Colluricincla harmonica*	CS3	ml
Dicruridae (flycatchers)			
Restless Flycatcher	*Myiagra inquieta*	CS3	ml
Magpie-lark	*Grallina cyanoleuca*		ml, ch, obs
Grey Fantail	*Rhipidura fuliginosa*		ml, ch, obs
Willie Wagtail	*Rhipidura leucophrys*		ml, ch, obs
Campephagidae (cuckoo-shrikes)			
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		ml, ch, obs
White-winged Triller	*Lalage sueurii*		ml
Artamidae (woodswallows and allies)			
Black-faced Woodswallow	*Artamus cinereus*	CS3	ml, ch
Dusky Woodswallow	*Artamus cyanopterus*	CS3	ml, obs
Masked Woodswallow	*Artamus personatus*		ml
Grey Butcherbird	*Cracticus torquatus*		ml, ch, obs
Australian Magpie	*Gymnorhina tibicen*		ml, ch, obs
Grey Currawong	*Strepera versicolor*	CS3	ml
Corvidae (ravens and crows)			
Australian Raven	*Corvus coronoides*		ml, ch, obs
Dicaeidae (flower-peckers)			
Mistletoebird	*Dicaeum hirundinaceum*		ml, obs
Hirundinidae (swallows)			
White-backed Swallow	*Cheramoeca leucosternus*		ml
Welcome Swallow	*Hirundo neoxena*		ml, ch, obs
Tree Martin	*Hirundo nigricans*		ml, ch, obs
Fairy Martin	*Hirundo ariel*		
Sylviidae (Old World warblers)			
Clamorous Reed-Warbler	*Acrocephalus stentoreus*		ch
Little Grassbird	*Megalurus gramineus*		ch
Rufous Songlark	*Cincloramphus mathewsi*		ml
Zosteropidae (white-eyes)			
Silvereye	*Zosterops lateralis*		ml, ch, obs

Table Five. Mammals of the project area. Conservation significance is indicated as described in Methods. Species recorded along the route either by Bamford (1986) at Mooliabeenee (Ml), or in the Chandala area (Ch) by Bamford (unpubl. data) are indicated. Observations during the site inspection (obs), including reports from landowners, are also shown.

Species		Cons. sign.	Reported
Tachyglossidae (echidnas)			
Echidna	*Tachyglossus aculeatus*		ml, obs
Dasyuridae			
Mardo	*Antechinus flavipes*	CS3	
Chuditch	*Dasyurus geoffroii*	CS1	
Brush-tailed Phascogale	*Phascogale tapoatafa*	CS2	
dunnart	*Sminthopsis dolichura*	CS3	ml
White-footed Dunnart	*Sminthopsis granulipes*	CS3	ml
dunnart	*Sminthopsis griseoventer*	CS3	ml
Peramelidae (bandicoots)			
Quenda or Southern Brown Bandicoot	*Isoodon obesulus*	CS2	ml, obs
Phalangeridae (possums)			
Brush-tailed Possum	*Trichosurus vulpecula*		
Burramyidae (pygmy possums)			
Western Pygmy Possum	*Cercartetus concinnus*	CS3	ml, obs
Tarsipedidae (honey possum)			
Honey Possum	*Tarsipes rostratus*	CS3	ml
Macropodidae (kangaroos and wallabies)			
Western Grey Kangaroo	*Macropus fuliginosus*		ml, obs
Euro	*Macropus robustus*	CS3	
Brush or Black-gloved Wallaby	*Macropus irma*	CS2	ml, obs
Mollosidae (mastiff bats)			
White-striped Bat	*Tadarida (Nyctinomus) australis*		ml
	Mormopterus planiceps	CS3	
Vespertilionidae (vesper bats)			
Gould's Wattled Bat	*Chalinolobus gouldii*		
Chocolate Wattled Bat	*Chalinolobus morio*		
King River Eptesicus	*Vespadelus (Eptesicus) regulus*		
	Falsistrellus mackenziei	CS2	
Lesser Long-eared Bat	*Nyctophilus geoffroyi*		
Gould's Long-eared Bat	*Nyctophilus gouldii*		
Greater Long-eared Bat	*Nyctophilus timoriensis*		ml
Muridae (rats and mice)			
House Mouse	*Mus musculus*	Introduced	ml
Noodji or Ashy-grey Mouse	*Pseudomys albocinereus*	CS3	ml
Moodit or Bush Rat	*Rattus fuscipes*	CS3	
Rakali or Water Rat	*Hydromys chrysogaster*	CS2	ml
Black Rat	*Rattus rattus*	Introduced	ml

Table 5 (cont.)

Species	Cons. sign.	Recorded
Leporidae (rabbits and hares)		
Rabbit *Oryctolagus cuniculus*	Introduced	ml, ch, obs
Canidae (foxes and dogs)		
European Red Fox *Vulpes vulpes*	Introduced	ml, ch, obs
Felidae (cats)		
Feral Cat *Felis catus*	Introduced	ml, obs

Table Six. Species considered extinct in the project area.

Species	Conservation Status
Burhinidae (stone-curlews)	
Bush Stone-curlew *Burhinus grallarius*	Priority 4 (CALM)
Psitaccidae (parrots and lorikeets)	
Ground Parrot (South-West) *Pezoporus wallicus flaviventris*	End (WA Act)
Cinclosomatidae (quail-thrushes and allies)	
Western Whipbird *Psophodes nigrogularis nigrogularis*	End (WA Act)
Dasyuridae	
Dibbler *Parantechinus apicalis*	End (WA Act)
Myrmecobiidae (numbat)	
Numbat *Myrmecobius fasciatus*	Vuln (WA Act, EPBC)
Thylacomyidae (bilbies or rabbit-eared bandicoots)	
Bilby, Dalgyte or Walpiri *Macrotis lagotis*	Vuln (WA Act, EPBC)
Peramelidae (bandicoots)	
Western Barred Bandicoot *Perameles bougainville*	End (WA Act, EPBC)
Pseudocheiridae (ring-tailed possums)	
Western Ring-tailed Possum *Pseudochierus occidentalis*	Vuln (WA Act, EPBC)
Potoroidae (rat-kangaroos and allies)	
Woylie *Bettongia penicillata*	Priority 5 (CALM)
Boodie *Bettongia lesueur*	Mainland race extinct, island races Vuln (WA Act, EPBC)
Macropodidae (kangaroos and wallabies)	
Muning or Banded Hare-Wallaby *Lagostrophus fasciatus*	Vuln (WA Act, EPBC)
Tammar *Macropus eugenii*	Priority 5 (CALM)
Tjawalpa or Crescent Nailtail Wallaby *Onychogalea lunata*	Extinct
Quokka *Setonix brachyurus*	Vuln (WA Act)
Muridae (rats and mice)	
Dayang or Heath Rat *Pseudomys shortridgei*	Vuln (WA Act)
Canidae (foxes and dogs)	
Dingo *Canis lupus dingo*	Least Concern

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Appendix 1. Categories used in the assessment of conservation status.

Environmental Protection and Biodiversity Conservation (EPBC) Act and the WA Wildlife Conservation Act (categories from IUCN, based on review by Mace and Stuart (1994)).

Extinct. Taxa not definitely located in the wild during the past 50 years.

Extinct in the Wild. Taxa known to survive only in captivity.

Critically Endangered. Taxa facing an extremely high risk of extinction in the wild in the immediate future.

Endangered. Taxa facing a very high risk of extinction in the wild in the near future.

Vulnerable. Taxa facing a high risk of extinction in the wild in the medium-term future.

Near Threatened. Taxa that risk becoming Vulnerable in the wild.

Conservation Dependent. Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known). Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern. Taxa that are not Threatened.

WA Department of Conservation and Land Management Priority species (species not listed under the Conservation Act, but for which there is some concern).

Priority 1. Taxa with few, poorly known populations on threatened lands.

Priority 2. Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.

Priority 3. Taxa with several, poorly known populations, some on conservation lands.

Priority 4. Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.

Priority 5. Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Appendix H

Air Quality Modelling

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: PDNH Neaves to Brand 2021
RUN: Hour 1
POLLUTANT: Oxides of Nitrogen

I. SITE VARIABLES

U=	1.0 M/S	Z0=	100. CM	ALT=	0. (M)
BRG=	270.0 DEGREES	VD=	.0 CM/S		
CLAS=	7 (G)	VS=	.0 CM/S		
MIXH=	50. M	AMB=	.0 PPM		
SIGTH=	10. DEGREES	TEMP=	15.0 DEGREE (C)		

II. LINK VARIABLES

LINK DESCRIPTION	*	LINK COORDINATES (M) X1	Y1	X2	Y2	*	TYPE	VPH	EF (G/MI)	H (M)	W (M)
A. Link A	*	0	-500	0	500	*	AG	670	6.1	1.0	12.0
B. Link B	*	5	-500	5	500	*	AG	670	6.1	1.0	12.0

III. RECEPTOR LOCATIONS

RECEPTOR	*	COORDINATES (M) X	Y	Z
1. Recpt 1	*	-10	0	1.8
2. Recpt 2	*	-25	0	1.8
3. Recpt 3	*	-50	0	1.8
4. Recpt 4	*	-100	0	1.8
5. Recpt 5	*	10	0	1.8
6. Recpt 6	*	25	0	1.8
7. Recpt 7	*	50	0	1.8
8. Recpt 8	*	100	0	1.8

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 2

JOB: PDNH Neaves to Brand 2021
RUN: Hour 1

IV. MODEL RESULTS (PRED. CONC, INCLUDES AMB.)

RECEPTOR	* PRED CONC (PPM)	* CONC/LINK (PPM) A	B
1. Recpt 1	.0	.0	.0
2. Recpt 2	.0	.0	.0
3. Recpt 3	.0	.0	.0
4. Recpt 4	.0	.0	.0
5. Recpt 5	.3	.1	.1
6. Recpt 6	.2	.0	.0
7. Recpt 7	.1	.0	.0
8. Recpt 8	.0	.0	.0

JOB: PDNH Neaves to Brand 2021
RUN: Hour 1
POLLUTANT: Carbon Monoxide

I. SITE VARIABLES

U=	1.0 M/S	Z0=	100. CM	ALT=	0. (M)
BRG=	270.0 DEGREES	VD=	.0 CM/S		
CLAS=	7 (G)	VS=	.0 CM/S		
MIXH=	50. M	AMB=	.0 PPM		
SIGTH=	10. DEGREES	TEMP=	15.0 DEGREE (C)		

II. LINK VARIABLES

LINK DESCRIPTION	LINK COORDINATES (M) X1	Y1	X2	Y2	TYPE	VPH	EF (G/MI)	H (M)	W (M)
A. Link A	0	-500	0	500	AG	670	7.3	1.0	12.0
B. Link B	5	-500	5	500	AG	670	7.3	1.0	12.0

III. RECEPTOR LOCATIONS

RECEPTOR	COORDINATES (M) X	Y	Z
1. Recpt 1	-10	0	1.8
2. Recpt 2	-25	0	1.8
3. Recpt 3	-50	0	1.8
4. Recpt 4	-100	0	1.8
5. Recpt 5	10	0	1.8
6. Recpt 6	25	0	1.8
7. Recpt 7	50	0	1.8
8. Recpt 8	100	0	1.8

JOB: PDNH Neaves to Brand 2021
RUN: Hour 1
POLLUTANT: Carbon Monoxide

IV. MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

RECEPTOR	PRED CONC (PPM)	CONC/LINK (PPM) A	B
1. Recpt 1	.0	.0	.0
2. Recpt 2	.0	.0	.0
3. Recpt 3	.0	.0	.0
4. Recpt 4	.0	.0	.0
5. Recpt 5	.3	.2	.2
6. Recpt 6	.2	.0	.1
7. Recpt 7	.1	.0	.0
8. Recpt 8	.1	.0	.0

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: PDNH Neaves to Brand 2021
RUN: Hour 1
POLLUTANT: PMx10

I. SITE VARIABLES

U=	1.0 M/S	Z0=	100. CM	ALT=	0. (M)
BRG=	270.0 DEGREES	VD=	.0 CM/S		
CLAS=	7 (G)	VS=	.0 CM/S		
MIXH=	50. M	AMB=	.0 PPM		
SIGTH=	10. DEGREES	TEMP=	15.0 DEGREE (C)		

II. LINK VARIABLES

LINK DESCRIPTION	*	LINK COORDINATES (M) X1	Y1	X2	Y2	*	TYPE	VPH	EF (G/MI)	H (M)	W (M)
A. Link A	*	0	-500	0	500	*	AG	670	3.2	1.0	12.0
B. Link B	*	5	-500	5	500	*	AG	670	3.2	1.0	12.0

III. RECEPTOR LOCATIONS

RECEPTOR	*	COORDINATES (M) X	Y	Z
1. Recpt 1	*	-10	0	1.8
2. Recpt 2	*	-25	0	1.8
3. Recpt 3	*	-50	0	1.8
4. Recpt 4	*	-100	0	1.8
5. Recpt 5	*	10	0	1.8
6. Recpt 6	*	25	0	1.8
7. Recpt 7	*	50	0	1.8
8. Recpt 8	*	100	0	1.8

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 2

JOB: PDNH Neaves to Brand 2021

RUN: Hour 1
POLLUTANT: PM*10

IV. MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

RECEPTOR	PRED CONC (PPM)	CONC/LTNK (PPM) A	B
1. Recpt 1	.0	.0	.0
2. Recpt 2	.0	.0	.0
3. Recpt 3	.0	.0	.0
4. Recpt 4	.0	.0	.0
5. Recpt 5	.1	.0	.0
6. Recpt 6	.0	.0	.0
7. Recpt 7	.0	.0	.0
8. Recpt 8	.0	.0	.0

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: PDNH Neaves to Maralla 2021
RUN: Hour 1
POLLUTANT: Carbon Monoxide

I. SITE VARIABLES

U=	1.0 M/S	Z0=	100. CM	ALT=	0. (M)
BRG=	270.0 DEGREES	VD=	.0 CM/S		
CLAS=	7 (G)	VS=	.0 CM/S		
MIXH=	50. M	AMB=	.0 PPM		
SIGTH=	10. DEGREES	TEMP=	15.0 DEGREE (C)		

II. LINK VARIABLES

LINK DESCRIPTION	*	LINK COORDINATES (M) X1	Y1	X2	Y2	*	TYPE	VPH	EF (G/MI)	H (M)	W (M)
A. Link A	*	0	-500	0	500	*	AG	1900	7.3	1.0	12.0
B. Link B	*	5	-500	5	500	*	AG	1900	7.3	1.0	12.0

III. RECEPTOR LOCATIONS

RECEPTOR	*	COORDINATES (M) X	Y	Z
1. Recpt 1	*	-10	0	1.8
2. Recpt 2	*	-25	0	1.8
3. Recpt 3	*	-50	0	1.8
4. Recpt 4	*	-100	0	1.8
5. Recpt 5	*	10	0	1.8
6. Recpt 6	*	25	0	1.8
7. Recpt 7	*	50	0	1.8
8. Recpt 8	*	100	0	1.8

JOB: PDNH Neaves to Maralla 2021

RUN: Hour 1
POLLUTANT: Carbon Monoxide

IV. MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

RECEPTOR	PRED CONC (PPM)	CONC/LINK (PPM) A	B
1. Recpt 1	.0	.0	.0
2. Recpt 2	.0	.0	.0
3. Recpt 3	.0	.0	.0
4. Recpt 4	.0	.0	.0
5. Recpt 5	.9	.4	.5
6. Recpt 6	.6	.3	.3
7. Recpt 7	.4	.2	.2
8. Recpt 8	.2	.1	.1

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: PDNH Neaves to Maralla 2021
RUN: Hour 1
POLLUTANT: Oxides of Nitrogen

I. SITE VARIABLES

U=	1.0 M/S	Z0=	100. CM	ALT=	0. (M)
BRG=	270.0 DEGREES	VD=	.0 CM/S		
CLAS=	7 (G)	VS=	.0 CM/S		
MIXH=	50. M	AMB=	.0 PPM		
SIGTH=	10. DEGREES	TEMP=	15.0 DEGREE (C)		

II. LINK VARIABLES

LINK DESCRIPTION	*	LINK COORDINATES (M) X1	Y1	X2	Y2	*	TYPE	VPH	EF (G/MI)	H (M)	W (M)
A. Link A	*	0	-500	0	500	*	AG	1900	5.3	1.0	12.0
B. Link B	*	5	-500	5	500	*	AG	1900	5.3	1.0	12.0

III. RECEPTOR LOCATIONS

RECEPTOR	*	COORDINATES (M) X	Y	Z
1. Recpt 1	*	-10	0	1.8
2. Recpt 2	*	-25	0	1.8
3. Recpt 3	*	-50	0	1.8
4. Recpt 4	*	-100	0	1.8
5. Recpt 5	*	10	0	1.8
6. Recpt 6	*	25	0	1.8
7. Recpt 7	*	50	0	1.8
8. Recpt 8	*	100	0	1.8

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 2

JOB: PDNH Neaves to Maralla 2021

RUN: Hour 1
POLLUTANT: Oxides of Nitrogen

IV. MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

RECEPTOR	PRED CONC (PPM)	CONC/LINK (PPM) A	B
1. Recpt 1	.0	.0	.0
2. Recpt 2	.0	.0	.0
3. Recpt 3	.0	.0	.0
4. Recpt 4	.0	.0	.0
5. Recpt 5	.6	.3	.3
6. Recpt 6	.4	.2	.2
7. Recpt 7	.3	.1	.1
8. Recpt 8	.2	.0	.0

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: PDNH Neaves to Maralla 2021
RUN: Hour 1
POLLUTANT: PM*10

I. SITE VARIABLES

U=	1.0 M/S	Z0=	100. CM	ALT=	0. (M)
BRG=	270.0 DEGREES	VD=	.0 CM/S		
CLAS=	7 (G)	VS=	.0 CM/S		
MIXH=	50. M	AMB=	.0 PPM		
SIGTH=	10. DEGREES	TEMP=	15.0 DEGREE (C)		

II. LINK VARIABLES

LINK DESCRIPTION	*	LINK COORDINATES (M) X1	Y1	X2	Y2	*	TYPE	VPH	EF (G/MI)	H (M)	W (M)
A. Link A	*	0	-500	0	500	*	AG	1900	2.8	1.0	12.0
B. Link B	*	5	-500	5	500	*	AG	1900	2.8	1.0	12.0

III. RECEPTOR LOCATIONS

RECEPTOR	*	COORDINATES (M) X	Y	Z
1. Recpt 1	*	-10	0	1.8
2. Recpt 2	*	-25	0	1.8
3. Recpt 3	*	-50	0	1.8
4. Recpt 4	*	-100	0	1.8
5. Recpt 5	*	10	0	1.8
6. Recpt 6	*	25	0	1.8

7. Recpt 7	*	50	0	1.8
8. Recpt 8	*	100	0	1.8

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 2

JOB: PDNH Neaves to Maralla 2021
RUN: Hour 1
POLLUTANT: PM*10

IV. MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

RECEPTOR	PRED CONC (PPM)	CONC/LINK (PPM) A	B
1. Recpt 1	.0	.0	.0
2. Recpt 2	.0	.0	.0
3. Recpt 3	.0	.0	.0
4. Recpt 4	.0	.0	.0
5. Recpt 5	.3	.2	.2
6. Recpt 6	.2	.0	.1
7. Recpt 7	.1	.0	.0
8. Recpt 8	.0	.0	.0

Appendix I

Noise Assessment

Herring Storer Acoustics

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BACKGROUND NOISE MONITORING

PERTH – DARWIN HIGHWAY

FOR

GUTTERIDGE HASKINS & DAVEY

BY

HERRING STORER ACOUSTICS

MAY 2005

REFERENCE: 4481-2-04044

CONTENTS

APPENDICES

1.0 INTRODUCTION

Herring Storer Acoustics (HSA) was commissioned by Gutteridge Haskins Davey (GHD) to undertake ambient noise level monitoring adjacent to the proposed Perth-Darwin Highway. Noise monitoring was undertaken at four (4) locations.

The purpose of the monitoring was to establish the existing acoustic environment. An assessment has been made with regards to the Main Roads Western Australia 'Noise Level Objectives' to determine the appropriate objective for assessment.

This report presents the methodology and the results of the noise monitoring.

2.0 CONCLUSION

The results of the noise monitoring are summarised below in Table 2.1.

TABLE 2.1 – AVERAGE WEEKDAY MEASURED NOISE LEVELS, dB(A)

Location	$L_{10(18hour)}$	$L_{eq,8hr}$ (0pm-6am)	$L_{eq,24hr}$	$L_{eq,day}$ (7am-10pm)	$L_{eq,night}$ (0pm-7am)
L1 – 547 Warbrook Road	42.5	35.0	44.4	46.0	37.0
L2 – 312 Raphael Road	42.6	36.2	43.5	45.2	39.4
L3 – Lot 25 Crest Hill Road	45.6	39.7	43.5	45.0	38.7
L4 – Lot 1 Bindoon-Moora Road	38.5	31.9	41.7	43.4	33.6

For Main Roads Western Australia 'Noise Level Objectives' the base criteria of an $L_{A10,(18hr)}$ of 63 dB(A) and an $L_{Aeq,(8hr)}$ of 55 dB(A) apply.

3.0 CRITERIA

MAIN ROADS WESTERN AUSTRALIA NOISE LEVEL OBJECTIVES

Main Roads Western Australia have criteria known as Noise Level Objectives, which as of recently, include both a day and night time permissible noise level. These are stated as:

"Noise level criteria to be used in the assessment are the Noise Level Objectives specified in Table [3.1] below. Objectives are specified upper limits of traffic noise which it is intended, should not be exceeded. Objectives apply outside residential buildings, and outside public buildings such as hospitals, schools and libraries. In the case of public buildings there is a scope to relax the objectives if affected rooms are air-conditioned, and therefore normally used with windows closed.

TABLE 3.1 - NOISE LEVEL OBJECTIVES

Base Objective	*Objective for High Ambient Areas*
63 dB(A) $L_{10(18hour)}$	*Ambient + 3 dB(A)*
55 dB(A) $L_{eq(8hour)}$	*Ambient + 3 dB(A)*

Notes:

(1) Noise levels are $L_{10\ (18hour)}$ values, from 6am to midnight, and $L_{eq(8hour)}$ values from 10 p.m. to 6 a.m.

(2) Ambient noise is the level of noise before the road project commences

(3) A high ambient area is where ambient noise is more than 60 dB(A) $L_{10(18hour)}$, or 52 dB(A) $L_{eq(8hour)}$.

(4) Due to the impracticality of controlling noise at the upper floors of multi-storey buildings, noise assessment is restricted to the ground floor level.

(5) Noise is assessed 1 metre from a building, and 1.2 to 1.5 metres above the ground floor level.

(6) The objectives apply to the expected 15 to 20 years after opening of the road project, using available traffic forecasts.

(7) Noise level objectives relate to the total traffic noise expected at a building facade, i.e. noise from the new road and any other roads."

Monitoring is required to determine the whether the area is in a high ambient noise area and therefore, which criteria is appropriate.

4.0 METHODOLOGY

The measurement locations selected were:

Location 1 - 547 Warbrook Road, City of Swan
Location 2 - 312 Raphael Road, City of Swan
Location 3 - Lot 25 Crest Hill Road, Shire of Chittering
Location 4 - Lot 1 Bindoon – Moora Road, Shire of Chittering

Note: Locations 1 and 2 are residences R4 and R25 as listed in Herring Storer Acoustics report of February 2004 (reference: 2834-1-04044), for which noise monitoring was recommended.

Monitoring was carried out for the following periods:

Locations 1 & 2
Saturday 15 January 2005 to Thursday 20 January 2005

Locations 3 & 4
Wednesday 23 Mach 2005 to Sunday 27 March 2005,
and Tuesday 29 March 2005

Note: Monday 28 March 2005 was excluded due to inclement weather.

The noise loggers record statistical noise level data of which, the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} levels are reported. These are defined below:

L_{A1} The noise level exceeded for 1% of the time (in this instance, the noise level exceeded for 36 seconds in each 1-hour period).

L_{A10} The noise level exceeded for 10% of the time (in this instance, the noise level exceeded for 6 minutes in each 1-hour period).

L_{Aeq} The equivalent continuous noise level for the 1-hour period (sometimes referred to as the average noise level).

L_{A90} The noise level exceeded for 90% of the time (in this instance, the noise level exceeded for 54 minutes in each 1-hour period).

The noise loggers for Locations 1 and 2 and 4 were placed at a distance of 1 metre from the facade facing the freeway interchange. At Location 3, there was no suitable location that was within 1m of a façade. However, given the volume of traffic in the area, no difference in noise levels was determined. The microphone heights are 1.5 metres above ground floor level. Photographs were taken at the site showing the logger location (refer Appendix B). The loggers were calibrated before and after the measurement period and have been subject to a laboratory calibration within the last 24 months.

Recorded logger data was then scrutinised for weather conditions during the period. Weather data was obtained from the Bureau of Meteorology and three days meeting the specifications for each location reported.

From the logger data, the $L_{10,18hr}$, $L_{eq,8hr(2200\text{-}0600)}$, $L_{eq,24hr}$, $L_{eq,Day(0700\text{-}2200)}$, $L_{eq,Night(2200\text{-}0700)}$ were calculated for three complete 24-hour periods at each location that meets the required weather conditions and are defined below:

$L_{10,18hr}$ is the average of the hourly L_{10} values between 0600 hours and 2400 hours.

$L_{eq,8hr(2200\text{-}0600)}$ is the logarithmic average of the hourly L_{eq} values between 2200 hours and 0600 hours on the same day.

$L_{eq,24hr}$ is the logarithmic average of the hourly L_{eq} values for the entire 24-hour period.

$L_{eq,Day(0700\text{-}2200)}$ is the logarithmic average of the hourly L_{eq} values between 0700 hours and 2200 hours.

$L_{eq,Night(2200\text{-}0700)}$ is the logarithmic average of the hourly L_{eq} between 2200 hours and 0700 hours on the same day.

The above are used by various criteria for assessment of transportation noise.

5.0 RESULTS & ANALYSIS

The results of the monitoring are presented in the Appendices as follows:

Appendix A Graphical Noise Level Data.

Appendix B Photographs at Monitoring Locations.

A summary of calculated parameters from each location are tabulated below.

TABLE 5.1 – 547 WARBROOK ROAD, dB(A)

Date	$L_{10,18hr}$	$L_{eq,8hr(2200-0600)}$	$L_{eq,24hr}$	$L_{eq,Day(0700-2200)}$	$L_{eq,Night(2200-0700)}$
Saturday 15/01/05	41.0	36.8	41.1	42.4	37.0
Sunday 16/01/05	42.5	38.8	45.7	47.4	38.8
Monday 17/01/05	40.7	34.5	44.0	45.7	37.2
Tuesday 18/01/05	45.2	35.0	45.0	46.8	36.3
Wednesday 19/01/05	41.5	36.5	42.4	44.0	37.2
Thursday 20/01/05	42.6	33.8	47.9	49.7	35.4
Average	42.5*	35.0*	44.4	46.0	37.0

* Weekday values were used to determine background for MRWA Noise Level Objectives

TABLE 5.2 – 312 RAPHAEL ROAD, dB(A)

Date	$L_{10,18hr}$	$L_{eq,8hr(2200-0600)}$	$L_{eq,24hr}$	$L_{eq,Day(0700-2200)}$	$L_{eq,Night(2200-0700)}$
Saturday 15/01/05	45.3	42.6	43.5	44.0	42.3
Sunday 16/01/05	44.1	42.9	46.8	48.1	42.7
Monday 17/01/05	43.4	34.5	43.8	45.7	35.7
Tuesday 18/01/05	44.1	36.8	44.7	46.2	39.8
Wednesday 19/01/05	40.9	39.7	39.3	43.0	39.7
Thursday 20/01/05	41.9	33.9	42.7	44.4	36.1
Average	42.6*	36.2*	43.5	45.2	39.4

* Weekday values were used to determine background for MRWA Noise Level Objectives

TABLE 5.3 – Lot 25 CREST HILL ROAD, dB(A)

Date	$L_{10,18hr}$	$L_{eq,8hr(2200-0600)}$	$L_{eq,24hr}$	$L_{eq,Day(0700-2200)}$	$L_{eq,Night(2200-0700)}$
Wednesday 23/03/05	47.6	41.1	47.0	48.5	42.3
Thursday 24/03/05	44.6	39.5	43.3	44.6	39.5
Friday 25/03/05	42.0	30.2	40.5	42.2	33.8
Saturday 26/03/05	46.1	37.6	42.8	44.2	38.6
Sunday 27/03/05	41.1	38.1	42.0	43.3	38.0
Tuesday 29/03/05	44.6	38.4	45.6	47.2	40.1
Average	45.6*	39.7*	43.5	45.2	38.7

* Weekday values (excluding Public Holidays) were used to determine background for MRWA Noise Level Objectives

TABLE 5.4 – Lot 1 BINDOON-MOORA ROAD, dB(A)

Date	$L_{10,18hr}$	$L_{eq,8hr(2200-0600)}$	$L_{eq,24hr}$	$L_{eq,Day(0700-2200)}$	$L_{eq,Night(2200-0700)}$
Wednesday 23/03/05	40.0	32.4	41.3	43.1	32.6
Thursday 24/03/05	38.7	29.5	40.5	42.1	31.6
Friday 25/03/05	38.5	25.6	44.2	46.1	34.3
Saturday 26/03/05	39.9	30.8	41.1	42.9	33.0
Sunday 27/03/05	39.1	34.9	40.5	41.9	36.4
Tuesday 29/03/05	36.9	33.9	42.4	44.2	33.7
Average	38.5*	31.9*	41.7	43.4	33.6

* Weekday values (excluding Public Holidays) were used to determine background for MRWA Noise Level Objectives

Based on the monitoring carried out, under the MRWA "Noise Level Objective" the base Objectives or an $L_{A10,(18hr)}$ of 63 dB(A) and an $L_{Aeq,(8hr)}$ of 55 dB(A) would be the appropriate criteria for compliance.

For: **HERRING STORER ACOUSTICS**

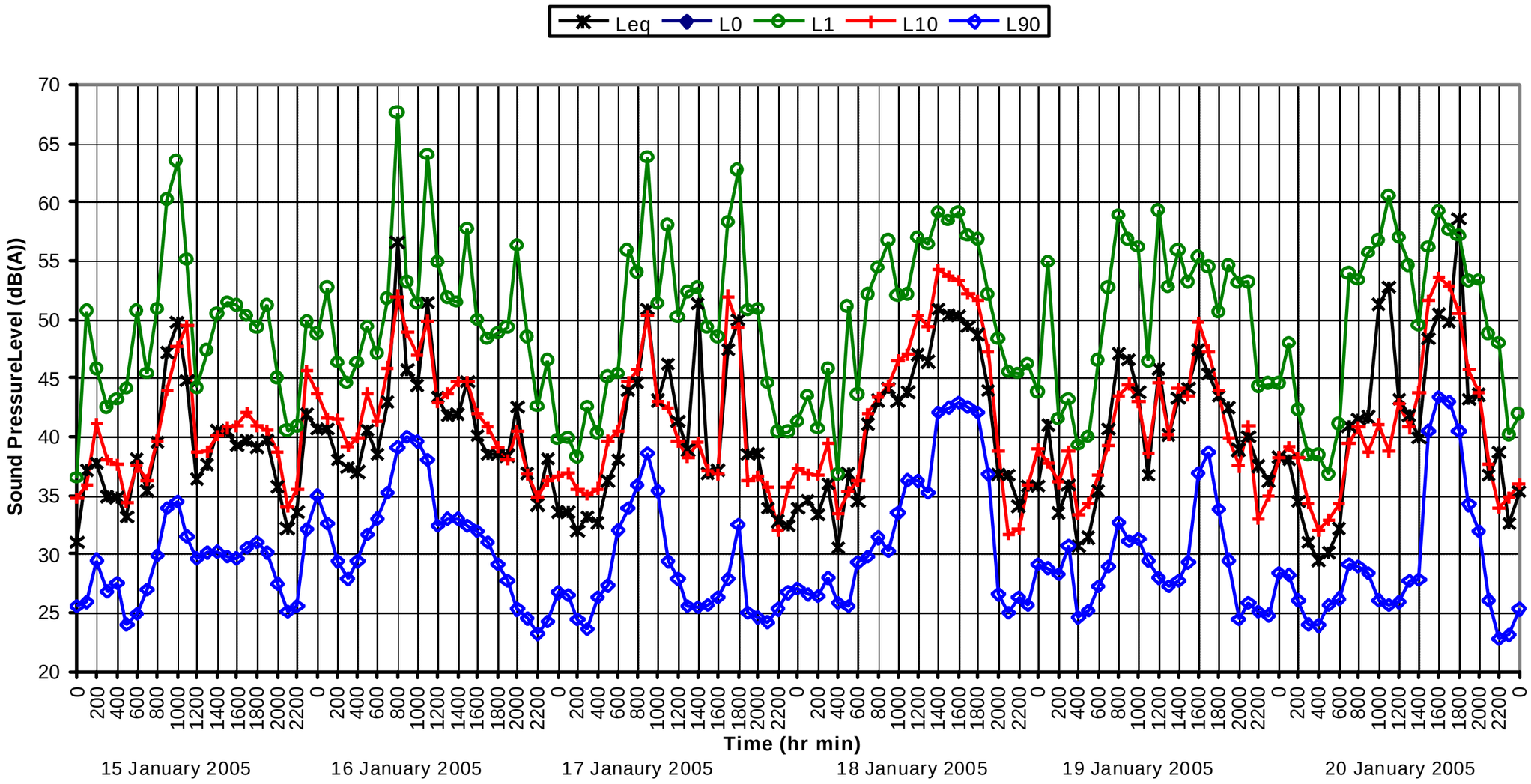
Tim Reynolds Checked: George Watts

26 May 2005

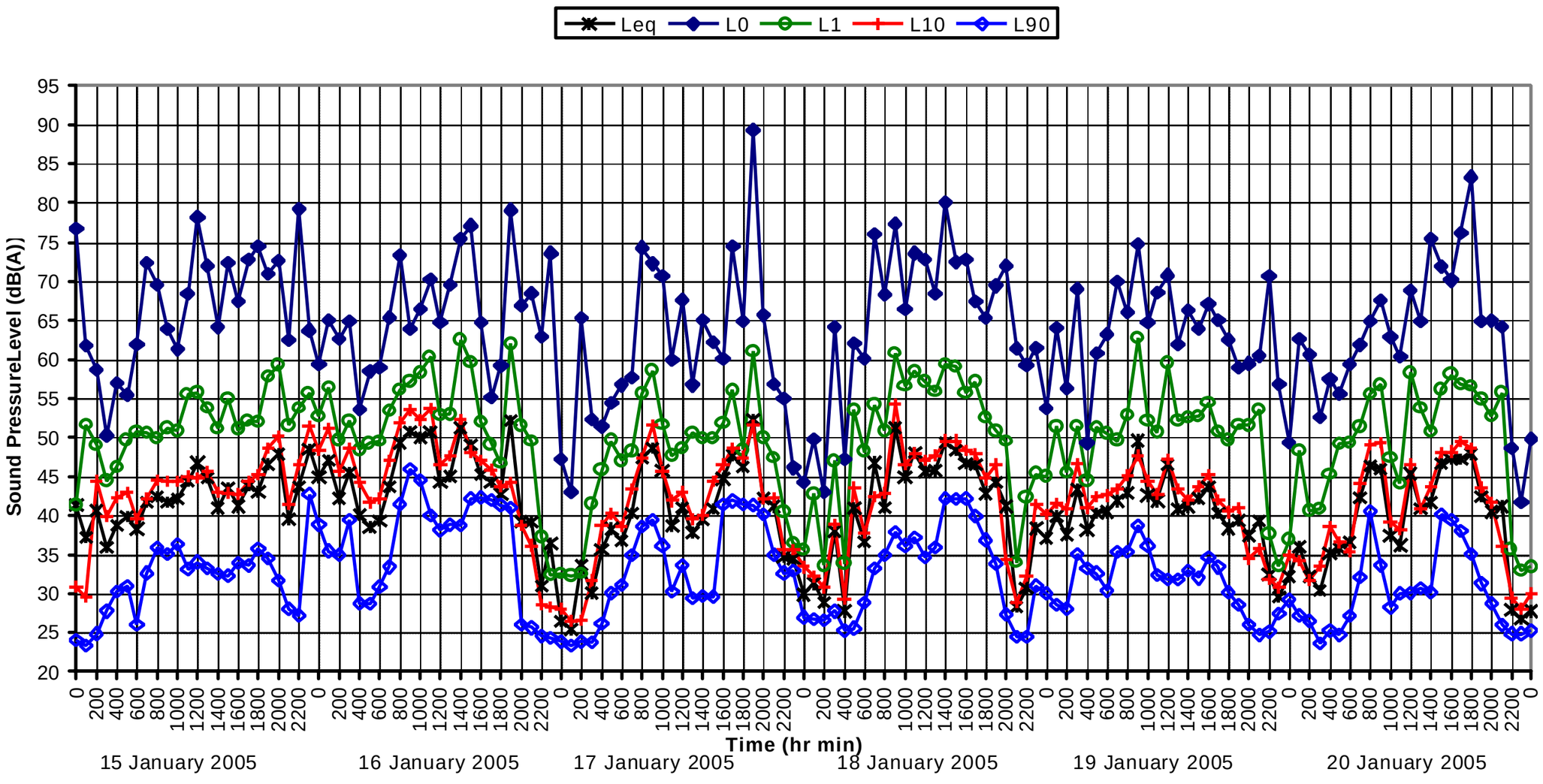
APPENDIX A

GRAPHICAL NOISE LEVEL DATA

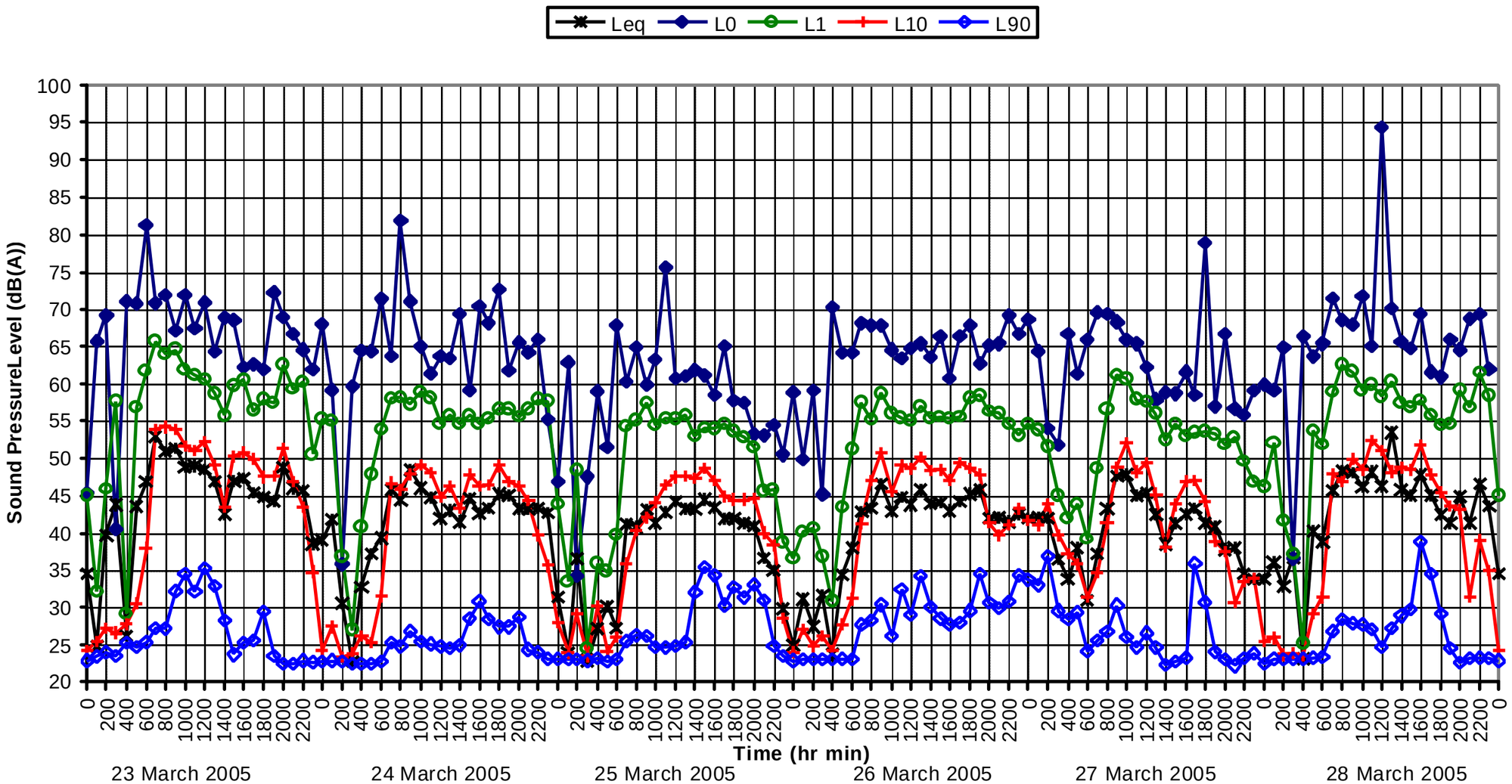
PERTH - DARWIN HIGHWAY NOISE MONITORING
LOCATION 1 : 547 WARBROOK ROAD (15 - 20 JANUARY 2005)



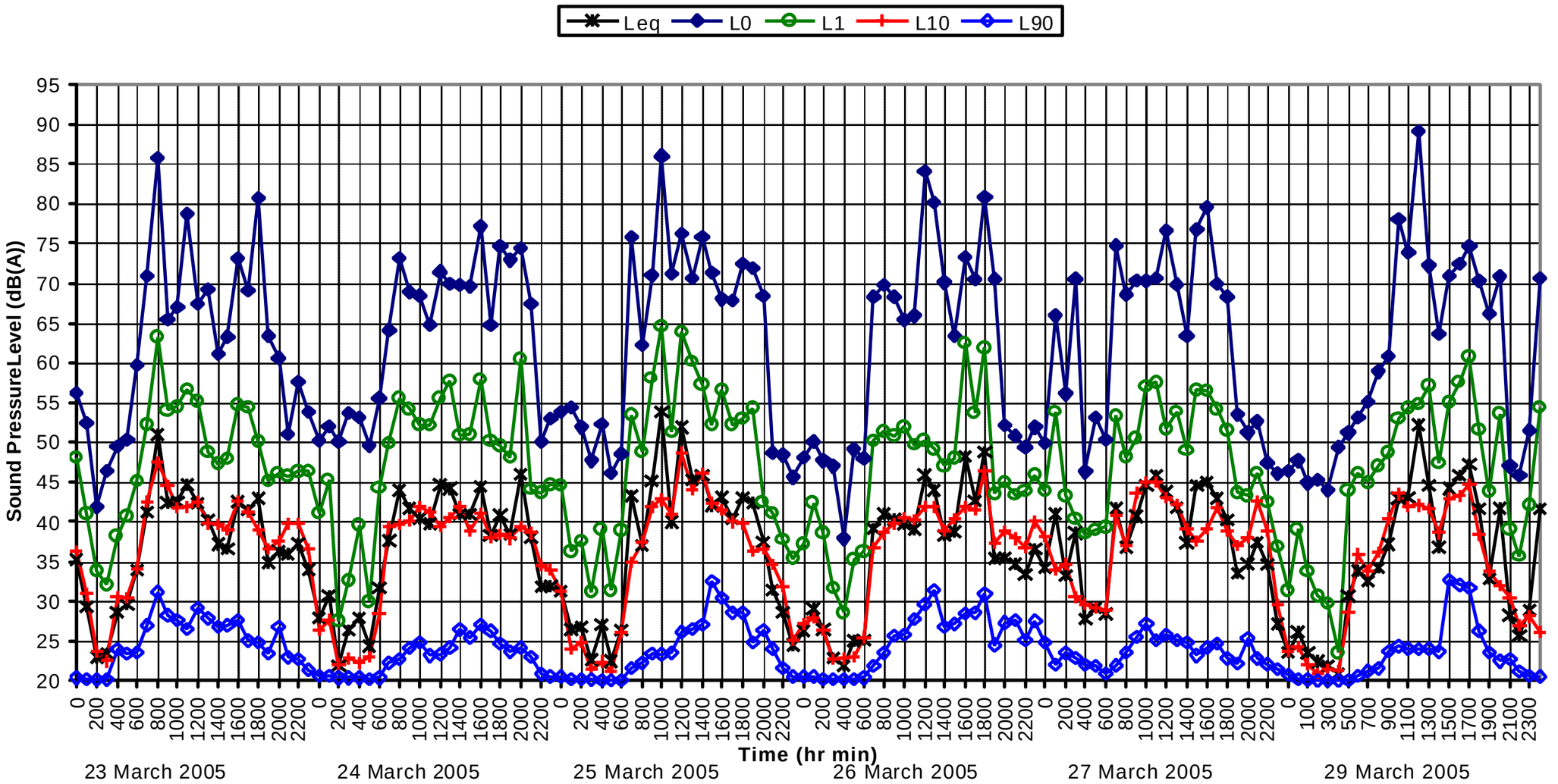
PERTH - DARWIN HIGHWAY NOISE MONITORING
LOCATION 2 : 312 RAPHAEL ROAD (15 - 20 January 2005)



PERTH - DARWIN HIGHWAY NOISE MONITORING
LOCATION 3 : Lot 25 CREST HILL ROAD (23 - 27 & 29 March 2005)



PERTH - DARWIN HIGHWAY NOISE MONITORING
LOCATION 4 : Lot 1 BINDOON-MOORA ROAD (23 - 27 & 29 March 2005)



APPENDIX B

PHOTOGRAPHS AT MONITORING LOCATION

LOCATION 1 - 547 WARBROOK RD TOWARDS RESIDENCE

LOCATION 1 - 547 WARBROOK RD VIEW FROM RESIDENCE

LOCATION 2 - 312 RAPHAEL RD TOWARDS RESIDENCE

LOCATION 2 - 312 RAPHAEL RD VIEW FROM RESIDENCE

LOCATION 3 – VIEW FROM MOOLIABEENE RD TO LOGGER

LOCATION 3 – VIEW FROM LOGGER TOWARDS PROPOSED HIGHWAY

LOCATION 4 – LOT 1 BINDOON – MOORA RD TOWARDS RESIDENCE

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